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Article

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Piero Cuccuini & Graziana Fiorini

First contribution to the taxonomic and cytotaxonomic study of *Parapholis* and *Hainardia* (*Poaceae*) in Albania

Abstract

Cuccuini, P. & Fiorini, G.: First contribution to the taxonomic and cytotaxonomic study of *Parapholis* and *Hainardia* (*Poaceae*) in Albania. — Fl. Medit. 30: 5-18. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

This is the first contribution to the study of *Parapholis* and *Hainardia* (*Poaceae*) in Albania. New taxa for the Albanian flora are reported for *Parapholis* (*P. marginata* and *P. strigosa*), together with the results of a comprehensive cytotaxonomic study of this genus, and a general taxonomic arrangement for *Hainardia* and *Parapholis* is provided, comparing the results with the corresponding data from adjacent Adriatic areas.

Key words: *Hainardieae*, kariotype, taxonomy.

Introduction

The genus *Parapholis* was created by Hubbard (1946) to include four species previously described under different genera: *P. incurva* (L.) C.E. Hubb. (≡ *Aegilops incurva* L.), *P. filiformis* (Roth) C.E. Hubb. (≡ *Rottboella filiformis* Roth), *P. pycnantha* (Hack.) C.E. Hubb. (≡ *Lepturus filiformis* var. *pycnanthus* Hack.) and *P. strigosa* (Dumort.) C.E. Hubb. (≡ *Lepturus strigosus* Dumort.), sharing spikelets sunk in rachis's cavity, 1 floret, glumes 2, inserted side by side, at maturity the rhachis disarticulating with complete internode.

Through a general revision of the genus, Runemark (1962) followed Hubbard's treatment and described a fifth species, *P. marginata* Runemark, distributed in the Eastern Mediterranean. Up to now, two further taxa have been either indicated from Iraq (*P. gracilis* Bor; Bor 1963) and SSSR (Georgia) (*P. incurva* var. *longiflora* (Grossh.) Tzvelev; Tzvelev 1976) as new species and new combination respectively. Together with *Pholiurus* Trin. and the monotypic *Hainardia* Greuter (only including *H. cylindrica* (Willd.) Greuter), it has been included by Greuter (1967) in the tribe *Hainardieae* Greuter, characterized by spikelets fast compressed and sunk in the rachis's cavity, alternate or at times opposite, 1 floret,1 glume in the lateral spikelets and 2 in the apical. The rhachis may disarticulate with complete internode (Cuccuini 2002; Cuccuini & Fiorini 2004).

Based on later studies (Soreng & al. 2015, 2017), the tribe has been either neglected or splitted between *Poeae* subtribes *Parapholiinae* Caro (*Parapholis* and *Hainardia*) and *Beckmanniinae* Nevski (*Pholiurus*).

No specific study has been published on this group in Albania. Main information can be retrieved from both international, national, regional or local floristic treatments and specific scientific reports (Janchen 1920; Ubrizsy & Pénzes 1960; Paparisto & al. 1962; Tutin & al. 1980; Mersinllari & Hoda 1985; Mullaj 1987; Hoda & Mersinllari 2000; Tan & Mullaj 2000; Vangjeli 2003; Shehu & al. 2010; Meyer 2011; Ball 2011). In his *Prodromus Florae peninsulae Balcanicae* Hayek (1933) mentioned only *Hainardia cilindrica* (sub *Lepturus cylindricus*Trin.), Demiri (1983) added *Parapholis incurva* (sub *Lepturus incurvatus*) Trin. Based on the most recent floristic overviews published by Vangjeli & al. (2000), Vangjeli (2015), Pils (2016) and Barina & al. (2018), the former *Hainardiae* are represented in the Albanian flora by three species: *H. cylindrica, P. filiformis* and *P. incurva*. In addition, *Pholiurus pannonicus* (Host) Trin. was reported from a single gathering (or probably from an observation) in the Vlore district, from Sazan island (Baldacci 1894d; Fiori 1927, cited also by Barina & al. 2018; Demiri 1983), where it could have formed an adventitious, maybe ephemeral population. Nevertheless, its actual occurrence in Albania cannot be confirmed, since no specimen could be traced either in Baldacci's or Fiori's herbaria (in PAD and FI) and no new observation is reported in the recent floristic survey of Sazan (Hoda & Mersinlari 2000).

This is the first contribution devoted to this topic and represents a base for additional investigations, both from the morphological and cytological point of view.

Materials & methods

All the above mentioned publications dealing with the flora of Albania or some specific areas or environments within this country provided the background of the study. For the identification of the specimens we referred mainly to Tutin & al. (1980), Cuccuini (2002), and Vangjeli (2015); for the micro-characters (e.g. lemma and pollen) we referred only to data in Cuccuini (2002), Cuccuini & Fiorini (2004) (concerning materials also from Adriatic region). In addition, a critical analysis was carried out on herbarium specimens from some herbaria hosting Albanian specimens (FI, FR, JE and the herbarium of Natural Science Museum of Tirana). A detailed list of revised specimen is provided. On the whole we checked 20 specimens and many duplicates belonging to the new collections in FI, that enabled cytological analysis, for about 120 individuals. Unfortunately, the physical witness of former *Hainardiae* from Albania are still poor or difficult to check, other herbaria with important Albanian collections don't have *Hainardieae* materials or didn't send anything even after many remainders.

Many botanists who worked on Albanian territory (such as Baldacci 1894a, 1894b, 1894c, 1894d, 1895, 1896, 1897, 1899a, 1899b, 1899c, 1901; Baldacci & Béguinot 1918; Degen 1895, 1897a, 1897b, 1901, 1922; Halácsy 1892) didn't mention at all any member of *Hainardia* or *Parapholis*. Even Antonio Baldacci – the outstanding Italian botanist who has been travelled in Albania between 1885 and 1897 and whose herbarium (ca. 100.000 specimens spread among different herbaria) probably represents the larger botanical collection from that country – only once collected *H. cylindrica* (sub *Monerma*) in 1888 in the Albanian Epirus.

Karyological analyses, when possible, were performed on root-tips of germinated seeds collected from exsiccata, which after 4 months of chilling (-15°C), were put in seed-beds in standard condition of 100% moisture at room temperature. After a pre-treatment of about 3 hours in 8-hydroxichinoline saturated solution at room temperature, the root tips were fixed for many hours in Carnoy's Fluid solution (Ethanol and Acetic Acid - 3:1) (Johansen 1940), also used as a preservative solution of root tips in the test tubes stocked at 5°C temperature. Afterwards, the material was washed in distilled water and stained with 40% water solution of lacto-propionic orcein (Dyer 1979) for 18−48 hours at room temperature, without hydrolyze. Observations were made on temporary preparations: a tip was dissected and squashed on clean glass slide with one drop of 45% acetic acid under a coverslip, before examination with a Zeiss Axiophot light photomicroscope. The somatic mitosis plates were captured with a digital photocamera Canon G5 mounted on the photomicroscope, in a personal computer by soft Canon Remote Capture, then resized to 600dpi and 1000 enlargements. Measurements were taken on digital photos with "rule tool" of Photoshop and values were processed with Excel in order to obtain chromosome ordering and homologue recognition, and karyotype formula according to chromosome nomenclature proposed by Levan & al. (1964). Karyological parameters (Table 1) have been also calculated as Ask%, CVCL, MCA, A1 and A2 to compare data with previous analyses (Fiorini & Cuccuini 2002).

Diagnostic characters

In addition to those traditionally provided in European and Albanian Floras (Tutin & al. 1980; Vangjeli & al. 2000; Cuccuini 2002; Vangjeli 2003, 2015), we provided some additional, key morphological diagnostic characters, as retrieved from the analysis of herbarium specimens and described in more detailed and/or recent taxonomic studies on this group (Runemark 1962; Paunero 1964; Cuccuini 2002; Fiorini & Cuccuini 2002; Cuccuini & Fiorini 2004). Moreover, a short list of micro-characters (e.g. lemma and pollen) even if usually not diagnostic, is provided in order to make easier the identification of both taxa and morphotypes, following only

Table. 1. Applied karyological parameters: **S**=short arm, **L**= long arm, (**totS**) or (**totL**) = sum of short (or long) arms in chromosome set, (**i…n**) describe a chromosome set from the first to the last one "**n**".

Index	**Formula**	**Term**	**References**
M, m.st, t, T	L/S 1=M; 1<m<1.7; 1.7<sm<3; 3<st<7; 7<t<∞	Arm/ratio = r	Levan & al. (1964)
CL	L+S	Chromosom lengt	
	L-S	Arm gap	
Ask %	totL/tot(L+S) × 100 50<<100	Centromeric index %	Arano & Saito (1980)
A1	1-Mean(S/L) 0<<1	Intrachromosomal asymmetry	Romero Zarco (1986)
A2	Dev.St.CL/Mean CL 0<< ∞	Interchromosomal asymmetry	Romero Zarco (1986)
CV CL	Dev.St.CL/Mean CL × 100 0<<100	Coefficient of Variation CL	Paszko (2006)
MCA	Mean(L-S)/(L+S) × 100 0<<100	Mean Centromeric Asymmetry %	Peruzzi & Eroğlu (2013)

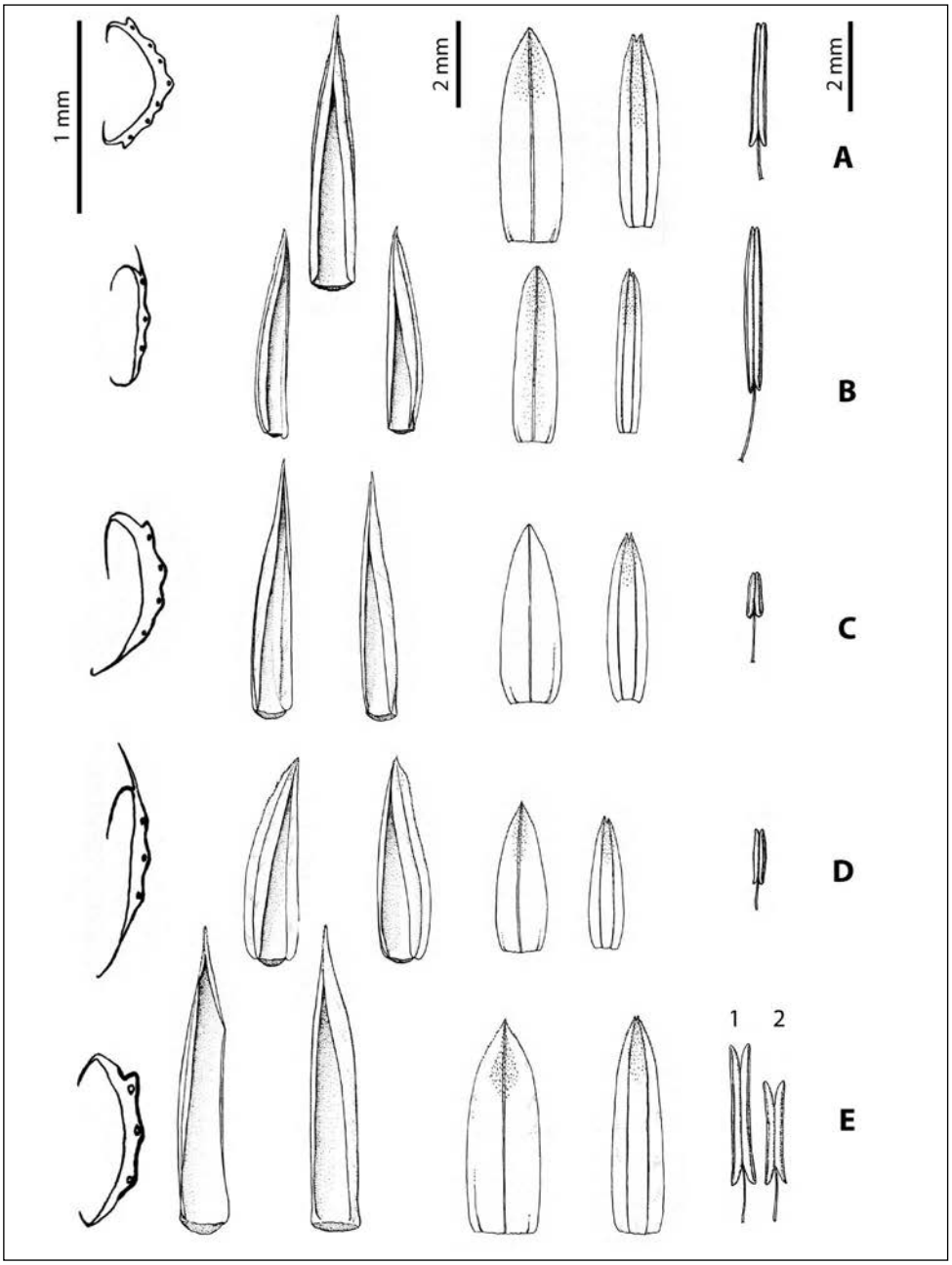


Fig. 1. A) *Hainardia cilindrica*; B) *Parapholis filiformis*; C) *P. incurva*; D) *P. marginata*; E) *P. strigosa*. From the left: upper glume section (from middle part), upper and lower glume/s, lemma and palea, anther/s (morphotype 1 and 2 in E), from Cuccuini, 2002 (B, C, D, E) and Cuccuini & Fiorini 2004 (A) modified. Scalebar: on the left for upper glume section; in the middle for the glumes, lemma and palea; on the right for anthers.

data, concerning also Adriatic region, in Cuccuini (2002), Cuccuini in Guarino & La Rosa (2019) and Cuccuini & Fiorini (2004).

Figure 1 points out, by an analytical drawing, the macrocharacters to favour an esyer identification.

In Table 2 a list of micro-morphological characters is provided to ensure the correct identification of the species when the most important diagnostic traits are absent or lead to doubtful outputs. Thickness epidermal cell wall in *Hainardia* lemma is usually 1.5-2 times higher than in *Parapholis incurva* and *P. marginata*, and up to 4 times higher than in *P. filiformis* and *P. strigosa*). In the morphologically more similar species "complexes" (*P. filiformis* vs. *P. strigosa* and *P. incurva* vs. *P. marginata*), useful information can also be retrieved from the absence/presence of esodermic cells, the length and the distribution pattern of the stomata.

Parapholis **taxonomic framework**

Parapholis C.E. Hubb., Blumea, suppl. 3: 10-21. 1946.
Lepidurus Janchen, Wiener Bot. Zeitschr. 93: 85. 1944, nom. prov.
Typus: *Parapholis incurva* (L.) C.E. Hubb., Blumea, suppl. 3: 85. 1944.

Parapholis filiformis (Roth) C.E. Hubb., Blumea, suppl. 3: 14. 1946.
Bas.: *Rottboella filiformis* Roth, Usteri. Ann. Bot. X. 38. 1794.

Table 2. Main micro-characters of the 5 taxa of *Parapholis* and *Hainardia* genera present in Albania.

Taxa	Lemma					Pollen
	thickness epidermal cell wall (µm)	ripple depth/cell width	esodermic cell	stomata length (µm)	stomata quantity and position	annulus tickness (µm)
Parapholis filiformis	thin, 1-2	1/4 - 1/5	widespread presence	21.5	a few number in apical part	1
P. incurva	medium, ≤ 3	1/3	absent	30	double row in apical central nervature	1
P. marginata	medium, ≈ 3	≥1/3	variables (from diffuse to present in small areas)	26	in several rows, up to the middle central nervature	1
P. strigosa	thin, 2	1/4 - 1/5	absent	26.5-31	in several rows on 2/3 of the length of the central nervature from the apex	2.5
Hainardia cylindrica	large, 3-4	1/2	presence in about 1/3 from the apex with increasing frequency	27-32	double row in apical central nervature	1.5

Typus: Lectotypus (designated by Cuccuini 2002: 33) "*Rottboella filiformis* Roth, *nov. Plant. Spec. Ex munif. Cel. Rhbt med. Doctoris ac phisici Vegesack*. 1796", (Ex Herb. G. Mayer, GOET).

More frequent Syn.: *Lepturus filiformis* (Roth) Trin.; *Lepturus incurvus* var. *filiformis* Fiori; *Pholiurus filiformis* (Roth) Schinz & Thell.; *Pholiurus incurvus* ssp. *filiformis* (Roth) Camus.

Parapholis marginata Runemark, Bot. Notiser: 115: 8-9. 1962.

Typus: Holotypus, "*Grece Kiklades. Sirina. Dio Adelfi the W-islands, 14-4-1960, Runemark & Nordenstam*" (LD).

***Parapholis incu*rva** (L.) C.E. Hubb., Blumea, suppl. 3: 14. 1946.

Bas.: *Aegilops incurva* L. Sp. Pl., 2: 1051. 1753.

Typus: Neotypus LINN 1281.11 (designated by Cuccuini 2002: 18-19). The same specimen was previously considered a lectotype by Cuccuini in Cafferty & al. (2000: 242-243).

More frequent Syn.: *Agrostis incurva* (L.) Scop. ("*incurvata*"); *Rottboellia incurvae* (L.) L. f. ("*incurvata*"); *Ophiurus incurvus* (L.) P. Beauv. ("*incurvatus*"); *Lepturus incurvus* (L.) Trin. ("*incurvatus*"); *Pholiurus incurvus* (L.) Hitchcock ("*incurvatus*")

***Parapholis strigos*a** (Dumort.) C.E. Hubb., Blumea , suppl. 3: 14. 1946

Bas.: *Lepturus strigosus* Dumort., Obs. Gram. Belg. 146-147. 1823, "*Lepiurus*"

Typus: Lectotypus "*Lepiurus, Ostenda s.d.*" campione posizionato sulla sinistra del foglio n° [specimen on the left of the sheet no.] 1088499 (Herb Dumortier, BR) (designated by Cuccuini 2002: 23).

***Hainardia* taxonomic framework**

Hainardia Greuter, Boissiera 13: 178. 1967

Typus: *Rottboellia cylindrica* Will., Sp. Pl. 1: 464. 1797

Hainardia cilindrica (Willd) Gruter, Boissiera 13: 117.1967

Bas.: *Rottboellia cylindrica* Willd. Sp. Pl. 1: 464. 1797

Typus: Lectotypus: [icon in] "*Gramen loliaceum majus*" Barrelier P.J., Gallia; Hispaniae et Italiam Obs. Tav. 5. 1714 (designated by Cuccuini & Fiorini 2004: 154).

More frequent Syn.: *Lepturus cylindricus* (Willd.) Trin; *Ophiurus cylindricus* (Willd.) Link, *Monerma cylindrica* (Willd.) Coss. & Dur.

Analytic key of Parapholis – Hainardia in Albania

1 Spikelets with 1 glume and 1 floret .....*Hainardia cylindrica*[a]
1 Spikelets with 2 glumes and 1 floret 2
2 Keel of glumes winged 3
2 Keel of glumes not winged or ±plicate 4
3 Anthers at least 2 mm long .....*Parapholis filiformis*
3 Anthers at least 1 mm long .....*Parapholis marginata*
4 Anthers at least 1 (–1.1) mm long .....*Parapholis incurva*[b]
4 Anthers at least 2–3.2 mm long .....*Parapholis strigosa*[c]

Notes

[a]Sometimes, in *H. cylindrica* plants with two-glumes-spikelets have been observed. Even if often interpreted as teratosis with no systematic significance, Castroviejo & al. (1979) interpreted them as the result of an inter-generic hybridization of *Hainardia cylindrica* with *Parapholis incurva*, namely *Hainardiopolis×pauneroi* Castroviejo, with the unbalanced abundance of the two parental species turning out in different introgressive morphotypes. On the contrary, we think that such individuals derive from an anomalous embryological development of *H. cylindrica* in extreme environments (Cuccuini & Fiorini 2004). Further studies are needed to solve this enigma.

[b]In *P. incurva* two morphotypes – both found in Albania – are known for this species which are associated to a different ecological context. Morphotype 1 is characterized by both erect or decumbent, vigorous shoots, up to 35 cm long, usually much branched at base, with strongly incurved spikes; it is the most widespread along coasts and lagoon shores and endowed with the higher chromosome numbers [2*n*=28, 30 (32) + (4-5) B], a record which is here confirmed also for the Albanian populations. On the contrary, the plants of morphotype 2 are erect, much less branched, 5–30 cm tall, with straight or only slightly curved spikes; they are more abundant in non-coastal habitats, from behind the coastal dunes to inner stands on both argillaceous outcrops, ruderal environments and salt-steppic depressions, and have less chromosome numbers [2*n*=24 + (0-2) B]. Our knowledge of such a variability and its relatedness with the growing conditions, both in Albanian territory and elsewhere, is still poor and inadequate to support the taxonomic value of several infra-specific taxa described until now.

[c]Current occurrence of *Parapholis strigosa* mainly include North-European populations, while its Mediterranean distribution is confined in the Adriatic basin. Along the seashores of central and northern Adriatic, i.e. from Abruzzi seashores in Italy until (at least) the Kvarner islands in Croatia, this species was found with a morphotype 1 with long anthers (2.7–3.2 mm). They are shorter (2–2.5 m) morphotype 2 in both the populations of Northern Europe and in the southernmost populations of W Adriatic, on Gargano lagoon, where the species starts to be progressively replaced by the vicariant *P. filiformis*. Since Albanian populations grows at the same latitudes of Gargano, further analysis would be interesting to check whether they also belong to morphotype (2).

Iconography

Parapholis incurva: Paunero (1964), fig 3-4. - Runemark (1962), fig. 3C. – Cuccuini (2002), fig. 3.

P. strigosa: Paunero (1964), fig. 7, sub *P. pycnantha*. – Runemark (1962), fig. 3E. – Cuccuini (2002), fig. 5.

P. filiformis: Runemark (1962), fig. 3F. – Paunero (1964), fig. 5. – Cuccuini (2002), fig. 11.

P. marginata: Runemark (1962), fig. 3D. – Paunero (1964), fig. 1. – Cuccuini (2002), fig. 9

Phenology

(April), May – June, (July) for all species.

Citotaxonomic Investigation

Chromosome counts resulted 2*n*=32=2M+14m+12sm+4st+(1-2)B in *Parapholis incurva* (Vlor, FI051505), 2*n*=14=4m+2m-sat+8sm+4B in *Parapholis filiformis* (Laguna Karavasta, FI051562), and probably 2n≤28 in *Parapholis strigosa* (FI051563) (Fig. 2).

Chromosome studies are summarized in Tab. 3, in which are compared previous investigated Italian data (Fiorini & Cuccuini 2002; Cuccuini & Fiorini 2004) about Adriatic area, with new Albanian data. Some karyological parameters recently introduced (Paszko 2006; Peruzzi & Eroğlu 2013) are upload for previous Italian data.

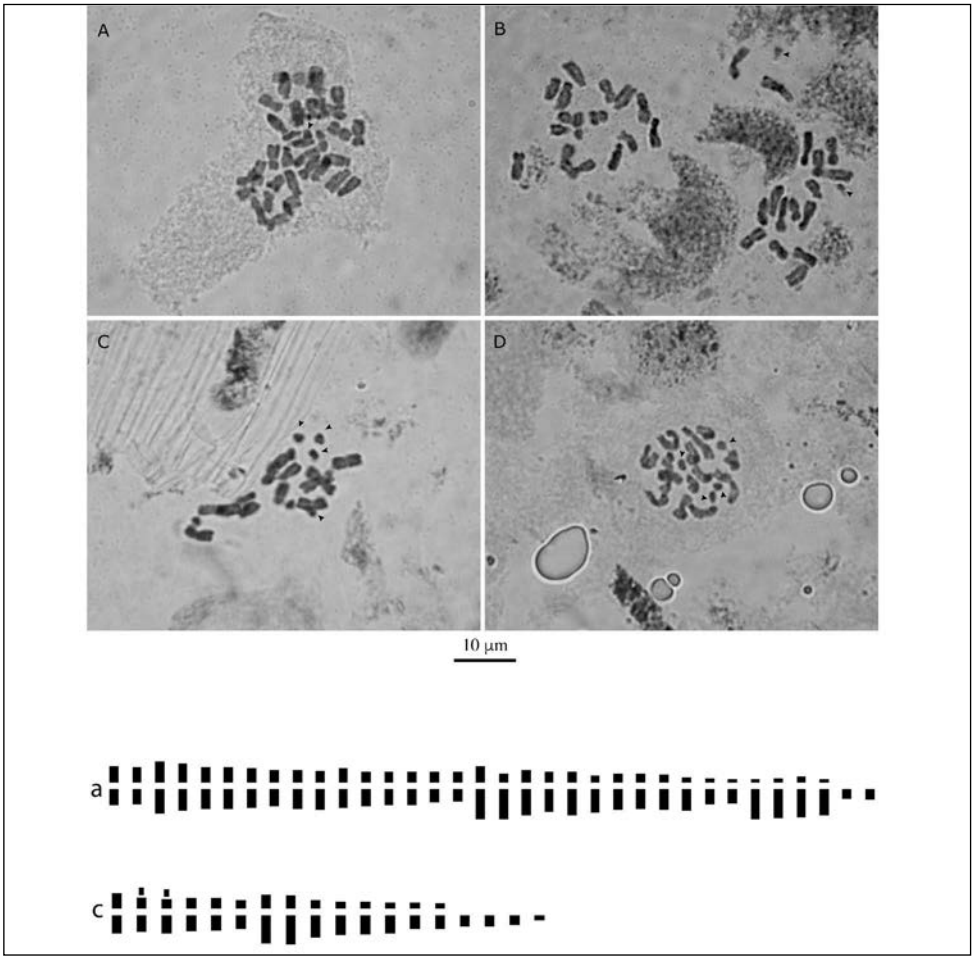


Fig. 2. Metaphase plates: (A, B) *Parapholis incurva* (Valona, FI051505), (a) karyogram 2*n*=32=2M+14m+12sm+4st+2B; (C) *Parapholis filiformis* (Laguna Karavasta, FI051562), (c) karyogram, 2*n*=14=4m+2m-sat+8sm+4B and (D) *P. filiformis* (Laguna Karavasta, FI055530) Arrows B-chromosomes. Scale bar 10 µm.

Table 3. **2*n***, chromosome number; ***n*X**, ploidy level; **formula**, kariotype; **µm** average chromosome lenght; **AsK**, centromeric index; **A1**, intrachromosomal asymmetry; **A2**, interchromosomal asymmetry; **CvCL,** coefficient of variation in chromosome lengt; **Mca,** mean centromeric asymmetry.

Specimen	localities	2*n*	*n*B	*n*X	base	Kariotype	µm	AsK	A1	A2	CvCL	Mca
P.incurva	ITALIA-Friuli VG-Marano Lagunare	28	4-5	4x	7	2M + 10m + 8sm + 8st	5,305	0,60	0,49	0,17	16,87	35,2
	ITALIA -Emilia Romagna - Goro	38	1-2	6x?	6	4M + 14m + 9sm + 11 st	5,88	0,66	0,44	0,16	15,75	32,55
	ALBANIA-Valona (033) Isolotti Ksanil (Isola SE) FI051505	32	1	4x	?	2M + 14m + 12sm + 4st+1B	3,95	0,64	0,39	0,24	24,56	26,92
	ALBANIA-Valona (026) Isolotti Ksanil (Isola SE) FI051505	32	2	4x	?	2M + 14m + 12sm + 4st+2B	4,5	0,64	0,39	0,22	22,43	31,32
P. filiformis	ITALIA-Campania-Lago di Fusaro	14	0-2	2x	7	8m + 6sm	5,6	0,61	0,36	0,15	14,92	23,23
	ALBANIA - laguna di Karavastase (staz.B-015) FI051562	14	4	2x	7	4m +2m sat + 8sm+4B	4,1	0,56	0,37	0,2	20,03	24,53
	ALBANIA - laguna di Karavastase (073) FI055530	14	4	2x	7	4m + 2m sat + 8sm+4B	4,5	0,5897	0,42	0,27	26,66	28
P. strigosa	ITALIA-FriuliVG-Grado	28	1-2	4x	7	24m + 4sm	4,7	0,54	0,27	0,16	15,71	16,24
	ALBANIA - laguna di Karvastase-Istmo FI051563	~ 28				---	---	---	---	---	---	---

General Conclusions

Based on our taxonomic analysis, Albania hosts *H. cylindrica* plus four species of *Parapholis*: *P. filiformis*, *P. incurva*, *P. marginata* and *P. strigosa*.

To put in evidence their diagnostic characters (macro as number of flowers, size of mature anthers, winged or not-winged glumes keel and general habit of the plant) allow an easier identification of herbarium specimens, an analytical iconography (Fig. 1) and a synoptic table listing the most important micro-morphological characters (lemma: epidermal and exodermic cells, stomata and pollen: annulus) traits are provided (Tab. 2). Two species were found to be new for Albania: *P. marginata* and *P. strigosa*. Both grow in Karavasta lagoon, where their habitat for saltmarsh and seashore habitats of recent origin is confirmed. Regarding *P. strigosa*, **s**ome plants belonging to specimen FI051563 differ from the typical ones for their lanceolate-acuminate, sharply winged (vs. mostly ovate, unwinged or slightly plicate) and slender habit. Even if they could be interpreted as a still undocumented result of hybridization between *P. strigosa* and *P. filiformis*, we think they are most probably anomalous individual of *P. strigosa*, since their chromosome number ($2n$ = 24-28) is much higher than the only one known ($2n$ = 14) for *P. filiformis.*

However, our data are not sufficient to a comprehensive, ecological revision of the genera. Several areas and environmental contexts potentially suitable for former *Hainardieae* (including inner clay outcrops, ruderal sites and secondary volcanic habitats) still need to be explored. Due to this incomplete geographic and ecologic sampling, an overall taxonomic vision of the variation of this group in Albania cannot be provided yet and further investigations are strongly encouraged.

Karyological analyses partially agree with those made on Italian populations of *Parapholis* by Fiorini & Cuccuini (2002). All reports here introduced are new data. A synoptic Table of all karyological data of Albania together with Italian reports is made to simplify reading.

P. filiformis*:* metaphasic plates show chromosome number $2n$=14 and some B chromosomes as in Italian populations. Average chromosome size are a little smaller. Karyotype formula is similar, but more asymmetric, because of 8sm instead of 6sm and confirmed by indices A1=0,42, A2=0,27 and MCA=28 are little bigger than in Italian populations.

P. incurva*:* metaphasic plates show chromosome number $2n$=32 and some B chromosome. This number has never been counted in Italian populations, but only in southerner Portugal (Castro & Fontes, 1946). The two metaphase plates show little differences because of smaller degree of contraction of chromosomes in the second photo (Fig. 2, B). Average chromosome sizes are smaller, than in Italian populations. Karyotype formula has different chromosome number, but shows similar proportional arrangement (M,m,sm,st). Indices of asymmetry show larger intrachromosome value and smaller interchromosome value than in Italian populations of Northern Adriatic area.

The karyological differences found in all investigated populations of *P.incurva*, in Mediterranean area (Fiorini & Cuccuini 2002),Albania enclosed, could be explained as a reaction to the strong selection of habitats and substratum (see above) in a fragmented and very large geographical area, that could induce different chromosome numbers, dysploid complements and B chromosomes.

About ***P. strigosa****,* we can only say that probably $2n \leq 28$. The number of seeds was insufficient for adequate investigation, therefore a scarce number of bad metaphasic plates were seen.

Specimina visa

Parapholis filiformis (Roth) C.E. Hubb.

Durrës, shkozet ligatina, 10/07/1964, *M. Zemuri & E. Palisergi* (Tirana); Durrës: Golem, në vende mogalore ligatina, 28/06/1986, *A. Mullay & V. Tartari* (Tirana); Prefettura di Fier, distretto di Lushnië, laguna di Karavasta, parte centrale dell'istmo che separa la laguna maggiore dal mare, presso la torretta di avvistamento, mosaico di erbosi e pozze salmastre, 0 m., 40° 57'1.08N, 19°28'52.16''E, 06/06/2017, *L. Cecchi* (*FI051562); Karavastasë, dune, 40°58'33''N, 19°28'29''E, 30/06/2018, *F. Selvi* (*FI055530); Prefettura di Fier, distretto di Lushnië, laguna di Karavasta, parte centrale dell'istmo che separa la laguna maggiore dal mare, presso la torretta di avvistamento, mosaico di erbosi e pozze salmastre, 0 m., 40° 57'1.08N, 19°28'52.16''E, 06/06/2017, *L. Cecchi* (*FI051561).

Parapholis incurva (L.) C.E. Hubb.

Shkoder, 3,7 km östlich Velipja, sandstrand,feuchte Mulde, 41.8552 N, 19.47145 (decimal), 11/062014, *T. Gregor & L. Meierott* (FR0121163 photo); (sub *P. incurva* subsp. *incurva*) Vlorë, 1,7 km westsüdwestlich Orikum, m. 2, 40.326017 N, 19.4535 (decimal), 20/05/2016, *T. Gregor*, (FR0126489); Prefettura di Valona (Vlorë), distretto di Saranda, isolotti costieri di Ksamil-isolotto sud occidentale (ALKS003), 39° 46'24.12''N, 19°59'29.99''E (± 100 m), 09/05/2017*, L. Cecchi, L. Kashta & al.* (*FI051504, *FI051505); Prefettura di Valona (Vlorë), distretto di Saranda, isolotti costieri di Ksamil-isolotto sud orientale (ALKS002), 39°46'23.24''N, 19°59'44.57''E (± 50 m), 11/05/2017, *L. Cecchi, L. Kashta & al.* (*FI051506);Karavastasë, dune, 40°58'33''N, 19°28'29''E, 30/06/2018, *F. Selvi* (*FI055531).

Parapholis marginata Runemark

Karavastasë, dune, 40°58'33''N, 19°28'29''E, 30/06/2018, *F. Selvi* (*FI055532).

Parapholis strigosa (Dumort.) C.E. Hubb.

Prefettura di Fier, distretto di Lushnië, laguna di Karavasta, parte centrale dell'istmo che separa la laguna maggiore dal mare, presso la torretta di avvistamento, mosaico di erbosi e pozze salmastre, 0 m., 40° 57'1.08N, 19°28'52.16''E, 06/06/2017, *L. Cecchi* (*FI051563); Dune, Karavastasë, 40° 58'33''N, 19°28'29''E, 30/06/2018, *F. Selvi* (FI055534).

Hainardia cylindrica (Willd.) Gruter

Karavastasë, dune, 40°58'33''N, 19°28'29''E, 30/06/2018, *F. Selvi* (FI055533); Prati melmosi di Vutzindrò (Epiro), giugno 1888, *A. Baldacci* (FI); in pratis humidissimis ad Vutzindrò, junio 1888, A. Baldacci (FI) [in Baldacci, 1894 the description of localitie is different: *in pratis hieme inundatis ad Vutzindrò (Epirus)*]; Borsh, am Lumi Borskit, 20/04/1959, *F. K. Mayer 3052* (JE) (two specimens).

Specimens with* have been used in karyologic analysis.

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Article

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Contribution to the knowledge of habitat and vascular plant diversity of Alibotush Reserve, Slavyanka Mountain (Bulgaria)

Abstract

Vladimirov, V., Bancheva, S., Delcheva, M., Vassilev, K. & Pedashenko, H.: Contribution to the knowledge of habitat and vascular plant diversity of Alibotush Reserve, Slavyanka Mountain (Bulgaria). — Fl. Medit. 30: 19-32. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

Alibotush Reserve is located in Slavyanka Mountain, Southwestern Bulgaria, near the state border with Greece. It was established as protected area in 1951 and currently covers 1638.12 ha, which is about 25% of the Bulgarian territory of the mountain. It has the strictest protection regime according to Bulgaria's national legislation and corresponds to IUCN category Ia. The article aims to present and analyse the floristic and habitat diversity of the reserve. Altogether 611 species, 287 genera and 72 families of vascular plants are reported for the area. The most species-rich families are *Asteraceae*, *Caryophyllaceae*, *Poaceae*, *Fabaceae*, *Rosaceae*. The biological spectrum of the flora, both in respect to biological types and life forms, shows strong prevalence of herbaceous perennials, respectively, hemicryptophytes. The endemism is relatively high – ca. 11.5%. The species of conservation concern are 54 (8.8%) and most of them are xerophytes and heliophytes. List of the vascular plant species recorded in the field or from earlier literature sources is provided. The habitat diversity is represented by 13 habitat types. Woodland vegetation dominates and covers 1330.5 ha in total, whereas grasslands are represented by 4 habitat types and cover 110.7 ha. A map of the habitats is provided.

Key words: Bulgarian flora, floristic diversity, habitats, protected areas, vegetation.

Introduction

Alibotush Reserve is located in Southwestern Bulgaria, near the state border with Greece, in the Slavyanka Mountain, which until 1955 was called Alibotush as well. The reserve was declared by Decree of the Council of Ministers No. 1171 of 24.09.1951, in order to preserve the unique relict forests of *Pinus heldreichii*, *P. nigra*, *Abies borisii-regis* and the rich flora and fauna. On March 1, 1977 the reserve was included in the World Network of Biosphere Reserves under UNESCO's Program 'Man and the Biosphere'. Initially, the area of the reserve was 523.9 ha, but after several extensions the current territory reaches a total of 1638.12 ha (Order № RD-206 / 04.03.2013 of the Minister of Environment and Water) which is about 25% of the Bulgarian territory of the mountain. During the period 1944–1989, Alibotush Reserve fell into the so-called "border zone"

which, combined with the difficult accessibility, is the main reason for the preserved natural biodiversity of the mountain. Therefore, the reserve remained poorly studied until nowadays, and there is no published scientific article dealing particularly with the flora and vegetation of the area.

The flora of the mountain was most intensively studied in 1920s and 1930s, when several works were published by N. Stojanov (1921, 1924) and A. Drenovski (1933a, b, 1934a, b, 1936). Later, mainly in connection with the preparation of the multi-volume edition "Flora of Republic of Bulgaria" (since 1963 until now) and of the Red Data Book of the Republic of Bulgaria (Velchev 1984; Peev & al. 2015), a number of botanists visited the mountain and published data on different plant species. Among them, it is worth mentioning the publications of Kitanov & al. (1983), Pashaliev & Dimitrov (1995), Dimitrov (2010), Aneva & al. (2015). However, a study particularly into the flora of the reserve has not been carried out yet. In most cases, the publications are on the flora of the entire mountain or on even the larger Slavyanka floristic region.

The territory of the reserve is included in the NATURA 2000 network in Bulgaria, especially in BG0001028 Sreden Pirin – Alibotush site.

The article aims to present and analyse the floristic and habitat diversity of Alibotush Reserve with an emphasis on the species of conservation concern.

Materials and methods

Several field trips were carried out along several transects in the reserve between July 2014 and October 2018. Major habitat types have been studied so as to fully cover the floristic composition. Plant identification and preparation of the species list was done according to Delipavlov & Cheshmedzhiev (2011), Flora of Bulgaria (Jordanov 1963, 1964, 1966, 1970, 1973, 1976, 1979; Velčev 1982, 1989; Kožuharov 1995; Peev 2012). Species of conservation concern and endemic taxa were determined according to Petrova (2006), Petrova & Vladimirov (2009, 2010), Peev & al. (2015), Bulgarian Biological Diversity Act (2002, 2007), Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES, https://www.cites.org/eng), Directive 92/43/EEC (1992) and Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention 1979). The chorological elements follow Assyov & Petrova (2012). Life forms follow Raunkiaer (1934) and were determined by the authors and verified with relevant literature sources, e.g. Dimopoulos & al. (2013) and Fischer & al. (2008). The floristic diversity of the region is compared to that for the entire country: 4064 species, 921 genera and 159 families (Petrova & Vladimirov 2018).

Habitat types were determined according to EUNIS habitat classification (EUNIS 2012) and Directive 92/43/EEC (Interpretation Manual of European Union Habitats 2007, Kavrakova & al. 2009). 'Habitat directive code' is abbreviated as 'HDC' throughout the text below. Mapping was done using ArcGIS 10.0 software (ESRI 2011). Spatial data was collected in the field using GPS devise Juno BS by Trimble and was later laid over the most recent orthophoto images available. Polygons were outlined manually by using features collected in the field as well as the orthophoto images. Mapping was done in scale 1:5000.

Geographical position of the study area – Alibotush Reserve is situated on the northern slopes of Slavyanka Mt., which is part of the Rila-Pirin Mountain Range and is located to the south of the main ridge of the Pirin Mts (Fig. 1). In morphographic and morphometric traits, Slavyanka Mt. belongs to the high non-glacial mountains. The reserve territory covers the altitude range of between 900 and 2200 m a.s.l., which determines the typical mountain climate. The average altitude is about 1500 m. According to the administrative division of the Republic of Bulgaria, the area of Alibotush Reserve falls entirely in the Blagoevgrad district, in the land of Goleshovo (Sandanski mun.), Paril and Nova Lovcha villages (Hadzhidimovo mun.).

Climate of the area – According to the climatic zoning of Bulgaria, Slavyanka falls in the Continental-Mediterranean climate, the Pirin region (Velev 2002). The average annual temperature decreases from 9.0°C in the lowest point of the reserve to 2.2°C at an altitude of 2200 m. The warmest months of the year are July and August. Average July temperatures are 18.5°C at 1000 m above sea level to 10.5°C at 2200 m (Management plan 2016). The coldest month is January, with temperatures between –1.1°C and –5.7°C. The maximum rainfall is in the winter (November-December) and is in the range of 100–150 mm. The minimum rainfall occurs in August-September and is 30 mm at the mountain's foot, and up to 50–60 mm in the high mountain parts.

Bedrock and soils – The bedrock of almost the entire territory of Alibotush Reserve is formed of marbles of the Dobrostan Marble Branch (Kozhuharov & Marinova 1989). Humus-carbonate soils (randzines) predominate in the reserve, covering 79% of its territory. Brown soils (cambisols) and alluvial-diluvial soils are also spread (WRB, FAO 2015).

Results and discussion

Floristic diversity – The flora of Alibotush Reserve comprises 72 families, 287 genera and 611 species and subspecies. List of the taxa is provided as Electronic Supplementary File 1 (ESF1). The taxonomic structure of the flora is presented in Table 1. Altogether *Lycopodiophyta*, *Equisetophyta* and *Polypodiophyta* comprise 9.7% of the families, 3.8% of the genera, and 2.5% of the species from the flora, *Pinophyta* – 4.2% of the families, 1.8% of the genera, 1.8% of the species, and *Magnoliophyta* – 86.1%, 94.4% and 95.7% respectively.

Table 1. Taxonomic structure of the flora.

Taxon	No. of species and subspecies	No. of genera	No. of families
Lycopodiophyta	1	1	1
Equisetophyta	1	1	1
Polypodiophyta	13	9	5
Pinophyta	11	5	3
Magnoliophyta	585	271	62
Magnoliopsida	*500*	*227*	*55*
Liliopsida	*85*	*44*	*7*
Total	**611**	**287**	**72**

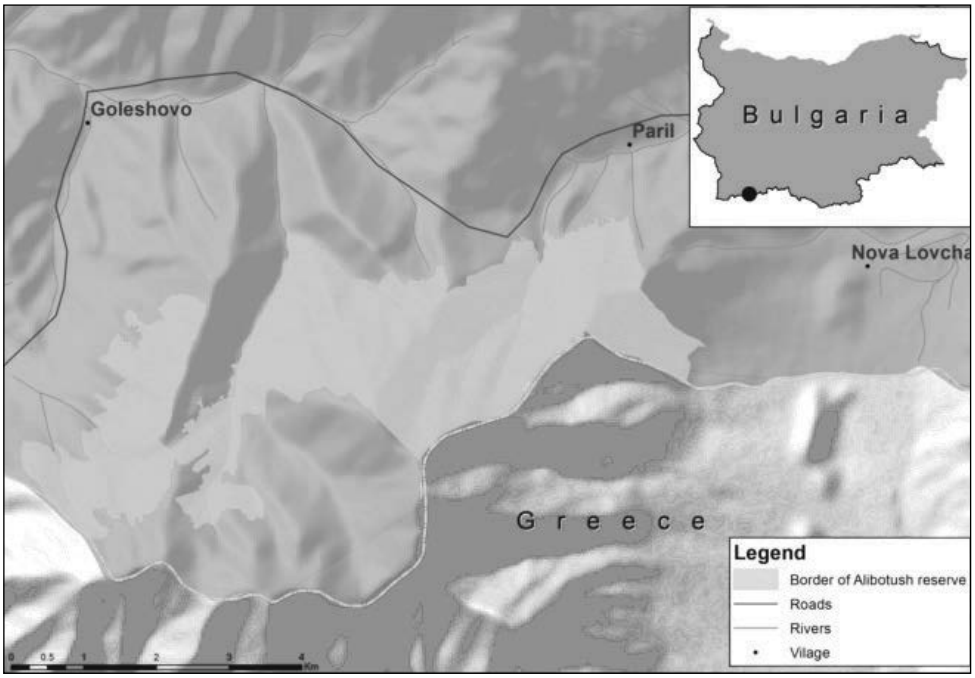


Fig. 1. Geographic position of Alibotush reserve.

The richest 10 families in specific and subspecific taxa are: *Asteraceae* (82, 13.4% of the total flora), *Caryophyllaceae* (44, 7.2%), *Poaceae* (43, 7.0%), *Fabaceae* (39, 6.4%), *Rosaceae* (38, 6.2%), *Lamiaceae* (31, 5.1%), *Scrophulariaceae* (25, 4.1%), *Brassicaceae* (22, 3.6%), *Apiaceae* (21, 3.4%), *Rubiaceae* (16, 2.6%). Altogether these families comprise 59% of the species in the reserve's flora. These data are somewhat similar to that for the entire Bulgarian flora, in which the richest families are: *Asteraceae*, *Poaceae*, *Fabaceae*, *Caryophyllaceae* and *Brassicaceae* (Petrova & al. 2005).

The biological spectrum of the flora of Alibotush Reserve is presented in Table 2.

The life-form spectrum of the flora of Alibotush Reserve is presented in Table 3.

The phytogeographic composition of the flora of Alibotush Reserve is presented in Table 4. The number of species in a reproductive phase of development by months is presented on Fig. 2. The highest number is registered in June and July which is typical for the mountainous regions in temperate Europe.

A total of 54 species of conservation concern (8.8% of the entire flora of the reserve) has been identified on the territory of the reserve. There are 47 species with a national IUCN category according to the national Red List of Bulgarian vascular plants (Petrova & Vladimirov 2009). Of these, 8 species are Critically Endangered (CR), 21 are Endangered (EN), 12 are Vulnerable (VU), and 6 are Near Threatened (NT). In the Red Book of the Republic of Bulgaria, vol. 1. Plants and Fungi (Peev & al. 2015) are included 33 species –

Table 2. Biological spectrum of the flora.

Biological type	No. of taxa	Share (%)
Perennial	425	69.5
Annual	47	7.7
Shrub	35	5.7
Biennial	24	3.9
Tree	20	3.3
Biennial – perennial	17	2.8
Annual – biennial	12	2.0
Shrub – tree	10	1.6
Tree – Shrub	8	1.3
Annual – perennial	7	1.1
Semishrub	4	0.7
Perennial – shrub	1	0.2
Semishrub – perennial	1	0.2
Total	**611**	**100.0**

Table 3. Life-form spectrum of the flora.

Life form	No. of taxa	Share (%)
Hemicryptophytes	369	60.4
Geophytes	63	10.3
Phanerophytes	63	10.3
Therophytes	48	7.8
Chamaephytes	42	6.9
Hemicryptophytes – Chamaephytes	9	1.5
Therophytes – Hemicryptophytes	7	1.1
Chamaephytes – Phanerophytes	4	0.6
Chamaephytes – Hemicryptophytes	2	0.3
Geophytes – Hemicryptophytes	1	0.2
Hemicryptophytes – Geophytes	1	0.2
Hemicryptophytes – Therophytes	1	0.2
Therophytes – Geophytes	1	0.2
Total	**611**	**100.0**

all taxa with 'Critically Endangered' and 'Endangered' category, as well as 4 'Vulnerable' species. Two species are listed in Annex II to Directive 92/43 / EEC (Habitats Directive) – *Himantoglossum jankae* and *Viola delphinantha*.

Balkan endemics are 61 species (ca. 10.0% of the total flora of the reserve), whereas the Bulgarian endemics are 9 species (1.5%).

The flora of the reserve comprises ca. 15% of the species diversity of the entire Bulgarian flora. Compared to other territories of a similar size, e.g. with Kongura reserve in the neighbouring Belasitsa Mt., the species diversity is high (300 species in Kongura reserve, Pedashenko & al. 2015). This can be explained by the higher habitat diversity of Alibotush Reserve, the larger altitudinal range, and the calcareous bedrock. The share of

Table 4. Floristic elements in the flora of Alibotush Reserve.

Floristic element	No. of taxa	Share (%)
subMed	81	13.5
Bal	61	10.2
Eur-Med	60	10.0
Boreal	49	8.2
Eur-As	47	7.8
Eur-Sib	45	7.5
Eur	41	6.8
subBoreal	30	5.0
Med	28	4.7
Pont-Med	23	3.8
Kos	14	2.3
Alp-Med	13	2.2
Carp-Bal	12	2.0
Bal-Anat	11	1.8
Bul	9	1.5
Eur-subMed	9	1.5
Ap-Bal	6	1.0
Pont	6	1.0
Other 30 geoelements	66	9.2
Total	**611**	**100.0**

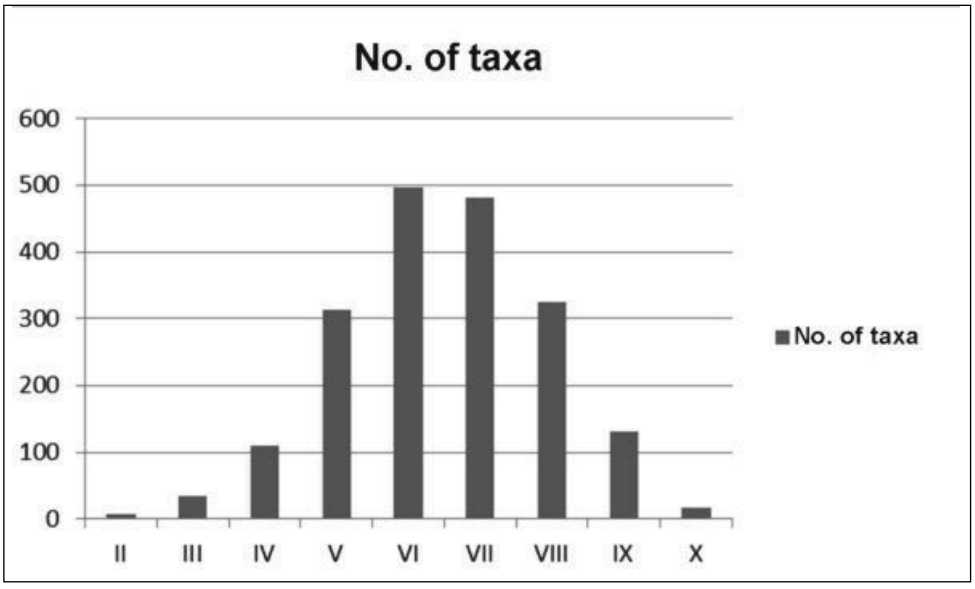


Fig. 2. Reproductive phenophase spectrum of the flora of Alibotush Reserve.

the species of *Polypodiophyta* is slightly higher than that in some other areas, e.g. Vrashka Chuka protected site (0.8%, Vladimirov 2012), Mt Golo Bardo (0.6%, Apostolova-Stoyanova & Stoyanov 2009), as well as in the whole country (1.1%, Petrova & al. 2005) which is due to the availability of suitable habitats.

The biological spectrum of the flora of Alibotush Reserve, both with respect to biological types and life forms, is similar to this of the entire Bulgarian flora, and demonstrates a pattern characteristic for the temperate mountainous floras, i.e. the strong prevalence of herbaceous perennials, respectively, the hemicryptophytes (Uzunov & Gussev 2003). However, it is worth pointing the relatively high representation of geophytes and therophytes which can be explained with the relatively strong influence of the Mediterranean climate despite the northern exposition and high elevation.

The phytogeographical analysis shows that in the flora of Alibotush Reserve prevail the following floristic elements – subMediterranean, Balkan endemics, Euro-Mediterranean, Boreal, Euro-Asiatic, Euro-Siberian and European, which altogether comprise nearly 64% of the total flora. Especially noteworthy is the presentation of both Balkan and Bulgarian endemic species – ca. 11.5% (ca. 11% for the total Bulgarian flora), which characterises the reserve as an area with high endemism in Bulgaria and of high conservation concern. This statement is supported also by the fact that Kongura reserve in the neighbouring Belasitsa Mt. shelters only about 3.3% of endemic species (Pedashenko & al. 2015) and this of the entire Mt Golo Bardo – 4.3% (Apostolova-Stoyanova & Stoyanov 2009). The high share of endemic species can be explained by the calcareous substrate, relatively high influence of the Mediterranean climate and the high habitat diversity, especially in open places, since most endemics in the Bulgarian flora are heliophytes and xerophytes (Velchev & Kozhuharov 2006). The high presentation of endemic species (11.5%) and species of conservation concern (8.8%) determines the high value of the reserve for the conservation of the vascular plant diversity. Moreover, the reserve is of crucial importance for the preservation of some species, e.g. *Centaurea parilica*, *Crepis schachtii*, *Erysimum drenowskii*, *E. slavjankae*, *Fritillaria drenovskii*, *Hieracium marotii*, *Peridictyon sanctum*, *Pinus heldreichii*, *Pulsatilla slaviankae*, *Viola delphinantha* etc., which in Bulgaria have their only or largest populations within the territory of the reserve.

According to the national legislation Alibotush is a strict reserve which has the strongest regime of protection (IUCN category Ia). Any human activities on the territory of the reserve are forbidden except for guarding of the reserve, scientific research and monitoring, visits by tourists only on marked trails and regulated (by the Ministry of Environment and Water) collection of seeds and wild species for scientific research or for reintroduction of the species to other territories. Although the strict protection regime ensures high naturalness of the area, some of the species of conservation concern may experience slight decline of their populations. The major threat is the change of the habitats mainly due to lack of any grazing and natural afforestation of some of the open places on lower altitudes. Most obvious are the changes in the Parilski Dol locality (Hambar-Dere) which is a deep natural gorge and is famous for the high plant diversity and concentration of endemic species. In the past, the area was grazed mainly by sheep from closest Paril village and provided suitable open habitats for many species of high conservation concern. After the establishment of the reserve, grazing by the sheep was stopped completely which allowed for natural afforestation of the whole gorge mainly by *Fagus sylvatica*, and the open spaces

were gradually replaced by forests. This deteriorated the conditions for most of the endemic plants which are mainly heliophyte and xerophyte species and their populations declined locally in the gorge and in some open places nearby, e.g. the populations of *Bromus parilicus*, *Centaurea parilica*, *Chondrilla urumoffii*, *Crepis schachtii*, *Pulsatilla slaviankae*, *Onosma rhodopea*, *Saxifraga* spp., *Sideritis scardica*, *Viola delphinantha*, etc. Also, the lack of any grazing may affect negatively the population of the symbolic for the area *Sideritis scardica* (popular for making herbal tea) since it enables the growth of the perennial grasses which are more competitive and gradually replace *Sideritis scardica* (usually not grazed by the sheep).

Habitat diversity

Habitat diversity on the territory of Alibotush Reserve is presented by 13 habitat types (Electronic Supplementary File 2). Woodland vegetation dominates and covers 1330.5 ha in total. Grasslands are represented by 4 habitat types (110.7 ha).

Grassland vegetation

E1.55. Eastern sub-Mediterranean dry grassland (HDC: 62A0 Eastern sub-Mediterranean dry grasslands (*Scorzoneratalia villosae*); 12.2 ha)

Abiotic characteristics – This habitat has limited distribution on the territory of the reserve forming rocky grassland within *Pinus nigra*, *P. heldreichii* and *Fagus sylvatica* forests. Ecologically it is similar to E4.438. Oro-Moesian calciphile stripped grasslands but is found at lower altitude between 900 and 1450 m a.s.l. Stands cover south- or southeast-facing slopes with rough microrelief and calcareous outcrops. Terrains are flat or slightly inclined. Soils are shallow to moderately deep.

Vegetation structure – Very species-rich phytocoenosis (number of species is between 39 and 52 species per 16 m^2) with semi-closed to closed horizontal structure and total cover of vegetation 75–100%. Species composition is rich of calcareous species such as *Stipa eriocaulis*, *Euphorbia myrsinites*, *Leontodon crispus*, *Teucrium polium*, *Artemisia alba*, *Melica ciliata*, *Anthyllis vulneraria*, etc. Species with higher cover and abundance are *Artemisia alba*, *Stipa eriocaulis* and *Tortella tortuosa* (*Bryophyta*). Cover of cryptogams is higher than in the other habitat types, e.g. between 10–35% for bryophytes and 5–60% for lichens. This habitat is also rich of species with conservation concern such as *Himantoglossum jankae*, *Hypericum rumeliacum*, *Fritillaria drenovskii*, *Anthemis macedonica*, etc.

E2.11. Unbroken pastures (HDC: -; 1.1 ha)

Abiotic characteristics – It is locally found under Gotsev peak and presents intensively used pasture. The ground is trampled. Terrain is flat to slightly or moderately-inclined with varying exposition. Soils are moderately-deep.

Vegetation structure – Xero-mesophytic community with semi-closed to closed horizontal structure and total cover of vegetation 85–100%. Species with higher abundance are *Agrostis capillaris*, *Dactylis glomerata*, *Cynosurus cristatus*, *Trifolium repens* and *Festuca* sp. Some shrubs are also found such as *Chamaecytisus absinthioides*, *Rubus idaeus* and *Juniperus sibirica*. Cover of cryptogams is only 5–8%.

E4.438. Oro-Moesian calciphile stripped grasslands (HDC: 6170 Alpine and subalpine calcareous grasslands; 97 ha)

Abiotic characteristics – This is widest distributed grassland habitat on the territory of the reserve. It occurs from 1500 to 2200 m a.s.l. predominantly on steep slopes with inclination of 30–40º and north-facing slopes. Soils are shallow to moderately deep, rich of skeletons. Bedrock type is marbled limestone.

Vegetation structure – Moderately species-rich community with semi-closed horizontal structure and total cover of vegetation 70–90%. Species with higher abundance are *Festuca valida*, *F. hirtovaginata*, *F. panciciana*, *Sesleria latifolia*, *S. coerulans*, *Peridictyon sanctum*, *Astragalus angustifolius*, *Anthyllis aurea*, *Sideritis scardica*, *Thymus jankae*, *Saxifraga ferdinandi-coburgi* and *Poa badensis*. This habitat type is rich of species with conservation concern such as *Festuca hirtovaginata*, *F. panciciana*, *Anthyllis aurea*, *Sideritis scardica*, *Centaurea parilica*, etc. On the territory of Slavyanka Mt and Alibotush reserve this vegetation has been also studied by Karakiev & Tzonev (2011).

E5.52. Alpic tall-grass communities (HDC: 6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels; 0.4 ha)

Abiotic characteristics – It has limited distribution in subalpine zone within *Pinus heldreichii* forests along streams. Soils are wet and moderately-deep. Terrains are slightly inclined to steep with varying aspects. Phytocoenosis are characterized by dense litter cover, which prevent the formation of cryptogam layer.

Vegetation structure – Moderately species-poor community, dominated by *Calamagrostis arundinacea* (cover 40–50%). Phytocoenosis have closed horizontal structure and total vegetation cover is 100%. Other species with higher abundance (cover 10–20%) are *Geranium sylvaticum*, *Hypericum maculatum*, *Ranunculus nemorosus*, *Luzula luzuloides*, *Senecio macedonicus* and *Alchemilla* sp.

Shrubland vegetation

F2.2917. Rhodopide mountain avens mats (HDC: 4060 Alpine and Boreal heaths; 0.5 ha)

Abiotic characteristics – This habitat is locally distributed in subalpine zone of Alibotush Reserve around Tsarev vrah peak. It occurs on flat to slightly inclined terrains with varying exposition. Soils are shallow with a high proportion of skeleton and rocky outcrops. Bedrock type is marbled limestone.

Vegetation structure – Communities have semi-closed horizontal structure with total cover of vegetation 80–90%. The dominated species is *Dryas octopetala* (cover 40–65%) and subdominants are *Juniperus sibirica* and *Thymus jankae*. Other shrubby species are *Vaccinium myrtillus* and *Daphne oleoides*. The herb layer is dominated by *Sesleria coerulans*, *Festuca valida*, *Achnatherum bromoides*, *Carex kitaibeliana* and *Hieracium petrovae*. The cover of cryptogam layer is about 10–15%.

F2.231. Mountain Juniperus nana scrub (HDC: 4060 Alpine and Boreal heaths; 28 ha)

Abiotic characteristics – This habitat is distributed in subalpine zone of Slavyanka Mt. and Alibotush Reserve from 1600 to 2000 m a.s.l. It occurs on moderately-steep terrains with inclinaton of 25–30º and north-facing or derivate slopes. Soils are shallow to moderately-deep with a high proportion of skeleton and rocky outcrops. Bedrock type is marbled limestone.

Vegetation structure – Its communities have closed horizontal structure with total cover of vegetation 100%. The dominated species is *Juniperus sibirica* (cover 90–95%). Other

shrubby species are *Chamaecytisus absinthioides*, *Rosa myriacantha*, *Rubus caesius* and *Daphne oleoides*. At the edge of the stands, close to woodlands, in phytocoenosis are also found some woody species such as *Pinus heldreichii*, *P. peuce*, *P. sylvestris* and *Fagus sylvatica*. The undergrowth layer is rich of species widespread in neighbouring grassland habitats. Species with higher abundance are *Carex kitaibeliana*, *Thymus jankae*, *Rhodax alpestris*, *Anthyllis aurea*, *Festuca valida* and *Luzula luzuloides*. The cover of cryptogams is about 2–5%.

Woodland vegetation

G1.661. Middle European dry-slope limestone beech forests (HDC: 9150 Medio-European limestone beech forests of the *Cephalanthero-Fagion*; 65 ha)

Abiotic characteristics – This habitat has limited distribution on the territory of the reserve. It occurs between 1100 and 1400 m a.s.l. on steep terrains with inclinaton of 25–40° and varying expositions. Soils are moderately-deep and bedrock type is marbled limestone.

Vegetation structure – Moderately species-rich community with closed horizontal structure with total cover of vegetation 90–100%. The dominated species in tree layer is *Fagus sylvatica*. Other woody species found in tree layer are *Populus tremula*, *Ostrya carpinifolia*, *Pinus nigra* and *P. heldreichii*. Shrubland layer has cover between 10–20% and is formed by the same species like in the tree layer. Herb layer is rich of species and has cover 40–50%. Species with higher abundance are *Euphorbia amygdaloides*, *Physospermum cornubiense* and *Brachypodium sylvaticum*. Cover of cryptogam layer is about 10% composed of *Pseudovernia furfuracea*, *Hypogymnia tubulosa*, *Hypnum cupressiforme*, *Homalothecium lutescens*, *Dicranum scoparium*, etc.

G1.6924. Southeastern Moesian Ostrya-beech forests (HDC: 91W0 Moesian beech forests; 179 ha)

Abiotic characteristics – This forests are distributed between 1100 and 1400 m a.s.l. along valleys, predominantly on northern slopes with inclinaton of 25–30°. Soils are moderately-deep and bedrock type is marbled limestone.

Vegetation structure – This vegetation has closed horizontal structure with total cover of vegetation 85–100%. Dominant species in tree layer are *Fagus sylvatica* and *Ostrya carpinifolia*. Single trees of *Pinus nigra*, *P. heldreichii* and *Carpinus orientalis* are also common. Shrubland layer has cover between 20–40% and is formed by the same species like in the tree layer together with *Rosa* sp., *Fraxinus ornus*, *Crataegus monogyna*, *Rubus* spp. Species with higher abundance in the herb layer are *Euphorbia amygdaloides*, *Physospermum cornubiense*, *Calamagrostis arundinacea* and *Brachypodium sylvaticum*. Cover of cryptogam layer is about 10–15%.

G1.737. Eastern sub-Mediterranean white oak woods (HDC: 91AA *Eastern white oak woods; 0.3 ha)

Abiotic characteristics – It is locally found on the territory of the reserve close to Nova Lovcha village. It occurs on moderately-steep and slightly inclined terrains with varying expositions. Soils are shallow to moderately-deep and rich of skeleton material. Bedrock type is marbled limestone.

Vegetation structure – It includes species-rich phytocoenosis with semi-closed horizontal structure. Total cover is 90–95%. In tree layer dominant species are *Quercus pubescens* and *Carpinus orientalis*. Shrub layer is well-developed and has cover 40–65%. It is formed

by the same species like in the tree layer together with *Fraxinus ornus*, *Prunus spinosa*, *Cotoneaster nebrodensis*, *Juniperus oxycedrus*, *Ligustrum vulgare*, *Acer campestre* and *Cornus mas*. The species composition of undergrowth is about 60–80%. Species with higher abundance are *Fragaria vesca*, *Dactylis glomerata*, *Trifolium alpestre*. Cover of cryptogams is 10–15% and is formed by species such as *Evernia prunastri*, *Hypnum cupressiforme*, *Orthotrichum affine*, etc.

G3.52. Western Balkanic *Pinus nigra* forests (HDC: 9530 *(Sub-) Mediterranean pine forests with endemic black pines; 294 ha)

Abiotic characteristics – It occurs between 1200 and 1600 m a.s.l. both on steep and slightly inclined terrains with varying expositions. Soils are shallow to moderately-deep and bedrock type is marbled limestone.

Vegetation structure – Moderately species-rich community with semi-closed horizontal structure, dominated by *Pinus nigra*. It forms monodominant communities or mixed woodlands with *Ostrya carpinifolia*, *Fagus sylvatica*, *Pinus heldreichii* and *Abies borisii-regis*. Shrub layer (cover between 20–45%) is mainly formed by the same species like in the tree layer together with *Fraxinus ornus*, *Carpinus orientalis*, *Juniperus oxycedrus*, *Genista carinalis*, *Crataegus monogyna*, *Daphne oleoides*, *Chamaecytisus absinthioides*, *Rubus caesius*. Herb layer is rich of species and cover 40–95%. Species with higher abundance are *Sesleria latifolia*, *Brachypodium sylvaticum*, *Physospermum cornubiense*, *Carex humilis*. Cover of cryptogams is 10–20%.

G3.616. Rhodopide white-barked pine forests (HDC: 95A0 High oro-Mediterranean pine forests; 759 ha)

Abiotic characteristics – It occurs at 700–1600 m a.s.l. on moderately steep slopes (20–30º) with varying expositions. Soils are shallow to moderately-deep with high proportion of skeleton materials. Bedrock type is marbled limestone.

Vegetation structure – This habitat type includes woodlands dominated by *Pinus heldreichii*. This tertiary relict species forms monodominant forests. Other woodland species found in tree layer as single trees are *Pinus nigra*, *P. sylvestris*, *Fagus sylvatica*, *Abies alba*, *A. borisii-regis* and *Ostrya carpinifolia*. Shrub layer is mainly formed by the same species like in the tree layer together with *Acer campestre*, *A. pseudoplatanus*, *Rosa canina*, *Fraxinus ornus* and *Crataegus monogyna*. The composition of the undergrowth is uniform. Species with higher abundance are *Calamagrostis arundinacea*, *Festuca hirtovaginata*, *Mycelis muralis*, *Hieracium petrovae*, *Luzula luzuloides*.

G3.171. King Boris's fir forests (HDC: 9170 Hellenic beech forests with *Abies borisii-regis*; 33.2 ha)

Abiotic characteristics – This habitat type is distributed around 1500 m a.s.l. on north-facing slopes with prevailing inclination 25–30º. The soils are moderately-deep with high proportion of skeleton. Bedrock type is marbled limestone

Vegetation structure – Communities have semi-closed to closed horizontal structure and are dominated by *Abies borisii-regis*. Other woodland species present in communities are *Pinus nigra*, *P. heldreichii*, *P. sylvestris* and *Fagus sylvatica*. Shrubland layer is mainly formed by the same species like in the tree layer together with *Juniperus sibirica*, *Crataegus monogyna*, *Rosa* sp. and *Chamaecytisus absinthioides*. Species with higher abundance in herb layer are *Oxalis acetosella*, *Luzula luzuloides* and *Physospermum cornubiense*.

Chasmophytic vegetation

H3.25. Alpine and sub-Mediterranean chasmophyte communities (HDC: 8210 Calcareous rocky slopes with chasmophytic vegetation; 2.4 ha)

Abiotic characteristics **–** It is found in subalpine and alpine zones within the belt formed by *Fagus sylvatica*, *Pinus nigra* and *P. heldreichii*, on fissures of calcareous cliffs. They cover an area from several square metres to several hundred square meters. Terrains are steep with varying aspects. Soils are shallow, rich of skeleton or are missing. Bedrock type is marbled limestone.

Vegetation structure **–** Phytocoenoses have open-horizontal structure with total cover 40–70%. Species with higher abundance (cover 10–15%) are *Festuca valida*, *Sedum album*, *Thymus jankae* and *Poa badensis*. Some typical chasmophytic species are also found such as *Asplenium ruta-muraria*, *A. trichomanes*, *Ceterach officinarum*, *Sempervivum leucanthum*, *Dianthus pinifolius*. Cover of cryptogams is 15–20%.

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Short note

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Sur la présence d'*Atriplex canescens* (*Amaranthaceae*) en Algérie: écologie, taxonomie et biogéographie

Abstract

Touati, L., Hamel, T. & Meddad-Hamza, A.: Sur la présence d'*Atriplex canescens* (*Amaranthaceae*) en Algérie: écologie, taxonomie et biogéographie. — Fl. Medit. 30: 33-38. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

On the occurrence of *Atriplex canescens* (*Amaranthaceae*) in Algeria: ecology, taxonomy and biogeography. – *Atriplex canescens* var. *gigantea* is recorded for the first time for the non-native flora of Algeria. The description of the finding locality, taxonomic notes and detailed distribution are provided.

Key words: Algeria, distribution, taxonomy, xenophytes.

Introduction

Dans le contexte mondial ou régional du bassin méditerranéen, les invasions biologiques constituent une menace permanente pour la biodiversité floristique avec la réduction de la flore spontanée (Lambdon & al. 2008; Vila & al. 2015).

En Algérie, les invasions végétales ont été peu étudiées (Ducellier & Maire 1923; Dobignard & Chatelain 2010-2013; Kazi Tani & al. 2012; Véla & al. 2013; Kazi Tani 2014; Meddour & El Mokni 2016; Hamel 2016; Adjim & Kazi Tani 2018; Miara & al. 2018; Hamel & Azzouz 2018; Sakraoui & al. 2019). La synthèse bibliographique réalisée par Meddour & El Mokni (2016) a montré que 45,29 % des plantes introduites en Algérie sont des plantes naturalisées, dont 18 % sont considérées comme envahissantes ou potentiellement envahissantes.

La composition taxonomique de la flore exotique n'est pas aléatoire et les familles avec le plus grand nombre de plantes xénophytes appartiennent aux plus grandes familles indigènes du monde (Pyšek, 1998; Pyšek & al. 2002, 2017). En effet, cette flore est dominée par les familles, *Asteraceae* Martivon et des *Amaranthaceae* Juss. *sensu* APG IV (2016).

Le genre *Atriplex* L. contient environ 260 espèces dont la majorité sont distribuées dans les régions arides et semi-arides d'Eurasie, d'Amérique et d'Australie (Sukhorukov & Danin 2009; Kadereit & al. 2010; Brignone & al. 2016). L'Algérie est représentée par 17 taxons dont deux sont naturalisées et un est adventice.

L'*Atriplex canescens* (Pursh) Nutt. est naturalisé en Egypte, Tunisie et Maroc (Dobignard & Chatelain 2011; Iamonico & El Mokni 2019). Son existence en Algérie n'a jamais été signalée. Nous rapportons ici pour la première fois la présence de cette espèce en tant que plante étrangère naturalisée de la flore algérienne.

Contexte de la découverte

En septembre 2018, lors de prospections botaniques habituelles entretenues dans les zones limitrophes des formations préforestières et steppiques du Tell et hauts plateaux Constantinois (C_1 & H_2 selon la subdivision biogéographique proposée par Quézel & Santa 1962), zones connues pour leur richesse floristique, l'un des auteurs (H.T) a récolté un spécimen d'*Atriplex*, dans les grandes steppes à *Macrochloa tenacissima* (L.) Kunth et *Artemisia herba-alba* Asso de Ben Attia (Souk Ahras Nord-Est algérien) (Fig. 1). L'examen de la plante a montré qu'il s'agit d'*A. canescens* var. *gigantea*, une nouvelle plante pour la flore algérienne (cf. Battandier 1888-1890; Battandier & Trabut 1905; Maire 1952-1987; Quézel & Santa 1962-1963; Dobignard & Chatelain 2011). Une deuxième visite en décembre 2019, nous a permis de recenser une vingtaine de pieds de cette plante avec une végétation xérophile/ halophile: *Argyrolobium saharae* Pomel, *Atractylis caespitosa* Desf., *Atriplex halimus* L., *Centaurea pubescens* Willd., *Deverra scoparia* Coss. & Durieu, *Ebenus pinnata* Aiton, *Ephedra alata* subsp. *alenda* (Stapf) Trab., *Ephedra major* Host, *Globularia alypum* L., *Olea europaea* L. subsp. *europaea*, *Ononis angustissima* subsp. *polyclada* Murb., *Opuntia ficus-indica* (L.) Mill., *Peganum harmala* L., *Limonium echioides* (L.) Mill., *Lotus halophilus* Boiss. & Spruner, *Lygeum spartum* L., *Mandragora officinarum* L., *Marrubium alysson* L., *Santolina africana* Jord. & Fourr., *Sedum sediforme* (Jacq.) Pau., *Sideritis incana* L., *Tamarix gallica* L., *Teucrium capitatum* L. et *Thymus algeriensis* Boiss. & Reut.

Deux spécimens collectés ont été déposés dans l'herbier du département de Biologie, faculté des Sciences, université Badji Mokhtar Annaba-Algérie.

Description taxonomique et répartition géographique

Atriplex canescens (Pursh) Nutt [≡ *Calligonum canescens* Pursh; ≡ *Obione canescens* (Pursh) Moq.; ≡ *Pterochiton canescens* (Pursh) Nutt.].

Arbuste dioïque de 10 a 18dm de long, avec une tige dressée, très ramifiée et pubescente. Les feuilles sont alternes linéaires-oblongues, subsessiles à courtement pétiolées, mucorinées à l'apex et a rùrvêtement entièrement blanchâtre (Fig. 2). L'inflorescence de la plante est en panicules spiciformes, elle est fixée sur l'extremite des rameaux fertiles avec de nombreux glomérules (Flore du Maroc 2019).

Atriplex canescens est une espèce néophyte originaire d'Amérique du Nord et du Mexique, alors qu'elle est étrangère en Australie (Atlas of Living Australia 2016), en Asie orientale (Freitag & al. 2001), en région de la Méditerranée orientale (Boulos 1999) et en Afrique (SANBI 2012). Elle est rencontrée dans les écosystèmes arides et désertiques du monde, où elle constitue une source fourragère importante pour le betail (El Shaer 2010; Mellado & al. 2012).

Atriplex canescens c'est une espèce assez variable. Taxonomiquement, cette variabilité a été distinguée au niveau variétal. En plus de la variété nominale (*A. canescens* var. *canescens*), le Plants Database du USDA/Natural Resources Conservation Service (2020) signale les cinq variétés suivantes:

- *A. canescens* var. *angustifolia* (Torr.) S. Watson;
- *A. canescens* var. *gigantea* S.L. Welsh & Stuz;
- *A. canescens* var. *laciniata* Parish;
- *A. canescens* var. *linearis* (S. Watson) Munz;
- *A. canescens* var. *macilenta* Jeps.

Les pieds d'*Atriplex canescens* trouvés en Algérie correspond à la var. *gigantea*.

L'âge des pieds observés de la plante en question avoisine les 15 à 20 ans. En se basant sur la littérature et nos prospections périodiques dans cette zone steppique, il est fort probable qu'au cours de ces dernières années cette espèce a été naturalisée pour réhabiliter des parcours en zones dégradées en raison de sa plus grande résistance au froid (Forti 1986). Ses caractéristiques écologiques et physiologiques spécifiques lui permettent de se développer vigoureusement dans les parcours steppiques (Henni & Mehdadi 2011). Bien entendu, la naturalisation des espèces xénophytes sur le territoire algérien est un processus continu, car de nombreuses espèces ont été déjà signalées (Véla & al. 2013).

L'utilisation des plantations pastorales à *Atriplex canescens* var. *gigantea*, par le Haut Commissariat au Développement de la Steppe (HCDS), constitue une approche prometteuse dans la lutte contre la désertification. Il présente une tolérance à la salinité, la sécheresse



Fig.1. Localisation de la station d'observation.



Fig. 2. Le spécimen prélève (Clichés de Leila TOUATI).

et aux métaux lourds (Shabala 2013). Ainsi, il possède un système racinaire très développé fixant les couches supérieures du sol et constitue un matériel biologique de choix pour l'enrichissement de la flore et la protection du sol dans les zones arides et semi-arides (Belkhodja & Bidai 2004; Le Houérou 2006).

Plusieurs pieds de la plante sont observés aux milieux des champs de cultures de la région de Ben Attia. Ce comportement est un bon indicateur de son caractère et son potentiel invasif (Brunel & Tison 2005).

Conclusion

La découverte d'*Atriplex canescens* var. *gigantea* dans les steppes de Souk Ahras ajoute une nouvelle espèce naturalisée pour la flore algérienne et elle constitue un ajout important pour la flore fourragère du pays.

Ce taxon a été planté pour la réhabilitation des parcours dégradés des zones steppiques algériennes. Donc, il est fort possible que d'autres populations de la plante sont présentes sur le territoire national.

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Article

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Floristic composition of pistachio-woodland (*Pistacieta atlantici*) of Georgia (South Caucasus)

Abstract

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The floristic composition of pistachio-woodland (*Pistacieta atlantici*) of Georgia (South Caucasus) is studied. 250 species of vascular plants, which belong to 174 genera and 50 families, were recorded. Floristic structure, composition of chorotypes and life forms are commented. Based on the systematic structure of this flora and composition of chorotypes, 3 the main directions of florogenetic connections are identified: 1. South-West Asia, 2. Mediterranean, 3. Eurasian steppe. Attenuated form shows the impact of Iran-Turan deserts and connections to Europe. It was found that the formation of pistachio-woodland of Georgia was implemented in the bosom of Ancient Mediterranean with close contact with the boreal flora. Connection with savannas is not observed.

Key words: vegetation, vascular flora, chorotype, florogenetic connection, life forms.

Introduction

General distribution area of *Pistacia atlantica* Desf. comprises Mediterranean, South-West Asia, Caucasus and Crimea. In Caucasus area of *P. atlantica* is characterized by disjunction area. In particular, it main area covers Iori and Sheki uplands and Bozdahgi foothills. *P. atlantica* also is distributed on Mtkvari-Arax lowland, South Armenia and western part of North Caucasus. Altitudinal range of *P. atlantica* is from sea level to middle mountain belt. Pistachio-woodland (*Pistacieta atlantici*) is one of characteristic formations of semiarid regions of South Caucasus. Here its main area comprises south-estern part of Iori plateu. A little spreads on Mtkvari-Arax lowland and in South Armenia (Ivanova 1950; Prilipko 1970; Gulisashvili & al. 1975; Ketskhoveli 1980; Khachidze 1985; Lachashvili & al. 2007; Lachashvili & Khachidze 2009). As well as the *Pistacia atlantica* distribution range, area of pistachio formation in the South Caucasus in the past was much more.

Pistacieta atlantici with other formations of xerophytic woodlands (arid open woodland, arid forest) are considered to be vegetation of the Tertiary period (Takhtajian 1946; Ivanova 1950; Agakhaniants 1981; Khachidze 1985). There is no consensus about its

origin and florogenetic connections. Some researchers identify it with savanna, or to indicate their savanna origin (Sosnovsky 1943; Gulisashvili & al. 1975; Gulisashvili 1980). And some researchers (Grossheim 1948; Rubtsov 1956; Ketskhoveli 1960, 1980; Khachidze 1985; Nakhutsrishvili 2013) consider pistachio forests in the independent type of vegetation "arid open woodland" (xerophytic open woodland). Kvachakidze (2001) uses term "arid forests". However, it should be mentioned, that none of the view are backed up by an analysis of the structure of pistachio-woodland communities. In most cases, the conclusions are built on the visual side pistachio communities, plant phenelogy and the general data. Part of the researchers (Kamelin 1989) pistachio-woodlands (*Pistacieta verae*, *Pistacieta atlantici*) with other formations of deciduous arid forests combines with special vegetation types, which they call East Mediterranean deciduous xerophilous forests, arid open woodlands and shrubberies. Some researchers of Caucasus forests, for example Dolukhanov (2010), hesitated to include pistachio-woodland in savanna before solving the problem and noted that with their structure, development and genesis pistachio-woodlands are original.

In the scientific literature data about the structure pistachio-woodlands of Georgia, and generally of South Caucasus, are scarce. The emphas is mostly on the typological composition. In rare cases their short geobotanical characterization is given (Khachidze 1985; Lachashvili & Khachidze 2009; Dolukhanov 2010). The floristic composition and its analysis are not presented.

The aim of our research was determining the floristic composition of *Pistacia atlantica* formation.

Based on analysis of systematic structure, compositions of chorotypes and life forms reveal their florogenetic connections.

Materials and methods

The floristic and phytocenological data were obtained by the route method for long time (1995-2015).

Chorotypes and their general areas correspond to the methods and principles of Ivanishvili (1973), Portenier (2000a, 2000b) and Gagnidze (2004). Phytogeographic zoning of Earth by Takhtadjan (1978) is taken into consideration. During the selection of chorotypes detailing was emphasized. Mono, double, triple, and in some occasions fourfold regional chorotypes are selected. The names of all those main botanic-geographic units, that the chorotype area contains, are used in the names of chorotypes. During determination of chorotype of the species and subspecies, the main attention is directed to the center of gravity of the species (subspecies) spread. In case the plant is ranked as subspecies (subsp.), the chorotype of the subspecies is given. By mentioned methodology, in the most chorotypes (where there a need and an opportunity were) lower-ranking units – chorological groups are separated. The selected chorotypes are apportioned in four major groups. They are: (1) boreal, (2) Ancient Mediterranean, (3) "connective" and (4) widespread. Such attitude gave the opportunity to conduct more detailed analyzes.

According to Takhtajan (1978) the boarders of the Ancient Mediterranean and Boreal regions are determined.

Endemics of Caucasus are separated within borders of Caucasus ecoregion (Solomon & al. 2013).

The main approach to the separation of phytocenological units (*Pistacieta*, *Junipereta*) is based on the dominant species, like it was used to be in the former USSR. Suffix "-eta", added on the genus name of dominant taxa, denotes "formation", which is the highest vegetation units (Shennikov 1964; Rabotnov 1983; Nakhutsrishvili 2013).

Life forms spectrum compiled according to classification systems of Raunkiaer (1934) and Serebriakov (1964).

The soil related terms are given according to Urushadze (1999, 2016).

Description of study area

In Georgia general area of *Pistacia atlantica* formation comprises southern-eastern part of Iori plateau, where well preserved in Vashlovani protected areas. A little intervenes in the northern and the northern-western parts of adjacent Eldari lowland (Fig. 1).

Altitudinal range of *Pistacia atlantica* formation in the southern-eastern parts of Iori plateau and the northern-western parts of Eldari lowland is between 250-600 m amsl. Communities of *Pistacieta atlantici* are distributed on the hills, plains and the lower part of monoclinal low ranges, also on the debris cones of dry gorges.



Fig. 1. Main area of *Pistacia atlantica* formation in Georgia.

In the southern-eastern part of Iori plateau, *Pistacia atlantica* formation with Juniper formation (*Junipereta*; *Juniperus foetidissima*, *J. polycarpos*) form zonal type vegetation, which occupy an intermediate location between the desert and steppe vegetations (Lachashvili & Khachidze 2009).

The southern-eastern part of Iori plateau belongs to semiarid regions. It is characterized by dry subtropical climate with relatively cold winter and long hot summer. Average annual temperature is 13°C. Total annual precipitation fluctuates within 350-400 mm. Evaporability is 900-1000 mm, precipitation-evaporation ratio – 0.4-0.6. The northern and the northern-western parts of Eldari lowland are within 250-300 m amsl and characterized by dry subtropical climate of semidesert. Average annual temperature is 14.2°C. Average total annual precipitation is 200 (250)-350 mm. Evaporability is 1000-1200 mm, precipitation-evaporation ratio – 0.3-0.5 (Kordzakhia 1961; Dzotsenidze 1964; Khachidze 1985).

The study area is not located none of meteostation. Nearest meteostation was away from main area of pistachio-woodland on average 12-20 km. Now meteostation does not function. Below is given klimadiagram built according to the data (Loladze 1967, 1970) of mentioned weather station (Fig. 2).

On the studied area pistachio communities mainly are developed on different modifications of grey-cinnamonic soils. Not infrequently soils are skeletal. Distribution of *Pistacia*

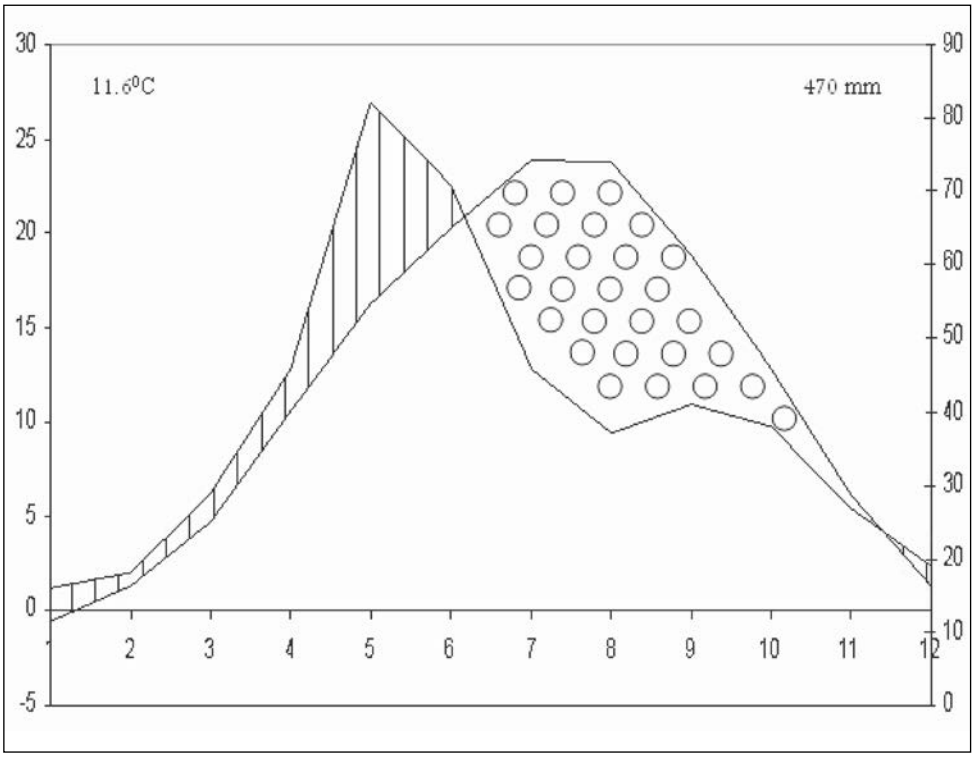


Fig. 2. Climograph of nearest meteo station from the study area

atlantica communities on Eldari lowland associated with debris cones of dry gorges, which covered with shingles and soil is salinized slightly.

Results

Systematic structure of flora - 250 species of vascular plants, belong to 176 genera and 50 families, recorded in *Pistacia atlantica* formation of Georgia (Table 1).

Table 1. General spectrum of vascular flora of Georgia *Pistacia atlantica* formation

Large Taxa	Families		Genera		Species	
	Number	%	Number	%	Number	%
*Pteridophyt*a	-	-	-	-	-	-
Gymnospermae	2	4	2	1.1	4	1.6
Angyospermae	48	96	172	98.9	246	98.4
among these:						
Dicotyledonae	40	80	139	79.9	196	78.4
Monocotyledonae	8	16	33	19	50	20
Total	50	100	174	100	250	100

Number of genera is disproportionately distributed by families. Most families are represented by 1-2 genera: 10 families – by two genera each, 25 families – by one genus. That is, out of 50 families, 35 comprising only 25.6% of the total number of genera (45 genera). Spectrum of 1-10 leading families by number of genera are given in table form (Table 2). Except *Amaranthaceae*, by 4 genera also *Ranunculaceae* is represented.

Table 2. Number of genera by 1-10 leading families in vascular flora of Georgia *Pistacia atlantica* formation.

Family	Number of Genera	%
1. *Asteraceae*	23	13.2
2. *Poaceae*	22	12.6
3. *Fabaceae*	13	7.5
4. *Brassicaceae*	11	6.3
5. *Caryophyllaceae*	11	6.3
6. *Lamiaceae*	10	5.8
7. *Rosaceae*	7	4.0
8. *Apiaceae*	7	4.0
9. *Rubiaceae*	5	2.9
10. *Amaranthaceae*	4	2.3
Total	113	64.9

The same families dominate by content number of species, though more or less different sequence is observed (Table 3).

Table 3. Number of species by 1-10 leading families in vascular flora of Georgia *Pistacia atlantica* formation.

Family	Number of species	%
1. *Poaceae*	35	14.0
2. *Asteraceae*	31	12.4
3. *Fabaceae*	30	12.0
4. *Brassicaceae*	16	6.4
5. *Caryophyllaceae*	14	5.6
6. *Lamiaceae*	13	5.2
7. *Rosaceae*	8	3.2
8. *Rubiaceae*	7	2,8
9. *Amaranthaceae*	7	2.8
10. *Apiaceae*	7	2.8
Total	168	67,2

Share of 1-5 leading families accounts 50.4% (126 species) of the total number of species. *Asparagaceae* and *Papaveraceae* are represented by 5 species each, and 3 families (*Liliaceae*, *Plantaginaceae*, *Ranunculaceae*) by 4 species each. 8 families comprise 3 species each, 9 families 2 species each and 18 families are represented by one species. As we can see, most of the families (27 families) are represented by 1-2 species and comprise only 14.4% of the total number of species.

Distribution of species by genera is represented in table form (Table 4).

Table 4. Number of Species in genera of the vascular flora of Georgia *Pistacia atlantica* formation.

Genus	Number of Species	Genus	Number of Species
Astragalus	7	*Galium*	3
Stipa	6	*Juniperus*	3
Medicago	5	*Linum*	3
Aegilops	4	*Papaver*	3
Bromus	4	*Sedum*	3
Onobrychis	4	*Silene*	3
Salsola	4	*Veronica*	3
Alyssum	4	*Vicia*	3
Allium	3	In the rest:	
Artemisia	3	24 genera	2-2
Gagea	3	131 genera	1-1

Composition of chorotypes (Geographical Range Types) - In order to determine the origin and florogenetic connections of vegetation, along with the study of systematic structure of flora, necessary to determination the composition of chorotypes. The study of chorotypes showed the following: 250 species of vascular plants recorded by us are grouped into 30 geographical range types. Their quantitative and percentage proportions are presented below by table form (Table 5).

Table 5. Proportion of chorotypes in the vascular flora of Georgia *Pistacia atlantica* formation.

Chorotype	Number of Species	%	Number of Species	%
Boreal species				
Caucasian	28	11.2	39	15.6
Caucasian-Eurasian steppe	9	3.6		
Caucasian-Euxinian	1	0.4		
Euxinian	1	0.4		
Ancient Mediterranean Species				
Ancient Mediterranean	3	1.2	80	32
Mediterranean	7	2.8		
Southwest Asian	8	3.2		
Southwest Asian-Turanian	8	3.2		
Southwest Asian-Turanian-Central Asian	4	1.6		
Turanian	1	0.4		
Mediterranean-Southwest Asian	37	14.8		
Mediterranean-Southwest Asian-Turanian	9	3.6		
Mediterranean-Southwest Asian-Turanian-Central Asian	2	0.8		
Caspian	1	0.4		
“Binding Species”				
Caucasian-Turanian	3	1.2	90	36
Caucasian-Southwest Asian	26	10.4		
Caucasian-Southwest Asian-Central Asian	1	0.4		
European-Mediterranean-Southwest Asian	15	6		
European-Caucasian-Southwest Asian	1	0.4		
European-Ancient Mediterranean	6	2.4		
European-Mediterranean	9	3.6		
Southwest Asian-Caucasian-Eurasian steppe	6	2.4		
Mediterranean-Southwest Asian-Eurasian steppe	18	7.2		
Mediterranean-Eurasian steppe	2	0.8		
Euxino–Hyrcanian	1	0.4		
Caucasian-Hyrcanian	1	0.4		
Pontian-Irano-Turanian	1	0.4		
Widespread Species				
Palaearctic	36	14.4	36	14.4
Holarctic	4	1.6	4	1.6
Cosmopolitan	1	0.4	1	0.4
Total				
	250	100	250	100

Composition of life forms **-** Spectrum of life form (Raunkiaer 1934) has the following form: therophytes - 120 species (48%), hemicryptophytes (with biennial plants) - 71 (28.4%), phanerophytes – 24 (9.6%), geophytes - 23 (9.2%), chamaephytes - 12 (4.8%). According to Serebryakov (1964) classification of life forms spectrum is as follows: annual plants – 120 species (48%), biennial plants – 7 (2.8%), perenial herbaceous plants – 87 (34.8%), semi-shrubs and draft semi-shrubs – 13 (5.2%), shrubs – 18 (7.2%), trees – 5 (2%).

Discussion

Systematic structure of flora - Basis of vascular flora is angiosperms. Dicotyledonous plants are 3,6 times more than monocotyledonous.

The data (Tables 2, 3) is clear that the genera and species disproportionally distributed by families which is characteristic of vegetation developed in the extreme conditions. However, in comparison with adjacent to the desert vegetation, in which share of 1-10 leading families is 76.5% of total number of species (Lachashvili & al. 2007; Lachashvili & Khachidze 2010), the one-sidedness is reduced.

Low species diversity of genera is expressed sharply (Table 4). 131 genera (75.3%) are represented only by one species and 24 genera (13.8%) by two species each. That is, there are 89.1% of genera are represented by 1-2 species. Thus, abundance of species in the floristic composition is due to relatively high number of genera.

The spectrum of first 10 (15) leading families by species composition gain great significance in the floristic study of the region as well as vegetation. Spectrum of first 10 leading families by content of species does not fit a standard frame of any important floristic centre (Mediterranean, Southwest Asia, Iran-Turan, etc), although the influence of various floristic centers is evident.

As in typical Mediterranean floras (Tolmachev 1986; Quezel 1978), the family of *Fabaceae*, *Caryophyllaceae* and *Brassicaceae* has high position with *Poaceae* and *Asteraceae* in the spectrum of flora of pistachio-woodland of Georgia. The same families dominate in almost every floras of Ancient Mediterranean. High share of family *Lamiaceae* (6 position in the spectrum) underlines connection with Ancient Mediterranean (especially Southwest and Midle Asian). Presence of another Ancient Mediterranean family – *Apiaceae* (Gagnidze 2000) in the top ten strengthens these ties. Both these families have leading positions in the floras of different regions of Ancient Mediterranean (Turril 1929; Kamelin & al. 1989; Asaadi 2009; Dehshiri & Jozipoor 2014; Baliousis 2016; Kargar Chigani & al. 2017).

Quite high position of family *Rosaceae* in the spectrum, which is marked the leading positions in the nemoral, Submediterranean and boreal floras, is noteworthy. This family in the Mediterranean floras relatively rarely is included in the top ten and his position is not defined. In forest regions of Ancient Mediterranean (for example, Southwest Asia), this family is in top 10 (Heydari & al. 2013; Aghaei & al. 2013; Mataji & al. 2013; Ghollasimood & al. 2014; Roshan & Heydari 2014; Azizi & Keshavarzi 2016). Position of *Rosaceae* in the Irano-Turanian floristic spectra decreases from floras of forest region to the non-forest (Tolmachev 1986; Lachashvili & al. 2007). Thus, one can say, that high position of *Rosaceae* in the floristic spectrum of pistachio-woodlands of Georgia should be considered as related signs of forest ecosystems.

Being in the top ten one of knot of Sahara-Gobi deserts family *Chenopodiaceae* (*Amaranthaceae*) is important, as a result of Irano-Turanian deserts influence. It is notable, that this family has the same position in floristic spectrum of pistachio-woodlands of Saharan Atlas - influence of Sahara deserts (Benaradj & al. 2015a).

Family *Liliaceae* should be separately mentioned. With the modern sense it is presented by 4 species. But if reviewed according to the old wider (s. l.) volume (including families: *Asparagaceae* – 5 species, *Amaryllidaceae* – 3, *Colchicaceae* – 1, *Xanthorrhoeaceae* – 1),

then with 14 species it would take the 5-6 position in the spectrum. 5-6 position of this family is logical and also indicates on the Mediterranean and Southwest Asian impact.

Therefore, systematic structure of pistachio-woodlands of Georgia indicates on the Ancient Mediterranean character of flora. Boreal links are also identified.

It should be marked, that in diffrent areas (for example, South Caucasus, Middle Asia and Saharan Atlas) in the floristic spectra of pistachio-woodlands ecosystems are mainly same families dominate (Malysheva 1989; Aleksanyan 2011a; Benaradj & al. 2015a). In spite of different positions of some families (for example: *Rubiaceae*, *Chenopodiaceae* and *Rosaceae*), the similarities between spectra are vivid.

Chorotypes - Large quantities of local - Caucasian and Caucasian-Southwest Asian species in the spectrum of chorotypes deserve special attantion. Area of most plants of Caucasian-Southwest Asian chorotype does not include all Southwest Asia and mainly limited with neighboring territory of South Caucasus. Broad participation of these chorotypes, in our opinion, indicates to forming of pistachio-woodland in semiarid regions of East Georgia and its outstanding Southwest Asia occurred in relationship with each other.

Southwest Asian species are represented by small quantity - totaly 8 species. Southwest Asian connections, mainly, are expreced by partisipation of different double, triple and quadruple regional chorotypes. The total share of these species is 50.8% (127 species).

Weak connection with the direction of Turan are vivid too. The total quantity of Turan related species is 21(8.4%). Their partisipation points to relativaly weak maintained connactions with Iran-Turan deserts.

Participation of Mediterranean chorotype plans is small – 7 species. Influence of the Mediterranean floristic centre and ties with it is expressed by participation of species of double, triple and quadruple regional chorotypes. Their total number is 92 species (36.8%). Distribution range of one parts of these species are confined by East Mediterranean.

In terms of Mediterranean and Southwest Asian connections one should especially point to large spectrum of Mediterranean-Southwest Asian (-Turan-Central Asian) species [48 (19.2%)].

The connection between Georgia pistachio-woodlands and Eurasian steppe is expresed in different chorotypes (Caucasian-Eurasian steppe, Southwest Asian-Caucasian-Eurasian steppe, Mediterranean-Southwest Asian-Eurasian steppe and Mediterranean-Eurasian steppe chorotypes). Ratio of the united species in these chorotypes is 14% (35 species).

Conections towards Europe are weaker (European-Mediterranean-Southwest Asian, European-Mediterranean, European-Ancient Mediterranean and European-Caucasian-Southwest Asian species). The total ratio of these spieces is 12.4% (31 species).

In the floristic composition important role also belongs to the Palaearctic species (14.4%). Three groups excreted among them: Palearctic – 16 species, South Palearctic – 12 and West Palearctic – 8.

Other chorotypes are represented by small number of species and does not play determinant role in shaping of floras structure. They with their participation enrich floristic composition. It should be noted that in the floristic composition of Georgia pistachio-woodland are not recorded tropical species.

By analyzing chorotypes it is obvious that in forming of Georgia pistachio-woodland Ancient Mediterranean species plays main role, which total share is almost 1/3 (32%). Comparison with them participation of Boreal species are small – 15.6% (39 species). And

the largest number represented so-called "binding" species (90 species – 36%), which wide spectrum highlights the connections of different directions. High share of "binding" species are fully logical because study area located at the crossroads of the borders of various floristic centres. Such ration of chorotypes indicates that of Georgia *Pistacieta atlantici* formation proceeded in the bosom of Ancient Mediterranean with close contact with the boreal flora. Connection with boreal floras in the first place are reflected by large participation local (Caucasian) and related with Eurasian steppe species. Here we shall remark, that part of researchers Caucasian chorotype are considering within Ancient Mediterraneanin (in particular in Submediterranean) region (Gagnidze 2004; Gagnidze & Davitadze 2000; Shetekauri & Gagnidze 2000). There are observed relatively weak ties to the European direction. Large participation of Palearctic species evidences on the connection with Europe and general with Palearctic, that support the boreal links. It is very important that in the modern floristic composition of pistachio-woodlands of Georgia connection with the tropics does not loom.

Floristic analysis of dry deciduous woodlands spread in the southern part of South Caucasus (South Armenia) revealed that also their formation is occurred in the bosom of Ancient Mediterranean with to the influence of boreal floras (Aleksanyan 2011b). The difference is that in South Armenia there is dominance of Ancient Mediterranean species. On their background participation of "binding" and boreal species is significantly reduced. Such changes indicate that the northward boreal connections increases, which is natural and logical. The Ancient Mediterranean origin of pistachio-woodland is also determined by the chorological analysis of Saharan Atlas. The influence of Mediterranean and Saharan-Sindian floristical centres is vivid (Benaradj & al. 2015a).

Endemics - Among Caucasian species, 21 are endemic of Caucasus. 12 species of them are endemics of South Caucasus. Area of most endemic species mainly includes arid and semiarid regions of Caucasus. Area of 7 species which are united in the Caucasian chorotype goes slightly beyond the range of this chorotype and is charactarised by iradiation area. In particular:

Caucasian with East Anatolian irradiation – 2 species (*Cotoneaster meyeri*, *Onobrychis radiata*);

Caucasian with North-East and East Anatolian irradiation – 2 species (*Astragalus brachycarpus*, *A. stevenianus*);

Caucasian with Anatolian irradiation – 2 species (*Erysimum leptophyllum*, *Scutellaria orientalis*);

Caucasian with Pontian irradiation – 1 species (*Scorzonera biebersteinii*);

These species can be regarded as Caucasian subendemics.

Apart from species of Caucasian chorotype, *Salsola nodulosa* – plant of Caucasian-Turan chorotype is endemic of Caucasus. Total number of Caucasian endemics is 22 species (8.8%). Their share with subendemics is 11.6%. To take in consideration that the research territory is located in the crossing area of the various floristic centres, this indicator should not be unsignificant.

Life forms - From the life forms spectrum it is clear that with largest number are represented those plants which unfavorable period tolerate (survives) in the form of seeds – 120 species (48%). By comparison with them number of species which buds has in the air are significantly smaller. Their total number is 36 (14.4%). Between them middle position

occupy species which the buds has to the level of the ground – 69 species (27.6%). With smaller number are represented those species, which unfavorable periods tolerate with specialized underground bodies – 23 (9.2%).

Outlined dominance of therophytes over hemicryptophytes is important aspect in herbaceuos plants' ratio. High ratio of therophytes emphasizes on Mediterranean character. Also, the spectrum has heteregeneous character; different signs of plats adaptation to enviromental conditions are vivid. In our view, such ratio of life forms is in compliance with the physical-geographic conditions (especially with climate and soil conditions) of study area.

The dominance of herbaceous plants is clearly highlighted in the spectrum of life form – 214 species (85.6%). Woody plants are represented by 23 species (9.2%) and semiwoody plant by 13 species (5,2%). One should remark, that dominance of herbaceous plants (especially of therophytes) in pistachio-woodlands and in general, in deciduous arid open woodland ecosystems is observed in different areas (Malysheva 1989; Alexsanyan 2011c; Benaradj & al. 2015b).

By analyzing of the life forms' spectrum, we can say that in comparison with the typical forest share of woody plants is significantly reduced. On their background the number of the herbaceous (especially of therophytes) and semi-woody plants increased. Proportion of herbaceous (therophytes, hemicryptophytes and geophytes), semi-woody and woody plants, obviously, indicates on the transitional character between grassland and forest vegetations. From our point of view, spectrum of life forms has Ancient Mediterranean character.

The ratio of life forms by chorotypes is interesting.

In the composition of phanerophytes dominance of Caucasian-Southwest Asian, Mediterranean-Southwest Asian and Mediterranean chorotypes identified. European links observed also.

In the composition of semishrubs and dwarf semishrubs, despite small number of species, chorotypes are diverse and dominance any chorotype is not observed. The most pronounced connections with Southwest Asia, Turan and Mediterranean. Participation of local (Caucasian and Caucasian-Turanian) species is important. In the mentioned life form diversity of chorotypes is conditioned by in the pistachio-woodlands communities participates chamaephytes which are characteristic for various ecotopes.

In the composition of hemicryptophytes florogenetic links with Eurasian steppe are most pronounced. Ties with Irano-Turan deserts are reduced to minimal. European-Mediterranean influence is also outlined. Participate of local and Caucasian-Southwest Asian species is not insignificant.

In the composition of geophytes Caucasian-Southwest Asian and Caucasian species are dominated. Connections with Eurasian steppe observed also. Among them Irano-Turanian species are in very small quantity.

In the composition of therophytes dominance of Mediterranean-Southwest Asian chorotype are identified. The role of those species, which distribution range is advanced, on the one hand, to Europe and, on the other hand, to east (Turan, Midle Asia, Central Asia) is also important. Most of these species are ephemers and their bioecological features and phenology are in line with of the researched region's climat. They perform important role in the formation of ephemeral synusia of Irano-Turan deserts and at the same time they relate to the characteristic species of South Caucasus (among them of Georgia) desert vegetation.

Thus, we can say that florogenetic connections with Southwest Asia and Mediterranean loom by almost all life forms and the links with Eurasian steppe mainly are reflected in the compositon of hemicryptophytes. Although, that the connections with Iran-Turan deserts reduced, in nearly all life forms (especially in therophytes) there are species that indicates on these links. The weak connections which are with Europe mostly revealed in the compositions of therophytes, hemicryptophytes and also phanerophytes (shrubs).

General Conclusions

Based on the analysis of systematic structure and chorotypes of floristic composition of Georgia pistachio-woodlands we can conclude that there are three the main directions florogenetic connections: (1) Southwest Asia, (2) Mediterranean and (3) Eurasian steppe. Floristic composition is enriched by local (Caucasian) species. In attenuated form are pronounced influence of Iran-Turan deserts, on the one hand and links to Europe on the other hand. It was found that the formation of pistachio-woodland of Georgia implemented in the bosom of Ancient Mediterranean in close contact with the boreal flora. Florogenetic connection with savannas is not observed.

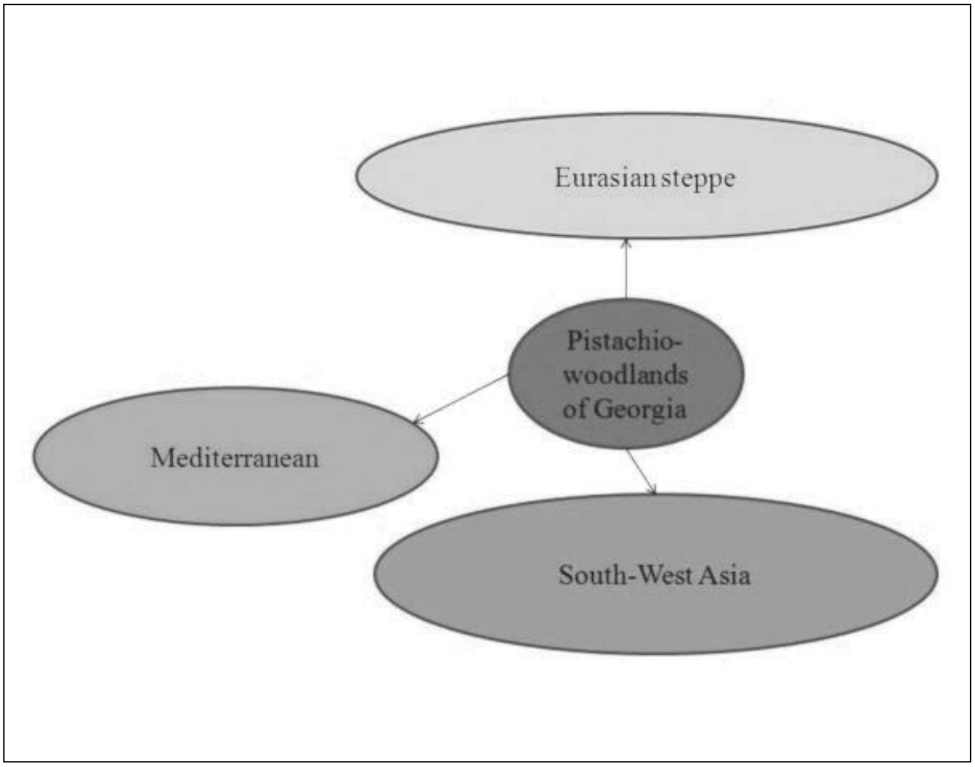


Fig. 3. Main directions of florogenetic connections of Georgia *Pistacia atlantica* formation.

The individual components of floristic composition (systematic structure, composition of chorotypes, life form spectrum) clearly indicates on the transitional character of floras – for these are characteristic relevant characteristics as of forests, so of hemixerophilous shrubberies and of steppe. At the same time, none of the sign explicit dominance does not reaches. The obtained results confirm the notion of examination *Pistacieta atlantici* in independent vegetation type which is called arid open woodlands (in synonims: xerophytic forests, xerophytic woodlands).

Given the fact that pistachio-woodlanlands of Iori and Sheki plateaus are a single origin this conclusion can generalize for pistachio-forests of eastern part South Caucasus.

Floristic composition indicating life forms (Raunkiaer 1934; Serebriakov 1964) and chorotypes for each species in table form are given in the Elcetronic supplementary file (ESF1).

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Article

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The vascular flora of Mt Tzena (northern Greece)

Abstract

Chasapis, M., Samaras, D. A., Theodoropoulos, K. & Eleftheriadou, E.: The vascular flora of Mt Tzena (northern Greece). — Fl. Medit. 30: 55-63. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

Mt Tzena is located in the northernmost part of North-Central Greece. A first floristic inventory of the mountain is presented based on an intensive field collection and literature records. The vascular flora of the study area consists of 1254 specific and subspecific taxa out of which 858 taxa are reported for the first time.

Key words: vascular plants, floristic inventory, Tzena mountain, Balkans.

Introduction

Mt Tzena presents a phytogeographical interest due to its geographical position and habitat richness. Nevertheless, the flora of the mountain was almost unknown until the seventies, like many other mountains along the northern borders of Greece, due to their poor accessibility. The botanical exploration of Mt Tzena started in the seventies and eighties with the Mountain Flora of Greece project (Strid & Papanikolaou 1981; Strid & Franzen 1982; Strid 1986; Strid & Tan 1991). A total number of 155 taxa were published in these works, mainly from the high altitudes of Mt Tzena. Other floristic contributions, not related with the above mentioned project, were those of Melzheimer & Greuter (1979) and Voliotis (1983, 1986) with the latter mentioning the presence of 170 taxa from Mt Tzena. In the two first volumes of Flora Hellenica (Strid & Tan 1997, 2002) 86 taxa were reported from Mt Tzena. Several other floristic reports from the Greek part of Mt Tzena have been published more recently by Tiniakou (1991), Schuler (2004), Parent (2005), Kučera & al. (2006), Tan & al. (2006), Biel & Tan (2008), Font & al. (2009), Gottschlich & Schuler (2011), Gonzalo-Estébanez (2013) and Chasapis & al. (2019). Despite the extensive collections during the last 5 decades from the mountains of northern Greece, the flora of Mt Tzena remains poorly known, with only 396 literature reports.

This study tries to fill the gap in knowledge of the incompletely known flora of Mt Tzena by presenting a complete catalogue of all vascular plants currently known from the mountain. A detailed floristic analysis is also being presented with a focus on the endemic and range-restricted plants.

Materials and methods

Study area – Mt Tzena is located in North-Central Greece, 83 km from the city of Thessaloniki. The mountain lies between 41º 06′ and 41º 11′ N of latitude and 22º 10′ and 22º 18′ E of longitude, and covers an area of 5,327 ha that ranges from 600 to 2182 m in elevation (Fig. 1). The study area is restricted among the borders between Greece and North Macedonia to the north, the stream "Katharo" to the west, the plateau "Notias" to the south and the forest road that connects "Perikleia" with the military outpost "Tagmatarchis Vasileios Papagiannis" to the east.

Metamorphic rocks (mainly schist and marble) dominate in the study area. A variety of sedimentary rocks (sandstone, limestone, travertine) and igneous rocks (andesite, dacite, trachyte etc.) can be also found (Mauridis & al. 1982; Galeos & al. 1996). Only the lowest elevational zone of Mt Tzena has a Mediterranean climate with wet, mild winters and dry, warm summers (Chasapis 2017). At mid- and high altitudes the climate is humid continental with Mediterranean influence (dry and warm summers). According to Köppen climatic classification, the lower elevations belong to the Csb type (Chasapis 2017), while the mid- and higher to the Dsb type (Beck & al. 2018). The highest elevational zone, above 1800 m, has no dry season and, therefore, belongs to the Dfb and Dfc types (Chasapis 2017; Beck & al. 2018).

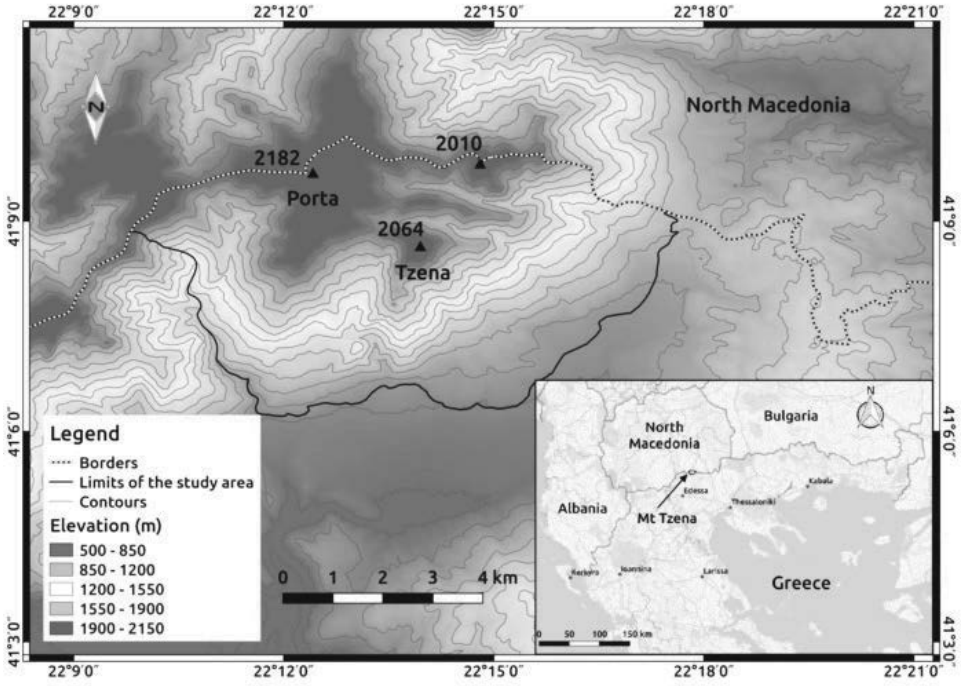


Fig. 1. Map of the study area.

Woods of deciduous broad-leaved tree species occupy more than 50% of the mountain area, extending to the altitude of 1800 m (Chasapis & al. 2013). The most common among them are the beech forests (*Carpino-Fagetea sylvaticae*), followed by thermophilous deciduous forests (*Quercetea pubescentis*). Beech forests are distinguished in three types: the acidophilous beech forests of the *Luzulo-Fagion sylvaticae* alliance, the mesic beech forests of the *Galio odorati-Fagion sylvaticae* and the thermophilous beech forests of the *Cephalanthero-Fagion sylvaticae* (Chasapis 2017). Thermophilous deciduous forests are distinguished in two types: the forests of *Quercus frainetto* Ten. (*Quercion confertae*) that appear in the east part of the study area on siliceous rocks, and the mixed forests of *Q. pubescens* Willd., *Ostrya carpinifolia* Scop. and *Carpinus orientalis* Mill. (*Fraxino orni-Ostryion*) that appear in the south-west and south-central part of the study area on calcareous rocks (Chasapis 2017).

The second most extended vegetation type of Mt Tzena is the dry grasslands (*Festuco-Brometea*) that occupy 24 % of the study area. Azonal vegetation appears along streams at low altitudes (< 750 m). The riparian vegetation consists mainly of the tree species *Platanus orientalis* L. and *Alnus glutinosa* (L.) Gaertn., with the presence of several willow species (*Salix alba* L., *S. eleagnos* Scop. and *S. purpurea* L.). Above the timberline the heaths of *Juniperus communis* subsp. *nana* Syme are the dominant vegetation type.

Data collection and analysis – The floristic catalogue (Electronic Supplementary File 1) is based on collections and field observations carried out by the first author during spring, summer and autumn of 2009-2014. Published records are also included in the catalogue. Plant specimens that were collected in the field are stored in the herbarium of the Laboratory of Forest Botany-Geobotany, in the Aristotle University of Thessaloniki, Greece (TAUF). Plant identification was based on the main national and European Floras (Jordanov & al. 1963-1995; Tutin & al. 1968-1980, 1993; Pignatti 1982; Strid 1986; Strid & Tan 1991, 1997, 2002) and selected taxonomic literature (Zohary & Heller 1984; Snogerup & Snogerup 2001; Bancheva & Raimondo 2003). The nomenclature follows Dimopoulos & al. (2013, 2016). Families, genera, species and subspecies are arranged alphabetically within the four main taxonomic groups: *Pteridophyta*, *Gymnospermae*, *Dicotyledoneae* and *Monocotyledoneae*. The definitions of species and taxa, as taxonomic ranks, follow Dimopoulos & al. (2016). Life-form categories of taxa are coded according to Raunkiaer's classification system as was modified by Dimopoulos & al. (2013). Life-form sub-categories are according to the classification system of Ellenberg & Mueller-Dombois (1967) as was modified by Pignatti (1982). Chorological types of taxa are based on the system established for the checklist of vascular plants of Greece (Dimopoulos & al. 2013).

Results & Discussion

Floristic analysis – The vascular flora of Mt Tzena consists of 1254 taxa, belonging to 102 families and 466 genera (Table 1). The total number of taxa is composed of 268 subspecies, 981 species that have no subspecies and 5 species of *Taraxacum* identified at section level. From these, 858 taxa (68.4 % of the total flora) are reported for the first time. From the remainder 396 literature references, 356 taxa were either collected or observed

Table 1. Numbers of plant families, genera, species, subspecies and taxa in the three main taxonomic groups of the vascular flora of Mt. Tzena.

	Families	Genera	Species[1]	Subspecies	Taxa[2]
Pteridophytes	9	13	24	2	25
Gymnosperms	4	5	10	5	11
Angiosperms	89	448	1176	261	1218
Total	**102**	**466**	**1210**	**268**	**1254**

1. are comprised of (a) species that have no subspecies and (b) species that have one or more subspecies
2. include 5 species of *Taraxacum* identified at the Section level.

by the first author, while 40 references could not be confirmed. Fifteen (15) additional taxa that have been reported from Mt Tzena but their presence in NC Greece has not been confirmed, were excluded from the floristic analysis. The presence of these 15 taxa in the study area is doubtful, therefore are noted in the floristic catalogue with a question-mark (?). Additionally, 4 hybrids are mentioned in the floristic catalogue but have been disregarded from the floristic analysis. Mt Tzena, despite its small area, presents a high diversity in vascular plants. This can be attributed to the broad elevation range of the mountain (600 – 2182 m), together with its habitat richness and geographical position. NC Greece has been recognised as a floristic region of high diversity (Dimopoulos & al. 2013; Strid & Tan 2017).

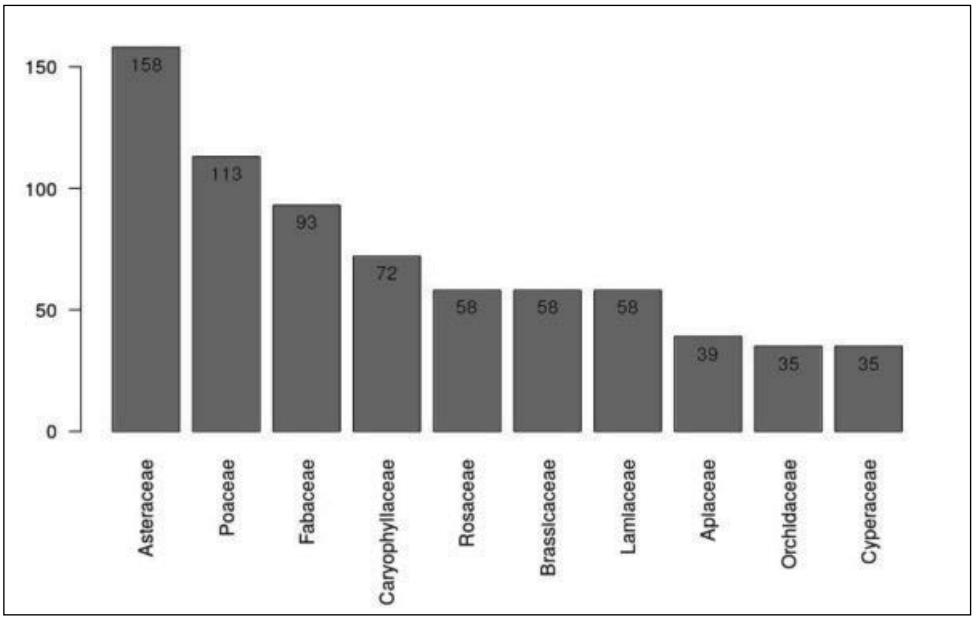


Fig. 2. The ten most taxa-rich families of the vascular flora of Mt Tzena.

The ten most taxa-rich families together include 719 taxa, representing the 57.3 % of the total flora of Mt Tzena (Fig. 2). The 4 most taxa-rich families are *Asteraceae*, *Poaceae*, *Fabaceae* and *Caryophyllaceae* with 158, 113, 93 and 72 taxa, respectively (Fig. 2). These four families are consistently the richest in number of taxa, for several high Greek mountains (Dimitrellos & Christodoulakis 1995, Vlachos & al. 2009) and for the Greek flora in general (Dimopoulos & al. 2013). Two other families, *Rosaceae* and *Cyperaceae*, are of significant interest (Fig. 2). The family of *Rosaceae* is the 5th richest in number of taxa, which reflects the transitional geographic position of Mt Tzena between the Mediterranean and continental areas. The family of *Cyperaceae* is exceptionally rich in number of taxa (35 taxa), most of which belong to the genus *Carex*. The richness of the family can be attributed to the presence of various hydrophilous plant communities, especially the subalpine calcium-rich fens.

Spectra – Hemicryptophytes and therophytes are the most abundant plant life forms in the flora of Mt Tzena with a proportion of 52.0 % and 20.8 % respectively (Fig. 3). Geophytes and phanerophytes follow with 13.3 % and 8.5 % respectively, while chamaephytes are the less abundant (5.4 %). The most abundant chorological group of plants are the Widespread taxa (634 taxa – 50.76 %), followed by the Mediterranean (326 taxa – 26.10 %) and Balkan taxa (275 taxa – 22.02 %) (Table 2). The proportion of Greek endemics and Aliens is much lower (0.56 %). According to Emberger (1967), hemicryptophytes characterize the temperate climatic zone.

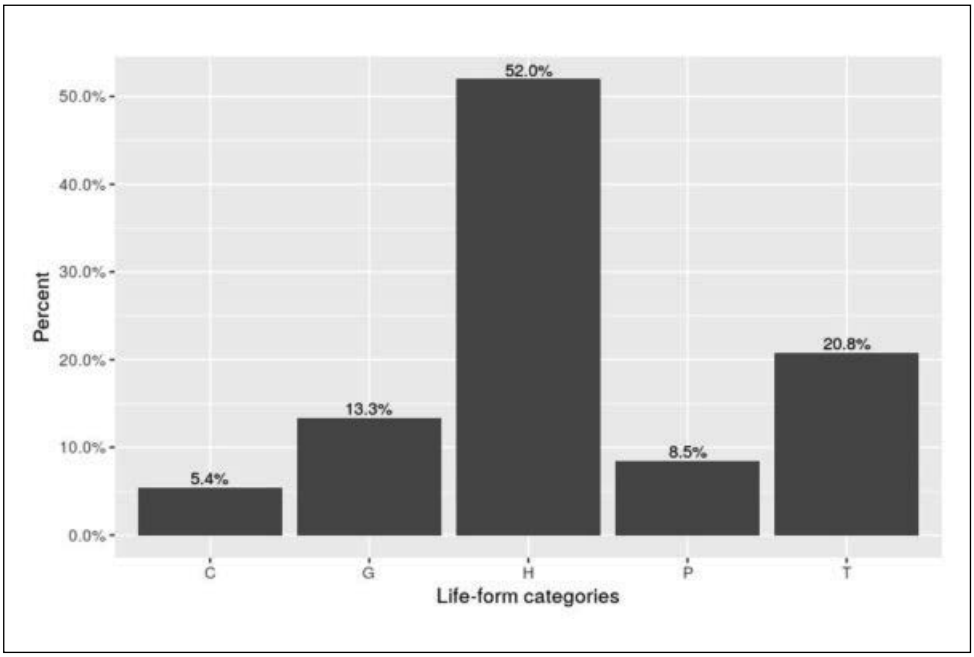


Fig. 3. Life-form spectrum of the vascular flora of Mt Tzena. P: Phanerophytes, C: Chamaephytes, H: Hemicryptophytes, G: Geophytes, T: Therophytes.

Table 2. Chorological spectrum of the vascular flora of Mt. Tzena. The 21 chorological categories are classified into 5 wider chorological groups.

		Nr. of taxa	%			Nr. of taxa	%
Widespread		**634**	**50.76**	**Mediterranean**		**326**	**26.10**
European-SW Asian	EA	278	22.26	Mediterranean	Me	142	11.37
Euro-Siberian	ES	110	8.81	Mediterranean-European	ME	121	9.69
European	Eu	92	7.37	Mediterranean-SW Asian	MS	40	3.20
Paleotemperate	Pt	62	4.96	E Mediterranean	EM	18	1.44
Cosmopolitan	Co	31	2.48	Mediterranean-Atlantic	MA	5	0.40
Circumtemperate	Ct	28	2.24	**Balkan**		**275**	**22.02**
Boreal	Bo	15	1.20	Balkan	Bk	162	12.97
Arctic-Alpine	AA	12	0.96	Balkan-Anatolian	BA	61	4.89
Subtropical-Tropical	ST	5	0.40	Balkan-Italian	BI	33	2.56
Irano-Turanian	IT	1	0.08	Balkan-C European	BC	20	1.60
Alien		**7**	**0.56**	**Endemic**	Gr	**7**	**0.56**
Total						**1249**	**100.00**

Endemism – The Greek endemic vascular flora of Mt Tzena consists of 7 taxa. From the Greek endemics, *Allium macedonicum* Zahar., *Laserpitium siler* subsp. *leave* (Halácsy) Hartvig, *Paronychia albanica* subsp. *graeca* Chaudhri, *Satureja montana* subsp. *macedonica* (Formánek) Baden and *Teucrium montanum* subsp. *helianthemoides* (Adamovic) Baden are found almost exclusively on calcareous rocks while *Dianthus corymbosus* Sm. and *Scilla subnivalis* (Halácsy) Speta can be found on both calcareous and siliceous ground. The Balkan endemics (Bk) is the richest category of endemics in the flora of Mt Tzena with 162 taxa, followed by the sub-Balkan endemics (BA, BI, BC) with 114 taxa.

Range-restricted plants – Among the Greek and Balkan endemics found on Mt Tzena, there is a considerable amount of narrow (single-area) endemic taxa, distributed in the central Balkan area (i.e. northern Greece, Bulgaria, Albania, North Macedonia, Montenegro, southern Serbia, southern parts of Bosnia & Herzegovina and Croatia). Narrow endemism in the mountains of northern Greece is often underestimated, as taxa occurring in small areas on both sides of the border with neighbouring countries have been simply classified as Balkan endemics. The concept of range-restricted taxa (Dimopoulos & al. 2013) was used here to evaluate the local character and uniqueness of Tzena's flora.

In the vascular flora of Mt Tzena participate 62 range-restricted taxa. Among them can be found some very narrow endemic taxa with a restricted distribution in a few localities of NC Greece and North Macedonia (*Achillea ageratifolia* subsp. *aizoon* (Griseb.) Heimerl*, Campanula formanekiana* Degen & Dörfl.*, Centaurea grbavacensis* (Rohlena)

Stoj. & Acht., *Stachys horvaticii* Micevski and *Viola frondosa* (Velen.) Hayek) or NC Greece and Serbia (*Ramonda nathaliae* Pančić & Petrovič).

Conclusions

Mt Tzena, despite its small area, presents a high diversity in vascular plants. The flora of the mountain is made up of 1254 taxa specific and subspecific. A total number of 858 vascular plants are recorded for the first time from the study area. Although Greek endemics represent a very small proportion of the total flora (0.56 %), Mt Tzena is very reach in Balkan endemics (162 taxa, ~ 13 % of the flora) and narrow endemic plants (62 taxa, ~ 5 % of the flora). Hemicryptophytes and therophytes are the most abundant plant life forms, while the most abundant chorological category consists of the widespread European-SW Asian plants.

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Article

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Species diversity and climate an intimate relationship over the last decades in the Mediterranean region: the case study of Sallum Sector, Egypt

Abstract

Amer, W. M., Elshayeb, N. F., Hegazy, A. K., Abbas, M. S., Soliman, A. S. & Abdel Wahab M. M.: Species diversity and climate an intimate relationship over the last decades in the Mediterranean region: the case study of Sallum Sector, Egypt. — Fl. Medit. 30: 65-79. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

The Mediterranean coastal land is one of the richest phyto-geographic territories of Egypt owing to its relatively high rainfall. Sallum sector is situated in the Libyan-Egyptian border. This study deals with, the vegetation covers in different habitats, floristic composition, species richness, species diversity, and chorotypes in Sallum sector. The current floristic composition was compared to that from the last ten decades, to elucidate: the past-present and the future vegetation trend; the change in floristic composition through these decades; trace the impact of climatic changes represented by temperature and rainfall. And, trace the desert expansion as the spatial distribution of the SaharoSindian chorotype. The combined dataset has demonstrated a poleward species sift, notable differences in their response to shortage in rainfall and increased temperatures, were observed among the recorded chorotypes and the species composition across studied habitat range. The SaharoSindian chorotype showed poleward expansion. The retrieved data including, a decline in the total number of the recorded species, changes in their distribution range, recording the timing erosion and the northward expansion of some indicator species. The decline in mean annual rainfall was inconsistent with positive shift in the mean maximum temperature with 1.5˚C. Northward expansion of xerophytes and loss of species diversity through the studied successive decades. Such study provides a case study for the effect of climatic changes in arid land, to support the climatic scenarios. Finally, urgent need of conservation effort and mitigation measures to control the genetic erosion in such arid coastal sector.

Key words: Mediterranean vegetation, climatic change, distribution shift, drought tolerant species, arid land.

Introduction

The Mediterranean coastal land is one of the richest phytogeographical territories in Egypt. It extends for 970 km from Sallum on the Egyptian-Libyan border in the west to Rafah on the Egyptian-Palestine border in the east with an average coastal belt 15-20 km, in north-south direction El-Hadidi (1980). Sallum sector, representing the most western

limit of the Mediterranean coastal land of Egypt, belongs to the Mareotis sector and is characterized by an attenuated desert climate. This sector extends from Sallum in the west to Ras El Hikma in the east Salama & al. (2005).

The general feature of the Sallum sector is the presence of limestone plateau crossed by shallow wadis running South to North which ends with limestone ridge close to the seashore of about 200 m a.s.l. (El-Hadidi 2000).

The previous records of the floristic elements in this sector comprised both Mediterranean and Saharo-Arabian types owing to its phytogeographic position, which lies within the Mediterranean/Saharo-Arabian regional transition zone White (1993).

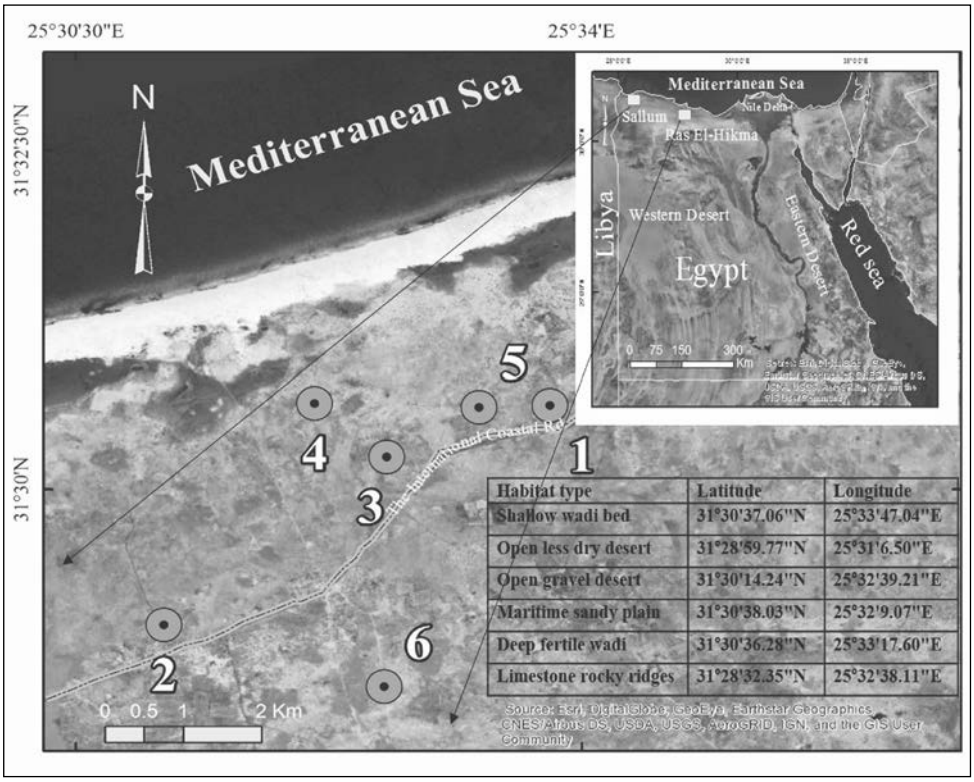
Nevertheless, floristic composition and phytosociology of this sector were dealt with several earlier studies, claiming that this sector remains one of the floristically less known territories in Egypt (Abdelaal & al. 2019). Hitherto, previous studies in the past few decades did not cover the environmental impacts on natural flora including both climatic and anthropogenic activities (Osman & El Garf 2015).

Climate is the biggest overall factor determining plant distribution and the main world types of climate are related to vegetation features. Climatic factors control not only the growth of plants but also the development, distribution, and densities of the vegetation of the earth. Climate is the biggest overall factor determining plant distribution and the main world types of climate are related to vegetation features (Zahran 1989). The climate change scenarios suggest that there is considerable uncertainty about possible future ecological impact, some scenarios produce opposite signs for ecological responses (Bachelet & al. 2001; Hegazy & al. 2008). Climatic changes are also expected to alter the distributions of most types of vegetation **(**Cramer & al. 2001; Scholtze & al. 2006). Besides, Parmesan (2007) claimed that only long-term field observations can reveal complex interdependencies between species, an essential component in estimating future responses to global warming. Therefore, this study was carried out to analyze the floristic composition, species richness, evenness, and species diversity during the last ten decades (1925-2018), in Sallum sector, to provide a past-present-and the expected future vegetation trend. Floristic and climatic data were collected from previous studies, herbarium records, and field inspection. Aiming to elaborate the following: 1- vegetation change through the last ten decades in terms of species types and chorology. 2- The impact of climatic changes as represented by temperature and rainfall. And, 3-The northward desert expansion monitored as the spatial distribution of xerophytic species.

Material and Methods

Study area: The study area in Sallum Sector is bordered from the east by Ras El-Hekma in the east at 27°51’E and 31°15’N that extends to 10 km westwards to Sallum city at 25° 9’25.32”E and 31°34’38.81”N. The sector extends from the seashore and runs 15 km southward to the fringes of the Diffa plateau (Fig. 1). Sallum sector was selected due to its lack of urbanization and on the availability of huge literature data, and the yearly excursion through educational program in Botany and Microbiology Department.

Recent vegetation analysis: the field observation and literature data indicating that the vegetation and soil showed considerable variability in this sector. Accordingly, six sites were select-



Habitat type	Latitude	Longitude
Shallow wadi bed	31°30'37.06"N	25°33'47.04"E
Open less dry desert	31°28'59.77"N	25°31'6.50"E
Open gravel desert	31°30'14.24"N	25°32'39.21"E
Maritime sandy plain	31°30'38.03"N	25°32'9.07"E
Deep fertile wadi	31°30'36.28"N	25°33'17.60"E
Limestone rocky ridges	31°28'32.35"N	25°32'38.11"E

Fig. 1. The representative vegetation sampling sites in the studied Sallum Sector (Egypt).

ed (each represented by squares of 20 × 20 m), to cover the vegetation of the different habitat types namely: shallow wadi, open desert with moist sand-sheet, open-gravel desert, calcareous-maritime sandy plain, deep wadi and the limestone rocky ridge (Fig. 1).

The species in each square were identified, counted and representative specimens were deposited in the Cairo University Herbarium (CAI). The sites were localized using a GPS model BHC NAVA 300 (positioned in Fig. 1 as the square centre point). Identification of taxa was based on voucher herbarium specimens and the reference books Täckholm (1974), Cope & Hosni (1991), Boulos (1999, 2000, 2002, 2009), while Wickens (1978) and Zohary (1973) were followed for species chorology.

The studied ecological parameters (species density, relative density, frequency, relative frequency, cover, relative cover and importance value (IV), were calculated, based on Phillips (1959). The number of individuals/species in each square (20 × 20 m), were counted in the field. While, the ecological parameters were calculated, based on (Hegazy & al. 1998). Species density = (number of individuals/square area). Relative density= (density for a species)/ (total density for all species) ×100. Frequency = (number of sampled quadrates in which species occurs)/ (total number of quadrates sampled). Relative frequency = (frequency value for a species)/ (total of frequency values for all species) ×100, Cover

= (total of intercept lengths for a species)/ (total transect length) ×100. Relative cover = (total of intercept lengths for a species)/ (total of intercept lengths for all species) ×100 and Importance Value of a species x = Relative density of the species x + relative cover of the species x + relative frequency of the species x.

Historical floristic composition: The historical data about previous species composition was compiled from the previous studies: El-Hadidi & Ayyad (1975), Yehia (1984 &1992), Shaltout (1985), El-Hadidi & al. (1986), El-kady & Sadek (1992), Kamal & El-kady (1993), Ayyad & Fakhry (1996), Shaltout & El-Kady (1999), El Garf (2003), Salama & al. (2003 & 2005), Osman & al. (2009), Youssef & al. (2014), Osman & El Garf (2015) and Abdelaal & al. (2019). In addition to the data obtained from herbarium specimens deposited in Cairo University Herbarium (CAI). Where, the collection site, was cited on the specimen label, each species site was changes to co-ordinates using Google map then these co-ordinates added to the recent map, for floristic comparison.

Chorological analysis: Chorology was the term given by phyto-geographer to divide the globe into areas with more or less well defined floras. The species traced in this work were related to its phyto-geographic regions according to White & Léonard (1991). The species consider mono-regional when distributed geographically in one region (e.g. Mediterranean region), and bi-regional if present in two regions (e.g. Mediterranean and SaharoSindian), more than two regions is pleuri-regionals.

Climatic data: Climatic data are based on the climatic data retrieved from the "National Meteorological Authority in Egypt" of Sallum Plateau station (No. 305), latitude 31º 57' longitude 25º 13' and elevation 6 m), and covers the last nine decades (92 years) from 1925 to 2017. The mean values of temperature and rainfall as shown in Figure (1), are shown for the periods: 1925-1950, 1946-1975, 1976-2000 and 2001-2017. The fundamental climate is the arid Mediterranean with mild winters, where January is the coldest month with mean minimum temperature ranges from 14.8 ºC during the period from 1925 to 1950, to 18.5 ºC (1976-2000). It was 17.3 ºC during the last 17 years (2001-2017). August is the hottest month with a mean maximum temperature of 30.1 ºC (1925-1950) that increased to 31.1 ºC (1976-2000), and beyond this, the temperature was 31.6 ºC during the last 17 years (2001-2017).

The distribution of the mean annual rainfall (Fig.2), shows a sharp decrease from about 241.2 mm/year during the period 1925-1950 to 105.0 mm/year in 1946-1975 and 98.9 mm/year in 1976-2000. During the last period 2001-2017, rainfall was significantly lower, it reached 53.8 mm/year. Winter is the main rainy season, with a maximum amount of rainfall during the four months November to February. The average maximum monthly rainfall, moved from November in 1925-1950, where rainfall value reached 51.09 mm, and decreased to 23.9 mm in 1946-1976, to January in 1976-2000, where 29.4 mm was the maximum amount recorded in December (2001-2017), with lower values reached 15.7 mm.

Results

Vegetation

The vegetation in this sector during 2018, as represented in this study covered the six habitats.

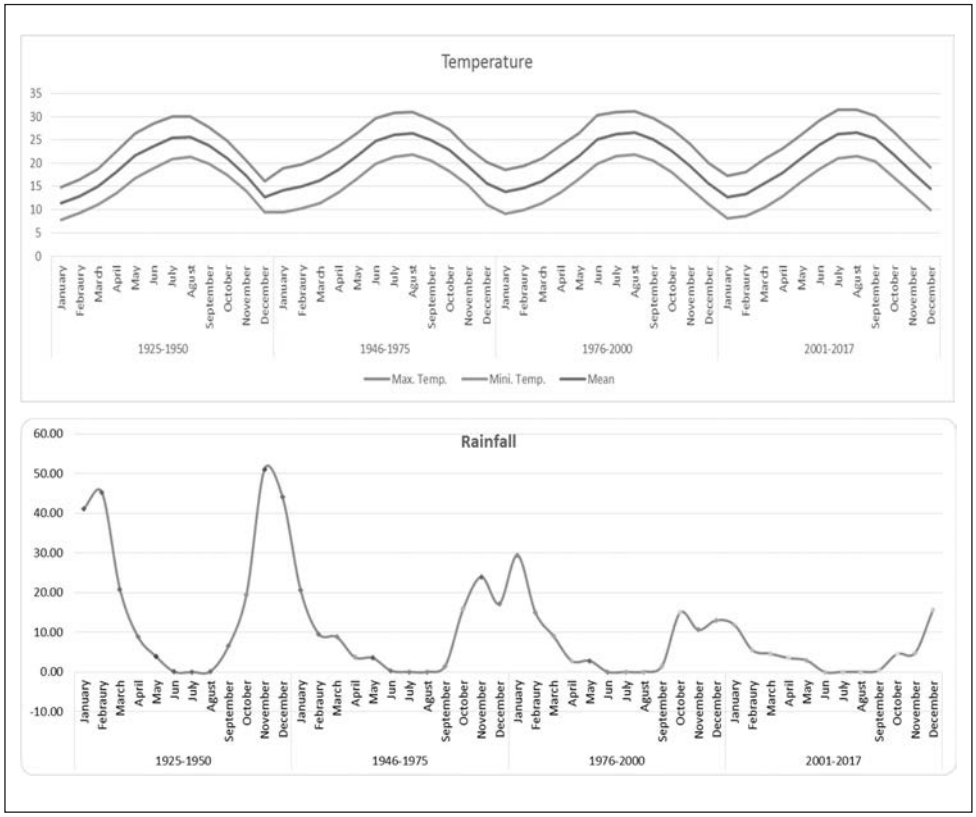


Fig. 2. Indicator climatic data of Sallum Sector as mean values of the studied decades (based on National Meteorological Authority in Egypt).

Shallow wadi bed: This habitat type, characterized by fine sand sheet, and total vegetation cover reached 23%. Table (1) shows that the dominant species based on the importance value (IV) are the annual legume species namely: *Astragalus peregrinus* Vahl (IV 25.6), followed by *A. annularis* Forssk. (IV 23.9) and co-dominated with the Mediterranean perennial species like *Asparagus stipularis* Forssk. (IV 14.0), *Asphodelus aestivus* Brot. (IV 12.6), *Lotus polyphyllos* E. D. Clarke (IV 13.0) and *L. creticus* L. (IV 10.12). While, *Deverra tortuosa* (Desf.) DC. of the SaharoSindian species attained an IV 19.2.

Open less dry non-saline desert: This habitat type retains total plant cover reached 17%. The vegetation dominated by the perennial xeric species: *Haloxylon salicornicum* (Moq.) Bunge ex Boiss. (IV 38.7), *Helianthemum lippii* (L.) Dum. Cours. (IV 33.7) and co-dominated by *Deverra tortuosa* (IV 23.8) and *Gymnocarpos decandrus* Frossk. (IV 19.7). The annual *Salsola kali* L. (IV 10.5) belongs to the Paleotropic species (Table 1).

Open gravel desert: This habitat showed a total plant cover of 22% (Table 1), dominated by perennial Mediterranean-SaharoSindian chorotype: *Thymelaea hirsuta* (L.) Endl. (IV 34.5), *Gymnocarpos decandrus* (IV 17.0) and *Marrubium alysson* L. (IV 11.7). The

Table 1. Vegetation pattern in Sallum sector during 2018, represented by squares "S1-S6" with its ecological parameters, species arranged in each square based on its importance value (IV) and Cover percentage (C%).

Species	Life duration	Floristic categories	C%	IV
S 1: Shallow wadi bed with total vegetation cover 23%				
Astragalus peregrinus Vahl	Annual	SA-SI	5	25.65
Astragalus annularis Forssk.	Annual	MED + SA-SI	5	23.92
Deverra tortuosa (Desf.) DC.	Perennial	SA-SI	3	19.28
Asparagus stipularis Forssk.	Perennial	MED	2	14.07
Hyoscyamus muticus L.	Perennial	MED + IR-TR	2	13.05
Lotus polyphyllos E. D. Clarke	Perennial	MED	1	13.003
Asphodelus aestivus Brot.	Perennial	MED	2	12.61
Lotus creticus L.	Perennial	MED	1	10.13
Marrubium alysson L.	Perennial	MED + SA-SI	1	9.28
Brassica nigra (L.) Koch	Annual	MED + ER-SR	1	8.68
S 2: Open less dry non-saline desert plain with total vegetation cover 17%				
Haloxylon salicornicum (Moq.) Bunge ex Boiss.	Perennial	SA-SI + IR-TR + S-Z	6	38.78
Helianthemum lippii (L.) Dum. Cours.	Perennial	SA-SI + S-Z	5	33.18
Deverra tortuosa (Desf.) DC.	Perennial	SA-SI	3	23.88
Gymnocarpos decandrus Frossk.	Perennial	MED + SA-SI	2	19.71
Salsola kali L.	Annual	PAL	1	10.52
S 3: Gravel desert with total vegetation cover 22%				
Thymelaea hirsuta (L.) Endl.	Perennial	MED + SA-SI	6	34.50
Zygophyllum album L. f.	Perennial	MED + SA-SI	4	21.52
Lycium europaeum L.	Perennial	MED	3	19.60
Gymnocarpos decandrus Frossk.	Perennial	MED + SA-SI	2	17.04
Marrubium alysson L.	Perennial	MED + SA-SI	1.5	11.75
Echinops spinosus L.	Perennial	MED	0.8	11.61
Helianthemum lippii (L.) Dum. Cours.	Perennial	SA-SI + S-Z	1.6	11.04
Peganum harmala L.	Perennial	MED + IR-TR + SA-SI	0.6	7.50
Herniaria hemistemon J. Gay	Perennial	MED	0.3	7.42
Astragalus peregrinus Vahl	Annual	SA-SI	0.5	6.19
Asparagus stipularis Forssk.	Perennial	MED	0.1	5.83
Farsetia aegyptia Turra	Perennial	SA-SI + S-Z	0.1	5.40
Haloxylon salicornicum (Moq.) Bunge ex Boiss.	Perennial	SA-SI + IR-TR + S-Z	0.4	5.301
Zilla spinosa (L.) Prantl	Perennial	SA-SI	0.3	4.85
Anabasis articulata (Forssk.) Moq.	Perennial	SA-SI	0.2	3.52
Urginea maritima L.	Perennial	MED+ER-SR	0.5	3.43
Neurada procumbens L.	Annual	SA-SI	0.1	3.06
S 4: Maritime saline sand dunes with total vegetation cover 13%				

Table 1. continued.

Carduncellus mareoticus (Delile) Hanelt	Perennial	MED	5	43.96
Lotus creticus L.	Perennial	MED	2	21.16
Asparagus stipularis var. *tenuispinus* Holmboe	Perennial	MED	2	20.76
Pancratium maritimum L.	Perennial	MED	2	17.12
Lotus polyphyllos E. D. Clarke	Perennial	MED	1	16.34
Ononis vaginalis Vahl	Perennial	SA-SI + IR-TR	1	9.86
S 5: Deep wadi with total vegetation cover 19%				
Atractylis carduus (Forssk.) C. Chr.	Perennial	MED + SA-SI	5	32.24
Astragalus mareoticus Delile	Annual	MED	5	29.64
Hippocrepis cyclocarpa Murb.	Annual	MED	4	24.38
Thymelaea hirsuta (L.) Endl.	Perennial	MED + SA-SI	3	23.01
Marrubium alysson L.	Perennial	MED + SA-SI	1	10.19
Citrullus colocynthis (L.) Schrad.	Perennial	SA-SI	1	7.73
S 6: Calcareous rocky ridge with total vegetation cover 18%				
Deverra tortuosa (Desf.) DC.	Perennial	SA-SI	6	39.57
Herniaria hemistemon J. Gay	Perennial	MED	5	33.83
Thymelaea hirsuta (L.) Endl.	Perennial	MED + SA-SI	3	23.89
Gymnocarpos decandrus Frossk.	Perennial	MED + SA-SI	2	19.05
Farsetia aegyptia Turra	Perennial	SA-SI + S-Z	1	10.50
Salsola kali L.	Annual	PAL	1	10.20

mono-regional Mediterranean elements are represented by the four species: *Lycium europaeum* L. (IV 19.5), *Echinops spinosus* L. (IV 11.6), *Herniaria hemistemon* J. Gay (IV 7.4), and *Asparagus stipularis* (IV 5.8). The mono-regional xeric (SaharoSindian chorotype) include *Zygophyllum album* L. f. (IV 21.5), *Astragalus peregrinus* (IV 6.1), *Neurada procumbens* L. (IV 3.0), *Zilla spinosa* (L.) Prantl (IV 4.8) and *Anabasis articulata* (Forssk.) Moq. (IV 3.5).

Maritime sand dunes: This maritime sand dune is a saline habitat type showed the lowest vegetation cover (13%; Table 1) among the studied habitats. Dominant by perennial psamophytes representing the Mediterranean chorotype. The dominant were: *Carduncellus mareoticus* (Delile) Hanelt (IV 43.9), *Lotus creticus* (IV 21.1), *Asparagus stipularis* (IV 20.9), *Pancratium maritimum* L. (IV 17.1) and *Lotus polyphyllos* (IV 16.3). The only traced bi-regional element in this site was the calcareous sand dune indicator *Ononis vaginalis* Vahl (IV 9.8), belongs to the IranoTuranian-SaharoSindian chorotype.

Deep wadi: this site represents the deep wadi habitat type, with total vegetation cover reached 19% (Table 1). Where the annuals were co-dominant with perennials. The dominant chorotype was the Mediterranean SaharoSindian elements, represented by the three perennials: *Atractylis carduus* (Forssk.) C. Chr. (IV 32.2), *Thymelaea hirsuta* (IV 23.0) and

Marrubium alysson (IV 10.1), and two annual species (*Astragalus mareoticus* Delile IV 29.6 and *Hippocrepis cyclocarpa* Murb. IV 24.3), of Mediterranean chorotype.

Calcareous rocky ridge: this site represents the calcareous limestone rocky ridges habitat type (not exceeding 20 m a.s.l.) with total vegetation cover reached 18% with characteristic xeric perennials (Table 1). The dominant species were SaharoSindian element *Deverra tortuosa* (Desf.) DC. (IV 39.5), and the Mediterranean *Herniaria hemistemon* J. Gay (IV 33.8). The bi-regionals Mediterranean-SaharoSindian chorotype was represented by *Thymelaea hirsuta* (L.) Endl. (IV 23.8), *Gymnocarpos decandrus* Forssk. (IV 19.0) and the common xeric species *Farsetia aegyptia* Turra (IV 10.4).

Taxonomic grouping

The species identified from this sector during field study in 2018 were 198 belonging to 45 families of *Angiospermae* and *Ephedraceae* (*Gymnospermae*), represented by two species. Five families represented 60.6% out of the total recorded species namely: *Asteraceae* (40 species), *Leguminosae* (27), *Poaceae* (25), *Chenopodiaceae* (18), and *Brassicaceae* (10). The other 40 families, were represented by low species richness not exceeding 6, such as *Labiatae* (5 species) and *Boraginaceae* (6 species), while18 families were represented by a single species.

The vegetation in Sallum sector during 2018, is of simple form comprised 41.9% annuals and 58.1% perennials. The annual species were represented in *Asteraceae* (23 species), *Fabaceae* (19 species), *Poaceae* (10) and *Brassicaceae* (8). The highest number of perennials were recorded in *Chenopodiaceae* (15 species).

Chorological analysis

The chorology of the identified species in Sallum sector during 2018, is shown in Table (2). The typical Mediterranean species represent 21.2% (42 species) of the total recorded species that included:Among the characteristic Mediterranean species are: *Arisarum vulgare* Targ. Tozz., *Caralluma europaea* (Guss.) N. E. Br., *Hyoseris radiata* L., *Lobularia libyca* (Viv.) C. F. W. Meissn, *Elymus fractus* (Viv.) Runem. ex Melderis, *Lotus polyphyllos*, *Lycium europaeum* and *Thymalaea hirsuta.* The total mono-regionals species represented 41.9% (83 species), followed by bi-regionals with 40.9% (81 species), and the pleuri-regionals comprises 17.1% (34 species) of the total chorotypes.

Generally, the Mediterranean chorotype is the dominant type (42 species) followed by SaharoSindian (40 species) and the Mediterranean elements extended to SaharoSindian region (MED + SA-SI) which represented by 41 species. The Mediterranean elements extended to IranoTuranian region (MED + TR-TR) that is represented by 10 species. *Allium aschersonianum* Barbey is the only species recorded from the mono-regional IranoTuranion chorotype.

Vegetation feature in the last ten decades:

This study covers vegetation survey during the period from 1925 to 2018. The climatic data showed the negative shift in rainfall and positive temperature shift (Fig.2). The reflection of these shifts on the species presence and diversity in Sallum Sector will be elucidat-

ed as a comparison between the historical and the field surveys during 2018 as follows:

Characteristic species of this study sector, since 1925 to 2018, includes: *Globularia arabica* Jaub. & Spach., *Diplotaxis erucoides* (L.) DC., *Lathyrus marmoratus* Boiss. & Blanche, *Scorzonera undulata* Vahl, *Noaea mucronata* (Forssk.) Asch. & Schweinf., *Lycium europaeum*, *Sporobolus pungens* (Schreb.) Kunth, *Teucrium polium* (Decne.) Asch. & Schweinf., *Melilotus messanensis* (L.) All., *Polygonum maritimum* L., *Gagea fibrosa* (Desf.) Schult. & Schult. f., *Marrubium alysson* L., *Caralluma europaea* (Guss.) N. E. Br. and *Asphodelus aestivus* Brot.

During the past decades, the five families namely: *Asteraceae, Fabaceae, Poaceae, Brassicaceae* and *Chenopodiaceae* were the common ones as represented with relatively high number of species. The number of species in four of these families decreased in the recent years, while, the *Chenopodiaceae,* that possesses salt tolerant species, showed higher evenness after 2000 among them *Atriplex halimus* L., *Suaeda aegyptiaca* (Hasselq) Zohary, and *Sarcocornia fruticosa* (L.) A. J. Scott

The field observation and the literature survey about the vegetation in Sallum Sector showed an increase in species evenness and diversity of the halophytic and halotolerant species. Among the species recorded in this sector for the first time after 1950, were *Mesembryanthemum crystallinum* L., and *M. forsskalii* Boiss. *M. nodiflorum* L. traced after 2000. Other species, showed northward expansion after 2000 as *Arthrocnemum macrostachyum* (Moric.) K. Koch, *Atriplex halimus* L., *Suaeda pruinosa* Lange, *S. vera* Forssk. (*Chenopodiaceae*) and *Spergularia marina* (L.) Griseb. (*Caryophyllaceae*).

The mean total number of species recorded in the study sector decreased from 226 species (1925-1950) to 198 species (2001-2018). Similar trend was noticed in perennial species decreased from 128 species (56.6%; in 1925-1950) to 115 species (58.0%, in 2001-2018). The, annuals decreased from 43.3% (98 species) to 41.9% (83 species), in the same intervals. Some of the annual species of Mediterranean-SaharoSindian chorotype were not recorded after 1975, such as *Hippocrepis areolata* Desv., *Astragalus annularis* Forssk. and *Medicago littoralis* Loisel.

Chorotypes shifting

The Mediterranean elements

The chorology of the vegetation elements (species) showed a shift from Mediterranean, IranoTuranian, and EuroSiberian to more xeric elements of SaharoSindian chorotype during the studied ten decades. The number of species grouped under Mediterranean chorotype decreased from 70 species (30.6%) in 1925-1950 to 42 species (21.2%) in 2001-2018 (Fig. 3). Among the Mediterranean elements, not recorded after 1950 is the *Prasium majus* L. Other species were not recorded after 1975 including *Daucus syrticus* Murb., *Malabaila suaveolens* Delile ex Coss., *Arisarum vulgare*, *Erucaria hispanica* (L.) Druce, *Alkanna lehmanii* (Tin.) A. DC., *Ajuga iva* (L.) Schreb. and *Hymenocarpus circinnatus* (L.) Savi. Some of the Mediterranean species sustained to 2018, but showed decreased evenness after year 2000, including *Lathyrus marmoratus* Boiss. & Blanche, *Astragalus hamosus* L., *Papaver rhoeas* L. and *Limonium narbonense* Mill. (Fig.3).

Mediterranean-IranoTuranian elements

The element s of this chorotype decreased from 36 species (15.9%; in 1925-1950) to 10 species (5.0%; in 2001-2018). Some of these species not recorded after 1950 such as *Plantago lagopus* L., while, some other species not recorded after 1975 including *Narcissus tazetta* L., *Eryngium campestre* L., *Garhadiolus angulosus* Jaub. & Spach, *Phagnalon rupestre* (L.) DC., *Ranunculus asiaticus* L., and *Lathyrus gorgonei* Parl. var. *lineatus* (Post) C. C. Towns. Alternatively, populations of some species decreased in the number of individuals by time among them: *Teucrium polium* (Decne.) Asch. & Schweinf., *Melilotus messanensis* (L.) All., *Ranunculus rionii* Lagger, and *Chenopodium giganteum* D. Don.

The contradictory observation was noticed for the halophytic species of the Mediterranean-IranoTuranian chorotype, which showed increased occurrence in its northward distribution such as *Cressa cretica* L. and *Spergularia marina* (L.) Griseb. Elements of the Mediterranean-Euro Siberian chorotype, showed decline such as *Echium rubrum* Forssk., not recorded after the year 1950, *Brassica nigra* (L.) Kochnot recorded after the year 2000, while, *Polygonum maritimum* L. occasionally recorded after the year 2000, in lower species evenness. The halophytic *Sarcocornia fruticosa* (L.) A. J. Scott, showed wider northward distribution and an increase in a number of individuals/population after the year 2000 (Fig.3).

SaharoSindian elements

The species belonging to this chorotype reflecting the xeric nature, where the number of species increased from 22 species (9.7%) in 1925-1950 to 40 species (20.2%) in 2001-2018. The common xeric species such as *Deverra tortuosa* DC., *Anthemis melampodina* Delile, *Heliotropium arbainense* Fresen., *Heliotropium digynum* (Frossk.) Asch. were traced after 1950. While, *Zilla spinosa* (L.) Prantl, *Tetraena simplex* (L.) Beier & Thulin and *Fagonia cretica* L. were showed a wider northward distribution after the year 2000 (Fig.3).

Pluri-regional elements

The elements of Mediterranean-IranoTuranian-EuroSiberian chorotype, decreased in the number of individual/population among them *Senecio vulgaris* L. and *Papaver argemone* L., which showed decreased in species evenness after year 1975. Some other species disappeared after 1975 including *Frankenia hirsuta* L., *F. pulverulenta* L., *Fumaria bracteosa* Pomel, and *Beta vulgaris* L.

Discussion

Sallum sector encompasses simple vegetation type of highly adapted drought-resistant species, analogous data reported by Salama & al. (2005). Floristic composition, indicated the presence of 60.6% of these species grouped under five families, comprising the flora of Mediterranean North African (Quézel 1978; Shaltout & El-Kady 1999). The recorded species reflect the semi-arid features of Sallum sector (Bornkam & Kehl 1985), while the dominance of therophytes indicates the sector aridity (Salama & al. 2005).

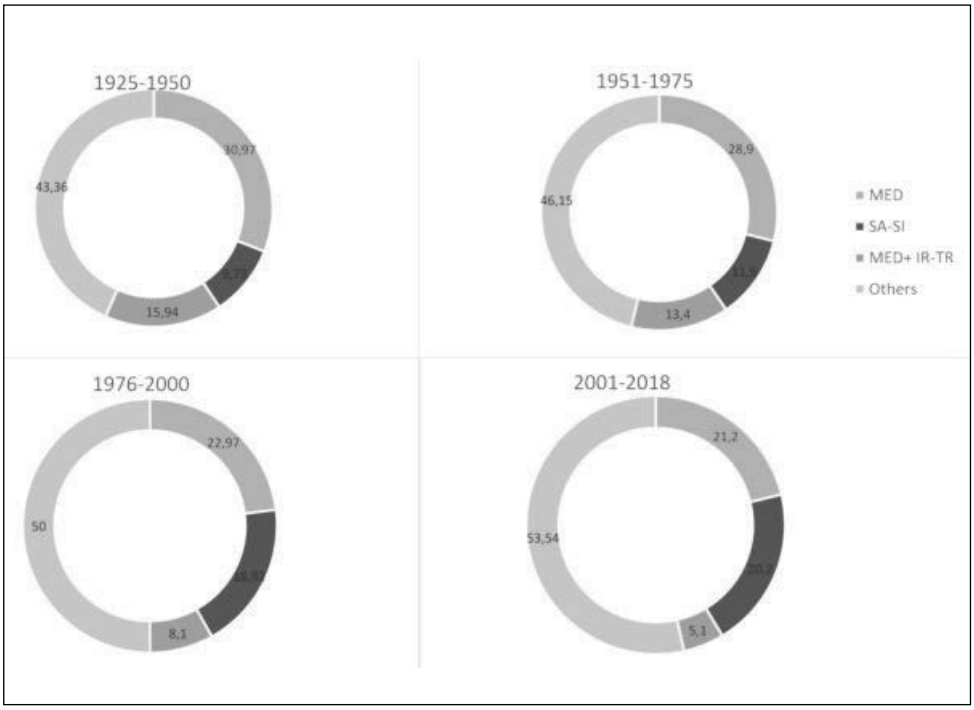


Fig. 3. Shifting in indicator chorotypes during the studied decades in Sallum Sector. The used abbreviations: MED: Mediterranean, SA-SI: SaharoSindian, IR-TR: IranoTuranian, and Others: other chorotypes cited in table 2.

The highest vegetation cover among the studied sites showed up to 23% cover traced in shallow wadi bed (Table 1). In spite of, this site is a part of the Egyptian desert with c. 5% cover (Salama & al. 2005), Zahran & Willis (2009) increased vegetation cover up to 60%. While, flourishing of the annual leguminous (*Astragalus peregrinus* and *A. annularis*) in wadi bed site; enhanced by water and organic matter availability offering suitable microhabitats; Abdelaal & al. (2019)**.**

On other hand, dry desert habitat (site 2 & site 3); showed lower vegetation cover and dominated by perennial drought tolerant species, as *Haloxylon salicornicum, Helianthemum lippi, Deverra tortuosa* and *Gymnocarpos decanderus* (site 2). While, *Thymelaea hirsuta*, *Zygophyllum album, Lycium europaeum* and *Gymnocarpos decanderus* dominated Site 3. Similar, observation was reported by Zahran & Willis (2009) confirmed the presence of c. 90% perennial xerophytes along with the western Mediterranean coast. The maritime saline sand dunes, prevailing the lowest vegetation cover (13%). This habitat formed of loose pseudo-ooltic sand subjected to sea spray, and dominated by perennial Mediterranean species *Carduncellus mareoticus, Lotus creticus* and *Asparagus stipularis*; indicating the rainfall scarcity (Zahran & Willis 1992).

Table 2. Chorotypes of the plant species collected from Sallum sector. Chorotype abbreviations: MED: Mediterranean, SA-SI: SaharoSindian, ER-SR: EuroSiberian, IR-TR: IranoTuranian, S-Z: SudanoZambezian, COSM: Cosmopolitan, PAI: Palaeotropic, PAN: Pantropic, NEO: Neotropic.

Pytochoria	Number of species	Percentage %
Mono-regionals		
MED	42	21.2
SA-SI	40	20.2
IR-TR	1	0.5
Sub-total	**83**	**41.92%**
Bi-regionals		
MED + SA-SI	41	20.7
MED + IR-TR	10	5.0
MED + ER-SR	13	6.5
SA-SI + IR-TR	8	4.0
SA-SI + S-Z	8	4.0
IR-TR + S-Z	1	0.5
Sub-total	**81**	**40.91%**
Pluri-regionals		
MED + SA-SI + IR-TR	10	5.0
MED + IR-TR + ER-SR	5	2.5
MED + SA-SI + S-Z	5	2.5
IR-TR + SA-SI + S-Z	3	1.5
MED + SA-SI + ER-SR	2	1.0
MED + IR-TR + SA-SI + ER-SR	1	0.5
COSM	4	2.0
PAL	2	1.0
PAN	1	0.5
NEO	1	0.5
Sub-total	**34**	**17.17%**
Total	**198**	**100%**

The chorotype analysis of the vegetation during 2018 (Table 2), revealed the presence of 41.9% of mono-regional Mediterranean chorotype; reported by Osman & El Garf (2015). While the co-dominance of the SaharoSindian chorotype may be related Sallum position in a Mediterranean Sahara regional transitional zone identified by White & Leonard (1991) and Salama & al. (2005). While, the bi-regional chorotype comprises 40.9% (Table 2); relevant figure was reported by Osman & El Garf (2015).

Among of the Mediterranean species showed notable decreased are *Daucus syrticus* Murb., *Malabaila suaveolens* (Delile) Coss., *Arisarum vulgare* O. Targ. Tozz., *Erucaria hispanica* (L.) Druce, *Alkanna lehmanii* (Tineo) A. DC., *Ajuga iva* (L.) Schreb., and *Limonium narbonense* Mill. Galal & Fawzy (2007) reported 35% decline in the coastal communities. The vegetation composition after the year 1950, showed higher evenness such as *Deverra tortuosa* (Desf.) DC., *Anthemis melampodina* Delile, *Heliotropium arbainense* Fresen and *H. digynum* (Forssk.) C. Chr., others as *Zilla spinosa* (L.) Prantl, *Tetraena simplex* (L.) Beier & Thulin and *Fagonia cretica* L. showed more evenness after the year 2000 (more are outlined in the Electronic Supplementary File 1). The monitored decline in species richness, is inconsistent with Ciccarelli & al., (2012), Ciccarelli (2014)

and Abdelaal & al. (2019). Kelly & Goulden (2008) reported that drought-induced 46% vegetation decline, from 1977 to 2007in South California.

Thymelaea hirsuta (L.) Endl. is among the interesting Mediterranean perennial species recorded in all the study sites, with increased species evenness northward and westward. This species restricted to 15-20 km from the seashore to southward (Shaltout & El-Kady 1999). Four decades ago Zahran & Boulos (1973), expanded the range of this species to 75km (from the seashore to southward). Globally, Parmesan & Yohe (2003) reported 6.1 km/decade poleward species shift in many species. However, Bachelet & al. (2001), claimed that climate change scenarios suggest that there is considerable uncertainty about possible future ecological impact, some scenarios produce opposite signs for ecological responses.

This study confirming the northward shift in both of Mediterranean and SaharoSindian chorotypes, where the later replaced the first. This pattern showed an intimate relationship between species diversity and climatic aspects. As Figure (2), outlined the sharp decrease in the mean annual rainfall and temperature increased after the year 1950 by 1.5˚C (Fig. 2). The rainfall decline was reported earlier by Zahran & Willis (2009). While, the recorded positive shift temperature (Fig. 2), supported by Grytnes (2003) and the IPCC (2007) mentioned that the global mean land surface has warmed 0.27 ˚C/decade since 1979. Parmesan & Yohe (2003) cleared that the meta-analysis of long-term (48–132 years) datasets carried out by showed that the geographic location of the northern range boundaries for 100% of 44 species– mirrored decadal temperature trends over the 20th century.

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Short note

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Solanum rostratum (*Solanaceae*): une nouvelle xérophyte invasive pour la flore d'Algérie

Abstract

Chelghoum, H., Ait Hammou, M., Miara, M. D. & Fertout-Mouri, N.: *Solanum rostratum* (*Solanaceae*): une nouvelle xérophyte invasive pour la flore d'Algérie. — Fl. Medit. 30: 81-86. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

Solanum rostratum (*Solanaceae*): a new invasive xerophyte for the flora of Algeria. – The authors report in this paper the presence of a new taxa for the Algerian flora. It is *Solanum rostratum*, an invasive plant well known for its high spreading capacity and a threat potential to natural and anthropogenic ecosystems. Some reflections resulting from this discovery are mentioned in particular the economic and ecological values of the plant as well as the threats linked to its possible spread across the country.

Key words: invasive plants, xenophytes, alien plants, Blida, Tiaret, North Africa.

Introduction

En Afrique du nord, la famille des *Solanaceae* est représentée par 92 genres comportant 260 taxons dont 9 endémiques (Dobignard & Chatelain 2013).

En Algérie, cette famille regroupe 38 taxons répartis en 12 genres dont *Solanum,* largement connus pour ces taxons cultivés à travers le monde. En effet, ce genre avec plus de 1500 espèces, est le plus important dans la famille des *Solanaceae* et l'un des plus importants genres des plantes à fleur (Frodin 2004). Il est représenté par 12 taxons dont 3 naturalisés, 2 adventices et 3 cultivés (Dobignard & Chatelain 2013). Il s'agit essentiellement de plantes à intérêt alimentaire ou ornementales à l'image de *S. bonariense* L., *S. fastigiatum* Willd et *S. glaucum* Dunal. Ces plantes sont souvent des xénophytes subspontanées des jardins (Quézel & Santa 1962-63).

Parmi ces xénophytes, *Solanum rostatum* Dunal. est une solanacée originaire des néotropiques et sud-ouest des États-Unis, largement connue à travers le monde comme plante invasive (Wei & al. 2007).

En effet, cette plante, a pu gagner beaucoup de pays du globe, notamment la région méditerranéenne ou elle fait désormais partie de la flore de plusieurs pays comme l'Espagne, la France et l'Italie (Valdés 2012 ; Domina & al. 2018; Galasso & al. 2018). En Afrique, Lind (1985) note que la plante a été introduite en Afrique du sud au moins depuis

1915. En Afrique du Nord, elle est signalée comme adventice au Maroc, en Tunisie et en Libye (Fennane & al. 2007; Dobignard & Chatelain 2013 ; Mahklouf 2016 ; APD 2020). Toutefois, *S. rostratum* n'a jamais été signalée en Algérie malgré sa présence dans les 3 pays frontaliers.

C'est ainsi que nous rapportons ici pour la première fois la présence de ce taxon en Algérie, tout en essayant de souligner quelques réflexions liées à cette nouvelle présence en l'occurrence les conséquences potentielles de cette présence sur les écosystèmes naturels et anthropiques dans le pays.

Morphologie, ecologie et reproduction

Solanum rostratum est une plante annuelle de taille basse a petite pouvant mesurer 20 à 100 cm de hauteur, très ramifiée, souvent assez ligneuse à la base; tiges étalées à prostrées, velues, à épines inégales jaunes et arquées pouvant atteindre 1 cm dans les calices de fructification. Feuilles pétiolées, pennatilobées, à lobes émoussés et un peu ondulés. Fleurs jaunes, 20 à 40 mm, par 3-10 en bouquets. Pédoncule 1-4 cm de long, pédicelle environ 1 cm de long, calice 5-12 mm de long. Corolle jaune, étoilée, pubescente à l'extérieur, de 15 à 25 mm de diamètre. Les étamines en nombre de 5 de couleur jaune, inégales dont quatre d'entre eux presque égaux et le cinquième en corne est plus longue que les autres, les anthères sont 2 fois plus longues que les filets. Le fruit est une baie sèche, globuleuse, 9-12 mm de diamètre, entouré du calice épineux, persistant. Les graines sont aplaties, ovoïdes, alvéolées, de couleur brun foncé (Blamey & Grey-Wilson 2009; Mahklouf 2016).

La plante se multiplie par graines (Bassett & Munro 1986). Elle est capable de produire plus de 1900 fruits, dont chacun contient en moyenne 41 graines, donc un totale d'environ 78000 graines (Zhao & al. 2013). *S. rostratum* se développe sur tout type du sol, mais elle préfère les milieux argileux et alcalins (Bassett & Munro 1986). Elle se trouve beaucoup plus dans les sites ouverts comme les bords des route, les décharges, les cultures, jachères, terrains perturbés des plaines ainsi que les lieux surpâturés (Fenane & al. 2007; Mahklouf 2016; Yang & al. 2019).

La pollinisation est de type Entomochorie, car la plante est largement visitée par de nombreux taxons d'abeilles et plein d'autres insectes (Bassett & Munro1986).

Présence en Algérie

Pendant l'automne de 2019, nous avons rencontré pour la première fois cette plante dans la région de Tiaret (commune de Taslemt) à l'ouest du pays. Plusieurs stations de présence de la plante ont été observées au bord de la route et sur les lisières des champs de culture avant de la croiser une nouvelle fois près d'une station de service entre El Afroun et Mouzaia dans la région de Blida au centre du pays. Une autre station a été finalement observée vers Oued El Alleug au bord de la route entre Blida et Alger (Fig. 1). Des photographies de la plantes ont été prisent sur le terrain (Fig. 2), alors qu'un spécimen d'herbier a été déposé au niveau de l'herbier de l'école nationale supérieure agronomique (ENSA).

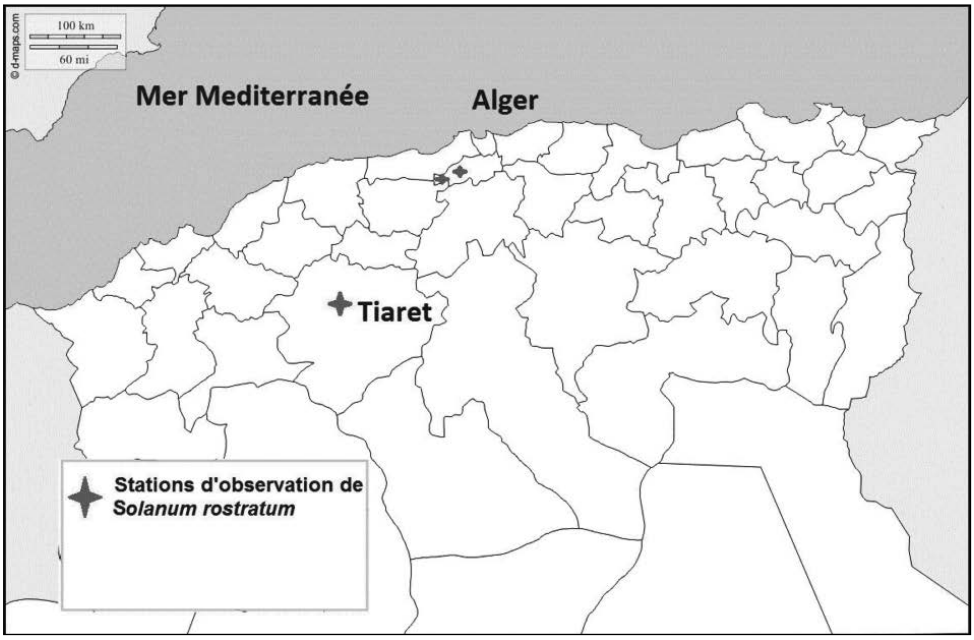


Fig.1. Les stations d'observation de *Solanum rostratum* en Algérie du Nord.

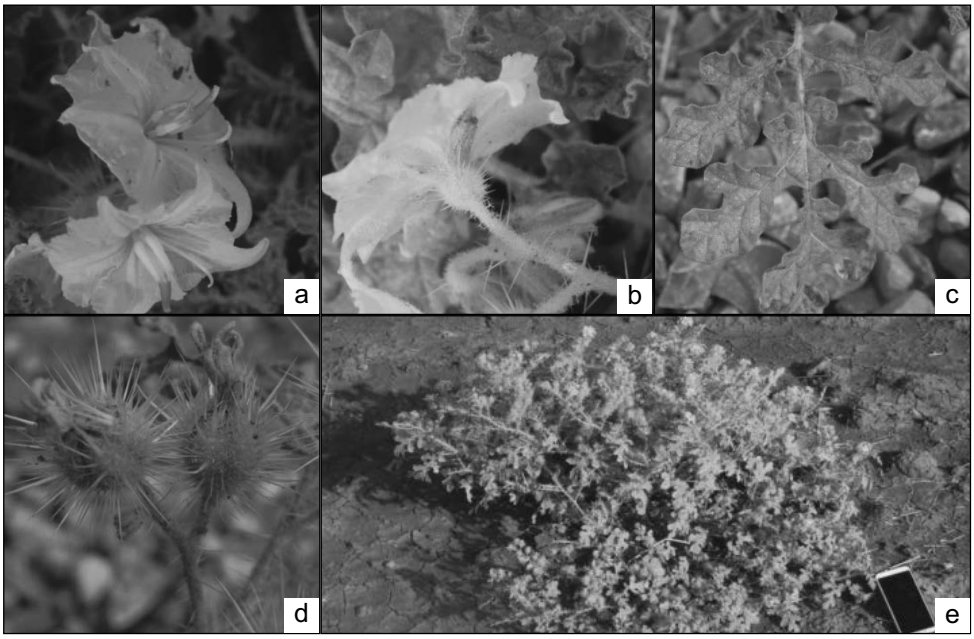


Fig. 2. Photographies de terrain de *Solanum rostratum*: a-b) corolle et calice; c) feuille; d) fruit; e) vue d'ensemble (Cliché H. Chelghoum, septembre 2019).

Quelques réflexions sur la découverte de *S. rostratum* en Algérie

Cette nouvelle découverte s'ajoute à plusieurs découvertes récentes dans le même contexte (Miara & al. 2018; Rebbas 2018) rapportant la présence de taxons invasifs a très forte capacités de propagation ce qui pourra constituer un réel danger sur les écosystèmes naturels du pays. D'après Yang & al. (2019), *S. rostratum* est une espèce invasive qui a causé beaucoup de dégâts au niveau des écosystèmes naturels et agricoles dans beaucoup de pays du monde dont la Chine.

Elle est ainsi susceptible de constituer une réelle menace pour les cultures, puisqu'elle forme une hôte pour divers ravageurs et maladies (Zhao & al. 2019).

Par ailleurs, une éventuelle propagation de cette plantes au niveau des systèmes naturels pourra contribuer à la banalisation de la flore originelle de ces systèmes. D'une part, par l'accroissement du phénomène de Thérophytisation qui constitue selon Miara & al. (2016) l'une des plus forte menaces sur l'originalité floristique des régions naturelles boisées en Algérie septentrionale. D'autre part, cette espece fait partie de plusieurs plantes possédant des effets allélopathiques qui ont été étudiés par Henri (1988), ce qui constitue une menace potentielle sur la flore des milieux infestés par cette plante notamment certaines endémiques annuelles souvent très fragiles et vulnérables.

Yang & al. (2019) soulignent que cette grande capacité d'adaptation de la plante est essentiellement en relation avec les caractéristiques de ses graines lui permettant une très forte dissémination.

Il est également à souligner que sur le plan économique, notamment celui pastoral, cette plante n'a aucune valeur nutritive ou fourragère pouvant lui attribuer une valeur agro-pastoral. Cette mauvaise herbe est au contraire nocive même pour l'être humain et les bétails, car l'ensemble de sa partie aérienne est couverte par des épines vénéneuses (Bassett & Munro 1986; Lin & al. 2011).

Conclusion

Ce papier rapporte les premières observations d'une plante invasive à très forte capacité de propagation en Algérie. *S. rostratum* a été observée au niveau de 3 stations au nord-ouest et au centre du pays, ce qui n'exclura pas son existence dans d'autres régions.

Bien que ce taxon vient enrichir en nombre la flore du pays, les conséquences de sa propagation rapide à travers le pays notamment au niveau des écosystèmes naturels et agricoles sont susceptibles d'être d'une gravité alarmante.

La nécessité de surveiller l'évolution de la propagation de cette plante sur notre territoire devra constituer une priorité pour les autorités responsables, alors que la nécessité de prendre les mesures nécessaires afin de limiter ses éventuels dégâts demeure d'une urgence avérée.

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Article

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F. Médail, M. Charrier, M. Chaieb, G. Domina, R. El Mokni, S. Pasta & E. Véla

Plantes vasculaires nouvelles ou rares pour la Tunisie présentes sur les îles (Galite, Zembra, Kuriat, Monastir, Kerkennah, Kneiss, Djerba)

Abstract

Médail, F., Charrier, M., Chaieb, M., Domina, G., El Mokni, R., Pasta, S. & Véla, E.: Plantes vasculaires nouvelles ou rares pour la Tunisie présentes sur les îles (Galite, Zembra, Kuriat, Monastir, Kerkennah, Kneiss, Djerba). — Fl. Medit. 30: 87-112. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

Vascular plants new or rare for Tunisia occurring on the islands (Galite, Zembra, Kuriat, Monastir, Kerkennah, Kneiss, Djerba). – This study concerns the indigenous vascular plants newly reported for Tunisia and discovered on the islands during some field trips performed since 2014. Five native taxa are new to Tunisia: *Bellis perennis*, *Carthamus creticus*, *Moraea mediterranea*, *Asplenium balearicum* and *Galium minutulum*, the latter two also being new to North Africa.
Information on 24 rare or poorly known taxa, most often of great biogeographical interest, is given, too. Most of these were discovered on the islands of the eastern coast (Kuriat, Monastir, Kerkennah, Kneiss, Djerba), but also on the northern islands of Zembra and La Galite. The new chorological data underline the first-rate conservation importance of these islands and islets for the preservation of the overall coastal biodiversity of Tunisia.

Key words: biogeography, endemism, coastal flora, small Mediterranean islands, rare plants.

Introduction

Depuis une dizaine d'années, les connaissances taxonomiques sur la flore vasculaire de la Tunisie ont progressé de manière significative avec la parution du *Catalogue synonymique commenté de la Flore de Tunisie* (Le Floc'h & al. 2010) et le développement de la *Base de données des plantes d'Afrique* (https://www.ville-ge.ch/musinfo/bd/cjb/africa). Divers taxons ont été décrits (ex. El Mokni & al. 2014, 2015a) et la chorologie de certaines espèces ou familles a pu être précisée (Greuter & Domina 2015; El Mokni & al. 2015b; Martin & al. 2015; Domina & El Mokni 2019; El Mokni & Domina 2019, 2020; Barone & al. 2020). La richesse floristique de la Tunisie est évaluée à environ 2540 taxons autochtones (Chatelain 2013, complété), mais il reste à améliorer les données sur la distribution et la biogéographie afin de mieux estimer leurs raretés et vulnérabilités, gage d'une meilleure prise en compte et conservation de ce capital naturel.

Dans ce contexte, les îles et îlots qui parsèment le littoral tunisien (Fig. 1) sont longtemps restés des territoires peu connus sur le plan floristique, bien que plusieurs taxons endé-

miques y aient été décrits assez récemment (Domina & El Mokni 2019). Depuis 2006, une vingtaine de prospections naturalistes ont été réalisées sur les îles tunisiennes dans le cadre de l'Initiative pour les petites îles de Méditerranée (Initiative PIM, http://initiative-pim.org); ces missions ont conduit à des inventaires fouillés de bon nombre d'îles et d'îlots et à l'établissement de listes floristiques les plus exhaustives possibles des espèces rencontrées sur ces territoires. Les premières missions réalisées sur les îles du Nord tunisien (archipels de Zembra et de La Galite; îles Cani, Plane, Pilau) ont fourni des découvertes très intéressantes sur le plan biogéographique (Pavon & Véla 2011; Véla & Pavon 2013); citons notamment la mise en évidence sur La Galite de six taxons nouveaux pour la Tunisie, en particulier la fougère atlantico-méditerranéenne *Asplenium marinum* L. (Muracciole & al. 2010) et l'orchidée tyrrhénienne *Serapias nurrica* Corrias (Véla & al. 2012).

À partir de 2014, les petites îles et îlots de la côte orientale ont fait l'objet de plusieurs prospections sous l'égide de l'Initiative PIM, qui ont concerné les archipels des Kerkennah (Médail & al. 2015a), des Kneiss (Médail & al. 2016), de Djerba (Médail & al. 2020 in prep.) et des Kuriat (Pasta & al. in prep.), tandis qu'au Nord la flore de l'archipel de Zembra a été étudiée à plusieurs reprises conduisant à des découvertes significatives (Domina & El Mokni 2012a; Domina & Jaouadi 2013; Médail & Véla 2020), et à l'amélioration des connaissances taxonomiques de certains taxons (Giovino & al. 2015; Astuti & al. 2017; Domina & al. 2017). La présente contribution reprend pour partie les mentions floristiques les plus intéressantes de ces rapports non publiés, les précise ou les complète.

Cette étude a pour objectif de présenter les taxons (espèces ou sous-espèces) autochtones nouvellement signalés en Tunisie et découverts sur les îles, notamment celles de la côte orientale, ou les populations insulaires nouvelles de taxons rares, le plus souvent de grand intérêt biogéographique et nécessitant des mesures de conservation.

Matériel et Méthodes

Ce travail se base sur un ensemble de prospections botaniques des îles et îlots de Tunisie réalisées dans le cadre de l'Initiative PIM (Petites Îles de Méditerranée) depuis 2012 (Tableau 1). Il concerne pour l'essentiel les petites îles et îlots de la côte orientale (archipels des Kuriat, Monastir, Kerkennah, Kneiss et Djerba), mais aussi l'île de Zembra située au Nord-Est du pays (Fig. 1). Les caractéristiques physiographiques principales (superficie, altitude maximale, longitude/latitude moyenne) des îles ou îlots considérés et les mentions de végétaux remarquables sont synthétisées dans le tableau 2. La liste des spécimens récoltés et déposés dans les herbiers du Museum d'histoire naturelle d'Aix-en-Provence / IMBE (AIX) et de l'Université de Palerme (PAL) figure en annexe 1 (ESF 1). La nomenclature retenue est celle de l'*African Plant Database* (version 3.4.0) (APD 2020).

Taxons autochtones nouveaux pour la Tunisie

Cinq taxons autochtones nouvellement signalés pour la Tunisie, dont deux nouveaux pour l'Afrique du Nord (*Asplenium balearicum* Shivas et *Galium minutulum* Jordan) ont été recensés dans le cadre de plusieurs missions de l'Initiative PIM conduites entre 2014 et 2019.

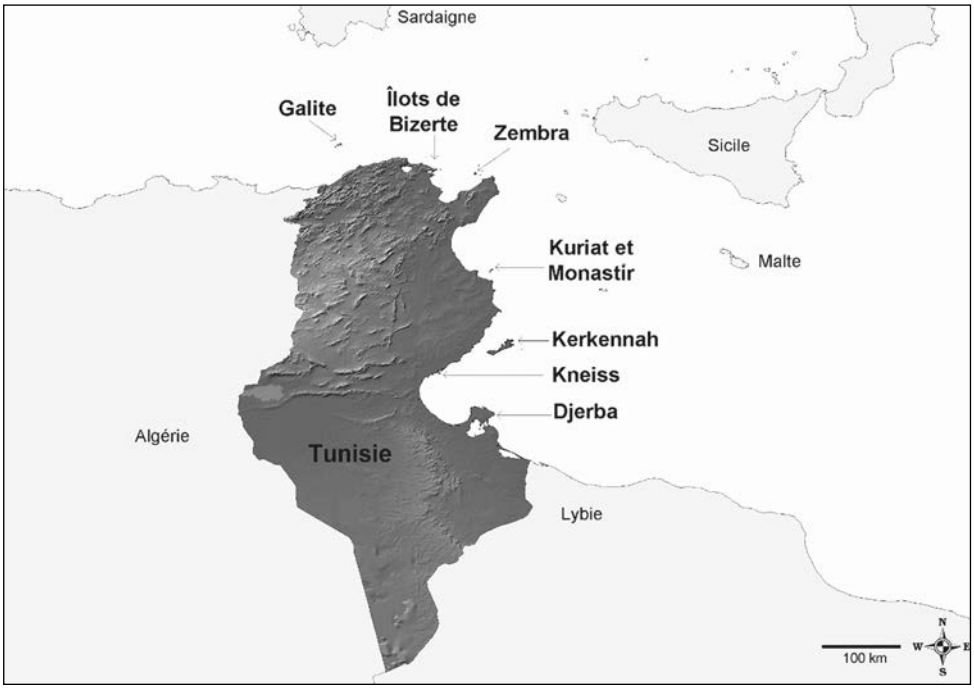


Fig. 1. Localisation générale des archipels présents le long des côtes de Tunisie (réalisation D. Pavon).

Asplenium balearicum Shivas **– Doradille des Baléares (*Aspleniaceae*)**

Cette petite fougère thermophile, présente dans les fentes des rochers siliceux de basse altitude, est un taxon allotétraploïde dérivant du croisement entre *Asplenium onopteris* L. et *A. obovatum* Viv. subsp. *obovatum* (Prelli 2001). La doradille des Baléares se caractérise par ses frondes triangulaires (c'est-à-dire avec les pennes basales les plus grandes), et elle se distingue d'*A. onopteris* (diploïde) par ses grosses spores, mais aussi par le sommet assez largement arrondi des pinnules. Cette doradille est une espèce sténo-méditerranéenne occidentale à distribution tyrrhénienne: Minorque, Sud de la France (îles d'Hyères, Estérel, Pyrénées-Orientales), Corse (Agriate, Cap Corse, région de Bonifacio), Sardaigne et Sicile où elle est aussi très rare (partie nord-orientale à Messina et Monticelli). Sa distribution est donc presque totalement insulaire, et souvent même micro-insulaire: île de Porquerolles (Provence, archipel hyérois); île de Capraia (archipel toscan); îles Pontines (Latium); îles siciliennes de Pantelleria, Lampedusa (non revu depuis la fin des années 1970: Pasta 2001), Ustica et Alicudi (Troìa & al. 2012b).

Cette fougère avait été inventoriée à Zembra dès juillet 1884 par P.N. Doûmet-Adanson et V. Mayet lors la première exploration botanique de l'île (Doûmet-Adanson 1888), mais déterminée comme *A. onopteris* var. *acutum*. Elle a été recensée récemment dans deux localités, en 2012 (G. Domina & R. El Mokni, obs. pers 26.VI.2012) sub *Asplenium billotii* F.W. Schultz, puis au printemps 2019 (F. Médail & E. Véla, obs. pers. 17.IV.2019) (Fig. 2 a, b) et ces spécimens récoltés ont été rapportés à *Asplenium balearicum* par R. Prelli

Tab. 1. Missions botaniques réalisées sur les îles de Tunisie dans le cadre de l'Initiative pour les petites îles de Méditerranée (Initiative PIM) depuis 2012.

Archipels	Objectif principal de la mission	Prospecteurs	Dates	Références
Zembra	Inventaire floristique (Zembra et Zembretta) et mise en place de placettes de suivi de la flore (Zembra)	Gianniantonio Domina Ridha El Mokni	26-29.VI.2012	Domina & El Mokni (2012a, b)
	Inventaire floristique et suivi des placettes (Zembra et Zembretta)	Gianniantonio Domina & Wahbi Jaouadi	10-14.V.2013	Domina & Jaouadi (2013)
	Inventaire floristique (Zembra et Zembrettina)	Frédéric Médail Errol Véla	16-18.IV.2019	Médail & Véla (2020)
Kuriat	Inventaires floristiques et carte de la végétation des 2 îles	Laetitia Hugot Aurélien Cheylan	28-29.III.2014	Pasta & al. (in prep.)
		Salvatore Pasta Ridha El Mokni	28-30.IV.2015	
Monastir ancienne île El Ghdamsi ou île Tonnara	Inventaire floristique	Frédéric Médail Salvatore Pasta Gianluigi Bacchetta Laetitia Hugot	24.X.2015	Médail (in prep.)
Kerkennah	Inventaire floristique des 12 îles et îlots satellites	Frédéric Médail Salvatore Pasta Mohamed Chaieb	27-30.III.2014	Médail & al. (2015a, b)
		Frédéric Médail Mohamed Chaieb	22-23.X.2015	
Kneiss	Inventaire floristique et carte de la végétation des 3 îles	Frédéric Médail Mohamed Chaieb Ludovic Charrier Matthieu Charrier	11-12.IV.2015	Médail & al. (2015b, 2016)
Djerba	Inventaire floristique et carte de la végétation de 8 îles et îlots satellites	Frédéric Médail Mohamed Chaieb Ludovic Charrier Matthieu Charrier	07-10.IV.2015	Médail & al. (2020)

(comm. pers., X.2019). Une population existe sur la partie sommitale de Zembra (alt. ca. 425 m), dans quelques anfractuosités fraîches et ombragées des rochers exposés au nord et soumis aux fréquentes brumes maritimes. Cette population comporte des individus aux frondes assez grandes, comparées aux petits spécimens récoltés par G. Domina, mais tous ont des spores de longueur (périspore exclue) comprise entre 35-38 µm (R. Prelli, comm. pers.). L'autre population connue se situe à plus basse altitude (180 m), sur un petit sommet au-dessus de l'ancien camp de vacances. L'espèce est à rechercher dans les secteurs ombragés, mais peu accessibles, de la partie septentrionale de Zembra. Cette découverte est très intéressante sur le plan biogéographique car la doradille des Baléares n'était pas signalée pour l'ensemble de l'Afrique du Nord.

Bellis perennis L. **– Pâquerette pérenne (*Asteraceae*)**

Cette herbacée pérenne eurasiatique est caractéristique des pelouses fraîches et prairies. Relativement commune en Europe, elle est bien plus rare au Sud de la Méditerranée, et sa distribution connue au Maghreb se limitait jusqu'alors au Nord du Maroc (Rif) (Fennane & al. 2014). La population de Zembra est donc une nouvelle mention de l'espèce pour la

Tab. 2. Localisation des populations de plantes vasculaires nouvellement signalées sur les îles de Tunisie, et caractéristiques physiographiques principales (superficie, altitude maximale, longitude/latitude moyenne) des îles ou îlots considérés.

Archipels et îles	Taxons
Archipel de La Galite **La Galite** 732 ha - Alt. 391 m N 37,529° / E 8,932°	*Narcissus obsoletus* (Haw.) Steud.
Archipel de Zembra **Zembra** 389 ha - Alt. 433 m N 37,128° / E 10,806°	*Asplenium balearicum* Shivas; *Bellis perennis* L.; *Galium minutulum* Jordan; *Ambrosina bassii* L.; *Centaurium erythraea* subsp. *rhodense* (Boiss. & Reut.) Melderis; *Crassula alata* (Viv.) A.Berger; *Filago lojaconoi* (Brullo) Greuter; *Fumaria bicolor* Nicotra; *Hyacinthoides lingulata* (Poir.) Rothm.; *Jacobaea maritima* subsp. *sicula* N.G. Passal., Peruzzi & Pellegrino; *Myosotis ramosissima* subsp. *tubuliflora* (Murb.) Greuter & Burdet; *Prospero pulchellum* (Munby) Speta; *Senecio lividus* L.
Archipel des Kuriat **Grande Kuriat** 251 ha - Alt. 4 m N 35,797 ° / E 11,033°	*Filago congesta* Guss. ex DC.; *Filago fuscescens* Pomel; *Teucrium luteum* subsp. *gabesianum* (S. Puech) Greuter & Burdet
Archipel des Kerkennah **Gremdi** 196 ha - Alt. ca. 3 m N 34,755° / E 11,321°	*Anthemis confusa* Pomel; *Centropodia forsskalii* (Vahl) Cope subsp. *forsskalii; Filago congesta* DC.; *Moraea mediterranea* Goldblatt; *Spergularia media* subsp. *sauvagei* (P. Monnier) Lambinon & Dobignard; *Sphenopus divaricatus* subsp. *permicranthus* (Hausskn.) H. Scholz; *Teucrium luteum* subsp. *gabesianum* (S. Puech) Greuter & Burdet
Archipel des Kerkennah **Roumadiya** 167 ha - Alt. ca. 4 m N 34,820° / E 11,316°	*Anthemis confusa* Pomel; *Filago congesta* DC.; *Filago fuscescens* Pomel; *Moraea mediterranea* Goldblatt; *Narcissus obsoletus* (Haw.) Steud.; *Salsola tunetana* Brullo; *Sphenopus divaricatus* subsp. *permicranthus* (Hausskn.) H.Scholz; *Teucrium luteum* subsp. *gabesianum* (S. Puech) Greuter & Burdet
Archipel des Kerkennah **Sefnou** 53 ha - Alt. ca. 4 m N 34,796° / E 11,224°	*Anthemis confusa* Pomel; *Filago congesta* DC.; *Moraea mediterranea* Goldblatt; *Parapholis marginata* Runemark; *Teucrium luteum* subsp. *gabesianum* (S. Puech) Greuter & Burdet
Archipel des Kerkennah **Lazdad** 22 ha - Alt. ca. 2 m N 34,768° / E 11,298°	*Spergularia media* subsp. *sauvagei* (P. Monnier) Lambinon & Dobignard; *Sphenopus ehrenbergii* Hausskn
Archipel des Kerkennah **Ramadiya** 4,15 ha - Alt. ca. 2 m N 34,824° / E 11,281°	*Moraea mediterranea* Goldblatt; *Sphenopus divaricatus* subsp. *permicranthus* (Hausskn.) H. Scholz
Archipel des Kerkennah **Gharsa** 1,64 ha - Alt. ca. 2 m N 34,758° / E 11,350°	*Allium subvillosum* Schult. & Schult. f.; *Moraea mediterranea* Goldblatt; *Sphenopus divaricatus* subsp. *permicranthus* (Hausskn.) H. Scholz; *Sphenopus ehrenbergii* Hausskn
Archipel des Kerkennah **Jeblia** 1,43 ha - Alt. ca. 2 m N 34,757° / E 11,362°	*Sphenopus divaricatus* subsp. *permicranthus* (Hausskn.) H. Scholz; *Sphenopus ehrenbergii* Hausskn
Archipel des Kneiss **El Bessila** 436 ha - Alt. ca. 7 m N 34,366° / E 10,314°	*Ammosperma cinereum* (Desf.) Baill.; *Parapholis marginata* Runemark; *Salsola tunetana* Brullo; *Sphenopus divaricatus* subsp. *permicranthus* (Hausskn.) H. Scholz
Archipel de Djerba **Djerba** 51.400 ha - Alt. ca. 53 m N 33,792° / E 10,890°	*Carthamus creticus* L.; *Dipcadi serotinum* subsp. *fulvum* (Cav.) Maire & Weiler; *Moraea mediterranea* Goldblatt; *Sphenopus divaricatus* subsp. *permicranthus* (Hausskn.) H. Scholz

Tabl. 2. suite.

Archipel de Djerba **Gataia el Bahria** 153 ha - Alt. ca. 5 m N 33,732° / E 10,715°	*Ammosperma cinereum* (Desf.) Baill.; *Astragalus pseudosinaicus* Gazer & Podlech; *Dipcadi serotinum* subsp. *fulvum* (Cav.) Maire & Weiler; *Moraea mediterranea* Goldblatt; *Salsola tunetana* Brullo; *Sphenopus divaricatus* subsp. *permicranthus* (Hausskn.) H. Scholz; *Sphenopus ehrenbergii* Hausskn
Archipel de Djerba **Jlij** 149 ha - Alt. ca. 1 m N 33,596° / E 10,867°	*Ammosperma cinereum* (Desf.) Baill.; *Astragalus pseudosinaicus* Gazer & Podlech (à vérifier); *Sphenopus divaricatus* subsp. *permicranthus* (Hausskn.) H. Scholz; *Sphenopus ehrenbergii* Hausskn
Archipel de Djerba **Gataia el Gueblia** 73 ha - Alt. ca. 2 m N 33,691° / E 10,774°	*Ammosperma cinereum* (Desf.) Baill.; *Astragalus pseudosinaicus* Gazer & Podlech; *Moraea mediterranea* Goldblatt; *Parapholis marginata* Runemark; *Salsola tunetana* Brullo; *Sphenopus divaricatus* subsp. *permicranthus* (Hausskn.) H. Scholz; *Sphenopus ehrenbergii* Hausskn
Archipel de Djerba **Dzira** 2,44 ha - Alt. ca. 3 m N 33,875° / E 10,739°	*Dipcadi serotinum* subsp. *fulvum* (Cav.) Maire & Weiller; *Salsola tunetana* Brullo

Tunisie (F. Médail & E. Véla, obs. pers. IV.2019). La pâquerette se localise dans un replat herbacé un peu rudéral caractérisé par la présence de *Parietaria judaica* (L.) L.*, Umbilicus horizontalis* (Guss.) DC.*, Hyoseris lucida* subsp. *taurina* (Pamp.) Peruzzi & Vangelisti au sommet de l'île (alt. 423 m), au pied d'une petite falaise orientée au nord-ouest et régulièrement soumise aux brouillards maritimes. Il est possible que l'espèce ait colonisé l'île assez récemment à la faveur d'une dispersion des graines par le vent depuis la Sicile où elle est commune, ou d'un transport fortuit par les nombreux oiseaux marins qui fréquentent l'île. Seuls quelques individus ont été aperçus mais un recensement plus précis serait à entreprendre et les secteurs favorables de la partie nord de l'île pourraient abriter d'autres sous-populations. Ce taxon a été aussi découvert au Cap-Blanc (Bizerte), dans un biotope similaire (R. El Mokni, obs. pers. 23.II.2020; El Mokni & Iamonico in prep.).

Carthamus creticus L. **– Carthame de Crète (*Asteraceae*)**

Espèce sud-méditerranéenne, présente depuis le Portugal jusqu'à la Turquie, ce carthame n'était curieusement pas formellement mentionné en Tunisie car dans le groupe du *Carthamus lanatus* L. seule la sous-espèce *montanus* (Pomel) Jahand. & Maire était indiquée (Le Floc'h & al. 2010). *Carthamus creticus* est parfois traité comme simple sous espèce: *Carthamus lanatus* subsp. *baeticus* (Boiss. & Reut.) Nyman. Il se distingue par ses fleurs jaune pâle dépassées par les bractées souvent récurvées et aussi la longueur des soies de l'akène (8-10 mm) qui sont brun-noirâtres, alors que *C. lanatus sensu stricto*, espèce commune à toute la Tunisie, possède des fleurs de couleur jaune intense, non dépassées par les bractées dressées et une longueur des soies de l'akène de 10-13 mm qui sont de couleur blanche.

L'espèce a été photographiée à Djerba par F. Debruille en février 2014 (http://www.orchid-nord.com/Flore-Djerba/Carthamus%20lanatus/Carthamus-lanatus.html) et identifiée par l'un de nous (E. Véla). Ce carthame a été aussi recensé récemment dans plusieurs localités (Bembla, Menzil-Nour, Falaise) de la région de Monastir (R. El Mokni, obs. pers. 16.II.2020), et le long des chemins de fer des métros du Sahel, zone de Baghdadi vers la ville de Mahdia (R. El Mokni, obs. pers. 12.V.2020).

Il s'agit d'une espèce allopolyploïde d'origine hybridogène (Garnatje & al. 2006) présente dans les friches, bords de champ et pelouses sèches pâturées. Parmi les populations géographiquement assez proches, ce carthame est présent sur l'île de Linosa (Brullo & Siracusa, 1995), mais il a probablement disparu en Sicile (Giardina & al. 2007).

Galium minutulum Jordan **– Gaillet nain (*Rubiaceae*)**

La distribution de cette petite Rubiacée annuelle sténo-méditerranéenne est centrée sur la région nord-tyrrhénienne où elle est surtout présente sur les îles (Corse, Sardaigne, Archipel toscan, îles d'Hyères), mais aussi en Péninsule ibérique; elle a été signalée récemment en Vendée (France occidentale) mais son indigénat est douteux (Chagneau 2015). La découverte du gaillet nain sur l'île de Zembra (F. Médail & E. Véla, obs. pers. 16.IV.2019) est très intéressante car l'espèce n'était pas connue en Afrique du Nord (Fig. 2 c). Ce gaillet a été découvert sur un petit talus argileux légèrement humide et couvert de bryophytes, en lisière de maquis à *Erica arborea* L. bordant le sentier de la partie sommitale de l'île. Sur les îles d'Hyères (Provence, France), deux niveaux de ploïdie ont été identifiés (Médail & al. 2000), et il conviendrait d'analyser la caryologie de la population de Zembra. Toutefois, la localisation de cette population à l'intérieur de l'île (et non en situation littorale), son écologie en ourlet de maquis et le port prostré (taille inférieure à 5 cm de haut) et grêle des individus, suggèrent une attribution à la race tétraploïde ($2n = 4x = 44$). Des prospections sur le littoral Nord tunisien méritent d'être entreprises afin de rechercher ce très rare taxon qui peut être confondu avec des gaillets annuels plus communs comme *Galium murale* (L.) All.

Moraea mediterranea Goldblatt **– Iris de Méditerranée (*Iridaceae*)**

Longtemps confondu avec *Moraea sisyrinchium* (L.) Ker Gawl. (= *Gynandriris sisyrinchium* (L.) Parl.) dont il est morphologiquement voisin, l'iris de Méditerranée s'en distingue par la présence d'une seule feuille basale, sa petite taille (<10 cm), et la couleur gris-bleu pâle de la fleur dont les pétales externes comportent une large macule jaune (O. Peri, comm. pers.). Décrit initialement sous le binome *Gynandriris monophylla* Boiss. & Heldr. ex Klat, l'espèce est distribuée en Méditerranée orientale (Grèce, Crète, Palestine, Israël, Jordanie, Egypte, Libye) mais n'était pas mentionnée jusqu'alors en Tunisie.

Dès la fin du XIXe siècle, Bonnet & Barratte (1896) signalaient ce taxon sur l'île de Djerba, sous le nom d'*Iris sisyrinchium,* population qui correspond en fait à *Moraea mediterranea* (O. Peri, comm. pers.). L'iris de Méditerranée a été recensé en avril 2015 sur deux îles satellites de Djerba: Gataia el Gueblia où il est assez commun (Fig. 2 e) et Gataia el Bahria où il est très rare. Les populations djerbiennes représentent à ce jour la limite sud-occidentale de distribution de ce taxon. Il a aussi été identifié un peu plus au Nord sur les îles Kerkennah (Gremdi, Roumadiya, Sefnou, Ramadiya, Gharsa) (F. Médail & al., obs. pers. III.2014) (Fig. 2 d), mais rapporté initialement à *Moraea sisyrinchium*. Cet iris est à rechercher dans les replats littoraux de sables fixés des secteurs arides et semi-arides de la Tunisie centrale et méridionale. En 2018, une petite population littorale a été découverte sur la côte nord de Bizerte au Cap-Blanc avec des individus toujours monophylles et une morphologie conforme à *M. mediterranea*, à l'exception de la couleur des tépales qui est violette très foncée chez cette population (R. El Mokni, obs. pers. 15.IV.2018). Diverses populations de Tunisie centrale, près de Mahdia (secteurs d'oued Glèet, oued Beja et Sakiat El Khadem), comportent des individus monophylles au sein d'individus dominants



Fig 2. a, b) *Asplenium balearicum* Shivas, rochers ombragés du sommet de l'île de Zembra, 17.IV.2019 (clichés F. Médail & E. Véla); c) *Galium minutulum* Jordan sur l'île Zembra, 16.IV.2019 (cliché E. Véla); d, e) *Moraea mediterranea* Goldblatt: d) sur l'île Gremdi (Kerkennah), 29.III.2014, e) sur l'île Gataia el Gueblia (Djerba), 07.IV.2015 (clichés F. Médail).

à deux-trois feuilles mais qui ont la coloration typique des tépales de l'iris de Méditerranée (R. El Mokni, obs. pers. 23.III.2020). Une analyse précise de la variation clinale de ces deux taxons en Tunisie serait à réaliser.

Localités insulaires nouvelles de taxons autochtones rares ou méconnus en Tunisie

Cette partie discute de la présence de 24 taxons rares ou méconnus à l'échelle de la Tunisie, dont les occurrences au sein des territoires insulaires du pays sont nouvelles d'après les données consultées (littérature, herbiers, sites internet).

Ammosperma cinereum (Desf.) Baill. – **Ammosperme cendré (*Brassicaceae*)**

Plante annuelle atteignant d'après les flores 30 centimètres de hauteur, elle peut dépasser 40 centimètres sur les sites insulaires tunisiens. Endémique nord-africaine, principalement saharienne (Hauts-plateaux et Nord du Sahara), l'espèce est connue avec certitude de l'Algérie à la Lybie mais n'est pas confirmée au Maroc. D'après Bonnet & Barratte (1896) et Pottier-Alapetite (1979), l'espèce existe en Tunisie centrale (Kairouan & Sidi Bouzid), ainsi que dans les marges sahariennes de la Tunisie méridionale, soit au niveau du Nefzaoua et du Djérid, et à Tozeur.

Inféodée aux substrats sablo-limoneux marqués surtout par une certaine salinité, elle se développe au bord des oueds ou sur des terrains gypseux ou gypso-haloclins, le long du littoral ou dans les sables sahariens.

Au niveau des écosystèmes insulaires de la Tunisie orientale, cette espèce n'est pas signalée dans l'archipel des Kerkennah. Dans l'archipel des Kneiss, elle n'a été observée que sur la Grande Kneiss (El Bessila) au sein de la zone sablo-limoneuse centrale un peu surélevée; ce biotope comportait une population de plusieurs centaines d'individus dispersés dans les trouées sableuses, entre les touffes des arbustes halorésistants (Médail & al. 2016). Elle est assez rare à Djerba selon Vanden Berghen (1981) qui la cite au nord d'Adjim, dans les moissons et friches. Les prospections des îles satellites de Djerba ont permis en plus de constater que l'espèce était aussi rare ou très rare à Gataia el Bahria, Gataia el Gueblia et Jlij (Médail & al. 2020). À la lumière de ce qui précède, on peut se demander si le contraste entre l'écologie initialement présaharienne ou saharienne de cette espèce et sa présence en milieu insulaire aujourd'hui, ne pourrait-elle pas attester de sa réponse vis-à-vis des changements climatiques actuels.

Allium subvillosum Schult. & Schult. f. *sensu lato* – **Ail d'hiver (*Alliaceae*)**

Ce complexe d'espèces de répartition sud-ouest méditerranéenne-macaronésienne a été observé aux Azores, dans le sud de la Péninsule ibérique, aux îles Baléares et aux îles Canaries (sous le taxon récemment distingué *Allium canariense* (Regel) N. Friesen & P. Schoenfelder). Il est commun au Maroc où il a été décrit et en Algérie, puis devient de plus en plus rare vers l'Ouest: en Italie, il a disparu de la plupart des localités citées au XIXe siècle, de même en Sicile occidentale et aux îles Egades et Pélagiennes; un isolat pourrait atteindre la Cyrénaïque en Lybie mais son identité reste à vérifier, vis-à-vis de *A. subhirsutum* notamment (El Gadi 1977). L'espèce occupe de préférence les sols sableux très filtrants et calcaires près du littoral, mais elle possède une vaste amplitude écologique (Pastor & Valdés 1983).

En Tunisie, ce taxon est cité dans la flore de Bonnet et Barratte (1896) sous le nom *A. subhirsutum* var. *vernale* (Tineo) Bonnet & Barratte dans "*les lieux herbeux, sables du littoral et de l'intérieur: presqu'île du Cap Bon, Hammam-Lif, Taroufa, ? Zougag*" et par Cuénod (1954) sous le nom *A. subhirsutum* subsp. *album* (Santi) Maire & Weiller qui signale notamment sa présence sur les sables et les rocailles du Cap Bon (Hammam Lif, Borj Cédria). Wilde-Duyfjes (1976) le mentionne seulement dans des localités anciennes à Kelibia, Djebel Cheban et à l'île Plane, d'après les herborisations de E. Cosson effectuées entre 1883 et 1888. Ce taxon semble donc très rare en Tunisie, mais il est sans doute aussi méconnu du fait de sa phénologie précoce (décembre à mars-avril).

Durant la mission de mars 2014 aux îles Kerkennah, une population restreinte à quelques individus a été découverte sur la petite île de Gharsa, au sein d'une formation arbustive d'espèces halophiles, située sur une dune maritime de sable fixé, et située à quelques mètres du bord de l'eau (Médail & al. 2015b). L'ail d'hiver n'avait jamais été signalé aux Kerkennah et cette population remarquable mériterait un suivi régulier.

Ambrosina bassii L. **– Ambrosinie aplatie (*Araceae*)**

L'ambrosinie est une petite géophyte de la famille des *Araceae*, à distribution tyrrhénienne limitée au sud de l'Italie, Sicile, Sardaigne, sud de la Corse, nord de l'Algérie et nord de la Tunisie. Dans ce dernier pays, l'espèce n'est pas rare et si Ben Khalifa & al. (2017) indiquent 14 populations classées en trois sous-espèces, il doit en exister plusieurs dizaines car l'espèce est précoce et discrète et peut être facilement confondue à l'état végétatif avec de jeunes *Arisarum vulgare* O. Targ.Tozz. L'espèce est nouvelle pour l'archipel de Zembra et elle existe en petites populations sur le replat sommital occidental de Zembra, notamment sous couvert de maquis à bruyère (*Erica arborea*) (E. Véla & F. Médail, obs. pers. 17.IV.2019). Les populations les plus proches se situent au Cap Bon (Cuénod 1954; Ben Khalifa & al. 2017).

Une analyse moléculaire montre la forte affinité génétique entre les populations d'*A. bassii* de Sicile et celles de Tunisie (Troìa & al. 2012a). Les auteurs de cette étude suggèrent que du fait des très faibles capacités de dispersion à longue distance de l'espèce il y a eu dans un « passé relativement récent » (pas de datation de l'arbre phylogénétique) une continuité entre ces deux ensembles, qu'ils attribuent à une connexion terrestre post-Messinienne. Cependant cette connexion reste fort discutée, bien que sans doute les côtes de Sicile et de Tunisie aient été beaucoup plus proches durant le dernier maximum glaciaire, il y a *ca*. 20 000 ans BP (Lo Presti & al. 2019; Thierry & al. 2019).

Anthemis confusa Pomel **– Anthémis confus (*Asteraceae*)**

Cet anthémis décrit des "lieux incultes de Gabès" a été par la suite rapporté à l'*Anthemis pedunculata* var. *decumbens* Coss. par Pottier-Alapetite (1981) ou à la subsp. *glareosa* var. *mucronulata* Le Houérou (Le Houérou 1960). Toutefois, la révision monographique des *Anthemis* nord-africain par C. Oberprieler montre qu'il s'agit bien d'une espèce distincte caractérisée par des bractées de l'involucre floral bordées de noir, marron foncé ou marron clair, et par des rameaux décumbants et prostrés (Oberprieler 1998).

Taxon intéressant sur le plan biogéographique, l'anthémis confus est une espèce subendémique à distribution centrée sur la Tunisie centro-méridionale, avec quelques localités en Algérie orientale et en Libye occidentale. Selon Pottier-Alapetite (1981), l'espèce est

commune en Tunisie méridionale, dans les oasis (Gabès, Djérid, Tozeur, Ksar Ghilane, Tataouine, etc.). Cet anthémis se rencontre dans les biotopes sableux plus ou moins rudéraux, depuis la côte jusqu'aux chotts internes. Ce taxon (sub. *A. pedunculata* var. *decumbens*) avait été déjà signalée aux îles Kerkennah (Pottier-Alapetite 1981), mais cette indication n'est pas reprise par Oberprieler (1998) en l'absence de *specimina visa*; ce taxon est bien présent dans cet archipel puisqu'il a été découvert sur les trois plus grandes îles satellites (Gremdi, Roumadiya, Sefnou) où il est rare et présent dans des pelouses arénacées légèrement humides (F. Médail & al., obs. pers. III.2014). Il est aussi présent à Djerba dans les "*dunes fixées, moissons et friches, talus sablonneux*" où le cite Vanden Berghen (1981) sous le nom d'*Anthemis arvensis* L.; la révision critique de ses récoltes par Lambinon (2000) confirme qu'il s'agit bien de *A. confusa*.

Astragalus pseudosinaicus Gazer & Podlech **– Astragale du Sinaï (*Fabaceae*)**

Décrite du Sahara algérien (Batna, Biskra, Laghouat, Ouargla, Saïda) où elle est la plus abondante, cette astragale se caractérise par des tiges couvertes de poils blancs, des feuilles sessiles ayant 6-11 paires de folioles elliptiques ou obovales, des fleurs sessiles avec un calice campanulé de couleur jaunâtre, et des gousses de 10-12 mm couvertes de poils de poils apprimés courts (ca. 0,1 mm) et de poils étalés-dressés longs (1-1,3 mm) naissant en partie de petits tubercules (Podlech & Zarre 2013). Ce taxon serait toutefois peu caractérisé selon M. Chambouleyron (comm. pers) et la section *Sesamei* DC. mériterait une révision complète à l'échelle du Maghreb.

Cette astragale occupe les zones désertiques ou semi-désertiques du Maghreb, depuis le Maroc oriental (Figuig, non revu) jusqu'à l'Egypte et Chypre. En Tunisie, la seule mention connue était celle de Pitard qui a récolté cette astragale dans la région de Gafsa en 1909, et cette part a été identifiée par les descripteurs du taxon. Cette astragale saharienne a été inventoriée sur trois îles satellites de Djerba: Gataia el Bahria, Jlij et Gataia el Gueblia (Fig. 3 a) où elle est assez commune (F. Médail & al., obs. pers. 07-09.IV.2015), mais elle est à rechercher sur l'île principale de Djerba. La distribution de cette astragale atteint le centre du pays, où elle a été collectée récemment à Kasr Hellal près de Monastir (R. El Mokni, obs. pers. 11.III.2020).

Centaurium erythraea **subsp. *rhodense*** (Boiss. & Reut.) Melderis **– Petite-centaurée de Rhodes (*Gentianaceae*)**

Ce taxon tétraploïde ($2n = 4x = 40$) serait issu selon Zeltner (1970) du croisement entre *C. erythraea* subsp. *erythraea* Rafn et *C. majus* Hoffmanss., mais cette hypothèse n'a pas été confirmée par la phylogénie moléculaire du groupe car *C. erythraea* subsp. *rhodense* se place dans un autre clade que celui des parents supposés (Mansion & al. 2005). Il est distribué depuis la Méditerranée centrale (Corse, Sardaigne, Tunisie, Sicile, Italie du Sud) jusqu'à la Turquie. Il se rencontre dans les pelouses plus ou moins humides. S'il est assez commun dans les pelouses siliceuses de Zembra où plusieurs stations ont été recensées dans la partie méridionale de l'île (F. Médail & E. Véla, obs. pers. 16-18.IV.2019), il semble très rare ailleurs en Tunisie puisqu'une seule autre localité est connue au nord de Sfax; mais la chorologie de ce taxon méconnu, en limite sud-occidentale de distribution, mérite d'être précisée.

Centropodia forsskalii (Vahl) Cope **subsp. *forsskalii* – Centropode de Forsskal (*Poaceae*)**

Graminée pérenne ou annuelle à tiges ascendantes de 20-40 cm, elle occupe les steppes arides et les zones désertiques sableuses. Elle présente une vaste distribution depuis le Sud marocain jusqu'à l'Iran. Commune dans tout le Sahara, elle atteint sa limite septentrionale de distribution en Tunisie méridionale (Tozeur, Nefta, Gabès, Gafsa) et centrale (Aïn Cherichera, Sidi Bouzid, Sbeïtla, Meknassy) (Cuénod, 1954). Selon Foley & Musso (1925), cette espèce est réputée très toxique car elle peut entraîner la mort des ovins qui la consomment au printemps.

Au niveau insulaire, l'espèce a été découverte dans l'archipel des Kerkennah où elle n'avait jamais été signalée (Médail & al. 2015b). Elle a été uniquement recensée sur l'île de Gremdi où elle est rare et localisée; sa présence est intéressante sur le plan biogéographique car elle fait partie des ultimes irradiations septentrionales du contingent de végétaux à distribution saharienne présents le long de la côte de Tunisie orientale.

Dipcadi serotinum **subsp. *fulvum*** (Cav.) Maire & Weiller **– Dipcadi fauve (*Asparagaceae*)**

Nous rapportons à cette sous-espèce, le dipcadi présent sur certaines îles satellites de Djerba (Gataia el Bahria et Dzira). Décrit initialement par A.J. Cavanilles près d'Essaouira (SW Maroc) sous le binome *Hyacinthus fulvus*, le dipcadi fauve a été récemment signalé au nord-ouest de l'Algérie, le long du littoral oranais par Véla & Mostari (2013), et au nord de la Tunisie, au sud d'Hammamet (Hammam Bent Jedidi) (El Mokni 2018) et au Cap Bon (zone zone de Ghardaïa à Beni Khiar) (R. El Mokni, obs. pers. 2019). Il s'agit d'une plante généralement robuste, avec un bulbe de 3-6 cm de diamètre, et une hampe florale atteignant 50-100 cm (Véla & Mostari 2013), mais les individus peuvent être bien plus petits selon les conditions météorologiques et édaphiques (E. Véla, obs. pers.). Les tépales de 15-18 mm sont de couleur vive, brun-rougeâtres (ce qui le distingue de *D. serotinum sensu stricto* qui a des tépales de 12-15 mm, rose-brunâtres ou beige-verdâtres) et la floraison s'étend de novembre à mars. L'écologie de ce taxon correspond aux dunes littorales, sur sables fixés, ce qui est le cas des populations micro-insulaires de Djerba; l'espèce peut former un faciès quasiment monospécifique sur l'île Dzira dans quelques clairières sablonneuses (F. Médail & al., obs. pers. 08.IV.2015).

Il reste à entreprendre une étude systématique de ce genre au moins à l'échelle du Maghreb et du Proche-Orient, et à examiner les liens entre *D. serotinum* et *D. erythraeum* Webb & Berthel., ce dernier étant signalé en Egypte, Israël, et Péninsule arabique. Ainsi, "*dans le Sud tunisien aride (sables de Nefta-Tozeur) et sans doute en Algérie frontalière existe un grand Dipcadi (h. 20-35cm) à feuilles dressées et fleurs marron foncé et tépales fortement cuculés bien distinct de D. serotinum s.s.*" (A. Dobignard, comm. pers.) qui se rapproche donc du *D. erythraeum* oriental.

Filago congesta Guss. ex DC. **– Cotonnière à fleurs serrées (*Asteraceae*)**

Ce filago doit être intégré selon Wagenitz (1969) au taxon décrit de Sicile par Augustin Pyramus De Candolle en 1838 sur la base des échantillons envoyés de Sicile par Gussone en 1831; il s'agit d'un taxon méconnu en Tunisie, inclus au *F. micropodioides* Lange par Le Floc'h & al. (2010) et indiqué avec doute dans ce pays par Dobignard & Chatelain

(2011). Ce taxon est pourtant bien présent dans diverses localités tunisiennes (Wagenitz 1969; G. Wagenitz, comm. pers.), et il correspond à *Evacopsis polycephala* décrit par Pomel à Sidi Bouzid, au Djebel Amour, en 1860. Pottier-Alapetite (1981) mentionne ce taxon sous *F. germanica* subsp. *spathulata* var. *prostrata* Parl. et var. *micropodioides* (Lange) Batt. et indique que c'est une "*plante grêle, prostrée, rameuse dès la base, grisâtre, à nombreux glomérules non dépassés par les feuilles florales, capitules 2-12 par glomérule, plongés dans un épais tomentum*"; ceci correspond bien à la description de notre échantillon déterminé par le spécialiste du genre, G. Wagenitz (*in litt.,* X.2014).

Ce taxon a une distribution sud-ouest méditerranéenne, et il est présent dans la partie orientale de la Péninsule ibérique, îles Baléares, Maroc, Algérie, Tunisie et Sicile. Il est signalé en Tunisie centrale (Sousse, Sfax, Kerkennah) et semble commun en Tunisie méridionale (Gafsa, Gabès, Zarzis, Tamezret, Kébili, Tataouine, etc.) selon Pottier-Alapetite (1981). Des prospections récentes ont confirmé sa vaste répartition au centre du pays (Monastir, Mahdia, Sousse), avec parfois de gros individus dont le diamètre dépasse 25-30 cm (R. El Mokni, obs. pers. 11-14.III & 05.IV.2020).

Sur l'archipel des Kerkennah, ce *Filago* a été recensé sur les trois plus grandes îles satellites (Gremdi, Roumadiya, Sefnou) où il est rare et localisé (Médail & al. 2015b) (Fig. 3 b), tout comme sur l'île Grande Kuriate (S. Pasta & R. El Mokni, obs. pers. 29-30.IV.2015).

Filago lojaconoi (Brullo) Greuter – **Cotonnière de Lojacono (*Asteraceae*)**

Cette petite composée annuelle jusqu'alors considérée comme endémique des îles volcaniques du détroit de Sicile (Pantelleria, Linosa) a été identifiée pour la première fois en Tunisie sur l'île de Zembra par Domina & El Mokni (2012b) près d'une excavation à l'Est du hameau (ancien ″camp de vacances″) et à ″Ain Kabbar″. Mais ce taxon avait déjà été observé localement sous le nom de *Filago gallica* var. *tenuifolia* f. *nana* Rouy et mentionné dans la *Flore de Tunisie* (Pottier-Alapetite 1981). L'espèce n'est pas rare dans les petites pelouses acidophiles et xérophiles, notamment sur le sentier du flanc méridional de l'île et en arrière de la plage du Sud (F. Médail & E. Véla, obs. pers. IV.2019). Elle a aussi été recensée sur le territoire continental tunisien, à Utique et à El Alia (Bizerte) (R. El Mokni, obs. pers. 2018). Cette découverte est importante car elle illustre le lien biogéographique entre Zembra et la Sicile, sans doute grâce à un ancien « pont siculo-tunisien » (Médail & Véla 2020).

Filago fuscescens Pomel – **Cotonnière dorée (*Asteraceae*)**

Ce taxon a été longtemps rattaché soit à *Filago germanica* L. soit à *Filago pyramidata* L. en tant que sous-espèce. Dans sa révision du genre, Wagenitz (1969) réhabilite ce taxon au rang spécifique et une phylogénie moléculaire récente confirme l'individualité de *Filago fuscescens*, positionné dans le même clade que *F. pyramidata* (Gutiérrez-Larruscain & al. 2018).

Si Wagenitz (1969) estimait que des spécimens de Tunisie et un autre de Tripolitaine (Libye), pouvaient être rapportés à *F. fuscescens*, sa présence en Tunisie n'est toujours pas signalée dans la base de données Euro+Med Plant Base (http://ww2.bgbm.org/EuroPlusMed/query.asp). Le Floc'h & al. (2010) l'ajoutent avec doute pour ce pays tout en soulignant sa présence à Djerba (Lambinon 2000). Nous confirmons bien la présence de

Filago fuscescens avec plusieurs populations en Tunisie centrale, à Ksar Hellal (Monastir) et Kerker (Mahdia) (R. El Mokni, obs. pers.), et deux populations micro-insulaires: l'une dans l'archipel des Kerkennah, sur l'île Roumadiya où il est très rare (F. Médail & al., obs. pers. 28.III.2014) (Fig. 3 c); l'autre sur l'île Grande Kuriate où il reste localisé (L. Hugot, obs. pers. 28.III.2014; S. Pasta & R. El Mokni, obs. pers. 29-30.IV.2015).

Ce taxon sud-ouest méditerranéen est donc présent au sud-est de l'Espagne, îles Baléares, Maroc, Algérie, Tunisie et Libye (Andrés-Sánchez & al. 2013).

Fumaria bicolor Nicotra – **Fumeterre bicolore (*Papaveraceae*)**

Espèce centro-ouest-méditerranéenne, elle se rencontre souvent sur les petites îles, îlots ou péninsules, à l'étage thermo-méditerranéen (Pavon & Pires 2019). Elle peut être localement abondante dans les secteurs de reposoir ou de nidification des oiseaux marins où elle détermine un faciès halo-ornitho-coprophile. En Tunisie, l'espèce n'a été longtemps connue que sur l'ancienne île de Tabarka (Pottier-Alapetite, 1979), puis elle a été découverte dans les années 2010 à Rimel et Menzil Jemil (sud-est de Bizerte) (R. El Mokni, obs. pers.). La détermination des fumeterres restant souvent délicate, l'existence d'autres stations littorales est fort plausible. L'espèce est nouvellement signalée sur l'île de Zembra où plusieurs populations de taille réduite ont été découvertes sur des placages herbacées rudéralisés servant de reposoirs aux oiseaux marins, et qui se localisent près des rochers de la partie occidentale du replat sommital de l'île (F. Médail & E. Véla, obs. pers. IV. 2019).

Hyacinthoides lingulata (Poir.) Rothm. – **Jacinthe à feuilles en languette (*Asparagaceae*)**

Cette plante bulbeuse endémique du nord-ouest de l'Afrique, depuis le Nord du Maroc jusqu'au Nord de la Tunisie, atteignait sa limite d'aire orientale connue dans le Cap Bon, au Jbel Korbous (Cuénod 1954). L'espèce a été photographiée à Zembra durant l'automne 2009 par R. Ouni (comm. pers.), et identifiée formellement lors des prospections d'avril 2019. Elle a été aussi notée dans les falaises du Jbel Haouaria (E. Véla & F. Médail, obs. pers. IV.2019). Ces occurrences étendent donc vers l'Est sa limite d'aire de répartition. Pour autant, cette jacinthe n'est pas rare en Tunisie et elle est même assez abondante en Algérie, mais sous des formes taxonomiques encore mal comprises. Le type, décrit de la région frontalière algéro-tunisienne, est curieusement indiqué comme fleurissant en mars alors que la très grande majorité des populations sont automnales. D'autres récoltes printanières sont connues près de Constantine (*in herbarium* P), et une population printanière de Kroumirie a même été récemment décrite comme espèce nouvelle sous le nom de *Hyacinthoides kroumiriensis* (El Mokni & al. 2014). Des formes un peu particulières (individus plus grands, bulbes gros et atypiques, couleur plus foncée des tiges et tépales) ont été observées sur la côte nord de Bizerte, au Cap-Blanc (R. El Mokni, obs. pers. 16.IX.2018). Toutes ces populations mériteraient donc une étude génétique à l'échelle de la Tunisie, et une étude taxonomique, phylogénétique et écologique à l'échelle globale.

Jacobaea maritima **subsp.** ***sicula*** Passalacqua, Peruzzi & Pellegrino – **Cinéraire de Sicile (*Asteraceae*)**

La cinéraire de Sicile est un taxon endémique récemment décrit, présent sur les îles Égades et du Canal de Sicile (Malte, Gozo, Lampedusa), et identifié pour la première fois à Zembra par

Domina & Jaouadi (2013). Sur cette dernière, la cinéraire est commune dans les falaises, rochers maritimes et pentes rocailleuses, et elle se rencontre aussi en arrière-plage de la côte sud, sur sable ou galets. Elle est également bien représentée sur l'îlot de La Cathédrale (F. Médail & E. Véla, obs. pers. IV.2019). Il s'agit des seules localités tunisiennes connues, mais sa présence continentale au Cap Bon, à Kélibia *sub « Senecio cineraria* DC. *»* reste à vérifier. Sa distribution peut s'expliquer par l'existence Plio-Pléistocène du pont siculo-tunisien. Il se distingue des autres taxons du groupe par ses involucres ne dépassant pas 6 mm de long, ses feuilles de 6–10 cm de long, ses tiges et involucres pubescents (Passalacqua & al. 2008). Selon ces auteurs, ce taxon pourrait être issu d'une dérive génétique de *J. maritima* subsp. *maritima* (ou de son ancêtre) combinée à une introgression génétique récente de *J. maritima* subsp. *bicolor* (Willd.) B. Nord. & Greuter.

Myosotis ramosissima* subsp. *tubuliflora (Murb.) Greuter & Burdet – **Myosotis à fleurs en tube (*Boraginaceae*)**

Il s'agit d'un petit myosotis annuel à inflorescence allongée et au calice étroitement campanulé. Endémique du Maghreb, il a été décrit en Tunisie septentrionale et en Algérie par Murbeck (1901), mais il semble être aussi présent au Maroc (sub *M. congesta* Shuttlew.). Ce myosotis semble rare en Tunisie puisque seulement huit localités sont citées (Pottier-Alapetite 1981), mais il a pu passer inaperçu. Les stations de l'île de Zembra sont nouvelles (F. Médail & E. Véla, obs. pers., 17.IV.2019) et ce myosotis a été recensé (i) dans une petite pelouse arenacée humide sur le replat sommital de l'île près de l'observatoire, où il forme un micro-faciès dense en bordure de sentier; (ii) dans une pelouse arénacée en mosaïque avec le maquis, sur un replat de la crête occidentale de l'île.

Narcissus obsoletus (Haw.) Steud. – **Narcisse tardif (*Amaryllidaceae*)**

Ce narcisse allotétraploïde à floraison automnale a longtemps été confondu avec l'ibéro-atlantique *N. serotinus* L. *sensu stricto*, et Le Floc'h & al. (2010) ne le distinguent pas encore. Il se différencie de ce dernier notamment par sa paracorolle orangée (Díaz Lifante & Andrés Camacho 2007) que Cuénod (1954) qualifie de "safranée". Les individus de la dition ont toutefois une paracorolle nettement lobée, contrairement à l'indication de *Flora Gallica* (Tison & Foucault 2014). Dans la *Flore de Tunisie* Cuénod (1954) ne cite que six localités de la Dorsale et du Nord-Est du pays, mais Burollet (1927) l'indiquait déjà plus au Sud, dans le Sahel de Sousse. L'espèce est d'ailleurs signalée par Le Houérou (1995), comme présente dans les steppes arides de la Tunisie centrale. Trois populations insulaires ont été recensées: (i) sur l'île de La Galite où le "*N. serotinus*" photographié par E. Véla (obs. pers., 12.XI.2008) correspond bien à *N. obsoletus;* (ii) à Monastir sur l'ancienne île El Ghdamsi ou île Tonnara, désormais rattachée artificiellement au continent, où l'espèce est assez rare et localisée dans quelques pelouses subhalophiles rudéralisées (F. Médail, obs. pers. 24.X.2015); sur l'île Roumadiya (archipel des Kerkennah) (Fig. 3 d, e), population la plus méridionale connue de Tunisie (F. Médail & M. Chaieb, obs. pers. 22.X.2015). Ce narcisse a été aussi recensé sur la côte nord-tunisienne, à Sidi Mechrig dans la région de Bizerte (R. El Mokni, obs. pers. 23.X.2015).

Parapholis marginata Runemark – **Lepture marginé (*Poaceae*)**

Espèce sténo-méditerranéenne méridionale, elle existe ponctuellement en Espagne (région de Valence et îles Baléares), sud de la Corse (îles Lavezzi), Sardaigne, Sicile,

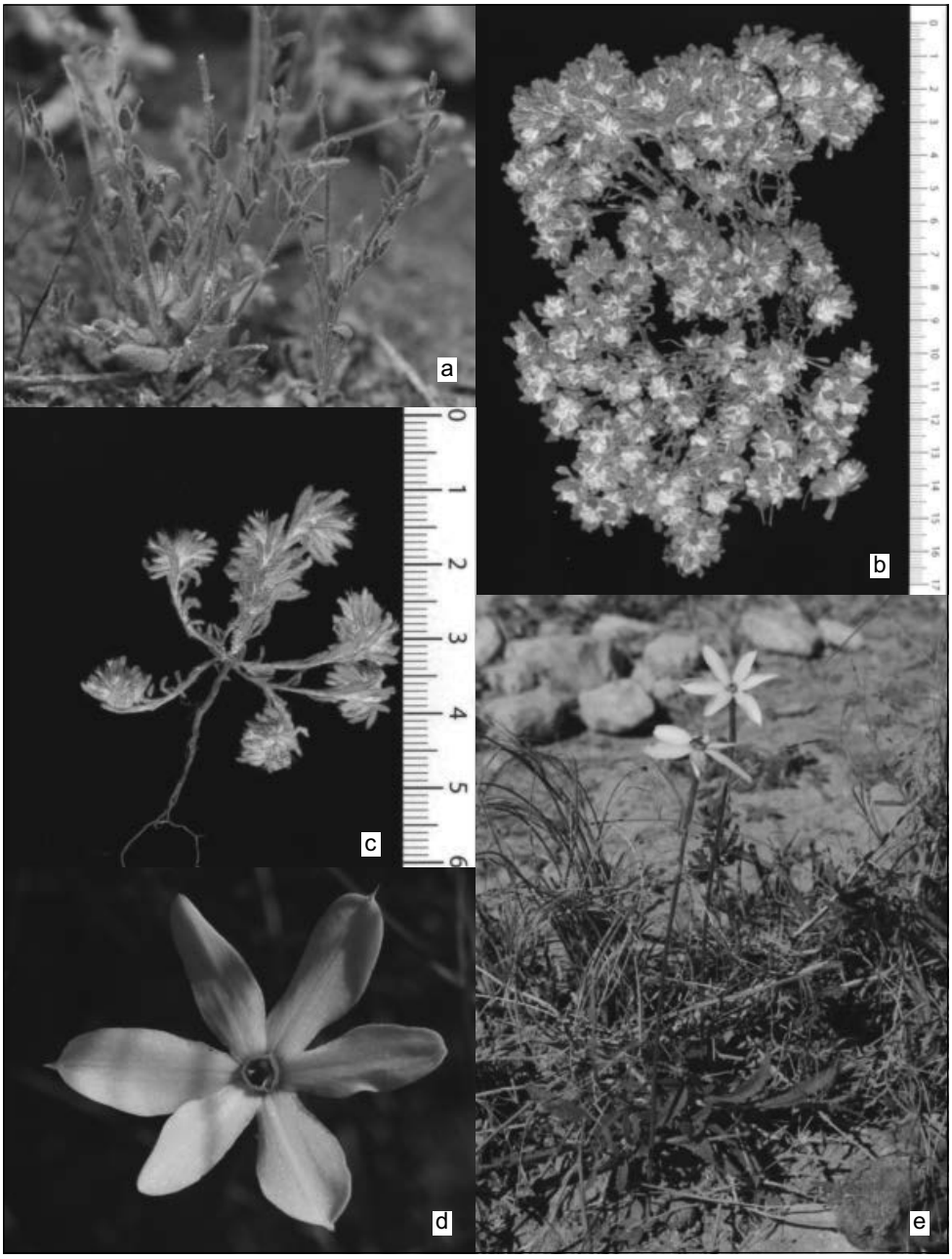


Fig 3. a) *Astragalus pseudosinaicus* Gazer & Podlech sur l'île Gataia el Gueblia (Djerba), 07.IV.2015 (cliché M. Charrier); b) *Filago congesta* DC. récolté sur l'île Gremdi (Kerkennah), 27.III.2014 (herb. F. Médail, AIX), (cliché D. Pavon); c) *F. fuscescens* Pomel récolté sur l'île Roumadiya (Kerkennah), 28.III.2014 (herbier F. Médail, AIX), (cliché D. Pavon); d, e) *Narcissus obsoletus* (Haw.) Steud. sur l'île Roumadiya (Kerkennah), 22.X.2015 (clichés F. Médail).

Albanie, Crète, îles grecques, Chypre, Libye, Egypte, Israël/Palestine (http://www.emplantbase.org/home.html, complété par Ricceri & Lanza 1982; Cuccuini & Fiorini 2020). La répartition de l'espèce doit être affinée au vu des risques de confusion avec des graminées d'habitus assez similaire, bien que ses caractères discriminants soient assez nets: glumes ailées, inflorescences courtes et ne sortant peu des gaines, faiblement courbées, anthères inférieures de 1 mm et son port étalé et robuste.

Cette graminée halo-psammophile se développe sur les sols sablonneux-rocailleux d'arrière-plage, les dépressions salées, les pelouses de prés salés, etc. En Tunisie, l'espèce n'est pas signalée dans la flore de Tunisie (Cuénod 1954), et elle a été probablement confondue avec *P. incurva* (L.) C.E. Hubb. par Le Houérou (1995). Elle a été indiquée pour la première fois sur l'île de Djerba par Vanden Berghen (1981) qui la considérait comme "assez commune", mais confondue en partie avec *P. incurva* selon Lambinon (2000); elle a été découverte sur l'île satellite de Gataia el Gueblia lors de la mission PIM d'avril 2015 (Médail & al. 2020). Cette graminée a aussi été récoltée à une seule reprise sur l'île principale (El Bessila) de l'archipel des Kneiss, au sein d'une petite pelouse sableuse (Médail & al. 2016). Elle a également été recensée sur les îles principales des Kerkennah et sur les îles satellites de Gremdi et Sefnou (Médail & al. 2015a).

Prospero pulchellum (Munby) Speta – **Scille élégante (*Asparagaceae*)**

Cette petite plante bulbeuse à floraison automnale est un taxon maghrébin encore méconnu car sous-observé et mal circonscrit sur le plan taxonomique (Véla 2019). Il s'agit d'un taxon diploïde psammophile dont on ne connaît pas les relations de parenté avec les autres scilles diploïdes de Méditerranée centrale et occidentale (*Prospero corsicum* (Boullu) J.-M. Tison du S-Corse et N-Sardaigne; *Prospero hierae* Brullo & al. des îles Egades; *Prospero* sp. de Malte et des îles Kerkennah, etc.). Les individus de Zembra possèdent toutes les caractéristiques morphologiques et écologiques de ceux de la localité type historique de Aïn Franin près d'Oran en Algérie (E. Véla, obs. pers.). À Zembra, l'espèce est très abondante, quoique discrète selon la saison et le stade phénologique correspondant, et elle se localise dans les petites pelouses arénacées un peu humides ou plus rarement dans les fentes sablonneuses de rochers en exposition sud (E. Véla & F. Médail, obs. pers. 16-18.IV.2019).

Salsola tunetana Brullo – **Soude de Tunisie (*Amaranthaceae*)**

Il s'agit d'une espèce endémique du Sud de la Tunisie et de la Libye (Tripolitaine) décrite par Brullo (1982) sur la base d'une récolte de Labbe réalisée en 1951 entre Mareth et Adjim. Longtemps confondue avec *S. longifolia auct.* ou *S. oppositifolia auct*., elle fait partie du groupe de S. *oppositifolia* sect. *Darniella* (Maire & Weiller) Brullo. La soude de Tunisie est un buisson de 30-50 cm de haut en général mais qui peut dépasser 1 m. Il se caractérise par des fleurs solitaires, des feuilles et bractées opposées, un périanthe cylindrique-campanulé de 1,5-2 x 1,8-2 mm avec 5 ailes subégales de 2,5-4,5 mm de largeur (Brullo, 1982). Cette soude a été identifiée à Djerba par Barbagallo & al. (1990) et elle figure dans plusieurs relevés phytosociologiques réalisés par ces auteurs. Elle a également été découverte sur les îles satellites de Djerba, à Gataia el Bahria, Gataia el Gueblia et Dzira où elle est commune ou assez commune (F. Médail & al., obs. pers. IV.2015). Ce taxon (sub *S. oppositifolia* ou *S. longifolia*) était aussi noté sur les deux îles principales des

Kerkennah, et nous l'avons recensé sur l'île satellite de Roumadiya où un individu arbustif au tronc monocaule de hauteur remarquable (1,5 m) atteste des potentialités insoupçonnées de croissance de l'espèce (F. Médail & M. Chaieb, obs. pers. 22.X.2015) (Fig. 4 c, d). La soude de Tunisie existe aussi sur l'île principale de l'archipel des Kneiss (El Bessila) où elle est assez rare et localisée (F. Médail & al., obs. pers 11-12.IV.2015).

La distribution et le statut de rareté de cette halophyte endémique restent à préciser dans le Centre et Sud tunisien. Notons qu'à Mahdia, on signale la présence d'un important peuplement de soude à feuilles longues, dont il serait intéressant de vérifier s'il s'agit bien de *S. tunetana* (M. Chaieb, obs. pers.).

Senecio lividus L. **– Séneçon livide (*Asteraceae*)**

Ce petit séneçon annuel sténo-méditerranéen est peu fréquent en Afrique du Nord et très rare en Tunisie; il a été signalé par E. Bonnet en 1883 au Cap Bon sur les pentes du Jbel Cheban (Bonnet & Barratte 1896), et plus récemment dans les Mogods au NW du lac d'Ichkeul (Greuter & Domina 2015). Il a été découvert sur l'île de Zembra au printemps 2007 (E. Véla, obs. pers.), puis revu dans quelques pelouses acides ou sous la canopée du maquis à *Erica arborea* L. situé sur la croupe sud-ouest de l'île (F. Médail & E. Véla, obs. pers. 17.IV.2019).

Spergularia media **subsp.** ***sauvagei*** (P. Monnier) Lambinon & Dobignard **– Spergulaire de Sauvage (*Caryophyllaceae*)**

Cette spergulaire endémique du Maghreb est présente du Maroc à la Tunisie. Plante pérenne aux rameaux aphylles et avec des pétales roses arrondis au sommet, elle se distingue du type par ses capsules dépassant nettement le calice. D'après Pottier-Alapetite (1979) ce taxon (sub *Spergularia marginata* subsp. *chevallieri* Pott.-Alap.) est distribué en Tunisie centrale (Sousse, Sfax, Kasserine) et méridionale (Gabès, Gafsa, Zarzis). Cette sous-espèce n'avait pas encore été signalée sur l'archipel des Kerkennah; elle n'a été recensée que sur Gremdi où elle est très rare (Fig. 4 e) et sur Lazdad où elle est un peu plus commune (Médail & al. 2015b). Elle occupe les sansouires, sur sables temporairement humides.

Sphenopus divaricatus **subsp.** ***permicranthus*** (Hausskn.) H. Scholz **– Sphénope divariqué (*Poaceae*)**

L'existence de différents nombres chromosomiques ($2n$ = 12, 28, 54) a attiré l'attention sur la variabilité morphologique de cette petite graminée annuelle. La susbsp. *permicranthus* se distingue par la glume inférieure de l'épillet de 0,1-0,4 mm de long et la lemme inférieure d'environ 1 mm (contre 1,5-1,7 mm chez le subsp. *divaricatus*), et des anthères d'environ 0,2 mm de long (au lieu d'environ 0,4 mm) (Scholz 1990).

La susbsp. *permicranthus* est un taxon à distribution centrée sur le sud-est de la Méditerranée mais il existe une localité mentionnée au sud de l'Espagne, dans la province d'Almeria (Scholz 1990). Plus méridionale que le type, cette sous-espèce est en effet distribuée en Syrie, Israel/Palestine, Chypre, Egypte, Libye, Tunisie et Algérie. Contrairement à l'indication de Le Floc'h & al. (2010), ce taxon n'est donc pas endémique de Libye-Tunisie. Sa présence en Tunisie a été mise en évidence par Lambinon (2000) sur la base de matériel provenant de Djerba. L'espèce a été retrouvée sur l'île principale lors de la mis-

sion d'avril 2015, et recensée sur les trois grandes îles satellites (Gataia el Bahria, Gataia el Gueblia, Jlij) où elle détermine une communauté particulière avec *Filago mareotica* Delile, bien représentée à Gataia el Gueblia. Plus au nord, elle a été inventoriée sur l'île principale (El Bessila) de l'archipel des Kneiss (Médail & al. 2016), et sur plusieurs îles satellites des Kerkennah (Gremdi, Roumadiya, Ramadiya, Gharsa, Jeblia) (Médail & al. 2015b) (Fig. 4 a). L'identification de la sous-espèce doit être précisée sur les îles Kuriat où l'espèce a été recensée sur les deux îles principales (L. Hugot, obs. pers. 28-29.III.2014; S. Pasta & R. El Mokni, obs. pers. 28-30.IV.2015).

Sphenopus ehrenbergii Hausskn. – **Sphénope d'Ehrenberg (*Poaceae*)**

Cette petite graminée annuelle se distingue de *Sphenopus divaricatus* par sa panicule moins étalée avec des pédicelles plus renflés, des glumes inégales (l'inférieure ovale-lancéolée aiguë, la supérieure aiguë atteignant 1,5 mm) (Maire, 1955). Il s'agit d'une espèce sub-halophile à distribution mondiale restreinte, puisqu'endémique tuniso-libyenne. Elle est présente en Libye occidentale (Tripolitaine, environs de Tripoli et Zaouïa), en Tunisie centrale où elle a été signalée aux îles Kerkennah par Doûmet-Adanson et Cosson et en Tunisie méridionale (Gabès) par Murbeck selon Cuénod (1954) qui l'estime "*rare, dans les terrains salés et humides du littoral*". L'espèce a été aussi recensée par Vanden Berghen (1981) sur l'île de Djerba et évaluée comme assez commune au sein des "*dépressions humides dans les dunes littorales, lisières des terres salées*". Elle présente la même écologie sur les îles satellites des Kerkennah, à Lazdad, Gharsa (Fig. 4 b) et Jeblia où elle semble rare (Médail & al. 2015b) tout comme sur les plus grandes îles satellites de Djerba (Gataia el Bahria, Gataia el Gueblia et Jlij) (Médail & al. 2020).

Teucrium luteum **subsp.** ***gabesianum*** (S. Puech) Greuter & Burdet – **Germandrée de Gabès (*Lamiaceae*)**

La germandrée de Gabès est, avec *Limonium cercinense* Brullo & Erben, la seule plante endémique strictement tunisienne présente sur l'archipel des Kerkennah. Elle se rencontre à Djerba, Matmatas et Gafsa sur les sols plutôt limoneux, mais aussi gypso-calcaires comme dans le cas du site de Gabès (Le Houérou 1960) ou sur les "*dunes fixées et les rocailles pacagées*" (Vanden Berghen 1981). Selon Le Houérou (1960) qui avait décrit ce taxon sous le nom de *T. polium* subsp. *gabesianum* (S. Puech) Greuter & Burdet, il se caractérise par "*son port longuement prostré à tiges longes de 20-50 cm, courant à la surface du sol*", ce qui n'est pas le cas des populations kerkenniennes qui ont des rameaux prostrés moins longs. Les tiges et les feuilles, fortement révolutées, sont couvertes d'un indument dense grisâtre. L'inflorescence pyramidale se compose de fleurs aux corolles jaune doré, longues de 8 mm.

Ce taxon a été recensé sur les trois plus grandes îles satellites des Kerkennah, avec des niveaux divers de rareté: commun à Sefnou, il est plus rare et localisé à Gremdi et Roumadiya (Médail & al. 2015b). La germandrée de Gabès a été aussi recensée plus au Nord, sur l'île Grande Kuriate (S. Pasta & R. El Mokni obs. pers., 29-30.IV.2015) et récemment vers le centre du pays, à Kerker (région de Mahdia) et à Mesjed-Aïssa (région de Monastir) (R. El Mokni obs. pers., 05.IV.2020) (Fig. 4 f).

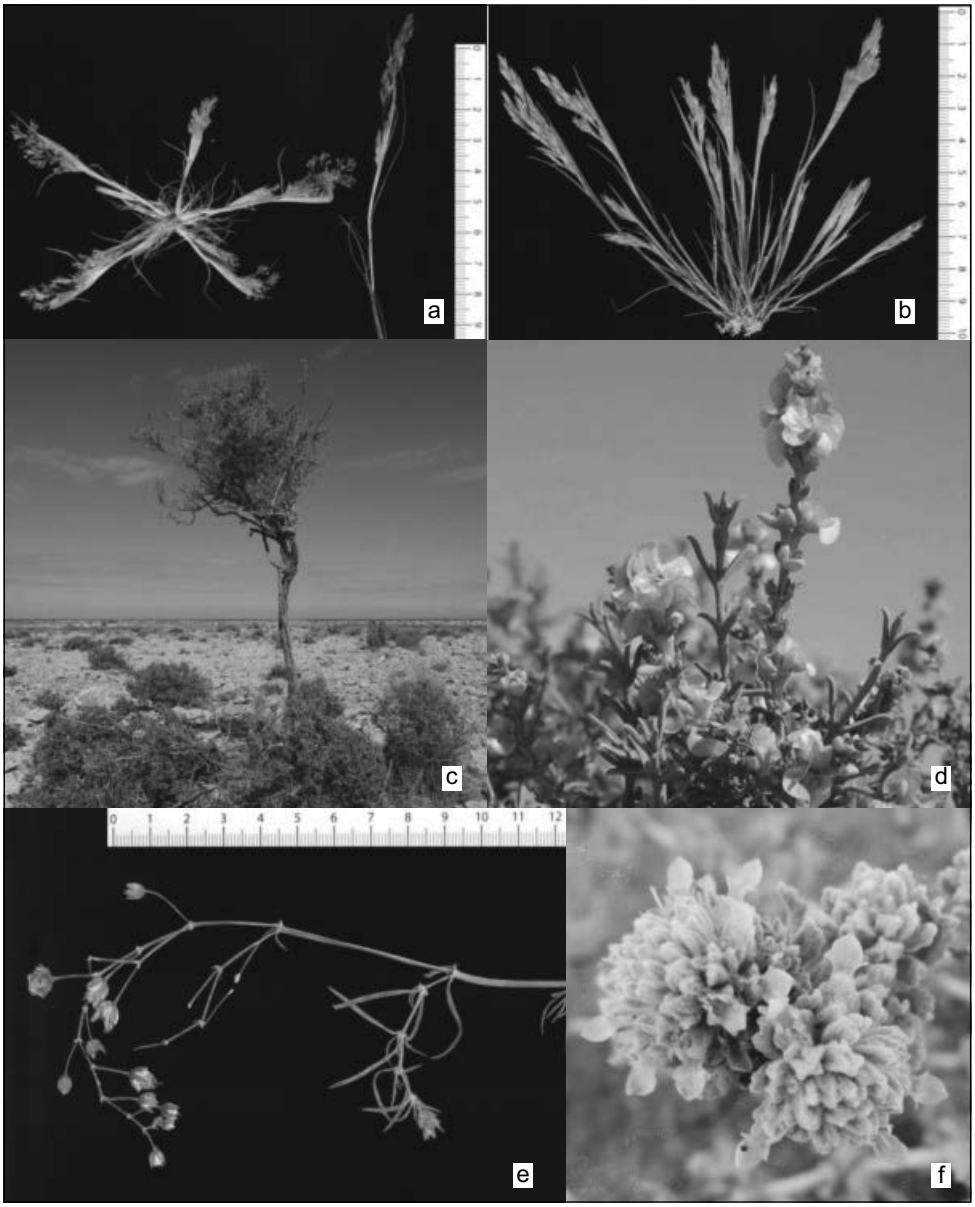


Fig 4. a) *Sphenopus divaricatus* susbsp. *permicranthus* (Hausskn.) H. Scholz récolté sur l'île Roumadiya (Kerkennah), 28.III. 2014 (herb. F. Médail, AIX), (cliché D. Pavon); b) *S. ehrenbergii* Hausskn. récolté sur l'île Gharsa (Kerkennah), 29.III.2014 (herb. F. Médail, AIX), (cliché D. Pavon); c) *Salsola tunetana* Brullo sur l'île Roumadiya (Kerkennah), individu remarquable de 1,5 m de haut et d) détail de l'inflorescence, 22.X.2015 (clichés F. Médail); e) *Spergularia media* subsp. *sauvagei* (P. Monnier) Lambinon & Dobignard récolté sur l'île Gremdi (Kerkennah), 27.III.2014 (herb. F. Médail, AIX), (cliché D. Pavon); f) *Teucrium luteum* subsp. *gabesianum* (S. Puech) Greuter & Burdet détail d'une l'inflorescence, dans une population continentale à Mesjed-Aïssa (région de Monastir), 05.IV.2020 (cliché R. El Mokni).

Conclusion

Cette contribution montre que la connaissance floristique de la Tunisie reste encore à améliorer, d'une part sur le plan taxonomique comme l'illustre la mise en évidence de taxons (*Dipcadi serotinum* subsp. *fulvum, Moraea mediterranea, Narcissus obsoletus*) jusqu'alors confondus avec des entités de plus vaste distribution, et d'autre part sur le plan chorologique car bon nombre de secteurs jusqu'alors négligés méritent des prospections fouillées.

Les îles tunisiennes sont un réservoir significatif de la biodiversité végétale du pays, avec de nombreuses espèces d'intérêt biogéographique (Pavon & Véla 2011; Véla & Pavon 2013; Médail & al. 2015a). La présente contribution recense la découverte sur l'île de Zembra de deux espèces tyrrhéniennes à distribution disjointe, *Asplenium balearicum* et *Galium minutulum* (Médail & Véla 2020), et de deux taxons jusqu'alors considérés comme endémiques des îles du Canal de Sicile, *Filago lojaconoi* et *Jacobaea maritima* subsp. *sicula* (Domina & El Mokni 2012).

Il existe aussi un contingent intéressant sur le plan phytogéographique, celui des végétaux sahariens *sensu lato*, c'est-à-dire dont la répartition géographique principale en Afrique du Nord est centrée au Sahara et qui arrivent en limite septentrionale de distribution sur les îles sableuses de la côte orientale. Plusieurs nouvelles signalisations sont relatives à cet ensemble (*Ammosperma cinereum*, *Astragalus pseudosinaicus, Centropodia forsskalii, Sphenopus divaricatus* subsp. *permicranthus*). Ce contingent est surtout bien présent sur l'archipel de Djerba où Vanden Berghen (1981) l'estime à 20% de la flore, soit environ 80 taxons; plus au Nord, sur l'archipel des Kerkennah, il atteint encore 25 taxons (Médail & al. 2015b). Dans un contexte plus global, la présence de ces végétaux d'affinité saharienne ou présaharienne découverts sur les îles tunisiennes laisse supposer un possible impact des changements climatiques (aridification accrue) sur leur processus migratoire.

Enfin, quelques endémiques *sensu lato* du Sud tunisien (*Anthemis confusa, Salsola tunetana, Teucrium luteum* subsp. *gabesianum*) sont nouvellement signalés sur les îles du golfe de Gabès.

Ces territoires insulaires représentent des refuges actuels majeurs pour la biodiversité littorale, comparés au littoral continental de la Tunisie qui subit de très forts impacts depuis des décennies.

Mais ces îles et îlots restent vulnérables face aux changements globaux (Médail, 2017; Neji & al. 2018), et il est nécessaire de développer sans tarder une politique ambitieuse de préservation de ce capital biologique unique avec la création de nouvelles aires protégées et le renforcement de la législation existante.

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Article

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Abbès Tanji

Notes about two summer annual grass weeds in Morocco: *Dinebra retroflexa* and *Cenchrus longispinus* (*Poaceae*)

Abstract

Tanji, A.: Notes about two summer annual grass weeds in Morocco: *Dinebra retroflexa* and *Cenchrus longispinus* (*Poaceae*). — Fl. Medit. 30: 113-119. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

Dinebra retroflexa was collected for the first time in Gharb in 2015 and 2017, and in Tadla in 2015. *Cenchrus longispinus* has been found in sandy soils in Rabat in 1985 and 1988, and in Larache in 2015. Heavy stands of both species observed at the collection sites in 2015 and 2017 suggested that both grasses are considered troublesome weeds in cultivated crops. This paper gives a brief description, distribution, and biology of both weeds.

Key words: weeds, xenophytes, alien flora, North Africa.

Introduction

With 142 genera and 399 species, the *Poaceae* is one of the richest plant families in the Flora of Morocco (Fennane & al. 2014). Such species richness is due to a great diversity of ecosystems, namely forest, steppe, desert, and aquatic ecosystems. In addition, Moroccan ecosystems extend over a range of bioclimatic levels from arid, semi-arid, sub-humid, to humid (Nassif & Tanji 2017). Fennane & al. (2014) included 3 grass weeds that were naturalized in Morocco: *Brachiaria eruciformis* (Sm.) Griseb., *Dactyloctenium aegyptium* (L.) Willd., and *Panicum capillare* L. (Tanji & Taleb 1997).

After Fennane & al. (2014), two non cited *Poaceae* have been added in Fennane (2018): *Dinebra retroflexa* and *Cenchrus longispinus*. Both grasses have been recently infesting crops in irrigated perimeters of Morocco. This paper gives a brief description, distribution, and biology of these two summer annual grass weeds.

Materials and Methods

This note is based on field observations, analysis of literature, and taxonomic investigations. Live specimens of *Dinebra retroflexa* were collected in 2015 and 2017 from cultivated fields in Gharb and Tadla irrigated perimeters, respectively. For the identification of

this taxon, various references were used including « The Online World Grass Flora » (Clayton & al. 2020), « Grasses of Egypt » (Ibrahim & al. 2016), and « Grasses of Libya » (Sherif 1995).

In 2015, *Cenchrus longispinus* plants were collected from Loukkos irrigated perimeter. For the identification of this species, different sources were used including « The Online World Grass Flora » (Clayton & al. 2020), « Flora Gallica, Flore de France » (Tison & de Foucault 2014), and Verloove & Sánchez Gullón (2012).

Results

***Dinebra retroflexa* (Vahl) Panz. (1813) (Viper grass)**

Bas: Cynosurus retroflexus Vahl (1791)

Dinebra retroflexa (Vahl) Panz. (1813) was not cited in Fennane & al. (2014) and efloramaghreb (2020). However, Dobignard & Chatelain (2010) reported its presence in Mauritania, Libya, and Egypt, and cited a synonym for it which is *Dinebra aegyptiaca* Delile. In 2018, *Dinebra retroflexa* was cited as a weed in Morocco (Fennane 2018). In the African Plant Database (APD 2020), two taxa are mentioned for Africa: *Dinebra retroflexa* (Vahl) Panz. var. *condensata* S.M. Phillips and *Dinebra retroflexa* (Vahl) Panz. var. *retroflexa* which is only mentioned for Egypt, Mauritania, and Libya.

According to « The Online World Grass Flora » (Clayton & al. 2020), *Dinebra retroflexa* has some specific features that can distinguish it from *Digitaria* species. The inflorescence of *Dinebra retroflexa* is linear or elliptic-oblong to pyramidal, composed of numerous racemes distributed along the floral axis, 10 to 35 cm (Fig. 1). The racemes are linear and are 1 to 8 cm long, stiff, ascending when young, reflexing and finally deciduous from the axis at maturity, folded down at maturity. During the spread, the whole raceme is detached with all its spikelets. The racemes bear 2 to 20 fertile spikelets on each raceme. The spikelets are alternate, sessile, 1-3-flowered, arranged in two rows on the lower sides of the rachis. The first flower is subsessile while the following ones are borne by a pedicel 0.5 to 1 mm long. The rachis is flattened, narrowly winged. The glumes are longer than the flowers, 6 to 8 mm long, asymmetric; the lower glume is shorter than the upper glume. They are coriaceous, lanceolate, with slightly recurved minutely scaberulous awns, usually overlapping and obscuring the florets. The lemmas are narrowly ovate, 2 to 2.5 mm long, membranous, acute to emarginate, mucronulate, glabrous or have some fine hairs near the dorsal vein. The paleas are membranous, bicarinated, and finely pubescent along the dorsal veins. The anthers are purplish red. The caryopsis is ellipsoid with adherent pericarp. The grain is ovoid, 1.5 mm long. Chromosome $2n = 20$.

Dinebra retroflexa is an annual *Poaceae* that multiplies by seed during spring (March-May) or summer (June-August). High temperatures and day length trigger germination, growth, and flowering. Moroccan climatic conditions would be suitable for this species to become a troublesome weed in summer crops in irrigated perimeters.

Live specimens of *Dinebra retroflexa* were collected from a corn (*Zea mays* L.) field in July 2015 and again in July 2017 in the same site in Sidi Kacem province, Gharb perimeter (Fig. 1). Plants of the same species were found in a corn field in June 2017 in Souk Sebt Ouled Nemma, Béni Mellal province, Tadla irrigated perimeter. Seed of this plant species were probably introduced with crop seeds, used machinery, or visitors' clothes.



Fig. 1. *Dinebra retroflexa*: detail of the inflorescences. Photo taken by the author in a corn field in Sidi Kacem province, Gharb irrigated perimeter in July 2015.



Fig. 2. Distribution of *Dinebra retroflexa* (triangles) in Morocco : Sidi Kacem, Gharb irrigated perimeter situated in Man 1 “Maroc Atlantique Nord 1” and Béni Mellal, Tadla irrigated perimeter situated in Mam 5 “Maroc Atlantique Moyen 5”.

This new taxon enriches the *Poaceae* family, and botanists should report it as a summer annual grass weed in “Maroc Atlantique Nord 1”, North Atlantic Morocco 1 (“Man 1” sector) and “Maroc Atlantique Moyen 5”, Medium Atlantic Morocco 5 (“Mam 5” sector) (Fig. 2).

Elsewhere, the species is considered an important weed in sugarcane (*Saccharum officinarum* L.), cotton (*Gossypium hirsutum* L.), peanut (*Arachis hypogea* L.), sorghum [*Sorghum bicolor* (L.) Moench], onion (*Allium cepa* L.), and rice (*Oryza sativa* L.) in Sudan (Ghobrial 1981; Ibrahim 1984; Babiker & Ahmed 1986; Karar & al. 2005).

A brief literature review showed that *Dinebra retroflexa* is found in Mauritania (Dobignard & Chatelain 2010), Libya (Dobignard & Chatelain 2010), Egypt (Lebrun 1998; Dobignard & Chatelain 2010; Ibrahim & al. 2016), Ethiopia, Sudan, Kenya, Rhodesia, Tanzania (Lebrun 1998), Somalia, Namibia, Botswana, South Africa, and Madagascar (APD 2020). It is also found in Spain (Valdés & Scholz 2009), Italy (Valdés & Scholz 2009; Domina & al. 2018), Czech republic (Valdés & Scholz 2009; Pysek & al. 2012), Poland (Sowa 1968), Turkey (Gonen & al. 2002), Israel (Valdés & Scholz 2009), Iraq (Lebrun 1998), India (Ibrahim & al. 2016; Clayton & al. 2020), the USA (Riefner & al. 2003), China, Malaysia, and Australia (Clayton & al. 2020).

***Cenchrus longispinus* (Hack.) Fernald (1943) (long spine sandbur)**

Neither Fennane & al. (2014) nor Dobignard & Chatelain (2010) or efloramaghreb (2020) mentioned *Cenchrus longispinus*. However, this species has been cited in Morocco (Verloove & Sánchez Gullón 2012; Fennane 2018; APD 2020).

According to « The Online World Grass Flora » (Clayton & al. 2020), *Cenchrus longispinus* has some particular features that can distinguish it from other *Cenchrus* species. Panicles are terminal, well exerted or partially enclosed in the sheath below, compact, oblong, 4 to 10 cm long, 1 to 2 cm wide (Fig. 3). Flowers are enclosed in round, spine-covered burs, with 2 or 3 spikelets per bur and 1 fertile flower per spikelet. Glumes are unequal in length and shorter than the lemma. Flower styles and stamens poke out from the tip of the bur. Burs are about 6 mm in diameter (excluding the spines) and densely short-hairy; spines are barbed, 3 to 6 mm long, often purplish, becoming very sharp when dried. Burs dry to a light tan and latch onto anything that passes by. Inside burs are 1 to 3 seeds. Chromosome number $2n = 34$ or 36.

Cenchrus longispinus plants were collected in July 2015 from the sandy soil of the garden at the headquarters of the extension service of the ORMVAL (Subdivision de l'Office Régional de Mise en Valeur Agricole du Loukkos) in Laouamra village, Larache province, Loukkos irrigated perimeter (Fig. 3). Verloove & Sánchez Gullón (2012) reported that *Cenchrus* plants collected by J. Lewalle in sandy soils in Souissi, Rabat, July 1, 1985, and August 7, 1988, would be *Cenchrus longispinus*.

Cenchrus longispinus is an annual *Poaceae* which multiplies by seed during spring (March-May) or summer (June-August). Germination, growth, and flowering may be initiated by high temperatures and day length.

Cenchrus longispinus seed contained in the burs can be divided into two groups. Seeds in the upper spikelet have the largest chance of survival and are likely to totally germinate in the same year they are produced. Seeds in the lower spikelet have a low chance of germination the first year they are produced and often go into dormancy (Twentyman 1974; Boydston 1990). Longspine sandbur seedlings can germinate from depths of 11 cm but emerged most readily from 1- to 3-cm depths (Boydston 1989). In the state of Washington, USA, if *Cenchrus longispinus* is allowed to grow season-long without crop competition, it has the potential to produce up to 133 000 seeds per plant (Boydston 1990).

In July 2015, several plants of *Cenchrus longispinus* were at the fruiting stage in the ORMVAL headquarters at Laouamra village, Loukkos irrigated perimeter (Fig. 3). Under local soil and climatic conditions, longspine sandbur could be one of the most problematic weeds of corn (*Zea mays* L.), sorghum [*Sorghum bicolor* (L.) Moench], peanuts (*Arachis hypogea* L.), alfalfa (*Medicago sativa* L.), sugarcane (*Saccharum officinarum* L.), strawberry (*Fragaria ×ananassa* (Weston) Rozier), potato (*Solanum tuberosum* L.), and other crops in Loukkos irrigated perimeter and other locations in Morocco. Longspine sandbur may become a greater problem when it begins to produce seed-forming burs. Alfalfa, corn or sorghum infested with longspine sandbur would be unpalatable. The spines on the burs facilitate attachment to almost anything, including people, animals, machinery, and tires, easily spreading the seed to other areas. Furthermore, hand weeding in various crops would be difficult or even an impossible task. This taxon enriches the *Poaceae* family, and botanists should report it as a summer annual grass weed in "Maroc Atlantique Nord 2 et 3", North Atlantic Morocco 2 and 3 ("Man 2 and Man 3" sector) (Fig. 4).

Elsewhere, *Cenchrus longispinus* has become a weed that is difficult to control in several crops in irrigated and dryland areas of Australia (Twentyman 1974), Canada (Soltani & al. 2010) and USA (Boydston 1989 & 1990; Anderson 1997; Hennigh & Al Khatib 2010).



Fig. 3. *Cenchrus longispinus*: inflorescence. Photo taken by the author from a sandy soil in Laouamra village, Larache province, Loukkos irrigated perimeter in July 2015.



Fig. 4. Distribution of *Cenchrus longispinus* (squares) in Morocco: Rabat situated in Man 3 "Maroc Atlantique Nord 3" and Larache province, Loukkos irrigated perimeter situated in Man 2 "Maroc Atlantique Nord 2".

The species is native to North America (Canada, Mexico, and the United States). It is found in sandy soils and beaches of the Corse island and Vaucluse in France (Tison & de Foucault 2014), Romania (Strat & al. 2017), Iran (Naqinezhad 2012), Greece, Italy, Croatia, Hungary, Israel (Valdés & Scholz 2009; Verloove & Sánchez Gullón 2012), Great Britain, Georgia, and Ukraine (Valdés & Scholz 2009), Australia**,** eastern Canada, and South America (Clayton & al. 2020).

Viper grass (*Dinebra retroflexa*) is a new taxon for the flora of Morocco that has been collected in Gharb in 2015 and 2017, and in Tadla in 2015. Longspine sandbur (*Cenchrus longispinus*) has been found in Rabat in 1985 and 1988, and in Larache in 2015. Both weeds were probably introduced with crop seeds, used machinery, or visitors' clothes. Heavy stands observed at the collection sites in 2015 and 2017 suggested that both species are considered troublesome weeds in cultivated crops.

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Article

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F. Verloove, E. A. Déniz Suárez & M. Salas Pascual

New records of non-native vascular plants in Gran Canaria (Spain, Canary Islands)

Abstract

Verloove, F., Déniz Suárez, E. A. & Salas Pascual, M: New records of non-native vascular plants in Gran Canaria (Spain, Canary Islands). — Fl. Medit. 30: 121-136. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

Recent field work by the authors on the island of Gran Canaria (Canary Islands, Spain) yielded new interesting records of non-native species. Seven species, i.e. *Centaurea sulphurea*, *Clematis flammula*, *Fallopia baldschuanica*, *Fraxinus angustifolia*, *Melilotus officinalis*, *Saponaria officinalis*, and *Searsia lancea* have not been recorded before from the Canary Islands, whereas 13 species (*Bellis perennis*, *Centaurea diluta*, *Chlorophytum comosum*, *Chondrilla juncea*, *Cyperus papyrus*, *Delphinium ajacis*, *Helianthus annuus*, *Lonicera japonica*, *Lupinus pilosus*, *Montanoa bipinnatifida*, *Ornithogalum arabicum*, *Trifolium cernuum*, and *Wigandia caracasana*) are reported for the first time from Gran Canaria. The actual presence of five further species (*Chenopodium vulvaria*, *Fallopia convolvulus*, *Kalanchoe daigremontiana*, *Paspalum dilatatum*, and *Volutaria tubuliflora*) – all considered doubtful, recently discovered or with only historical occurrences in Gran Canaria – is confirmed. Chorological and ecological details are presented for these species and their invasion status is assessed. Many of them are reputed weeds, either agriculturally or environmentally.

Key words: xenophytes, alien flora, floristic inventories.

Introduction

This paper is a sequel to Verloove (2013 and 2017) and Verloove & al. (2018). We present new records for species that are either new to the Canary Islands (and even Macaronesia as a whole) or new to the island of Gran Canaria. The emphasis is on species that are naturalized or on their way to future naturalization, (potentially) invasive or that are otherwise of interest. In addition, comments are presented on some species for which the actual presence in Gran Canaria required confirmation.

Materials and methods

Herbarium specimens were collected for most of the records and these are deposited in the herbaria BR (Meise Botanic garden, Belgium) and/or LPA (Jardín Botánico Canario

Viera y Clavijo, Gran Canaria) (herbarium acronyms according to Thiers 2020). For records that were not substantiated by a voucher, photographs were made. These, following Gómez Bellver & al. (2019), were, provided by a herbarium label, deposited in PAL. Some species are also illustrated in this paper.

The invasion status for each taxon was assessed based on criteria as proposed by Blackburn & al. (2011).

Results

Taxa newly recorded for the flora of Gran Canaria and/or the Canary Islands

Bellis perennis L. (*Asteraceae*)

New record for the flora of Gran Canaria.

Category C3: Individuals surviving in the wild in location where introduced, reproduction occurring, and population self-sustaining (Blackburn & al. 2011).

Observation: GRAN CANARIA: San Bartolomé de Tirajana, San Agustín, 27°46'15.96"N, 15°32'34.73"W, irrigated lawn in front of Hotel Meliá Tamarindos, 2 June 2019, *M. Salas Pascual* s.c.

Bellis perennis is native to large parts of Eurasia and a common weed in other temperate regions of the world. It was not yet mentioned from the Canary Islands by Acebes Ginovés & al. (2010). In 2013 it was recorded in an irrigated lawn in La Palma (Otto & Verloove 2016) and it is also known to one of us (FV) from Tenerife since 2017 (Verloove, in prep.). In 2019 it was recorded for the first time from Gran Canaria as well, in circumstances identical to those in La Palma.

Centaurea diluta Aiton (*Asteraceae*)

New record for the flora of Gran Canaria.

Category D2: Self-sustaining population in the wild, with individuals surviving and reproducing a significant distance from the original point of introduction (Blackburn & al. 2011).

Herbarium: GRAN CANARIA: Arucas, Barreto, Camino Real a Riquiánez, 28º06´31.05"N, 15º 31´15.58"W, 25 May 2019, *E. A. Déniz Suárez* 13 (BR).

This western Mediterranean weed (Devesa & López Nieto 2014) has been known from the Canary Islands from La Gomera and Tenerife (Méndez & Wildpret 1978; Acebes Ginovés & al. 2010), subsequently also from Lanzarote (Gil González & al. 2014). It is here reported for the first time from Gran Canaria.

A small group of individuals (probably less than 30) was observed at an altitude of 265 m. The population is located on the edge of a mud pond, in a highly anthropized peri-urban area, with scattered houses and abandoned farmland. Accompanying species included, among others: *Carthamus lanatus* L., *Scolymus maculatus* L., *Beta macrocarpa* Guss., *Lactuca serriola* L., *Helminthotheca echioides* (L.) Holub, *Salvia canariensis* L. and *Pallenis spinosa* (L.) Cass.

Centaurea sulphurea Willd. (*Asteraceae*) (Fig. 1a)

New record for the flora of the Canary Islands.

Category D2: Self-sustaining population in the wild, with individuals surviving and reproducing a significant distance from the original point of introduction (Blackburn & al. 2011).

Herbarium: GRAN CANARIA: Tejeda, crossing at Roque Bentayga, 27º59´21.03"N, 15º38´05.33"W, 16 May 2019, *E. A. Déniz Suárez* 12a (BR); Vega de San Mateo, Morro de la Almagría, next to the road, 28º00´06.54"N, 15º35´39.54"W, 16 May 2019, *E. A. Déniz Suárez* 12b (BR); Vega de San Mateo, Degollada Becerra, 27º59´21.18"N, 15º35´35.10"W, 23 May 2019, *E. A. Déniz Suárez* 12c (BR); Vega de San Mateo, Degollada Florida, 27º59´08.73"N, 15º35´19.61"W, 10 June 2019, *E. A. Déniz Suárez* 11 (BR).

Centaurea sulphurea is native to southwestern Europe (Iberian Peninsula and Morocco, Algeria and Libya; Devesa & López Nieto 2014). It is considered to be a noxious weed in California (Keil & Ochsmann 2006) and has not been recorded before in the Canary Islands (Acebes Ginovés & al. 2010).

This species was recently detected in four localities in Gran Canaria. A first one is located in Morro de la Almagría, on both sides of the C-150 road, 500 meters from the Cruz de Tejeda in the direction of Los Pechos at an altitude of 1,535 m. It is composed of a fairly large group of specimens (at least one hundred). Accompanying species are, among others, *Vinca major* L., *Ferula linkii* Webb, *Avena barbata* Pott ex Link and *Aeonium simsii* (Sweet) Stearn. A second locality is located on the margin of the road from Cruz de Tejeda to Los Pechos (Degollada de Becerra or Degollada de las Palomas), at an altitude of 1,550 m. This population is smaller (less than 50 individuals) and accompanied by species such as *Carthamus lanatus* L., *Vicia angustifolia* L., *Avena sativa* L., *Lathyrus angulatus* L., *Teline microphylla* (DC.) P. E. Gibbs & Dingwall, *Pinus canariensis* C. Sm. (repopulation), *Ferula linkii* Webb, *Silybum marianum* (L.) Gaertn. and *Galactites tomentosa* Moench. The third population, with at least 100 individuals, although mostly of small sizes, is located in Degollada Florida at the junction between the C-150 and the C-135 roads, at an altitude of 1,590 m. The plants grow under a cattle trough next to the road, and, like the rest of localities, in grazing areas. The last population is located between Patacabras and Casas del Lomo, on both sides of the crossing to Roque Bentayga (Tejeda) at an altitude of 1,147 m. It counts less than fifty individuals. Accompanying species are *Carthamus lanatus* L., *Scolymus hispanicus* L. subsp. *hispanicus*, *Hirschfeldia incana* (L.) Lagr.-Foss., *Anchusa azurea* Mill., *Prunus dulcis* (Mill.) D.A. Webb, *Cladanthus mixtus* (L.) Oberpr. & Vogt, *Allagopappus viscosissimus* Bolle, *Silybum marianum* (L.) Gaertn. and *Galactites tomentosa* Moench.

In Gran Canaria *Centaurea sulphurea* is found in upland pastures with high biodiversity and – except in the last population – in areas with high annual rainfall, cold weather conditions in winter and in traditionally grazed spaces. In Tejeda it is found in a slightly lower zone with a warmer and drier climate.

Although in Gran Canaria the species occurs in relatively undisturbed areas it is most likely an introduced species that is dispersed by cattle, especially sheep.

Chlorophytum comosum (Thunb.) Jacques (*Asparagaceae*)

New record for the flora of Gran Canaria.

Category C2: Individuals surviving in the wild in location where introduced, reproduction occurring, but population not self-sustaining (Blackburn & al. 2011).

Observations: GRAN CANARIA: Teror, Finca de Osorio, on the edge of the road under a group of *Laurus* trees, 28º04´31.04”N, 15º32´59.14”W, 31 July 2018, *E. A. Déniz Suárez* s.c.; Moya, Fontanales-San Fernando, 28º03´42.92”N, 15º36´11.02”W, 2018 (casual), *E. A. Déniz Suárez* s.c.; Vega de San Mateo, Urb. El Pintor, 28º00´34.52”N, 15º31´53.10”W, self-seeding individuals, 2018, *E. A. Déniz Suárez* s.c.

This South African ornamental is widely cultivated, also in the Canary Islands, from where it was not mentioned yet by Acebes Ginovés & al. (2010). However, this species was reported already by Rodríguez Delgado & García Gallo (2005) who found it in El Bosque del Adelantado in La Esperanza (Tenerife). After that, Santos & al. (2013a) confirmed this species from Los Batanes-Barranco del Río (La Laguna), also in Tenerife. In 2014, Otto & Verloove (2016) found this species in La Villa de Mazo in La Palma, as ephemeral species.

It has been observed on several occasions in Gran Canaria, for instance near to the Osorio (Teror) estate at an altitude of 650 m. Another individual was seen alongside the road from Fontanales to San Fernando (belonging to the municipality of Moya**)**. In Vega de San Mateo, in the Urbanization El Pintor, at an altitude of 828 m., self-seeding individuals were seen in a garden.

Chlorophytum comosum is regarded as a minor environmental weed in New South Wales, Queensland and Victoria in Australia. Plants become established in native habitats when they are introduced to the area in discarded garden refuse. Once established they spread by plantlets and individual clumps can spread quite extensively, excluding native plants in the ground layer of natural vegetation (Weeds of Australia 2019).

Chondrilla juncea L. (*Asteraceae*) (Fig. 1b)

New record for the flora of Gran Canaria.

Category D2: Self-sustaining population in the wild, with individuals surviving and reproducing a significant distance from the original point of introduction (Blackburn & al. 2011).

Observations: GRAN CANARIA: Vega de San Mateo, Era del Barranco (Los Pechos), between grassland and scrubland, close to road GC-130, 27º57´54.13”N, 15º33.32.62”W, 18 June 2019, *E. A. Déniz Suárez* s.c.; Vega de San Mateo, Llanos de Ana López, 27º59´06.80”N, 15º34´42.73”W, in the middle of a repopulation of *Pinus canariensis*, 19 August 2019, *E. A. Déniz Suárez* s.c.

Chondrilla juncea is a native species in the Mediterranean region. Elsewhere in suitable climates it is a noxious weed, for instance in Australia and parts of North America (Panetta & Dodd 1987; Gottlieb 2006). In the Canary Islands it was only known so far from Tenerife (Santos Guerra 1996; Acebes Ginovés & al. 2010).

In Gran Canaria this species is found since 2018 in two localities. A first population was found in Era del Barranco-Los Pechos (Vega de San Mateo), at an altitude of 1,810 m. This area belongs to the protected area called “Paisaje Protegido de Las Cumbres”. The species grows on the margins of the GC-130 road and the number of individuals is low, less than 30, although the species often tends to form dense clusters of individuals. The plants were observed to be eaten by rabbits. The locality is a “mosaic” area composed of open grasslands, patches of *Micromerio benthami-Telinetum microphyllae*, *Echio plantaginei-Galactition tomentosae* vegetation (syntaxa here and below are in accordance with del Arco Aguilar & Rodríguez Delgado 2018) and surrounded by restocking pine forests. It is

an area that has been traditionally pastored and that was affected by the forest fires of 2017. *Chondrilla juncea* grows among endemics that are in danger of extinction, for instance *Onopordum carduelium* Bolle. Other accompanying species of interest are: *Erysimum albescens* (Webb & Berthel.) Bramwell, *Marrubium vulgare* L., *Adenocarpus foliolosus* (Aiton) DC., *Teline microphylla* (DC.) P. E. Gibbs & Dingwall, *Allium ampeloprasum* L., *Anthriscus caucalis* M. Bieb., *Ranunculus cortusifolius* Willd., *Asphodelus ramosus* L. and *Leopoldia comosa* (L.) Parl. among others. A second population was discovered in Llanos de Ana López (Vega de San Mateo): a small group of about five individuals was observed at an altitude of 1,620 m. The plants are located in the middle of a repopulation of *Pinus canariensis* C. Sm. which was also affected by the aforementioned forest fire of 2017. The species grows together with *Lactuca serriola* L., another expanding species on the island. In both places the precipitation is high and the weather is cold in winter with, occasionally, times of snow.

Chondrilla juncea probably is a recent introduction in Gran Canaria, unless it had been overlooked so far. It is unknown when and how it was introduced. Like other species of *Asteraceae* such as *Scolymus* or *Carthamus* among others, cattle may be responsible for its propagation.

Clematis flammula L. (*Ranunculaceae*)

New record for the flora of the Canary Islands.

Category C1: Individuals surviving in the wild (i.e. outside of captivity or cultivation) in location where introduced, no reproduction (Blackburn & al. 2011).

Herbarium: GRAN CANARIA: Vega de San Mateo, La Lechucilla, entrance to the Carretera General, 27º59´57.82”N, 15º32´35.93”W, 27 June 2019, *E. A. Déniz Suárez* 2 (BR); Vega de San Mateo, road to El Chorrillo, 28º01´08.55”N, 15º31´30.53”W, 25 July 2019, *E. A. Déniz Suárez* 3 (BR).

Clematis flammula is a native species in the Mediterranean area and sometimes grown as an ornamental vine elsewhere. Up to present, it had not been recorded in the Canary Islands (Acebes Ginovés & al. 2010).

In recent years it was recorded on two occasions in Gran Canaria, both located in Vega de San Mateo. In La Lechucilla the species is growing next to a huge specimen of *Podranea ricasoliana* (Tanfani) Sprague. A further specimen was observed on a border next to *Rubus ulmifolius* Schott.

The plants found in Gran Canaria were first thought to belong to *Clematis vitalba* L., a more temperate species that also has weedy tendencies and likely to occur also in the Canary Islands. *C. flammula* is distinguished by its twice pinnate leaves (vs. once pinnate) and its sepals that are only hairy on the lower side (vs. on both sides).

Cyperus papyrus L. (*Cyperaceae*)

New record for the flora of Gran Canaria.

Category C1: Individuals surviving in the wild (i.e. outside of captivity or cultivation) in location where introduced, no reproduction (Blackburn & al. 2011).

Observation: GRAN CANARIA: Santa Brígida, 28º02´07.67”N, 15º29´45.01”W, a single culm in a pond, 27 November 2019, *E. A. Déniz Suárez* s.c.

Cyperus papyrus is probably native to Central Africa but it has been cultivated since ancient times elsewhere in the Old World tropics. It was once collected in Tenerife, in La Quinta in 1971 (Verloove 2017).

In Gran Canaria this species grows in a pool in Santa Brígida where it is persisting since several years. In 2019, however, the pool was cleaned and all plants except a single culm were removed.

Delphinium ajacis L. (*Ranunculaceae*)

Consolida ajacis (L.) Schur

New record for the flora of Gran Canaria.

Category C3: Individuals surviving in the wild in location where introduced, reproduction occurring, and population self-sustaining (Blackburn & al. 2011).

Herbarium: GRAN CANARIA: Vega de San Mateo, La Lechuza, 28º00´26.18”N, 15º33´11.74”W, 7 June 2019, *E. A. Déniz Suárez* 10 (BR).

Delphinium ajacis is probably native to southern Europe and adjacent parts of Asia. It is a frequent weed elsewhere and is also grown as an ornamental. In the Canary Islands it has been recorded so far from Tenerife (García Gallo 1987, Santos Guerra & al. 2014, Acebes Ginovés & al. 2010) and subsequently from La Palma and El Hierro by Santos & al. (2014).

In Gran Canaria a single population was discovered in the neighborhood of La Lechuza next to the GC-15 road at an altitude of 1,040 m. According to locals, the species was grown there many years ago and apparently has established itself locally.

Fallopia baldschuanica (Regel) Holub (*Polygonaceae*) (Fig. 1c)

New record for the flora of the Canary Islands.

Category C1: Individuals surviving in the wild (i.e. outside of captivity or cultivation) in location where introduced, no reproduction (Blackburn & al. 2011).

Observation: GRAN CANARIA: Vega de San Mateo, Camino Real to El Chorrillo, 28º00´49.66”N, 15º31´47.39”W, a single but very huge specimen, 9 May 2018, *E. A. Déniz Suárez* s.c.

Fallopia baldschuanica is a commonly grown ornamental vine from Asia. It is very vigorous and easily escapes from cultivation. Up to present it had not been recorded in the wild in the Canary Islands (Acebes Ginovés & al. 2010).

In Vega de San Mateo (*camino real* to Chorrillo), at an altitude of 750 m, a huge specimen with stems up to ca. 15 m long is growing on the verge of the road. The species is very aggressive and overgrows native species such as *Ferula linkii* Webb. It was also seen cultivated elsewhere in Vega de San Mateo.

Fallopia baldschuanica is here accepted in a broad sense as to include *F. aubertii* (L. Henry) Holub.

Fraxinus angustifolia Vahl (*Oleaceae*)

New record for the flora of the Canary Islands.

Category C1: Individuals surviving in the wild (i.e. outside of captivity or cultivation) in location where introduced, no reproduction (Blackburn & al. 2011).

Herbarium: GRAN CANARIA: Tejeda, Los Llanos de la Pez, 27º57´56.05”N, 15º35´03.01”W, 15 April and 27 May 2019, *E. A. Déniz Suárez* 8 (BR).

Fraxinus angustifolia is native to central and southern Europe, northwest Africa and southwest Asia. Not a single species of the genus has been recorded so far in the Canary Islands (Acebes Ginovés & al. 2010).

In Gran Canaria a group of several individuals was recorded in 2019 in Los Llanos de la Pez (Tejeda) in the middle of a repopulation of *Pinus canariensis* C. Sm., at an altitude of 1,675 m.

Helianthus annuus L. (*Asteraceae*)

New record for the flora of Gran Canaria.

Category C2: Individuals surviving in the wild in location where introduced, reproduction occurring, but population not self-sustaining (Blackburn & al. 2011).

Observation: GRAN CANARIA: Gáldar, barranco de Gáldar, in the riverbed, 28º09´18.07”N, 15º39´56.61”W, 26 March 2018, *E. A. Déniz Suárez* s.c.

This North American species has been recorded in the Canary Islands from Tenerife and Fuerteventura (Acebes Ginovés & al. 2010). Otto & Verloove (2016) also reported this species from La Palma. It is here reported for the first time from Gran Canaria.

A single individual was observed in the ravine of Gáldar along with other species of ruderal habitats such as *Ricinus communis* L.

Lonicera japonica Thunb. (*Caprifoliaceae*) (Fig. 1d)

New record for the flora of Gran Canaria.

Category D2: Self-sustaining population in the wild, with individuals surviving and reproducing a significant distance from the original point of introduction (Blackburn & al. 2011).

Observations: GRAN CANARIA: Teror, Finca de Osorio, near the main house, 28° 4’15.70”N, 15°32’34.53”W, 665 m, 19 March 2019, *M. Salas Pascual* s.c; Teror, Finca de Osorio, path from La Huerta to Las Camelias, 28° 4’9.82”N, 15°32’49.40”W, 675-700 m, 19 March 2019, *M. Salas Pascual* s.c.

Lonicera japonica is an East Asian vine that is widely cultivated as an ornamental. In the Canary Islands it was only known so far from Tenerife where it is considered an invasive species (Acebes Ginovés & al. 2010). It is here reported for the first time from Gran Canaria.

It was recorded since 2018 in two localities at the Finca de Osorio in Teror. A first population is found at the path from La Huerta to Las Camelias. The species proliferates there on *Castanea sativa* Mill. but also on the ground and on low scrub and covers about 200 m². A second population is found at an altitude of 665 m and overgrows *Laurus novocanariensis* Rivas Mart., Lousã, Fern.Prieto, E.Días, J.C.Costa & C.Aguiar scrubland. This location is close to a garden, where the plant could come from, whereas the first town is about 500 m away.

Lupinus pilosus L. (*Fabaceae*)

New record for the flora of Gran Canaria.

Category D2: Self-sustaining population in the wild, with individuals surviving and reproducing a significant distance from the original point of introduction (Blackburn & al. 2011).

Observation: GRAN CANARIA: San Bartolomé de Tirajana, road to Degollada de La Manzanilla, 27º55´03.65”N, 15º34´36.40”W, between scattered pine grove and *Cistus monspeliensis* scrubland, 25 February 2017, *E. A. Déniz Suárez* s.c.

Lupinus pilosus is endemic to Israel where it is found in Mediterranean scrubland. It is regularly grown elsewhere as a culinary herb or as an ornamental. It has been recorded in the Canary Islands from La Palma and Tenerife (Santos Guerra 1996; Acebes Ginovés & al. 2010; Santos Guerra & al. 2014). It is here reported for the first time from Gran Canaria.

This species is very common in San Bartolomé de Tirajana, especially along the road that leads to the Degollada de La Manzanilla. It grows in the middle of scattered pine grove and *Cistus* scrubland, near country houses. It most likely escaped from former plantations and now has established itself in this area

Melilotus officinalis (L.) Pallas (*Fabaceae*)

New record for the flora of the Canary Islands.

Category D2: Self-sustaining population in the wild, with individuals surviving and reproducing a significant distance from the original point of introduction (Blackburn & al. 2011).

Herbarium: GRAN CANARIA: Las Palmas de Gran Canaria, San Miguel, 28º06´49.83”N, 15º27´20.15”W, flowerbed near the cemetery, 14 March 2019, *E. A. Déniz Suárez* 7 (BR); Las Palmas de Gran Canaria, at the cemetery of San Miguel, 28º06´49.83”N, 15º27´20.15”W, 13 June 2019, *E. A. Déniz Suárez* 6 (BR).

Melilotus officinalis is native to Eurasia and widely naturalized elsewhere as an agricultural weed. It had not been recorded before in the Canary Islands (Acebes Ginovés & al. 2010). It is here reported for the first time from Gran Canaria.

It is naturalized as a weed in flowerbeds close to the cemetery of San Miguel in Las Palmas de Gran Canaria.

Melilotus segetalis (Brot.) Ser. was recently also reported from Gran Canaria (Marrero 2019), for the first time in the Canary Islands.

Montanoa bipinnatifida (Kunth) K. Koch (*Asteraceae*) (Fig. 1e)

New record for the flora of Gran Canaria.

Category C1: Individuals surviving in the wild (i.e. outside of captivity or cultivation) in location where introduced, no reproduction (Blackburn & al. 2011).

Observation: GRAN CANARIA: Santa Brígida, Camino de Las Arenillas, 28° 2’0.47”N, 15°28’17.46”W, rough ground adjacent to the road, a single shrub, 17 April 2018, *F. Verloove* s.c.

This Mexican species is grown as an ornamental in warm-temperate and subtropical regions across the world. In the Canary Islands it was previously reported from Tenerife (Knapp 1976; Acebes Ginovés & al. 2010) and it was recently also observed in La Palma (Otto & Verloove 2020). It is here reported for the first time from Gran Canaria.

A single shrub was seen in shrubland in Santa Brígida (Camino de Las Arenillas) in 2018.

Ornithogalum arabicum L. (*Asparagaceae*)

New record for the flora of Gran Canaria.

Category C2: Individuals surviving in the wild in location where introduced, reproduction occurring, but population not self-sustaining (Blackburn & al. 2011).

Observation: GRAN CANARIA: Vega de San Mateo, Aríñez, 28º01´04.45”N, 15º34´08.63”W, escaped from a plantation, 15 June 2018, *E. A. Déniz Suárez* s.c.

This Mediterranean species is often cultivated for ornamental purposes (Star of Bethlehem)

and has been reported from Tenerife in the Canary Islands (Acebes Ginovés & al. 2010). It is here reported for the first time from Gran Canaria.

Scattered individuals were seen as escapes from an ornamental plantation in Ariñez (Vega de San Mateo) at an altitude of 1,180 m.

Saponaria officinalis L. (*Caryophyllaceae*)

New record for the flora of the Canary Islands.

Category C1: Individuals surviving in the wild (i.e. outside of captivity or cultivation) in location where introduced, no reproduction (Blackburn & al. 2011).

Observation: GRAN CANARIA: Vega de San Mateo, Aríñez, 28º01´04.14”N, 15º34´10.89”W, next to a ditch, 23 October 2018, *E. A. Déniz Suárez* s.c.

Saponaria officinalis is a Eurasian species that is widely cultivated. It had not been recorded before in the Canary Islands (Acebes Ginovés & al. 2010).

Two individuals were observed in Ariñez (Vega de San Mateo) at an altitude of 1,170 m. The plants grow on the edge of an old ditch that was recently piped. As a result the population was reduced in size.

Searsia lancea (L. f.) F. A. Barkley (*Anacardiaceae*) (Fig. 1f)

Rhus lancea L. f.

New record for the flora of the Canary Islands.

Category C2: Individuals surviving in the wild in location where introduced, reproduction occurring, but population not self-sustaining (Blackburn & al. 2011).

Herbarium: GRAN CANARIA: San Bartolomé de Tirajana, Maspalomas, Palmeral Elmassa, 27°45’46.01”N, 15°35’11.40”W, bare ground under palms, young shrub (spontaneous), 17 March 2013, *F. Verloove* 10043 (BR, LPA).

Searsia lancea is a shrub or small tree native to South Africa. It is grown as an ornamental in warm-temperate regions across the world. It is drought tolerant and easily reproduces from seed. Its berries are dispersed by birds and small mammals. As a result, *S. lancea* has locally naturalized in areas where it was formerly introduced. In North America, for example, it is considered a weed or an invasive species in some southern states.

Scattered individuals of this species have been recorded in Maspalomas in Gran Canaria since 2013. All specimens were non-flowering and clearly not planted (potential parent plants were not observed in the immediate surroundings). They grow under the canopy of palms and other ornamental trees along the side of the road, benefiting from the scarce but permanent water supply from the irrigation pipes. Although only vegetative plants were seen, these were very characteristic: leaves are trifoliate with narrowly lanceolate leaflets with entire margins. The leaves are leathery and glabrous and have a distinct resinous smell when crushed.

This species was initially described as a species of the genus *Rhus*. Recent molecular studies have shown, however, that the South African representatives of that genus are better placed in a separate genus *Searsia* (Miller & al. 2001; Yang & al. 2016).

Trifolium cernuum Brot. (*Fabaceae*)

New record for de flora of Gran Canaria

Category C1 (?): Individuals surviving in the wild (i.e. outside of captivity or cultivation) in location where introduced, no reproduction (Blackburn & al. 2011).

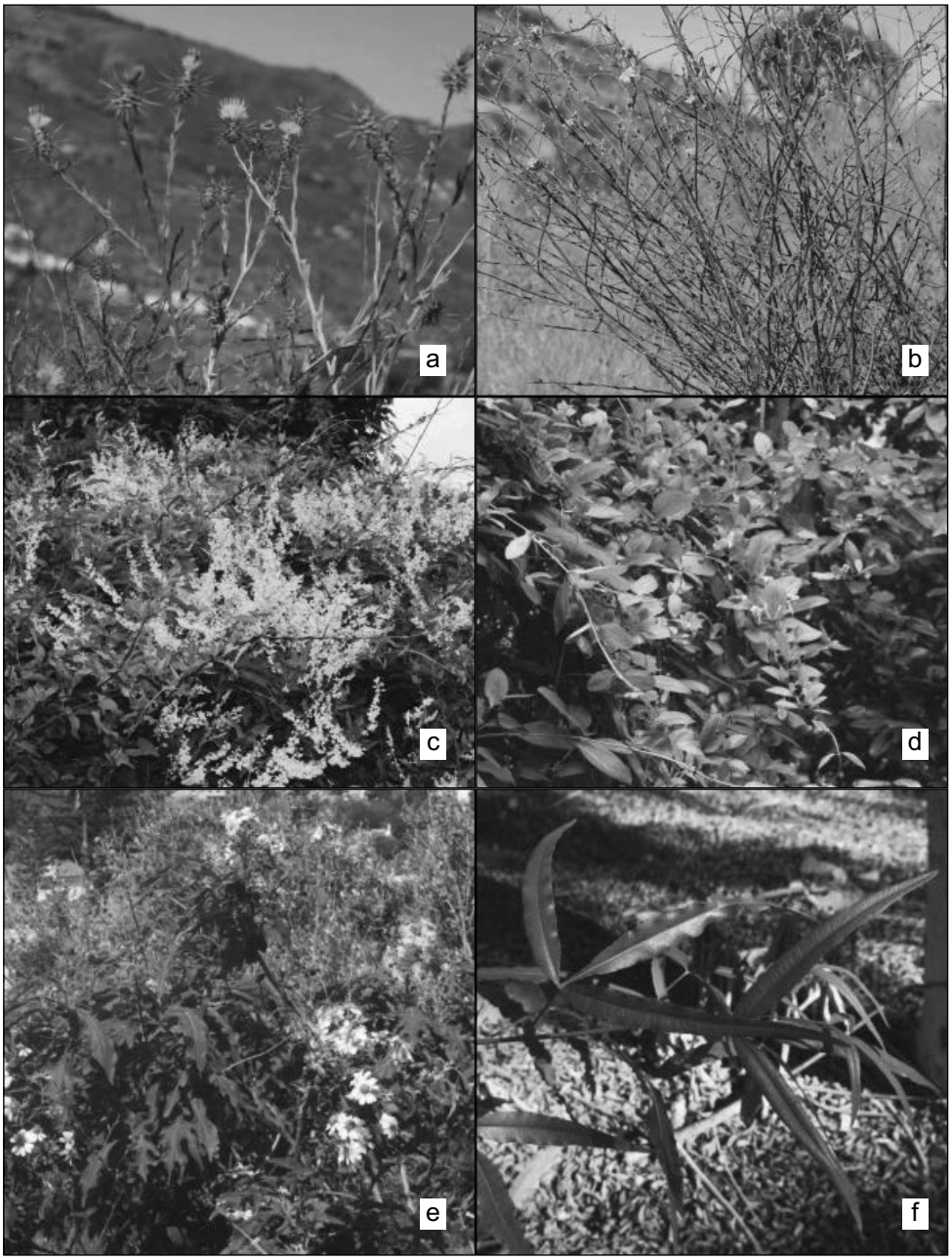


Fig. 1. **a)** *Centaurea sulphurea*. Tejeda, near Roque Bentayga, May 2019, E.A. Déniz Suárez; **b)** *Chondrilla juncea*. Vega de San Mateo, Era del Barranco, June 2019, E.A. Déniz Suárez; **c)** *Fallopia baldschuanica*. Vega de San Mateo, May 2018, E.A. Déniz Suárez; **d)** *Lonicera japonica*. Teror, Finca de Osorio, March 2019, M. Salas Pascual; **e)** *Montanoa bipinnatifida*. Santa Brígida, April 2018, F. Verloove; **f)** *Searsia lancea*. Maspalomas, November 2015, F. Verloove.

Herbarium: GRAN CANARIA: Vega de San Mateo, Las Lagunetas, Barranco de La Mina, 28º00´02.28”N, 15º35´05.54”W, 30 April 2019, *E. A. Déniz Suárez* 15 (BR).

Trifolium cernuum is native to the western Mediterranean area but widely naturalized as a weed elsewhere in the world, for instance in the southern United States and Australia. It was not yet mentioned from the Canary Islands by Acebes Ginovés & al. (2010). However, it was cited for the island of El Hierro by Stierstorfer & von Gaisberg (2006). Subsequently, Santos & al. (2013b) reported it for Tenerife.

In Gran Canaria, only one individual was found in the rocky bed of the ravine of La Mina in Las Lagunetas (Vega de San Mateo), at an altitude of about 1,200 m. The vegetation corresponds to the *Rubo-Salicetum canariense* community. It was accompanied by other species of *Trifolium* such as: *T. campestre* Schreb. and *T. dubium* Sibth. Other outstanding species present in the area are: *Salix canariensis* Link and *S. fragilis* L. in the tree layer and *Nasturtium officinale* R. Br., *Apium nodiflorum* (L.) Lag. and *Lemma minuta* Kunth in the flooded area. *Urtica morifolia* Poir., *Rubus ulmifolius* Schott and *Ageratina adenophora* (Spreng.) R.M. King & H. Rob. were also seen in the vicinity. Worth noting is the presence of a population of an introduced expansive species in Gran Canaria, *Lunaria annua* L. (see also Marrero 2019).

Wigandia caracasana Kunth (*Boraginaceae*)

New record for the flora of Gran Canaria.

Category C2: Individuals surviving in the wild in location where introduced, reproduction occurring, but population not self-sustaining (Blackburn & al. 2011).

Herbarium: GRAN CANARIA: Santa Brígida, close to Bandama Golf, Camino Las Arenillas, 28° 1’57.19”N, 15°27’58.11”W, foot of wall, cracks in concrete, scattered plants escaped from garden, 17 April 2018, *F. Verloove* 13190 (BR).

Wigandia caracasana, a native to Central America, is frequently grown as an ornamental shrub. It easily reproduces from seed and naturalized wherever introduced, to such an extent that it is often considered being weedy. In the Canary Islands it has been known since several decades from Tenerife (Knapp 1976; Acebes Ginovés & al. 2010) where it has locally become rather frequent, for instance near Puerto de la Cruz.

It is here reported for the first time from Gran Canaria. Few plants were seen as an escape from an ornamental plantation in Santa Brígida in 2018. In similar circumstances this species was also observed by the first author in Firgas (between Camino Los Dolores and Presa de Casablanca) in 2018.

Confirmation of the presence and/or new localities for taxa recently first reported from Gran Canaria

Chenopodium vulvaria L. (*Amaranthaceae*)

New localities for Gran Canaria.

Category D2: Self-sustaining population in the wild, with individuals surviving and reproducing a significant distance from the original point of introduction (Blackburn & al. 2011).

Observations: GRAN CANARIA: Vega de San Mateo (Aríñez), La Sequera, roadside GC-400, 28º01´26.11”N, 15º33´58.00”W, a small group, summer 2016, *E. A. Déniz Súarez* s.c.; Vega de San Mateo, La Higuera, 28º00´25.20”N, 15º31´54.69”W, ruderal, roadside

in the neighborhood of La Higuera, 29 September 2016, *E. A. Déniz Súarez* s.c.; Vega de San Mateo, Fire Station, 28º00´46.04”N, 15º31´40.35”W, roadside GC-41, casual, summer 2018, *E. A. Déniz Súarez* s.c.; Vega de San Mateo, Cuatro Caminos, 28º00´05.09”N, 15º32´28.20”W, on farmland alongside the road GC-41, summer 2018, *E. A. Déniz Súarez* s.c.; Vega de San Mateo, Vista Alegre, 28º00´57.14”N, 15º31´28.20”W, 7 July 2018, *E. A. Déniz Súarez* s.c.; Vega de San Mateo (Aríñez), La Sequera, 28º01´26.11”N, 15º33´58.00”W, roadside GC-400, 9 August 2018, *E. A. Déniz Súarez* s.c.

Chenopodium vulvaria is a Eurasian weed that was reported previously from the Canary Islands in El Hierro and Tenerife, not yet from Gran Canaria (Stierstorfer & von Gaisberg 2010; Acebes Ginovés & al. 2010). In a recent thesis (Quintana Vega 2015) the species was reported for the first time from Gran Canaria from Valleseco. Specific locations were not indicated but the species was said to be frequent in cultivated fields and disturbed places.

The new records here presented, all from other municipalities than those cited by Quintana Vega (2015), confirm its recent expansion throughout the island, especially in the northern and central parts.

The species occurs in several localities in Vega de San Mateo. A population was observed, for the first time in the summer of 2016, on the edge of the GC-400 road in “La Sequera” (Ariñez), at an altitude of 1,094 m. In the same year, some specimens were also seen next to a plot and on the edge of the road in the neighborhood of La Higuera at an altitude of 936 m. In the years 2018 and 2019, the previous locations were confirmed, adding others, almost always formed by isolated individuals or in small groups. An isolated individual was also seen near the Vega de San Mateo Fire Station at GC-41 at an altitude of 870 m. On farmland along GC-41 road, about 100 meters from the roundabout of Cuatro Caminos between Las Chozas and Hacienda de Bravo, the species grows together with *Chenopodium album* L. and *Dysphania anthelmintica* (L.) Mosyakin & Clemants at an altitude of 947 m. Finally, two individuals were observed at the edge of the road next to an entrance to a house in Vista Alegre, at 775 m a.s.l.

Fallopia convolvulus (L.) A. Löve (*Polygonaceae*)

New localities for Gran Canaria.

Category D2: Self-sustaining population in the wild, with individuals surviving and reproducing a significant distance from the original point of introduction (Blackburn & al. 2011).

Herbarium: GRAN CANARIA: Vega de San Mateo, Las Lagunetas, 28º00´05.57”N, 15º34´51.06”W, 4 June 2019, *E. A. Déniz Suárez* 1 (BR).

Fallopia convolvulus is a common Eurasian species that is widely naturalized in all temperate regions of the world, often as a pernicious weed in agricultural fields. In the Canary Islands it certainly is an introduced species that was known so far from El Hierro, La Palma, La Gomera and Tenerife, but not yet from Gran Canaria (Acebes Ginovés & al. 2010). Marrero (2019), however, recently reported about its first discovery in Gran Canaria, in Valleseco from where it is already known since 2006.

We found it in 2019 in Las Lagunetas (Vega de San Mateo), at a height of 1,200 m, in the central part of the island, with cold and rainy weather conditions in autumn-winter and sunny and hot summers. A small population was observed at a crossroad leading to agricultural farms, at the edge of farmland. It was accompanied by *Amaranthus viridis* L., *Lactuca serriola* L., *Sonchus oleraceus* (L.) L., *Hirschfeldia incana* (L.) Lagr.-Foss. and *Chenopodium album* L.

This is a little known species that may have been overlooked. Our observation probably is the third for Gran Canaria, the first two being from the municipality of Vega de San Mateo, which expands its range.

Kalanchoe daigremontiana Raym.-Hamet & H. Perrier (*Crassulaceae*)

Confirmation for Gran Canaria.

Category C3: Individuals surviving in the wild in location where introduced, reproduction occurring, and population self-sustaining or D2: Self-sustaining population in the wild, with individuals surviving and reproducing a significant distance from the original point of introduction (Blackburn & al. 2011).

Observations: GRAN CANARIA: Las Palmas de Gran Canaria, Tafira, hillside of the Canarian Garden, 28° 3'57.15"N, 15°27'37.05"W, 290 m, 15 September 2017, *M. Salas Pascual*, s.c.; Las Palmas de Gran Canaria, Barranco de Guiniguada, 28° 4'37.96"N, 15°27'27.63"W, 180 m, 26 January 2019, *M. Salas Pascual*, s.c.

Kalanchoe daigremontiana was reported from Gran Canaria by Kunkel & Kunkel (1971) and Acebes Ginovés & al. (2010; as *Bryophyllum daigremontianum* (Raym.-Hamet & Perrier) A. Berger). However, it has been shown that most records in fact refer to *K.* ×*houghtonii* D.B. Ward, its hybrid with *K. delagoensis* Eckl. & Zeyh. The latter is much more aggressive than either parent species (Mesquida & al. 2017). Also in the Canary Islands these taxa have been confused up to present (Otto & Verloove 2016).

However, genuine *K. daigremontiana* also occurs in the wild in Gran Canaria. Several individuals are found in a wide area in the northern end of the hillside where the Botanic Garden in Tafira is located. The plants are clearly established in this area: they were first seen there in 2014 and regularly confirmed since then. Another population in expansion is found in the ravine of the Barranco de Guiniguada, at 170 m altitude, from pruning remains of nearby gardens.

Paspalum dilatatum Poir. (*Poaceae*)

Confirmation for Gran Canaria.

Category D2: Self-sustaining population in the wild, with individuals surviving and reproducing a significant distance from the original point of introduction (Blackburn & al. 2011).

Herbarium: GRAN CANARIA: Tejeda, La Culata, 27º58´ 25.56"N, 15º35´57.23"W, 2 August 2019, *E. A. Déniz Suárez* 17 (BR).

This South American weed was only cited from La Palma and Tenerife by Acebes Ginovés & al. (2010), based on Knapp (1976) and Santos Guerra (1983) respectively. However, it is also known from Gran Canaria. Kunkel (1972) found it on the northern slope of the Montañón Negro, at an altitude of almost 1,500 meters. Sventenius collected *Paspalum dilatatum* in Barranco del Sao in 1971 (LPA 231) (Suárez Rodríguez 1994). From the Tejeda-Aldea Basin it was reported by Pérez Chacón & Suárez Rodríguez (1983).

Our own collection confirms its actual presence in Gran Canaria. It was observed as a small group of only three plants growing next to a ditch alongside the road GC-608, in the neighborhood of La Culata.

Volutaria tubuliflora (Murb.) Sennen (*Asteraceae*)

Confirmation for Gran Canaria.

Category D2: Self-sustaining population in the wild, with individuals surviving and reproducing a significant distance from the original point of introduction (Blackburn & al. 2011).

Observations: GRAN CANARIA: Telde, La Garita, 28º00´49.59”N, 15º23´07.79”W, ruderal habitats and abandoned farmland, close to the village, 5 February 2017, *E. A. Déniz Suárez* s.c.; Telde, Ojos de Garza, 27º56´57.45”N, 15º23´17.22”W, by the square and near the hermitage, 18 February 2017, *E. A. Déniz Suárez* s.c.; Las Palmas de Gran Canaria, Jinámar, 28º01´49.24”N, 15º23´53.67”W, near the sea, 28 February 2018, *E. A. Déniz Suárez* s.c; Agaete, 28º05´59.43”N, 15º42´05.31”W, near the village, alongside the ravine, 9 February 2019, *E. A. Déniz Suárez* s.c.

Volutaria tubuliflora is widely dispersed in North Africa and is locally also found in Spain and Sicily. In the Canary Islands it is considered to be “possibly native” in El Hierro, Tenerife and Lanzarote (Acebes Ginovés & al. 2010). It was recently also recorded in La Palma, where it is thought to be a recent introduction (Otto & Verloove 2020).

It was not mentioned by Acebes Ginovés & al. l.c. from Gran Canaria although it is relatively frequent in coastal areas of the island. Hansen (1972) already drew the attention to its presence in the LPA herbarium, without providing details (see also Bramwell & Bramwell 2001).

This species is an increasing weed in desert-like habitats, for instance in California and Chile (Teillier & al. 2014; McDonald 2019).

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Short note

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L'arctothèque souci (*Arctotheca calendula*): une nouvelle espèce exotique pour la flore algérienne

Abstract

Hamel, T., Azzouz, Z., Bellili, A. M., Boutabia, L. & Telailia, S.: L'arctothèque souci (*Arctotheca calendula*): une nouvelle espèce exotique pour la flore algérienne. — Fl. Medit. 30: 137-142. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

The Cape marigold (*Arctotheca calendula*): a new exotic species for the Algerian flora. – The authors report the recent discovery in Algeria of a xenophyte belonging to the *Asteraceae*. *Arctotheca calendula*, native to South Africa, was observed for the first time, in the northeast of the country (Oriental Numidia).

Key words: alien species, xenophytes, *Asteraceae*, Oriental Numidia, Algeria.

Introduction

Des observations de terrain au cours des dernières années ont permis non seulement l'amélioration des connaissances floristiques de la Numidie K_3 (*sensu* Quézel & Santa 1962) (voir par exemple de Bélair 2005 ; Belouahem & al. 2011; Bouldjedri & al. 2011; Hamel & al. 2013; Hamel & Meddad-Hamza 2016; Allem & al. 2017; Hamel & al. 2018; Dechir & al. 2019; Boutabia & al. 2019; Fetnaci & al. 2019; Hamel & al. 2019), mais aussi la découverte de nombreux nouveaux taxons indigènes pour la flore algérienne (de Bélair & Boussouak, 2002; de Bélair & Véla 2011; de Bélair & al. 2012; Véla & al. 2012; Véla & de Bélair 2013; Hamel & Boulemtafes 2017a) et non indigènes (Véla & al. 2013; Hamel 2016; Meddour & El Mokni 2016; Miara & al. 2018; Hamel & Azzouz 2018; Sakhraoui & al. 2019a 2019b). Ainsi que de nouvelles localités des espèces (Hamel et Boulemtafes 2017b; Boulemtafes & al. 2018; Hamel & al. 2020).

Nous rapportons dans ce travail une première contribution qui évoque, jusqu'à présent, la présence réelle d'*Arctotheca calendula* sur le territoire algérien.

Observations et détermination

En premier lieu, il convient de noter que cette espèce ne semble pas avoir été préalablement signalée en Algérie (cf. Battandier 1888-1890; Battandier & Trabut 1905; Maire

1952-1987; Quézel & Santa 1963; Dobignard & Chatelain 2011), alors qu'elle est présente au Maroc (Fennane & Ibn Tattou 1998; Valdes & al. 2002) ainsi qu'à proximité en Tunisie (Le Floc'h & al. 2010).

En Europe, la plante est naturalisée de longue date au Portugal et en Espagne (Webb 1976), puis elle apparait en France dans des campings des Landes (Vivant 1980) et dans les Pyrénées atlantiques (Lazare & Royaud 1994), de même elle est introduite en Italie (Domina & al. 2018). Toutefois, cette plante originaire d'Afrique du Sud est très variable dans son port et ses caractères foliaires (Harvey & Sonder 1894).

Nous avons recueilli les premiers pieds d'*Arctotheca calendula* en avril 2018 sur la rive de la mare El Behaira dans le Parc National d'El Kala (Nord-est algérien) (Fig. 1). Le matériel original est déposé dans l'herbier du département de Biologie, université Badji Mokhtar-Annaba-Algérie. Il correspond à la description présentée par Blanca & al. (2009): [une plante vivace velue stolonifère à tige rougeâtre. Les feuilles sont pennatilobées en rosette basale. Les capitules (de 4 à 5 cm) portent des fleurs périphériques stériles, tandis que le disque est composé par des fleurs hermaphrodites. Les graines sont recouvertes de laine brun pâle et surmontées de 6 à 8 écailles courtes] (Fig. 2 & 3).

La station d'observation est marquée par une végétation psammophile dominée par une strate herbacée parfois plus ou moins ligneuse à *Cynodon dactylon* (L.) Pers., *Erigeron bonariensis* L., *Gnaphalium antillanum* Urb., *Linaria pinifolia* (Poir.) Thell., *Bellis annua* L., *Cladanthus mixtus* (L.) Chevall., *Convolvulus arvensis* L., *Bellis prostrata* Pomel,

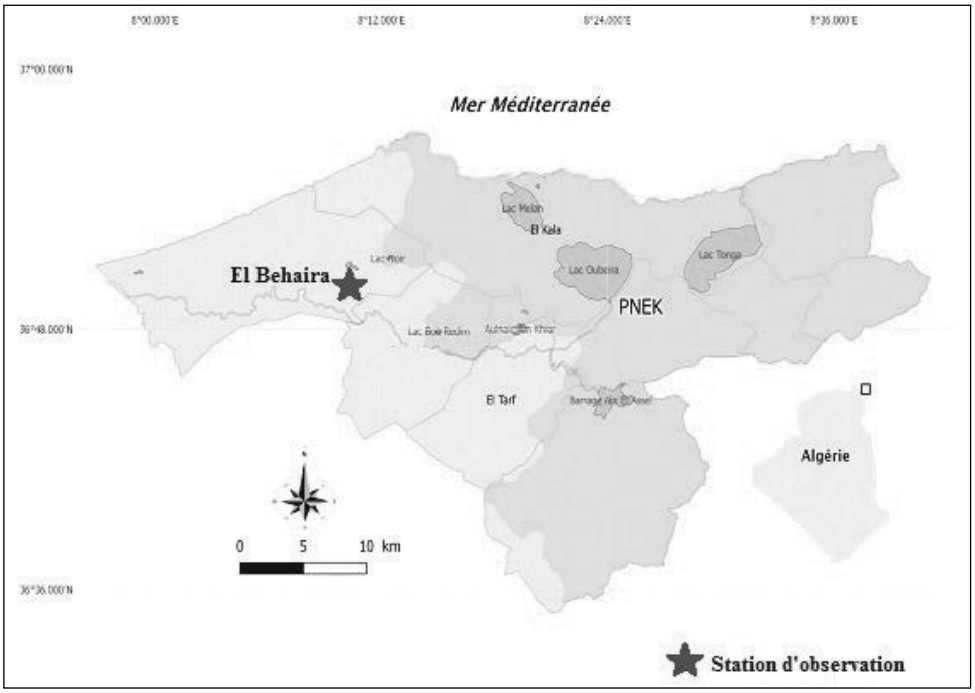


Fig. 1. Localisation de la station d'observation.



Fig. 2. Aspect et port de la plante (cliché HAMEL Tarek, le 28-04-2018).



Fig. 3. Habitat de la plante (cliché HAMEL Tarek, le 28-04-2018).

Stachys ocymastrum (L.) Briq., *Lysimachia arvensis* (L.) U. Manns & Anderb., *Trifolium campestre* Schreb, *.Lotus corniculatus* subsp. *preslii* (Ten.) P. Fourn., *Trifolium repens* L., *Ranunculus sardous* Crantz, *Opuntia ficus-indica* (L.) Mill. et *Nicotiana glauca* Graham sur une superficie de 100 m^2.

Il est important de noter que cette station est très proche des cultures d'arachides donc il est fort probable que la population de l'arctothèque souci provienne de graines introduites accidentellement au niveau de ces terrains. Néanmoins, la plante préfère les territoires avec une humidité abondante. L'akène doit être facilement transporté par le vent, l'eau, les oiseaux, autres animaux et par l'homme au cours des travaux d'agricultures (Vivant 1993).

En revanche, cette plante semble avoir une concurrence relativement faible sur les espèces indigènes, mais si elle est établie, elle peut avoir un impact modéré sur les communautés naturelles.

Conclusion

Arctotheca calendula est une nouveauté pour l'Algérie, elle vient s'ajouter au groupe des plantes xénophytes. Eu égard à l'expansion rapide de cette espèce dans les pays voisins (cas du Maroc par exemple), cette découverte souligne le besoin de suivre de près l'évolution de l'aire de l'espèce qui peut devenir vite envahissante et nuisible.

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Article

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Revision of the *Lactuca* species (*Asteraceae*) occurring in the Maltese Islands

Abstract

Mifsud, S. & Mifsud, O.: Revision of the *Lactuca* species (*Asteraceae*) occurring in the Maltese Islands. — Fl. Medit. 30: 143-154. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

An investigation on the species of *Lactuca* occurring in the Maltese Islands was carried out on 105 populations in natural habitats and 15 herbarium specimens. The main aim was to revise the four *Lactuca* species reported in historical literature of which the occurrence of *L. virosa* was doubtful, whereas *L. saligna* has not been reported for the last 30 years or more. Results confirmed the presence of three species: the agricultural cultivated crop *Lactuca sativa*; the frequently occurring *L. serriola* (both f. *serriola* and f. *integrifolia*) and the rediscovery of *L. saligna* from Gozo. *L. virosa* was not confirmed in this study and is considered as a past misidentification that persisted till present date derived from the misconception that the leaves of *L. virosa* are entire, whereas those of *L. serriola* are lobed. Achenes morphology and leaf characters were used for the determination of the species, and consequently, magnified images of the achenes and their morpho-metric assessment are given. The variation and infraspecific taxa of *L. serriola* are also discussed based on field findings. A brief account on the history of *Lactuca* species in Malta, a distributional map and an identification key are also given.

Key words: *Compositae*, Crop Wild Relatives, flora.

Introduction

Lactuca L. is a fairly large genus in the family *Asteraceae* which comprises some 100 species distributed throughout most regions of the world. Member species occur naturally in Europe, Tropical and Temperate Asia, Africa and North America (Lebeda & al. 2004) with some species introduced in Australia and many countries in South America (POWO 2019). The most representative or well-known species of the genus is the vegetable *Lactuca sativa* L. – the garden lettuce, with a production of 26.87 million tons in 2017 (FAO 2017). Seventeen species occur in Europe according to Lebeda & al. (2004) and from the neighbouring countries to Malta, ten are recorded in Italy (Euro+Med 2019), six in Sicily (Giardina & al. 2007; Euro+Med 2019) and four in Tunisia (Le Floc'h & al. 2010).

From preliminary studies and ad-hoc examinations of *Lactuca* species from numerous surveys we conducted in Malta since the year 2002, *L. sativa* (as a crop), *L. ser-*

riola have been confirmed, but *L. virosa* could not be substantiated. This contradicted with the historical and current literature stating that *L. virosa* is a frequent wild lettuce in Malta, with some old reports indicating that is is more common than *L. serriola* (Lanfranco 1995, 2001; Bonett & Attard 2005), or even that only *L. virosa* occurs in the Maltese Islands (Lanfranco 1969). Confused by the two opposing scenarios, a study on the wild species of *Lactuca* occurring in the Maltese Islands was conducted between 2018 and 2019. Its aim was to confirm or not the current presence, distribution and ecology of *L. virosa* and perhaps other *Lactuca* species which occur in Sicily or Tunisia and highlight differences in their ecological and habitat preference. In addition, the study was also aimed to find populations of *L. saligna* which appears to have become extirpated. Reference to herbarium specimens collected from Malta was also taken into account as this gives important evidence of what was the concept of plants reported as *L. virosa* in the late nineteenth and early twentieth century.

In addition, this study stemmed up from the well-documented confusion in historical literature were *L. virosa* was widely confused with *L. serriola,* where apparently, there was a misconception that plants with unlobed leaves were treated as *L. virosa* whereas plants with runcinate-lobed leaves were identified as *L. serriola* (Prince & Carter 1977; Oswald 2000). For example Prince & Carter (1977) stated that up to the early 20th century, unlobed-leaved plants of *Lactuca* were assigned as *L. virosa* by British botanists and old British Floras specifically referring as an example to Bentham (1865): "*The name of L. scariola is often limited to the varieties with more erect leaves, with deeper and narrower lobes ; and those with broader leaves, toothed only, and not so glaucous, have been considered as a distinct species, under the name of L. virosa*". The same treatment was indeed expressed by Maltese botanists namely Borg (1927) where he mentioned that *L. scariola* var. *silvestris* (L.) Moris (= *L. serriola*) has runcinate and pinnatifid leaves while in his account for *L. virosa* he wrote: "[Leaves] *usually individed, or rarely slightly lobed and with reddish sport* [spots].". Prince & Carter (1977) were aware about this confusion and to stop this saga, they reorganised the taxonomic concepts between *L. virosa* and *L. serriola*, stating that both species can have pinnatifid or entire leaves and assigned the unlobed-leaf form of *L. serriola* into a new combination - *L. serriola* f. *integrifolia* (S. F. Gray) S. D. Prince & R. N. Carter. This misconception had probably influenced Maltese botanists in their floristic work till the present date, although it does not exclude the possibility that both species existed and may still occur in Malta. This investigation should hence bring new knowledge to settle this uncertain situation.

Material and methods

Based on the morphological accounts and keys by Ferakova (1976), Prince & Carter (1977), Rich & Jermy (1998), Tison & al. (2015) and Pignatti (2018), the agricultural crop *L. sativa* is well distinguished from the other species occurring in the Maltese archipelago by its broad cauline leaves, whereas *L. saligna* has characteristic narrow leaves with pointed auricles. Prince & Carter (1977) studied well the distinction between the closely related *L. virosa* and *L. serriola* (and also *L. saligna*), where

besides giving several morphological differences in foliar and floral characters they emphasised that the best distinguishing characters are present in the achenes. A dichotomous identification key was adopted from the floristic accounts cited above and used to determine the Maltese material. As expected, the key depended heavily on the characters of the achenes and inferred that fruit-collection is instrumental in the planning of the methodology.

The methodology incorporated the examination of leaves *in situ* and more importantly the collection and examination of achenes of *Lactuca* plants from different habitats throughout the Maltese Islands. About 30 achenes from at least three fruiting heads were collected from a single plant (hereafter referred to as a *specimen*) between the end of June and the end of August of years 2018 and 2019. Observations on the habitat, population, ecology and digital photographs were also taken in situ.

A total of 105 specimens were examined, 23 from Gozo and 82 from mainland Malta and achenes were collected from each specimen. Two short visits in Comino (30th August and 14th September 2019) did not result in any findings of *Lactuca* spp. The fruits were stored in a labelled paper sachet and were examined under a stereo microscope during September 2019. The collected specimens are tabulated in the Electronic Supplementary File 1 (ESF 1, table 2).

Moreover, herbarium specimens of *Lactuca* from the private collection of Edwin Lanfranco and Michael Briffa as well as voucher specimens deposited at the Argotti Botanical Gardens [ARG] were also examined of which information about these specimens are given in the Electronic Supplementary File 1 (ESF 1, table 3).

We had also received voucher specimens of *Lactuca serriola* and *Lactuca virosa* collected from Montpellier, France by Prof. Erol Vela on June 2019. These, and achenes of *L. sativa* collected from open fields in Xagħra Gozo (10-July-2019) and of *L. saligna* from Xewkija, Gozo (13-Sep-2019) were used as reference material to compare the fruits of specimens collected from the wild with fruits of known or reference *Lactuca* species.

The achenes were examined under a stereomicroscope using a magnification of 16× and digital images of five fruits for each specimen were taken. The colour, mottling and texture including the presence of bristles were noted. Images were also taken against an eyepiece graticule scale by which the length and width of the achenes were measured using the software Piximeter V5.9 by Alain Henriot. The width was measured along the widest part of the fruit. The length included the beak, here denoted as the coloured part above the apex of the achene just below the white shaft of the pappus. The location of each specimen was plotted on a digital map using Google Earth Pro (Fig. 1).

Results

Distinction and an identification key to **Lactuca** *spp. recorded in Malta*

The most important distinctive characters were found to be present in the achenes and leaves (lamina and auricles) and these were the main morphological components to construct an identification key (see below). The morphological findings of the achenes of the four *Lactuca* species published or collected from the Maltese Islands are summarised in Table 1.

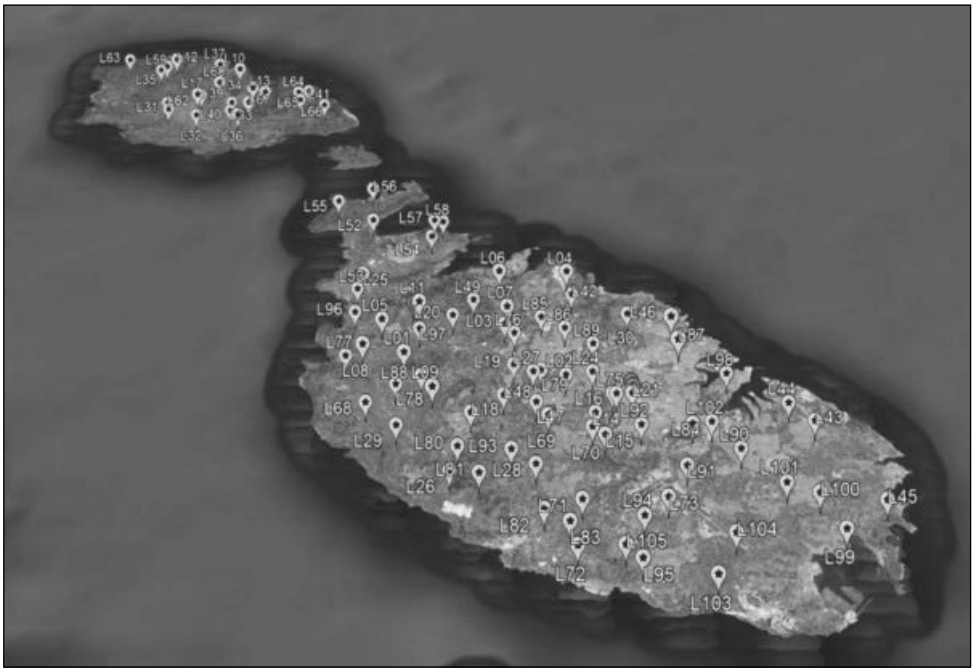


Fig. 1. Map showing location of collected specimens.

Table 1. Comparison of morphological characters of achenes from reference *Lactuca* species: *L. serriola* (Montpellier)*, L. virosa* (Montpellier)*. L. saligna* (Xewkija, Gozo) and cultivated *L. sativa* (Xewkija Gozo).

Achene character	*L. serriola*	*L. virosa*	*L. saligna*	*L. sativa*
Colour	Light to medium olive brown	Dark maroon-brown, reddish when still immature	Medium to dull bronze-brown	Silvery-grey with golden tones towards the apex
Outline shape	Oblanceolate	Elliptical	Oblanceolate	Obovate
Broadest part	Upper part	Middle part	Upper part	Upper part
Apex (beak not included)	Blunt, rarely acute	Blunt	Acute	Rounded-obtuse
No. of ribs	6-7	8-9	7-8	7-10
Beak	Long	Moderately long	Short	Very short, mucronate
Mottling	Sometimes present	Not mottled	Not mottled	Not mottled
Bristles	Long and distinct on the face and sides of the achene's apex	Absent or sparse and very short only on the faces	Subnil, sparse and very short at the apex when present	Short, indistinct on the face and sides of the achene's apex
Length (mm)	2.9–3.2	4.3–4.6	3.4–3.8	3.3–3.7
Width (mm)	0.8–1.0	1.4–1.6	0.8–1.0	1.1–1.3

Key to the* Lactuca *taxa reported in the Maltese Islands

1 Vegetable crop; leaves bright green, >10 cm wide, all without spinulose margin. . ***L. sativa***
- Wild plants; leaves dull green, < 8cm wide, sometimes with spinulose margin. **2**
2 Adult plants never reaching 100 cm of height; leaves <12 mm wide (usually 4–8 mm) without rigid spinules at the margin or midrib; cauline leaves linear-oblong with a sagittate base made of long narrow lobes. ..... ***L. saligna***
- Adult plants usually more than 100 cm high (up to 200 cm); leaves > 15 mm wide lined with rigid spinules on the margin and the main veins; cauline leaves broad oblong-obovate with a cordate base made of broad lobes. **3**
3 Leaves pointing in a different direction; leaf lobes wide and distinctly clasping the stem; achenes dark, maroon, ca. 4.5 mm long, glabrous at the sides, sometimes with short, indistinct bristles on the face. ..... ***L. virosa***
- Leaves twisted and pointing at one vertical plane; leaf lobes acute and small; achenes light (rarely medium-dark) olive brown or peanut colour, ca. 3.0 mm long, distinctly bristly on both the face and the sides at the apical part of the achene. .... ***L. serriola* (4)**
4 Leaves distinctly lobed, runcinate-pinnatifid ..... ***L. serriola* f. *serriola***
- Leaves entire and unlobed or shallowly lobed ..... ***L. serriola* f. *integrifolia***

Literature records of* Lactuca *species from the Maltese Islands.

1. *Lactuca saligna* L. This species is first reported from Cottonera by Gavino Gulia (1858-59) and then (1869) at Corradino. Sommier & Caruana Gatto (1915) report it from fields and herbaceous places as a "*not common*" plant in Malta at Gnien il-Kbir and Buskett, and list the earlier records of Gulia. Borg (1927) meanwhile records this species as frequent here and there in Malta (often common around Attard), and besides *L. saligna* s.s., he lists also the *L. saligna* f. *wallrothii* Spreng., and *L. saligna* var. *virgata* Trusch. It is then reported by Vella & Penza (1938) who consider it as a native plant. Lanfranco (1969) states that it is not frequent and present mostly beside walls. Haslam & al. (1977) report the older records and give a new record by Gauci from Villa Rundle, Victoria in Gozo. Casha (2013) just mentions that it is found in our islands without providing any personal records. The last sighting was from Victoria in the eighties (pers. comm., Michael Briffa & Edwin Lanfranco May-2019).

2. *Lactuca sativa* L. First listed by Zerafa (1827) as a cultivated plant followed by Gulia (1855-1856). Borg (1927) listed this species as *L. scariola* var. *sativa* (L.) Moris, and that many forms are cultivated in Malta as a vegetable. Several authors also consider it as a cultivated plant: Haslam & al. (1977), Lanfranco (1993), Camilleri (2004), Casha (2013) and Weber & Kendzior (2006). According to Camilleri (2004), at least *L. sativa* 'Capitata' and *L. sativa* 'Romana' are frequently harvested for the local market. Weber & Kendzior (2006) are the first to record it as a rare naturalised plant at Ta' Gajdore, Ramla Valley, Xagħra, Gozo.

3. *Lactuca serriola* L. First recorded by Borg (1927) as *L. scariola* var. *silvestris* Lam. as a rather rare plant found at Girgenti and possibly elsewhere and which is easily mistaken for *L. virosa* L. Penza (1969) mentions it as its synonym of *L. scariola* L., and recounts that he found it at Għajn il-Kbira. Haslam (1977) only mentions Borg's record without giving any new locations. Lanfranco (1995) reported it under the Maltese name of Ħass tal-Pizzi and stated that it is frequent and increasing in numbers. Sultana (2006) lists it as fre-

quent in disturbed localities throughout the Maltese Islands. Weber & Kendzior (2006) also states that it is a frequent-common and gives it the Maltese name Ħassa Salvaġġa tal-Pizzi. Casha (2013) records it as common in disturbed habitats including roadsides, paths, fields and gardens and is the first to show a photograph of the achenes. It is also reported by Lanfranco & Bonett (2015) as a frequent species.

4. *Lactuca virosa* L. Recorded first by Zerafa (1827) who states that this species grows 'in agerribus' (on fortifications) and flowers in June. Grech Delicata (1853) mentions that it occurs in the same habitat but is in flowers from May. He is the first author to coin the name 'Ħass Selvaġġ' to a wild *Lactuca* species. This species was then recorded from Cottonera (Gulia 1855-56, 1869) and from Corradino (Gulia G. 1889-90) both as indigenous and indicating that it is common in our islands. Sommier & Caruana Gatto (1915) state that it occurs here and there in some localities in Malta in fields and uncultivated places, and only cites previously recorded sites. In the catalogues of plants found in the Argotti Botanical Gardens, Borg & Penza (1924) and later, Vella & Penza (1938) gives this species as a native plant. Borg (1927) states that *L. virosa* was rather frequent in fields and gardens in Malta, and was rather rare in Gozo. Lanfranco (1960, 1969) consider it as a frequent plant and later gives its medicinal properties (Lanfranco 1975, 1993). It is reported by Penza (1969), Haslam & al. (1977), Lanfranco (1995) and Bonett & Attard (2005) as a frequent species in agricultural and suburban sites and ascribes the Maltese name of Ħass Xewwieki. Weber & Kendzior (2006), Casha (2013) and Lanfranco & Bonett (2015) just states that *L. virosa* also occurs in our islands but they do not show photographs in their work.

Distribution, habitat and chorology

Specimens have been found in two types of habitats in Malta. About 75% of the specimens were collected from agricultural areas, namely fallow or neglected fields, field margins or less often inside harvested fields (grains are usually harvested in May-June in Malta), sides of rubble walls and footpaths or lanes near fields (refer to ESF 1, Table 2). The minor portion of specimens were located in semi-urban to urban areas such as roadsides, footpaths, curbs, public gardens and parks, paved ground, traffic islands, wasteground (soil heaps) and rarely from old walls. Nevertheless, many of the urban-located specimens were up to 300 m away from agricultural land. No plants of *Lactuca* were found in Comino during two surveys carried out in August and September of 2019. Similarly, *Lactuca* was not reported from Selmunett (Mifsud & al. 2016) or satellite islets in the Maltese archipelago (Sciberras & Sciberras 2010). A map showing the sites where the 105 specimens were collected is shown in Fig. 1.

Specimens were uncommon or often absent in agricultural or derelict areas near the coast such as at l-Aħrax tal-Mellieħa, Marfa, Ħal-Far, Kalkara (Malta) as well at Xlendi, Ta' Cenc, Sanap and Marsalforn in Gozo, albeit vast agricultural areas are present in these localities. On contrast, specimens were locally frequent inland. As a result, it can be inferred that wild *Lactuca* species do not prefer coastal areas. In addition, many of the *Lactuca* specimens were found in clayey soil. While the incidence of clayey soil in fields is higher compared to fields with reddish (terrarossa) soil, there seems to be an ecological correlation that *Lactuca* species prefer clayey soils, possibly because this has more residual moisture during the arid and warm months of June and July when the plants are fully mature.

With regards the chorology of the specimens examined *in situ*, plants undergo a daily cycle where flowers blossom for only about three hours, opening at dawn, (ca. 6 a.m.) and close back at about 9 a.m. Then the fruiting heads open to expose their achenes at about 10 a.m. and remain open indefinitely. The flowering period is from end of June till the beginning of September with few plants persisting till the mid-September depending on the onset of rainy autumn climate.

Reference material

The morphological findings of the achenes of *L. virosa, L. sativa, L. saligna* and *L. serriola* are reported in table 1 and photographed side by side in Fig. 2. The achene of *L. virosa* is distinct by having a dark maroon colour with an elliptic-fusiform flattened lenticular shape lined by a distinct thick-ribbed margin. It is the largest fruit at an average length of 4.5 mm. *L. serriola* is unique by having a brush of conspicuous hyaline bristles at the apex and a light greyish olive-brown colour. The intensity of the colour varies between different specimens but it is never dark. Achenes of *L. sativa* are quite similar to *L. serriola* but apart from the apical bristles being very reduced, they have a broader obovate shape and a pale silvery-grey colour with a faint amber-golden hue at the apex. Compared to the other achenes, it has a more rounded or obtuse apex. Finally, achenes of *L. saligna* have a medium toned dull bronze-brown colour without, or if present, inconspicuous bristles at the apex.

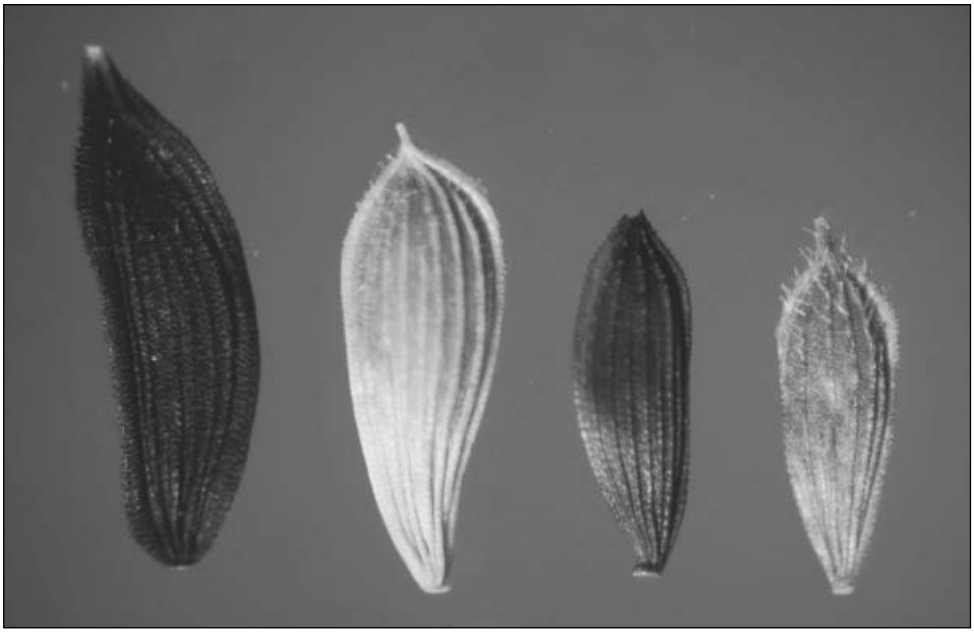


Fig. 2. Comparison of achenes of (left to right): *Lactuca virosa* (Montpellier, France), *L. sativa* (Xewkija, Gozo, Malta), *L. saligna* (Xewkija, Gozo, Malta) and *L. serriola* (Montpellier, France).

Achenes morphology and variation of specimens collected from the Maltese Islands

The characters of the fruits and the outline shape of the leaves of each examined specimen is reported in the ESF 1 (Table 3). The fruits of all specimens had a homologous morphology with some minor and taxonomically insignificant variation in the outline shape, size, amount of mottling and the length of the beak. Images of one achene from each of the 105 specimens are illustrated in Fig. 5a (L01 to L50) and Fig. 5b (L51 to L105) in the ESF 2. A general description of the important characters observed from the examination of the fruits is given below.

Colour: typically light olive brown throughout the whole achene, varying from either being medium dark (but never very dark) to occasionally greyish and discoloured on the other extreme. Some fruits (L03, L06, L10, L22, L42, L44, L62 and L87) had a yellowish hue here referred to as peanut colour.

Mottling: There was a diverse pattern of mottling in terms of number and distinctness (contrast) of small blobs on the fruit coat. Only seven specimens (L07, L09, L16, L31, L43, L94 and L103) had fruit with a fairly distinct mottling, the remaining having indistinct mottling with few or/and faded blobs, or nothing at all. The only relationship which could be linked was that none of the peanut-coloured fruits where mottled.

Shape: oblanceolate, broadest slightly below the beak, approximately ¾ the length of the achene, then tapering down into a blunt base. Sides linear or rarely vaguely curved. On average, achenes were about three times as long as wide, but some were more elongated with a length/width ratio of up to ×4.

Ribs: Six to seven longitudinal and parallel ribs, one at each margin of the fruit. Some specimens had a slightly flattened or minutely winged margin at the upper part of the achene.

Beak: Distinct and about 0.2 to 0.5 mm long. Elongated achenes had longer beaks.

Texture: Presence of simple but distinct hyaline bristles, located both on the face and the sides at the upper fifth of the fruit. The bristles measured 0.2–0.3 mm on average, then abruptly reduced in size and disappearing towards the lower part of the achene.

Size: Rather constant size of 3.0 ± 0.4 × 1 ± 0.1 mm (2.65–3.41 × 0.88–1.05 mm). Fourteen specimens had achenes longer than 3.5 mm, the longest being 4 mm long usually with long beaks. Three specimens had achenes shorter from 2.6 mm (2.4 mm being the shortest) which were found to be wider than average and had relatively shorter beaks.

The colour, size, shape and more importantly the presence of bristles at the apical part of the achene of all the 105 specimens corresponded to species *Lactuca serriola*. *L. virosa* was not confirmed from the entire collection.

Results from herbarium specimens collected from the Maltese Islands

The voucher specimens loaned from Edwin Lanfranco consisted of two specimens labelled as *L. virosa*, three as *L. serriola* and four as *L. saligna* (ESF, Table 3). Specimens labelled *L. serriola* and *L. saligna* were confirmed but specimen L501, labelled as *L. virosa* (collected by Michael Briffa), was badly preserved and lacked fruits, making its determination impossible. However, L502 (*L. virosa*) was better preserved with its few leaves having an oblong shape with an entire and unlobed margin similar to L501 and seven achenes within the debris. The achenes were identical to that of *L. serriola* and hence L502 has been ascribed to this species.

Five specimens are deposited in [ARG] of which two (L511 & L512 : Table 3) were not collected from the Maltese Islands (pers. comm. Christian Borg at [ARG], Oct 2019) and labelled as *L. perennis* L. (a species not recorded from Malta) and *L. augustana* All., now a synonym of *L. serriola*, but this specimen was clearly *L. saligna* instead.

The voucher specimens L514 (*L. saligna*) and L515 (*L. scariola*) were confirmed to match the labelled species. On the other hand, the specimen L513 collected by Caruana Gatto and labelled as *L. virosa* and consisting of only of ten unlobed cauline leaves (no achenes available) was determined using Prince & Carter (1977: table 2) who provide distinguishing characters on the cauline leaves. In regards, the white midrib (not maroon); the "herring-bone" pattern formed by the midrib and lateral veins; the glaucous colour of the lamina and the non-undulated outline observed in specimen L513 correspond to *L. serriola*. Moreover, the auricles of the leaves of *L. virosa* are wide and distinctly clasping the stem whereas in *L. serriola* the lobes are narrow and acute and clasping the stem less distinctly (Keil & Stebbins, 2012) as was the case for specimen L513.

Discussion

The examination of the 105 specimens of wild species of *Lactuca* and of the herbarium specimens did not confirm the presence of *L. virosa* on the Maltese Islands. From the three herbarium specimens cited as *L. virosa,* L501 and L513 (refer to Table 3) with entire leaves were instead found to correspond to *L. serriola* f. *integrifolia,* while L500 was undetermined due its bad state of preservation. This corroborates the misconception initiated from the historical literature (Zerafa 1831; Grech Delicata 1853; Gulia 1858-59, etc.) and flowing indisputably to the contemporary floristic works where *L. virosa* was determined as the wild lettuce with unlobed leaves, and *L. serriola* with runciform-lobed leaves, as was, for example, the case in Great Britain in the mid-nineties (Prince & Carter 1977). It seems that the achenes were ignored for the determination of *Lactuca* species by previous authors and students of the Maltese Flora, because from the literature review we carried out, none emphasised the distinct taxonomic value that the achenes have. It was perhaps because of this lack of knowledge that, as stated by Borg (1927), it was easy to confuse these two closely-related *Lactuca* species.

Poor herbarium evidence makes it is difficult to assess and ascertain historical records, however, two considerations were taken into account. Since historical literature indicated that *L. virosa* was not rare in Malta – for example: "*Malta, qua e là, Hamrun, Zabbar, Ghirghenti, Marsa, ecc.!*" (Sommier & Caruana Gatto 1915) – there is no plausible justification to explain why this species succumbed while the closely related *L. scariola* survived if both share the same habitat (Sommier & Caruana Gatto 1915; Borg 1927). Moreover, Caruana Gatto's specimens L513 (Table 3) cited as *L. virosa* but being determined as *L. serriola* f. *integrifolia* further supports the general misconception about these two taxa since the early 20th century.

With regards to *L. saligna*, the species was more common in the past, both from the old records and the herbarium specimens collected between 1960-1990 (refer to Table 3). The last sightings dated about 30 years ago from Victoria, Gozo (pers. comm. Edwin Lanfranco, 2019 & Michael Briffa, 2019) and since it has not been confirmed or reported in either publications of reports by the citizen science, *L. saligna* was considered extirpated or presumably extinct. The rediscovery by one us [SM] close to the Xewkija Industrial

Estate, Gozo (Fig. 3), is a welcome finding for the Flora of the Maltese Islands. Two plants were observed on the 8th of November 2017, in their vegetative state and confirmed as *L. saligna* the year after (7th October 2018), where five adult plants were found very close to each other. A survey on the 18th September 2019 resulted in nine flowering plants showing a small but significant increase in its population.

This study also resulted in an assessment of the variation of *L. serriola* in the Maltese Islands. Both *L. serriola* f. *serriola* (89% of the population) and *L. serriola* f. *integrifolia* (= *L. virosa* auctt. melit. non L.) (see Fig. 4) were encountered, the latter represented by specimens L07, L23, L26, L30, L33, L39, L41, L58, L63, L65, L80 and L82 (refer to ESF 1). Few plants here referred as *intermediate* forms were characterised by having variably lobed leaves mostly being shallowly lobed or/and possessing entire and lobed leaves on the same plant (L14, L26, L33, L35, L38, L40, L52 and L62). In the past, these forms were given some recognition (Ferakova 1976; Prince & Carter 1977; Haslam & al. 1977; Pignatti 1982) but currently, *L. serriola* is considered as a monogenetic variable species where these old forms based on the shape and lobation of the leaves have no more any taxonomic value.

Out of interest, Sommier & Caruana Gatto (1915) and Borg (1927) give the impression that *L. serriola* and *L. virosa* were scarce or infrequent in Malta, where they only give and a handful of localities in their flora. In contrast, the current distribution of *L. serriola* is widespread throughout the Maltese Islands (Fig. 1) and this divergence raises doubts if this species was introduced in Malta around the end of the 19th century and flourished during the last 100 years.

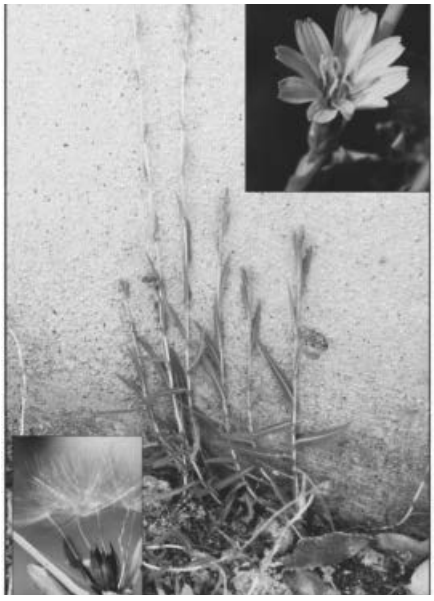


Fig. 3. *Lactuca saligna*, Xewkija (close to Ulysses Grove), Gozo (7-Oct-2018).



Fig. 4. *Lactuca serriola* with entire leaves where it was previously referred to as f. *integrifolia* and sometimes misidentified as *L. virosa*. (specimen L41, Qala, Gozo).

Conclusions

This investigation concludes that *Lactuca virosa* does not occur in the Maltese Islands. Most probably, it was a past misidentification based on the misconception that plants having entire or shallowly-lobed leaves were determined as *L. virosa,* whereas only plants with runcinate-lobed leaves were ascribed as *L. scariola.* In the past these plants where instead referable to as *L. serriola* f. *integrifolia* and f. *serriola* respectively *sensu* Ferakova (1976). The fact that all herbarium specimens labelled as *L. virosa* had entire leaves supports this supposition. It stands out that examination of the achenes was not carried out for the determination of *Lactuca* species in Malta. Moreover, *L. saligna*, a species of urban habitats that has not been observed for more than 30 years has been substantiated from Xewkija, Gozo in 2017. Hence the wild *Lactuca* species occurring in the Maltese Islands are *L. serriola* (common), *L. saligna* (very rare) and the cultivated crop *L. sativa* which seldom escapes as a casual and short-lived alien close to fields where it was originally in cultivation.

Acknowledgements

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Article

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Les peuplements à *Fraxinus dimorpha* (*Oleaceae*) dans les Monts des Ksour occidentaux (Sud ouest algérien): diversité phytocenotique, dynamique structurale et perspectives de conservation

Abstract

Hadjadj, K., Benaissa, M., Mahammedi, M., Belkacem, G. & Guerine, L.: Les peuplements à *Fraxinus dimorpha* (*Oleaceae*) dans les Monts des Ksour occidentaux (Sud ouest algérien): diversité phytocenotique, dynamique structurale et perspectives de conservation. — Fl. Medit. 30: 155-165. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

The stands of *Fraxinus dimorpha* (*Oleaceae*) in the Western Ksour Mountains (South West Algeria): phytocenotic diversity, structural dynamics and conservation prospectives. – *Fraxinus dimorpha* is a threatened species appearing on the IUCN red list. It structures a valuable pre-forest heritage in the Western Ksour Mountains (Algeria), both for its ecological and social value. Thus, the aim of this first study is to contribute to the knowledge of the floristic diversity and the structural dynamics of *Fraxinus dimorpha* stands in this area.
The floristic diversity's analysis of *Fraxinus dimorpha* preforests in western Ksour Mountains has revealed the existence of 188 specific and subspecific taxa belonging to 40 families and 145 genera. The biogeographic spectrum indicates the dominance of Mediterranean taxa with 95 species. 30 endemic species have been identified of which 19 are Algerian-Moroccan ones. The Analysis of biological types indicated the dominance of therophytes over the other life forms (69 taxa, or 36.70%). The study of structural dynamics (diametric classes) showed the dominance of perches (42%), little wood (37%) and medium wood (21%).

Key words: Floristic diversity, ash tree, Algeria, North Africa.

Introduction

Le frêne dimorphe (*Fraxinus dimorpha* Coss. & Durieu) fait partie de la famille des Oléacées. C'est une essence de montagnes, endémique de l'Afrique du Nord avec une répartition restreinte au Maroc et en Algérie (Charco 2001; Fennane & Ibn Tattou 2005; Fennane & al. 2007; Euro+Med 2015). En Algérie le frêne dimorphe est localisé dans l'Aurès (notamment dans les forêts des Oued Ensigha, Oued Boulgem et Oued Tamza), Djebel Tougour près de la province de Batna, la vallée de l'Oued Abdi près de la province de Constantine, Bellezma, Djbel M'zi (Monts des Ksour), Toudja et les Monts de la Kabylie (Battandier & Trabut 1895; Charco 2001). Au Maroc, il existe à l'état disséminé dans l'Haut Atlas (Ayachi, Maâsker, Vallée de l'Ourika près de Marrakech), l'Haut Atlas

central principalement à Ait M'hamed, près de la province d'Azilal, entre 1300 et 1700 m d'altitude, Moyen Atlas (Nord Est du Moyen Atlas et Moyen Atlas central), l'Anti Atlas (Monts Saghro), Monts de Berkine et l'Atlas Saharien (Battandier & Trabut 1895; Boudy 1950; Charco 2001; Fennane & Ibn Tattou 2005; Fennane & al. 2007; Taleb & Fennane 2008; Euro+Med 2015).

L'espèce pousse dans les roches calcaires ou siliceuses moyennes Il préfère les habitats ouverts et ensoleillés, mais peut être trouvée dans les habitats ombragés. Il fleurit de Février à Mars et produit des fruits de Juillet à Septembre (Emberger 1938; Abdessemed 1981; Charco 2001; Genin & al. 2016). C'est une essence xérophyte qui préfère les bioclimats arides et semi-arides, tempérés et frais avec une température entre -20 à 35 ° C. L'espèce tolère également le climat très chaud et sec des montagnes bordant le Sahara (Emberger 1938; Genin & al. 2016).

Fraxinus dimorpha est utilisé en médecine populaire pour ses effets diurétiques, laxatifs, antirhumatismaux et purgatifs doux ainsi que pour traiter la constipation, l'hydropisie, l'arthrite, la douleur rhumatismale, la cystite, la fracture osseuse et le cuir chevelu. Les fruits et les graines sont utilisés comme épices pour leurs qualités culinaires, médicinales et aphrodisiaques (Bellakhdar 1997; Kostova & Iossifova 2007; M'Sou & al. 2016).

Compte tenu de la rareté voir même l'absence des études écologiques et dendrométriques réalisées sur le frêne dimorphe dans les Monts des Ksour, cette recherche constitue une première contribution s'inscrivant dans le cadre de la connaissance, la préservation et la conservation de cette essence signalée endémique de l'Afrique du Nord par Fennane & al. (2007) et Dobignard & Chatelain. (2010-2013) et figurant sur la liste rouge de l'UICN des espèces menacées (Rankou & al. 2017).

Matériels et méthodes

Zone d'étude

Situés au sud de la Meseta oranaise et au nord de la plateforme saharienne, les Monts des Ksour occupent la partie la plus occidentale de l'Atlas saharien (Fig.1). Il s'agit d'une chaîne intracontinentale, formée de terrains méso-cénozoïques plissés lors de l'orogenèse alpine (Aït Ouali 1991; Kacemi & al. 2011). Les Monts des Ksour est une région assez élevée avec certains sommets dépassant les 2000 m (Fillali 2011). Ils sont constitués de chaînons allongés, d'orientation SW-NE, séparés des hautes plaines oranaises au nord par l'accident nord-atlasique et de la plate-forme saharienne au sud par l'accident sud-atlasique. Ils se prolongent à l'ouest par le Haut Atlas marocain et à l'est par l'Atlas Saharien central (Djebel l'Amour) et oriental (Monts des Ouled Naîls) (Yelles & al. 2001; Fillali 2011).

Méthodes

Dans les Monts des Ksour, le frêne dimorphe se localise principalement au niveau des versants à forte pente rocailleuse, généralement dépassant 25 %. Devant cette situation nous avons opté pour un échantillonnage aléatoire dirigé qui tient compte de la variabilité des peuplements de frêne dimorphe rencontré. La liste des espèces est établie à partir de 84 relevés floristiques réalisés sur une superficie de 100 m^2.

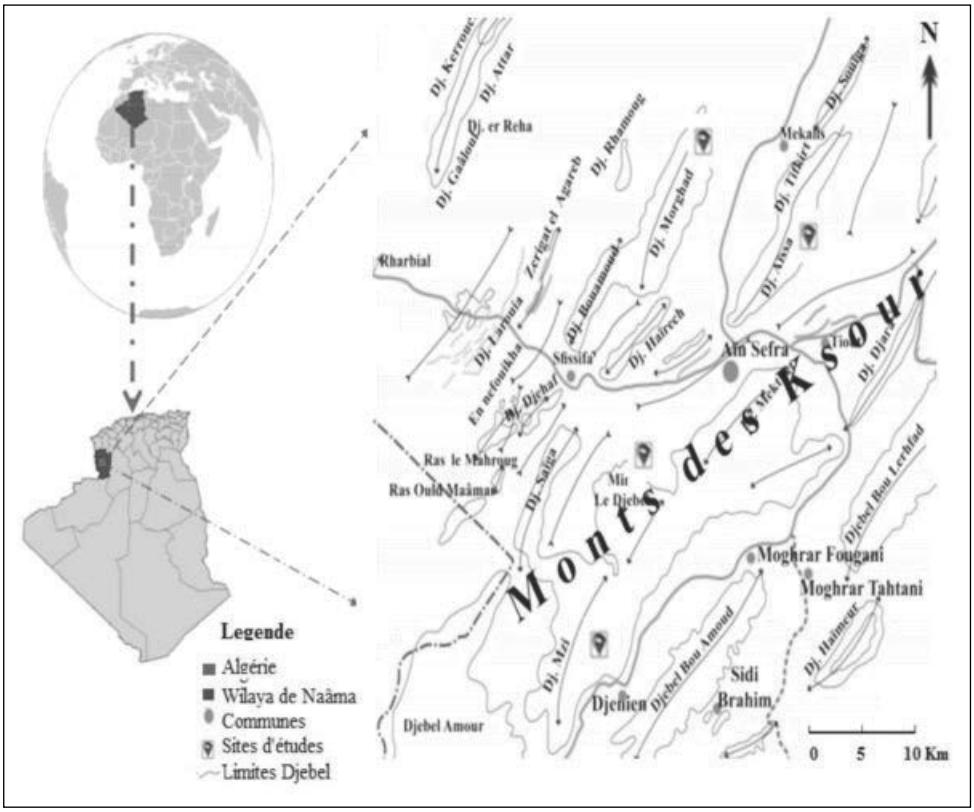


Fig. 1. Situation géographique de la zone d'étude.

Les espèces ont été identifiées selon la Nouvelle Flore d'Algérie et des régions désertiques méridionales (Quézel & Santa 1962-1963), la Flore de l'Afrique du Nord (Maire 1952-1987), la Flore et végétation du Sahara (Ozenda 2004). La nomenclature a été actualisée pour les espèces recensées à la lumière des travaux récents compilés dans l'Index synonyme et bibliographique de la flore nord-africaine (Dobignard & Châtelain 2010-2013).

Une stratification verticale de la flore inventoriée a été réalisée. Les différentes strates retenues dans cette proposition méthodologique sont celles décrites par Delassus (2015):

- Strate arborescente: constituée des arbres dont la hauteur est généralement > 7 m;
- Strate arbustive supérieure: constituée d'arbustes hauts ou de jeunes arbres ayant des hauteurs comprises entre 3 et 7 m;
- Strate arbustive basse: constituée d'arbustes bas ou de jeunes arbres de hauteur comprise entre 1 et 3 m;
-Strate herbacée: constituée des espèces herbacées et des chaméphytes; jeunes plantules des espèces ligneuses, généralement inférieure à 1 m.

Les espèces identifiées ont été indiquées par leur type biogéographique recomposé par Quézel & Santa (1962-1963), Pignatti (1982), Dobignard & Chatelain (2010-2013) et par

leur type biologique. La classification à laquelle nous nous sommes référés est celle de Raunkiaer (1934). Elle se base sur la position qu'occupent les méristèmes en dormance par rapport au niveau du sol durant la saison difficile et se subdivise ainsi en: phanérophyte, chamaephyte, hémicryptophyte, thérophyte et géophytes.

En plus de l'étude du cortège floristique, une évaluation de la dynamique (structure verticale et structure diamétrique) des peuplements du frêne dimorphe a été réalisée. Pour ce faire nous avons mesuré la hauteur totale et la circonférence à 1,30 m du sol de tous les sujets rencontrés dans les relevés floristiques.

Résultats et discussion

Dans l'Atlas saharien occidental (Monts des Ksour), le frêne dimorphe a plutôt tendance à former des peuplements plus au moins ouverts entre 1800 m à 2200 m d'altitude. Il se mélange à la plupart des autres essences préforestières autochtones, il s'associe au chêne vert, pistachier térébinthe, pistachier de l'Atlas, genévrier de phénicie, genévrier oxycèdre.

Maire (1916) signale la présence du frêne dimorphe dans la plupart des montagnes sud oranaises de 1800 à 2100 m sur les grès et les calcaires. Il indique qu'il n'a pas rencontré l'espèce au niveau de Djebel Aissa.

Nos prospections sur terrain dans le territoire de Djebel Aissa ont démontré la présence de cette essence à partir de 1500 m jusqu'au 2100 m d'altitude notamment au niveau Ras Ettwil et oued ouled Benzziane.

Diversité phytocenotique

188 taxons appartenant à 40 familles et 145 genres ont été identifiés (Supplément Électronique 1), ce qui représente 4,37% de la flore totale algérienne estimée à 4300 espèces par Dobinard et Châtelain (2010-2013). Les familles les plus riches en taxons sont: *Asteraceae* avec 37 espèces (19,68%), *Poaceae* 22 espèces (11,70 %), *Brassicaceae* et *Lamiaceae* 14 espèces (7,44 %), *Caryophyllaceae* 13 espèces (6,91 %), *Apiaceae* 9 espèces (4,78 %), *Plantaginaceae* et *Fabaceae* 8 espèces (4,25 %). Ces familles représentent 66,45 % de la flore inventoriée.

Dans l'inventaire vertical de la végétation accompagnant le frêne dimorphe nous avons distingué les strates suivantes: *arbustive supérieure, arbustive basse et herbacée.*

Fraxinus dimorpha se trouve accompagné dans la strate arbustive supérieure par: *Juniperus oxycedrus* L., *J. phoenicea* L. subsp. *phoenicea., Pistacia atlantica* Desf.*, Quercus ilex* subsp. *ballota* (Desf.) Samp.*, Phillyrea latifolia* L., *Acer monospessulanum* L., *Crataegus monogyna* Jacq.

Types géographiques

L'étude biogéographique des végétaux est considérée par plusieurs auteurs (Paccalet 1981; Quézel 1983; Gaston 1991) comme un critère d'appréciation de la diversité biologique.L'analyse du spectre biogéographique des espèces recensées (Tableau 1) montre une dominance des espèces méditerranéennes (95 espèces) ce qui représente 50,53 % de l'ensemble de la flore étudiée. Le type géographique de large répartition et cosmopolite

Tableau 1. Types géographiques des espèces.

Ensembles chorologiques	Nombre	%	Ensembles chorologiques	Nombre	%
MEDITERRANEEN	**95**		Eurasiatique	11	
Méditerranéenne	47		Paléotempéré	6	
Oroméditerranéenne	3		Sud- Ouest européenne	1	**13,30**
Ouest méditerranéenne	16		Européenne	5	
Sud méditerranéenne	2		**LARGE REPARTITION ET COSMOPOLITES**	**38**	
Circumméditerranéenne	3		Cosmopolites	2	
Ibéromaurétanienne	12		Méditerranéo-Atlantiques	4	
Afrique nord, Espagne, Caucasase, Turkey	1	**50,53**	Euro-méditerranéennes	15	
Afrique du nord	11		Macaronésiennes-méditerranéennes	3	
ENDEMIQUES	**30**		Macaronésiennes, méditerranéennes, Asie, occidental	2	
Nord-africaines	5		Paléotropicales	2	**20,21**
Algéro-marocaines	19		Méditerranéenne Asiatiques	2	
Algéro –Marocain-Tunisie, Canarie	1		Eurasiatique. Nord Africaine. Tripoli	3	
Endémiques ibéro-marocain	1		Canarie-Méditerranéen.	1	
Algéro –Marocain, Péninsule Ibérique	4	**15,96**	Méditerranéen-Irano-Touranien	3	
SEPTENTRIONAL	**25**		Méditerranéen, Saharo – Sindien	1	
Circumboréale	2				

est représenté par 38 espèces (21,20 %), dont 15 taxons sont euro-méditerranéennes. Les espèces endémiques sont de l'ordre de 30 espèces (15,96 %), dont la majorité sont algéro-marocaine (19 espèces). En fin, l'ensemble géographique septentrional compte 25 taxons (13,30 %). Les espèces eurasiatiques sont les plus abondantes avec 11 taxa.

Types biologiques

Les types ou formes biologiques qui désignent le comportement adaptatif de l'espèce, renseignent sur le type de la formation végétale, son origine et ses transformations. La répartition des types biologiques de l'ensemble de la flore de notre région d'étude est caractérisée par le schéma qui suit: Th > He >Ch>Nph>Ph>Géo>Phl (Fig. 2). Nous constatons une nette dominance des thérophytes qui constituent à elles seules un peu plus du tiers

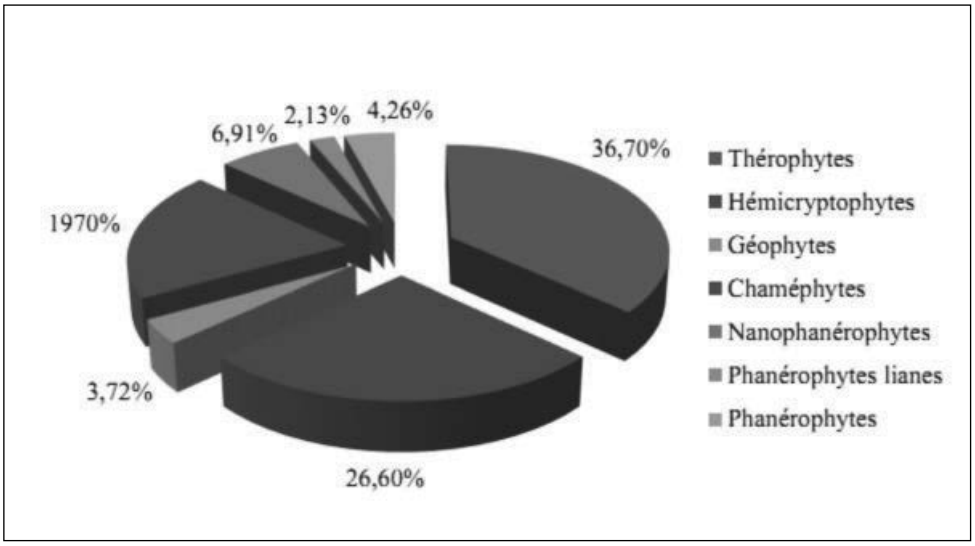


Fig. 2. Types biologiques.

de l'ensemble de la végétation, avec un total de 69 espèces, soit 36,70 %. En deuxième position viennent les hémicryptophytes et sont représentées par 50 taxons soit 26,60 %. Les chaméphytes occupent la troisième position avec 37 espèces ce qui représente 19,68 %. Ces trois types biologiques (thérophytes, hémicryptophytes, chaméphytes) représentent une catégorie majoritaire par rapport aux autres types biologiques, leur taux cumulé est estimé à 82, 98 %.

Le reste des espèces appartient aux nanophanérophytes 6,91 %, phanérophytes, 4,26 %, géophytes, 3,72% et les phanérophytes lianes2, 13 %.

Cette richesse en thérophytes comme on le sait est une caractéristique des zones méditerranéennes et arides où domine un fort stress hydrique et une perturbation du milieu par le pâturage (Grime 1977; Daget 1980; Madon & Médail 1996; Bonnet & al. 1999; Barbero & al. 2001; Hamada & al. 2004; Aidoud 2005; Amghar & al. 2008). En effet, la richesse en thérophytes représente un signe d'aridité du milieu et le phénomène de thérophytie est considéré par Daget (1980) comme une stratégie d'esquive des périodes défavorables.

Structure des peuplements

Le frêne dimorphe se présente sous forme de cépée saine en raison d'une part de sa localisation dans les versants difficilement accessibles et d'autre part épargnée suite à la présence du chêne vert qui constitue pour la population riveraine une excellente source de bois de chauffage. La connaissance de la dynamique des peuplements de frêne dimorphe constitue un élément indispensable à l'élaboration de scénarios et variantes de gestion raisonnée de ces écosystèmes preforestiers.

Structure diamétrique

La structure diamétrique totale, ou répartition des tiges par classes de diamètre, est établie en prenant en compte tous les individus inventoriés (Roullet 1974; Gaudin 1996). Elle est porteuse d'information sur la stabilité (équilibre) du peuplement (Favrichon 1998). Pour des raisons pratiques nous avons choisi les classes suivantes:

Ø ‹7,5 cm: Perches (P);
7,5‹Ø ‹ 22,5: Petit bois (PB);
22,5 ‹Ø ‹ 42,5: Moyen bois (MB);
42,5 ‹Ø ‹ 62,5: Gros bois (GB);
› 62,5 cm: Très gros bois (TGB).

Les données recueillies de l'ensemble des relevés montrent que les classes les mieux représentées dans la frênaie étudiée sont respectivement les perches, avec un effectif de 226 individus, soit 42,40 % de l'effectif total, le petit bois avec un taux de 36,60%, soit 195 individus et le moyen bois représenté par 112 individus, soit 21 % de l'effectif global (Fig. 3). De manière générale, l'aspect de la structure définit la jeunesse des cépées qui forment le taillis, ou les classes de gros bois et très gros bois sont totalement absentes.

Le diamètre moyen de l'ensemble de la frênaie est de 13,29 cm. Cette valeur est nettement supérieure à celle estimée par Chafai (2016) qui lance une valeur moyenne de 5,17 cm pendant l'étude de la dynamique spatiale et de la biomasse du frêne dimorphe dans la cédraie de l'Ouled Yagoub (wilaya de Khenchela).

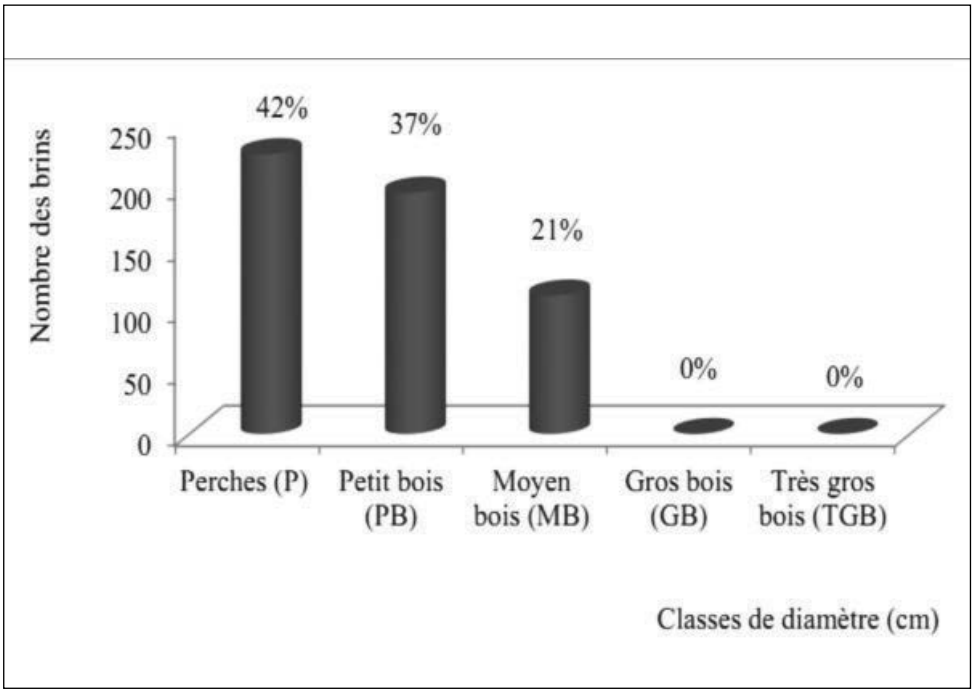


Fig. 3. Structure diamétrique du peuplement de frêne dimorphe dans les Monts des Ksour occidentaux.

Structure verticale

La structure verticale représente la distribution des individus par classes de hauteur. Elle offre, entre autres, l'intérêt de pouvoir fournir un indicateur de richesse du site (Favrichon & al. 1998). Elle renseigne sur les potentialités de la station et sur le dynamisme du peuplement forestier (M'Hirit 1982).

Les hauteurs des sujets échantillonnés sont regroupées ci-dessus en classes pour facilité leurs représentation graphique.

Classe 1: 1 – 2,50 m;
Classe 2: 2,50 – 4 m;
Classe 3: 4 – 5,50 m;
Classe 4: + 5,50 m.

La hauteur moyenne du peuplement varie de 1,80 à 6 m. La valeur moyenne pour l'ensemble de la frênaie est 3,70 m. La figure 4 schématise la distribution des classes de hauteur en fonction des effectifs. Elle révèle la dominance de la classe [2,50 – 4 m], suivie de celle de [1 – 2,50 m], et en troisième place la classe [4 – 5,50 m]. Les fréquences respectives sont 43,71 %, 27,95 % et 21,95 % soit un total de 93,62 %. Les sujets dont les hauteurs dépassent 5,50 m ne représentent que 6,38 %. Malheureusement la faible présence de cette classe rend cette structure sujette à des perturbations, de ce fait ce peuplement semble être déséquilibré.

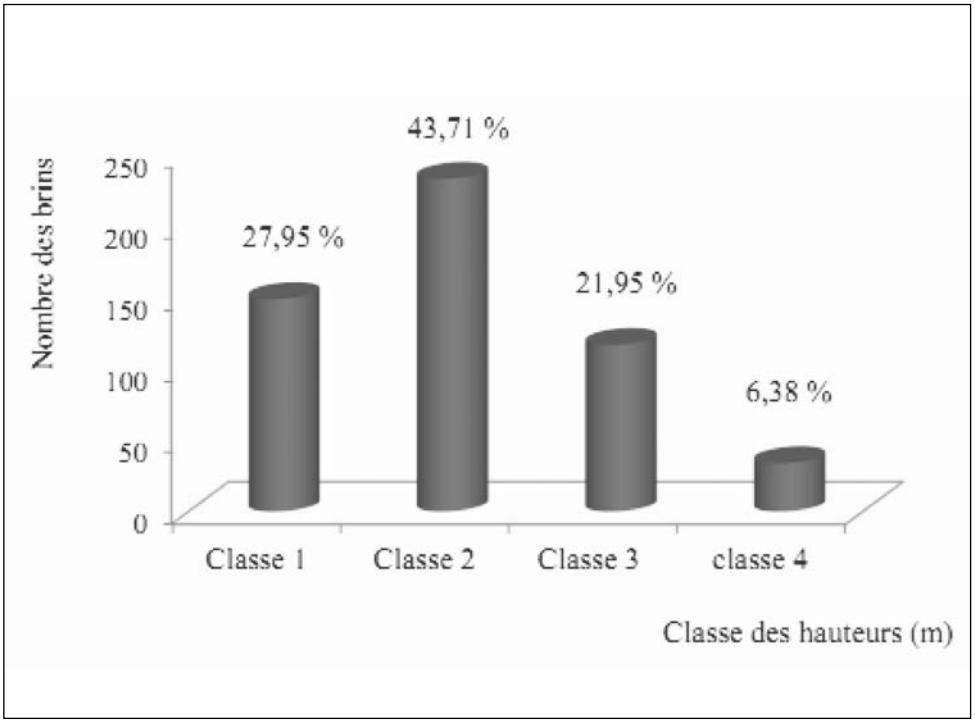


Fig.4. Structure verticale du peuplement de frêne dimorphe dans les Monts des Ksour occidentaux.

Conclusion et perspectives

Les plantes rares, endémiques ou menacées de n'importe quel pays ou région sont de toute évidence celles qui suscitent le plus d'intérêt en matière de recherches, de protection et d'estimation de la biodiversité. En effet, en plus de leur intérêt biogéographique, elles sont rares dans un certain sens à l'échelle mondiale.

Fraxinus dimorpha, espèce menacée suivant la liste rouge de l'Union Internationale pour la Conservation de la Nature (UICN) dans la catégorie EN en danger, protégée par la loi algérienne selon le décret exécutif n °12-03 du04 janvier 2012 établissant la liste des espèces incultes protégées, sa présence dans les Monts des Ksour témoigne donc de la particularité des conditions environnementales, difficilement réalisable dans les autres zones forestières algériennes. Pour préserver l'espèce et ses habitats natifs, les actions suivantes sont recommandées:

Cartographie de l'ensemble des frênaies des Monts des Ksour

Protection des sites potentiels contre la perte et la fragmentation de l'habitat, la déforestation, la collecte excessive et le surpâturage.

Mise en clôture des sites vulnérables pour protéger l'espèce de la surexploitation, du surpâturage, du piétinement et de la collecte impitoyable.

Création d'aires protégées pour assurer la régénération complète des espèces, des écosystèmes et pour restaurer la qualité des milieux sauvages.

Sensibilisation des usagers sur la gestion participative de ces territoires.

Estimation exacte de la taille des populations et étude de leurs dynamiques, tendances, biologie et écologie.

Identification des peuplements porte graines et création d'une banque de semences.

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Article

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A. Lambevska-Hristova, S. Bancheva, M. Karadelev & G. Hristov

New data on the diversity of lignicolous fungi in communities of *Juniperus excelsa* (*Cupressaceae*) in Bulgaria

Abstract

Lambevska-Hristova, A., Bancheva, S., Karadelev, M. & Hristov, G.: New data on the diversity of lignicolous fungi in communities of *Juniperus excelsa* (*Cupressaceae*) in Bulgaria. — Fl. Medit. 30: 167-183. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

This paper provides information about the diversity of lignicolous fungi in communities of *Juniperus excelsa* in the Special area of conservation of NATURA 2000 "Kresna-Ilindentsi" in the Valley of Struma river floristic region, Bulgaria, where its associations is best developed. Six new species for the Bulgarian fungi are reported for the first time. New chorological data concerning three lignicolous fungi is presented too. Two of the recorded taxa, *Antrodia juniperina* and *Pyrofomes demidoffii* have high conservation value, assessed with the recent IUCN criteria, as dangerous parasites or saprobes on *J. excelsa*. Their role as indicators of the Greek juniper populations' state was evaluated.

Key words: Greek juniper, Conservation, Mycological diversity, Kresna-Ilindentsi, SAC NATURA 2000, Wood-decay fungi.

Introduction

Juniperus excelsa M. Bieb. (Greek juniper, *Cupressaceae*) is a rare species in Bulgaria, protected by the Biological Diversity Act (2002). It is included in the Red List of Bulgarian Vascular plants (Petrova & Vladimirov 2009) as "Vulnerable" and is a key species for habitat with European importance, named "39G3 Forests of Grecian juniper", included in the Council Directive 92/43/EEC (1992), the Bulgarian Biological Diversity Act (2007) and the Red Data Book of Republic of Bulgaria as "Critically Endangered" (Tzonev & Dimitrov 2015). *J. excelsa* occurs in Bulgaria only in areas with a pronounced Mediterranean climate – in the Rhodope Mts. and the Struma river Valley floristic regions. In the first locality, the population is small and strongly degraded, while the most representative communities in the country are situated in the Struma river Valley (Fig. 1).

In 2019 a study of the population state of Greek juniper in the Special area of conservation (SAC) of NATURA 2000 "Kresna-Ilindentsi", in the Valley of Struma river was undertaken. During the fieldwork, the attention of the team was attracted by the large num-



Fig. 1. Forest communities of Greek Juniper (*Juniperus excelsa*) in "Moravska" protected place.

ber of lignicolous fungi developing on the dead wood of *J. excelsa*, most of which proved to be new to the Bulgarian Mycota.

The purpose of this work is to announce the establishment of six new lignicolous fungi for the Bulgarian Mycota, and to provide information on the morphology and key features of species differentiation, their distribution, and role as indicators of the Greek juniper populations' state. In addition, the paper aims to provide information on new chorological data for some lignicolous fungal species.

Material and methods

For this study, three major localities of distribution of *J. excelsa* in Struma river Valley were selected, which are the most representative in terms of numbers and density: 1. "Tisata" Nature Reserve in the Kresna Gorge and Stara Kresna region, 2. The Valley of Vlahi river and 3. "Moravska" protected place and Kamenitsa village. The route and stationary methods were used for selected objects.

The Kresna Gorge is one of the least areas with well-preserved forest of Greek juniper in Bulgaria, mainly between 100 and 300–400 m alt. The most representative communities are in "Tisata" Nature Reserve and in its buffer zone. During the field work a remarkable floristic diversity was established with predominance of xerophytes with mostly southern and eastern origin. The vegetation is composed by sclerophilic evergreen and deciduous

shrubs and small trees with many open places covered by rich herbaceous vegetation. Some rare, endangered and protected plants are included in the composition, as *Anthemis auriculata* Boiss., *Prangos trifida* (Mill.) Herrnst. & Heyn (*Cachrys alpina* M. Bieb.), *Colchicum lusitanum* Brot., *Delphinium balcanicum* Pawł., *Goniolimon tataricum* (L.) Boiss., *Ornithogalum oreoides* Zahar., *Sempervivum ciliosum* Craib, *Campanula jacquinii* (Sieber) A. DC. (*Trachelium rumelianum* Hampe), *Verbascum roripifolium* (Halácsy) I. K. Ferguson, etc.

The specimens were identified used standard methods (in accordance with Eriksson & Ryvarden 1973; Jülich 1984; Breitenbach & Kränzlin 1986; Domański 1991; Gilbertson & Ryvarden 1986, 1987; Hansen & Knudsen 1997; Bernicchia & Gorjón 2010), implying microscopy and application of reagents (Melzer's reagent and 5% KOH). Measurements and photographs were examined at magnification up to 1000×, with a LW scientific microscope and MiniVID camera.

The nomenclature follows Index Fungorum, while the nomenclature of vascular plants follow The Euro+Med PlantBase – the information resource for Euro-Mediterranean plant diversity (http://ww2.bgbm.org/EuroPlusMed [last accessed 19.02.2020]). The studied specimens were deposited in the Mycological Collection of the Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences (SOMF).

The monitoring and assessment of the population state of *J. excelsa* has been carried out in accordance with the approved methodologies of the National Biodiversity Monitoring System of the Executive Environment Agency of Bulgaria (http://eea.government.bg/bg/bio/nsmbr/prakticheskо-rakovodstvo-metodiki-za-monitoring-i-otsenka/visshi-rasteniya).

Results

The variety of lignicolous fungi is impressive. To date, no targeted studies have been conducted on *J. excelsa* communities.

As a result of this study, six new basidiomycetes for Bulgaria have been identified, as follows:

1. *Megalocystidium luridum* (Bres.) Jülich, Persoonia 10(1): 140 (1978) [*Stereaceae*].
Bas.: *Corticium luridum* Bres., Fung. trident. 2(11-13): 59 (1898). Syn.: *Gloeocystidiellum luridum* (Bres.) Boidin, C. r. hebd. Séanc. Acad. Sci., Paris 233: 1668 (1951).

Morphological description. Basidiome resupinate, effused, adnate, hymenophore smooth, yellowish to pale cream-brown, margin indifferentiated, hyphal system monomitic, hyphae with clamps, thin-walled, smooth, 2-3 µm, gloeocystidia numerous, tubular, thin-walled, 60-120 × 6-10 µm, with glanular contents, basidia clavate, 35-60 × 5-8 µm, with 4-sterigmata, and with a basal clamp, basidiospores ellipsoid, thin-walled, smooth, 7-9 × 4-7 µm, amyloid (Fig. 2, A-B). The presence of gloeocystidia and the amyloidity of the basidiospores make this species easy to recognize. The closely related species *M. leucoxanthum* (Bres.) Jülich, has clearly larger and allantoid spores.

Ecological remarks. A widespread white-rot lignicolous species that occurs on decayed wood, mostly of deciduous tree, rarely on conifers.

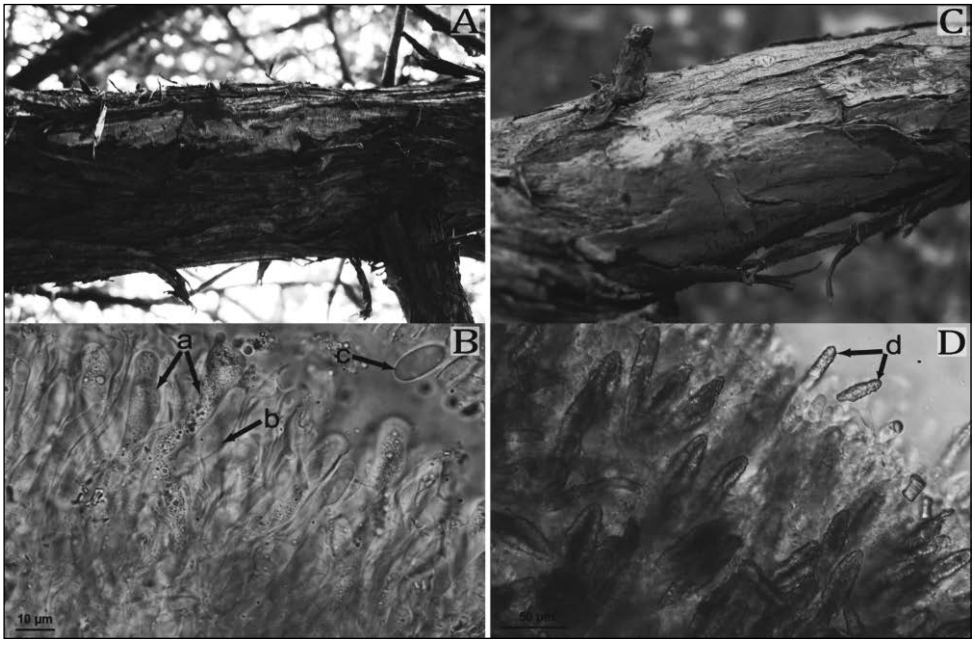


Fig. 2. A) Macroscopic view of basidiome of *M. luridum*; B) Microscopical features of *M. luridum*: section of basidiome, a) presence of numerous gloeocystidia with glanular content, b) basidia, c) basidiospore; C) Macroscopic view of basidiome of *P. junipericola*; D) Microscopical features of *P. junipericola*: section of basidiome, d) presence of numerous incrusted cystidia (lamprocystidia).

Host. On deciduous wood of *Alnus incana* (L.) Moench, *Castanea sativa* Mill., *Fagus sylvatica* L., *Fraxinus ornus* L., *Quercus pubescens* Willd. and also on coniferous wood of *Juniperus communis* L.

General distribution. M. luridum has been reported from different parts of Europe, Turkey, and the Caucasus (Eriksson & Ryvarden 1975; Bernicchia & Gorjón 2010). The species has not been previously reported for Bulgaria.

Distribution in Bulgaria. Struma river Valley, "Moravska" protected place.

Material examined. Struma river Valley, "Moravska" protected place, 1,5 km W of Kresna town, mixed forest with domination of *J. excelsa*, fallen branches of *J. excelsa,* N 41.710916° E 23.142861°, 360 m, 03.V.2019, leg. A. Lambevska-Hristova & G. Hristov, det. A. Lambevska-Hristova & M. Karadelev (SOMF 30 224).

2. *Peniophora junipericola* J. Erikss., Symb. bot. upsal. 10(5): 52 (1950) [*Peniophoraceae*].

Morphological description. Basidiome resupinate, effused, closely adnate, but margin loosening from the substratum, hymenophore smooth to rimose when dry, pinkish or greyish red to violaceous, pale brownish red when old, margin whitish, hyphal system monomitic, hyphae with clamps, basal hyphae thick-walled, brown, 3-4 µm wide, subhymenial hyphae hyaline to brown, thin- to thick- walled, 2.5-4 µm wide, cystidia: lamprocystidia hyaline to brown, thick-walled, encrusted, 40-80 × 6-15 µm, gloeocystidia

fusiform. Basidia subcylindrical, 30-50 × 5-7 µm, with 4-sterigmata and with a basal clamp. Basidiospores allantoid, 7-12 × 2.2-4 µm, smooth, thin-walled, hyaline (Fig. 2, C-D). The species is very similar to *P. pithya* (Pers.) J. Erikss. which occurs on conifers, but differs mainly in colour of basidiome and the margins (Eriksson & al. 1978).

Ecological remarks. According to the Eriksson & al. (1978) ideal ecological conditions for this species are the combinations of dry and warm weather, alternating with periodic humidity.

Host. P. junipericola is considered a white rot saprobe that is apparently restricted only to species of genus *Juniperus* and on *Cupressus, Platycladus* (Ginns & Lefebre 1993; Boidin 1994; Isikov 1997; Minter & al. 2009; Bernicchia & Gorjón 2010; Lambevska & al. 2013).

General distribution. The species is known from Europe, Caucasus, Central Asia and North America (Parmasto & Parmasto 1992; Boidin 1994; Miller & al. 1994; Dämon & al. 2009). The new finding from Bulgaria widens the distributive area of such interesting species.

Distribution in Bulgaria. Struma river Valley, "Moravska" protected place; Kresna Gorge, "Tisata" Nature Reserve, near Peyo Yavorov railway station.

Material examined. Struma river Valley, "Moravska" protected place; 1,5 km W of Kresna town; mixed forest with domination of *J. excelsa*, fallen branches of *J. excelsa*, N 41.710916° E 23.143166°, 352 m, 04.V.2019, leg. A. Lambevska-Hristova & G. Hristov, det. A. Lambevska-Hristova (SOMF 30 225); Kresna Gorge, "Tisata" Nature Reserve, near Peyo Yavorov railway station, mixed forest with domination of *J. excelsa*, *J. excelsa*, N 41.744500° E 23.158833°, 250 m, 03.V.2019, leg. A. Lambevska-Hristova & G. Hristov, det. A. Lambevska-Hristova (SOMF 30 226).

3. *Peniophora meridionalis* Boidin, Bull. trimest. Soc. mycol. Fr. 74(4): 455 (1958) [*Peniophoraceae*].

Morphological description. Basidiome resupinate, effused, hymenophore smooth or slightly tuberculate, beige ochraceous or brown, margin indifferentiated, hyphal system monomitic, hyphae with clamps, hyaline to brown, 2-5 µm wide, cystida: gloeocystidia, 35-50 × 4.5-5 µm, cylindrical, thin-walled, lamprocystidia subcylindrical, thick-walled, encrusted, 30-55 × 8-20 µm, dendrohyphidia projecting with branched part, encrusted, brownish, basidia subclavate, 25-45 × 4.5-5.5 µm, with 4-sterigmata and a basal clamp, basidiospores cylindrical to allantoid, 7-10 × 2.5-3.5 µm, smooth, thin-walled, hyaline (Fig. 3, A-B). Easily recognized microscopically, *P. meridionalis* is characterized by the presence of three kinds of cystidia: gloeocystidia, lamprocystidia and dendrohyphidia.

Ecological remarks and host. It is a thermophilous species which occurs mainly on various deciduous trees and conifers (Bernicchia & Gorjón 2010), often on *Cupressaceae* (*Cupressus sempervirens* L. and *Juniperus oxycedrus* L.).

General distribution. The species is generally distributed in Europe, Asia, Africa, the Canary Islands, Australia (Boidin 1994; Andreasen & Hallenberg 2009). It has not been previously reported for Bulgaria.

Distribution in Bulgaria. Kresna Gorge, "Tisata" Nature Reserve, near Peyo Yavorov railway station.

Material examined. Kresna Gorge, "Tisata" Nature Reserve, near Peyo Yavorov railway station, mixed forest with domination of *J. excelsa*, dead woood of *J. oxycedrus*, N 41.746444° E 23.153166°, 209 m, 03.V.2019, leg. A. Lambevska-Hristova & G. Hristov, det. A. Lambevska-Hristova & M. Karadelev (SOMF 30 227).

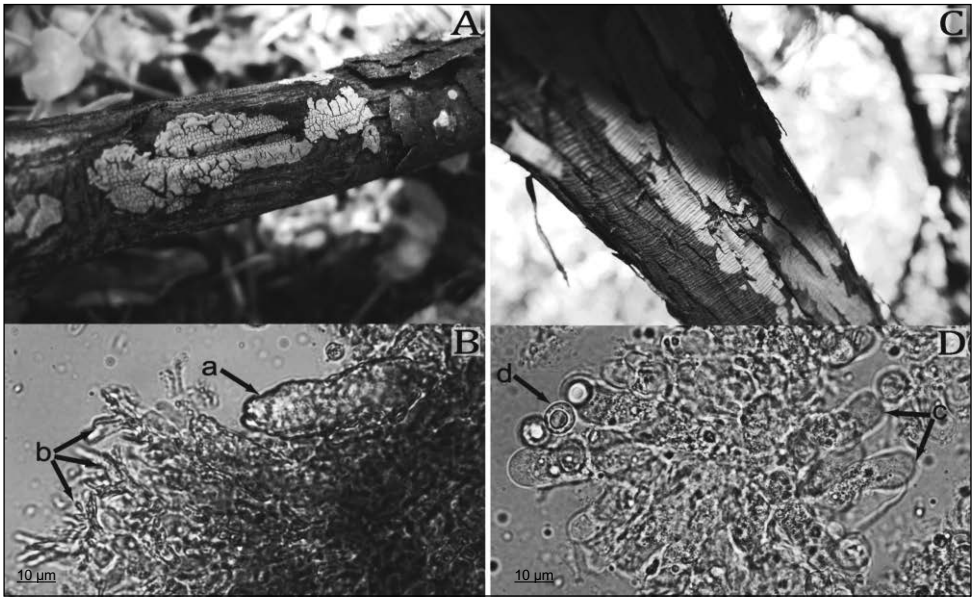


Fig. 3. A) Macroscopic view of basidiome of *P. meridionalis*; B) Microscopical features of *P. meridionalis*: section of basidiome, a) encrusted lamprocystidia, b) dendrohyphidia projecting with branched part, encrusted; C) Macroscopic view of basidiome of *R. rickii*; D) Microscopical features of *R. rickii*: section of basidiome, c) basidia, d) basidiospore.

4. *Radulomyces rickii* (Bres.) M.P. Christ., Dansk bot. Ark. 19(2): 128 (1960) [*Radulomycetaceae*].

Bas.: *Corticium rickii* Bres., Öst. bot. Z. 48:136 (1898).

Morphological description. Basidiome resupinate, effused, adnate, hymenophore smooth, orange-white to pale orange or greyish orange, margins thinning, paler concolorous, hyphal system monomitic, hyphae with clamps, hyaline, thin-walled, 3-3.5 µm wide, cystidia absent, hyphal ends present, with obtuse apex, often with protuberances and branches; basidia clavate to cylindrical, 25-40 × 5-10 µm, with 4-sterigmata and a basal clamp, with oildrops, basidiospores broadly ellipsoid to subglobose, thin-walled, 6-9 µm, smooth or minutely warted. Among the *Radulomyces* species, it is characterized by the warted globose basidiospores but also in the broadly cylindrical basidia (Fig. 3, C-D). The very similar *R. confluens* (Fr.) M.P. Christ. differs in having slight but significant difference in spore size and form and also a small difference in basidiome size (Ghobad-Nejhad & Kotiranta 2007).

Ecological remarks and host. The species grows on decayed, mostly decorticate wood from both conifers and broadleaved trees (Bourdot & Galzin 1928; Malençon 1952; Christiansen 1960; Cunningham 1963; Boidin & al. 1988; Legon & al. 2005; Gorjón & al. 2006 and Bernicchia & Gorjón 2010).

General distribution. The species is reported from Europe, Australia, North Africa (Morocco), Western Asia (Iran), South America (Argentina, Brazil, Colombia) and New Zealand (Ghobad-Nejhad & Kotiranta 2007). It has not been previously reported for Bulgaria

Distribution in Bulgaria. Kresna Gorge, "Tisata" Nature Reserve, near Peyo Yavorov railway station.

Material examined. Kresna Gorge, "Tisata" Nature Reserve, near Peyo Yavorov railway station, mixed forest with domination of *J. excelsa*, fallen branches of *J. excelsa*, N 41.746444° E 23.153166°, 209 m, 03.V.2019, leg. A. Lambevska-Hristova & G. Hristov, det. A. Lambevska-Hristova & M. Karadelev (SOMF 30 228).

5. *Xylodon asperus* (Fr.) Hjortstam & Ryvarden, Syn. Fung. (Oslo) 26: 34 (2009) [*Schizoporaceae*].

Bas.: *Grandinia aspera* Fr., Hymenomyc. eur. (Upsaliae): 627 (1874). Syn.: *Hyphodontia aspera* (Fr.) J. Erikss., Symb. bot. upsal. 16(1): 104 (1958).

Morphological description. Basidiome resupinate, effused, adnate, white, cream and even ochraceous colour, hymenophore odontoid with scattered aculei and with smooth hymenium between them, hyphals ends in the aculei usually smooth or with few crystals, hyphal system monomitic, hyphae with clamps, slightly thick-walled, 2-3 µm wide, cystidia absent, hyphal ends frequently capitate, basidia cylindrical, constricted, 18-25 × 4-5 µm, with 4-sterigmata and a basal clamp, basidiospores ellipsoid, 5-6 × 3.5-4 µm, smooth, thin-walled (Fig. 4, A-B). According to the data published by Breitenbach & Kränzlin (1986), this lignicolous saprotroph is very closed to *X. brevisetus* (P. Karst.) Hjortstam & Ryvarden and differ from it only by somewhat larger spores and which occurs preferentially on spruce.

Ecological remarks and host. The species within the genus *Xylodon* are primarily wood decomposers, cause decaying of white rot type on dead wood of conifers, but often also on deciduous trees. The species in this widespread genus commonly occur in temperate to tropical areas (Wang & Chen 2017). In Bulgaria it was recently collected on fallen branches of Greek juniper, a substrate that has not previously been reported in the literature.

General distribution. Asia (Hjortstam & Ryvarden 2004; Dai 2011; Ghobad-Nejhad 2011; Gafforov & al. 2017), Europe (Langer 1994; Bernicchia & Gorjón 2010); North America (Gilbertson 1980; Tapia & al. 2016); South America (Langer 1994; Hjortstam & Ryvarden 2008). The species is distributed in temperate and tropical regions with cold and hot seasonable climate (Gafforov & al. 2017). Very common species in all European countries, but it has not been previously reported for Bulgaria.

Distribution in Bulgaria. Kresna Gorge, "Tisata" Nature Reserve, near Peyo Yavorov railway station.

Material examined. Kresna Gorge, "Tisata" Nature Reserve, near Peyo Yavorov railway station, mixed forest with domination of *J. excelsa*, fallen branch of *J. excelsa*, N 41.744500° E 23.158833°, 250 m, 03.V.2019, leg. A. Lambevska-Hristova & G. Hristov, det. A. Lambevska-Hristova & M. Karadelev (SOMF 30 229).

6. *Xylodon juniperi* (Bourdot & Galzin) Hjortstam & Ryvarden, Syn. Fung. (Oslo) 26: 38 (2009) [*Schizoporaceae*].

Bas.: *Corticium serum* var. *juniperi* Bourdot & Galzin, Bull. Soc. Mycol. Fr. 27(2): 246 (1911). Syn.: *Hyphodontia juniperi* (Bourdot & Galzin) J. Erikss. & Hjortstam, Cortic. N. Eur. (Oslo) 4: 666 (1976).

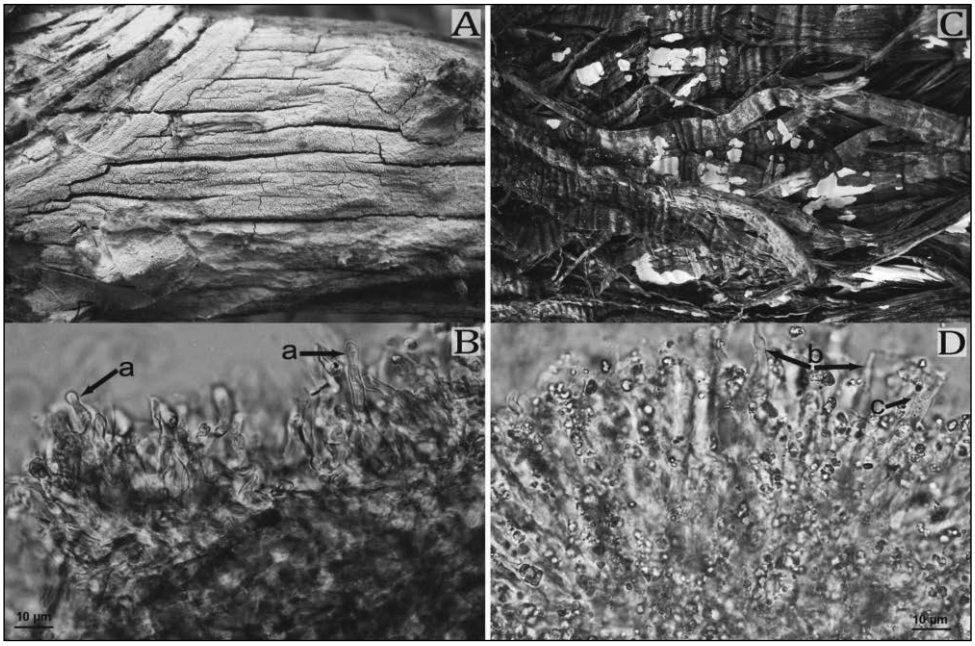


Fig. 4. A) Macroscopic view of basidiome of *X. asperus*; B) Microscopical features of *X. asperus*: section of basidiome, a) capitate hyphae; C) Macroscopic view of basidiome of *X. juniperi*; D) Microscopical features of *X. juniperi*: section of basidiome, b) cystidia as subulate hyphal ends, encrusted (cystidium), c) basidia.

Morphological description. Basidiome resipinate, closely adnate, white-cream coloured, hymenophore smooth and with some scattered small granules, white, margin not especially distinct, but well defined, hyphal system monomitic, hyphae with clamps, thin-walled, 2-5 µm wide, encrusted, cystidia as subulate hyphal ends, 20-30 × 2-5 µm wide, encrusted, basidia subclavate to subcylindrical, 15-25 × 4-5 µm, with 4-sterigmata, thin-walled and with a basal clamp, basidiospores ellipsoid, thin-walled, smooth, 5-6 × 3-4 µm, non-amyloid (Fig. 4, C-D). It is very similar to *X. crustosus* (Pers.) Chevall., differs in having ellipsoid spores and odontoid hymenophore.

Ecological remarks. Yurchenko, Xiong & Wu (2013) mentioned that it occurs in boreo-nemoral, nemoral and mediterranean types of biomes. As shown in its distribution, *X. juniperi* prefers to grow in warm and moderately dry regions, more often on low mountains or stony areas. Species of *Xylodon* are wood-decaying saprobes, causing a white rot in coniferous and deciduous wood and therefore participating in carbon recycling of forest ecosystems (Eriksson & Ryvarden 1976).

Host. According to the available literature, the taxa prefers juniper species, but is known also on hard deciduous wood (Bernicchia & Gorjón 2010). Here we report it for the first time on Greek juniper.

General distribution. The species is known from North America, South America, Asia, Africa and Europe. According to Yurchenko, Xiong & Wu (2013) this species has predominantly temperate-holarctic distribution. It has not previously been reported in Bulgaria.

Distribution in Bulgaria. Kresna Gorge, "Tisata" Nature Reserve; near Peyo Yavorov railway station.

Material examined. Kresna Gorge, "Tisata" Nature Reserve; near Peyo Yavorov railway station; mixed forest with domination of *J. excelsa*, fallen branches of *J. excelsa*, N 41.746444° E 23.153166°, 209 m, 03.V.2019, leg. A. Lambevska-Hristova & G. Hristov, det. A. Lambevska-Hristova & M. Karadelev (SOMF 30 230).

During this study, new chorological data for three lignicolous fungi were also identified:

1. ***Amylostereum laevigatum*** (Fr.) Boidin, Revue Mycol., Paris 23(3): 345 (1958) [*Amylostereaceae*].

Bas.: *Thelephora laevigata* Fr., Elench. Fung. (Greifswald) 1: 224 (1828).

Material examined. Struma river Valley, "Moravska" protected place, 1,5 km Western of Kresna town, mixed forest with domination of *J. excelsa*, fallen branches of *J. excelsa*, N 41.711694° E 23.145305°, 336 m, 05.V.2019, leg. A. Lambevska-Hristova & G. Hristov, det. A. Lambevska-Hristova & M. Karadelev (SOMF 30 231).

A. laevigatum is a key element of boreal ecosystems, due to their wood-decomposing abilities. The species cause decaying of white rot type in conifers (Lambevska-Hristova & Karadelev 2019). Till now, it is known from *Cupressus sempervirens*, *Juniperus communis, J. communis* subsp. *nana* Syme, *J. excelsa*, *J. foetidissima* Willd., *J. oxycedrus, Taxus baccata* L. and *Thuja occidentalis* L. (Eriksson, Hjortstam & Ryvarden 1981; Karadelev 2000; Bernicchia & Gorjón 2010; Lambevska-Hristova & Karadelev 2019). Here we report it for the first time on fallen branches of *J. excelsa*.

In Bulgaria the species was known, so far, only from Western Rhodopes Mts. (Reid & Vanev 1984). The species is known from the temperate regions of Eurasia and North America.

2. ***Hymenochaete fuliginosa*** (Pers.) Lév., Annls Sci. Nat., Bot., sér. 3 5: 152 (1846) [*Hymenochaetaceae*].

Bas.: *Thelephora fuliginosa* Pers., Mycologia Europaea 1: 145 (1822). Syn.: *Hymenochaete subfuliginosa* Bourdot et Galzin, Bull. Soc. Mycol. Fr. 38(2): 184 (1922).

Material examined. Kresna Gorge, "Tisata" Nature Reserve, near Peyo Yavorov railway station, mixed forest with domination of *J. excelsa*, fallen branches of *J. excelsa*, N 41.744500° E 23.158833°, 250 m, 03.V.2019, leg. A. Lambevska-Hristova & G. Hristov, det. A. Lambevska-Hristova & M. Karadelev (SOMF 30 232).

H. fuliginosa is a wood saprophyte which grows preferentially on fallen trunks and branches of conifers, such as *Abies, Juniperus, Larix, Picea*, *Pinus* and *Taxus,* but also on different deciduous substrates, such as *Alnus*, *Populus* and *Salix* (Corfixen & Parmasto 2017). It causes a white rot on coniferous and deciduous wood. In Macedonia, it generally grows on *J. excelsa* (Karadelev 1993; Karadelev & Rusevska 2004). Here we report it for the first time on fallen branches of Greek juniper.

This species has been reported previously only once from Bulgaria as *Hymenochaete subfuliginosa* Bourd. Et Galz., from Eastern Stara Planina Mts., more than 30 years ago (Kuthan & Kotlaba 1989). The general distribution covers North America, Europe, and

temperate Asia. According to data provided by Kriegelsteiner (2000), in Europe it is distributed from southern France through Central Europe to Northern Europe.

3. *Xylodon crustosus* (Pers.) Chevall. [as 'crustosum'], Fl. gén. env. Paris (Paris) 1: 272 (1826) [*Schizoporaceae*].

Bas.: *Odontia crustosa* Pers., Observ. Mycol. (Lipsiae) 2: 16 (1800). Syn.: *Hyphodontia crustosa* (Pers.) J. Erikss., Symb. bot. upsal. 16(1): 104 (1958).

Material examined. Kresna Gorge, "Tisata" Nature Reserve, near Peyo Yavorov railway station, mixed forest with domination of *J. excelsa*, dead fallen branches of *J. excelsa*, N 41.744222° E 23.157416°, 278 m, 04.V.2019, leg. A. Lambevska-Hristova & G. Hristov, det. A. Lambevska-Hristova & M. Karadelev (SOMF 30 233).

According to Gafforov & al. (2017) this saprotrophic odontoid species is well adapted to the arid and semi-arid environments. It occurred on dead wood of conifers, such as *Abies alba* Mill., *J. communis*, *J. oxycedrus*, *J. phoenicea* L., *Pinus pinea* L. and *Taxus baccata*, but also on different deciduous tree (Bernicchia & Gorjón 2010). In "Tisata" Nature Reserve, we found it on dead fallen branches of *J. excelsa*. This host has not previously been published for the species in the literature.

Previously, the species was known in Bulgaria only from the Central Rhodopes Mts., reported as *Odontia crustosa* Pers. (Pilát 1937). The general distribution covers South Africa, Asia, Europe, North America, South America and Australia (Hallenberg 1981; Wu 1990; Langer 1994; Maekawa 1994; Ginns 1998; Hjortstam & al. 2005; Hjortstam & Ryvarden 2007a, 2007b; 2009; Bernicchia & Gorjón 2010; Dai 2011; Ghobad-Nejhad 2011; Kaur & al. 2014; Tapia & al. 2016).

Fungi of high conservation value

During the recent study two lignicolous species of high conservation significance were registered, the saprobe *Antrodia juniperina* (Murrill) Niemelä & Ryvarden and the parasite *Pyrofomes demidoffii* (Lév.) Kotl. & Pouzar. They are included in the Red Data Book of the Republic of Bulgaria (Denchev & al. 2015) and the Red List of Fungi in Bulgaria (Gyosheva & al. 2006), as Endangered EN [B2ab(i,ii,iv)].

Antrodia juniperina (Murrill) Niemelä & Ryvarden. (Brown rot) [*Fomitopsidaceae*].

The species has been reported, till now, only from Struma river Valley ("Tisata" Nature Reserve) and Central Rhodopes Mts. (Stoichev 1990; Denchev & Assyov 2010, Tzonev & Dimitrov 2015). It is worth to mention also that no specimens were found in SOMF to support this record. We found the species in addition to the "Tisata" Nature Reserve (19 samples) also in following 4 localities: "Moravska" protected place (20 samples), Kamenitsa village (3), Stara Kresna region (2) and along Vlahi river Valley (4). This is the first indication for the occurrence of this species in "Moravska" protected place, Stara Kresna region and along Vlahi river Valley. The protected sites "Tisata" and "Moravska" are the best place for development and conservation of this taxon compared to other areas. According to the published data by Doğan & Karadelev (2006) it grows exclusively as a saprobe, rarely as a parasite, on dry branches and old trunks of *J. excelsa* and *J. foetidissi-*

ma. In Europe, it is a very rare species with restricted range that follows the spread of the juniper host (Fig. 5, A). It is particularly frequent on old trunks of Greek juniper in the Balkans (Macedonia, Bulgaria and Albania).

Material examined. Struma river Valley, 1 km SE of Kamenitsa village, mixed forest with domination of *J. excelsa*, *J. excelsa*, N 41.644825° E 23.165250°, 225 m, 03.V.2019, leg. A. Lambevska-Hristova & G. Hristov, det. A. Lambevska-Hristova (SOMF 30 234); Kresna Gorge, "Tisata" Nature Reserve, near Peyo Yavorov railway station, mixed forest with domination of *J. excelsa*, *J. excelsa*, N 41.744611° E 23.158527°, 254 m, 04.V.2019, leg. A. Lambevska-Hristova & G. Hristov, det. A. Lambevska-Hristova (SOMF 30 235); Struma river Valley, "Moravska" protected place, 1,5 km W of Kresna town, mixed forest with domination of *J. excelsa*, *J. excelsa*, N 41.711055° E 23.143861°, 339 m, 04.V.2019, leg. A. Lambevska-Hristova & G. Hristov, det. A. Lambevska-Hristova (SOMF 30 236); Kresna Gorge, 3 km S of Stara Kresna viilage, mixed forest with domination of *J. excelsa, J. excelsa*, N 41.763305° E 23.172027°, 460 m, 30.X.2019, leg. A. Lambevska-Hristova, S. Bancheva, I. Aneva & A. Tanev, det. A. Lambevska-Hristova (SOMF 30 237) and Vlahi river Valley, 2 km W of Vlahi village, mixed forest with domination of *J. excelsa*, *J. excelsa*, N 41.740444° E 23.206777°, 419 m, 05.V.2019, leg. A. Lambevska-Hristova & G. Hristov, det. A. Lambevska-Hristova (SOMF 30 238).

Pyrofomes demidoffii (Lév.) Kotl. & Pouzar (Juniper pocket rot) [*Polyporaceae*].

It has been previously recorded from Struma river Valley ("Tisata" Nature Reserve) and Central Rhodopes Mts. (Stoichev 1982 as *Phellinus demidoffii*; Denchev & Assyov 2010;

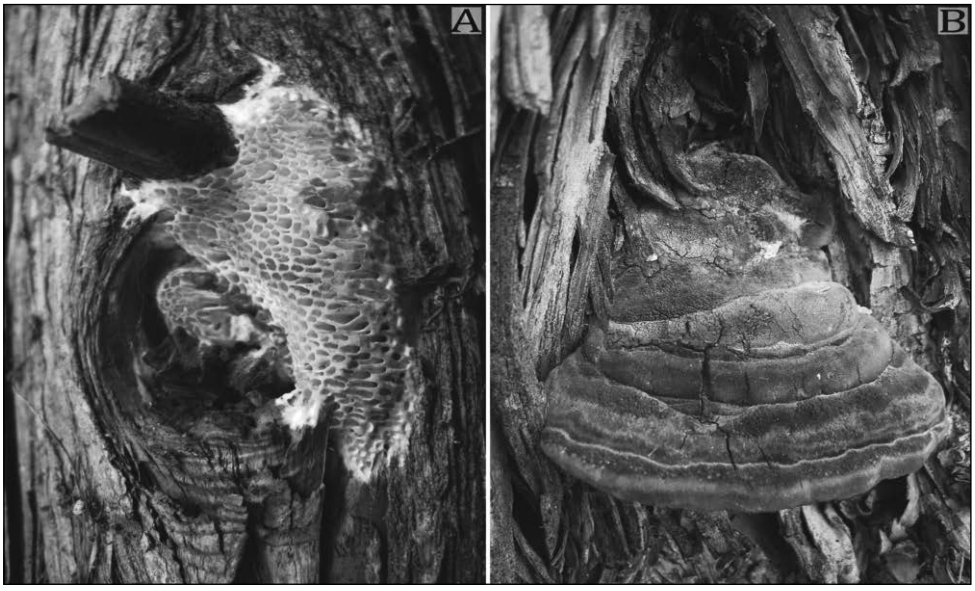


Fig. 5. A) *Antrodia juniperina* (Murrill) Niemelä & Ryvarden; B) *Pyrofomes demidoffii* (Lév.) Kotl. & Pouzar.

Alexov & al. 2012; Tzonev & Dimitrov 2015). It occurrence is now confirmed with new material from "Tisata" Nature Reserve (3 samples). In addition we found it also in "Moravska" protected place (4) and Stara Kresna region (11). This species was found for the first time in "Moravska" protected place and Stara Kresna region. It is a dangerous parasite that causes a considerable damage in *Juniperus* associations (Fig. 5, B). It parasites on old juniper trees usually present in a good developed forests. The species is registered on *J. excelsa* and *J. foetidissima* (Doğan & Karadelev 2006). Juniper pocket rot is a rare species in Europe with restricted area of distribution which following the host distribution. It is particularly frequent on old trunks of Greek juniper in the Balkans (Macedonia, Bulgaria and Albania).

Material examined. Kresna Gorge, "Tisata" Nature Reserve, near Peyo Yavorov railway station, mixed forest with domination of *J. excelsa*, on trunk of *J. excelsa*, N 41.745166° E 23.159883°, 227 m, 03.V.2019, leg. A. Lambevska-Hristova & G. Hristov, det. A. Lambevska-Hristova (SOMF 30 239); Struma river Valley, "Moravska" protected place, 1 km W of Kresna town, mixed forest with domination of *J. excelsa*, *J. excelsa*, N 41.712555° E 23.147361°, 339 m, 05.V.2019, leg. A. Lambevska-Hristova & G. Hristov, det. A. Lambevska-Hristova (SOMF 30 240) and Kresna Gorge, 3 km S of Stara Kresna viilage, mixed forest with domination of *J. excelsa*, *J. excelsa*, N 41.762916° E 23.171250°, 437 m, 30.X.2019, leg. A. Lambevska-Hristova, S. Bancheva, I. Aneva & A. Tanev, det. A. Lambevska-Hristova (SOMF 30 241); Kresna Gorge, near train station Stara Kresna, *J. excelsa*, 20.VIII.2011, leg. P. Nedelev, det. B. Assyov (SOMF 29 396).

The distribution map of species of *A. juniperina* and *P. demidoffii* in the SAC "Kresna-Ilindentsi" is shown in Fig. 6.

Discussion

The territory of Bulgaria falls in the northern part of the distribution of *J. excelsa* and the conservation of its populations is of great importance for the preservation of their specific gene pool. The presence of such a wide variety of saprobic fungi in the Greek juniper forests is evidence of their good functional condition, especially in "Tisata" Nature Reserve, followed by the "Moravska" protected place. This is because the prerequisite for their good development is the presence of old trees and dead wood. In this sense, the presence or absence of saprobic fungi in the juniper forests is a good indicator and can be used in assessing their conservation state.

The Greek juniper forests are an outstanding biodiversity hotspot for rare and specific fungal species with a restricted distribution in Europe. Part of them, such as the endangered *Antrodia juniperina* and *Pyrofomes demidoffii*, are characteristic taxa for the habitat of *J. excelsa*, which is rare for Europe and with priority for conservation. Some of the established taxa, such as *A. laevigatum*, *A. juniperina*, *P. junipericola*, *P. demidoffii* and *X. juniperi* grow exclusively on juniper species, including on *J. excelsa*. A part of them, such as *A. juniperina* and *P. demidoffii* are rare, and their protection in the studied area is invaluable for the mycodiversity of the country.

In our estimation, the presence of the parasite *P. demidoffii* on Greek juniper does not currently have a significant negative impact on the forests, but in the future it is necessary to monitor the extent of its spread and impact.

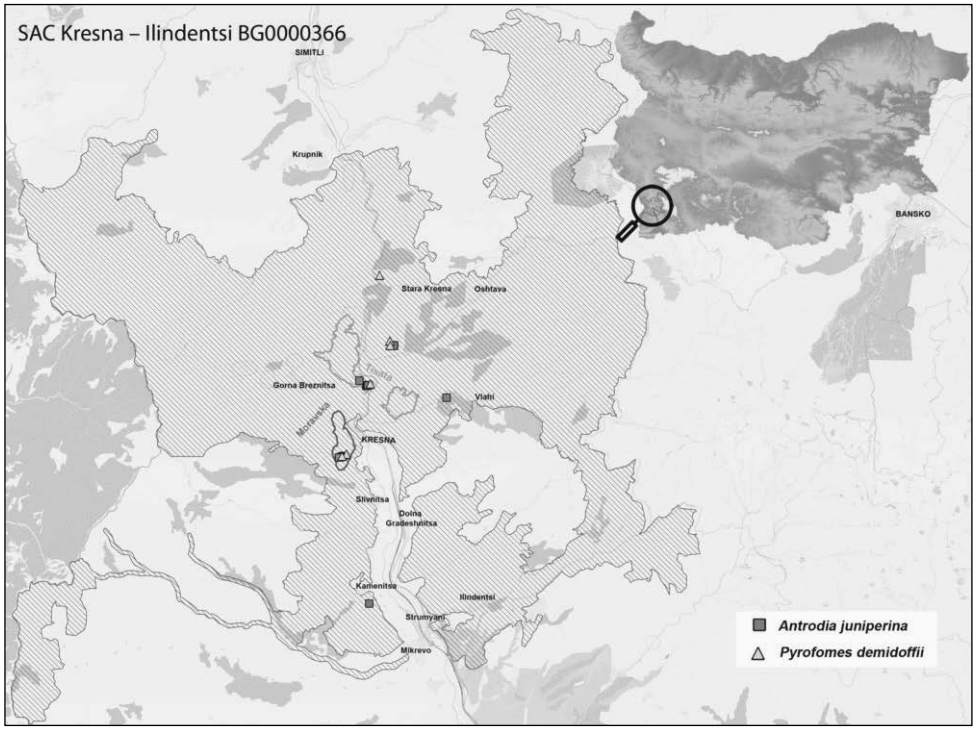


Fig. 6. Distribution map of *Antrodia juniperina* and *Pyroformes demidoffii* in the SAC "Kresna-Ilindentsi".

The present study reveals in addition 11 records of aphyllophoroid fungi from the studied area: *Byssomerulius corium* (Pers.) Parmasto, *Corticium roseum* Pers., *Dacrymyces stillatus* Nees, *Peniophora cinerea* (Pers.) Cooke, *P. incarnata* (Pers.) P. Karst., *P. lycii* (Pers.) Höhn. & Litsch., *P. nuda* (Fr.) Bres., *P. quercina* (Pers.) Cooke, *Polyporus arcularius* (Batsch) Fr., *Vuilleminia comedens* (Nees) Maire, and one ascomycete: *Propolis farinosa* (Pers.) Fr. These species were found as saprobes on deciduous wood of different trees in the habitat of the Grecian Juniper.

Conclusion

The results of this study provide the evidence that the Grecian juniper forests in SAC "Kresna-Ilindentsi", possess an extraordinary richness of plants and fungi, some of which are of high conservation importance. The fungal and plant diversity there must be monitored periodically and strictly protected for future generations.

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Article

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More new geophytes for Tunisian and North African alien flora

Abstract

El Mokni, R. & Hadj Khalifa, K.: More new geophytes for Tunisian and North African alien flora. — Fl. Medit. 30: 185-196. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

This paper deals with ten bulbous species that are new to the Tunisian allochthonous flora, *Chasmanthe floribunda*, *Freesia alba*, *Gladiolus murielae*, *Hippeastrum puniceum*, *Hymenocallis littoralis*, *Narcissus papyraceus* subsp. *papyraceus*, *Nothoscordum gracile*, *Tulbaghia violacea*, *Zephyranthes candida* and *Z. rosea*. Moreover, six of them are new aliens to North Africa and one genus has not been reported before in the Mediterranean area. All reported plants have been introduced since many years mainly as ornamentals, subsequently escaped in the wild.

Key words: Xenophytes, Bulbous plants, Iridaceae, Amaryllidaceae, petaloid Monocots.

Introduction

Non-native plants, known also as exotic, introduced, alien, or non-indigenous, are those taxa whose presence in a given area is due to intentional or unintentional human involvement, or which have arrived there without the help of people from an area in which they are native (Pyšek & al. 2004a). In the past two decades and due to a better coverage of the Tunisian territory with floristic studies, the knowledge on the non-native flora of Tunisia and N Africa significantly increased (see e.g., El Mokni & Iamonico 2018a, 2018b, 2019, 2020; El Mokni & Verloove 2019; El Mokni & Domina 2020; Iamonico & El Mokni 2020; Médail & al. 2020). However, information about alien bulbous plants (geophytes) is mostly recent and still scarce (see e.g., El Mokni & El Aouni 2011, 2012; El Mokni & al. 2020; Médail & al. 2020). The present contribution aims at improving the botanical knowledge about Tunisian flora and updating data on its non-indigenous component.

Materials and Methods

Field work carried out by the authors in Central and Northern Tunisia (N Africa), mostly between 2008 and 2020, revealed new national and even N African records. All records here reported are amended by general information for each genus, including data on its

actual distribution worldwide. The actual status/degree of naturalization for each taxon is assessed based on numerous sources such as Richardson & al. (2000), Richardson & Pyšek (2006), Pyšek & al. (2004b). Further comments on distribution, habitats occupied and some field photographs are also presented. Vouchers are kept in the personal herbarium of Ridha El Mokni kept at the Faculty of Pharmacy of Monastir (Herb. El Mokni!).

The paper presents taxa in alphabetical sequence. Nomenclature of the presented taxa is mostly in accordance with recent sources (cf. APD 2020; Euro+Med PlantBase 2020; WCSP 2020).

Results: floristic records

Chasmanthe floribunda (Salisb.) N. E. Br. var. ***floribunda*** (***Iridaceae***) (Fig. 1. D & E)

New for the non-native flora of Tunisia and flora of the Maghreb (see e.g., GBIF 2020; APD 2020).

TUNISIA: Beja, Nefza, few individuals growing within a cultivated area of *Eucalyptus* spp. trees near the dam of 'Sidi Barrak', 50 m a.s.l., 11.05.2014, *R. El Monki s.n.* (Herb. El Mokni!), Bizerta, Jarzouna, one individual in a swampy area with *Juncus* spp., 05 m a.s.l., 08.03.2019, *R. El Monki s.n.* (Herb. El Mokni!); Bizerta-City (Bab Mateur), few juvenile individuals under walls, 30 m a.s.l., 04.03.2020, R. *El Monki s.n.* (Herb. El Mokni!); Jendouba, Tabarka towards Elhouemdeya, within roadsides, 30 m a.s.l., 04.03.2020, *R. El Monki s.n.* (seeds were colleced). (Herb. El Mokni!).

Chasmanthe N.E. Br. is a small genus of three species endemic to the south-western, southern and south-eastern Cape Province (cf. De Vos 1985). Early in the seventeenth century species of *Chasmanthe* were already cultivated in Europe and England, where it was known that they came from Africa (De Vos 1985; Duncan 2001). *C. floribunda* has a wide distribution in the south-western Cape from Caledon to the Gifberg south of Vanrhynsdorp (De Vos 1985). It is now cultivated in numerous south-western Cape gardens, including the National Botanic Gardens at Kirstenbosch where large stands of both varieties are in flowers from July to August (De Vos 1985). *Chasmanthe floribunda* var. *floribunda* is easily distinguished from closer *C. aethiopica* (L.) N.E. Br. and *C. bicolor* (Ten.) N.E. Br., by its longer upper segment of perianth tube and its distichous flower spike usually with 20-40 flowers. The typical variety shows orange-red flowers with dark purple anthers (De Vos 1985). In Europe, the species is reported from Portugal, France and Italy (Galasso & al. 2018; Domina & al. 2018; GBIF 2020). In North Africa, *Chasmanthe floribunda* var. *floribunda* is reported only in Canary Islands as "introduced" (APD 2020). It is here reported for the first time from Tunisia and the whole Maghreb, where the plant can be classified as a 'casual alien', since it currently appears only in sporadic individuals (not more than 20) in different regions in the country.

Freesia alba (G.L. Mey.) Gumbl. (≡ *F. refracta* var. *alba* G.L. Mey.) (***Iridaceae***) (Fig. 1. B & C)

New for the non-native flora of Tunisia and of N Africa. (see e.g., GBIF 2020; APD 2020).

TUNISIA: Bizerta, three individuals growing near a public garden where the species could be cultivated around or some bulbs were brought within the soil from some evacu-

ated pots in this garden, 10 m a.s.l., 22.02.2012, *R. El Monki s.n.* (Herb. El Mokni!), *ibidem* 21.02.2013, *R. El Monki s.n.* (Herb. El Mokni!).

The genus *Freesia* Klatt characterized morphologically mainly by its sharply deflexed or horizontal flower spike, deeply divided style branches and verrucose or papillate capsules, comprises 16 species distributed through sub-Saharan Africa, with a marked centre of diversity in the winter rainfall region of the southwestern Cape (Manning & Goldblatt 2010). Many species are widely cultivated as ornamentals where *Freesia alba* (G.L. Mey.) Gumbl. and its horticultural hybrids with *F. corymbosa* N.E.Br. and *F. leichtlinii* Klatt, are often erroneously attributed to *F. refracta* (Jacq.) Klatt (Goldblatt & Manning 2008; Galasso & al. 2018). In fact, *F. refracta* is known to rarely cultivated (Goldblatt 1982). *F. alba* is easily distinguished by its bracts green; tepals predominantly white, often with yellow markings on lower tepals (Goldblatt 1982; Manning & Goldblatt 2010).

In Europe, *F. alba* was reported from Spain (Balearic Islands) (Sáez & al. 2016), France, Sardegna and Cyprus (GBIF 2020). In N Africa, the taxon is here reported for the first time from Tunisia (APD 2020). The plant can be classified as 'casual alien' at the time it appears only with few naturalising individuals within one region (NE Tunisia). In Bizerta, among other bulbous plants, *F. alba* is highly cultivated as ornamental, in villas balconies in the city center and along the corniche road.

Gladiolus murielae Kelway (≡ *Acidanthera murielae* Hoog) (***Iridaceae***) (Fig. 1. G)

New for the non-native flora of Tunisia and N Africa. (see e.g., Euro+Med PlantBase 2020; GBIF 2020; APD 2020).

TUNISIA: Bizerta, six flowering individuals growing near the coast. The species could be cultivated around or some bulbs were brought within the soil from some evacuated pots in the area, 5 m a.s.l., 31.12.2018, *R. El Monki s.n.* (Herb. El Mokni!).

Gladiolus L. includes over 270 species (Goldblatt & al. 2014; IPNI 2020). It occurs in Africa, Madagascar, Mediterranean Europe and the Middle East as far east as Afghanistan and throughout the world (Lewis & al. 1972). The genus is centered in southern Africa (Goldblatt 1994) but widely cultivated for cut flowers. About 22 species occur wildly in the Mediterranean area (Euro+Med PlantBase 2020), among them only two species occur in Tunisia (*G. dubius* Guss [incl. *G. reuteri* Boiss., *G. illyricus* var. *reuteri* (Boiss.) Font Quer, *G. communis* auct.] and *G. italicus* Mill. [incl. *G. segetum* Ker Gawl.]) (Dobignard & Chatelain 2010). *Gladiolus murielae* Kelway grows natively in the highlands in rocky, partly shaded places, on cliffs, rocky outcrops, and in forest margins between 1800 and 2400 m a.s.l. in Tigray, Gonder, Shewa, and Wellega floristic regions (IPNI & WCSP 2020). It also occurs in Burundi, Tanzania, Malawi and Mozambique (Geerinck 2005). The main flowering period in Ethiopia is from July to September (Demissew & Nordal 2010). The plant is distinguished from closer species (mainly *G. candidus* (Rendle) Goldblatt and *G. gunnisii* (Rendle) Marais, with a perianth tube twice as long as the tepals) by the white flowers with prominent dark purple streaks and tepals 35–45 mm long (Demissew & Nordal 2010). In Europe, the species has been reported from Belgium, France, Germany and Sweden (GBIF 2020). This seems the first report of *Gladiolus murielae* for North Africa. We propose it as 'casual alien' at the time it appears only with few naturalising individuals within one region (NE Tunisia).

Hippeastrum puniceum (Lam.) Voss (***Amaryllidaceae***) (Fig. 1. A)

New for the non-native flora of Tunisia and North Africa (see e.g., Govaerts & al. 2020; APD 2020).

TUNISIA: Bizerta, Corniche, four flowering individuals growing within road side escaped from some cultivated individuals of the other side of the road towards Nadhour, 11.04.2018, *R. El Monki s.n.* (Herb. El Mokni!); Bizerta, Jarzouna, one individual in a swampy area with Juncus spp., 05 m a.s.l., 08.03.2019, *R. El Monki s.n.* (Herb. El Mokni!); Jendouba (Fernana), only three flowering individuals under walls, 30 m a.s.l., 04.03.2008, *R. El Monki s.n.* (Herb. El Mokni!); Monastir (Monastir-City), five flowering individuals under walls, 30 m a.s.l., 17.03.2020, *R. El Monki s.n.* (Herb. El Mokni!).

Hippeastrum Herb. is essentially a genus with neotropical distribution that can be found in wild from Mexico and the West Indies to Argentina, the majority in eastern Brazil, the Peruvian Andes and Bolivia (de Andrade & al. 2012; Büneker & Bastian 2017). It comprises approximately 70 species (Judd & al. 1999), 34 being found in Brazil with 22 endemics (Dutilh 2010). Due to its great beauty, *H. puniceum* (Lam.) Voss., a native to the Caribbean and to South America (Glenn 2002), is used as ornamental plant worldwide, whereas in some countries it is cultivated for medicinal purposes (Hanelt 2001). Probably by escape from cultivation, the species has been naturalized outside its natural range, mainly in the tropics and subtropics, including Africa (Wester 1992; Hosking & al. 2003; Velayos & al. 2013). In Europe, *H. puniceum* is reported only from Spain (Govaerts & al. 2020). In N Africa, it is here its first report from Tunisia (APD 2020). The species (distinguished by its 2–4-flowered inflorescences; flowers slightly zygomorphic; perianth reddish to salmon, with whitish midstripe on adaxial surface of each outer tepal; bracts up to 5 cm) can be classified as 'casual alien' since it appears only with few flowering individuals (ca. 4+2+1 in an area that cannot exceed 40 m^2) within three regions (NE, NW and CE Tunisia).

Hymenocallis littoralis (Jacq.) Salisb. (≡ *Pancratium littorale* Jacq.) (***Amaryllidaceae***) (Fig. 1. F)

New for the non-native flora of Tunisia and the Maghreb (see e.g., Euro+Med PlantBase 2020; GBIF 2020; APD 2020).

TUNISIA: Monastir, two flowering individuals growing within the sidewalks of a cultivated area. The species could be cultivated around or some bulbs were brought with their soil from florists selling bulbs, 20 m a.s.l., 08.10.2016, *R. El Monki s.n.* (bulbs were collectd). (Herb. El Mokni!).

The genus *Hymenocallis* Salisb., with around 40 species, is native to warmer regions of the New World, from the north of Brazil to the south east of the United States (Flory 1976; Smith & Flory 1990); many of them are endemic to Mexico (Tapia-Campos & al. 2012) and one species (*H. senegambica* Kunth & Bouché [= *H. littoralis* (Jacq.) Salisb.] to West Africa (Singh 2019). This latter with its faintly fragrant, white flowers with extremely long, narrow, hanging petals and with a central membranous cup stretched between the stamens is commercially important and is being cultivated on large scale in western India, especially in Gujarat and Maharashtra, and it occupies a premium position in the flower market of Mumbai (Singh 2019). In Europe, no report seems to be mentioned till now (see e.g., Euro+Med PlantBase 2020; GBIF 2020). In North Africa, the plant is reported only

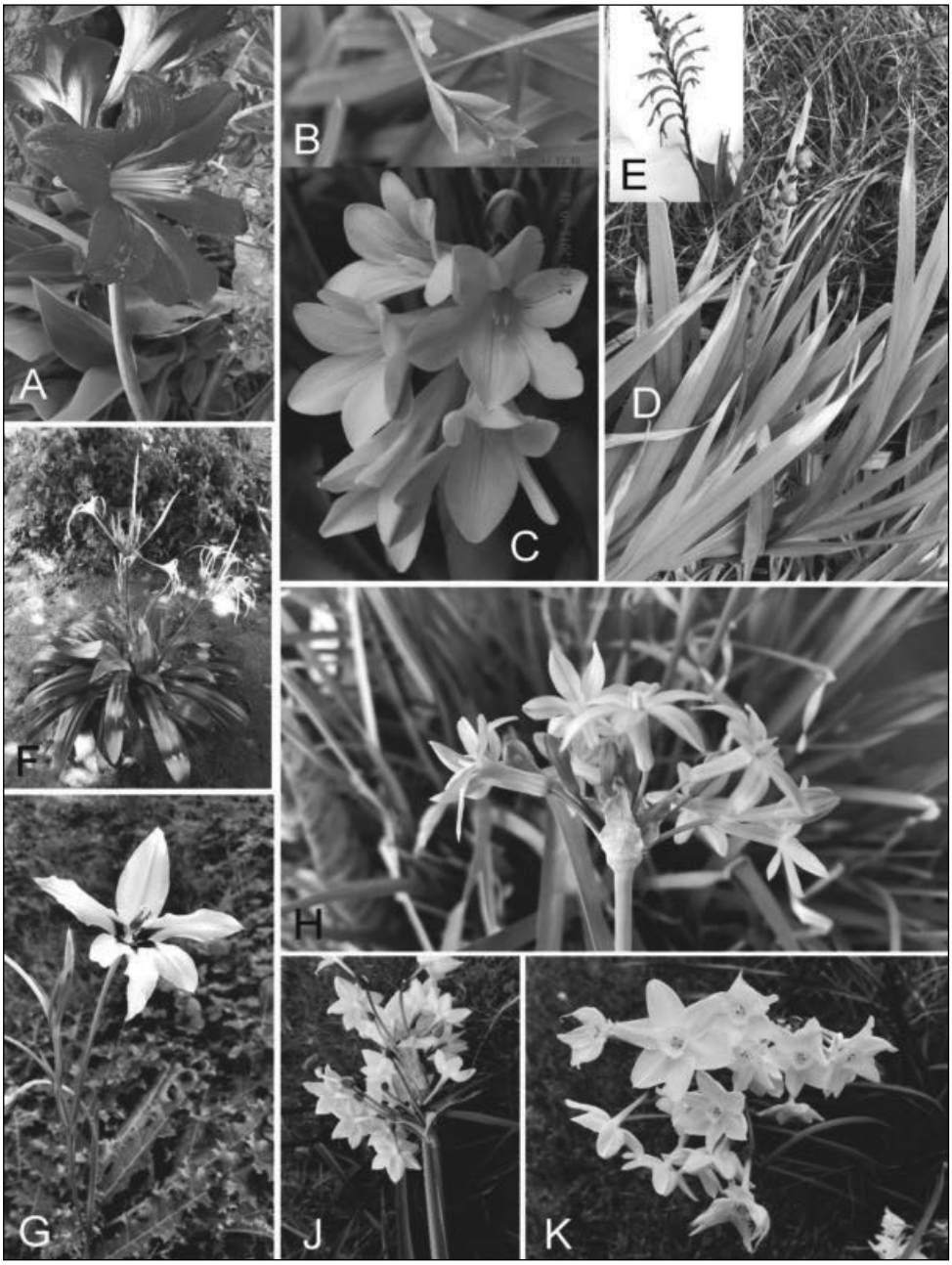


Fig 1. A. *Hippeastrum puniceum* (Monastir); B. & C. *Freesia alba* (Bizerta); D. & E. *Chasmanthe floribunda* var. *floribunda* (Jendouba/Bizerta); F. *Hymenocallis littoralis* (Monastir); G. *Gladiolus murielae* (Bizerta); H *Tulbaghia violacea* (Monastir); J. & K. *Narcissus papyraceus* subsp. *papyraceus* (Monastir). Photos credits: Ridha El Mokni (A, B, C, D, E, F, G & H) and Kawther Hadj Khalifa **(**J & K).

from Canary Islands (GBIF 2020). This is the second report from the Mediterranean area and the first one from Tunisia and the Maghreb. The plant can be classified as 'casual alien' as it appears only with few escaped individuals within one region (CE Tunisia).

Narcissus papyraceus Ker Gawl. subsp. ***papyraceus*** (***Amaryllidaceae***) (Fig. 1. J & K)

New for the non-native flora of Tunisia and North Africa (see e.g., Euro+Med PlantBase 2020; GBIF, 2020; APD 2020).

TUNISIA: Monastir, few flowering individuals growing within sidewalks. The species could be cultivated around and escaped from pots, 10 m a.s.l., 03.01.2020, *R. El Monki s.n.* (Herb. El Mokni!).

The genus *Narcissus* L. with more than 50 species of herbaceous bulbous plants which are native of Europe, N Africa and W Asia. It has a mainly Mediterranean distribution, where the centre of diversity is the Iberian Peninsula (see e.g., Webb 1980; Grey-Wilson & Mathew 1981) with thousands of cultivars available worldwide (Kington 1998). Among all known taxa, many introduced have escaped from cultivation and became naturalized elsewhere (cf. Spaulding & Barger 2014). In North America, six species (*N. bulbocodium*, *N. jonquilla*, *N. papyraceus*, *N. poeticus*, *N. pseudonarcissus*, *N. tazetta*) and four hybrids (*N.* ×*incomparabilis*, *N.* ×*intermedius*, *N.* ×*medioluteus*, *N.* ×*odorus*) from different origins occur actually in the wild (Spaulding & Barger 2014). In Europe, *N. papyraceus* subsp. *papyraceus*, native to France, Greece, Spain, Italy, Portugal, Sicily and Malta, is reported as alien (status unknown) only from Corse and the Azores (GBIF 2020). In N Africa, *N. papyraceus* subsp. *pachybolbus* (Durieu) D.A. Webb is reported as native only to Morocco and Algeria (APD 2020). In Tunisia, it is here that *N. papyraceus* subsp. *papyraceus* is reported for the first time from North Africa. The subspecies (distinguished by glaucous leaves; compressed 2-edged scape and usually crenulate corona, Webb 1980) can be classified as 'casual alien' since it appears only with few flowering individuals (ca. 26 in an area of 400 m^2) within only one region (CE Tunisia).

Nothoscordum gracile (Aiton) Stearn (≡ *Allium gracile* Aiton) (***Amaryllidaceae***)

New for the non-native flora of Tunisia (see e.g., Euro+Med PlantBase 2020; GBIF 2020; APD 2020).

TUNISIA: Bizerta, Bizerta City, many individuals (ca. 30 in 10 m^2) growing within roadsides near the Bus/Taxi Station, 05 m a.s.l., 02.05.2014, *R. El Monki s.n.* (Herb. El Mokni!); Monastir, Monastir City, many individuals (ca. 60 in 200 m^2) growing within roadsides near the market and the Post Office, 15 m a.s.l., 08.04.2019, *R. El Monki s.n.* (Herb. El Mokni!).

Nothoscordum Kunth is a small genus native to southern Mexico and western South America, with over than 30 recognised species most of them widely naturalised in many parts of the world (Ravenna 1991). All known species of *Nothoscordum* are native to America; *N. borbonicum* Kunth has become naturalized in Europe, Africa, Asia and Australia, for it spreads rapidly by seeds and persists by prolific bulblets production (Stearn 1986). Plants of this genus are much like *Allium* but do not have an oniony smell in the flowers or leaves. *Nothoscordum* also differs from *Allium* in that the perianth segments are joined at the base, and in certain species they are fused about halfway (Pyke 2019). In Europe, *N. gracile* is reported as alien with status "unknown" from the Azores,

Cyprus, France, Greece, Spain, Italy, Portugal, Madeira, Sicily and Malta (Euro+Med PlantBase 2020; GBIF 2020). In N Africa, *N. gracile* is reported only from Canary Islands and Algeria (APD 2020; GBIF 2020). In Tunisia, it is here firstly reported and can be classified as a 'casual alien' since it appears only with few flowering individuals (ca. 90 in an area around 210 m^2) within only two regions (NE & CE Tunisia).

Tulbaghia violacea Harv. (≡ *Omentaria violacea* (Harv.) Kuntze) (***Amaryllidaceae***) (Fig. 1. H).

New for the non-native flora of Tunisia (see e.g., APD 2020; Euro+Med PlantBase 2020; GBIF 2020).

TUNISIA: Monastir, Monastir-City, few individuals growing under walls and within roadsides not far away from some big pots where the plant was cultivated as ornamental., 20 m a.s.l., 03.07.2019, *R. El Monki s.n.* (Herb. El Mokni!).

Tulbaghia L. is a small genus endemic to southern Africa and includes about 30 species (Vosa 2000; Lyantagaye 2011). The plants are, however, cultivated in different countries for their medicinal properties and horticultural importance (Benham 1993). Members of *Tulbaghia* are self-incompatible, and possess distinct alliaceous smell for which they are commonly known as 'wild garlic' (Lakshmi 1988). In Africa, *T. violacea* is the most prevalent species of the genus (Vosa 2000). In Europe, the plant has been reported in Portugal, France, Italy and Malta (GBIF 2020). In N Africa, the taxon is only reported from Morocco (GBIF 2020). This is the first record from Tunisia, where it can be classified as a 'casual alien' as it appears only with few flowering individuals within very restricted area in Monastir region (CE Tunisia).

Zephyranthes candida (Lindl.) Herb. (≡ *Amaryllis candida* Lindl.) (***Amaryllidaceae***)

New for the non-native flora of Tunisia and N Africa (see e.g., Euro+Med PlantBase 2020; GBIF 2020; APD 2020).

TUNISIA: Bizerta, Bizerta-Sidi-Salem, few individuals (ca. 10 in 4 m^2) growing within roadsides near the apartments of Sidi Salem area, 05 m a.s.l., 23.08.2014, R. *El Monki s.n.* (Herb. El Mokni!); Tunis, few individuals in ornamental flowerpots, 19.10.2019, *P. Leboulenger, s.c.*

The genus *Zephyranthes* Herb. is a genus of about 70 species originating from warm temperate, subtropical, and tropical areas of the New World including Argentina, the Caribbean, Mexico and North America (see e.g., Bateman & al. 2004; Chowdhury & Hubstenberger 2006; Spurrier & al. 2015). Due to their great beauty and vigor, several species have become established throughout the warmer climates of the world including parts of Africa, Asia, Australia and even many south Pacific Islands. A number of species are cultivated due also to their gorgeous flowers, and are known by plant breeders as "rain lilies" owing this name to their tendency to flower after a rain period (Fernández & al. 2004). Among these we can find *Z. candida* and *Z. rosea* Lindl. The former with distinguished white perianth, very short to indistinct tube, spathe covering the ovary and semi-cylindrical leaves non-exceeding 4 mm in width is originally from southern South America – Argentina, Uruguay, Paraguay, and southern Brazil (Siddiqui & al. 2007). Used as an ornamental plant in gardens and cultivated in many countries, the species has become naturalized over much of the world from the southeastern USA, the West Indies, southern Africa, southern Asia including China, Korea, Japan, as well as Australia (Queensland), a

number of south Pacific Islands and even in Bangladesh (cf. Siddiqui & al. 2007). In the Mediterranean area, the plant was reported only from Italy and Syria (GBIF 2020). No records are available from North Africa (Euro+Med PlantBase 2020; GBIF 2020; APD 2020) before the present record; in Tunisia we consider it as a 'casual alien' since it appears only with few flowering individuals (10 in an area of 4 m^2) within only one region (NE Tunisia).

Zephyranthes rosea Lindl. (≡ *Amaryllis rosea* (Lindl.) Spreng. ≡ *Atamasco rosea* (Lindl.) Greene) (***Amaryllidaceae***)

New for the non-native flora of Tunisia, North Africa and Mediterranean area (see e.g., Euro+Med PlantBase 2020; GBIF 2020; APD 2020).

TUNISIA: Bizerta, Bizerta-Corniche, few individuals in nursery ornamental flowerpots, 15 m a.s.l., 12.09.2014, *R. El Mokni s.n.* (Herb. El Mokni!); Tunis, few individuals in ornamental flowerpots, 02.09.2019, *P. Leboulenger, s.c.*

Zephyranthes rosea, characterized by clear-red to pink perianth, well open flowers with short tube, erect stamens, all with same size and declined style, is considered native to Central America and the Caribbean, but is spontaneous also in southern and southeastern Brazil (Raina & Khoshoo 1971). In the Mediterranean area, the plant seems not to have been recorded from either Europe or N Africa (Euro+Med PlantBase 2020; GBIF 2020; APD 2020). So, this is the first record for the whole Mediterranean region, where it can be regarded as a 'casual alien', since it appears only with few flowering individuals within very restricted nursery ornamental pots in Bizerta and Tunis (NE Tunisia).

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Article

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Life forms interactions in semiarid Mediterranean annual grassland community

Abstract

Alhamad, M. N., W.: Life forms interactions in semiarid Mediterranean annual grassland community. — Fl. Medit. 30: 197-205. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

Species interaction plays a central role in structuring plant communities. However, few studies have investigated the nature of species interaction among different life forms along a productivity gradient. The current study is aimed to investigate the nature of life forms interactions and its impact on production of annual grasses grown in semiarid Mediterranean areas. Competition treatments (absence/presence of neighbours) were applied in randomized complete block design over two growing seasons. Relative interaction index (RII) was used to measure competition intensity. RII standardizes the reduction in growth of one species due to presence of neighbour species. Competition reduced grass biomass production by approximately 15%. Competition role was eliminated under low productivity conditions. Results showed that competition may limit the direct effect of defoliation on dominant grass species. Further, competition effect on dominant annual grasses showed positive and negative effects in relation to site productivity and best explained by a sinusoidal model. This hypothesized sinusoidal model suggests that facilitation and competition are alternatively affecting grassland communities along productivity gradient. The nature of interaction changes with changing community productivity revealing a cyclic pattern. The reflection points where interaction switches from facilitation to competition may explain the mechanism of maintaining high species diversity at intermediate level of community productivity. The experimental defoliation exerted a pronounced effect on plant productivity and modified the nature of interaction between annual grasses and other growth forms. These mechanisms may explain the ability of *Avena* and *Hordeum* species to form persistent annual climax grasslands in semi-arid rangelands. These findings may suggest that *Avena* and *Hordeum* species may be used in revegetating degraded areas in the north-eastern part of Jordanian Mediterranean grasslands.

Key words: competition, relative interaction index, *Avena*, *Hordeum*.

Introduction

Middle Eastern Mediterranean grasslands have evolved 8000-9000 years before present (BP) (Harlan 1975; Hunt & al. 2004). These grasslands were prehistorically subject to persistent pressure from grazing domesticated animals (Noy-Meir & Seligman 1979; Perevolotsky & Seligman 1998; Alhamad 2006). Competition among plant spices is a key

player in structuring semi-arid grassland communities (Fowler 1986; Alhamad & Alrababah 2008), linking their maintenance, productivity, and management to biodiversity and livestock production.

Grace & Tillman (1990) showed that competition has a significant role in shaping the structure of terrestrial plant communities. Three mechanisms have been used to explain the relationship between site productivity and competitive interactions among plant species. The first of these mechanisms shows that competition can be intense in high-productivity locations and reduced in low-productivity environments (Grime 1979; Huston 1979; Keddy 1989). The second mechanism says that the intensity of competition does not depend on the productivity of the environment, but that the nature of competition changes according to the availability of growth resources. Where competition among plants is light or space in high-productivity environments, and when site productivity decreases, competition between plants becomes over water or soil nutrients (Newman 1973; Tilman 1982 & 1987). Taylor's theory of resource competition (Taylor & al. 1990) was used to explain the mechanism of competition between plants. This theory suggests that there is no causal relationship between productivity and competition, and that the primary determinant of competition is the ratio of supply of resources to demand it, and this ratio depends on the frequency of disturbance events such as drought and grazing.

Livestock production systems in the eastern part of the Mediterranean region depend on semi-arid grassland as the main fodder source for feeding grazing animals (Noy-Meir & Briske 2002; Alhamad 2006). The semi-arid grassland is found under an annual rainfall of 200-300 mm in the north-eastern part of Jordan (Alhamad & Alrababah 2008). The unsustainable grazing activities have led to a noticeable decline in biodiversity and a sharp decrease in the productivity of these lands (Alhamad 2006; Alhamad & Alrababah 2008). The prolonged uncontrolled grazing pressure led to successive degradation, in which the tallest perennial herbs were replaced by shorter perennial herbs and then later replaced by annual herbs to finally end up with barren land.

Natural annual grasslands communities occur in heterogeneous patches dominated by one or two annual grass species (George & al. 1992; Alhamad & Al-Rababah 2013). Where annual grass seedlings have competitive advantages over the development of perennial plant seedlings, in such patchy communities (Harris 1977). The biological inertia prevents the transforming of annual-dominated grasslands showed community into perennial-dominated grassland (George & al 1992). However, the shift between dominant annual species has been observed. Mechanisms that involved in plant community change are grazing impact, establishment, and competition beside seed banks (Westboy 1980; Walker 1988).

A fuller understanding of the relationship between site productivity and plant species competition, may help to develop sustainable grazing strategies to revegetate degraded arid rangelands and maintain the biological diversity in these areas (Fowler 1986; Alhamad 2006; Alhamad & Al-Rababah 2013). Therefore, this study was initiated to establish experimentally the foundation to understand the relative effects of site productivity on competition, and their interaction to reliably interpret the direct effects of defoliation (Noy-Meir & Briski 1996).

The present study was conducted to answer the following questions (1) what is the effect of competition from neighboring plants on the competitive performance of annual grasses under semi-arid conditions? (2) Is the nature of interaction modified by growth resources?

Materials and methods

Site description

The experimental site is located at Jordan University of Science and Technology (JUST) campus, in northeastern semi-arid grasslands of Jordan. The site is located 18 km to the east of Irbid city (32° 34' N, 36° 01' E). The campus was established in 1986. The site is characterized by a flat to gently rolling topography with less than 8% slope located at 520 m above sea level. The soil of the experiment site consists of deep silty clay soils and generally contains a low percentage of soil organic carbon (1.0%).

The plant community is a typical semi-arid Mediterranean annual grassland that is dominated by wild oat (*Avena sterilis* L.), and wall barley (*Hordeum murinum* L.). Companion species include *Senecio vernalis* Waldst. & Kit., *Vicia peregrina* L., *Trigonella arabica* Delile, *Erucaria hispanica* (L.) Druce, *Anthemis palestina* Reut. (see Alhamad & Alrababah 2008).

Climate

The locality is characterized by semi-arid Mediterranean conditions of mild rainy winters and dry hot summers. The long-term average annual precipitation is 230 mm. The site received a total rainfall of 208 mm during the 2003/2004 season and 226 mm during the 2004/2005 season .

Experimental design

The experiment was carried out in the 2003/2004 and 2004/2005 growing seasons. Eight replicated blocks were located in a natural grass community, dominated by wild oat (*Avena sterilis*) and wild barley (*Hordeum murinum*). The ground cover was generally continuous and little bare soil was exposed. Two 2 × 2 m plots were arranged within each block. These plots were allocated to two competition treatments in a complete block design. The two competition levels were: (i) no competition (all non-grass species were removed from the stand); (ii) full competition from neighboring plants (all native species in the stand including grass and non-grass species were allowed to grow). Under no competition treatment, all non-grass species were clipped down to soil surface in early February. Further clipping was performed as needed to eliminate interspecific competition between grasses and other species.

Above- ground biomass productions were collected from the center of each experimental plot using the 0.25 m^2 quadrat. The clipped material within each quadrat was separated into grasses and other species. Harvesting was performed when flag leaves and awns were dry. The harvested material was weighed oven dry to obtain the final biomass production of grasses.

Statistical analysis

A two-way analysis of variance (ANOVA) was used to assess the effects of competition and year on final and cumulative biomass production of grasses. The experimental error term was used as the denominator for constructing the F-test. 95 % confidence intervals (CI) were constructed around the main means of competition. Student's t-test (α=0.05) test was used to compare competition treatment means. ANOVA, CI, and Student's t-test were performed using JMP 5.1 software (JMP 1989-2004).

Intensity of competition

Competition intensity were measured on the basis of the relative interaction index (RII) proposed by Armas et al. (2004) as follows:

$RII = (B_{+neighbor} - B_{-neighbor})/(B_{+neighbor} + B_{-neighbor})$, where

$B_{+neighbor}$ = grasses biomass in presence of competitor neighbor plants

$B_{-neighbor}$ = grasses biomass in absence of competitor neighbor plants

To explore the relationship between competition intensity and graminoids biomass, we have plotted the RII against herbaceous biomass (the biomass of plots in the presence of neighbor species) for all levels of defoliation first and then for each of the three levels of defoliations separately. The relationship was then fit to various models using CURVEFIT software (CurveExpert 2001).

Results and discussion

The ANOVA analysis indicates a significant difference ($p<0.01$) between the growing season 2003/2004 and 2004/2005, therefore, each year were analyzed separately (Table 1). During the growing season 2003/2004, grasses from competition-free plots produced significantly higher biomass compared to plots where competition from non-grass plants exist (Table 2). Similar results were observed during the 2004/2005 growing season (Table 2). However, productivity in the second growing season was higher than the first season, reflecting the favorable growth condition during the 2004/2005 season (Tables 2 and 3). The reduction in biomass production of grasses was 13.8 and 14.6, for the successive growing seasons, respectively (Table 2).

Competition intensity using relative interaction indexes showed a complex pattern. This pattern was best explained by the sinusoidal model (Fig 1) combined with a significant level of correlation coefficient of 0.65 (Table 3). In a previous study, Alhamad & Alrababah (2008) reported that competition showed significant interaction with different defoliation intensities in annual Mediterranean grasslands. The competition was a key player in the productivity of these grasslands under no defoliation or light defoliation. Competition reduced the biomass production of grasses in both growing seasons (Table 2).

Table 1. Analysis of variance (ANOVA), F values and significance levels for grass biomass production (g m^{-2}) randomized complete block design experiment over 2 years in semi-arid Mediterranean grassland (n=32).

Source	DF	Biomass production
Model	9	65.4**
Year	1	265.6**
Replicate	7	6.4**
Competition	1	29.3**
Error	23	288.8
Total	32	

Table 2. Mean biomass production (g m^{-2}). Standard error (SE) and lower and upper 95 % confidence Interval (CI) and Percent Change in biomass production of grasses as affected by competition treatment.

Competition level	Mean	Lower. 95% CI	Upper. 95% CI	% change
First year				
- neighbor	100.71 a	96.77	104.64	
+neighbor	86.84 b	82.91	90.77	-13.8
SE	1.94			
Second year				
- neighbor	162.15 a	154.97	169.37	
+neighbor	138.48 b	131.26	145.70	14.6
SE	3.56			

Mean values (g m^{-2}) within competition level and defoliation intensity that are followed by the same letter are not different according to Student's t-tests (α=0.05).

These results are in agreement with previous research findings (Pacala & Crawley 1992; Rodriguez & Brown 1998). However, Del-Val & Crawley (2011) found that clipping a neighboring species did not improve the growth of target species. Neighbor removal approaches have been the most successful approach to study competition in plant communities. It may include the removal of all plant species except the target species or functional group species (Aarssen & Epp 1990).

The study results indicated that the impact of competition on plant growth is not linear linked to site productivity. Also, the study found clear evidence of the cyclical interaction between competition intensity and site productivity under semi-arid grassland environments. Further, the results showed the positive effect of declining competition from neighboring species on grass production. This response agreed with previous research results (Fonteyn & Mahall 1981; Fowler 1986). The competitive fitness is largely depending on the relative tolerance of annual grasses to grazing as compared to their competing neighbors (Anderson & Briske 1995).

Table 3. Fit Sinusoidal model (y=a+b*cos (cx+d) parameters, standard error (SE) and correlation coefficient (R) between relative competition intensity (y) and herbaceous biomass (x) (g m^{-2}).

Model parameter	value
a	-0.04894
b	0.169894
c	0.018701
d	-2.3921
SE	0.15
R	0.65*

* significant at the 0.05 level

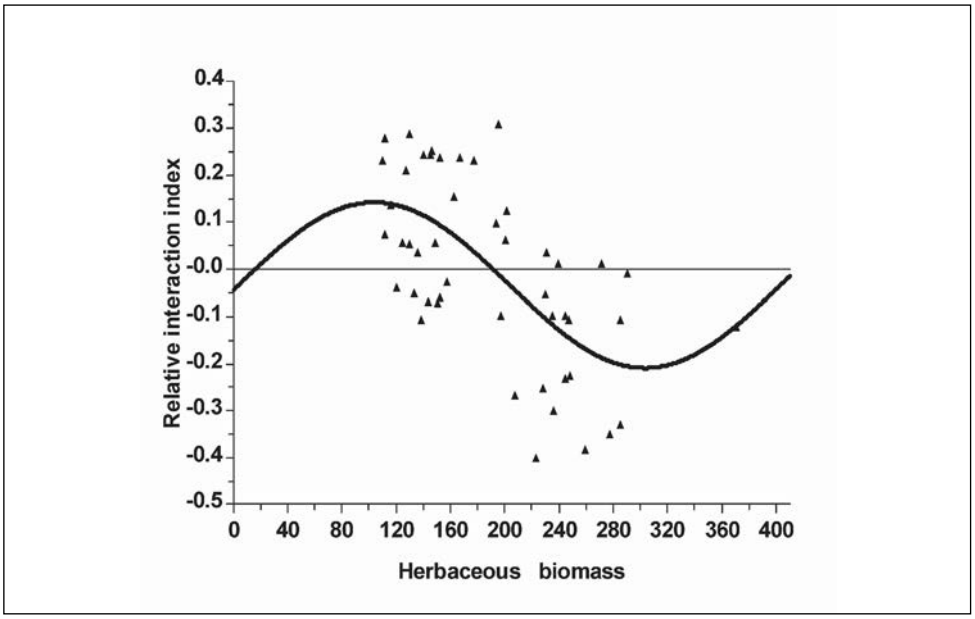


Fig 1. Curve fitting model between competition intensity (RII) and herbaceous biomass (g m^{-2}).

RII has defined limits that are symmetrical around 0. This index measures the performance of target species or functional group species in the presence and absence of neighbors. RII ranges from -1 to 1 with positive values indicating facilitation and negative values indicating competition (Armas & al. 2004). The normalized nature of RII, makes it a more suitable index to compare the changes of competition intensity among different environmental gradients or level of defoliations than absolute measures of competition intensity. RII is 0 when neighbors do not affect performance. When RII becomes negative, then competitive exclusion exists. Positive values of RII indicate facilitation and usually occur in harsh environmental conditions (Bertness & Hacker 1994).

In the present study, neighbor removal showed positive and negative effects on remaining grass species as indicated by the sinusoidal model (Fig 1). The nature of the interaction between grass growth form and other non-grass species changed as site productivity changed (Fig. 1). The presence of competition and facilitation interactions among multiple plant species has a profound effect on community organization (Lortie & al. 2004). The results showed the presence of a reflection point corresponding to primary productivity of about 200 kg /ha at which the nature of interaction switches from facilitation to competition (Fig. 1). These results are in agreement with Grime (1979) theory on plant competition. These changes in the nature of plant interaction from facilitation to competition at intermediate levels of community productivity may give a mechanistic explanation to the peaking of species diversity at moderate levels of productivity (Grime 1973). The nonequilibrium interactions of different growth forms of competing plant populations allow a community of competitors to coexist (Huston 1979).

Conclusion

The present study detected a considerable non-equilibrium interaction between annual grass species and other growth forms. The nature of interaction changes with changing community productivity revealing a cyclic pattern as explained by the sinusoidal model. The reflection points where interaction switches from facilitation to the competition may explain the mechanism of maintaining high species diversity at intermediate community productivity. These mechanisms may explain the ability of *Avena* and *Hordeum* species to form persistent and closed annual climax grasslands in arid and semi-arid Mediterranean rangelands even under grazing pressure. These findings may suggest that *Avena* and *Hordeum* species may be used in re-vegetating degraded areas in the north-eastern part of Jordanian Mediterranean grasslands.

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Article

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Le littoral de Mostaganem (Algérie), une "zone importante pour les plantes" (ZIP) autant négligée que menacée

Abstract

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The coast of Mostaganem (Algeria), an "important area for plants" (ZIP) as much neglected as threatened. – The flora of the coastline of Mostaganem still till nowadays remains very little known, even though it has been historically very well studied, like the whole Oran's coastal area. The objective of our study is to inventory the local plant diversity and define its state of conservation with a view to possible recognition of the region as an Important Plant Area (IPA). We used the criteria of irreplaceability, rarity, endemism, protection and threat for each taxon. A total of 54 species and/or subspecies with patrimonial value distributed over all of the 15 studied sites, including 9 IPA trigger species distributed over 11 of the 15 sites. This therefore justifies the consideration of two IPAs, one concerning the entire coastline on both sides of the town of Mostaganem whereas the other concerning the entire lower Cheliff valley. Several taxa have already disappeared from some coastal sites, and a historic coastal site has already been completely depleted in trigger and patrimonial taxa. Despite the legal protection of some of these species, their biotopes continue to be degraded or even destroyed by urbanization and tourist development on the coast. Controlling these developments by raising awareness among the authorities, and reducing tourist pressure by raising public awareness is a priority to be undertaken urgently for the conservation of the plant diversity of patrimonial value in Mostaganem and Algeria.

Key words: coastal dunes, endemism, determining species, *Jasione corymbosa* subsp. *battandieri*, legal protection, scarcity, urbanization, seaside tourism.

Introduction

Une analyse mondiale des lacunes révèle qu'une grande partie de la biodiversité se trouve en dehors des aires protégées (Langhammer & al. 2007). La flore de l'Algérie comprend 4449 taxons, dont 430 pour lesquels c'est le seul pays de présence en Afrique du Nord. Parmi eux, 290 sont des endémiques nationales, soit un taux d'endémisme égal à 6,51% de la flore totale et 7,33% de la flore indigène (Dobignard & Chatelain 2010-2013). Le Nord de l'Algérie recouvre deux points chauds régionaux de biodiversité: 1) le littoral oranais et mostaganémois qui appartient à l'Arc bético-rifain et 2) le Tell oriental qui appartient au

point-chaud «Kabylies-Numidie-Kroumirie» (Médail & Quézel 1997; Véla & Benhouhou 2007). Au sein de cette vaste zone sous influence méditerranéenne du nord du pays, 21 puis 39 zones importantes pour les plantes (ZIP) ou « Key Biodiversity Areas (KBA) for plants » ont déjà été recensées (Yahi & al. 2012; Benhouhou & al. 2018) en attendant d'autres zones complémentaires en cours d'étude. Elles sont caractérisées par un ensemble de conditions écologiques variées englobant: zones humides, marais salants, rochers littoraux, dunes côtières, dunes continentales, massifs de forêt et maquis, affleurements rocheux et systèmes rivulaires.

Dans la littérature, la région de Mostaganem est connue pour être riche en espèces végétales endémiques et rares (Quézel & Santa 1962-1963), ce qui fait d'elle une éventuelle ZIP. Mais à ce jour, elle demeure peu étudiée, son littoral n'ayant fait l'objet d'aucune recherche floristique ciblée, bien qu'il présente les mêmes caractéristiques climatiques, biogéographiques et édaphiques que les ZIPs voisines du Sahel d'Arzew, du Sahel d'Oran, des îles Habibas et des Monts des Traras (Yahi & al. 2012) qui appartiennent tous au même hotspot régional.

De nombreux travaux sur la végétation du littoral oranais ont été réalisés (Alcaraz 1982; Aimé 1991), mais ces auteurs se sont intéressés aux grands ensembles végétaux qui impriment aux paysages une physionomie particulière. Les travaux réalisés durant les années 1980 au niveau de la zone du littoral mostaganémois avaient pour objectif l'étude de la relation sol-végétation ou climat-végétation (Belgat & Meziani 1984; Mederbal 1992), ou bien d'une espèce particulière telle que le thuya de Berbérie, *Tetraclinis articulata* (Vahl) Mast. (Hadjadj & al. 1991). Pourtant Pomel (1874-1875), Battandier (1888, 1895), Quézel & Santa (1962-1963), citent souvent la région de Mostaganem à travers l'endémisme et la rareté de nombreuses espèces. En particulier, ce sont tous les sahels littoraux du secteur oranais, auquel appartient Mostaganem, qui présentent la plus grande valeur brute en endémisme (Véla & Benhouhou 2007).

C'est dans ce contexte, que s'inscrit notre travail qui consiste à combler ce manque en réalisant un inventaire des espèces existantes dans la région de Mostaganem en choisissant plusieurs sites, selon la diversité des habitats, des paysages et des espèces végétales. L'objectif principal étant de diagnostiquer la végétation spontanée de la région afin de confirmer ou infirmer le classement du littoral mostaganémois comme nouvelle ZIP pour l'Algérie. Un objectif plus général en arrière-plan consiste à essayer de retrouver sur le terrain le maximum d'espèces rares et/ou endémiques de la région afin d'évaluer leur état de conservation et de hiérarchiser les urgences d'actions conservatoires à entreprendre pour les sauvegarder avec leurs écosystèmes littoraux.

Présentation de la zone d'étude

Le littoral mostaganémois s'étend sur près de 100 km sur les 400 km de la côte oranaise, il est situé au Nord-Ouest de l'Algérie (Fig. 1), entre l'embouchure de la Macta à l'ouest jusqu'à l'oued Kramis et un peu au-delà à l'est, en passant par le Cheliff le plus grand fleuve en Algérie. Les unités géographiques formant cette région sont: le plateau de Mostaganem qui s'élève progressivement de l'Ouest vers l'Est, à partir des marais de la Macta; il s'étend jusqu'à l'embouchure du Cheliff qui le sépare des premières hauteurs des

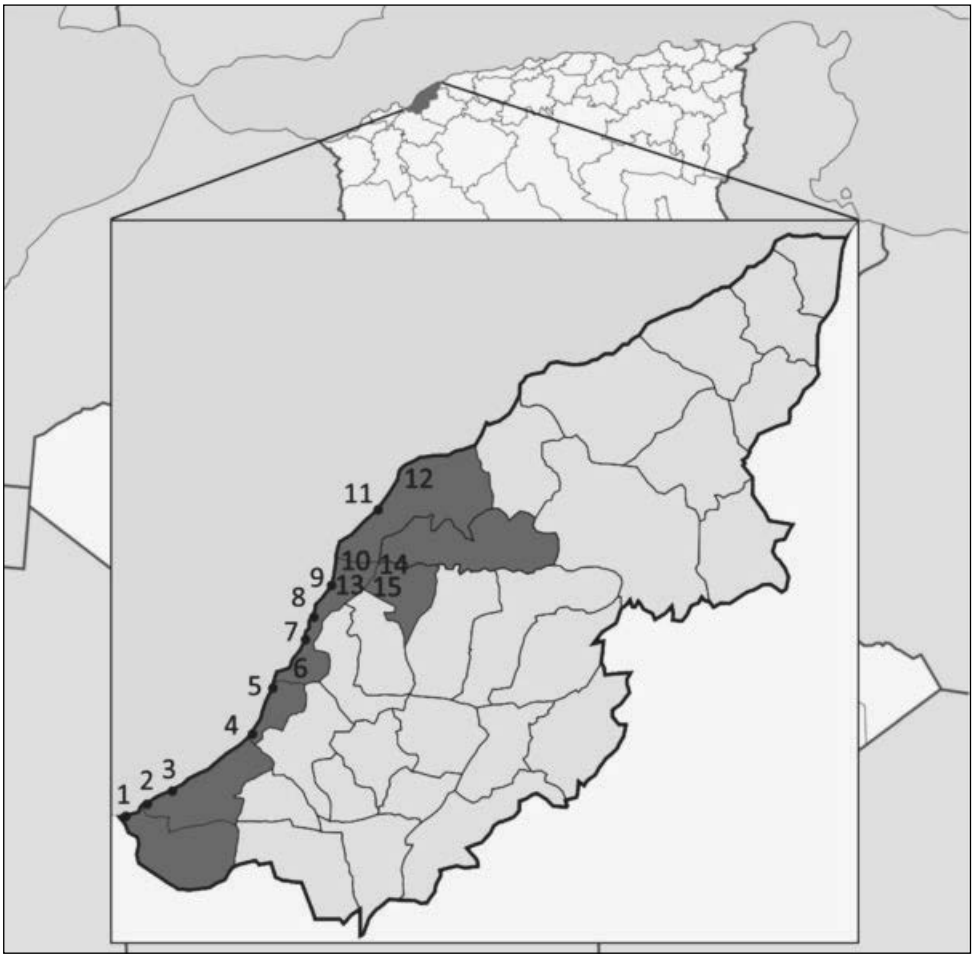


Fig. 1. Localisation des sites d'inventaire floristique et de la zone d'étude (wilaya de Mostaganem, Algérie). Les stations littorales sont matérialisées par un point noir, les stations internes ont leur numéro positionné sur leur localisation. 1: La Macta, 2: Sidi Mansour, 3: Stidia, 4: Ouérah, 5: Sablettes, 6: Mostaganem, 7: Sidi Mejdoub, 8: Kharouba, 9: Sonacther, 10: Cheliff, 11: Chaaibia, 12: Capivi, 13: Aizib, 14: Amarna, 15: Aïn Boudinar.

monts du Dahra; les monts des Dahra dont les petites collines basses près de l'embouchure s'élèvent progressivement vers l'est. Ces unités présentent un relief ondulé, formé de petits massifs à dominance argileuse dont les plus importants culminent entre 300 et 550 m et des pentes comprises entre 12% et 25%.

Le littoral est composé de plages sableuses et de falaises rocheuses, plus accessible à l'ouest (grands ensembles dunaires linéaires plus ou moins consolidés) qu'à l'est (alternance de corniches rocheuses et de petites plages sableuses ceinturant l'embouchure de petits oueds côtiers). Le couvert végétal se caractérise par un cortège floristique pérenne, diver-

sifié et associé à une formation boisée à base de genévriers (*Juniperus oxycedrus* subsp. *macrocarpa* (Sm.) Neilr., *J. phoenicea* subsp. *turbinata* (Guss.) Arcang.), thuya de Berbérie (*Tetraclinis articulata*) et pin d'Alep (*Pinus halepensis* Mill.), ou à base d'une végétation psammophile et/ou halophile particulière à différents stades de dégradation, au niveau des dunes mobiles et de la côte rocheuse soumise aux embruns marins (Simonneau & Santa 1958).

La zone d'étude est située au sein du secteur phytogéographique oranais, et du sous-secteur des sahels littoraux (O1) selon Quézel & Santa (1962-1963). La situation géologique est diversifiée avec le plateau de Mostaganem sur une dalle gréso-calcaire et la chaine des monts de Dahra dominée par des argiles et des marnes du Miocène (Dalloni & al. 1956). Le bioclimat est semi-aride avec des influences maritimes donnant des hivers doux, et des étés frais, malgré une période sèche longue. La température moyenne annuelle est de 18.2°C, l'amplitude diurne moyenne de 7.0°C, les minimas moyens de janvier 9.0°C, les maximas moyens d'août 28.4°C. Les précipitations annuelles sont de 377 mm, dont 14 mm de précipitations estivales (juin-août) et 135 mm de précipitations hivernales (décembre-février) (station de Mostaganem phare, période 1913-1938, d'après Seltzer 1946).

Méthodologie

Les quinze sites sélectionnés représentent une gamme d'habitats allant du littoral, jusqu'aux reliefs, traversant des zones humides, plaines et petites collines. Du sud-ouest vers le nord-est sur le littoral, puis d'ouest en est dans la vallée, se succèdent nos quinze stations d'échantillonnage: 1) l'embouchure de la Macta (rive droite); 2) la forêt de Sidi Mansour; 3) la forêt des dunes de Stidia; 4) les dunes d'Oureah; 5) les dunes des Sablettes; 6) Mostaganem ville (cité des 400 logements); 7) la corniche de Sidi Mejdoub; 8) le quartier de Kharouba; 9) le site industriel de l'ex-Sonacther; 10) l'embouchure du Cheliff (Cheliff-plage); 11) la plage de Chaaibia; 12) la forêt de Capivi; 13) les monts de Aizib; 14) la basse vallée du Cheliff (Douar Amarna); 15) les coteaux d'Ain Boudinar (Fig. 1). L'ensemble des sites occupe une surface de 325 km², s'étalant principalement sur cinq communes littorales (Fornaka, Stidia, Mezaghrane, Mostaganem, Ben Abdelmalek Ramdan) ainsi que Ain Boudinar et Sidi Bel Attar vers l'intérieur.

L'inventaire botanique du littoral mostaganémois a été réalisé durant douze années consécutives (2009-2020). L'ensemble de la zone d'étude a été parcourue autant que possible, avec une prospection de chaque habitat durant les quatre saisons, de chaque année de la période d'étude. Les espèces, qu'elles soient en fleurs, en fruits ou en graines, sont photographiées et des échantillons sont récoltés de manière provisoire pour identification. L'identification s'est faite en plusieurs étapes: tout d'abord en se référant à la flore d'Algérie de Quézel & Santa (1963-1963), complétée par la flore d'Afrique du Nord de René Maire (1952-1987) pour les familles qui sont parues; Ensuite la plupart des identifications sont vérifiées, complétées et actualisées en consultant la flore du Maroc (Fennane & al. 1999-2014) et celle d'Andalousie orientale (Blanca & al. 2011).

La nomenclature est ajustée selon l'index synonymique de Dobignard & Chatelain (2010-2013) et sa version actualisée en ligne (African Plant Database 2020).

Tab. 1. Caractéristiques chorologiques et biologiques des espèces végétales déterminantes ZIP recensées sur la zone d'étude de 2009 à 2020 (ZIP = Zones Importantes pour les Plantes).
Nomenclature retenue: Dobignard & Chatelain 2010-2013 + APD 2020 (ou déviation).
Rareté: rareté en Algérie. Source: Quézel & Santa 1962-1963 (ou données personnelles). CC: très commun; C: commun; AC: assez commun; AR; assez rare; R: rare; RR: très rare.
Irr.: Irremplaçabilité. Source: bibliographie + herbiers P, MPU, LY.
End.: Endémisme (+ type d'endémisme). Source: Euro+Med PlantBase. SRE = Endémique restreinte à un seul site (Site Restricted Endemic). RRE = Endémique à aire restreinte (Range Restricted Endemic).
Pays: Pays de présence en Afrique du Nord. Source: Dobignard & Chatelain 2010-2013 (ou Euro+Med PlantBase, ou autre). Mad.: Madère; Can.: Canaries; Mar.: Maroc; Alg.: Algérie; Tun.: Tunisie; Lib.: Libye; Egy: Égypte.
UICN: Catégorie liste rouge de l'UICN. Source: UICN 2019 (ou Walter & Gillet 1998). non: non évalué. R: Rare.
Prot.: Protection légale. Source: Journal Officiel de la République Algérienne 2012.
Type: type biologique sensu Raunkiaer. Sources diverses. Théro: thérophyte; Géo: géophyte; Hémi-crypto: hémi-cryptophyte; Cham.: chaméphyte; Nano-phanéro: nano-phanérophyte; Phanéro: phanérophyte.

Nom	Rareté	Irr.	End.	Pays	UICN	Prot.	Type
Brassica fruticulosa (ssp. *glaberrima*)	(R : O1, O2)	1/2	End (RRE)	Alg	non	non	Théro / Chamé
Cistanche mauritanica	R : O1, O2	1/3*	End (RRE)	Mar-Alg	non	non	Théro
Cuscuta epithymum ssp. *planiflora* (var. *callosa*)	(RR)	1	End (SRE)	Alg (-Mar)	non	non	Théro
Erysimum semperflorens (ssp. *elatum*)	RR: O1, de la Macta à Mostaganem	1	End (SRE)	Alg	non	non	Chamé
Jasione corymbosa (ssp. *battandieri*)	(R) O1 : Mostaganem, Dahra	1/2	(End, RRE)	Alg	non	non	Théro
Malcolmia arenaria	(AR : O1)	non	End (RRE)	Mar-Alg	non	non	Théro
Polygala munbyana	R: O1, A1	1/5*	End (autre)	Mar-Alg	non	oui	Chamé
Salvia balansae	(RR: O1 Dahra à Pont du Cheliff)	1	End (SRE)	Alg	(R)	oui	Nano-phanéro
Senecio pinguiculus	(RR : O1, de Mostaganem à Ouillis)	1	End (SRE)	Alg	non	non	Théro

Enfin, pour argumenter les synonymies douteuses, et afin de retrouver les critères des anciens taxons aujourd'hui méconnus voire ignorés, nous avons consulté autant que nécessaire la première flore d'Algérie (Battandier 1888-1890; Battandier & Trabut 1895) et les remarquables travaux initiateurs de Pomel (1874-1875).

Les sites de la zone d'étude sont sélectionnés en appliquant les critères utilisés pour la sélection des ZIP dans les pays d'Afrique du Nord et du Proche Orient. Ce choix a jusque-là surtout été réalisé au moyen d'une évaluation des données existantes (Radford & al. 2011) et tels qu'ils sont décrits selon Plant life (2002). Il faut rappeler que ces critères sont appliqués, après quelques remaniements, dans l'identification des ZIP au Maroc et en Algérie (Fennane 2004; Yahi & al. 2012). Ainsi, qu'ils s'agissent de données bibliographiques ou de données originales de terrain, la définition d'une ZIP se fait classiquement selon deux critères:

Le premier critère A, concerne la présence de populations significatives d'une ou de plusieurs espèces menacées (endémiques et/ou rares), présentant un intérêt de conservation sur le plan mondial ou régional (méditerranéen);

Le second critère B, considère l'existence d'une richesse botanique exceptionnelle (site abritant un grand nombre d'espèces dans plusieurs types d'habitats définis) selon (Anderson 2002). Cette méthode est rarement utilisée en Algérie par manque de données, notamment sur le continent, mais l'a été parfois sur les systèmes micro-insulaires (Véla & Pavon 2013).

Mais selon Radford & al. (2011), à défaut d'une évaluation exhaustive de la liste rouge UICN des espèces menacées, une zone est considérée comme importante pour les plantes quand des espèces y présentent une aire de répartition limitée. Cette dernière est inférieure à 5 000 km^2 pour les espèces dites « endémiques à répartition limitée » (*restricted range endemic - RRE*), et inférieure à 100 km^2 pour les espèces dites « endémiques limitées à un seul site » (*site restricted endemic - SRE*).

Dans la pratique, sera considéré comme déterminante pour le classement en ZIP:

La présence d'au moins une espèce SRE (espèce à elle seule déterminante ou déclencheuse, *trigger species*) ;

La présence de plusieurs espèces RRE avec une part importante de leur population mondiale (plus de la moitié) ;

La présence d'au moins une espèce menacée (catégories CR, EN, VU) avec une part non négligeable de leur population mondiale (au moins 5%) ;

La présence d'au moins une espèce RRE dont les effectifs mondiaux sont faibles, l'aire d'occupation très réduite et/ou l'habitat gravement fragmenté par les activités humaines. Elle a donc toutes les chances d'être considérée comme menacée en cas d'évaluation future pour la Liste Rouge de l'UICN.

Deux autres principes renforcent notre méthode de travail, ceux de l'irremplaçabilité et de la vulnérabilité ; mesures clés de la conservation de la biodiversité (Langhammer & al. 2011). Ainsi, nous retiendrons aussi comme ZIP les sites où les espèces n'existent en Algérie que dans la région mostaganémoise, et sont par conséquent, irremplaçables à l'échelle nationale.

La rareté au niveau national est évaluée selon les critères subjectifs donnés par Quézel & Santa (1962-1963), et pour les espèces non présentes dans cet ouvrage, selon nos propres estimations en se calant sur le même critère. Le niveau de menace est publié dans la Liste Rouge des espèces menacées de l'UICN (http://iucnredlist.org) actualisée deux fois par an. Néanmoins, beaucoup d'espèces n'ayant pas encore été évaluées selon les nouveaux critères en vigueur (catégories et critères version 3.1 de 2001), nous avons également consulté la liste rouge de 1997 (Walter & Gillet 1998) qui est la seule à ce jour à avoir visé l'exhaustivité, bien que désormais caduque. L'estimation du niveau de restriction des espèces endémiques (SRE, RRE), et de l'unicité / irremplaçabilité d'une espèce en Algérie pour la région de Mostaganem, ont été faite à l'aide de toute la bibliographie historique connue (de 1789 à 1962), de la liste préliminaire de Yahi & al. (2012), et d'autres sources disponibles: herbiers historiques déposés en France (consultables via l'infrastructure ReColNat https://explore.recolnat.org/search/botanique/type=index), bases de données actuelles participatives (Tela Botanica https://www.tela-botanica.org/widget:cel:cartoPoint?referentiel=isfan#; iNaturalist https://www.inaturalist.org/observations?place_id=7300&iconic_taxa=Plantae).

Résultats des inventaires

Nous avons recensé au moins 141 espèces végétales, parmi lesquelles 54 rares et/ou protégées en Algérie, et/ou endémiques algériennes ou algéro-marocaines, réparties en 28 familles (Tab. 1 & Electr. Suppl. File 1). Les espèces patrimoniales identifiées sont dominées par les thérophytes (18), puis les géophytes (11), les chaméphytes (9), les nano-phanérophytes (8). Arrivant ensuite les hémicryptophytes et les phanérophytes avec chacun 3. Les types intermédiaires (1 théro-/chaméphytes ; 1 théro-/géophyte) sont rarissimes, tandis que les lianes sont absentes. En termes de rareté, 20 espèces et/ou sous-espèces sont plus ou moins communes, et 34 sont plus ou moins rares, dont 17 « rares » et 8 « très rares » à l'échelle nationale (au sens de Quézel & Santa 1962-1963). Par ailleurs, 31 espèces et/ou sous-espèces ne présentent pas un niveau d'irremplaçabilité notable, mais au contraire 23 autres possèdent moins de dix stations en Algérie : 4 sont uniques à Mostaganem (et dont 3 sont des endémiques strictes !), 6 n'existent qu'en une autre localité en Algérie, et 6 seulement en deux autres localités. Du point de vue de l'endémisme, 35 espèces et sous-espèces sont endémiques d'Afrique du Nord, dont 5 limitées à une région restreinte (RRE) et 5 autres réduites à un seul site (SRE). Les deux premiers de ces SRE sont localisées dans la basse vallée du Cheliff (*Salvia balansae* De Noé subsp. *balansae* et sa plante parasite *Cuscuta callosa* Pomel). Les trois autres croissent sur le littoral sableux au nord immédiat de Mostaganem : *Erysimum semperflorens* subsp. *elatum* (Pomel) Maire; et deux taxons critiques, *Senecio pinguiculus* Pomel (synonyme de *S. leucanthemifolius* Poir.selon APD 2020) et *Jasione corymbosa* subsp. *battandieri* (Maire) Véla & Mostari comb. nov. , probables endémiques strictes eux aussi. En termes de présence par pays nord-africain, 15 espèces et/ou sous-espèces n'occurrent qu'en Algérie, et tandis que 2 co-occurrent seulement en Algérie et Tunisie, au moins 19 (voire 22 ?) d'entre elles co-occurrent au Maroc et en Algérie seulement. Au moins 9 de ces taxons (figures 2 à 11) sont déterminants ou « déclencheurs » (« *trigger species* ») des zones importantes pour les plantes au sens de Yahi & al. (2012). Outre les cinq précédentes SRE, il faut considérer l'endémique oranaise *Brassica fruticulosa* subsp. *glaberrima* (Pomel) Batt., les orano-rifaines *Cistanche mauritanica* (Coss. & Dur.) Beck et *Malcolmia arenaria* (Desf.) DC., et l'algéro-orano-rifaine *Polygala munbyana* Boiss. & Reut.

Les plus fréquents des taxons déterminants sont de loin *Brassica fruticulosa* subsp. *glaberrima* avec 9 stations (Tab. 2) et *Malcolmia arenaria* s. s. (9 stations plus une dixième disparue). Ils sont suivis par *Senecio pinguiculus* (6 stations) puis *Erysimum semperflorens* subsp. *elatum* (5 stations). Quant à *Jasione corymbosa* subsp. *battandieri*, il est présent sur trois stations dont deux, celle de Sidi Mejdoub et celle de Kharouba ont quasiment disparu, respectivement suite à l'aménagement d'une route et d'un parc de loisir. Aussi ne persiste-t-il plus, de manière encore stable, que dans la station de Chaaibia, elle-même déjà dégradée et menacée par l'aménagement récent et la fréquentation touristique de la plage qui s'ensuit.

Les stations les plus riches en taxons déterminants ZIP (Tab. 2) sont Sidi Mejdoub et Kharouba avec cinq taxons , Stidia, Cheliff, Cahaibia et Capivi avec quatre taxonsLe site urbain de Sidi Mejdoub hébergeait jusqu'à peu de belles populations de cinq taxons déterminants, mais une modernisation de la route littorale ces dernières années a détruit une grande partie de l'écosystème et désormais trois taxons y sont en situation critique

Tab. 2. Délimitation des Zones Importantes pour les Plantes (ZIP, **en gras**) en fonction de la présence et de l'abondance d'espèces et/ou sous-espèces déterminantes ZIP (*trigger species*) recensées sur les sites d'étude de 2010 à 2020. Cette liste ne prend pas en compte les autres espèces patrimoniales recensées (voir tableau 1). X: moins de 10 individus; XX: 10-100 individus; XXX: plus de 100 individus; (…) population désormais détruite.

Taxon / Site	*Brassica fruticulosa* ssp. *glaberrima*	*Cistanche mauritanica*	*Erysimum semperflorens* ssp. *elatum*	*Jasione corymbosa* ssp. *battandieri*	*Polygala munbyana*	*Senecio pinguiculus*	*Malcolmia arenaria s. s.*	*Cuscuta callosa*	*Salvia balansae s. s.*
Macta	**X**						XX		
S. Mansour	**XXX**						**XXX**		
Stidia	**XXX**	**XX**				**XX**	**XXX**		
Oureah	**XX**								
Sablettes									
Mostaganem			**(X)**				**(XX)**		
S. Mejdoub	**XXX**		**X (XX)**	**X (XXX)**		**XX**	**X (XX)**		
Kharouba	**XXX**		**XX**	**X**		**XX**	**XXX**		
Sonacther						**XX**			
Cheliff	**XX**		**XX**			**XX**	**XX**		
Chaaibia	**XXX**			**XX**		**X**	**XX**		
Capivi	**X**		**XXX**		**X**		**XX**		
Aizib									**X**
Amarna								**XX**	**XXX**
A. Boudinar							**XX**	**XX**	**XXX**

(*Erysimum semperflorens* subsp. *elatum*, *Jasione corymbosa* subsp. *battandieri*, *Malcolmia arenaria* s. s.). Seules les stations de Sablettes et Mostaganem, à ce jour, n'hébergent pas de taxon discriminant ZIP, bien que cette dernière, désormais entièrement urbanisée, en hébergeait encore deux il y a seulement quelques années, et que cela devait vraisemblablement être aussi le cas pour la première.

Au-delà de ces taxons discriminants, tous les sites hébergent plusieurs espèces et/ou sous-espèces à valeur patrimoniale (endémiques/subendémiques, raretés nationales, etc., cf. Tab. 1 & Electr. Suppl. File 1), sauf Ouérah qui n'en héberge qu'une (par ailleurs déterminante ZIP, *Brassica fruticulosa* subsp. *glaberrima*), Mostaganem et les Sablettes qui n'en hébergent que deux. Les sites hébergeant le plus de taxons patrimoniaux sont, par ordre décroissant, les suivants : Kharouba (16 +1 non revu présumé disparu), Capivi (15), Stidia (15), Amarna (11), Ain Boudinar (8), Chaaibia (7), Sonachter (5), Cheliff (4), Sidi Mejdoub (3+2 non revus présumés disparus), Aizib (3), Macta (3), Sidi Mansour (3), Mostaganem (2), Sablettes (2), Oureah (1).

Discussion

Difficultés taxonomiques

Tout travail biogéographique et d'inventaire des priorités de conservation se heurte à des difficultés taxonomiques, surtout dans les pays où la flore et la faune sont peu voire très peu connues et/ou n'ont pas été révisées continuellement, comme c'est le cas en Algérie. La dernière flore algérienne de Quézel & Santa (1962-1963) et l'index synonymique de l'Afrique du Nord de Dobignard & Chatelain (2010-2013) résolvent certains conflits taxonomiques, mais en mettent surtout certains en lumière tandis que d'autres restent toujours oubliés. Voici quelques-uns de ces conflits que nous avons tenté de résoudre pour les besoins de l'étude:

Brassica fruticulosa subsp. ***glaberrima*** (Pomel) Batt. [≡ *B. glaberrima* Pomel] (Fig. 2). Il s'agit d'un taxon décrit au rang d'espèce par Pomel (1875), qui n'utilisait jamais le rang de sous-espèce, dans les « terrains sablonneux maritimes à Karouba (Mostaganem) ». Il a ensuite été rapproché, au rang de sous-espèce, des autres taxons du groupe de *B. fruticulosa* Cirillo par Battandier (1888), qui en ajoute alors une nouvelle localité à la Macta. C'est enfin René Maire (1965, post-mortem) qui ajoute une localité de Cosson à Orléans ville (aujourd'hui Chlef), où la plante a toutes les chances d'y avoir été seulement adventice et rudérale. Dobignard (2009) a entamé un examen critique des plantes marocaines, l'invitant à proposer de synonymiser *B. fruticulosa* subsp. *mauritanica* (Coss.) Maire avec *B. fruticulosa* subsp. *cossoniana* (Boiss. & Reut.) Maire. Il ne fait alors que suggérer une possible synonymie de *B. fruticulosa* subsp. *glaberrima* avec *B. fruticulosa* subsp. *radicata* (Desf.) Batt. côté algérien, ce qui en ferait un ensemble strictement littoral algérien à aire disjointe algéro-mostaganémoise. Nous n'avons pas d'avis sur la question, et à titre de précaution, conservons le taxon de Pomel comme autonome et endémique de Mostaganem. Il va de soi qu'en cas de synonymie avec le taxon algérois, l'aire d'occurrence, au lieu d'avoisiner les 100 km² (seuil limite une SRE / RRE), approcherait les 5.000 km² (environ 4500) ce qui en ferait encore une endémique à aire restreinte (RRE).

Bellevalia variabilis Freyn. [≡ *B. dubia* var. *variabilis* (Freyn) Maire]. Actuellement considérée comme synonyme de *Bellevalia dubia* (Guss.) Rchb. par toutes les bases de données actuelles (APD, Euro+Med, WCSP), ce taxon a pourtant été initialement décrit comme espèce par le spécialiste du genre (Freyn 1885), à partir de récoltes des environs d'Oran et de Chlef (NW Algérie). C'est René Maire (1941) qui a rapproché ce taxon et quelques autres de *B. dubia* (Guss.) Rchb. au sens large, dans une optique très synthétique dont il était coutumier. Or en Sicile, localité type de *B. dubia*, les plantes montrent une inflorescence de coloration très différente et reconnaissable au premier coup d'œil (J.M. Tison, comm. pers.). Au Maroc il s'agit de *B. dubia* var. *riphaeana* (Pau) Maire & Weiller [≡ *B. dubia* f. *riphaeana* Pau], taxon présumé endémique (Fennane & al. 2014) et peu étudié. Quant au taxon nommé *B. dubia* var. *maura* Braun-Blanq. & Maire, il tend à être assimilé comme synonyme de l'espèce distincte *B. mauritanica* Pomel, et ce contre l'avis même de René Maire (1960). Au final, le taxon qui nous concerne apparaît comme endémique oranais (NW Algérie).

Cuscuta callosa Pomel [≡ *Cuscuta planiflora* var. *callosa* (Pomel) Batt.] (Fig. 4). Cette espèce holoparasite a été décrite initialement de la basse vallée du Cheliff sur son hôte spécifique et endémique du site, *Salvia balansae* Noë ex Coss. Tout d'abord décrite comme espèce possiblement endémique (Pomel 1874), elle a ensuite été rapprochée de *C. planiflora* Ten. au rang variétal par Battandier (1890). Ce n'est que par synonymie, proposée sans aucune explication, avec *C. microcephala* Pomel [≡ *C. epithymum* var. *microcephala* (Pomel) Trab.] que Dobignard & Chatelain (2011) la signalent aussi du Maroc. Nous n'avons à ce stade pas de raison de modifier la position initiée par Pomel qui a bien distingué les deux taxons qu'il a décrits lui-même dans le même travail.

Dipcadi fulvum (Cav.) Webb & Berthel. [≡ *Hyacinthus fulvus* Cav., *D. serotinum* subsp. *fulvum* (Cav.) Maire & Weiller, *D. s.* var. *fulvum* (Cav.) Ball]. Nous avions précédemment (Véla & Mostari 2013) annoncé la présence de ce taxon comme nouveau pour l'Algérie, à partir de récoltes effectuées dans les régions de Mostaganem (forêt de Stidia) et d'Oran (fort de Santa-Cruz), mais il y avait déjà été recensé par Webb & Berthelot (1842-1850) sur une récolte de Bové « in collibus circà Oran », avant d'être tombé dans l'oubli. A ce jour son statut taxonomique reste incertain (sous-espèce, voire variété de *D. serotinum* ?) et sa délimitation imparfaite, à tel point que sa répartition demeure imprécise : originairement décrit d'Essaouira sur le littoral atlantique au Maroc, il a été récemment signalé en Tunisie littorale par El Mokni (2018). Quant à ses affinités éventuelles avec *Dipcadi erythraeum* Webb & Berthel. (Webb & Berthelot 1842-1850) d'Egypte et du Levant, elles n'ont toujours pas été étudiées.

Erysimum semperflorens subsp. ***elatum*** (Pomel) Maire [≡ *E. elatum* Pomel, *E. grandiflorum* var. *elatum* (Pomel) Batt. & Trab.] (Fig. 5). Plante décrite comme espèce par Pomel (1875), qui la donne endémique de la région de Mostaganem, «de la Macta au Chélif». Battandier (1890) à son tour la conserve au rang d'espèce, ce qui dénote une reconnaissance forte de sa part. Mais par la suite Battandier & Trabut (1905) la rapprochent au rang variétal de *E. grandiflorum* Desf. Dans une optique bien plus synthétique, mais sans justification particulière. C'est finalement René Maire (1977, post-mortem) qui la rapproche de *E. semperflorens* (Schousboe) Wettst., espèce décrite du Maroc, tout en lui conservant un rang de sous-espèce, ce qui pour lui est hautement significatif. De ce fait, si la sous-espèce type (subsp. *semperflorens*) est endémique du littoral atlantique marocain, la sous-espèce *elatum* est quant à elle endémique du littoral mostaganémois.

Gagea mauritanica Durieu. Cette espèce a été récoltée à Mostaganem en 1851 par Balansa (cf. herbarium P) aux cotés de *G. durieui* Parl ex Trab. (sub. *G. chrysantha*). Nous l'avons retrouvée à Capivi, mais en l'absence de la seconde. Son statut chorologique a fait débat ces deux dernières décennies, suite à un signalement provisoire en France et en Italie, finalement démenti après la distinction d'une espèce nouvelle (Peruzzi & Tison 2006). À l'inverse, la station unique du sud de Majorque (Baléares, Espagne) est confirmée (Lansdown 2016). De ce fait, l'espèce ne doit pas être considérée comme endémique d'Algérie au sens strict, au contraire de Dobignard & Chatelain (2010-2013). On peut d'ailleurs imaginer que son aire réelle n'est pas encore connue en globalité du fait de sa grande discrétion et des confusions possibles avec notamment *G. algeriensis* Chabert si l'on ne déterre pas correctement l'appareil souterrain, ou même *G. durieui* au stade non florifère.

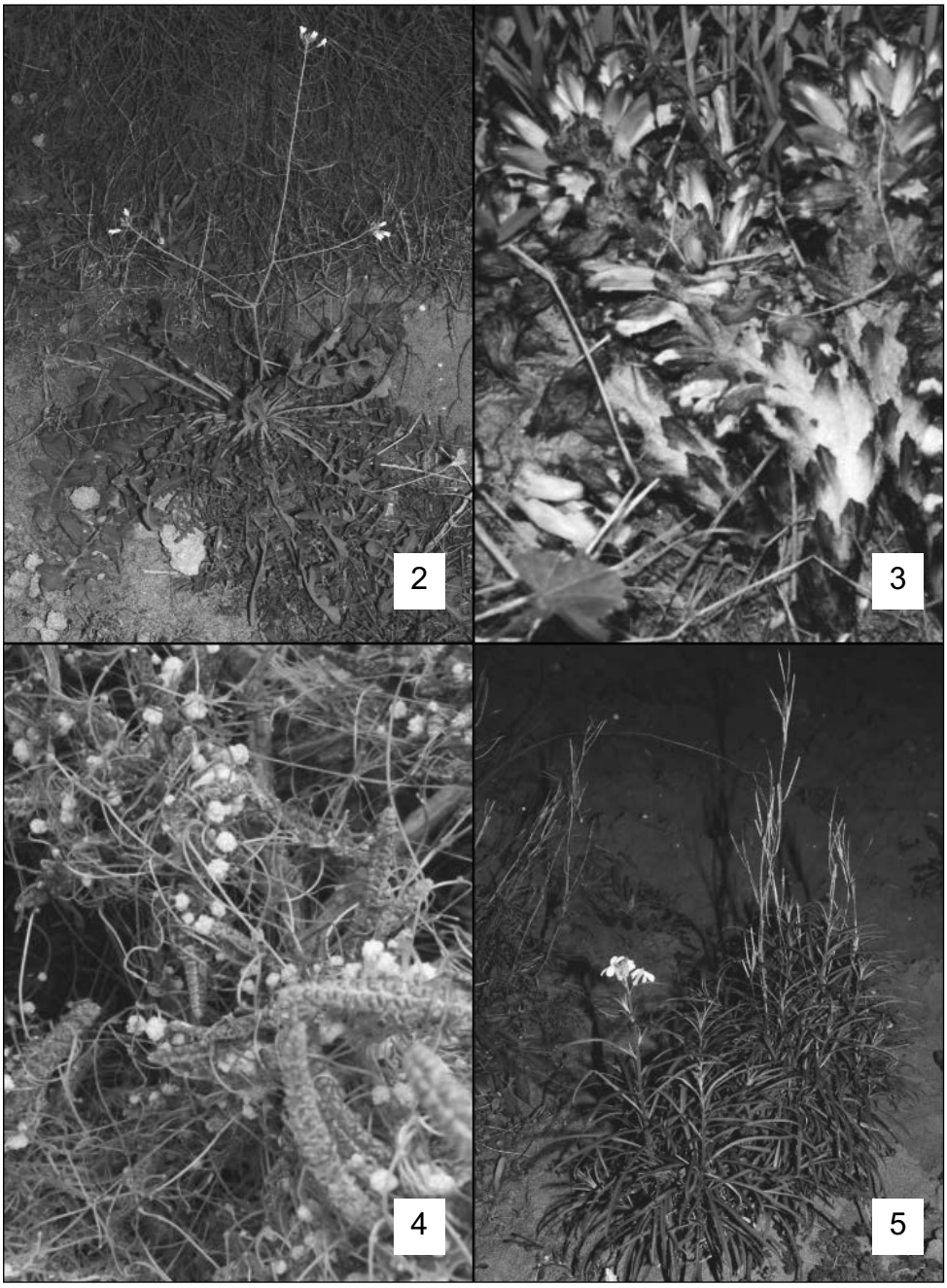


Fig. 2. *Brassica fruticulosa* subsp. *glaberrima*, Sidi Mejdoub, 17.I.2020, photo E. Véla.
Fig. 3. *Cistanche mauritanica*, forêt de Stidia, 27.II.2016, photo E. Véla.
Fig. 4. *Cuscuta callosa* (sur *Salvia balansae*), douar Amarna (rive gauche), 08.III.2016, photo A. Mostari.
Fig. 5. *Erysimum semperflorens* subsp. *elatum*, Cheliff plage, 16.I.2020, photo E. Véla.

Jasione corymbosa subsp. ***battandieri*** (Maire) Véla & Mostari, comb. nov. [bas.: *J. corymbosa* var. *battandieri* Maire, Bull. Soc. Hist. Nat. Afrique N. 28: 367 (1937)] (Fig. 6, 7). Cette jasione a une histoire taxonomique longue et hésitante. Les plantes oranaises furent tout d'abord décrites sous *Jasione glabra* Durieu (Boissier & Reuter 1852) avant d'être rapprochées de *J. corymbosa* Poir. sous la sous-espèce *J. c.* subsp. *glabra* (Boiss. & Reut.) Batt. (Battandier 1888-1890). Puis les plantes mostaganémoises furent découvertes et identifiées sous *J. corymbosa* subsp. *blepharodon* (Boiss. & Reut.) Batt. avant de remarquer leur originalité sans les nommer (Battandier 1910). C'est finalement Maire (1937) qui les a formellement décrites au rang variétal sous le nom *J. c.* var. *battandieri* Maire. Cela en fait un taxon endémique de Mostaganem, qui nous parait mériter le rang subspécifique, vicariant de la sous-espèce *glabra* endémique NW Algérie / NE Maroc et de la sous-espèce type endémique S Espagne / NW Maroc (Valdès & al. 2002).

Limonium sp. pl. Malgré la révision taxonomique d'Aimé & Roiron (1984) pour l'Oranie, et les mises au point nomenclaturales de Greuter & Burdet (1987), les saladelles d'Algérie demeurent confuse sur le plan taxonomique et mal connues sur le plan chorologique, ce qui rend difficile à la fois leur identification mais aussi l'estimation de leur valeur patrimoniale. À ce stade, il nous parait utile de corriger la répartition de *L. gougetianum* (Girard) Kuntze *sensu lato* en Algérie et de la subsp. *multiceps* (Pomel) Greuter & Burdet en particulier. En effet, Aimé & Roiron reprennent à l'identique la répartition de Quézel & Santa (1963), à savoir « C: A1, K1-2. R: O1: Dahra » pour la sous-espèce type et « R: A1: à l'W de Cherchell » pour la sous-espèce *multiceps*. Pourtant, plusieurs parts d'herbier (P-05388269, P-05388277, P-05388278), dont une identifiée *L. multiceps* par Maire (MPU-160017), et toutes provenant entre Ain el-Turck et Cap Falcon près d'Oran, confirment la présence non seulement de l'espèce à l'ouest du Dahra, mais également de la sous-espèce à l'ouest de Ténès. De ce fait la subsp. *gougetianum* est bien endémique algéro-tunisienne (à l'est de Cherchell) et la subsp. *multiceps* endémique algérienne (à l'ouest de Cherchell). Quant à *Limonium pescadense* Greuter & Burdet, nom nouveau pour l'ancien nom illégitime *Statice psilocladon* Boiss., il est donné comme algéro-tunisien dans les bases de données et index synonymiques. Mais si le type provient d'Alger (Pointe Pescade), les plantes de Tunisie sont des variétés distinctes: var. *intermedia* Boiss. (îles Plane, Cani et Zembretta) et var. *albida* Boiss. (île Zembra et Jbel Haouaria). Or, depuis la description de ces deux dernières variétés comme espèces nouvelles endémiques de Tunisie (*L. pyramidatum* Brullo & Erben, *L. zembrae* Pignatti, cf. Brullo & Erben 1989 ; Domina & Mokni 2019), l'ancienne variété type correspond à l'espèce *L. pescadense* au sens strict et se retrouve endémique d'Algérie, vraisemblablement depuis Oran à l'ouest (Cap Falcon) jusqu'à Skikda à l'Est (Senhadja) d'après les planches d'herbier consultables sur P et MPU.

Malcolmia arenaria (Desf.) DC. [≡ *Hesperis arenaria* Desf.; incl. *M. biloba* Pomel ≡ *M. arenaria* var. *biloba* (Pomel) Batt.] (Fig. 8). C'est Desfontaines (1798) qui a le premier décrit l'espèce «dans le sable sur le littoral maritime près d'Arzew» mais sous le genre *Hesperis*. Pomel (1874) a de nouveau décrit l'espèce sous le genre *Malcolmia* cette fois-ci, dans les « sables maritimes à Oran, Cap Falcon, Ghamra ». C'est Battandier (1888) qui rapproche l'espèce de Pomel de celle de Desfontaines, en l'intégrant au rang de variété, et il en fait de même avec une autre espèce voisine, *M. versicolor* Pomel. Mais c'est René



Fig. 6. *Jasione corymbosa* subsp. *battandieri*, Sidi Mejdoub (route littorale), 07.V.2013, photo A. Mostari.



Fig. 7. Habitat historique de *Jasione corymbosa* subsp. *battandieri*, Sidi Mejdoub (site actuellement détruit), 07.V.2013, photo A. Mostari.

Maire (1977, post-mortem) qui associe clairement la var. *biloba* au type de l'espèce, ce qui en fait un synonyme superflu de la variété nominale (var. *arenaria*). En revanche il conserve distincte la var. *versicolor* (Pomel) Batt., ce qui suggère, chez lui, une assez forte valeur taxonomique. Au vu des critères morphologiques forts (taille et couleur des pétales), écologiques (sables maritimes *vs*. sables de l'intérieur) et géographiques (littoral algéro-marocain de Mostaganem à Melilia *vs*. Hautes Plaines et Atlas saharien algéro-oranais), les deux taxons nous paraissent justifiés, au moins au rang de sous-espèce (combinaison inexistante pour *versicolor*), voire à celui d'espèce, comme initialement proposé par Pomel.

Salvia balansae Noë ex Coss. (Fig. 10). Cette espèce, initialement décrite de la région de Mostaganem, est donné dans les flores comme endémique d'Algérie mais avec une aire disjointe pour le peu surprenante (Quézel & Santa 1963): la basse vallée du Cheliff près de Mostaganem d'une part, et la vallée de l'oued Abdi dans l'Aurès d'autre part, soit plus de 500 km vers l'est et plus de 1000 m plus haut. Le seul point commun entre ces deux sites est le bioclimat semi-aride, mais l'un très maritime avec des hivers doux et l'autre très continental avec des hivers frais (Seltzer & al. 1946). En réalité les plantes des deux sites diffèrent, non seulement par la couleur des fleurs mais aussi la forme des feuilles (Beghami, Mostari & Véla, in prep.). De ce fait, la plante du bas Cheliff au sens strict est bel et bien une endémique restreinte à ce seul site (SRE).

Senecio pinguiculus Pomel [≡ *S. leucanthemifolius* f. *pinguiculus* (Pomel) Batt.] (Fig. 11). Cette espèce, décrite des sables maritimes de Abdelmalek Ramdane (ex-Ouillis), est remarquable par son port bas, diffus et ramifié et ses feuilles caulinaires entières, cordiformes à la base et semi-amplexicaules. Nos échantillons (Sidi Mejdoub, Kharouba, Sonacther, Cheliff-plage et Chaaibia) correspondent bien, par leur écologie et leur morphologie, au type de Pomel (P-00084029) et aux récoltes de Battandier & Trabut (MPU-959050, MPU-959051), à l'exception de la coloration des bractéoles, qui ne nous paraît être un critère constant. Les plantes, strictement psammophiles mais non halophiles, sont surtout remarquables sur le vif par leur couleur mate et glaucescente. Cette espèce n'a, semble-t-il, été signalée que sur le cordon sableux de Mostaganem, dont elle serait une endémique stricte (SRE) ?

A contrario, certains taxons décrits comme distincts ne sont pour l'instant plus reconnus comme tels, et jusqu'à preuve du contraire doivent être considérés comme synonymes avec un autre taxon plus répandu. On citera quelques exemples nous concernant:

Arenaria cerastioides Poir. Les sablines du groupe ibéro-maghrébin d'*A. cerastioides*, autrefois regroupées sous *A. arenarioides* (Crantz) Fernald *sensu lato*, forment un ensemble de micro-taxons encore peu étudiés et mal résolus au Maghreb. Même après avoir écarté *A. hispanica* Crantz, ibéro-marocain, et *A. saxigena* (Humbert & Maire) Dobignard, endémique marocain, il demeure sous *A. cerastioides sensu lato* six variétés méconnues (Maire 1963), toutes présentes en Algérie, dont quatre présumées endémiques, une partagée avec le Maroc, une autre avec la Tunisie. Dobignard & Chatelain (2010-2013) proposent une synonymie englobante de ces six variétés, à défaut d'étude spécifique. Deux d'entre elles, var. *oranensis* (Batt.) Maire et var. *parviflora* (Maire) Maire, sont mentionnées en Oranie, d'où elles sont présumées endémiques. Il va de soi qu'une meilleure caractérisa-



Fig. 8. *Malcolmia arenaria s.s.*, forêt de Stidia, 27.II.2016, photo E. Véla.
Fig. 9. *Polygala munbyana*, forêt de Capivi, 11.III.2012, photo A. Mostari.
Fig. 10. *Salvia balansae s.s.*, douar Amarna (rive droite), 16.I.2020, photo E. Véla.
Fig. 11. *Senecio pinguiculus*, Kharouba (cité), 17.I.2020, photo E. Véla.

tion taxonomique des plantes algériennes en général, et mostaganémoises en particulier, pourrait en faire des plantes à valeur patrimoniale plus élevée, et possiblement un taxon déterminant ZIP.

Arisarum vulgare Targ. Tozz., sensu lato. Le genre est représenté en Algérie par deux taxons à priori bien distincts morphologiquement et chorologiquement : *A. simorrhinum* Durieu limité à l'Oranie et *A. vulgare* s. s. dans le reste du Tell. Mais la situation est compliquée par la présence d'individus nettement intermédiaires en nombre assez conséquent dans la zone de contact des deux précédents (Mostaganem, Tlemcen). Quézel & Santa (1962) rangeaient les deux taxons principaux en sous-espèces, et proposaient une troisième sous-espèce pour le taxon intermédiaire, bien que ce dernier serait plutôt une combinaison hybride à ranger alors en notho-subspecies. En péninsule ibérique, Galán et Castroviejo (2007) proposent un schéma taxonomique distinguant les deux espèces et leur hybride (*A.* × *aspergillum* Dunal), tout en conservant pour *A. simorrhinum* une variabilité infraspécifique incluant deux variétés (*A. simorrhinum* var. *subexsertum* (Webb & Berthel.) Talavera et *A. simorrhinum* var. *clusii* (Schott) Talavera) présentant des caractéristiques intermédiaires avec *A. vulgare*. La situation devient encore plus confuse suite aux travaux de Dobignard (2009), qui propose que *A. v.* subsp. *vulgare* soit absente d'Afrique du Nord et remplacée par *A. v.* subsp. *subexsertum* (Webb & Berthel.) G. Kunkel et accompagnée de *A. v.* subsp. *hastatum* (Pomel) Dobignard dans la zone frontière algéro-marocaine. Nous n'arrivons pas à appliquer en Algérie aucun des schémas précédents, et nous préférons garder la vision à deux espèces et leur hybride.

Calendula suffruticosa cf. subsp. *monardii* (Boiss. & Reut.) Ohle. La révision de Ohle (1975) ne comprend malheureusement aucune plante provenant de Mostaganem. Ces plantes avaient pourtant été signalées par Battandier (1888-1890) sous le nom de *C. suffruticosa* Vahl, à considérer au sens large puisque ce dernier au sens strict (subsp. *suffruticosa*) est endémique de Tunisie (Ohle 1975), ce qui est en contradiction avec l'opinion de Dobignard & Chatelain (2011) qui la donne présente dans les trois pays du Maghreb. Par ailleurs, les clés d'identification de Quézel & Santa (1963) et de Ohle (1975) ne se basent pas sur les mêmes critères et ne s'appuient pas sur le même schéma taxonomique, de sorte qu'il n'est pas possible d'arriver à un consensus. Pour ces raisons, nous n'avons pas réussi à identifier nos échantillons, tant ceux à fleurs jaune citron (Sablettes, Sidi Mejdoub) que ceux à fleurs jaune orangé (Kharouba), qui par les caractères fructifères paraissent toutefois proche de la subsp. *monardii*, présumée endémique du littoral du nord de l'Algérie.

Carduus balansae Boiss. & Reut. (inclus dans *C. myriacanthus* DC.). Les chardons des groupes ibéro-maghrébins *C. meonanthus* Hoffmanns. & Link et *C. spachianus* Dur. présentent un polymorphisme très confus sur le plan taxonomique. La position de Dobignard & Chatelain (2011) et de Greuter (2006+) est d'inclure *C. balansae*, décrit d'Algérie (Mostaganem), dans *C. myriacanthus*, décrit du Maroc (Tanger et Essaouira), ce qui en ferait un taxon présent sur trois pays et dans l'ensemble assez commun. Mais cela contredit l'opinion de Boissier & Reuter (1856) qui le reconnait comme espèce affine tout en précisant qu'il s'en distingue facilement par plusieurs critères. Dans un tel cas, le taxon *C. balansae* au sens strict pourrait avoir un statut bien plus patrimonial, voire d'espèce déterminante ZIP. C'est pourquoi une étude comparative des plantes espagnoles, marocaines et algériennes serait la bienvenue.

Ferula cf. *tingitana* L. Au sens strict, cette férule paraît limitée en Afrique du Nord au Cap Spartel, dans la péninsule tingitane à l'extrême nord du Maroc. C'était déjà l'avis de Pau (1924), et c'est également notre avis après examen de toutes les parts des herbiers d'Afrique du Nord à MPU (E. Véla, A. Mostari & T. Hamel, inéd.). Il y a donc lieu de revoir la synonymie proposée avec *F. bolivari* Pau (endémique du Rif ?), ainsi que toutes les mentions nord-africaines de *F. glauca* L. (endémique franco-italienne). Les plantes de la région d'Oran (Santa-Cruz) et de Mostaganem (littoral) gagneraient à être sérieusement étudiées. En attendant, nous les conservons sous ce nom de rattachement provisoire en tant qu'espèce rare dans le pays, mais il est probable qu'une fois son statut taxonomique résolu nous puissions être devant une espèce endémique et déterminante ZIP.

Ononis variegata var. *alleizzetei* Faure et Maire (inclus dans *O. variegata* L.). Cette variété, décrite dans les « sables à Mostaganem », « diffère de la variété typique avec laquelle on rencontre des formes intermédiaires, en particulier par la stature, les tiges dressées, les grappes allongées, les feuilles très velues, les pédoncules allongés » (Maire 1937). Les isotypes (P-00084332, P-00465617, P-00465618) ont été récoltés par A. Faure le 01/05/1936 à Mostaganem vers le Djebel Diss, dans les pelouses sablonneuses. À ce stade, nous manquons d'observations pour pouvoir répondre à la question de son autonomie taxonomique.

Orobanche cf. *densiflora* Salzm. ex Bertol. Cette espèce, bien que signalée par différents auteurs en divers pays, y compris en Algérie par Munby (1859, 1866), est aujourd'hui considérée comme endémique des régions de Cadiz en Espagne et Tanger au Maroc (Sánchez Pedraja & al. 2016). Ce point de vue est conforme à ce que l'on peut observer dans les herbiers d'Afrique du Nord à MPU (E. Véla, A. Mostari & T. Hamel, obs. pers.). Les plantes que nous avons observées sur le cordon dunaire de Mostaganem seraient alors à rapprocher de *O. sanguinea* f. *loriformis* G.Beck ?

Phlomis herba-venti L. Cette espèce polymorphe au Maghreb possède un découpage infraspécifique qui n'est pas encore clairement établi, et ce malgré les travaux de Dobignard (2009). Nos plantes évoquent la subsp. *herba-venti* telle que décrite par ce dernier, mais la répartition respective de cette sous-espèce et de la subsp. *pungens* (Willd.) De Filipps en Algérie, ainsi que la réalité des populations dites « intermédiaires », ne sont pas connues à ce jour.

Caractérisation des zones importantes pour les plantes (ZIP)

Neuf espèces et/ou sous-espèces déterminantes ZIP sont présentes autour de Mostaganem et réparties sur 13 de nos 15 sites prospectés (Tab. 2).

Sur le littoral au sud-ouest de la ville, les sites adjacents de Macta / Sidi Mansour / Stidia / Oureah sont concernés par la présence de *Brassica fruticulosa* subsp. *glaberrima*, puis au nord-est de la ville, les sites de Sidi Mejdoub / Kharouba puis de Cheliff / Chaaibia / Capivi hébergent également ce taxon. Tous sauf un (Oureah) hébergent aussi *Malcolmia arenaria* s. s. Ces deux taxons semblent les plus caractéristiques de la zone et de la valeur patrimoniale des sites concernés.

L'ensemble de ces sites quasi-coalescents forme **une première zone importante pour les plantes**, que nous nommerons **«cordon littoral de Mostaganem»**. Elle est seulement interrompue, artificiellement, en son milieu par la zone portuaire et la zone urbanisée au sud de celui-ci (quartier Salamandre). Il y a peu, la bordure maritime de Mostaganem-ville hébergeait encore deux taxons déterminantes ZIP. Et encore aujourd'hui, le quartier adja-

cent des Sablettes, plus au sud, héberge au moins une plante patrimoniale (*Limonium pescadense*) et a vraisemblablement dû héberger par le passé une ou plusieurs taxons déterminantes ZIP. Par ailleurs, au vu de la continuité écologique du littoral sableux, il est probable que la ZIP s'étende encore vers le nord-est sur les communes voisines de Hadjadj et de Sidi Lakdhar, voire au-delà jusqu'à la limite de la wilaya ? Mais nous n'avons pas encore prospecté ces zones qui devront donc l'être à l'avenir.

Cette nouvelle ZIP jouxte en son extrémité sud-ouest la ZIP de la zone humide de la Macta (« *Macta wetlands* », Benhouhou & al. 2018). Elle en est toutefois très distincte par son habitat (pelouses et broussailles *vs*. végétation aquatique ou amphibie) et la nature de son terrain (anciennes dunes littorales consolidées *vs*. bas-fond dépressionnaire et alluvionnaire). On ne leur connaît d'ailleurs pas à ce jour d'espèce(s) déterminante(s) en commun, mais la présence historique de *Cistanche mauritanica* à Mohammadia (ex-Perrégaux) est toujours possible et serait à rechercher dans l'enceinte de la ZIP de la Macta.

Juste avant son embouchure, le fleuve Cheliff serpente entre le plateau de Mostaganem au sud et les reliefs collinaires des Dahra au nord. Les derniers reliefs fermant l'embouchure (Djebel Aizib au sud, prolongeant le Djebel Diss, et djebel Zegmoum au nord) sont quasiment dépourvus d'espèces discriminantes ZIP malgré la présence d'individus relictuels de *Salvia balansae* s. s. et d'au moins une autre espèce patrimoniale de valeur très relative (*Thymus munbyanus* subsp. *ciliatus*). En revanche dès l'entrée dans la vallée, les bas-fonds du Douar Amarna, tant rive gauche (le village) que rive droite (les parcelles cultivées), hébergent deux espèces discriminantes ZIP, *Salvia balansae* s. s. et sa plante parasite *Cuscuta callosa*. Cette espèce assez dominante forme un faciès de végétation caractéristique (Santa & Daumas 1958), qui s'étend au-delà d'Ain Boudinar (ex-Belle Côte) jusqu'à Ain Tedeles puis en direction de Sour (ex-Bellevue), où il recouvre essentiellement les terrains sédimentaires marins du Miocène (Dalloni & al. 1956). Sur les alluvions quaternaires récentes de l'oued Chéliff, l'espèce est également présente, tant rive gauche que rive droite, mais sous forme de pieds isolés ou de petites populations relictuelles fragmentées par l'agriculture (Mostari & al. 2016).

L'ensemble de ces sites, depuis ceux que nous avons prospectés (Aizib, Amarna, Ain Boudinar) jusqu'aux sites historiques où l'espèce est encore présente (Ain Tedeles, Sour) forme **une seconde zone importante pour les plantes**, que nous nommerons **«vallée du bas Cheliff»**. L'étendue historique (avant 1830) est sans doute un peu plus grande et surtout plus continue que l'aire actuelle, du fait du développement de l'agriculture sous l'impulsion des colons français. Mais entre la fin de l'occupation française (Daumas & Santa 1958) et aujourd'hui, nous n'avons pas remarqué de changement majeur dans les zones à faciès dominant à *Salvia balansae*. Seuls les pieds ou micro-populations isolées rive droite n'étaient pas référencées par le passé, sans qu'il soit possible de conclure à une extension récente. Tout au plus ces reliques existaient déjà mais n'avaient pas été cartographiées car déjà trop fragmentées et résiduelles.

Cette nouvelle ZIP est dans le prolongement exact de l'extrémité ouest la ZIP du Dahra occidental (« *Western Dahra range* », Benhouhou & al. 2018). Cette dernière n'est pas délimitée à ce jour avec précision, et la très vaste zone cartographiée l'a été à titre provisoire et indicatif, et surtout dans une optique incitative (E. Véla, donnée pers.). Malgré le signalement maladroit de l'espèce *Salvia balansae* comme espèce déterminante, c'est en réalité surtout pour ses deux bugranes endémiques (*Ononis avellana* Pomel et *O. crinita*

Pomel) que le site a été retenu. C'est donc en fonction de ces deux espèces caractéristiques des collines argileuses du Dahra occidental qu'il faut délimiter la ZIP en question. Les rares données bibliographiques historiques (Battandier 1888-1890; Quézel & Santa 1962-1963) mentionnent notamment Sidi Belattar (ex-Pont du Cheliff), Sidi-Ali (ex-Cassaigne), puis d'autres sites beaucoup plus à l'est en direction de Ténès. Il est donc vraisemblable que ce ne sont pas les mêmes formations géologiques qui sont en jeu, et cela devra être confirmé par une étude de terrain ciblant ces deux espèces, étude qui n'a toujours pas été réalisée à ce jour. En attendant, et devant la grande différence d'enjeux et de superficie des deux secteurs concernés, la moitié aval de la basse vallée du Cheliff d'une part (moins de 30 km²), et l'immensité des collines argileuses du Dahra d'autre part (plus de 500 km² ?), nous préférons considérer deux ZIP distinctes.

Menaces et enjeux de la ZIP «cordon littoral de Mostaganem»

Les habitats naturels et semi-naturels du cordon littoral de Mostaganem peuvent se regrouper en trois stades successifs de la dynamique et d'éloignement au rivage, où ils sont soumis à diverses menaces (Tab. 3).

Sur la plage elle-même, les dunes vives sont colonisées par l'Oyat (*Ammophila arenaria* subsp. *arundinacea* (Host) H. Lindb.) et son lot habituel de plantes associées (*Euphorbia paralias* L., *Ononis variegata* L., *Pancratium maritimum* L., *Pseudorlaya pumila* (L.) Grande, etc.). Ce sont là des espèces encore communes tout autour de la Méditerranée, bien qu'en régression un peu partout. En effet elles sont soumises à une forte pression anthropique estivale, notamment les aménagements pour automobiles et le piétinement par les baigneurs pour l'accès à la mer. Cependant ces écosystèmes sont particulièrement adaptés aux changements naturels incessants et en cela plus résilients à la fragmentation et à la perte de leurs habitats (Malavasi & al. 2018). De plus, partout en Europe méditerranéenne, des opérations de protection et sauvegarde du littoral sableux ont été entrepris pour faire face à cette érosion (Heslenfeld & al. 2004) et il serait sans doute possible également d'appliquer de telles mesures en Algérie (Toubal & al. 2019).

En arrière de la plage, des dunes subfossiles plus ou moins consolidées en grès s'étendent sur une largeur variable pouvant pénétrer à plus d'un kilomètre à l'intérieur des terres, et atteindre des altitudes de plusieurs dizaines de mètres, voire cent mètres à Kharouba et même deux cents mètres à Capivi.

Les plus proches de la mer et/ou les plus jeunes en termes de dynamique sont colonisées par un maquis bas à Rétam (*Retama raetam* subsp. *bovei* (Spach) Talavera & Gibbs) qui héberge la plupart des espèces déterminantes ZIP, tantôt à l'abri des buissons (*Erysimum semperflorens* subsp. *elatum*), tantôt à découvert dans les clairières (*Brassica fruticulosa* subsp. *glaberrima*, *Malcolmia arenaria* s. s., *Senecio pinguiculus*), ainsi que de très nombreuses autres espèces patrimoniales (cf. Tab. 1 & Electr. Suppl. File 1) ou tout simplement caractéristiques de cet habitat et de sa fragilité (*Linaria tingitana* Boiss. & Reut., *Reseda stricta* Pers., etc.). Les clairières hébergent de nombreuses thérophytes mais aussi diverses géophytes (*Dipcadi fulvum*, *Drimia numidica* (Jord. & Fourr.) J.C. Manning& Goldblatt, *Romulea ramiflora* Ten., etc.). À cela, il faut ajouter de remarquables espèces holoparasites de la famille des orobanches (*Boulardia latisquama* F.W. Schultz, *Cistanche mauritanica* (Coss. & Durieu) Beck, *Orobanche* cf. *densiflora* Salzm. ex Bertol.). Ces habitats sont très dégradés de nos jours dans les sites périurbains (Sablettes, Sidi Mejdoub, Kharouba),

notamment pour les besoins de fréquentation humaine de loisir (parc touristique « Mostaland », nombreuses corniches avec parking « vue sur mer », zones commerciales balnéaires…). Autrefois épargnées par l'agriculture à cause de leurs mauvais sols, puis épargnés par l'urbanisation directe pour les mêmes raisons, ils sont aujourd'hui convoités pour des aménagements de plein air tout aussi destructeurs. Pour preuve la destruction quasi-totale ces dernières années (en moins d'une décennie) d'une station à Sidi Mejdoub avec deux espèces déterminantes ZIP (*Jasione corymbosa* subsp. *battandieri*, *Senecio pinguiculus*), une espèce patrimoniale (*Ammochloa pungens*), et d'autres caractéristiques locales (dont *Cynomorium coccineum* L.), suite au dédoublement de la route littorale et aménagements de parkings panoramiques et de commerces. Dans le site adjacent de Kharouba, l'aménagement du parc de loisir « Mostaland » a déjà fait disparaître une station d'espèce patrimoniale (*Arenaria cerastioides*) et de nombreuses autres caractéristiques locales. Au-delà des premières extinctions locales avérées (*Erysimum semperflorens* subsp. *elatum* et *Malcomia arenaria* s. s. dans le secteur Mostaganem ville), d'autres sont donc vraisemblablement imminentes dans les secteurs voisins, notamment à Sidi Mejdoub et Kharouba, et pourraient s'étendre à d'autres espèces déterminantes ZIP, comme *Jasione corymbosa* subsp. *battandieri*.

Cette dégradation et ce besoin de conservation avaient déjà été noté par Belgat & Mezianien (1984), mais aujourd'hui leur espoir de conservation durable a atteint un niveau tellement bas qu'il en devient critique. **La prise de conscience de leur intérêt et de l'urgence de leur protection pour une conservation active nous parait une priorité absolue!** Ils sont à ce point méconnus et délaissés par les écologues que l'on peut encore lire dans le « dictionnaire de biogéographie végétale » (Métailié & Da Lage 2015) que la rétamaie est un « peuplement frutescent, présteppique et paucispécifique »! Pourtant, diverses rétamaies thermo-méditerranéennes ont été étudiées au sud-ouest de l'Espagne avec le vicariant *Retama monosperma* (L.) Boiss. (Munoz Vallés & al. 2013; Muñoz Vallés & al. 2014), et à l'est de l'Algérie sur le littoral de Jijel (Khennouf & al. 2018), et ont montré la grande richesse spécifique et la haute valeur patrimoniale de ces écosystèmes dunaires fixés et le rôle d'espèce-clé qu'y joue le Rétam.

Les plus éloignées de la mer, lorsqu'un stade dynamique suffisamment avancé le permet encore, sont boisées par des races arborescentes de Genévriers (*Juniperus phoenicea* subsp. *turbinata* (Guss.) Arcang., *J. oxycedrus* subsp. *macrocarpa* (Sm.) Ball) et/ou des reboisements de Pins (*Pinus halepensis* Mill., *P. pinaster* Aiton *sensu lato*, *P. pinea* L.) à partir de souches pas forcément indigènes. Bien que tous deux protégés par la loi (anonyme 2012), les genévriers sont l'objets de dégradations, de coupes rases, voie de destruction de leur habitat. Ils sont accompagnés de buissons bas formant une garrigue en sous-bois et/ou dans les clairières. C'est à ce niveau que croissent diverses espèces patrimoniales voire discriminantes ZIP, comme *Cistus heterophyllus* et *Polygala munbyana*, en compagnie de divers cistes caractéristiques des zones sableuses (*Cistus halimifolius* L.) ou plus généralistes (*Cistus monspeliensis* L.) et de nombreuses géophytes (*Allium* sp. pl., *Scilla* s. l., *Urginea* s. l., etc.).

Au-delà, dans les zones moins sableuses, ces matorrals arborescents cèdent la place à des formations plus clairsemées par l'action historique des incendies, coupes de bois et surpâturages chroniques, à base de Thuya de Barbarie (*Tetraclinis articulata* (Vahl) Mast.), de Pin d'Alep de souche indigène, d'Oléastre (*Olea europaea* L. subsp. *europaea* "var. *sylvestris*(Mill.) Lehr") et de Lentisque (*Pistacia lentiscus* L.). Le plus souvent, ces habitats

bien plus répandus sont dépourvus d'espèces déterminantes ZIP, et en cela ne doivent pas être considérés comme faisant partie de la ZIP au sens strict.

Notre échantillonnage relativement intensif est cependant loin d'être exhaustif, et il ne serait pas raisonnable de déclarer disparue sans les avoir recherchées de manière ciblée, un certain nombre d'espèces autrefois explicitement signalées à Mostaganem (Battandier 1888-1890; Battandier & Trabut 1895; Quézel & Santa 1962-1963; Aimé & Roiron 1985). Citons parmi les plus remarquables:

- sur les plages, sables maritimes et pâturages sablonneux: *Anacyclus linearilobus* Boiss. & Reut. (endémique d'Algérie), *Aristida adscensionis* var. *coerulescens* (Desf.) Durand & Schinz º *A. coerulescens* Desf., *Astragalus longicaulis* Pomel, *Avena ventricosa* Coss., *Cerinthe gymnandra* subsp. *oranensis* (Batt.) Valdés (*C. oranensis* Batt.), *Mecomischus pedunculatus* (Coss. & Durieu) Oberpr. & Greuter (º *Cladanthus pedunculatus* Coss. & Durieu, endémique d'Algérie, SRE, Mostaganem !), *Heteranthemis viscidehirta* Schott (*Chrysanthemum viscosum* Desf.), *Crepis arenaria* subsp. *suberostris* (Batt.) Greuter (*C. suberostris* subsp.*typica* Bab. endémique d'Algérie), SRE , O1: Mostaganem et Macta), *Echium arenarium* Guss., *Filago pygmaea* subsp. *linearifolia* (Pomel) Dobignard (*Evax linearifolia* Pomel), *G. durieui* Trab. (*G. chrysantha* auct.), *Limonium cymuliferum* (Boiss.) Sauvage & Vindt, *Malcolmia littorea* (L.) R.Br. (taxon Ibéro-Marocano-Algérien), *Linaria bordiana* Santa & Simonn. "subsp. *kralikiana* (Maire) D.A. Sutton" (= *L. elegans* Munby non Cav. = *L. bordiana* var. *kralikiana* Maire, endémique d'Algérie, SRE, O1: Mostaganem, cf. Sutton 1988), *Silene sclerocarpa* L. Dufour (= *S. cerastoides* auct.), *Vulpia geniculata* subsp. *attenuata* (Parl.) Trab.;

- sur les rochers du littoral: *Anthemis chrysantha* J.Gay, *Fumaria munbyi* Boiss. & Reut., *Limonium densiflorum* (Guss.) Kuntze.

Menaces et enjeux de la ZIP «vallée du bas Cheliff»

Quant aux habitats naturels et semi-naturels de la vallée du bas Cheliff, ils peuvent se regrouper en deux à trois groupes principaux entrecoupés et fragmentés par des parcelles cultivées : les berges limoneuses de l'oued, les pentes et ravines argileuses, et les garrigues rocheuses partiellement arborées. Ils sont eux aussi soumis à diverses menaces (Tab. 3).

Les berges de l'oued sont couvertes d'un double linéaire de tamariçaie à *Tamarix africana* Spreng., qui couvrent parfois une sous-strate herbacée annuelle à *Otospermum glabrum* (Lag.) Willk., une espèce de chamomille supportant l'inondation temporaire. En cela les habitats naturels sont assez bien préservés, étant loin de l'urbanisation et peu attaqués par l'agriculture qui n'ose pas trop approcher le lit du fleuve.

En s'écartant du lit en direction des versants, les talus et ravins argileux hébergent une végétation clairsemée très intéressante. Les clairières sont habitées par des pelouses sèches à affinités steppiques méditerranéennes, riches en annuelles dont des genres de Brassicacées monospécifiques et endémiques maghrébin (*Psychine* Desf.) ou algéro-marocain (*Cordylocarpus* Desf.), ainsi que de nombreuses géophytes (*Ophrys* sp., *Prospero* sp., etc.) dont l'endémique algérienne *Aristolochia fontanesii* Boiss. & Reut., ici en limite occidentale de son aire de répartition (Nardi 1984). Les faciès plus denses, bas et buissonnants, sont dominés par la sauge endémique du site (*Salvia balansae* s. s.) et d'autres Lamiacées plus basses et plus répandues comme des thyms (*Thymus* sp. pl.) ou de la lavande (*Lavandula dentata* L.). Ces écosystèmes sont soumis à la pression plus ou moins régulière

Tab. 3. Liste des principales menaces identifiée (ou potentielles) sur chaque secteur de la ZIP « littoral de Mostaganem » (1-12) et de la ZIP voisine « basse valée du Cheliff » (14-15). X: menace affectant l'écosystème de manière non significative; XX: menace dégradant l'écosystème de manière significative plus ou moins réversible; XXX: menace perturbant gravement et durablement le fonctionnement de l'écosystème.

Site / Menace	1. Macta	2. Sidi Mansour	3. Stidia	4. Oureah	5. Sablettes	6. Mostaganem	7. Sidi Mejdoub	8. Kharouba	9. Sonachter	10. Chelif	11. Chaaibia	12. Capivi	14. Amarna	15. Ain Boudinar
Surpâturage		XX	X					X	X	XX	XX	XX	XX	XX
Agriculture		X	X							XX	X	X	XX	XX
Industrie						XXX			XX					
Logements				XX	XXX	XXX	X	XX		X			X	
Routes et parkings		X		X	XXX	XXX	XXX	XX	XX		XX	X		
Fréquentation humaine	XX	XX	XX	XX	XXX		XXX	XX	XX		XX	X		
Coupes illicites											XX			
Incendies		(X)	(X)						(X)		(X)	X	X	(X)

et ancestrale du pâture ovin et caprin, mais surtout ils sont grignotés sur les marges par l'agriculture traditionnelle et/ou l'urbanisation villageoise (Mostari & al. 2016).

Enfin les sols les moins pauvres seront propices à l'installation d'une végétation plus dense et plus haute, à base de pins (*Pinus halepensis*), de broussailles épineuses (*Asparagus* sp. pl., *Calicotome intermedia* C. Presl) et de nombreux sous-arbrisseaux (*Micromeria inodora* (Desf.) Benth.). Ces écosystèmes bien plus répandus sont soumis aux cycles classiques des incendies et selon les localités à la pression de pâturage. Ils hébergent diverses espèces patrimoniales mais aucune espèce déterminante ZIP, et leur état de conservation n'est pas préoccupant. En cela, ils ne sont pas une priorité dans le contexte local.

Notre échantillonnage est trop incomplet dans ce type d'habitats à l'intérieur des terres (parcours, garrigues et pinèdes), pour nous avoir permis de rencontrer plusieurs espèces possédant des mentions historiques à Mostaganem (Battandier 1888-1890; Battandier & Trabut 1895; Quézel & Santa 1962-1963). Citons à titre d'exemple et pour mémoire: *Avena eriantha* Durieu (*A. pilosa* subsp. *eriantha* (Durieu) Trab.), *Avena longiglumis* Durieu, *Calicotome spinosa* (L.) Link (dont ce serait la station la plus occidentale), *Castellia tuberculosa* (Moris) Bor (*Catapodium tuberculosum* Moris), *Cuscuta epithymum* subsp. *kotschyi* (Des Moul.) Arcang. (*C. kotschyi* Des Moul., *Cuscuta cuspidata* Pomel), *Cytisus arboreus* (Desf.) DC. "subsp. *baeticus* (Webb) Maire" (non retenu par APD 2020), *Helianthemum polyanthum* (Desf.) Pers., *H. viscarium* Boiss. & Reut., *Lepidium glastifolium* Desf., *Lonicera biflora* Desf., *Lotus halophilus* Boiss. & Spruner (= *L. pusillus* Viv.), *Ophrys subfusca* (Rchb. f.) Batt., *Ornithopus sativus* subsp. *isthmocarpus* (Coss.) Dostál (*O. isthmocarpus* Coss.), *Teucrium montanum* L., *Silene apetala* Willd.; ou encore *Cephalaria syriaca* (L.) Roem. & Schult. et *Omphalodes linifolia* (L.) Moench, dans les champs cultivés autour de Mostaganem.

Perspectives

La dégradation irréversible déjà très avancée, et le danger imminent toujours très présent, nous invitent à solliciter un classement urgent de protection des espèces et des écosystèmes les plus critiques du littoral de Mostaganem. Les espaces géographiques constitués par le cordon dunaire de Mostaganem (de La Macta à Capivi, sur une largeur moyenne d'un kilomètre +/-500 m) d'une part, et la vallée du bas Cheliff (tout le versant nord du plateau, depuis la limite communale Mostaganem / Ain Boudinar jusqu'à la limite Ain Tédelès / Sour) d'autre part, peuvent désormais être classés zones importantes pour les plantes (ZIP) sur la base des critères recommandé par Plantlife International (2004) et Radford & al. (2011). Au sein de ces sites, les mesures de conservation et de planification devront être hiérarchisées et organisées en fonction des taxons et/ou des écosystèmes les plus vulnérables et/ou les plus irremplaçables (Langhammer & al. 2007; Pressey & Taffs 2001). Certes les outils manquent encore, notamment en ce qui concerne la liste rouge des espèces menacées de l'UICN, encore très incomplète en Méditerranée : à ce jour seules les Monocotylédones ont été relativement bien évaluées, soit environ 20% de la flore vasculaire totale (Véla & al. 2018). Il conviendra donc, dès que possible, d'évaluer selon la liste rouge de l'UICN les neuf espèces déterminantes présentes dans les deux ZIPs identifiées ici, afin de disposer d'un outil de diagnostic et de suivi ciblé. Mais d'autres outils peuvent compenser provisoirement le manque de connaissances, comme la méthode basée sur l'estimation à dire d'expert (Fennane & De Montmollin 2016), autrefois intuitivement pratiquée en l'absence des recommandations officielles actuelles en vigueur (UICN 2001). En effet, à défaut de données « idéales » ils peuvent constituer un jeu de données «réalistes» (Langhammer & al. 2007) dans les pays méga-divers et sous-prospectés comme le Maroc ou l'Algérie. Sans cela, on risquerait d'attendre trop longtemps une véritable liste rouge complète selon les critères en vigueur, tout du moins plus longtemps que la situation dramatique du site ne le permettrait.

Aussi nous espérons une prise de conscience collective de la communauté scientifique nationale et internationale, des organisations non gouvernementales internationales, des services administratifs de la wilaya et de l'État, des associations locales de sauvegarde de l'environnement, des habitants de Mostaganem et de tous les touristes visiteurs. Si les écologistes, si les Mostaganémois, si les Algériens, ne prennent pas en charge la sauvegarde de leur patrimoine naturel endémique et unique avant qu'il ne soit trop tard, alors qui le fera ?

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Article

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Xeranthemum cylindraceum (*Asteraceae*) in Italy: first record for the Sicilian flora

Abstract

Costa, R. M. S. & Di Gristina, E.: *Xeranthemum cylindraceum* (*Asteraceae*) in Italy: first record for the Sicilian flora. — Fl. Medit. 30: 235-243. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

The distribution in Italy of *Xeranthemum cylindraceum*, an annual herbaceous species of *Asteraceae*, up to now indicated only for most of the peninsular regions, is examined. The geographical distribution of this species in the Italian regions is provided on the basis of the specimens preserved in FI. In addition, there is an unpublished record from Sicily. In this island the species is therefore reported for the first time. It was found in the territory of Erice (Trapani), in a meadow on calcareous soils, on the northern slopes of Mt S. Giuliano.

Key words:vascular flora, Compositae, chorology, Sicily, Erice.

Introduction

Asteraceae is the most represented family in the Italian native vascular flora (Bartolucci & al. 2018). In this family, there are several critical taxa, mainly belonging to *Hieracium* L.*, Pilosella* Vaill.*, Taraxacum* F. H. Wigg, and *Centaurea* L. In the last two decades, the in-depth study has made it possible to identify and describe new taxa. In addition, native plants, already known in other countries, or new alien, are frequently reported. The family, therefore, is continuously enriched. The same in Sicily, an Italian island region which - like Sardinia - has an independent biogeographical history with respect to the Peninsula, and which is notoriously a Mediterranean biodiversity hot-spot (Médail & Quézel 1997).

The native vascular flora of Sicily has been well explored in the past (Raimondo 1988) and the Sicilian territory is one of the well-known floristic territories among Italian and Mediterranean regions (Raimondo & al. 2005). However, not all of the regional territory was investigated with the same in-depth level.

everal taxa have recently been described or rediscovery for the Sicilian flora: *Hieracium pignattianum* Raimondo & Di Grist., *H. madoniense* Raimondo & Di Grist., *H. pallidum* subsp. *aetnense* Gottschl., Raimondo & Di Grist., *H. hypochoeroides* subsp. *montis-scuderii* Di Grist., Gottschl., Galesi, Raimondo & Cristaudo, *H. busambarense* Caldarella, Gianguzzi & Gottschl., *H. schmidtii* subsp. *nebrodense* (Lojac.) Di Grist., Gottschl. &

Raimondo, *Pilosella hoppeana* subsp. *sicula* Di Grist., Gottschl. & Raimondo, *Taraxacum garbarianum* Peruzzi, Aquaro, Caparelli & Raimondo, *Centaurea eycina* Raimondo & Bancheva, *C. saccensis* Raimondo, Bancheva & Ilardi, *C. giardinae* Raimondo & Spadaro, *C. sicana* Raimondo & Spadaro, and *C. aegusae* Domina, Greuter & Raimondo (Raimondo & Bancheva 2004; Raimondo & al. 2004; Raimondo & Di Gristina 2004, 2007; Raimondo & Spadaro 2006, 2008; Peruzzi & al. 2009; Gottschlich & al. 2013; Caldarella & al. 2014; Di Gristina & al. 2016; Domina & al. 2017).

In addition to the newly described taxa, the Sicilian flora is also enriched by the reports of species already known in other Italian regions. This is also the case of *Xeranthemum cylindraceum* Sm., a species known in most of the peninsular regions (Bartolucci 2018; Pignatti 2018; Arrigoni 2020), which in our contribution is reported for the first time in Sicily.

Materials and Methods

Systematic field excursions in the north of Sicily were carried out in order to investigate taxonomy and distribution of taxa belonging to *Xeranthemum* L. The herbarium study is based on spcimens housed in FI, in PAL and in the personal collection of Prof. F. M. Raimondo, temporarily housed at the Research, Documentation and Training Center, PLANTA, in Palermo. Wikiplantbase #Italia v1.0 (Peruzzi & al. 2019-) was used as source of additional distibution data.

Taxonomy

Xeranthemum cylindraceum Sm., Fl. Graec. Prodr. 2(1): 172 (1813).

Annual herb with erect trunk, up to 70 cm, tetragon, simple or branched, tomentose, with indumentum of hairs and sessile glans. Leaves linear or lanceolate, cuneate at the basis and mucronate at the apex, tomentose at the lower page and revolute at the margin. Terminal capitula subcylindrical, 1-1.2 × 0.4–0-7 cm. Bracts imbricate, the external ovate, appressate, muticate, with a dorsal band tomentose-glandulose, white; the inner linear or linear-lanceolate, glabrous, erect or patent, with apex acute, purplish. Corolla with withish pipe and limb roseate-purplish. Achenes ovate-cuneate, 4–6 mm, with triangular section, sericeous-hirsute. Pappus with 8–10 unequal hairs.

Iconography: Rodriguez Riano & De Vesa (2014) Fl. Iber., 16(1): 60 (Fig. 1).

Fenology: flowering from May to August.

Biological form: Scapose therophyte (T scap).

Ecology: Steppic plant of the warm areas of Europe and the arid belt of southern Siberia, in Italy it occurs in meadows and mountain forest clearings from the coast up to 1,500 m a.s.l. (Pignatti 2018), where it generally occurs in arid calcareous meadows (Arrigoni 2020).

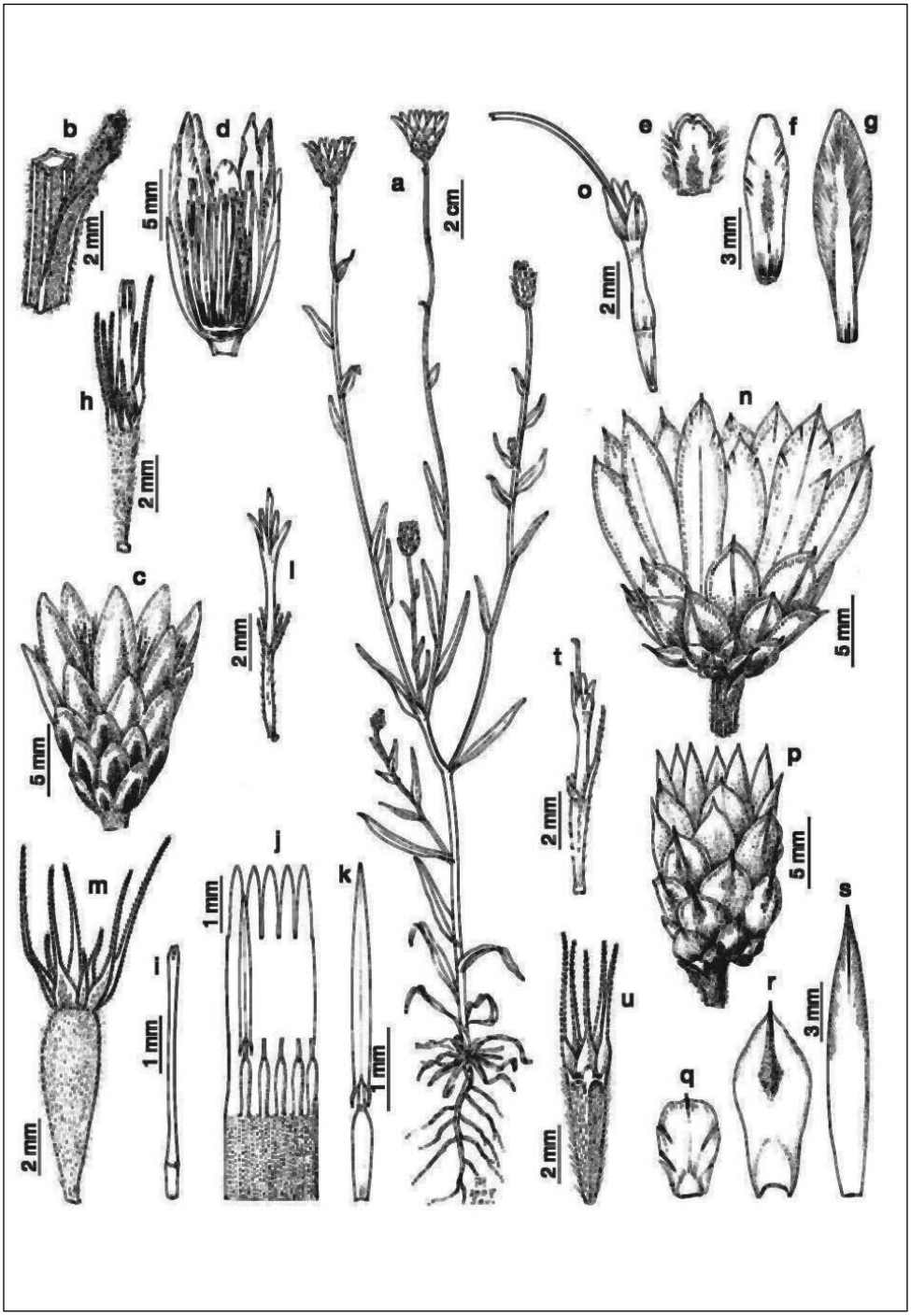


Fig. 1. Iconographic plate of *Xeranthemum cylindraceum* (from Rodriguez Riano & De Vesa 2014).

Chorology: with reference to the chorological type, Pignatti (1982, 2018) assigns the taxon to the south Siberian-south European chorotypes (S-Siber. – S-Europ.). Arrigoni (2020) considers it an Euroasiatic alien species.

Distribution in Italy

According to Greuter (2006-), the distribution area of *Xeranthemum cylindraceum* includes most of Europe, the western regions of North Africa and the Middle East.

In Italy, this taxon is recorded for many regions with the exception of Emilia Romagna, Friuli-Venezia Giulia, Sardinia and Sicily and its presence is given as doubtful only for the Val d'Aosta and Liguria (Bartolucci & al. 2018; Peruzzi & al. 2019) (Fig. 2). Arrigoni (2020) reports it as casual in the Padanian area. In light of the studied specimens, *X. cylindraceum* is also present in Sicily limited to the Mt Erice known as Mt. S. Giuliano near Trapani. In this area the species occurs in a small population in a meadow on calcareous clayey soil, on the edge of the Valderice-Erice road (*Raimondo* in PAL, PAL-Gr and CT).

Specimina in FI

TOSCANA − Colle di S. Colombano, Rota, 1845, da *Moretti* in Ott. 1845 (FI !) - Pratovecchio 1847, da *Parlatore* in Luglio 1847 (FI !) - luoghi argillosi della Curigliana di Cascina, *Savi*, VII.1854 (FI !) - In campis prope Montiloro in agro Florentino, *Caruel*, 29.VII.1863, da *Caruel* in Ott. 1863(FI !) - Campi di Prataglia, *sine coll*., 1863 (FI !) - App. Casentinese a Giampereta, 19.VII.1864, da *Marcucci* in Ott. 1864(FI !) - Fra Soci e Poppi, nei campi, 16.IX.1867, da *Parlatore* in Sett. 1867(FI !) - Campi di Capanno sopra Prataglia, reg. sup. del castagno, 28.VII.1867, da *Parlatore* in Sett. 1867 (FI !) - Prataglia nell'Appennino del Casentino, luoghi aridi della reg. super. del castagno, 1100 m circa, 23.VII.1867, da *Parlatore* in Sett. 1867 (FI !) - In Apennino Etrusco, Prataglia, *sine coll*., VIII.1867 (FI !) - Appennino del Casentino a Prataglia, VIII.1867, da *Parlatore* 1869 (FI !) - Monte Senario, 23.VII.1868, da *Bucci* in Lug. 1868 (FI !) - Presso Pratovecchio, 7.VII.1872, da *Giemoni* in Agosto 1872 (FI !) - ad muros prope Pratovecchio, in Casentino*, Arcangeli*, 27.VII.1875, da *Arcangeli* in aprile 1876 (FI !) - San Casciano dei Bagni, in agris, *Levier* et *Sommier*, 23.VI.1886 (FI !) - Verso Montrioli in Casentino, *Sommier*, 1.VII.1889 (FI !) -Monte Giovi, Cascina Giunti, *Sommier*, 20.VI.1889 (FI !) - Fra Mandrioli e Pratovecchio in Casentino, *Sommier*, 1.VII.1889, da Sommier Febbraio 1890 (FI !) - Nei campi presso l'Olmo (Firenze), *Martelli*, IX.1892 (FI !) - Monte del Fallito presso Bibbiena in Casentino, *Gemmi*, 12.IX.1892 (FI !) - Prope Florentiam fra Vaglia e Mte Senario, *Sommier*, 20.VII.1893 (FI !) - Fra l'Alma e Pratolino, *sine coll*., 2.VII.1901(FI !) - Prope Florentiam presso a Monte Rotondo a casa Guadagni in Mugello, *Sommier*, 24.VI.1902 (FI !) - Prope Florentiam Pian di Mugnone alle Caldine, *Sommier*, 17.VII.1904 (FI !) - Prope Florentiam inter Pratolino et M. Senario, *Sommier*, 24.VI.1908 (FI !) - Prope Florentiam inter Pratolino et Monte Senario, in aridis, *Sommier*, 25.VII.1909 (FI !) -Chiusi della Verna (Arezzo), in arvis et in sterilibus, alt. m 1020, *Mazzeschi et Contardo*, 20.VII.1966 (FI !) - Massa Trabaria, luoghi erbosi asciutti a Montelabreve (Arezzo), c. 850 m.s.m., suolo arenaceo-marnoso, humus subnullo, *Brilli-Cattarini et Gubellini*, 2.VII.1981(FI !) - Monte Labro (Grosseto), nei pressi del Santuario, 900-1000 m s.m.ca., *Baldini et Luccioli*, 13.XII.1992 (FI !) - Grosseto, da Santa Fiora verso Castel'Azzara, guado, risalendo la riva destra del Torrente Scabbia (affluente del Fiora), substrato ripariale con Salici, Ontani, Cerri, Ghiaioni di calcare, m 570 circa s.l.m., *Sforzi et Senesi*, 22.VI.2003, det. *Sforzi* (FI !) - Grosseto, Monte Acuto nei pressi di Pari, Lecceta a coltivi (uliveti, vigneti) abbandonati, m 462 s.l.m., *Sforzi et Senesi* 06.VII.2003, det. *S. Sforzi* (FI !)

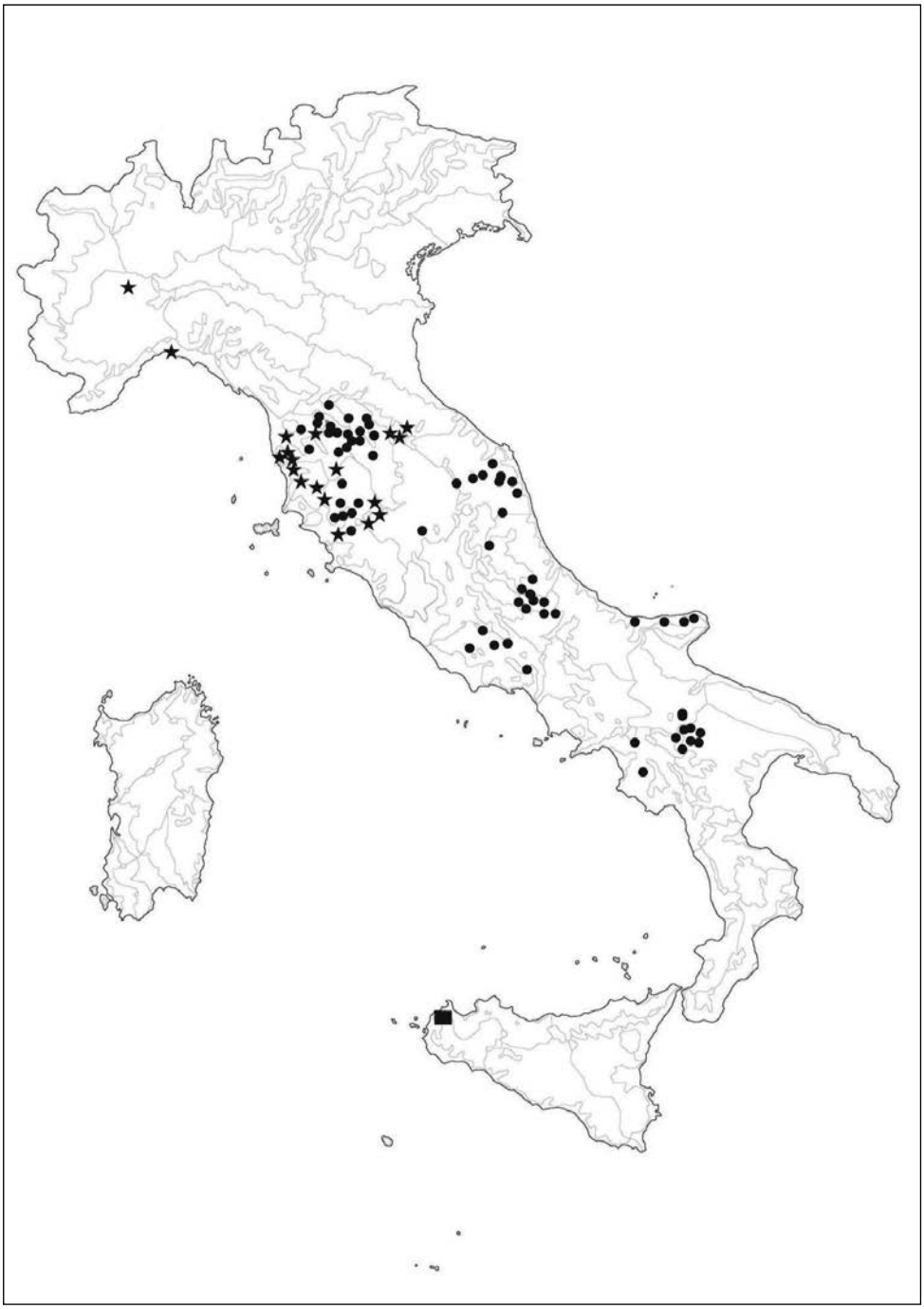


Fig. 2. Italian distribution of *Xeranthemum cylindraceum*: dots) herbarium specimens in FI; stars) additional distribution from Peruzzi & al. 2019-; square) new record from Sicily.

MARCHE – Vicino ad Acquasanta nel Piceno, reg. del castagno, *sine coll*., 11.VII.1836 (FI !) - legit in Mte. Fortino alla Battiferra, *Dominicus Marzialetti*, VII.1893, da *Marzialetti* in Aprile 1851 (FI !) - Ubique in pasc. m. Catria, Pascoli del ……, da *Giannini* 1864 (FI !) - Sopra Fonte Avellana nel M. Catria, reg. del faggio, 500 m, 26.VII.1866, da *Parlatore* in Sett. 1866 (FI !) - legi in sub Apennino Piceno a Mt. Fortino, *Gennari*, da *Gennari* in Luglio 1877 (FI !) - A Fabriano, *Narducci*, IV.1877 (FI !) - Nel ….Fermanello nel …., *Narducci*, IV.1877 (FI !) - Macerata presso il ponte di Fiastra nell'Abbazia di Bandini, ed in altre località, *Narducci*, sine die (FI !) - Jesi (Marche), *Grilli*, 15.VI.1907 (FI !) - Cingoli, VII.1932 (FI) da ….. (FI) - Cingoli, 10.VII.32, da …..(FI)

UMBRIA – Presso La Morcella, *Bicioni*, sine die, det. *Palomba* (FI !)

LAZIO – da Vicovaro alla spiaggia lungo i stradali di Subiaco, inter segetis, 28.VII.1857, da *Molli* in Genn. 1858 (FI) - Ad agrorum margines Campaniae, Ausonia, *Terracc*., VI.1874, da *Terracciano* in Apr. 1875 (FI !) - Vallepietra alla SS. Trinità sulla rupe, *Vaccari*, 29.V.1904 (FI !) - Salita da Palombara al Mt. Gennaro, 600:1100, *Vaccari*, 15.VII.1906 (FI !) - S.S. Trinità sulla rupe, *Vaccari*, 12.VI.1911 (FI !)

ABRUZZO – Ad radices Montis "Morrone", a Caramanico non longe, ad agrorum margines,. *Sommier*, 4.VII.1872 (FI !) - Ad radices Montis Morrone, ad agrorum margine, *Sommier*, 4.VII.1872 (FI !) - In campis arenosis ad radicem Montis Morrone supra Caramanico (Apud Cit.), *Levier*, 4.VII.1874 (FI !) - Morrone, sopra Salle Caramanico, *Profeta*, VIII.1874 (FI !) - In collibus siccis prope Caramanico in Aprutio, *Groves*, VII.1875 (FI !) - Nei seminati presso il laghetto di S. Giacomo sul Mte. dei Fiori (Abruzzi), *Gemmi*, 14.VII.1877 (FI !) - Monte Morrone (Abruzzi), *Profeta*, Estate 1891 (FI !) - Caramanico (Majella), salendo al Convento di S. Nicola, 600-700, *Vaccari*, 2.7.1906 (FI !) - Caramanico, dirupi sopra S. Croce, 600-700 m, *Vaccari*, 3.VII.1906 (FI !) - Tocco Casuaria (Majella), presso le sorgenti del petrolio, 300-500, *Vaccari*, 3.VII.1906 (FI !) - ……colle delle Vacche fra Teramo ed Aquila, 1300, *Vaccari*, 27.VII.1906 M. Petroso, Abruzzi, *Marzislati*, sine die (FI !)

CAMPANIA – In campis montosis, *Tenore*, da *Tenore* in Marzo 1844 (FI !) - Piaggine (Salerno), in saxosis siliceis, c. 650 m., *Lacaita*, 15.VII.1919, da *Lacaita* XII.1920 (FI !) - Campania, *Moraldo*, 15.VII.1978 (FI !) - Luoghi aridi argillosi, Calabritto, al Santuario M. della Neve, Est, *Moraldo*, sine die (FI !)

PUGLIA – Nei boschi fra S. Marco e S. Nicandro, *Martelli*, 11.V.1893, da *Martelli* Marzo 1894 (FI !) - Campi presso Lesina (Foggia), *Fiori*, 18.VI.1898 (FI !) - Gargano nelle colline attorno a Vieste, *Bèguinot*, VII.1902 (FI !) - Gargano, Foresta Umbra verso Vico, suolo calcare, 700 m., *Fiori*, 9-11.VII.1915 (FI !)

BASILICATA – In apricis aridis, Melfi sui colli, *Terracc*., VI.1860, da *Terracciano* 1870 (FI !) - ai Bagni del Monticchio (Vulture), *Biondi*, VII.1880 (FI !) - sugli argini a Potenza, *Biondi*, 20.VII.1880 (FI !) - Potenza, in Pascuis aridis montis Montocchio, solo calcareo, alt. 800-1200 m, *Gavioli*, 7.VIII.1906 (FI !) - Lucania, Pignola in saxosis aridis, loco dicto Campo di Giorgio, solo argilloso calcareo, alt. 800 m, *Gavioli*, 24.VI.1922 (FI !) - Potenza, in pascuis loco dicto Vallone dei gamberi, solo argilloso, alt. 750-1000, *Gavioli*, 29.VI.1923, (FI !) - Potenza, loco dicto …. di Montegrosso, alt. ….., solo calcareo, *Gavioli*, 30.VI.1924, (FI !) - Potenza, M. Montocchio, in pascuis alt 800-1100 m, *Gavioli*, 16.VI.1926 (FI !) - Lucania, Pignola, in pascuis aridis prope lacum, alt 800 m., *Gavioli*, 9.VII.1933 (FI !)

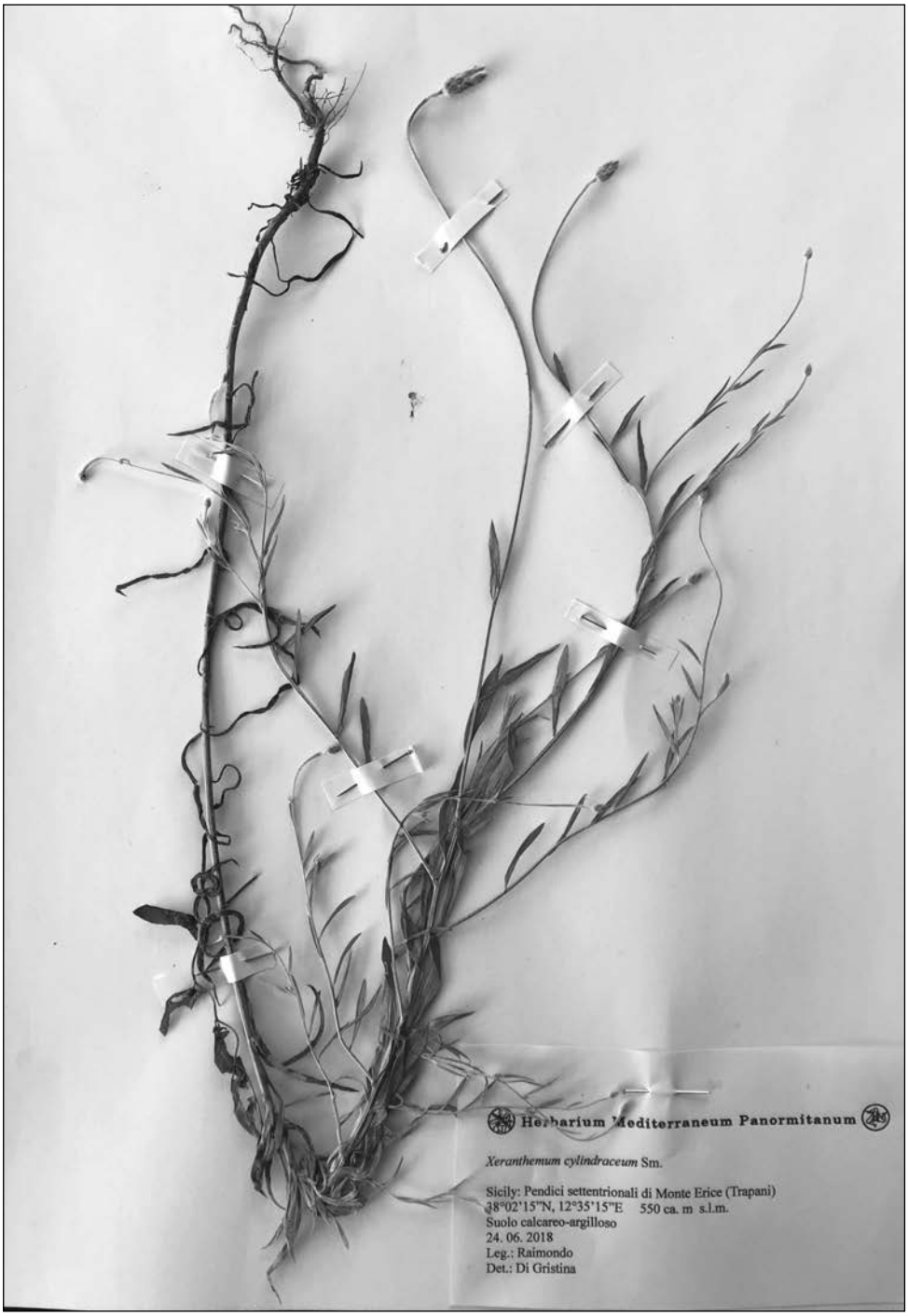


Fig. 3. Sicilian specimen of *Xeranthemum cylindraceum* from Mt Erice (Trapani).

Sicilian record

SICILIA – Erice, pendici settentrionali orientali di Monte S. Giuliano su litosuolo calcareo-argilloso, circa 550 m s.l.m., *Raimondo*, 12.06.2018 (PAL, PAL-Gr, CT) (Fig. 3).

Discussion and conclusion

Xeranthemum is a genus represented in Europe and the Mediterranean by only three species (Greuter 2006+); two of them are also native to Italy. Compared to *X. inapertum* (L.) Mill. – present in all Italian regions, including islands and with the exception of Lombardy, Trentino Alto Adige and Friuli-Venezia Giulia – *X. cylindraceum* is less widespread and absent in Sardinia. In Sicily it is here repoerted from the northern slope of Mt San Giuliano (Erice, Trapani). The study of the herbarium specimens preserved in FI allows us to document the distribution of this taxon in the Italian Peninsula (Fig. 2) and at the same time to update the distribution, including the unpublished Sicilian record.

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Article

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The Sicilian wild cabbages as biological resources: taxonomic update and a review on chemical constituents and biological activities

Abstract

Malfa, G. A., Acquaviva, R., Bucchini, A. A. E., Ragusa, S., Raimondo, F. M. & Spadaro, V.: The Sicilian wild cabbages as biological resources: taxonomic update and a review on chemical constituents and biological activities. — Fl. Medit. 30: 245-260. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

Considering the growing interest that wild brassicas have as sources of bioactive molecules as well as a genetic resource, the authors review and update the taxonomy of *Brassica* sect. *Brassica*, limited to the native flora of Sicily, an island considered to be an active diversification center for the group of species of the aforementioned section. Regarding the taxonomic aspects, *Brassica tardarae* is here considered a subspecies of *B. rupestris*; the distinction at the subspecific level of *B. raimondoi*, a critical taxon included in *B. incana*, is also confirmed. In addition, two new subspecies are proposed, respectively in *B. incana* and *B. rupestris*. The taxonomic information relating to the taxa reported is enriched by synthetic chorological data. A thorough examination of the literature concerning the chemical aspects and biological activity of some Sicilian taxa referred to *Brassica* sect. *Brassica*, allowed to highlight not only important bioactive molecules such as glucosinolates, but also the demonstrated biological activities. From these studies, therefore, the enormous potential of Sicilian wild cabbages emerges, not only as a recognized genetic resource, but also as a biological and nutraceutical one. This would demonstrate the considerable economic importance of these plants which can have positive effects on the innovation of agricultural production.

Key words: vascular flora, *Brassica* sect. *Brassica*, *Brassicaceae*, taxonomy, phytochemicals, glucosinolates. Sicily.

Introduction

The Mediterranean region due to its mild but variable clime and the fertility of its soils has been the cradle of a complex of botanical species of agricultural and food significance. In particular Sicily, due to its geographical isolation, represents a centre of biodiversity for many wild *Brassica* species that importantly contributed by the crossbreeding, to the diversity of Sicilian crops, so providing some varietal groups determinate by unique characteristics and marked organoleptic qualities (Branca & al. 2018). Moreover, some wild

Brassica species have been an important source of food in the diet of Sicilian populations for centuries as a part of the Mediterranean diet and several studies have been documented the nutritional and the medicinal properties of the edible wild plants respect to the cultivated crops (Licata & al. 2016; Berni & al. 2018). These searches have attributed the beneficial effects on human health of *Brassicaceae* species and of the horticultural varieties to the presence of glucosinolates and phytochemical compounds such as polyphenols, carotenoids, vitamins and trace minerals (Baecher 1994; Kataya & Hamza 2008).

Interestingly, the particular profiles and the high concentrations of wild *Brassica* secondary metabolites vary enormously between species and genetic and epigenetic factors largely influence their production. The protective activities resulted to be linked to the ability of glucosinolates to modulate many enzymes involved in carcinogens metabolism and to increase the cellular antioxidant capacity (Prieto & al. 2019). From a taxonomy point of view, the *B. oleracea* group forms a distinct unit known as *B. oleracea* cytodeme, characterized by the same diploid genome $2n = 18$ ($x = 9$) (Snogerup & al. 1990). It includes a total of 13 taxa at specific and intraspecific level, among them 10 are endemism exclusively present in some restricted areas of Sicily. Suffruticose perennials and not obligate chasmophytes plants, thrive on rocky soils from the coast to up to an altitude of 1400 m. Young plants are herbaceous, but in the adults the main stem turns woody, old individuals usually show a shrubby shape (Raimondo & al. 1991). The classification of these taxa at specific and intraspecific level resulted complex and sometimes controversial due to some peculiar characteristics such as the susceptibility to mutations and the crossbreeding among species.

Many studies based on morphological observations, molecular and biological analysis tried to provide certain indication about the relationship within the populations belonging this group. The most reliable results obtained using random amplified polymorphic DNA markers, have shown that the Sicilian taxa are genetically distinct from *B. oleracea* L. and have indicated that *B. incana* Ten., *B. macrocarpa* Guss. and the *B. villosa-rupestris* group represent distinct clades with high variability among the species and among the various isolated populations (Geraci & al. 2001). In this context, the present contribution reviews all the studies on wild Sicilian taxa of *Brassica* sect. *Brassica* (*Brassicaceae*) including new taxa recently described or proposed here as new, and for the first time in our knowledge, we report a detailed summary on the phytochemical composition and the biological activities of the few species and subspecies analysed.

Metodology and contents

In the present article we based our investigation on different databases including Web of Science, PubMed, Google scholar, Scopus. To achieve better results, we used the combinations of some key words: *Brassica*, *Brassicaceae*, Taxonomy, Chorology, Ecology, IUCN, genetic, phytochemicals, secondary metabolites, bioactive compounds, nutraceuticals, biological activities, cancer, disease, *Brassica incana* subsp. *incana*, *Brassica incana* subsp. *raimondoi* Brullo & al., *Brassica insularis* Moris, *Brassica macrocarpa*, etc.
Original studies concern:

- the reduction to subspecific level of the recently described *Brassica tardarae* Ilardi, Troìa & Geraci (2020);

- the re-proposal at the subspecific level of *B. raimondoi* Sciandrello & al. (*B. incana* subsp. *raimondoi* (Sciandrello & al.) Raimondo & Spadaro);
- the proposition of two new subspecific taxa in the context of *B. incana* and *B. rupestris* Raf. respectively.

Taxonomy

Brassica in the native flora of Sicily is represented by numerous specific and infraspecific taxa. In particular, the sect. *Brassica* that comprises polyennial suffruticose species, relatives of cultivated cabbages. Within the whole group, the variability of the populations is quite accentuated and the fact of being often confined both spatially and ecologically, has made it possible to distinguish various subspecie in *B. incana*, *B. rupestris* and *B. villosa,* especially in more wide distribution and variability.

The recent checklist of the Italian flora (Bartolucci & al. 2018) assigns the following native taxa to Sicily:

Brassica incana Ten. subsp. *incana*
Brassica insularis Moris
Brassica macrocarpa Guss.
Brassica rupestris Raf. subsp. *rupestris*
Brassica rupestris subsp. *hispida* Raimondo & Mazzola
Brassica trichocarpa C. Brullo, Brullo, Giusso & Ilardi
Brassica villosa Biv. subsp. *villosa*
Brassica villosa subsp. *bivonana* (Mazzola & Raimondo) Raimondo & Mazzola
Brassica villosa subsp. *brevisiliqua* (Raimondo & Mazzola) Raimondo & Geraci
Brassica villosa subsp. *drepanensis* (Caruel) Raimondo & Mazzola
Brassica villosa subsp. *tineoi* (Lojac.) Raimondo & Mazzola

Recent studies have led to the description of a new species, *Brassica tardarae* Ilardi Troìa & Geraci (2020) which is added to the others listed. Deeming the approach of Snogerup & al. (1990), which in Sicily recognizes on a specific level only *B. macrocarpa*, *B. insularis*, *B. rupestris* and *B. villosa*, and considering *B. trichocarpa* to be distinct at a specific level, a new taxonomic framework for *Brassica* sect. *Brassica* in Sicily. This is also based on new collections and field observations by two of the authors (F. M. Raimondo and V. Spadaro) and, again, following the recent description by *B. tardarae.*

Critical analysis

Brassica incana subsp. ***hirta*** Raimondo & Spadaro **subsp. nov.**

Differs from *B. incana* Ten. subsp. *incana* for its very hairy indument, for the leaves usually bare o lobed at the base, flowers always yellow (Fig. 1).

Type: Sicilia, Madonie in Contrada Gonato (Castelbuono), sulle rupi calcaree, ca. 1100 m. s.l.m. Raimondo (PAL, holotype; PAL-Gr and FI, isotype).



Fig. 1. Details of *Brassica incana* subsp. *hirta*: a) accentuated hairiness of the stem and petiole; b) leaf lobed at the base.

B. incana subsp. ***raimondoi*** (Sciandr., C. Brullo, Brullo, Giusso, Miniss. & Salmeri) Raimondo & Spadaro [Bas. *Brassica raimondoi* Sciandr., C. Brullo, Brullo, Giusso, Miniss. & Salmeri, Pl. Biosyst. 147(3): 813 (2013).

This taxon, described at a specific level as *B. raimondoi*, is represented by an isolated, small population located on the calcareous sub-coast of Castelmola, overlooking the well-known tourist center of Taormina (Messina), and is readily distinguished by the white color of the flowers. It is in contact with the coastal population of *B. incana* subsp. *incana* with yellow flowers from Capo S. Alessio. From this, *B. raimondoi* is distinguished by various characters as well as by the color of the flowers, the latter character almost evenly distributed in the population. However, the same also occurs in the Tyrrhenian coastal population as is appreciated in that of Capo d'Orlando, where plants with yellow and white flowers coexist in the same site. On the Ionian side of Sicily, the isolation of the two populations – coastal (Capo S. Alessio) and sub-coastal (Castelmola) respectively - is not only spatial but also phenological, so that they are hardly able to contract reproductive relationships, remaining genetically isolated. Due to the set of discriminating characters of the taxon described by Sciandrello & al. (2013), this taxon, according to our interpretation, already expressed (Raimondo & Spadaro 2015), can retain its autonomy in the subspecific rank; this is also based on the systematic approach followed in our studies on Sicilian wild brassicas (Raimondo & al. 1991; Raimondo & Mazzola 1997).

Brassica rupestris subsp. ***monilicarpa*** Raimondo & Spadaro **subsp. nov.**

Differs from *B. rupestris* Raf. subsp. *rupestris* for the smaller, crassulent and glabrous leaves; adaxial surface of the blade endowed with few or many short bulbous hairs; shorter siliqua, often moniliform, longer beak, generally with 1–3 seeds, exceptionally up to 6 (Fig. 2).

Type: Palermo, pendici settentrionali di Monte Gallo, su litosuolo calcareo, 150 m a.s.l., 25.V.2015, *Raimondo* & *Spadaro* (PAL, holotype; PAL-Gr and FI isotype).

Brassica rupetris subsp. ***tardarae*** (Ilardi, Troìa & Geraci) Raimondo, **comb. et stat. nov. [**Bas. *Brassica tardarae* Ilardi, Troìa & Geraci in Plants 9, 947: 4/10 (2020).

Type: Gole della Tardara, territorio di Sambuca di Sicilia (provincia di Agrigento), *in rupibus calcareis,* Ilardi, Troìa, Geraci, 9 May 2019 (Holotypus PAL 109799).

Similar to *Brassica rupestris* Raf., differs mainly for the form of blade and fruit, shortest and distinctly tetragonous. Described on a specific level as *B. tardarae*, the taxon, is to be considered within the variability of *B. rupestris*. Some leaf characters support this different interpretation: such as the presence in the dorsal face of the blade of bulbose, hispid hairs especially, that is typical in *B. rupestris* and in its other subspecies. Considering the distribution of the population, separated from the others referring to *B. rupestris*, we propose here to assign this taxon to the rank of subspecies.



Fig. 2. Details of *Brassica rupestris* subsp. *monilicarpa*: a) crassulent leaf; b) fruits.

Updated taxonomic framework

Based on the above, the resulting taxonomic framework is therefore the following:

Brassica incana Ten. subsp. ***incana***
Distribution: Sicily, eastern Tyrrhenian and Ionian coasts of the island.

Brassica incana subsp. ***hirta*** Raimondo & Spadaro **subsp. nov.**
Distribution: Sicily, Madonie Mountains (Castelbuono, Palermo).

B. incana subsp. ***raimondoi*** (Sciandr., C. Brullo, Brullo, Giusso, Miniss. & Salmeri) Raimondo & Spadaro
*Distribution:*Sicily, Ionian coast to Castelmola (Messina)

Brassica insularis Moris
Distribution: Sicily, Pantelleria island.

Brassica macrocarpa Guss.
Distribution: Sicily, Egadi islands (Favignana and Marettimo).

Brassica rupestris Raf. subsp. ***rupestris***
Distribution: Sicily, limestone reilefs of the Tyrrhenian coast between Cefalù and Monte Pellegrino and in the inside until Rocca Busambra (Corleone, Palermo). Critical the presence of the species in S. Italy.

Brassica rupestris subsp. ***monilicarpa*** Raimondo & Spadaro **subsp. nov.**
Distribution: Sicily, Monte Gallo and Monte Billiemi (Palermo).

Brassica rupestris subsp. ***hispida*** Raimondo & Mazzola
Distribution: Sicily, Monte Pizzuta (Piana degli Albanesi, Palermo).

Brassica rupetris subsp. ***tardarae*** (Ilardi, Troìa & Geraci) Raimondo, **comb. et stat. nov.**
Distribution: Sicily, Tardara, gorges between Menfi and Sambuca di Sicilia (Agrigento).

Brassica trichocarpa C. Brullo, Brullo, Giusso & Ilardi, Phytotaxa 122(1): 47 (2013).
Distribution: Sicily, Monte Cuccio (Palermo).

Brassica villosa Biv. subsp. ***villosa***
Distribution: Sicily, Monte Occhio (Partinico, Palermo).

Brassica villosa subsp. ***bivonana*** (Mazzola & Raimondo) Raimondo & Mazzola
Distribution: N.W. Sicily, to Monte Inici until Monte Passo del Lupo and Monte Cofano (Trapani).

Brassica villosa subsp. ***brevisiliqua*** (Raimondo & Mazzola) Raimondo & Geraci
Distribution: Sicily, Tyrrhenian coast between San Vito Lo Capo and Monte Cofano (Trapani).

Brassica villosa subsp. ***drepanensis*** (Caruel) Raimondo & Mazzola
Distribution: Sicily, Monte San Giuliano (Erice, Trapani).

Brassica villosa subsp. ***tineoi*** (Lojac.) Raimondo & Mazzola
Distribution: C. Sicily (Terrapilata presso Caltanissetta, Marianopoli, S. Caterina, Serre di Chibbò, Vallelunga, Campobello di Licata, Rocca Limata-Petralia Sottana).

Phytochemical characteristics

In recent decades, epidemiological evidence suggests that consuming plant-based foods containing significant amounts of bioactive molecules, also known as phytochemicals, provides a large number of human health benefits (Baecher 1994; Kataya & Hamza 2008). The data of the scientific literature in particular report that vegetables belonging to the *Brassicaceae* family, in addition to their not negligible nutritional values, are a good source of secondary metabolites with different biological activities such as vitamins, carotenoids, phenolic compounds, terpenes and glucosinolates, a class of biologically active compounds characteristic of this family (Prieto & al. 2019).

Moreover, many studies based on phytochemical and genetic analysis, focus attention on the potential higher levels of bio-actives in ancient varieties and wild species than the commercial cultivars belonging the *Brassica oleracea* complex (n = 9) (Giamoustaris & Mithen 1996; Branca & al. 2018). Plant secondary metabolites are mostly involved in plant defence mechanisms against biotic and abiotic stress, wild species which grow well in a wild context, possess some more efficient stress response mechanisms than those of cultivated varieties (Berni & al. 2018).

The more capable defence mechanisms may be correlated with a larger quantity of phytochemicals (Berni & al. 2018).Few researches refer to the phytochemical composition of wild Sicilian taxa within the present review (Table 1). The first study found based on the research methods of this work, was conducted by Mithen and collaborators on the levels and distribution of glucosinolates in different wild populations of the *B. oleracea* group including *B. incana, B. rupestris, B. drepanensis, B. macrocarpa, B. insularis*. Wild brassicas showed higher total glucosinolate content than cultivated forms with a variable glucosinolate pattern (Mithen & al. 1987). Particularly, Sicilian species showed the following amounts for *B. incana* 11.27 µmol/g, *B. rupestris* 11.88 µmol/g, *B. drepanensis* 4.73 µmol/g, *B. macrocarpa* 3.76 µmol/g, *B. insularis* 12.26 µmol/g, characterized by the predominant presence of glucoiberin and glucoiberverin as main compounds in *B. rupestris* and *B. drepanensis* respectively. Glucoiberin was found at high level only in *B. rupestris* among the examined taxa (Mithen & al. 1987). A successive study confirmed high levels of 3-methylthiopropyl glucosinolate and a smaller amount of 3-methylsulphinylpropyl glucosinolate in *B. drepanensis* and high levels of 2-propenyl glucosinolate in *B. atlantica* (*B. insularis*) (Giamoustaris & al. 1997).

In a study with the purpose to selective increase 4-methylsulphinylbutyl glucosinolate as promising chemopreventive agent in broccoli by hybridization with wild species, the authors reported that *B. villosa* (124 ± 19 µmol/g), *B. drepanensis* (62.6 ± 10.9 µmol/g) and *B. atlantica* (*B. insularis*, 95.3 ± 26.6 µmol/g) demonstrated 10-fold greater level of total glucosinolates than the cultivars (4.3-16.6 µmol/g) , with the predominantly presence of 3-methylsulphinylpropyl (119 ± 18 µmol/g), 3-methylthiopropyl (51.6 ± 9.3 µmol/g) and 2-propenyl (92.8 ± 25.4 µmol/g) glucosinolates, respectively. Resulted hybrids showed similar total levels of aliphatic glucosinolates to those found in the wild species (Faulkner & al. 1998).

Another comparative research on glucosinolates profile reveleated that *B. macrocarpa* possess a peculiar content of sinigrin whereas *B. rupestris* displayed a similar profile to those of the examined crops (Branca & al. 2002).

The most inclusive study regarding the reviewed species and subspecies is by Scialabba & al. (2019) in which is reported the tocopherol, fatty acid and phytosterol content in dry seeds of nine wild taxa of Sicilian *Brassica* sect. *Brassica* precisely, *B. villosa* subsp. *villosa*; *B. villosa* subsp. *bivonana*; *B. villosa* subsp. *drepanensis*; *B. villosa* subsp. *tineoi*; *B. villosa* subsp. *brevisiliqua*; *B. rupestris* subsp. *rupestris*; *B. rupestris* subsp. *hispida*; *B. macrocarpa*; *B. incana*. The research shows that α- and γ-tocopherol were the major isomers detected and total tocopherol content reported vary from the lower content of 125.1 ± 13.6 mg/kg of *B. macrocarpa* to the higher of 597.8 ± 54.1 mg/kg and 541.3 ± 30.6 mg/kg for *B. villosa* subsp. *villosa* and *B. villosa* subsp. *drepanensis* respectively. The seeds fatty acids composition of the taxa analysed showed a similar profile with the unsaturated fractions (52.5–66.5 %) more abundant than saturated ones (33.5–47.5 %). *B. incana* showed the highest total fatty acids content (2761.5 ± 123.1 mg/kg) and the higher percentage of unsaturated fatty acids (66.5 %). Total phytosterols amount were detected significantly higher in four of the five subspecies of *B. villosa* group (*B. villosa* subsp. *villosa* (495.7 ± 24.0 mg/kg), *B. villosa* subsp. *bivonana* (565.4 ± 19.1 mg/kg), *B. villosa* subsp. *drepanensis* (456.8 ± 19.3 mg/kg), *B. villosa* subsp. *tineoi* (518.0 ± 15.6 mg/kg) and in all the examined taxa relatively to the total phytosterols content, sytosterol was the most abundant with 61.7–69.6 %, followed by brassica sterol with 16.0–19.8 % and campesterol with 11.9–20.7 %. The authors concluded indicating that these taxa, belonging *B. villosa* group are potentially the most bioactive ones due to the highest total tocopherol, γ-tocopherol and phytosterol contents (Scialabba & al. 2010).

The analysis of volatile constituents in leaves and roots of *B. incana* in a work of Tripodi & al. (2012) revealed a large number of volatile constituents such as alcohols, aldehydes, esters, acids, ketones and terpenes including thiocyanates and isothiocyanates. For the latter class belonging to glucosinolates derivatives, the roots showed the highest content and the largest number this compounds (leaves 2877 µg/g, roots 76824 µg/g). Methyl thiocyanate (2262 µg/g), 3-butenyl isothiocyanate (2262 µg/g), 4-pentenyl isothiocyanate (2039 µg/g), 3-methylthiopropyl isothiocyanate (µg/g 360) and Hexyl isothiocyanate (181 µg/g) were listed in roots and only 3-butenyl isothiocyanate (28770 µg/g) was found in *B. incana* leaves (Tripodi & al. 2012).

Seeds of wild population of *B. incana*, *B. rupestris, B. villosa* and *B. macrocarpa* were also analysed for their glucosinolate profile, ascorbic acid, polyphenols and carotenoid content by Branca & al. (2013) revelating that the level of total glucosinolates varied over

a wide range. The highest content of glucosinolates was found in a population of *B. rupestris* (78.5 ± 8.5 μM dw) with a remarkable presence of glucoiberin and sinigrin and the absence of glucoraphanin. *B. villosa*, *B. incana* and *B. macrocarpa* showed a glucosinolates content of 37.8 ± 2.4, 51.7 ± 8.2 and 53.0 ± 2.7 μM dw respectively with the main compounds identified as glucoiberine, progoitrine, glucoraphanin, sinigrin, sinalbin, gluconapin, glucoiberverin, glucobrassicin, gluconasturtiin, neo-glucobrassicin. Gluconapin and glucobrassicin were ubiquitous in all the analysed taxa. *B. rupestris* displayed the highest amount of ascorbic and also the greater content of total carotenoids while the population of *B. incana* exhibited the highest content of total polyphenols (Branca & al. 2013).

In a research with the aim to evaluate if soil properties may affect the accumulation of secondary metabolites in *B. rupestris*, the authors reported the highest poliphenols content in *B. rupestris* grown in poor soil (4342 μg/g as tannic acid) conversely, the glucosinolates were almost higher in *B. rupestris* grown in the more fertile soil with a major content of organic matter (2442 μM/g) (Muscolo & al. 2019).

The phenolic compositions of *B. incana* leaves and inflorescences recently reported by Miceli & al. (2020), identified a total of 17 and 20 polyphenolic compounds and a total phenolic content of 37.20 ± 0.93 mg gallic acid equivalent/g extract and 27.98 ± 0.32 mg gallic acid equivalent/g extract respectively. Both extracts contain derivatives of the flavonols quercetin, kaempferol, and isorhamnetin, and of the hydroxycinnamic acids sinapic acid and ferulic acid, coniugated with sugars or hydroxycinnamic acids. Qualitatively, the polyphenolic profiles of the extracts differ only for the compounds kaempferol-3-O-diglucoside-7-O-glucoside, quercetin-3-sophoroside-7-glucoside, and feruloylmalate, isolated only in the inflorescences. The most abundant flavonoids for leaves extract were isorhamnetin-3-glucoside-7-glucoside (3.33 mg/g ± 0.54 % relative standard deviation (RSD)), kaempferol-3-sinapoylsophoroside-7-glucoside (2.84 mg/g ± 0.77 % RSD) and kaempferol-3-feruloylsophoroside-7-glucoside (2.11 mg/g ± 0.98 % RSD); for the inflorescences extract kaempferol-3-feruloylsophoroside-7-glucoside (2.14 mg/g ± 0.48 % RSD) isorhamnetin-3-glucoside-7-glucoside (1.79 mg/g ± 0.32 % RSD) and quercetin-3-hydroxyferuloylsophoroside-7-glucoside (1.59 mg/g ± 0.57 % RSD) were the main compounds (Miceli & al. 2020).

Lastly chronologically, a phytochemical characterization of four different Sicilian species specifically, *B. incana, B. macrocarpa, B. villosa,* and *B. rupestris* was conducted by Picchi & al. (2020). The study reported that the content of the main phenolics ranged from 163.9 (*B. macrocarpa*) to 533.9 (*B. incana*) mg/100 g dry weight (d.w.), ascorbic acid from 7.6 (*B. villosa*) to 375.8 (*B. villosa*) mg/100 g d.w., and of total biothiols from 0.59 (*B. macrocarpa*) to 5.13 (*B. villosa*) mg/100 g d.w. Interestingly the authors noted that wild *Brassica* species studied showed a higher content of flavonol derivatives with respect to *B. olearea* crops, where gentiobiosides are the most representative phenolic compounds. The most abundant compounds isolated in the different wild species were: kaempferol synapoyl glucoside (67.5–81.3 mg/100 g d.w.), kaempferol cafeoyl glucoside (43.5–62.5 mg/100 g d.w.), and kaempferol feruloyl glucoside 4 (52.3–99.7 mg/100 g d.w.) in the samples of *B. incana*; Kaempferol feruloyl glucoside (30.7 ±1.8 mg/100 g d.w.) kaempferol glucosides (23.7 ± 6.6 and 28.1 ± 1.9 mg/100 g d.w., in *B. macrocarpa*; quercetin sinapoyl glucoside (12.5–73.7 mg/100 g d.w.), kaempferol feruloyl glucoside (45.4–74.8 mg/100 g d.w.), and kaempferol synapoyl glucoside (19.5–62.0 mg/100 g d.w.) in *B.*

Table 1. Bioactive phytochemical components of some wild Sicilian taxa of *Brassica* sect. *Brassica*.

Taxa	Plant Organ	Phytochemicals	References
B. incana *B. rupestris* *B. drepanensis* *B. macrocarpa* *B. insularis*	Leaf	Glucosinolates	**Mithen & al. 1987**
B. drepanensis *B. insularis (B. atlantica)*	Leaf	Glucosinolates	**Giamoustaris A. & Mithen R. 1996**
B. drepanensis *B. villosa* *B. insularis (B. atlantica)*	Inflorescence	Glucosinolates	**Faulkner & al. 1998**
B. macrocarpa *B. rupestris*	Leaf	Glucosinolates	**Branca & al. 2002**
B. villosa *B. bivonana* *B. drepanensis* *B. tinei* *B. brevisiliqua* *B. rupestris* *B. hispida* *B. macrocarpa* *B. incana*	Seed	Tocopherol, Fatty Acids, Phytosterols	**Scialabba & al. 2010**
B. incana	Leaf and root	Alcohols, Aldehydes, Esters, Acids, Ketones, Terpenes Thiocyanates, Isothiocyanates	**Tripodi & al. 2012**
B. incana *B. rupestris* *B. villosa* *B. macrocarpa*	Leaf	Ascorbic Acid, Polyphenols, Carotenoid and Glucosinolates	**Branca & al. 2013**
B. rupestris	Leaf	Total Phenols, Glucosinolates, Anthocyanins, Flavonoids, Ascorbic Acid	**Muscolo & al. 2019**
B. incana	Leaf and Inflorescence	Total Phenols, Polyphenols	**Miceli & al. 2020**
B. incana *B. macrocarpa* *B. villosa* *B. rupestris*	Leaf	Phenolics, Ascorbic Acid, Biothiols	**Picchi & al. 2020**

rupestris extracts; kjaempferol synapoyl glucosides (24.8–86.1 mg/100 g d.w., 25.8–81.4 mg/100 g d.w.), quercetin sinapoyl glucoside (11.6–76.1 mg/100 g d.w.), kaempferol-3-O-diglucoside-7-O-diglucoside (46.9–80.4 mg/100 g d.w.), in *B. villosa* extracts. A higher amount of hydroxycinnamoyl gentiobiosides particularly the compound 1,2-disinapoyl gentiobioside, was found in *B. incana* and *B. villosa* compared to *B. rupestris* and *B. macrocarpa* (Picchi & al. 2020).

Biological activities

Several species of *Brassica* sect. *Brassica* show nutritional, pharmaceutical and industrial importance. Epidemiological studies have shown a correlation between the consumption of broccoli (*B. oleracea*) and the risk of developing diverse human diseases (Baecher 1994; Kataya & Hamza 2008). These health benefits are to their secondary metabolites such as nitrogen-sulfur derivatives (glucosinolates, isothiocyanates), polyphenols including idrossicinnamic acids and flavonoids, trace minerals such as selenium and several vitamins which possess antioxidant, antimicrobial, anti-inflammatory, anti-obesity, antidiabetic, anticancer and immunomodulatory properties (Gan & al. 2017; Le & al. 2020). *In vitro*, *in vivo* studies and clinical trials have shown that some isothiocyanates such as sulforaphane, allyl isothiocyanate and phenethyl isothiocyanate and their degradation products possess antineoplastic activities that are exerted through the induction of phase II enzymes, by the block of cell cycle and the induction of apoptosis or through the inhibition of tumor invasion and of angiogenesis (Meng & al. 2000; Hecht 2000; Conaway & al. 2002; Riedl & al. 2009; Dinkova-Kostova & al. 2012; Yang & al. 2016).

The cardiovascular effects are certainly due to the antioxidant properties of polyphenols, carotenes and vitamins and to their ability to lower cholesterol levels in blood (Jones & al. 2000; Scialabba & al. 2010). Instead, the anti-inflammatory properties are attributable to their capacity to decrease proinflammatory cytokines such as tumor necrosis factor-α (TNF-α), interleukin-6 (IL-6), and to increase the levels of anti-inflammatory cytokines such as IL-10 and IL-22 (Ferruzza & al. 2016; Sotokawauchi & al. 2018). Despite the large biological activities reported for several species and cultivars belonging to *Brassicaceae*, not many studies have been conducted on the wild Sicilian taxa object of the present review (Table 2). Faulkner and collaborators reported that extracts from inflorescences of *B. drepanensis, B. villosa* and hybrids between these two wild species and commercial broccoli cultivars, were potent inducers of quinone reductase activity in murine hepatoma cells (Faulkner & al. 1998). The quinone reductase activity is strictly correlated with the induction of phase II detoxification enzymes such as glutathione transferase and UDP-glucuronosyl transferase. Extracts from the wild species and hybrids exhibited a strong significant increase in the ability to induce quinone reductase respect to the commercial cultivars, due to the greater glucosinolate content and the higher conversion to sulphoraphane (Faulkner & al. 1998). After, other studies reported only results on the antioxidant capacity of different tissues extracts performed by various tests. However, all the samples examined showed a good antioxidant capacity, closely related to the phytochemical profile (Branca & al. 2013; Miceli & al. 2020; Picchi & al. 2020). Such experimental data based on so non-identical conditions provide extremely different outcomes which result hardly to compare.

In another research, since *B. macrocarpa* resulted to be the rich of glucosinolates compounds in the leaves, the biomass of this species was tested against the root-knot nematode attacks (*Meloidogyne* spp.) on tomato crops. The study showed that the addition of *B. macrocarpa* biomass to the substratum significantly reduced the diffusion of root knot nematodes indicanting the potential use of *B. macrocarpa* as a biofumigant for the control of this pest (Argento & al. 2019).

Lastly in a recent study, two *B. incana* extracts from leaf and inflorescence were evaluated for their antitumor potential on MCF-7 and CaCo-2 cancer cell lines. Both extracts showed no appreciable cytotoxic activity on MCF-7 cell line conversely, both the extracts showed a dose dependent manner cytotoxic effect on CaCo-2 cells accompanied by a time- and dose-dependent release of lactate dehydrogenase, a well-known marker of necrotic cell death. The authors also reported that the extract from inflorescence, despite the lower phenolic content and radical scavenging activity, exerted a higher cytotoxic action than the extract from leaf in a cell model of colon cancer. Furthermore, both extracts from *B. incana* exhibited no toxicity in the brine shrimp lethality bioassay indicating their potential safety use (Miceli & al. 2020).

Table 2. Biological activities of some wild Sicilian taxa of *Brassica* sect. *Brassica*.

Taxa	Plant Organ	Biological test	References
B. drepanensis *B. villosa*	Inflorescence	Quinone Reductase Activity	**Faulkner & al. 1998**
B. incana *B. rupestris* *B. villosa* *B. macrocarpa*	Leaf	DPPH Scavenging Activity Crocin Bleaching	**Branca & al. 2013**
B. macrocarpa	Leaf	Root-Knot Nematodes Meloidogyne spp	**Argento & al. 2019**
B. incana	Leaf and Inflorescence	Superoxide Anion Activity DPPH Scavenging Activity MTT Assay, LDH Release Brine Shrimp Lethality Bioassay	**Miceli & al. 2020**
B. incana *B. macrocarpa* *B. villosa* *B. rupestris*	Leaf	Superoxide Anion Activity DPPH Scavenging Activity	**Picchi & al. 2020**

Discussion and conclusions

Despite the few studies, the majority of the wild Sicilian taxa of *Brassica* sect. *Brassica* (*Brassicaceae*) examined in the last decades have been found to be a rich source of phytochemical compounds compared to the most cultivated variety belonging the *B. oleracea* group. Although, the partial data and the various outcomes reported by the different authors, on one hand confirms the potential of some taxa as a source of phytochemicals with a promising broad range of biological activities, on the other hand highlights the necessity to study and to better characterize the phytochemical profiles of each taxon with a systematic identification of the various classes of secondary metabolites present in some important plant organs such as leaf, inflorescence, root and seed, together with more in-depth studies focused on their promising biological and pharmacological properties. These species and subspecies with their primary and unique gene pool may represent a very useful tool, not only for the genetic improvement of *Brassica* crops, but also for their possible cultivation and commercialization as superfood, since they are traditionally used as edible plants in Sicily, and in addition for the use in nutraceutical and pharmaceutical applications. The taxonomic updating carried out and the recognition of new subspecies that accentuate the character of the island of Sicily as a diversification center of the *Brassica* sect. *Brassica*, offers further research opportunities aimed also at the further enhancement of the interesting biological resource which is still little known.

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Article

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Découverte d'*Epipactis microphylla* (*Orchidaceae*) au Djebel Babor (nord-est de l'Algérie), orchidée nouvelle pour l'Afrique du Nord

Abstract

Bougaham, A. F., Rebbas, K. & Vela, E.: Découverte d'*Epipactis microphylla* (*Orchidaceae*) au Djebel Babor (nord-est de l'Algérie), orchidée nouvelle pour l'Afrique du Nord. — Fl. Medit. 30: 261-271. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

Discovery of *Epipactis microphylla* (*Orchidaceae*) in Djebel Babor (north-eastern Algeria), a new orchid for North Africa. — *Epipactis microphylla* is a European-Hyrcanian, forest mycoheterotrophic species, widespread in temperate and submeridional zones, from Andalusia to the Caspian Sea. This orchid has been discovered in Djebel Babor, in northeastern Algeria, in a mixed undergrowth of Cedars, Zean oaks and Holm oaks, where it is to date the only known resort in North Africa. This discovery confirms the interest of Babors' Kabylia in general and the new Babor-Tababort National Park in particular.
Key words: protected areas, rare species, peripherical distribution, important plant area, partial mycoheterotrophy.

Introduction

Bien que mondialement reconnue comme un des principaux point-chauds de biodiversité végétale (Médail & Quézel 1997; Médail & Myers 2004), la région méditerranéenne demeure méconnue, en particulier sur ses rives sud et est. L'ensemble de montagnes du Tell littoral algéro-tunisien dénommé «Kabylies-Numidie-Kroumirie» ne fait pas exception avec une forte diversité végétale et un fort taux d'endémisme (Véla & Benhouhou 2007), qui se traduisent par la reconnaissance d'une dizaine de « zones importantes pour les plantes » (Yahi & al. 2012; Benhouhou & al. 2018).

Malgré l'engouement énorme qu'ont suscité les orchidées européennes (Delforge 2016), l'orchidoflore des rives sud de la Méditerranée demeure méconnue. L'Algérie cependant commence à faire exception, avec un nombre de publications régulièrement croissant depuis 2002, surtout dans le nord-est du pays (Martin & al. 2020). Grâce à cela, des découvertes ou des redécouvertes remarquables sont encore possibles, comme celles de *Ophrys pallida* (Hadji & Rebbas 2013), *Neottia nidus-avis* (Madoui 2019) et *Cypripedium calceolus* (Nemer & al. 2019). La région des Babors ne fait pas exception, y compris pour les autres familles botaniques, comme la fougère *Christella dentata* (Rebbas & al. 2019).

Les espèces du genre *Epipactis* sont des géophytes à rhizomes, à aire de distribution essentiellement eurasiatique; quelques espèces se rencontrent en Amérique du Nord et en Afrique centrale et orientale (Govaerts & al. 2020). Genre comportant plus de 50 espèces dont 17 pour la France (Bournérias & al. 2005), et à titre de comparaison seulement 2 en Algérie (African Plant Base 2020). Au cours des deux décennies de nombreux taxons (essentiellement autogames) ont été décrites en Europe (cf. Delforge 2016).

En Afrique du Nord, seules *Epipactis helleborine* et/ou *E. tremolsii* ont été signalées, en partie selon que la seconde est considérée ou non comme synonyme ou variation stationnelle de la première, et ceci seulement au Maroc et en Algérie (Battandier & Trabut 1884; Jahandiez & Maire 1931; Maire 1960; Quézel & Santa 1962; Raynaud 1985; Le Floc'h & al. 2010; Fennane & al. 2014; Babali & al. 2018).

Epipactis microphylla n'est pas citée dans l'index de Dobignard & Chatelain (2010-2013), ni dans sa mise à jour en ligne (African Plnat Base 2020), ni dans l'Euro+Med Plant Base (Euro+Med 2020) elle-même basée sur la World Checlist of selected plant families (Govaerts & al. 2020). Et aucune autre espèce du groupe d'*Epipactis atrorubens* (sensu Delforge 2016), auquel appartient *E. microphylla*, n'y a été signalée non plus.

Enfin, dans les inventaires floristiques récents au niveau des Babors, il n'est toujours pas fait mention de cette orchidée (Gharzouli & Djellouli 2005; Gharzouli 2007; Kreutz & al. 2013-2015; Madoui & al. 2017; Madoui & Vela 2020; Martin & al. 2020).

Le présent travail vient faire le point sur la découverte d'*Epipactis microphylla* au Djebel Babor, son écologie et sa biogéographie en Algérie.

Vérification des herbiers

Les principaux herbiers historiques concernant l'Algérie (P et MPU en tête) sont aujourd'hui tous basés en France.

Le portail de la plate-forme française e-ReColNat (https://explore.recolnat.org/search/botanique/simplequery=Epipactis), a fourni pour le genre «*Epipactis*» et le continent «Afrique», 21 spécimens, tous localisés dans l'herbier P. Parmi eux, 20 sont étiquetés « *Epipactis helleborine* » et proviennent du Maroc et d'Algérie, ils incluent tous les 15 spécimens précédents (Tableau 1). Enfin un dernier spécimen est étiqueté «*Epipactis africana*» et provient d'Ouganda et ne concerne donc pas l'Afrique du Nord.

Site de la découverte

La chaine des Babors est constituée par de nombreux djébels, disposées en chaînons, sensiblement parallèles, orientés nord-est sud-ouest (Duplan 1952). Nettement détaché de l'ensemble, le Djebel Babor est une montagne de la chaîne des Babors culminant à 2004 m d'altitude en Petite Kabylie, à l'extrémité nord de la wilaya de Sétif, qui se situe immédiatement à 4 km au sud du Djebel Tababort, le second plus haut sommet culminant à 1969 m (Fig. 1).

Le Babor est une extrusion de 7 km de long sur 5 km de large, émergeant du Crétacé supérieur. La série liasique est constituée par des calcaires et des marnes schisteuses.

Tableau 1. Liste des spécimens d'Epipactis concernant le secteur Afrique du Nord référencés dans les herbiers français (d'après e-ReColNat)

Numéro	Rangement	Collection d'origine	Etiquette d'origine	Pays	Lieu et/ou habitat	Date	Collecteur
P02082988	*Epipactis helleborine*	Herbier L. Faure	*Epipactis latifolia* All.	Maroc	Pentes rocheuses vers 2.800 mètres. Flanc sud du Djebel Ayachi. Grand Atlas oriental	1938/07/25	Maire, R.
P02082986	*Epipactis helleborine*	Herbier L. Faure	*Epipactis latifolia* All.	Maroc	Pentes nord d'un sommet vers 1350 m à Bou Céder près de Tafedina. Moyen-Atlas	1938/06/27	Faure, L.
P02082989	*Epipactis helleborine*	Herbier L. Faure	*Epipactis latifolia* All.	Algérie	Rochers d'un ravin des flancs nord du Chelia vers 1800 mètres. Massif de l'Aurès	1937/06/30	Maire, R.
P02082984	*Epipactis helleborine*	Herbier L. Faure	*Epipactis latifolia* All.	Algérie	Dans la forêt de Toumiet, vers 1200 mètres, sur la piste de Bossuet à Aïn-Tintadine. (Dt. d'Oran)	1951/06/28	Maire, R.
P02082985	*Epipactis helleborine*	Herbier L. Faure	*Epipactis latifolia* All.	Algérie	Ravin rocailleux près de la maison forestière de Tagda (1.700 m) Massif de l'Aurès	1937/06/01	Maire, R.
P00421323	*Epipactis helleborine*	Herbier E. Cosson	*Epipactis latifolia* All.	Algérie	Daya, autour de la cascade	1887/06/13	Clary, J.B.E.
P00379303	*Epipactis helleborine*	Herbier E. Cosson	*Epipactis latifolia* All.	Maroc	Tétuan: Serusa	1911/04/06	Pitard, C.J.
P00379304	*Epipactis helleborine*	Herbier E. Cosson	*Epipactis latifolia* All.	Maroc	Dj. Azighza, tribu des aït Bou Oulli	1879/08/07	Ibrahim Ammeribt
P00379305	*Epipactis helleborine*	Herbier E. Cosson	*Epipactis latifolia* All.	Maroc	Dj. Azighza, tribu des aït Bou Oulli	1879/08/07	Ibrahim Ammeribt
P00379306	*Epipactis helleborine*	Herbier E. Cosson	*Epipactis latifolia* All.	Algérie	Bou-Taleb et des Madids. Prairie d'Ofgan	1873/06/00	Olivier, E. et Reboud, V.
P00379307	*Epipactis helleborine*	Herbier E. Cosson	*Epipactis latifolia* All.	Algérie	Environs de la Zaouia, massif du Djebel Chettaba	1878/07/00	Reboud, V.
P00379308	*Epipactis helleborine*	Herbier E. Cosson	*Epipactis latifolia* All.	Algérie	Aït Yala	1888/06/19	Letourneux, A.
P00379309	*Epipactis helleborine*	Herbier E. Cosson	*Epipactis latifolia* All.	Algérie	Contre forêts du Djebel hulia	1856/05/00	Letourneux, A.
P00379310	*Epipactis helleborine*	Herbier E. Cosson	*Epipactis latifolia* All.	Algérie	Djebel Tababor, prov. de Constantine	1861/07/22	Cosson, E.
P00379311	*Epipactis helleborine*	Herbier E. Cosson	*Epipactis latifolia* All.	Algérie	Versant nord du Djebel Babor, prov. de Constantine	1880/06/00	Cosson, E.
P00379312	*Epipactis helleborine*	Herbier E. Cosson	*Epipactis latifolia* All.	Algérie	Djebel Tababor, prov. de Constantine	1880/06/26	Cosson, E.
P00379313	*Epipactis helleborine*	Herbier E. Cosson	*Epipactis latifolia* All.	Algérie	Djebel Tababor, prov. de Constantine	1880/06/25	Cosson, E.
P00379314	*Epipactis helleborine*	Herbier E. Cosson	*Epipactis latifolia* All.	Algérie	Daya	1853/07/00	Munby, G.
P00379315	*Epipactis helleborine*	Herbier E. Cosson	*Epipactis latifolia* All.	Algérie	Lambèse	1853/05/00	Balansa, B.
P00379316	*Epipactis helleborine*	Herbier	*Epipactis latifolia* All.	Algérie	Lambèse	1853/05/00	Balansa, B.

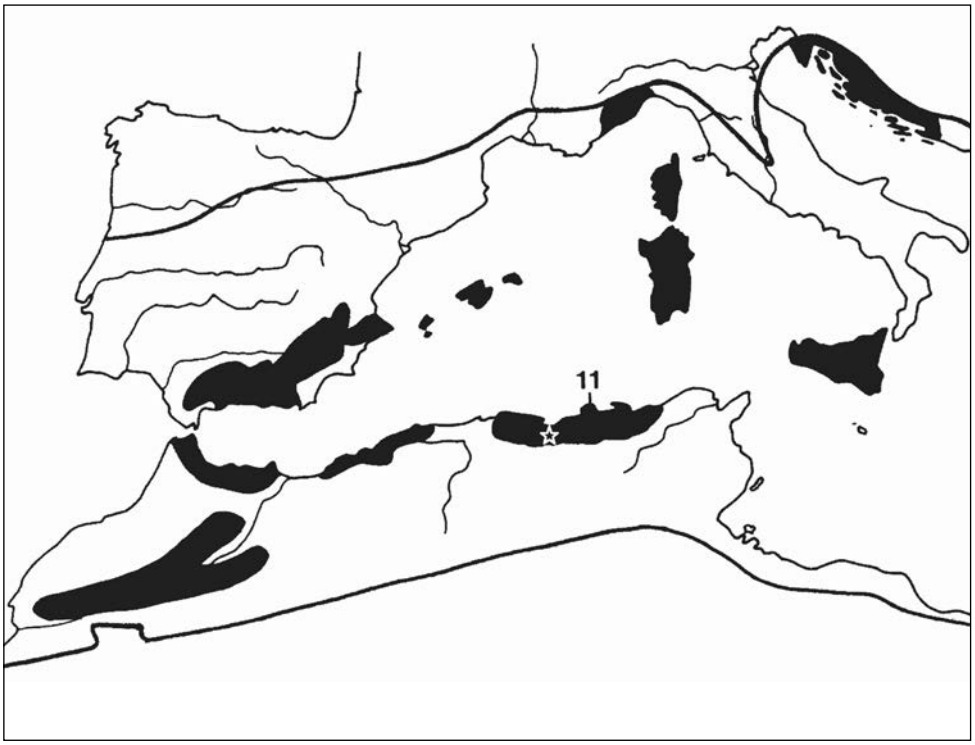


Fig. 1. Localisation géographique du Djebel Babor (étoile) et du hotspot régional « Kabylies-Nuidie-Kroumirie » (n°11) parmi le hotspot mondial de biodiversité du bassin méditerranéen (d'après Médail & Quézel 1997 et Véla & Benhouhou 2007, modifié).

Le Néocomien qui forme les crêtes est formé des marno-calcaires et des schistes. Le Crétacé supérieur est transgressif sur tout le versant nord du Babor, peu détritique à la base, chargé en bancs calcaires détritiques et conglomérats (Duplan 1952).

Selon la carte pluviométrique de l'Algérie du nord (A.N.R.H. 1993) les précipitations moyennes annuelles varient entre 1000 et 1400 mm.

A 2000 m d'altitude, au sommet du Djebel Babor, la durée d'enneigement commence dans les derniers jours du mois de novembre et dure jusqu'aux premiers jours du mois de mai (Auberty 1943). Aucune donnée récente ne nous permet de savoir si cette durée tend à se réduire ces dernières décennies, bien qu'il nous semble que cela soit le cas.

Selon Gharzouli (2007) le versant nord du massif est dans une ambiance bioclimatique per-humide, avec des variantes à hiver froid à très froid, au-delà de 1600 m d'altitude et humide à hiver frais à froid entre 1000 et 1600 m. Par contre le versant sud est dans une ambiance bioclimatique humide à hiver froid à frais à partir de 1600 m d'altitude, subhumide à hiver frais entre 1600 et 1000 m et semi-aride frais en deçà de 1000 m.

Contexte de la découverte et description botanique

Epipactis microphylla (Ehrh.) Sw., Kongl. Vetensk. Acad. Nya Handl. 21: 232 (1800).

Nous avons observé 20 individus isolés d'*E. microphylla* dans la première station (1388 m, 36°30'43,1" N et 05°29'48,8" E) et cinq individus dans la deuxième station (1260 m, 36°30'47,4" N et 05°29'47,6" E) le 11 juin 2020. Les stations se trouvent sur le versant nord du mont de Babor sur une pente de 35 à 45 % (Fig. 2). Le site est représenté par une zone semi-ombragée située dans une formation mixte du *Cedrus atlantica* (Endl.) Carrièrre et de *Quercus canariensis* Willd. Le tableau 2 présente une liste de la flore inventoriée dans la station d'*E. microphylla*. Le premier spécimen d'herbier récolté est déposé dans l'herbier du Laboratoire de Botanique de l'université de M'sila, le second spécimen sera déposé dans l'herbier officiel de l'école nationale supérieure agronomique (ENSA) d'Alger.

L'Epipactis à petites feuilles est une orchidée rhizomateuse, à rhizome court d'où partent plusieurs racines charnues paraissant fasciculées (Crespo 2005). Elle est associée par mycorhization typique des orchidées, non pas à des Rhizoctonia, mais à divers Ascomycètes ou Basidiomycètes, telles les truffes, russules, etc.. En cela elle pratique une mycohétérotrophie partielle, puisque les mêmes champignons sont aussi reliés par ectomycorhizes aux racines des arbres forestiers. Elle peut ainsi devenir achlorophyllienne, voire à floraison souterraine cléistogame (Selosse & al. 2004). La tige est haute de 15–40 cm, vert grisâtre, très cryptique avant la floraison, puis visible jusqu'à la fructification ; possède 3 à 5 feuilles espacées dépassant rarement 30 mm de longueur ; à feuilles médianes plus courtes que les entre-nœuds. L'inflorescence se compose de 4 à 15 fleurs espacées, longues de 5 à 7 mm, à extérieur verdâtre lavé de pourpre, souvent peu ouvertes, à épichile plus clair que les tépales extérieurs, souvent blanchâtre. Les gibbosités de l'épichile sont fortement sillonnées en travers, généralement plus longues que le quart de l'organe (Fig. 3-4) (Tison & al. 2014).

Répartition géographique et écologie d'*Epipactis microphylla*

Cette orchidée se trouve en Europe continentale, depuis l'Espagne méridionale (Sierra Nevada) jusqu'au nord d'Iran (Renz 1978), ainsi que sur les îles Baléares (Majorque et Minorque) et Tyrrhéniennes (Corse, Sardaigne et Sicile), la Crète et Chypre (Govaerts & al. 2020). Le nouveau site algérien d'*Epipactis* à petites feuilles est donc situé à plus de 400 km au sud-est des sites des îles Baléares (Crespo 2005) et 400 km au sud-ouest des sites de Sardaigne (GIROS 2009).

En Espagne, elle croit dans divers sous-bois (chênes verts, chênes zéens, chênes lièges,) et matorrals sclérophylles à leur marge, plus rarement en pinèdes denses, d'ordinaire en lieux ombragés, sur substrats pas trop secs (souvent pierreux), principalement basiques, entre 50 et 1.300 m d'altitude, et fleurit de mai à août (Crespo 2005). En France méditerranéenne, elle croît dans les forêts fraîches à sèches, souvent par pieds isolés, à tous les étages de végétation (thermo-, méso- et supra-méditerranéen, collinéen, montagnard), où elle fleurit en mai-juin (Tison & al. 2014). En Italie, elle habite les bois de feuillus, plus rarement de conifères, sur sols calcaires ou volcaniques, de 0 à 1800 m d'altitude. Elle y est réputée peu visible, échappant parfois à l'observation, et à dominance autogame (GIROS 2009).



Fig. 2. Station d'*Epipactis microphylla*, 11.06.2020.



Fig. 3. Illustration d'*E. microphylla* au Babor: a) Feuilles; b) Fleurs ; 11.06.2020, photos A.F. Bougaham.

En Algérie le site appartient au sous-secteur K2 dit de «Petite Kabylie», partie du secteur K dit «Kabyle et Numidien», lui-même partie à la fois la plus pluvieuse, la plus littorale et la plus montagneuse de l'ensemble géomorphologique du Tell algéro-constantinois (Quézel 1962). L'espèce habite donc les sous-bois les mieux préservés (riches en humus) des forêts les plus mésophiles du pays, où l'on rencontre également sa cousine la Néottie nid-d'oiseau (Madoui 2019), achlorophyllienne et totalement mycohétérotrophe quant à elle.

La flore associée (Tableau 2) est composée, pour la strate arborée, de cèdres (*Cedrus atlantica* (Endl.) Carrière), de chênes (*Quercus canariensis* Willd, *Q. ilex* subsp. *ballota* (Desf.) Samp.), d'érables (*Acer campestre* L., *A. obtusatum* Willd.) et d'ifs (*Taxus baccata* L.), sur lesquels grimpent du lierre endémique algéro-tunisien (*Hedera algeriensis* Hibberd). On y retrouve donc, en mélange, des espèces de montagne méditerranéenne plutôt sèche, avec des espèces de forêts européennes plutôt mésophiles. La strate herbacée quant à elle est composée d'autres orchidées de la tribu des Neottieae (*Cephalanthera rubra* (L.) Rich., *Epipactis helleborine* (L.) Crantz.), des bulbeuses prestigieuses (le Cyclamen d'Afrique endémique du Maghreb, le rarissime Cyclamen des Babors endémique strict et méconnu, la Pivoine de l'Atlas endémique de Kabylie), ainsi que quelques dicotylédones, graminées ou fougères.

Tableau 2. Liste de la flore inventoriée dans la station d'*Epipactis microphylla.*

Acer campestre L.	*Hedera algeriensis* Hibberd.
Acer obtusatum Willd.	*Hypochaeris radicata* L.
Acinos alpinus subsp. *meridionalis* (Nyman) P.W. Pall.	*Linaria reflexa* (L.) Chaz.
Arabis turrita L.	*Melissa officinalis* L.
Arabis alpina L.	*Origanum vulgare* subsp. *glandulosum* (Desf.) Letsw.
Andryala intergrifolia L.	*Paeonia mascula* subsp. *atlantica* (Coss.) Greuter & Burdet
Helictochloa cincinnata (Ten.) Romero Zarco	*Petasites pyrenaicus* (L.) G. López
Bellis sylvestris Cirillo [sensu lato]	*Plagius maghrebinus* Vogt & Greuter
Anisantha rubens (L.) Nevski	*Platanthera bifolia* subsp. *kuenkelei* (H. Baumann) Kreutz
Cedrus atlantica (Endl.) Carrière	*Phlomis bovei* de Noé
Cephalanthera rubra (L.) Rich	*Polystichum setiferum* (Forssk.) Woyn.
Cyclamen repandum Sm. [var. *baborense* Debussche & Quézel]	*Quercus canariensis* Willd.
Cyclamen africanum Boiss. & Reut.	*Quercus ilex* subsp. *ballota* (Desf.) Samp.
Cynoglossum cheirifolium L.	*Rosa canina* L. [sensu lato]
Cystopteris fragilis (L.) Bernh.	*Rubus incanescens* (DC.) Bertol.
Dactylis glomerata L. [sensu lato]	*Senecio perralderianus* Coss. & Durieus
Daphne laureola L.	*Stachys officinalis* subsp. *algeriensis* (de Noé) Franco
Epipactis helleborine (L.) Crantz	*Taxus baccata* L.
Galium rotundifolium L.	*Teucrium chamaedrys* L. [sensu lato]
Geranium lucidum L.	*Viburnum tinus* L.
Geranium purpureum Vill.	*Vicia ochroleuca* subsp. *baborensis* (Batt. & Trab.) Greuter & Burdet
	Viola reichenbachiana Boreau

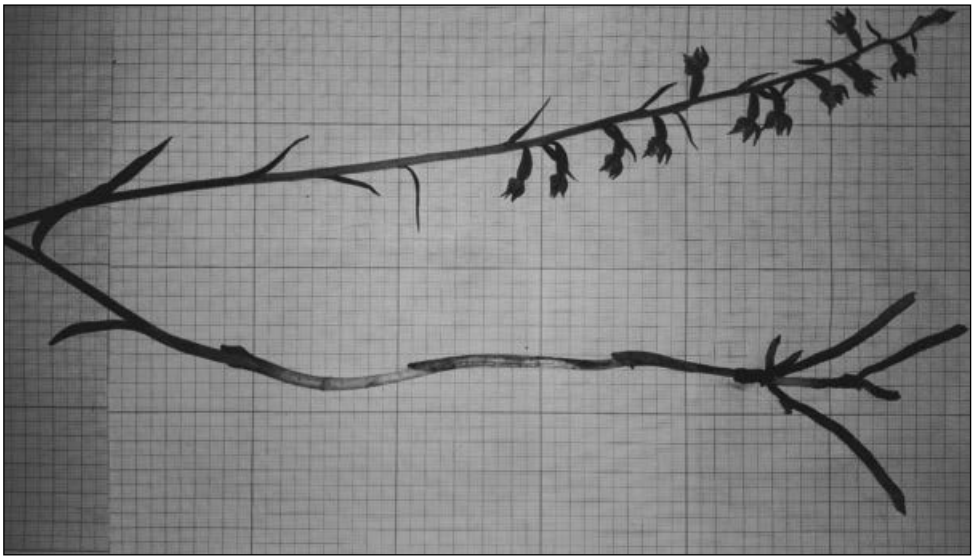


Fig. 4. Un spécimen de la plante, récolté sur le versant nord de Babor, 11.06.2020.

Identification du genre *Epipactis* en Algérie

Suite à cette nouvelle espèce, il nous paraît nécessaire de proposer une clé du genre pour l'Algérie. Nous la rédigeons ci-après sur le modèle de la flore d'Algérie la plus utilisée à ce jour (Quézel & Santa 1962):

Epipactis Zinn

Rhizome à racines fasciculées. Fleurs en grappe spiciforme. Bractées herbacées, les inférieures plus longues que les fleurs. Labelle brusquement rétréci dans sa partie moyenne séparant un « hypochile » creux nectarifère et un «épichile» en forme de petite langue.

1 – Tige à 5–9 feuilles grandes (dépassant l'entre-nœud) et très larges. Grappe dense pouvant atteindre 40 cm (15–50 fleurs, voire +), à pilosité discrète et peu dense (surtout sur l'ovaire). Fleurs vertes plus ou moins lavées de pourpre, y compris le labelle et la base de l'ovaire. Epichile présentant à la base deux gibbosités peu boursouflées et de taille modeste. – Forêts des montagnes – R: K1-2-3, C1-2, O3, AS3 – Euras. – (= *E. latifolia* var. *platyphylla* Irm., incl. *E. tremolsii* Pau) .....636. ***E. helleborine*** (L.) Crantz.

1 – Tige à 3–5 feuilles courtes (atteignant à peine l'entre-nœud) et peu larges. Grappe lâche et pauciflore (5–25 fleurs), à pilosité très dense et nettement hirsute (y compris sur l'ovaire). Fleurs vertes à peine lavées de pourpre clair (pétales), labelle blanc et verdâtre. Epichile présentant à la base deux gibbosités très boursouflées-verruqueuses, de taille remarquable. – Forêts des montagnes pluvieuses – RR: K2 (Babor) – Europ.-Caucas. .....636. ***E. microphylla*** (Ehrh.) Sw.

Menaces et problématique de conservation

En Europe, c'est une espèce protégée en France au plan régional ; en Belgique et au Luxembourg sur le plan national (Bournérias & al. 2005). A Chypre, la population n'est que d'environ 40 individus (Rankou 2011); en Italie, l'espèce est signalée dans toutes les régions italiennes à l'exception du Val d'Aoste. *Epipactis microphylla* est local et souvent rare où il est présent avec une aire de répartition assez large. Les populations sont très petites, très fragmentées et diminuent. La zone d'occupation de l'espèce est inférieure à 500 km² et l'aire de répartition de l'espèce est très étroite et menacé par l'utilisation agricole de l'habitat, l'abandon des cultures de noisettes, l'utilisation d'herbicides, le creusement et la consommation par les animaux sauvages, la gestion inappropriée des forêts et la déforestation. Par conséquent, *E. microphylla* a été évaluée comme étant presque menacé (NT) en se rapprochant des critères B2ab (iii, iv, v) (Rankou 2011).

En Algérie il nous paraît utile et urgent d'ajouter cette espèce à la liste des espèces végétales non cultivées protégées sur l'ensemble du territoire national (JORA 2012). On peut néanmoins espérer que le classement récent du massif en parc national contribuera à la préservation de cet écosystème forestier majeur, et que la difficulté d'accès à la zone la préservera des pillages éventuels. Il conviendra cependant d'analyser l'utilisation actuelle de la zone ainsi que les menaces éventuelles (surpâturage, incendies, réchauffement climatique) de la petite population, d'envisager la gestion future et les mesures de conservation. Il sera important d'étudier la phytosociologie détaillée des deux stations ainsi que la mycologie de l'ensemble du site. Enfin, un suivi de la dynamique de la population de cette orchidée sur plusieurs années sera très utile pour son évaluation dans une future liste rouge nationale algérienne selon les catégories et critères de l'UICN (2012).

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Article

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Dries Engelen

Inventorying and mapping the orchids of the island of Antikythera (Greece), including a new taxon: *Ophrys aegilica* (*Orchidaceae*)

Abstract

Engelen, D.: Inventorying and mapping the orchids of the island of Antikythera (Greece), including a new taxon: *Ophrys aegilica* (*Orchidaceae*). — Fl. Medit. 30: 273-291. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

The Mediterranean Basin with all its islands encompasses a high diversity of plant species. Nonetheless, floristic overviews of these islands are often incomplete or lacking entirely and as a result they have an increased chance of harboring undescribed taxa. In 2014, I stumbled on such a likely new taxon belonging to the mammosa-complex of the genus *Ophrys* (*Orchidaceae*) on Antikythera, Greece. Therefore, in March 2018, I organized a 3 week orchid survey on the island during which 14226 specimens of 12 species were recorded, including the new taxon *Ophrys aegilica*. It mostly resembles *O. taigetica*, but differs from this species in habitat preference and flowering time, as well as a few morphological features (e.g. size of the petals). Furthermore, I report on the local status of other orchid species on Antikythera, including 4 which have not previously been observed on the island: *Anacamptis papilionacea* subsp. *aegaea*, *Neotinea maculata*, *Ophrys bombyliflora*, and *O. attica*. For at least three species their occurrence on Antikythera marks the border of their distributional range in Greece. These results underline the importance of botanical surveys on Mediterranean islands during winter and early spring in order to get a complete picture of the occurrence and distribution of plant species. For the future conservation of orchids on Antikythera it is important that the vegetation keeps its open character, especially on former agricultural terraces, and that currently unknown pollinators are identified.

Key words: Mediterranean Basin, Greek flora, plant distribution, island endemics.

Introduction

The Mediterranean Basin is a global plant biodiversity hotspot with more than 25.000 vascular species (about 10% of the world's total) on just 1.6% of the earth's land surface (Médail & Quezel 1997; Comes 2004). More than half of these plant species are endemic to the region, many of which have a narrow distributional range, particularly on islands and in high mountain areas (Médail & Quezel 1997; Greuter 2001; Georghiou & Delipetrou 2010). Although the number of studies documenting this spectacular diversity is growing (e. g. Strid & Tan 2017), many islands remain

understudied and either lack proper species' distributions data or a flora inventory altogether (Greuter 2001). The following study aims to make a small contribution to this knowledge gap by focusing on orchids of the island of Antikythera. Despite its location between Crete and the Peloponnese, the two areas with the highest levels of endemism in Greece (Médail & Quezel 1997; Georghiou & Delipetrou 2010), this Greek island has been scantly visited by botanists or (amateur) orchid enthusiasts.

Antikythera is a small (20.8 km^2, maximum altitude 379, coastline 24 km), rather remote Greek island in the southwestern Aegean Sea. It is situated 38 km southeast of Kythira and 35 km northwest of western Crete (Fig. 1a & 1b). The climate is typically Mediterranean and is characterized by warm winters without much frost or snow, and a relatively dry period of up to 6 months between April and September. There are around 30 permanent inhabitants, who share the island with a large population of roughly 3000 feral goats (Palmer & al. 2010).

The oldest signs of human presence on Antikythera date back to the 5th millennium BC and these were probably people that visited the island seasonally (Bevan & al. 2007). Small settlements and the construction of agricultural terraces first appeared in the 2nd millennium BC. Since then, Antikythera has had a history of periods with (re)colonization alternated with (long) periods of complete abandonment (Bevan & al.

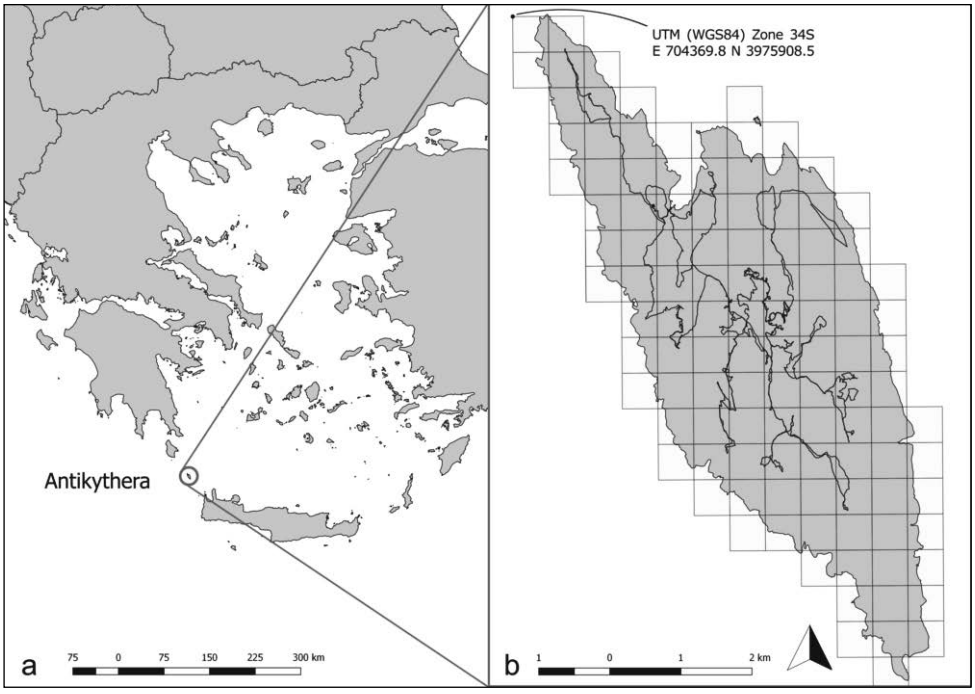


Fig. 1. a) Map of Greece with geographic location of Antikythera. b) Overview map of Antikythera, showing the routes surveyed for orchids in March 2018. The coordinates in the top left corner correspond to the Greek coordinate system GRS87 EPSG: 2100 E 433500, N 3973500.

2007). During the early 19th century, the island supported close to 1000 inhabitants, but this number started declining throughout the 20th century and especially after World War II (Bevan & al. 2007).

Over time around 30 percent of Antikythera's surface was converted into agricultural terraces, while the rest of the island was grazed by goats. At present nearly all these terraces are abandoned and contain secondary plant communities of different structure and species diversity (Palmer & al. 2010). Due to the geographical location of Antikythera and the fact that the island was formerly part of a land-bridge connecting Crete to the Peloponnese (Georghiou & Delipetrou 2010), the vegetation on Antikythera is a mix of plant species belonging to the Kythira-Peloponnese communities, as well as those part of the Crete-Karpathos communities (Tzanoudakis & al. 2006). For a long time, the only plant list available for the island was the floristic catalogue of Greuter & Rechinger (1967) which mentions a total of 226 plant taxa, but this was largely based on botanical surveys done in May. More recently, Tzanoudakis & al. (2006) visited the island in April and during autumn and documented an additional 120 taxa. Antikythera is home to 25 Greek endemic taxa (Tzanoudakis & al. 2006), including the autumn-flowering *Allium aegilicum*, which is exclusively found on the island (Tzanoudakis 2000).

The total of 346 plant taxa includes only three orchid species, namely *Spiranthes spiralis*, *Anacamptis pyramidalis* and *Ophrys sicula* (Tzanoudakis & al. 2006). However, on many other Mediterranean islands the flowering season of orchids starts well ahead of April and can even be as early as mid-December (Antonopoulos & al. 2010). In the Atlas of the Greek orchids, Antonopoulos & Tsiftsis (2017) mention 5 more species for Antikythera, namely *O. omegaifera*, *O. tenthredinifera*, *O. ceto*, *Serapias parviflora* and *S. orientalis* subsp. *orientalis*, but this is largely based on observations of Nikos Tsiopelas and myself.

Material and Methods

The first time I visited Antikythera was at the end of March 2014 when I joined the bird ringing camp of the Hellenic Ornithological Society at the Antikytheran Bird Observatory. I stayed until the middle of April and then returned for nearly four weeks in May. During this period of two months, I observed several species of orchids, namely *Ophrys omegaifera*, *O. sicula*, *O. ceto* and *Anacamptis pyramidalis.* On the 31st of March I also came across some plants clearly belonging to the *Ophrys mammosa*-complex, but without the typical mammosities (Fig. 2). Unfortunately, only few withering plants were left during this time and so I could not study them any further. In March 2015 I wanted to have a closer look at the orchid, but last-minute alterations in the boat schedule put an end to those plans. Finally, in March 2018, I managed to visit the island for a proper three weeks, giving me enough time to study this species and the orchids of Antikythera in general.

Together with a friend, Diego Jansen, I walked along all the existing paths of the island, but also randomly through different kinds of habitats while on the way documenting our track (Fig. 1b) and every (group of) orchid(s) we encountered. The different routes did not overlap. During our first survey from March 10 to March 18 we walked a total of 70 kilometers and we only registered orchids that were in full flower or at the end of flowering.



Fig. 2. First plant of *Ophrys aegilica* found on Antikythera in March 2014 – photo taken on 31.03.2014.

We walked the same routes again after a twelve-day interval in order to spread our sampling efforts as much as possible during our stay on the island. In the second survey (from March 22 to March 30) we registered only the flowering plants and those that were still in the budding stage. We left out the plants at the end of flowering in order to prevent double counting the same individuals. Orchids were identified based on personal experience gained during previous visits to Greece and with the help of species guides (Delforge 2016; Antonopoulos & Tsiftsis 2017) and two websites (www.ophrys-genus.be; www.orchidsofbritainandeurope.co.uk). All observations were recorded on a smartphone using the ObsMapp application and each taxon has been photographed in order to strengthen the credibility of the records. The results can be seen in Table 1 and distribution maps based on the observations can be seen in Fig. 3.

Furthermore, plant and flower measurements were taken of 35 individuals of *Ophrys aegilica* from seven locations on the island, covering its entire distributional range on Antikythera. The values presented in the results section are the arithmetic means -/ + the standard deviation with the smallest and highest measured values between brackets.

Results

A total of 14226 individual orchids, belonging to 12 different species, were counted during the three week period on Antikythera (Table 1): 6440 during the first survey and 7786 during the second round. All eight species known from the island were observed, except *Serapias orientalis* (Greuter) H. Baumann & Künkele subsp. *orientalis* (Fig. 4). Furthermore, five species were observed for the first time on Antikythera (indicated with *), of which one is a new taxon altogether (Figs. 5 & 6).

Serapias parviflora Parl.: This autogamous species has a large distribution range in southern Europe. In Greece it mainly grows in the western and southern regions and flowers during April and May (Antonopoulos & Tsiftsis 2017). On Antikythera the species was observed in two locations, but almost all of the 52 plants were seen close to the village of Katsaneviana. The plants were only observed during the second survey when the first individuals just started flowering.

Serapias orientalis (Greuter) H. Baumann & Künkele subsp. ***orientalis***: While being a fairly common species in southern Greece and around the Aegean Sea (Antonopoulos & Tsiftsis 2017), only a single record is known from Antikythera. Nikos Tsiopelas found a single plant in the center of the island in April 2015 (Fig. 4). Although the flowering time of the species ranges from middle March to middle May, no individuals were found during our survey.

Anacamptis pyramidalis (L.) Rich.: In most of Europe and Greece this is a very widespread and common orchid species and on Antikythera this is no different. With 7262 individuals counted, it was by far the most numerous orchids on the island. It can form large colonies, especially on the calcareous soils like marl. The first plants started to flower at the end of March, but the vast majority of the plants still had closed flower buds at this point. The flowering peak of *A. pyramidalis* on Antikythera is during April (pers. obs. 2014).

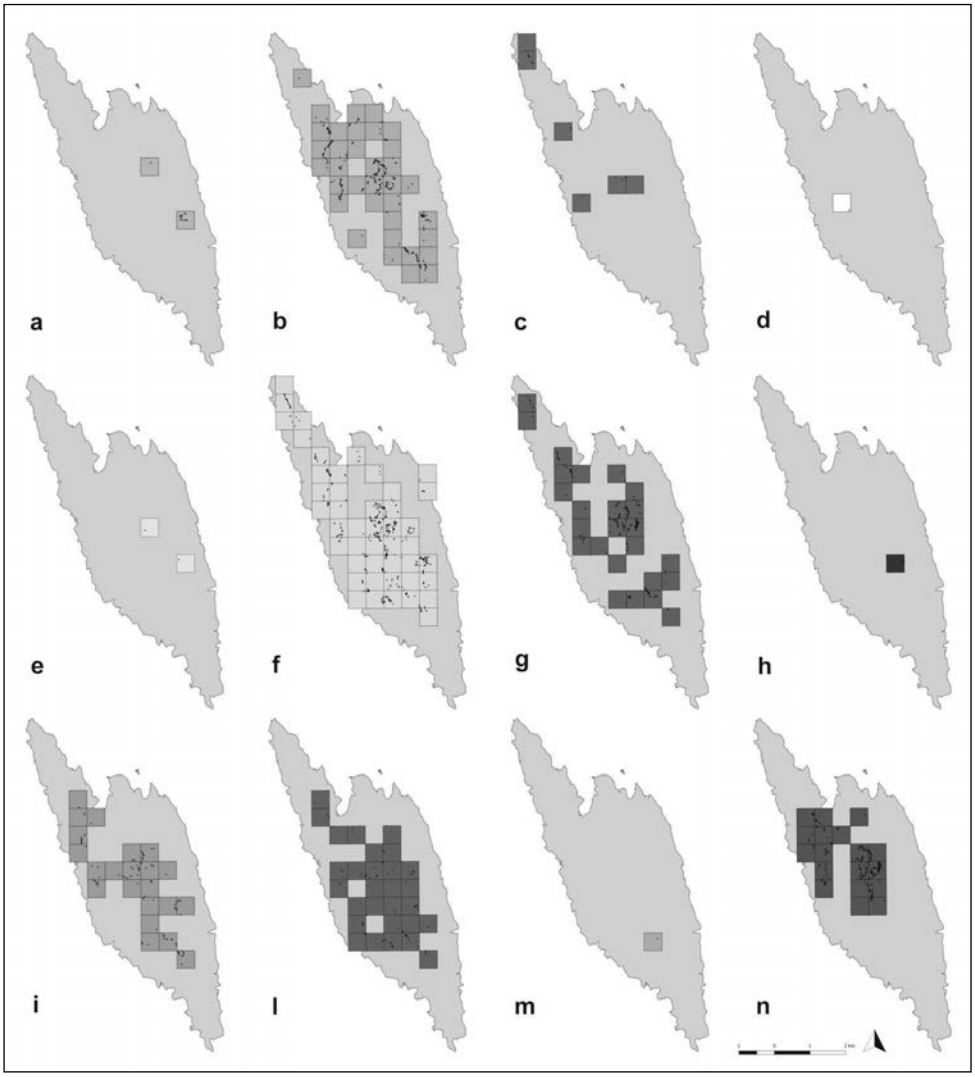


Fig. 3. Distribution maps of 12 orchid species on Antikythera based on 14226 individuals (as listed in Table 1) observed in March 2018. The black dots within the 500 × 500 m squares mark the actual locations of observations. a) *Serapias parviflora*; b) *Anacamptis pyramidalis*; c) *Anacamptis papilionacea* subsp. *aegaea*; d) *Neotinea maculata*; e) *Spiranthes spiralis*; f) *Ophrys sicula*; g) *O. omegaifera*; h) *O. bombyliflora*; i) *O. tenthredinifera* s. l.; l) *O. ceto*; m) *O. attica*; n) *O. aegilica*.

* ***Anacamptis papilionacea*** subsp. ***aegaea*** (P. Delforge) L. Lewis & Kreutz: It is the first time this early flowering subspecies, or any *A. papilionacea* for that matter, has been observed on Antikythera. It was formerly known as *A. papilionacea* subsp. *heroica* (E. D. Clarke) H. Baumann (see Lewis & Kreutz 2013) and its distribution range includes south-

Table 1. Updated list of orchid species known to occur on Antikythera, including the numbers of individuals found per species during the two surveys in March 2018.

Species	**# of ind. survey 1 10 - 18 March**	**# of ind. survey 2 22 - 30 March**	**Total**
Serapias parviflora Parl.	0	52	52
Serapias orientalis (Greuter) H. Baumann & Künkele subsp. *orientalis*	0	0	0
Anacamptis pyramidalis (L.) Rich.	0	7262	7262
Anacamptis papilionacaea subsp. *aegaea* (P. Delforge) L. Lewis & Kreutz	484	0	484
Neotinea maculata (Desf.) Stearn	1	0	1
Spiranthes spiralis (L.) Chevall.	0	7	7
Ophrys sicula Tineo	2191	200	2391
Ophrys omegaifera H. Fleischmann	1399	27	1426
Ophrys bombyliflora Link	116	0	116
Ophrys tenthredinifera Willd. s. l.	462	2	464
Ophrys ceto P. Devillers, J. Devillers-Terschuren & P. Delforge	0	186	186
Ophrys attica (Boiss. & Orphanides) B. D. Jackson	2	0	2
Ophrys aegilica D. Engelen	1785	50	1835

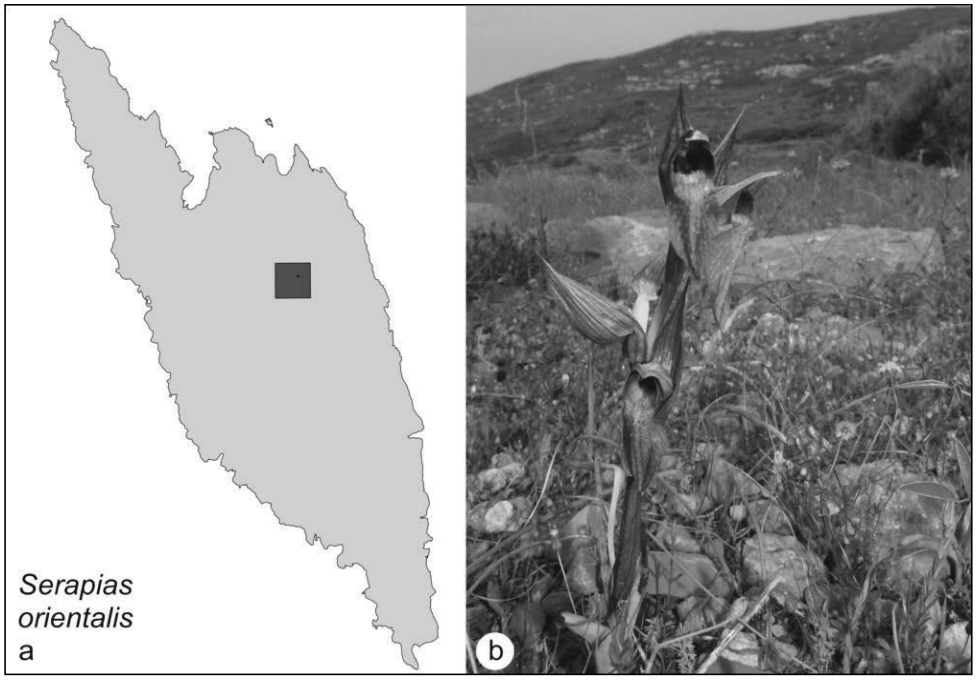


Fig. 4. Location (a) and photo (b) of the only individual of *Serapias orientalis* subsp. *orientalis* ever recorded on Antikythera – photo taken on 19.04.2015 by Nikos Tsiopelas.

ern and insular Greece, as well as western Turkey (Antonopoulos & Tsiftsis 2017). Several small populations were found across the island and a total of 484 individuals were counted. Most plants had started to wither already by the first survey round in the middle of March.

* ***Neotinea maculata*** (Desf.) Stearn: This autogamous species has a wide distribution, ranging from the Canary Islands, across Europe and into the Levant. In Greece it is more common in the southern areas and the islands (Antonopoulos & Tsiftsis 2017), but for Antikythera it is the first time this species is observed. Only a single individual was found on the road to Plagara, the highest peak of Antikythera (379 m). This individual was found during the first survey and had already started to wither by that time.

Spiranthes spiralis (L.) Chevall.: This autumn-flowering orchid is widespread in Europe and Greece. During spring the rosettes are visible, but they wither away before the flowering spike appears, which is an adaptation to hot and dry summers (Waller 2016). Seven rosettes were found in two places on the island, but it is likely this species has been overlooked at times during this study.

Ophrys sicula Tineo: This is one of the most common *Ophrys* species in Greece (Antonopoulos & Tsiftsis 2017) and with 2192 individuals counted, it is the second most numerous species on Antikythera. Flowering individuals were observed during both survey rounds, but they were clearly more abundant during the first one (Table 1). It is the most widespread orchid species on the island and grows in all kinds of habitats; sometimes with just a few plants, but other times in large colonies.

Ophrys omegaifera H. Fleishmann: Like *O. sicula* this species was observed during both survey rounds. It mostly flowers during March, but few individuals are still found in April as well (pers. observ. 2014). With 1399 individuals counted, it was the fourth most numerous species in this study and prefers abandoned terraces dominated by *Sarcopoterium spinosum* (L.) Spach and *Erica manipuliflora* Salisb. Currently Antikythera seems to be the most western point of the distribution range of *Ophrys omegaifera* in Greece, as the records known from Kythira and the Peloponesse are from before 1985 (Antonopoulos & Tsiftsis 2017).

* ***Ophrys bombyliflora*** Link: This widespread Mediterranean species is quite common in coastal Greece (Antonopoulos & Tsiftsis 2017), but it is the first time this species is observed on Antikythera. During the first survey a colony of 116 individuals was found near the village of Katsaneviana, but all these plants had completely disappeared by the time of the second visit.

Ophrys tenthredinifera Willd. s. l.: This taxon is widespread in southern Europe and plants growing in the eastern Mediterranean were previously known as *O. villosa* Desf. (see Paulus & Hirth 2012). However, in recent years Greek plants belonging to the *tenthredinifera*-complex have been split into a number of new (sub)species, such as *O. leochroma* P. Delforge, *O. ulyssea* P. Delforge, *O. dictynnae* P. Delforge, *O. korae* M. Hirth & Paulus and *O. lycomedis* P. Delforge (Paulus & Hirth 2012; Delforge 2005, 2013). Both Crete and Kythira are home to several species from this complex, but on

Antikythera there seems to be only one species form. The 464 individuals found in this study were almost exclusively seen during the first survey and the species is largely gone after the middle of March. It is difficult to say, however, whether this species is the widespread *O. tenthredinifera* s. s. or the Cretan endemic *O. dictynnae* P. Delforge. The species are difficult to separate morphologically and both species could still be flowering during the first half of March (Antonopoulos & Tsiftsis 2017). Furthermore, an insect study on the island during the spring of 2014 (Petanidou & al. unpublished data) did not find *Eucera nigrilabris* (the pollinator of *Ophrys tenthredinifera*), but did come across *Eucera albofasciata* (the pollinator of *Ophrys dictynnae*). Further pollination studies in the *tenthredinifera*-complex are needed on Antikythera specifically to shed light on this issue, but also generally to better understand how reproductive isolation between the different species is achieved (Cuervo & al. 2017).

Ophrys ceto Devillers, Devillers-Tersch. & P. Delforge: The distribution of this species in Greece is centered around the Cyclades islands, ranging from Kythira to Samos, and its flowering season runs from mid-April to mid-May (Antonopoulos & Tsiftsis 2017). Antikythera is the most southern point of its distribution and the first flowering plants were found during the second survey at the end of March. However, the vast majority of the 186 counted plants had closed flower buds that will open during April and May. Individuals in full flower have been observed as late as 15th of May (pers. observ. 2014), suggesting quite a long flowering period for *O. ceto* on Antikythera.

* ***Ophrys attica*** (Boiss. & Orph.) Soó: It is the first time this or any species of the *Ophrys umbicilata*-complex has been observed on Antikythera. For *O. attica* the island seems to be the most southern point of its distribution range in Greece (Antonopoulos & Tsiftsis 2017). During the first survey two flowering individuals were found several meters from each other on the southern plateau of the island. A revisit to this location during the second survey showed that both plants had been eaten by goats.

* ***Ophrys aegilica*** D. Engelen: This is a new taxon and the first time any species belonging to the *Ophrys mammosa*-complex has been observed on Antikythera. Even widespread species of this complex in Greece, such as *O. mammosa* Desf. (with its characteristic mammosities) and *O. spruneri* Nyman (with its purple sepals and trilobed lip) have never been found on the island. *O. aegilica* was the third most counted species during the surveys with a total of 1835 plants. Among the observed plants was also an individual with a hypochromic inflorescence (Fig. 6). Its distribution is focused around the terraces found in the centre of the island. Flowering starts in March and the very last plants wither during the first days of April.

Ophrys aegilica D. Engelen ***spec. nov.***

Holotype – About 700 m. southwest of Skariana area, in the central north part of Antikythera island, Greece; UTM (WGS84) Zone 34S: E 707821.1, N 3971649.8 (35°52'1.40"N, 23°18'6.48"E); roadside with phrygana; 143 m a.s.l.; 22.03.2018, Leg. Dries Engelen (NHMC 43-12785) (Fig. 7).

Description – Plant 10 - 35 cm, inflorescence usually 2 – 7 flowers (maximum 12). Sepals triangular with rounded tops, greenish, occasionally with reddish tinge, lateral sepa-



Fig. 5. Four orchid species found for the first time on Antikythera: a) *Anacamptis papilionacea* subsp. *aegaea* – photo taken on 12.03.2018; b) *Neotinea maculata* – photo taken on 18.03.2018; c) *Ophrys bombyliflora* – photo taken on 14.03.2018; d) *O. attica* – photo taken on 13.03.2018.

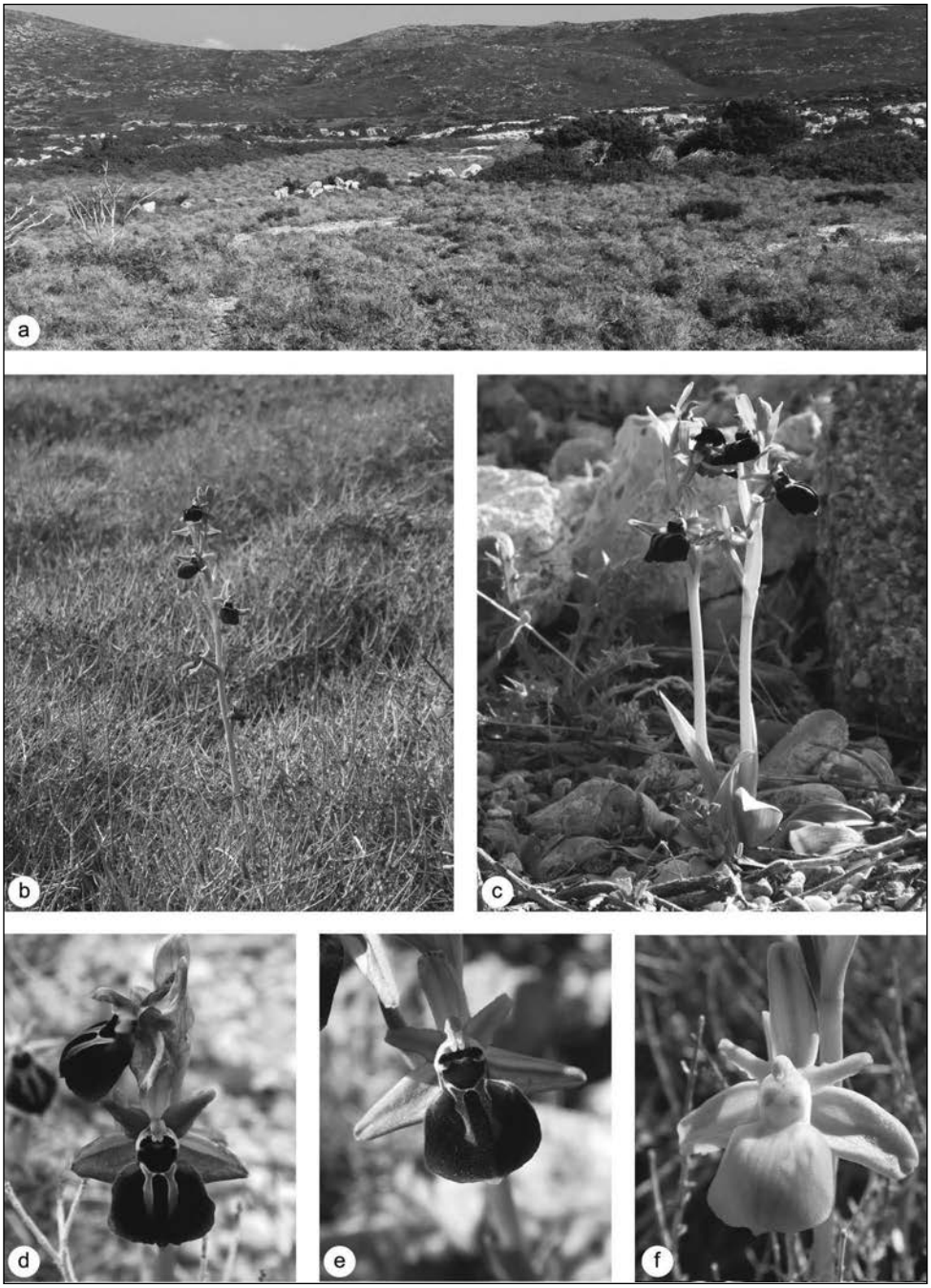


Fig. 6. *Ophrys aegilica*: a) Habitat with *Coridothymus capitatus* and *Sarcopoterium spinosum* – photo taken on 14.03.2015; b, c) Entire plant – photos taken on 11.03.2018; d, e) Close-ups of flower – photos taken on 10.03.2018; f) Hypochromic individual – photo taken on 11.03.2018.

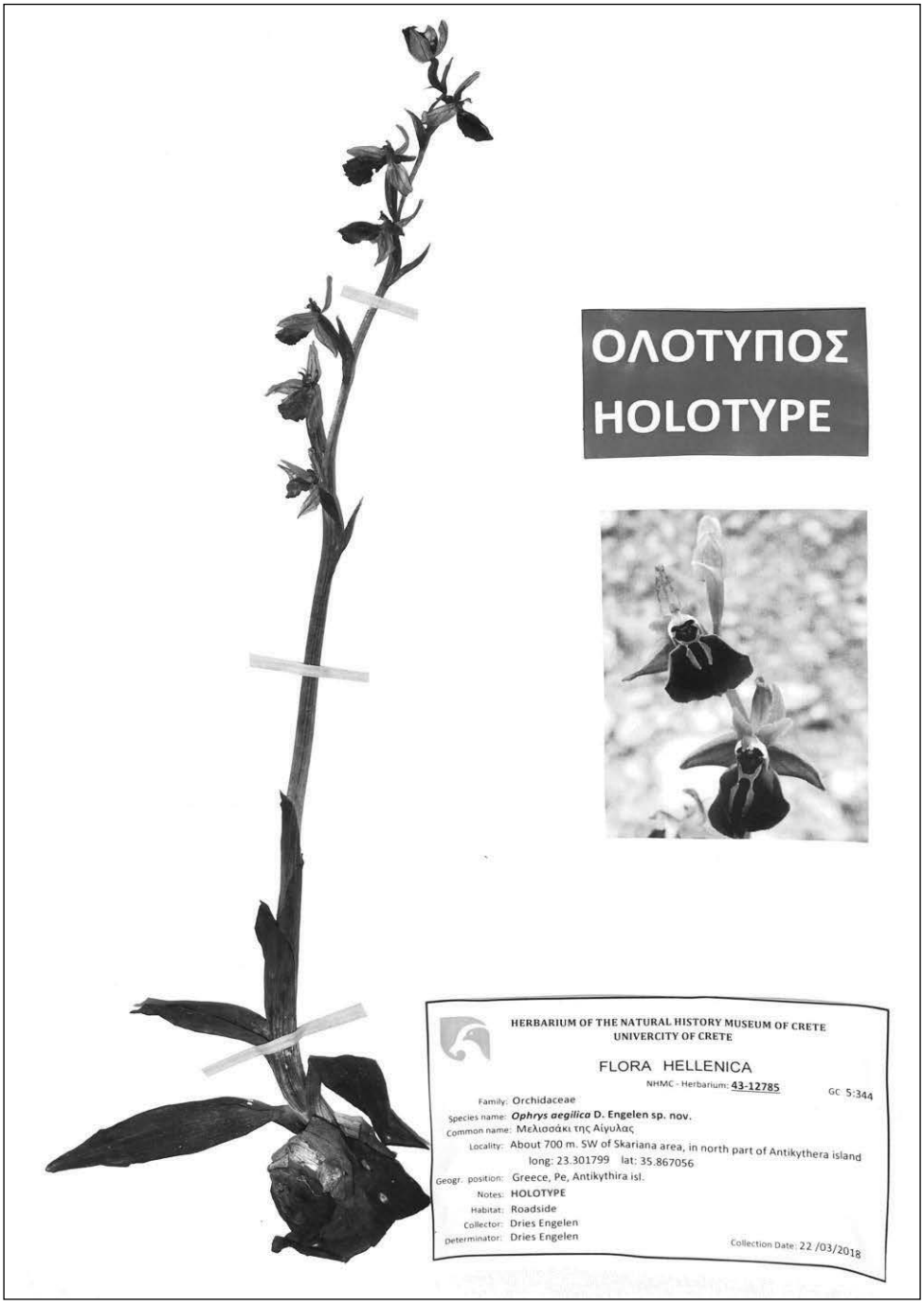


Fig. 7. Holotype of *Ophrys aegilica,* Antikythera, 22.03.2018; Herbarium of the Natural history Museum of Crete, University of Crete.

ls bicoloured, basal half weakly to strongly reddish, length x width (9)10.9 – 14.1(16.5) × (5)5.4 – 6.8(7) mm. Petals triangular, broadened at base and rounded tops, yellow-green, sometimes with reddish tinge, lightly undulated with an irregular margin, length × width (7)7.2 – 9.5(12) × (2.5)2.9 – 4.0 (4.4) mm. Labellum oval to rounded-trapezoid shape, entire margin occasionally obscurely three lobed, burgundy colour (dark reddish purple tending towards brown-black) rarely with a very thin yellow border, length (10)11.4 – 13.4 (15) mm, center of lip bulged, mammosities absent or very weakly apparent, small hairs along (half of) the lip margin, same colour as the lip with a whitish shimmer. Appendage small, triangular elongation of the lip, yellow-orange to light red, always lighter than lip colour, rarely completely lacking. Speculum H-shaped, occasionally missing horizontal line, covering three quarters of the lip, bright metallic blue, sometimes with (partial) white border. Basal field reaching half of the gynostemium, same colour as the lip. Pseudo-eyes same blueish colour as the speculum, sometimes also connected to it. Stigmatic cavity constricted at base, outer upper side white or whitish-reddish. Stigmatic hole dark with a large whitish specular stage, which sometimes has a hint of blue similar to the colour of the speculum, and is occasionally connected to the pseudo-eyes by a white line. Gynostemium greenish in center and reddish on sides, sometimes entirely reddish or entirely greenish.

Diagnosis – *O. aegilica* clearly belongs to the *mammosa*-complex as it has the characteristic dark-blue to black pseudo-eyes, the dark basal area of the lip, the green and red bicolored lateral sepals, the velutinate petals and the small appendix prolongating the labellum (Delforge 2016; Antonopoulos & Tsiftsis 2017). The near absence of mammosities in *O. aegilica* is a characteristic also found in *O. hansreinhardii* M. Hirth, a species which also flowers at the same time (Hirth 2007). However, *O. hansreinhardii* is distributed from southern Albania to northwestern Greece, is often found at higher altitudes (~600 m a.s.l.) and is clearly distinguished by several morphological characteristics (Table 2). Flowers of *O. aegilica* have a larger lip size; smaller lateral pilosity; rarely backwards folded sepals; and overall appear to be less dull with stronger contrast between the blue-grey speculum and the dark red lip. Furthermore, the pollinator of *O. hansreinhardii* (*Andrena assimilis*) has not been found on Antikythera (Petanidou & al. unpublished data).

Another species of the *mammosa*-complex which usually lacks mammosities is *Ophrys taigetica* Presser & S. Hertel, found in the Peloponnese (Presser & Hertel 2010). Although this is geographically closer to Antikythera, *O. taigetica* is found in *Abies cephalonica* Loudon and *Pinus nigra* J. F. Arnold mountain forests (950 – 1560 m a.s.l.) and flowers from mid-May to early June. Apart from these ecological distinctions, *Ophrys aegilica* also differs morphologically from *O. taigetica* in the size of its petals, the stronger red-purple tinge of the lateral sepals and the more pronounced blue colour of the speculum, pseudo-eyes and specular stage (Table 2).

Etymology – As *O. aegilica* is the first orchid species described from Antikythera, its name is derived from Aegila (Αἰγιλα), which was the name of Antikythera during the Hellenistic and Roman times. This classical name probably meant ‘goat island’ (Bevan & Conolly 2013).

Pollinator – Currently unknown.

Habitat – *O. aegilica* can be found in stony wastelands and road sides, but it predominantly grows on relatively recently abandoned terraces with a loose and open phrygana vegetation dominated by *Coridothymus capitatus* (L.) Rchb. and *Sarcopoterium spinosum*

(Fig. 6). It prefers dry, calcareous soil. Antikythera is an almost wholly limestone island with comparatively high pH levels and magnesium content and low levels of zinc and phosphorus (Bevan & al. 2013).

Flowering time – The species starts flowering in early March and only very few flowering individuals will be left during the beginning of April. Other orchids flowering at the same time are *Ophrys omegaifera*, *O. sicula* and *O. tenthredinifera* s. l. In the same habitat *Anacamptis pyramidalis* starts flowering when *Ophrys aegilica* is nearly finished.

Altitudinal distribution – From sea level until 200 m.

Distribution – *O. aegilica* seems to be endemic to Antikythera. Its distribution is focused around the terraces found in the centre of the island (Fig. 3) where it can form large groups in places with suitable habitat conditions.

Discussion

Plant communities of Mediterranean islands are often understudied. A short but intense orchid survey on the island of Antikythera in March 2018 revealed 5 taxa not known to occur on the island, including a previously undescribed endemic: *Ophrys aegilica*. This new species belongs to the *mammosa*-complex, a group that currently contains over 30 species of which the distribution is centered around the Northeastern Mediterranean (Delforge 2016). While *O. mammosa* is the most widespread species of this complex in Greece (Antonopoulos & Tsiftsis 2017), it seems to be absent from Antikythera and instead replaced by *O. aegilica*. It is therefore not surprising that the pollinator of *O. mammosa,* the mining bee *Andrena morio*, was not found on the island during an insect survey between late March and late April 2014 (Petanidou & al. unpublished data). A similar situation occurs on nearby Crete where *Ophrys mammosa* and its pollinator are lacking, and replaced by the Cretan endemic *O. doerfleri* Fleischmann and its pollinator *Andrena fuscosa* (see Paulus & Hirth 2017). Pollinator specificity is one of the main factors resulting in reproductive isolation between taxa and speciation events in the genus *Ophrys* (Ayasse & al. 2010; Breitkopf & al. 2014; Cuervo & al. 2017; Paulus & Hirth 2017). Particularly *Eucera* or *Andrena*-pollinated *Ophrys* species have had recent episodes of diversification (Breitkopf & al. 2014) and emphasize the importance of studies on Antikythera to identify the pollinator of *O. aegilica* and to clarify the aforementioned *O. tenthredinifera* s. s./ *O. dictynnae* issue (see result section). Also, as the reproductive success of orchids is often limited by pollinator access (Vereecken & al 2010), identifying the pollinator and ensuring its wellbeing will ultimately benefit the conservation of *O. aegilica*.

The new orchids found on Antikythera during this study, combined with those mentioned for the island in the new "Atlas of the Greek orchids" (Antonopoulos & Tsiftsis 2017) add a total of 10 taxa to the existing plant list of Antikythera (Greuter & Rechinger 1967; Tzanoudakis & al. 2006), making for a total of 356 species. For *O. omegaifera*, *O. ceto* and *O. attica* (and possibly *O. dictynnae*) Antikythera even marks a new border of the distributional ranges of these species in Greece. Also, the fact that species such as *Neotinea maculata* and *Anacamptis papilionacea* subsp. *aegaea* were already at the end of flowering during the first half of March, underlines the importance of botanical surveys on Antikythera and other Mediterranean islands during the winter months in order to obtain

Table 2. Ecological and morphological characteristics of *Ophrys aegilica* compared to other closely related taxa from the *mammosa*-complex.

	Ophrys mammosa	*Ophrys spruneri*	*Ophrys doerfleri*	*Ophrys hansreinhardii*	*Ophrys taigetica*	*Ophrys aegilica*
Source	Delforge (2016: 554)	Delforge (2016: 549)	www.cretanflora.com	Hirth (2007: 509-513)	Presser & Hertel (2010: 160-167)	Own observations
Pollinator	*Andrena morio*	*Xylocopa iris*	*Andrena fuscosa*	*Andrena assimilis*	Unknown	Unknown
Distribution	North-eastern Medit.	Greece	Crete	Albania and Northwestern Greece	Peloponnese	Antikythera
Habitat	Short grassland, phryganae, scrub, open woodland;	Short grassland, phryganae, scrub, open woodland;	Phryganae, terraces, scrub, thin forests;	Chalk soil; phryganae with *Erica arborea*;	Mountain forests with *Abies cephalonica* and *Pinus nigra*	Phryganae with *Coridothymus capitatus* and *Sarcopoterium spinosum*;
Altitude	To 1400 m	To 900 m	To 1200 m	~ 600 m	950–1560 m	To 200 m
Flowering time	Mar – early May	Late Feb – early May	Mar – Apr	March – April	Mid May – early June	March – early April
Sepals	10 – 17 mm; 4 – 8 mm; olive green, lateral sepals bicoloured, tinted violet in lower half	10 – 16.5 mm; 5 – 6,5 mm; lateral sepals bicoloured whitish and dark violet-pink	Green-white to pink (like *O. spruneri*)	10.1 – 11.8 mm; 3.5 – 5 mm; green, lateral sepals lightly red tinted	12 – 14 mm; 3 - 6 mm; lateral sepals mostly green, sometimes light reddish in lower half	10.9 – 14 mm; 5.4 – 6.8 mm; greenish, lateral sepals bicoloured, basal half weakly to strongly reddish
Petals	7 – 12 mm; 2 – 4.5 mm; yellowish-green or purplish; little curvy; small or no hairs	7 – 12 mm; 2 – 4 mm; pink-purple or yellow-brownish; curvy	Often Pinkish-red; smooth or velvety; little curvy	7 – 8.6 mm; 2.3 – 5.1 mm; greenish, red-brown; little curves and small hairs	9 – 14 mm; 2 mm width, yellower or browner than sepals; little curvy and without hairs	7.2 – 9.5 mm; 2.9 – 4.0 mm; Yellow-green with reddish tinge; little curvy
Lip	12 × 17 mm; Entire; Reddish-brown to blackish-purple	12 × 17 mm; Tri-lobed; Blackish-purple	Smaller than *O. mammosa*; Entire, Convex (beak-like); Dark reddish to brown-black with paler red (rarely yellow) border	9.4 – 11 mm; Entire, Rounded-trapezoid; Blackish-purple	11 – 13 mm; Entire, Oval to rounded; Reddish Black-brown; sometimes with light red or yellow border	11.4 – 13.4 mm; Entire, Oval to rounded-trapezoid; Dark reddish-purple to brown-black, sometimes with light red (rarely yellow) border

Table 2. continued.

Mammosities	Yes	Usually absent	Yes	Small or absent	Usually absent	Usually absent
Peripheral Pilosity	Short, more at shoulder	Short, more at shoulder	Short, more at shoulder	Strong pilosity along entire lip margin	Short, more at shoulder	Short, more at shoulder
Appendage	Short or absent; greenish-yellow to crimson-brown	Short or absent; greenish to crimson-brown	Small to absent; yellow-greenish or red-brown	Short; yellowish-pink	Small; yellowish (rarely red)	Small; yellow-orange to light red
Speculum	H-shaped; glossy bluish-grey or lilac, sometimes with white border	H-shaped; glossy azure-blue with white border	H-shaped; glossy bluish-grey or lilac, usually with white border	Dissolved H-shape; bluish-purplish, rarely with white border	Dissolved H-shape; a bit blueish; sometimes with white border	H-shaped; bright metallic blue, sometimes with white border
Pseudo-eyes	Whitish-pale blue with grey central spot	Blackish-pale blue with grey central spot	Whitish to blue with grey central spot	Black	Black, sometimes with white border	Pale blueish
Stigmatic cavity colour	Blackish with blue specular stage	Blackish whit pale blue specular stage	Blackish, with bluish specular stage	Darker than lip, white or lila-ish specular stage	Coloured like lip with lighter specular stage	Blackish with white-blueish specular stage

complete floristics overviews of these places. Alike observations have been made on other, similar-sized Greek islands where some species are known to flower as early as late December (Antonopoulos & al. 2010). Especially when climatic conditions are as such that plants tend to wither and visually disappear altogether in the timespan of just a few weeks. Most of the flowering orchids encountered on Antikythera during the first half of March had completely vanished by the time of the second survey at the end of March, as was the case for instance for all individuals of *Oprhys bombyliflora*.

On Antikythera, orchids predominantly grow on abandoned agricultural terraces (Fig. 8; compare with Bevan & al. 2013: 258, Fig. 3c). As this habitat was created by humans, who have now largely left the island, the future presence of the orchids will mainly depend on the speed and type of vegetation succession (Kranjčev 2001). Directly after abandonment terraces hold a rich herbaceous flora with many annual species, but this is quickly followed by the establishment of the first woody perennials, such as *Coridothymus capitatus* and *Sarcopoterium spinosum*, but later also *Genista acanthoclada* DC., *Erica manipuliflora* and *Calicotome villosa* (Poir.) Link. (Tzanoudakis & al 2006; Palmer & al 2010). These phryganic communities are rich in orchids, but 20 – 60 years after cultivation has ceased, this habitat develops into low maquis with evergreen, sclerophyllous shrubs such as *Pistacia lentiscus* L., *Juniperus phoenicea* L. and *Quercus coccifera* L. (Palmer & al 2010). Over time the maquis grows taller and becomes nearly impenetrable and orchids are more restricted to the edges of the habitat or road sides. However, as Antikythera holds a large population of feral goats that browse the

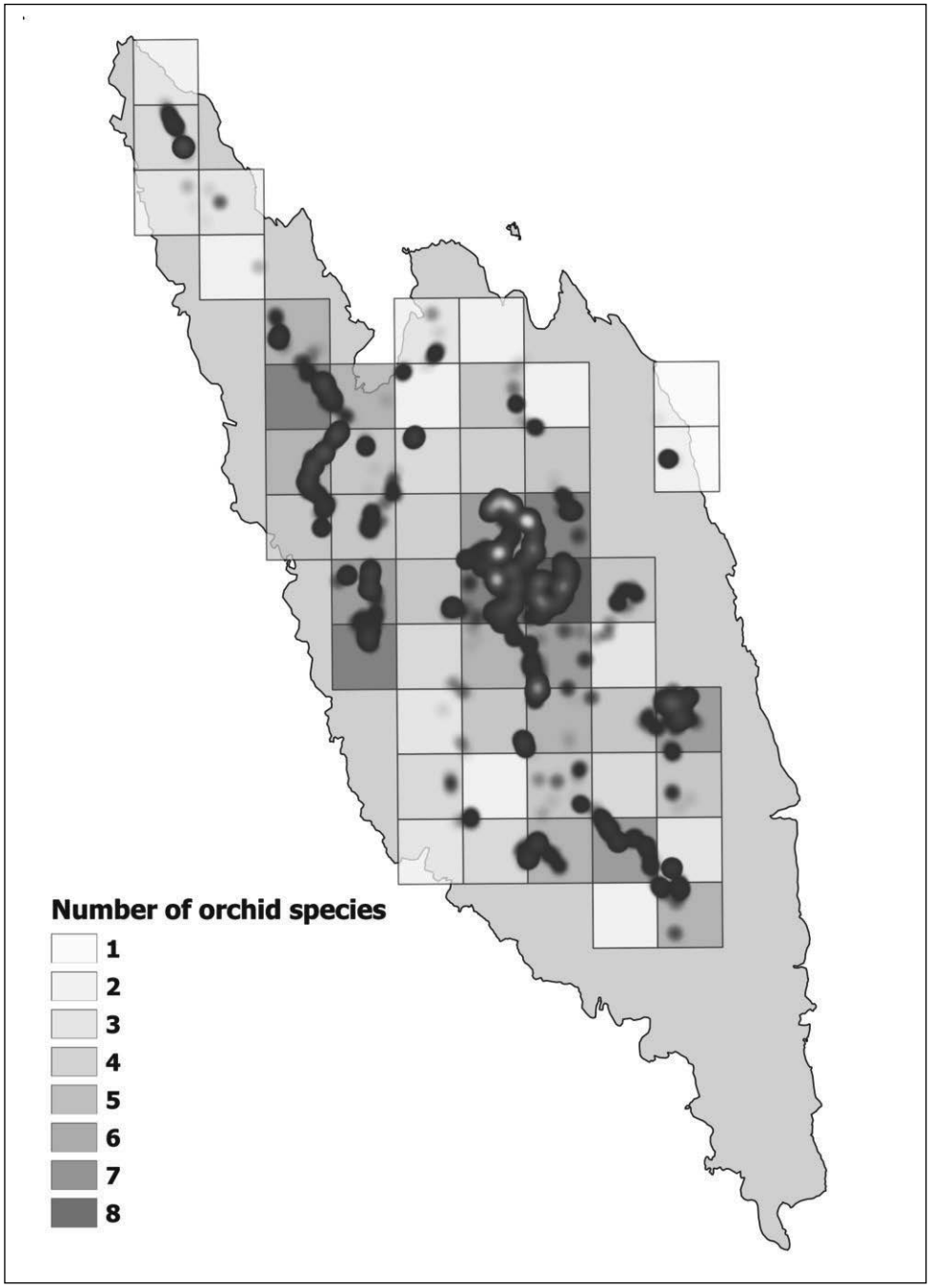


Fig. 8. Orchid richness of Antikythera, both in terms of number of species present within a 500 × 500 m square (the higher the diversity, the darker the shade of green) and overall abundance (heatmap based on all 14226 individuals, as listed in Table 1, in which brighter colours indicate higher abundance).

island, the succession of the vegetation is slowed down (Palmer & al. 2010). While grazing may benefit orchid populations on a larger scale by keeping the habitat more open and delaying succession, it can still have severe impacts on individual plants and species with small populations (Georghiou & Delipetrou 2010). During this study several orchids were observed that had been grazed and for *Ophrys attica* it even meant that the only two individuals found on the island were both eaten. Also, in the case of Antikythera it should be pointed out that the majority of orchids was found on abandoned agricultural terraces (Fig. 8); places from which goats were formerly excluded. Thus, for the maintenance of orchid populations on Antikythera, and the endemic *O. aegilica* in particular, it is important that the vegetation on some of the abandoned terraces keeps its open phryganic character, but preferably by other means than grazing.

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Article

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The vascular flora of Mount Limbara (northern Sardinia): from a troubled past towards an uncertain future

Abstract

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Mount Limbara is located in the north-eastern part of Sardinia (Italy). It is the third highest peak of the island and covers an area of 262.47 km². In the past, the studies concerning the flora of this mountain interested only restricted sectors or specific taxa, but a comprehensive floristic study of the whole territory was lacking. An annotated flora of the vascular flora growing in this area is here presented, based on field surveys carried out from 1993 to 2020, on the analysis of literature and on a review of specimens from five herbaria. The flora of Mount Limbara amounts to 1,147 taxa grouped in 46 orders, 120 families and 486 genera. The endemic and sub-endemic taxa are 86, while the alien flora consists of 137 taxa. The number of alien taxa is mostly related to human introduction. Among the taxa recorded in the past, 69 are here excluded and considered doubtful while 41 taxa are not confirmed. We compared the flora of Mount Limbara with that of other Sardinian mountains, highlighting the importance of this area, which appears to have the richest mountain flora of Sardinia, but also of the non-native flora. Finally, 132 taxa included in the Italian lists of threatened plants grow in the massif, thus adding conservation value to the study area.

Key words: checklist, endemism, native taxa, alien taxa.

Introduction

Plant checklists supply key information for biodiversity and ecological studies by providing a comprehensive summary of the floristic composition of a specific study area (Walker 2003). The literature is rich in local floras referring to small areas such as mountains, protected areas, islands and National parks. However, the completion of checklists requires a large amount of time in the field, species identification and conservation of samples, as well as bibliographic and herbarium research (Martellos & Nimis 2015).

For what concerns the island of Sardinia (Italy), there is a vast literature related to local floristic checklists, mostly carried out on coastal areas, smaller islands and islets, but also mountains (Arrigoni 2006). Nevertheless, among the highest mountains of Sardinia, only

the Gennargentu massif, with two different recent works published (Bacchetta & al. 2013, Arrigoni & Camarda 2014), can be currently considered a well-studied area.

Sardinia is the second largest island in the Mediterranean basin, with an area of 24,090 km². Its position in the centre of the Tyrrhenian area, together with the neighbouring island of Corsica, is due to slow movement from the Gulf of Lions/Provence, occurring between the late Oligocene and the early-middle Miocene (Bache & al. 2010). This implies an isolation of about 20 Ma (Carminati & Doglioni 2005), which is responsible for many environmental peculiarities of the two islands, though Sardinian flora is poorer than in other insular regions. It consists of 2,441 native taxa (Bartolucci & al. 2018a), while in Corsica 2,724 taxa are known (Jeanmonod & Gamisans 2013) and in Sicily as many as 2,787 taxa (Bartolucci & al. 2018a). This paucity could be partly related to the lower height reached by Sardinian mountains (Gennargentu, 1834 m; M. Corrasi, 1437 m; M. Limbara, 1359 m), if compared with Corsican (M. Cintu, 2706 m; M. Ritondu, 2622 m; Paglia Orba, 2525 m) and Sicilian ones (Etna, 3343 m; Madonie, 1979 m; Nebrodi, 1847 m).

Biogeographically, Sardinia and Corsica were considered part of a separated biogeographic province from Italo-Tyrrhenian, which includes the western coastal regions of Italy from Liguria to Calabria (Ladero Alvarez & al. 1987; Bacchetta & Pontecorvo 2005). More recently, the province including Sardinia, Corsica and the Tuscan Archipelago was considered the Sardo-Corsican super-province (Bacchetta & al. 2012). The whole territory of Sardinia has been divided into 6 biogeographical sectors and 22 sub-sectors: Mount Limbara is included in the Goceano-Logudorese sector and Gallurese sub-sector (Fenu & al. 2014).

The present study began in 1993. Our interest is justified by the considerable ecological importance of the site, due to the characteristic microclimate resulting from its location and altitude range but is also closely linked to its historical vicissitudes. This work goes to complete the knowledge of a mountain flora that, despite the presence of a previous floristic work (Veri & Bruno 1974), was still not sufficiently studied, given its importance in the Mediterranean context. Our aim was to provide a detailed checklist of the vascular flora of Mount Limbara, to enable future characterisation of its biotic environments, help in identifying target species, understanding ecological changes, as well as in the fulfilment of the management plan for the Special Area of Conservation ITB011109 “Monte Limbara”.

Materials and method

Study area

Geography of the mountain

The Limbara massif is located in north-eastern Sardinia, delimiting the historical regions of Gallura and Monte Acuto, and covers the municipalities of Berchidda, Calangianus, Oschiri and Tempio Pausania, in the administrative province of Sassari (Fig. 1). The total area studied in this work covers 262.47 km², of which 166.24 km² are included in the SAC ITB011109 “Monte Limbara”, designated by the Habitat Directive 92/43/EEC (Natura 2000 2017).

Mount Limbara has a limited elevation. The highest peaks reach about 1300-1350 m a.s.l. (P. Balistreri, 1359 m; P. Sa Berritta, 1352 m; P. Bandera, 1345 m; P. Giugantinu, 1333 m), but the SAC also includes the lowlands as low as 160 m a.s.l. along the northern shores of Lake Coghinas, making a total altitudinal difference of around 1200 m (Calvia 2016).

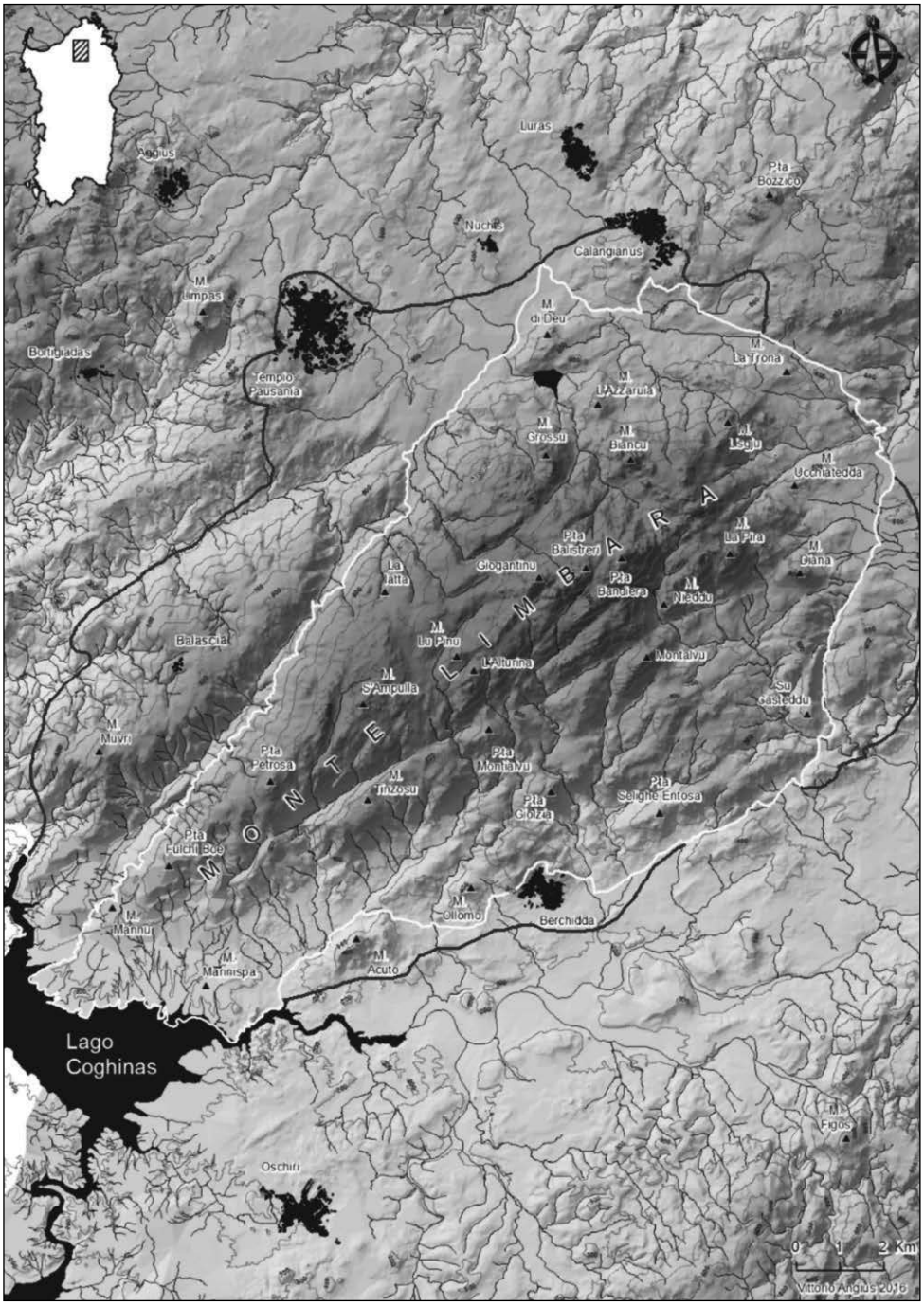


Fig. 1. Map of the study area. Black lines correspond to the borders of our study area; white line corresponds to the borders of the SIC ITB011109 “Monte Limbara”.

This research was carried out primarily within the boundaries of the SAC, also including four connected zones defining the best characterization of the area (Calvia 2016).

Bioclimate of Mount Limbara

The Limbara massif is characterised by the interaction between the Mediterranean climate (dominant in the lowlands) and the temperate climate (prevalent in the topmost zone). The presence of a non-Mediterranean bioclimate was firstly hypothesised by Arrigoni (1968a). Later, analysis of the thermo-pluviometric data from the station of Vallicciola (1050 m a.s.l.), for the years 1965-87, showed a sub-Mediterranean variant of the temperate bioclimate, with a lower supra-temperate thermotype, an upper humid ombrotype, and an eu-oceanic continental type (Farris & al. 2007). This is confirmed by the Bioclimate Map of Sardinia (Canu & al. 2015). Furthermore, three bioclimates were identified: Oceanic Pluviseasonal Mediterranean (lowlands); sub-Mediterranean temperate (transition areas) and Oceanic temperate (summit areas).

As regards the iso-bioclimates present in the study area, cartographic analysis enabled the identification of eight types (Canu & al. 2015): five types are included in the Oceanic Pluviseasonal Mediterranean bioclimate; two iso-bioclimates are included in the sub-Mediterranean temperate bioclimate; only one iso-bioclimate is attributable to the Oceanic temperate bioclimate.

Geological and hydrographical features

The mountain has a granitoid lithology dating back to the Hercynian orogeny of the Carboniferous (Carmignani & al. 2001). There are two main intrusive types with different facies: the inequigranular monzogranites on the north-eastern side of the area, and the equigranular leucogranites in the rest of the mountain (Carmignani & al. 2001). The only exception is found on the south-western sides of the massif, as far as the shores of Lake Coghinas, where the predominant lithoid types are metatexites and amphibolites with shorter intrusions, mainly granodiorite and vein rocks of different compositions (Carmignani & al. 2001).

The hydrogeological structure is defined by the hydrographic basins of the main rivers of northern Sardinia: all the streams flowing down the eastern and southern slopes of the mountain (Berchidda, Oschiri) flow into Lake Coghinas. The majority of the streams flowing down the north-western slopes of the mountain (Calangianus, Tempio Pausania) drain into Lake Liscia, with some exception, flowing into the Coghinas river. Finally, on the northern side (Calangianus), a single stream becomes part of the Rio Padrongianus and flows into the Gulf of Olbia (Calvia 2016).

In some areas, small water reservoirs have been created for fire protection use. Finally, another water reservoir was recently created on the northern slope of the mountain for water withdrawal use (Calvia 2016).

Vegetation

Historical writings depict a past landscape quite different from now: wide holm oak forests, vast cork oak woodlands in the basal areas and downy oak in the cooler ones. In the most mesophilous parts, yew and holly were widespread (Moris 1837-1859; Casalis 1851; Cavara 1908; Spano 1958; Desole 1966).

The current situation is greatly modified: cuts, charcoal-burning, wildfires and grazing have almost completely degraded the mountain vegetation, which consisted primarily of garrigue and scrub vegetation until the second half of the last century (Ruggero 1999). Then, a slow recovery of the native tree cover occurred but on the other hand, many non-native species, mostly conifers, have been introduced (Pavari 1935; Pavari & De Philippis 1941; Veri & Bruno 1974), accompanied by the implementation of significant hydraulic and forestry measures (Ruggero 1999).

Today the vegetation of the mountain is largely a mosaic characterised by different types of vegetation. Scrub and oak woodlands predominate, with the former tending often to evolve towards the latter. The holm oak woodlands extend over wide areas, but usually consist of coppices, rarely converted into high forests (Ruggero 1999). This kind of woodland is included in the vegetational associations *Galio scabri-Quercetum ilicis*, more thermophilous, and *Saniculo europeae-Quercetum ilicis*, more mesophilous (Bacchetta & al. 2009). Natural high forests are today very rare and generally localized in the steepest and wildest areas of the mountain. In the basal areas, the most represented type of woodland is the Sardinian calcifuge meso-Mediterranean cork oak association *Violo dehnhardtii-Quercetum suberis* (R.A.S.-P.F.A.R. 2007). There are other minor types of woodland such as the relict quaking aspen stands, or the maritime pine woodlands of the north-eastern sides (Calvia 2016). The less evolved soils are covered by mountain garrigue with Salzmann's broom and caraway thyme, an association known as *Violo limbaraе-Genistetum salzmannii* (Valsecchi 1994), interspersed with patches of grassland with therophytes and hemicryptophytes. An important chasmophyte flora thrives among the granite outcrops, belonging to the *Potentillion crassinerviae* alliance (Bacchetta & al. 2009) and *Arenarion balearicae* in the shadier ones (Biondi & al. 2014). The vegetation of temporary ponds and wet places falls within different associations of the *Isöeto-Nanojuncetea*, *Isöeto-littorelletea*, *Phragmito-Magnocaricetea* classes (Bagella & al. 2009). Finally, more than 1,800 ha are today covered by reforestations and many areas are now affected by naturalised or invasive trees (Ruggero 1999), especially conifers: e.g. *Abies cephalonica* Loudon, *Cedrus atlantica* (Endl.) Carrière, *Pinus nigra* subsp. *laricio* Maire, *P. pinea* L.

History of the studies

The early botanists who visited some parts of the Limbara massif were Moris (1837-1859), Reverchon (often cited by Barbey 1884) and Nicotra (1895, 1896). Herbarium specimens and publications by Cavara (1908) and Terracciano (1909, 1910a, 1910b, 1914) are available and are related to field excursions on limited areas of the mountain. Other findings are reported by Fiori (1913), Negodi (1931), Schmid (1933). During the second half of the 20th century, other scholars searched for specific taxa or studied vegetation and climate: Desole (1960, 1966), Joncheere (1963), Arrigoni & Vannelli (1967), Arrigoni (1968b, 1970), Arrigoni & al. (1976-1991), Valsecchi (1977a, 1979, 1993, 1994). In the last two decades the mountain has been cited in various floristic works (Fridlender 1999, 2000; Foggi & al. 2007; Desfayes 2008; Peruzzi & al. 2011; Sáez & al. 2011, and Farris & al. 2012).

The first checklist of the vascular flora of Mount Limbara amounted to 506 taxa (Veri & Bruno 1974). Though important from many points of view, it was incomplete, since the

cited authors surveyed only a few points scattered through the central zone of the mountain, while omitting the rest of the area, as well as all zones under 500 m a.s.l.

Data collection and analysis

We studied the flora of Mount Limbara mostly through research in the field, from 1993 to 2020. For each taxon found (excepted many orchids), we prepared one or more herbarium specimens that are now preserved in our herbaria (Roma-Marzio & al. 2017), or sometimes in CAG, FI, PAV, RO, and ROV (acronyms follow Thiers 2018).

In addition to research in the field, we carried out a bibliographic study, completed by observation of herbarium specimens from CAG, FI, RO, SS, and SASSA.

For each taxon we reported scientific name, biological and chorological type, abundance code, habitats, altitudinal range, first report on the area, herbarium specimen/s seen and notes (potential). For the alien taxa we add abbreviations, following Galasso & al. (2018a): A = adventitious; P = planted; CAS = Casual; INV = invasive; NAT = naturalised; OP = only planted (our addition).

For the systematics and nomenclature, we followed Bartolucci & al. (2018a) and Galasso & al. (2018a), except where the opinions of the authors differed, as specified in the notes. The plants were determined using Italian floras and floras of other countries (Fiori 1923-29; Tutin & al. 1964-80, 1993; Zangheri 1976; Pignatti 1982, 2017-2019; Bolòs & Vigo 1984-2001; Castroviejo & al. 1986-2015; Arrigoni 2006-2015; Jeanmonod & Gamisans 2013; Tison & de Foucault 2014), and through literature (Arrigoni & al. 1976-1991; Valsecchi 1977a, 1979; Jeanmonod & Gamisans 1992; Valsecchi 1993; Bacchetta & al. 2003; Domina & Arrigoni 2007; Garbari & al. 2007; Habashi & Jeanmonod 2008; Portal 2009; Frignani & Iiriti 2011; Peruzzi & al. 2011).

The biological forms follow Raunkiaer's classification (Raunkiaer 1934). The names of orders and families follow PPG I (2016) for pteridophytes, Farjon (2017) for gymnosperms, APG IV (2016) for angiosperms; genera are reported according to Peruzzi (2010). All the taxa within each family are listed in alphabetical order. All the scientific names are reported in bold and italic, but those considered alien are reported in italic only. The OP taxa have an additional asterisk (*).

Geographical abbreviations are reported following Pignatti (2017-2019).

We considered as endemics all taxa limited to the Sardo-Corsican biogeographic province (Bacchetta & al. 2012), as well as those included in other Italian regions (Peruzzi & al. 2014). Those present in limited areas of other countries are reported as sub-endemics. For (sub-)endemic taxa, geographic abbreviations follow Euro+Med Plantbase (2020).

Abundance is expressed as follows: EX = extinct; RRR = extremely rare, taxa found only once and not confirmed later; RR = very rare, taxa found in one or more localities, but with a number of individuals lower than 50; R = rare, taxa found in one or more localities but having a more consistent number of plants than the previous category; S = sporadic, taxa scattered in the area but not abundant; C = common, taxa found in a wide range of localities and locally abundant; CC = very common, taxa widespread in the whole study area and often dominant.

Results

The floristic list consists of 1,147 taxa (see appendix 1), which are divided as follows: 1,010 taxa native (88%), and 119 (10.4%) alien. An additional 18 taxa are OP (1.6%).

The flora includes 46 orders, 120 families (15 of which are alien/OP taxa only) and 486 genera (61 of which are alien/OP taxa only).

The taxa at the species level are 1,025, while 109 are the subspecies, 9 are hybrids and 4 are varieties. Pteridophytes consist of 13 families, 18 genera, 33 species. Gymnosperms are represented by 3 families, 11 genera and 22 species (18 of them introduced). Angiosperms are 104 families, 461 genera and 1,090 taxa, divided as follows: 17 families, 113 genera and 276 taxa are Monocots (20 of them non-native); 87 families, 350 genera and 814 taxa are Dicots (99 non-native).

The most represented families are *Asteraceae* (138 taxa), *Poaceae* (125), *Fabaceae* (110), *Caryophyllaceae* (38), *Apiaceae* and *Lamiaceae* (36). The richest genera are *Trifolium* (27 taxa), *Carex, Ranunculus* (18), *Juncus*, *Vicia* (17), *Euphorbia (15)*, *Galium* and *Medicago* (14).

Among the biological life forms, a predominance of therophytes is observed (see Fig. 2).

From a chorological point of view, all strictly Mediterranean (35.8%) and Euro-Mediterranean (16.4%) elements dominate (see Fig. 3).

The endemic contingent of Mount Limbara amounts to 86 taxa, belonging to 67 genera and 35 families. All the vascular endemics found are Angiosperms, with 64 Dicots and 22 Monocots. The most represented families are *Asteraceae* (12 taxa), *Lamiaceae* (8), *Asparagaceae*, *Iridaceae*, *Orchidaceae* and *Poaceae* (4).

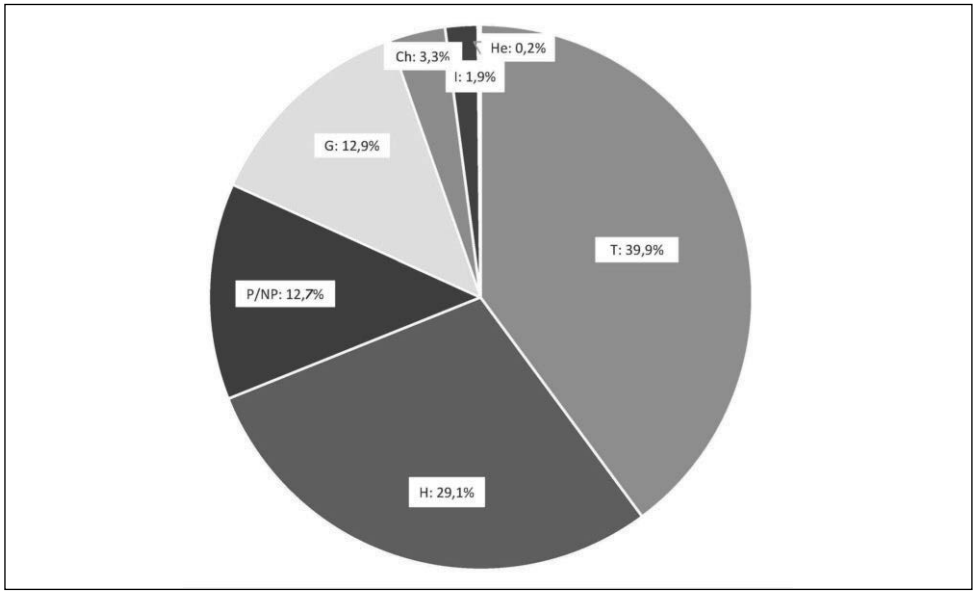


Fig. 2. Biological spectrum of the vascular flora of Mount Limbara.

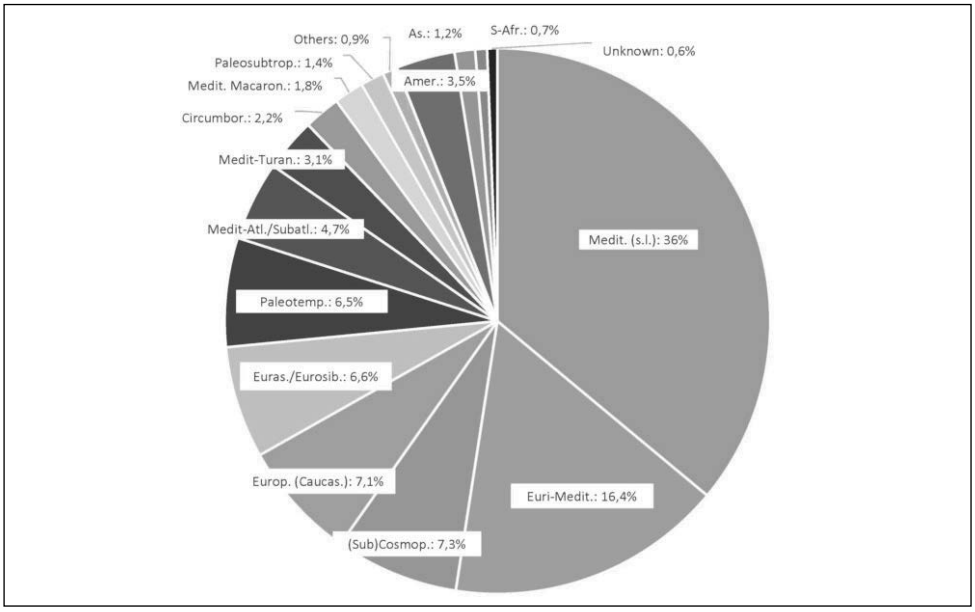


Fig. 3. Chorological spectrum of the vascular flora of Mount Limbara.

The chorology of the endemics shows a predominance of Sardo-Corsican taxa (see Fig. 4).

Three taxa are exclusive to Limbara (*Hieracium mattirolianum* subsp. *martellianum* (Zahn) Greuter, *H. racemosum* subsp. *limbarae* (Arrigoni) Greuter, *Rubus limbarae* Camarda), representing 3.5% of the entire endemic flora. Furthermore, 8 endemic taxa (9.3% of the total) have their *locus classicus* in the area: *Barbarea rupicola* Moris, *Festuca sardoa* (Hack.) K.Richt., *Hieracium bernardii* subsp. gallurense (Arrigoni) Greuter, *H. mattiroloanum* subsp. *martellianum*, *H. racemosum* subsp. *limbarae*, *Romulea* ×*limbarae* Bég., *Rubus limbarae*, *Viola limbarae* (Merxm. & W. Lippert) Arrigoni (see Béguinot 1908; Arrigoni 1985; Camarda 2003; Peruzzi & al. 2015).

The alien plants on Limbara are attested in 137 taxa, 47 of them are CAS, 67 NAT, 5 INV, while 18 are OP. From a chorological point of view, American taxa dominate, being 40 (6 of which are OP), followed by Asian (14, 3 OP) and Mediterranean (14, 2 OP).

The biological spectrum of the alien taxa shows the richness of phanerophytes, being 61 (nano-phanerophytes included), 18 of which are only planted. Therophytes follow, with 31 taxa, then there are 19 hemicryptophytes, 14 geophytes, 10 chamaephytes, and 2 hydrophytes.

We excluded 69 taxa reported by mistake and doubtful (see ESF 1). We separated 41 taxa reported before in the area, but not confirmed later nor found during this research (see ESF 1).

The taxa enlisted in the threatened lists amount to 132, corresponding to 13% of the native floristic contingent: 13 were classified as DD (Data Deficient), 73 LC (Least Concern), 27 NT (Near Threatened), 3 VU (Vulnerable), and 16 EN (Endangered).

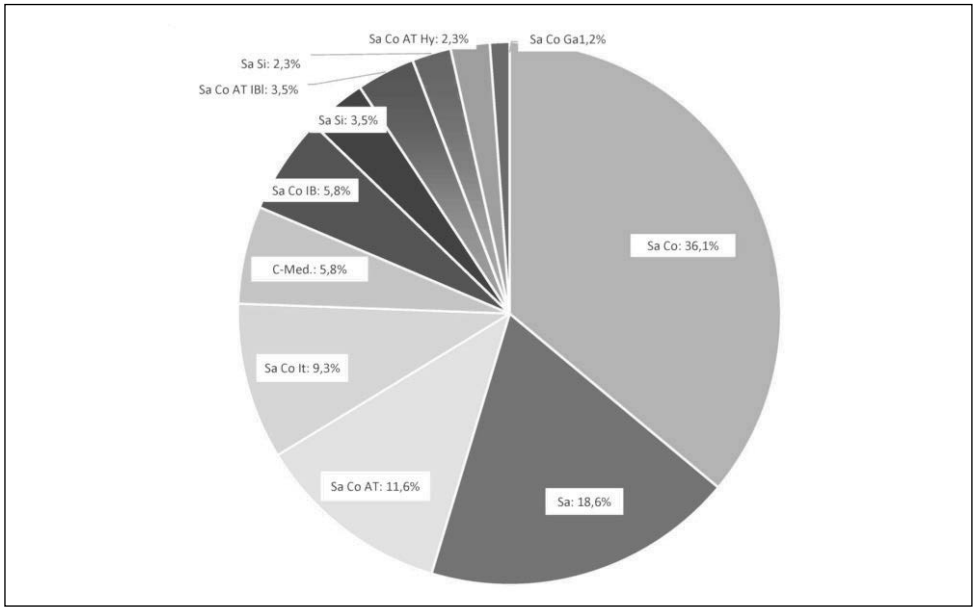


Fig. 4: Chorological spectrum of the endemic and sub-endemic taxa of the vascular flora of Mount Limbara.

Discussion

Biogeographic features and anthropogenic factors

The updated vascular flora of the Limbara massif consists of 1,147 taxa. This area, roughly corresponding to 1% of the entire Sardinia, hosts about 38.5% of its vascular flora (Galasso & al. 2018a). The 1,009 native taxa correspond approximately to 41% of the native flora of the island (Bartolucci & al. 2018a). However, the most imposing number is that of alien taxa, 119 (OP excluded), corresponding to 22.8% of the alien flora present in Sardinia (Galasso & al. 2018a).

The H/T ratio, indicator of the Mediterranean (H/T= <1) or continental (H/T= >1) nature of the flora (Cannucci & al. 2017), shows a general value lower than 1 in all the areas of the mountain lower than 1200 m a.s.l. The lowest value is on the basal zones (0.6) then increases with the altitude, reaching 0.76 between 500 and 800 m a.s.l., and 0.81 in the mountain area from 800 to 1200 m. Finally, the highest peaks have a value of 1.04. This data highlights the weak continentality of the tops of the mountain and a certain similarity with the 1.03 value provided from Foresta Anela, on the Goceano mountain chain (Farris & al. 2018).

One interesting fact emerging from this study concerns the chorological analysis, particularly about the endemic contingent. As the Limbara massif is located at an intermediate position between the southernmost mountain of Corsica (Montagne di Cagna, with similar elevation and geology) and the mountains of central Sardinia (Supramontes and

Gennargentu), the high number of Sardo-Corsican endemics is not surprising, corresponding to 36.1% of the entire endemic vascular flora. Considering in particular the Sardo-Corsican province (sensu Bacchetta & al. 2012), i.e. including the Tuscan Archipelago, it rises to 47.7%. The percentage of endemic taxa shared by Mount Limbara and Corsica increases to 76.8% when widely distributed taxa are considered. On the other hand, the endemics exclusive to Sardinia amount to 18.6%.

A further factor emphasising the affinity between Mount Limbara and Corsica emerges from the presence of several taxa that, despite having often a wider distribution elsewhere, in Sardinia grow only in Gallurese sub-sector (sensu Fenu & al. 2014) and on the Limbara massif in particular: e.g. *Cyclamen hederifolium* Aiton, *Daphne laureola* L., *Festuca sardoa* (Hack.) K. Richt., *Genista salzmannii* DC., *Knautia integrifolia* (L.) Bertol., *Ornithopus perpusillus* L., *Pinus pinaster* Aiton.

On the Limbara massif, the interaction between the Mediterranean climate of the lowlands and the temperate climate of the topmost zone can be observed (see Fig. 5). In this context, the slopes of the mountain (influenced by the Oceanic Pluviseasonal Mediterranean bioclimate) up to an altitude of approximately 500 m, show the highest presence of taxa, 927, corresponding to 80.9% of the whole flora, widespread in 102.11 km² (38.9% of the entire study area). Quite the opposite, the oceanic temperate zone, comprised from 1200 m to the peaks of the massif, hosts 440 taxa, corresponding to 38.4% of the total vascular flora of Mount Limbara, but concentrated in 2.6 km² (1% of the entire study area). This richness is partially due to the impact of human activities and the intense anthropisation of the area (roads, military bases, radio-television communicatory centres, parking areas), which degraded the surrounding zones, allowing the occurrence of a more synanthropic flora.

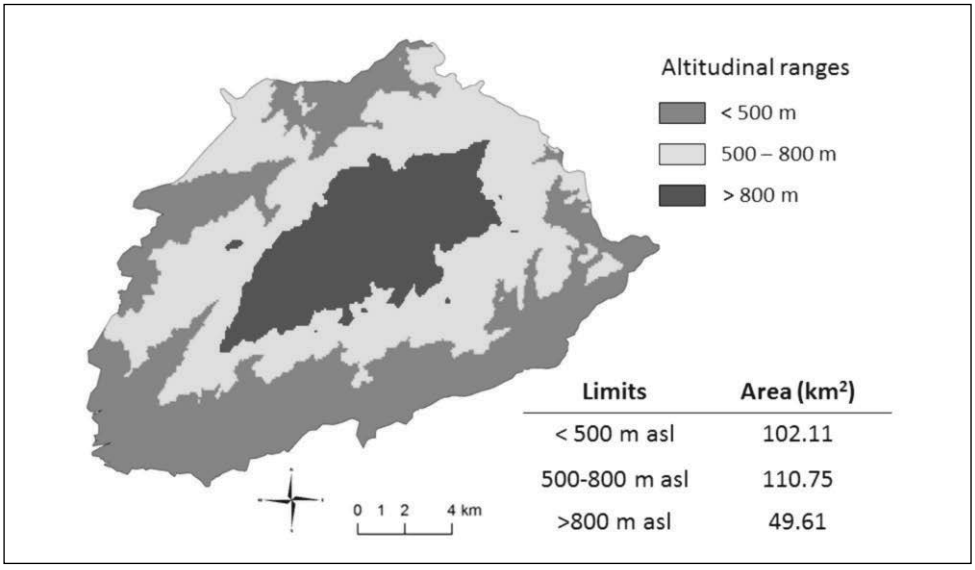


Fig. 5. Map of the elevation subdivision of the study area.

The strong anthropisation explains also the high percentage of alien taxa, probably the highest for what concerns the mountain areas of Sardinia. Comparing the flora of Mount Limbara and other floras, these differences are underlined: e.g. Montalbo had an alien contingent of 12 taxa only (Camarda 1984a); Marganai, 14 (Angius & al. 2011); Gennargentu, 38 (Bacchetta & al. 2013) (see Table 1). By comparing our data with those collected by Veri & Bruno (1974), further differences are observable (see Table 2). In particular, the amount of phanerophytes represents the most impacting data, being today 146 taxa. In the last forty-five years their number has drastically increased since the mentioned authors counted 81 taxa only (30 of which had been planted then or shortly before). This confirms the increasing number of alien taxa in the last decades. The 137 alien taxa currently known, corresponding to 11.9% of the entire mountain flora, are the result of a wide variety of actions, especially reforestations (76 taxa were directly introduced by cultivation), which have modified many aspects of the original landscape and are already affecting the stability of many mountain environments (Bartolucci & al. 2018b; Galasso & al. 2018b, 2019). However, the number of non-native and endemic taxa is inversely proportional from the lowlands to the tops. The higher number of alien taxa is found on the lower parts of the study area (91, 9.8% of the entire basal flora) while the endemics are 47 (5% only). These percentages are reversed at the tops of the mountain, where non-native taxa are 20 (4.7%) while endemics are 55 (12.5%). Hence, despite the large presence of human settlements and disturb, the natural value of the mountain tops is still significant, confirming the hypothesis of a nano-hotspot in this area, as proposed by Fois & al. (2018).

Conservation value of the mountain

We highlight the relatively high number of threatened taxa growing in the study area (Conti & al. 1997; Hugot 2010; Fenu & al. 2011; Cañadas & al. 2013; Caria & al. 2013; Marengo & al. 2015; Porceddu & al. 2015; Rossi & al. 2015; Fenu & al. 2016; Orsenigo & al. 2020; Rossi & al. 2020). The 132 taxa included in the red lists of the vascular plants of Italy, equal to 13% of the native flora of the mountain, suggest the conservation value of the massif. Despite 13 taxa are classified as Data Deficient, and other 73 as Least Concern, the presence of 27 Near Threatened, 3 Vulnerable and 16 Endangered taxa is valuable.

Of the taxa classified as Vulnerable, *Odontites corsicus* (Loisel.) G. Don and *Ranunculus ophioglossifolius* Vill. are common throughout the study area. *Marsilea strigosa* Willd. is common along the shores of Lake Coghinas. This population represents one of the richest communities of Italy in terms of number of individuals (Caria & al. 2013). Finally, among the endangered taxa, *Carex panormitana* Guss. and *Spiranthes aestivalis* (Poir.) Rich. have among the richest populations known worldwide, counting thousands of plants (Manca & Calvia 2012; Pisanu & al. 2013).

Interestingly, 41 taxa included in the red lists of the vascular plants of Italy are closely linked to wet environments, underlining the importance of these vulnerable habitats due to climate change and related consequences, as well as human induced disturbance (Filipe & al. 2013, Bagella & al. 2016, Angiolini & al. 2019). Some typical taxa of wet environments, previously collected on the area, are now locally extinct (*Ludwigia palustris* (L.) Elliott, *Ranunculus repens* L., *Spirodela polyrhiza* (L.) Schleid.) or are facing a reduction of their extent (e.g. *Anacamptis laxiflora* (Lam.) R.M. Bateman,

Table 1. Comparative analysis of the present flora and that described by Veri & Bruno (1974).

Typology	Native	Alien	Only planted	Total	%	% OP not included	% only native
Therophytes	427	30	0	457	39.9	40.5	42.3
Hemicriptophytes	314	19	0	333	29.1	29.5	31.1
Geophytes	134	14	0	148	12.9	13.0	13.2
Phanerophytes	85	44	18	147	12.7	11.4	8.4
Chamaephytes	28	10	0	38	3.3	3.4	2.8
Hydrophytes	20	2	0	22	1.9	2.0	2.0
Helophytes	2	0	0	2	0.2	0.2	0.2
Total	1010	119	18	1147	100.0	100.0	100.0
Present study							
Therophytes	157	0	0	157	29.4	31.0	31.1
Hemicriptophytes	185	0	0	185	34.6	36.6	36.6
Geophytes	85	0	0	85	15.9	16.8	16.8
Phanerophytes	51	1	29	81	15.1	10.3	10.1
Chamaephytes	25	0	0	25	4.7	4.9	5.0
Hydrophytes	0	0	0	0	0.0	0.0	0.0
Helophytes	2	0	0	2	0.4	0.4	0.4
Total	505	1	29	535	100.0	100.0	100.0
Veri & Bruno (1974)							

Pridgeon & M.W. Chase, *Epilobium montanum* L., *Mentha requieni* Benth., *Oenanthe lisae* Moris).

Though not mentioned in any list, several other taxa growing on Mount Limbara, that are rare at a regional level and are facing a decrease within their ranges, deserve protection (e.g. *Cyperus flavescens* L., *Lysimachia minima* (L.) U. Manns & Anderb., *Nymphaea alba* L.).

Paradoxically, not only rare plant species are contracting their habitats on the Limbara massif, but we speculate that also several synanthropic and nitrophilous taxa. Since the second half of the 20th century, many areas of the mountain started to be abandoned, then colonised again by pioneer taxa, as a consequence of land use change. Traditional pastoralism often required the usage of setting wildfires for obtaining new pastures for the flocks (Desole 1960). The abandonment of such activities freed vast areas of the mountain from the human pressure, thus allowing the slow recovery of high scrublands and woodlands (Calvia 2016). During the last decades, in protected areas of the mountain, as well as those where the ovine stocks have disappeared, the vegetation recovery is fast, as observed also in other Mediterranean areas (Lasanta-Martínez & al. 2005; Rocchini & al. 2006). Consequently, we have observed that a number of taxa connected with livestock, frequent in a recent past, are facing a rapid reduction from the central areas of the mountain (e.g.

Table 2. Comparative analysis between the vascular flora of Mount Limbara and those of other mountain areas of Sardinia.

Site	Elevation (m a.s.l.)	Area (km²)	No. of taxa	No. of natives	No. of endemics	% endemics	No. of non native	% non native	Source
M. Limbara	160-1359	262.5	1147	1010	86	7.5	137	11.9	This work
M. Limbara	160-500	102,1	927	836	48	5.2	91	9.8	This work
M. Limbara	500-800	110.8	891	817	57	6.4	74	8.2	This work
M. Limbara	800-1200	47	763	709	76	10	54	7.1	This work
M. Limbara	1200-1359	2.6	440	420	55	12.5	20	4.5	This work
M. Limbara	ca. 500-1359	n.r.	506	505	55	10.9	1	0.2	Veri & Bruno 1974
Gennargentu	1500-1834	16.8	214	n.d.	66	30.8	n.d.	n.d.	Arrigoni & Camarda 2014
Gennargentu	900-1834	240	675	n.d.	105	15.6	n.d.	n.d.	Arrigoni & Camarda 2014
Gennargentu	ca. 1000-1834	500	948	910	141	14.9	38	4	Bacchetta & al. 2013
Supramontes	0-1463	335	n.d.	n.d.	138	n.d.	n.d.	n.d.	Fenu & al. 2010
Anela forest	600-1158	12.8	391	391	45	11.5	n.d.	n.d.	Farris & al. 2018
Monte Albo	150-1127	68	659	647	49	7.5	12	1.8	Camarda 1984a
Monte Gonare	538-1083	10	520	513	23	4.4	7	1.3	Camarda 1984b
Sarrabus-Gerrei	0-1067	1597	1447	1327	112	7.7	120	8.3	Iiriti 2006
Marganai	200-939	36.1	648	634	73	11.3	14	2.2	Angius & al. 2011
Sardinia	0-1834	24090	2400	n.d.	ca. 215	ca. 9	n.d.	n.d.	Arrigoni 2006-2015
Sardinia	0-1834	24090	2408	n.d.	258	10.7	200	8.3	Conti & al. 2005
Sardinia	0-1834	24090	2441	2441	331	13.6	n.d.	n.d.	Bartolucci & al 2018a
Sardinia	0-1834	24090	2922	n.d.	n.d.	n.d.	481	16.5	Galasso & al. 2018a

Arum italicum Mill., *Carduus* sp. pl., *Chenopodium album* L., *Ferula communis* L., *Thapsia garganica* L., *Urtica* sp. pl.), though remaining frequent where agro-pastoral activities still occur. On the other hand, as woodland surfaces are increasing, some taxa which faced a dramatic collapse during the last centuries, e.g. *Ilex aquifolium* L., *Pinus pinaster*, *Taxus baccata* L. (Desole 1960, 1966), are now spreading again. This woodland recovery confirms the trend previously observed in other Italian contexts (Falcucci 2007; Puddu 2012; Barbati & al. 2013; Smiraglia & al. 2015; Farris & al. 2018).

Conclusions

After 27-year long research, the vascular flora of Mount Limbara is here presented, showing a plant richness that is the highest between the mountain areas studied this far in Sardinia. Despite the deep modifications occurred during the last centuries and the degradation due to human activities as well, the Limbara massif preserves a relevant flora. However, the checklist here reported includes also a high number of alien taxa (137). Consequently, the management problems, mostly connected to the introduction of alien taxa and soil modifications, such as drainage of wet sites, pose an intriguing question about the future variations of these threatened environments and their flora. With this study, we highlight the massive invasion that is taking place on many parts of the mountain, due to

the rapid naturalisation of pioneer species, e.g. *Cytisus scoparius* (L.) Link and *Pinus nigra* subsp. *laricio*. From this point of view, it is important also the comparison of our data with those reported by past authors, to understand how impacting are today the actions borne through the massive plantations of the recent past. Thus, the vascular flora of Mount Limbara, can represent a starting point for the further studies of the changes involving plant invasions in wild mountain areas, specifically in the Mediterranean area.

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Article

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Geographic distribution and population composition of *Ephedra fragilis* (*Ephedraceae*) in continental Italy

Abstract

Caruso, G & Montepaone, G.: Geographic distribution and population composition of *Ephedra fragilis* (*Ephedraceae*) in continental Italy. — Fl. Medit. 30: 315-326. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

Ephedra fragilis is a very rare plant in peninsular Italy. The only formerly known locality of this species is located at San Ferdinando, Calabria. The present survey, extended to 60 coastal and subcoastal localities of central-southern Italy, re-found and re-evaluated the conservation status (which resulted improved) of the already known locality of the studied species and found a new locality at Capo Bruzzano, Calabria. Unfortunately, in spite of the wide investigated area, the survey didn't find any new population outside the Calabrian territory.

Key words: conservation, coastal habitats, Calabria.

Introduction

The genus *Ephedra* L. (*Ephedraceae*) includes about 60 species living in arid environments distributed across the Mediterranean region, C-Asia, NW-America, Mexico, S-Andes and Patagonia (Meusel & al. 1965; do Amaral Franco 1986). In Europe, during glacial ages, implying xeric conditions, the genus reached its maximum expansion (Elenga & al. 2000). In the Italian vascular flora, *Ephedra*, according to Pignatti (2017), counts 8 taxa: *E. fragilis* Desf., *E. foemina* Forsk., *E. nebrodensis* Tineo in Guss., *E. distachya* L., *E. podostylax* Boiss., *E. dubia* Boiss., *E. helvetica* C.A. Mey. and *E. negrii* Nouviant.

E. fragilis Desf., described from North Africa (Desfontaines 1799), is a dioecious taxon, showing a W-Steno-Mediterranean distribution (Pignatti 2017), with also Macaronesian disjunctions (do Amaral Franco 1986). The autoecology of *E. fragilis* is linked to thermomediterranean, dry, sandy or rocky habitats, both along the sea coastline and near inland up to 300 m a.s.l. (Bell & Bachman 2011). According to Bell & Bachman (2011) the conservation status of this taxon is LC (Least Concern) at European level.

In Italy, while the occurrence of *E. fragilis* is well documented for Sicily (Giardina & al. 2007), the presence of this taxon on continental Italy has always been quite controversial. No recent record for this taxon is known (or confirmed) for the Italian peninsula. Although Calabria has recently recorded an increased number of published studies on native and inva-

sive alien species (among the most recent: Spampinato & al. 2017, 2018, 2019; Maiorca & al. 2020; Maruca & al. 2019; Musarella & al. 2019, 2020; Musarella 2020; Rosati & al. 2020), very few are the records of *E. fragilis* in the southernmost administrative region of continental Italy (Caruso & al. 2009, 2010b, 2012; Pignatti 2017). Due to Calabria geographical proximity to Sicily, the ecological similarities of these regions (especially coastal and subcoastal areas), as well as the formerly recorded occurrence of *E. fragilis* in this territory, although other continental administrative regions of Italy have been surveyed; Calabria has been considered the focus area for the purpose of this research.

Macrobioclimate of CS-Italy, according to Rivas-Martinez & Rivas-Saenz (1996-2019) bioclimatic classification system, and to the bioclimatic classification of Italian territory proposed by GIS Natura (Ministero dell'ambiente e della tutela del territorio, Direzione per la protezione della Natura, Politecnico di Milano 2005) is mostly Mediterranean along the coast and Temperate in the inland with the increasing altitude. Temperate macrobioclimate occurs on the Tyrrhenian coast from northern third of Tuscany, while on Adriatic coast from the northern half of Abruzzo. Ombrotype of the study area is mainly subhumid, and locally is dry in N-Calabria, E-Basilicata and most of the Apulian territory; the hyperhumid ombrotype is confined to the mountain areas. Thermotype is thermo-Mediterranean on the coastal areas of the southern sector of the studied area; going up on the Apennine range it becomes gradually meso-Mediterranean, supra-Mediterranean and supra-temperate. Other recent interpretations of the bioclimate of Italy, such as those provided by Pesaresi & al. (2014, 2017), despite well argumented, provide a more restricted interpretation of the thermo-Mediterranean belt, not suitable for our analysis. Anyway, most of the investigated stands (except those from 001 to 007) are encompassed by the thermo-Mediterranean belt as designed by Pesaresi & al. (2014, 2017).

In Calabria, *E. fragilis* has been historically recorded many times (Porta 1879; Fiori 1923-25; Chiarugi 1956; Zangheri 1976; Pignatti 1982; Géhu & al. 1984) but always confused with *Ephedra distachya* as shown by Caruso & al. (2012). In fact, Brullo & al. (2001) and Spampinato (2014) reported for Southern Calabria only *E. distachya* subsp. *distachya*. More recent data on Calabria vascular flora (Bernardo & al. 2011), based on field and herbaria surveys (Caruso & al. 2009, 2010, 2012) better defined the species distribution. Flora d'Italia (Pignatti 2017) based the treatment of *Ephedraceae* on Nouviant (1996, 1997a, 1997b, 1998a, 1998b) without the detailed data provided by Caruso & al. (2009, 2010b, 2012). Anyway, Pignatti (2017) confirms the occurrence of *E. fragilis* in Calabria, as well as Bartolucci & al. (2018), while both of them do exclude the occurrence of the investigated species in other continental regions of the Italian Peninsula. Calabria, a peninsula surrounded by 740 km of coasts, shows important differences between Tyrrhenian (mostly rocky) and Ionian (mostly sandy) coast (Regione Calabria 2001) often more or less environmentally modified (Biondi & al. 1996; Niccoli & Procopio 1995; Veltri & al. 2000; Regione Calabria 2001).

Aim of this work is to investigate and map, on reliable literature data and field research, the geographical distribution of *E. fragilis* in continental Italy, and provide updated information on the quantitative, distributive and ecological data, and on the conservation status of this rare species in the surveyed area.

Methods

Geographical distribution - The survey has been based on literature and field data. Field investigation (2010-2019) has been addressed to verify and update data from literature, as well as to seek new formerly unknown stands of *Ephedra fragilis*. Being Central-Southern Italy a quite huge study area, the autoecology of the investigated species has been considered in order to focus more restricted areas to be studied. Central Italy conventionally encompasses the region Tuscany, Latium, Umbria and Marche, while Southern Italy encompasses Abruzzo, Molise, Apulia, Basilicata, Campania and Calabria. Inside this wide territory, only those sectors compatible with the ecology of the investigated species have been taken in account in order to select the areas deserving further field survey. Altitudinal range 0-300 m a.s.l., short distance by the sea coast, thermo-Mediterranean thermotype, have been considered to select the suitable areas. Data on thermotypes has been provided by a shape file included into GIS Natura 2.0 DVD (Ministero dell'ambiente e della tutela del territorio, Direzione per la protezione della Natura, Politecnico di Milano 2005). A preliminary GIS analysis, performed with QGIS software excluded Tuscany, Abruzzo, Molise (no thermo-Mediterranean areas) and Umbria (no sea coast, no thermo-Mediterranean thermotype) from survey. Where the species occurs the single plants (at least those appearing physically separated by other plants) of the target species have been geo-referenced by a GPS device (Garmin Montana 615t) and specimen identification has been performed by Flora d'Italia (Pignatti 2017) and Flora Europaea (Markgraf 1964), while nomenclature of floristic surveys follows Bartolucci & al. (2018) and, for alien taxa Galasso & al. (2018). Screened data have been organized as a geographical database and outputted as maps representing the general and local distribution of the species.

As shown in Fig. 1 and in the Electronic Supplementary File 1 (ESF1) the total investigated locations are 60, mostly located in Calabria (41), in Basilicata (5), Campania (5) Latium (5) and Apulia (4).

Population structure analysis – The continental sub-population of the studied species has been registered and mapped. The formerly known Tyrrhenian location has been here treated as two different subpopulations, because artificially divided in two different sectors by some human infrastructures, but in the past probably part of a unique coastal dune system. Each single individual has been georeferenced, measured (height, occupied area) and other information has been collected: geology, altitude, sex (dioecious species), slope and orientation.

Results

Geographic distribution - The field work produced no positive results in the investigated 19 localities across Latium, Campania, Basilicata and Apulia, while 3 of the 41 localities surveyed in Calabria showed the occurrence of *E. fragilis*. Localities CAL012 and CAL013, already known from literature (Caruso & al. 2012) but formerly reported as a single population, are located at San Ferdinando N #1 and #2 (San Ferdinando municipality, Reggio Calabria province) on the Tyrrhenian coast. Stand CAL024, before the present survey totally unknown, is located at Capo Bruzzano (Bianco municipality, Reggio Calabria province) on the Ionian coast of Calabria (Fig. 2).

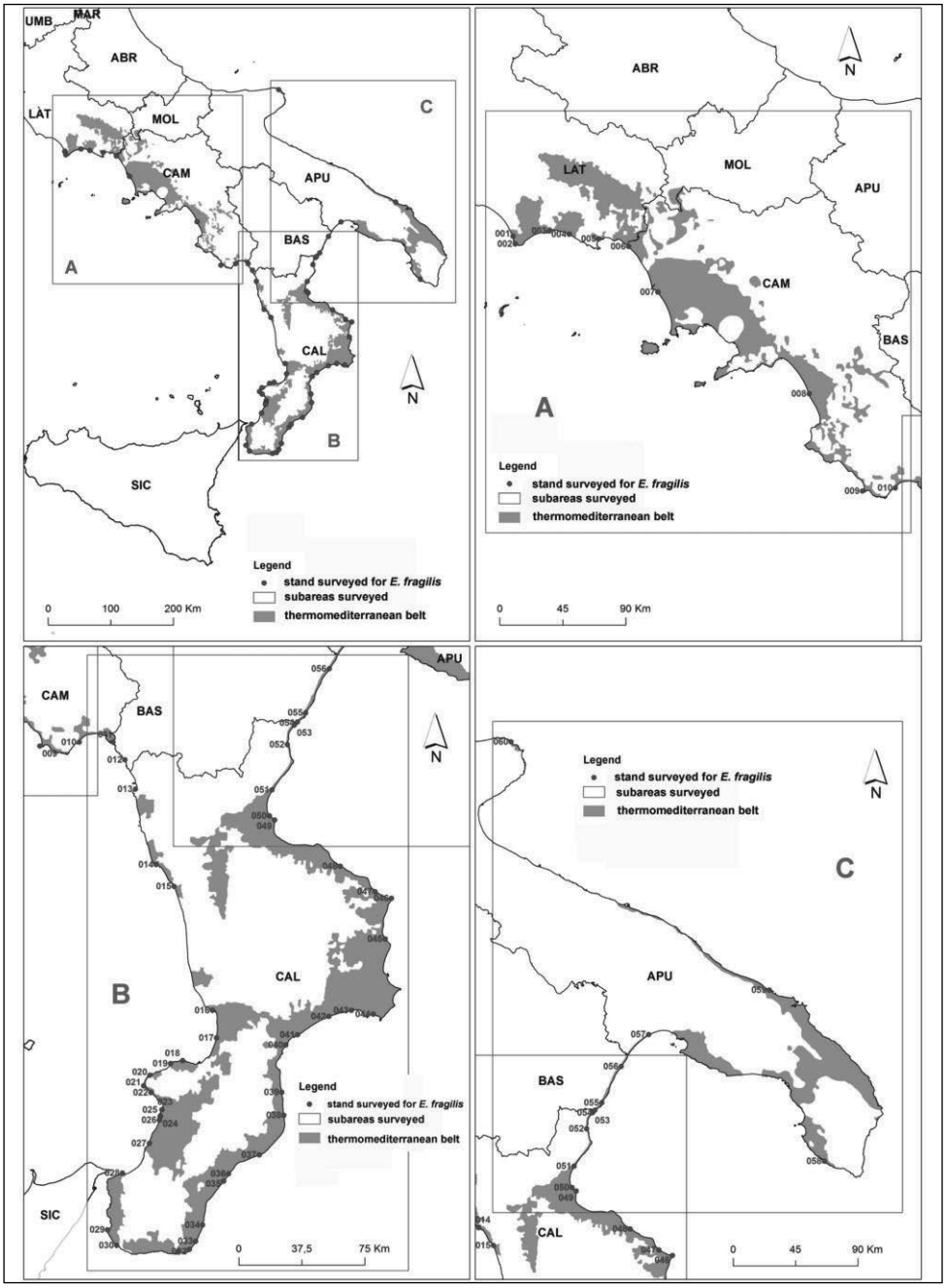


Fig. 1. Study area (Central-Southern Italy) and localities (blue dots) investigated in Latium, Campania, Basilicata, Calabria and Apulia administrative regions as part of this survey on *Ephedra fragilis*. The scale changes in different figures; the fuchsia color shows the thermo-Mediterranean thermotype belt.

Population survey – From the census of the continental sub-population of *E. fragilis* resulted the main group of plants occurs on the Tyrrhenian stands. Plants belonging to the investigated species in the area show three main different morphologies: young individuals, both coming from seed (generally well isolated, 2-5 m, from adult individuals) or from vegetative multiplication (often closer, 1-2 m, to the mother-plant), are less than 1 m high and usually cover an area 1 m^2 wide. Growing up, these individuals tend to cover a wider surface (circa 2-10 m^2) creeping away from the plant base, but they rarely increase their height over 2 m from soil. When in the immediate vicinity of the plant there is a shrub or a small tree *E. fragilis* behaves as a climbing vine, using these support-species as a tool to gain height (probably advantageous in seed dispersal) up to 4 m. Not uncommon are individuals (2-6) growing so close each other to be practically impossible to consider as isolated individuals (subunits; Tab. 1). Comparing the collected new data (Tab. 1) with those formerly available (Caruso & al. 2012) the stands (formerly treated as one biogeographic unit) increased from 17 to 36 individuals. Males are still 2, but females had grown from 4 to 8, while vegetative individuals from 11 to 26. The field survey found a formerly completely unknown new stand of *E. fragilis*. This sub-population counts 2 plants, supposedly young, with no apparent sex (due to absence of reproductive organs) (Fig. 3).

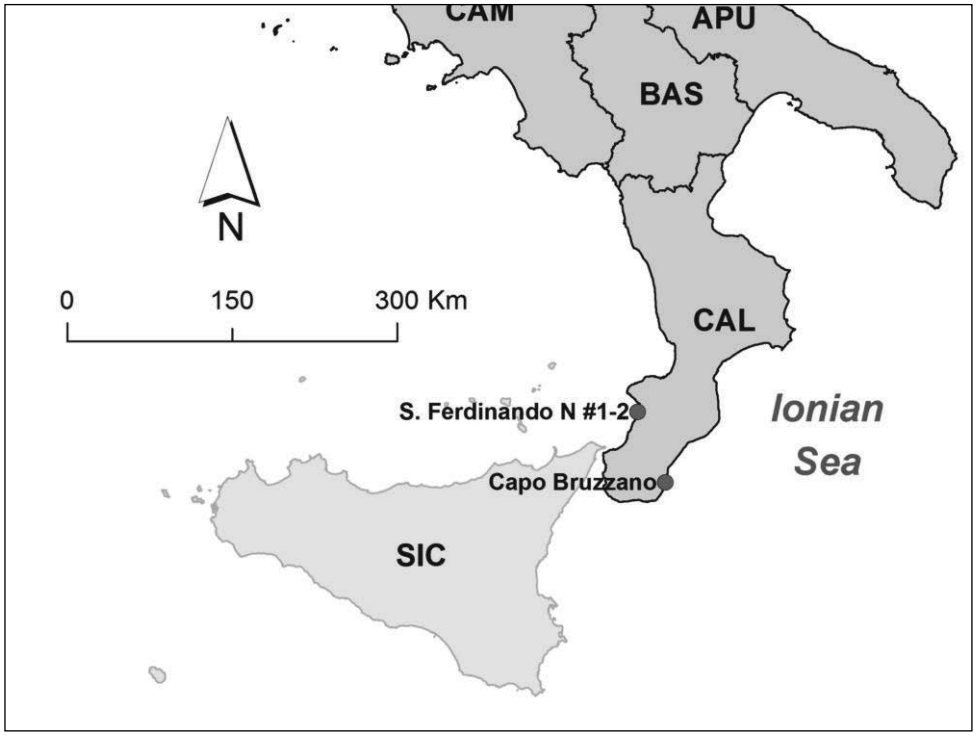


Fig. 2. Distribution of the localities (red dots) with *Ephedra fragilis* on continental Italy. Stands located at S. Ferdinando are difficult to distinguish each other (here represented by just one red dot) because at this scale symbols tend to overlap.

Table 1. Continental Italian population of *Ephedra fragilis*. Sex: V = vegetative; F = female; M = male; S = sand; SCH = schist; Geol. = geology; Area (in m^2): H = height in *m* (from soil); SUBUNITS = individuals forming the unit (counted as a single individual); SLOPE = inclination of the hillside (in sexagesimal degrees); Aspect = orientation of the hillside.

NR	SEX	LAT	LONG	ALT	GEOL.	AREA	H	SUBUNITS	SLOPE	ASPECT
CAL012-001	V	38° 29.73'N	15° 55.03'E	7	S	1	1	1	-	-
CAL012-002	V	38° 29.72'N	15° 55.03'E	7	S	14	2	1	-	-
CAL012-003	V	38° 29.71'N	15° 55.02'E	7	S	1	1	2	-	-
CAL012-004	F	38° 29.71'N	15° 55.03'E	7	S	3	1,5	1	-	-
CAL012-005	F	38° 29.71'N	15° 55.02'E	7	S	27	4	3	-	-
CAL012-006	V	38° 29.71'N	15° 55.04'E	7	S	10	2	2	-	-
CAL012-007	F	38° 29.71'N	15° 55.05'E	7	S	10	1	1	-	-
CAL012-008	V	38° 29.71'N	15° 55.04'E	7	S	1	1	1	-	-
CAL012-009	F	38° 29.70'N	15° 55.05'E	7	S	11	2	1	-	-
CAL012-010	M	38° 29.70'N	15° 55.02'E	7	S	6	1,5	1	-	-
CAL012-011	M	38° 29.68'N	15° 55.01'E	7	S	5	1,5	1	-	-
CAL013-001	V	38° 29.58'N	15° 55.00'E	7	S	2	1	1	-	-
CAL013-002	V	38° 29.58'N	15° 55.00'E	7	S	1	1	1	-	-
CAL013-003	V	38° 29.58'N	15° 55.33'E	7	S	12	1	1	-	-
CAL013-004	V	38° 29.57'N	15° 55.33'E	7	S	1,5	1	1	-	-
CAL013-005	F	38° 29.57'N	15° 55.01'E	7	S	2	1	1	-	-
CAL013-006	F	38° 29.57'N	15° 55.00'E	7	S	3,5	1	1	-	-
CAL013-007	V	38° 29.56'N	15° 55.03'E	7	S	2	1	1	-	-
CAL013-008	V	38° 29.56'N	15° 55.00'E	7	S	1	1	1	-	-
CAL013-009	V	38° 29.55'N	15° 55.00'E	7	S	6	1	1	-	-
CAL013-010	V	38° 29.54'N	15° 54.99'E	7	S	27	2	6	-	-
CAL013-011	V	38° 29.54'N	15° 55.02'E	7	S	13	4	5	-	-
CAL013-012	V	38° 29.52'N	15° 55.01'E	7	S	3	2	1	-	-
CAL022-001	V	38° 2.73'N	16° 8.64'E	30	SCH	1	1	1	45	SW
CAL022-002	V	38° 2.34'N	16° 8.64'E	40	SCH	1	1	1	45	SW
					TOT.	**165**		**38**		

Ecology and conservation – E. fragilis in absence of anthropic disturb successfully colonizes that flat sandy plain representing the highly altered remains of a coastal dune system. As written above, the number of plants has increased, and these numbers, quite modest in absolute terms, are, however, very important in a conservation perspective. The increasing number of plants demonstrate the ability of this species to colonize a so hostile environment and, above all, the positive trend of the local population, the unique formerly known stand of this very rare plant on continental Italy. This positive conservative outcome is mainly due to the actions wanted by the municipality administration that turned the abandoned area into a sub-urban park freely available for jogging and cycling, and, of course, colonizing plants. It's not clear if S. Ferdinando municipality was aware of the occurrence in the area of plants deserving conservation measures such as *E. fragilis* and the rare endemic *Retama raetam* subsp. *gussonei* (Webb) Greuter (*Fabaceae*) (Caruso & al. 2010a). Anyway, due to the inaccessibility to cars, plants had the opportunity to occupy, along the years, an increasing surface relatively undisturbed. The habitat is characterized by the occurrence of psammophilous taxa such as *Achillea maritima* (L.) Ehrend. & Y.P. Guo subsp. *maritima*, *Calamagrostis arenaria* subsp. *arundinacea* (Husn.) Banfi, Galasso & Bartolucci, *Artemisia campestris* subsp. *variabilis* (Ten.) Greuter, *Cakile maritima* Scop. subsp. *maritima*, *Convolvulus soldanella* L., *Centaurea seridis* subsp. *sonchifolia* (L.) Greuter, *Euphorbia peplis* L., *Crithmum maritimum* L., *Cyperus capitatus* Vand., *Echinophora spinosa* L., *Elymus farctus* (Viv.) Melderis, *Eryngium maritimum* L., *Glaucium flavum* Crantz, *Jasione montana* L., *Lobularia maritima* (L.) Desv., *Lotus cytisoides* L., *Matthiola sinuata* (L.) W.T. Aiton, *Medicago marina* L., *Paronychia argentea* Lam., *Polygonum maritimum* L., *Reichardia picroides* (L.) Roth, *Reseda alba* L. subsp. *alba*, *Salsola tragus* L., *Silene vulgaris* subsp. *tenoreana* (Colla) Soldano & F.Conti, *Sporobolus virginicus* (L.) Kunth., with other native species such as *Asparagus acutifolius* L., *Asphodelus ramosus* L. subsp. *ramosus*, *Chondrilla juncea* L., *Cynodon dactylon* (L.) Pers., *Linaria vulgaris* Mill. subsp. *vulgaris*, *Retama raetam* subsp. *gussonei*, *Rhamnus alaternus* L. subsp. *alaternus*, *Scolymus hispanicus* L. subsp. *hispanicus*, *Tamarix africana* Poir., *Verbascum macrurum* Ten. and a few alien taxa such as *Acacia saligna* (Labill.) H.L. Wendl., *Amaranthus blitoides* S. Watson, *Arundo donax* L., *Carpobrotus acinaciformis* (L.) L.Bolus, *Cestrum parqui* L'Her., *Eucalyptus camaldulensis* Dehnh. subsp. *camaldulensis*, and *Ricinus communis* L.

The *Ephedra fragilis* individuals found at Capo Bruzzano live on a semi-rupicolous steep slope, where soil is almost absent and the rocky basement is mainly represented by schist. The finding of this species in an area formerly investigated, although not systematically (Caruso 2015), confirms how difficult is to observe a small isolated individual in environments different from coastal dunes. The local flora reflects the mixed ecology of this cliff and the anthropic action: *Acanthus mollis* L. subsp. *mollis*, *Allium commutatum* Guss., *A. subhirsutum* L. subsp. *subhirsutum*, *Artemisia arborescens* (Vaill.) L., *Bituminaria bituminosa* (L.) C.H. Stirt., *Cytisus infestus* (C. Presl) Guss. subsp. *infestus*, *Centaurea sicula* L., *Centranthus ruber* (L.) DC. subsp. *ruber*, *Charybdis maritima* (L.) Speta, *Convolvulus elegantissimus* Mill., *Crithmum maritimum* L., *Daucus carota* subsp. *drepanensis* (Lojac.) Heywood, *Dittrichia viscosa* (L.) Greuter subsp. *viscosa*, *Euphorbia dendroides* L., *Ferula communis* L. subsp. *communis*, *Ficus carica* L., *Galactites tomentosus* Moench, *Hyparrhenia sinaica* (Delile) G. López, *Linum usitatissimum* subsp. *angus-*

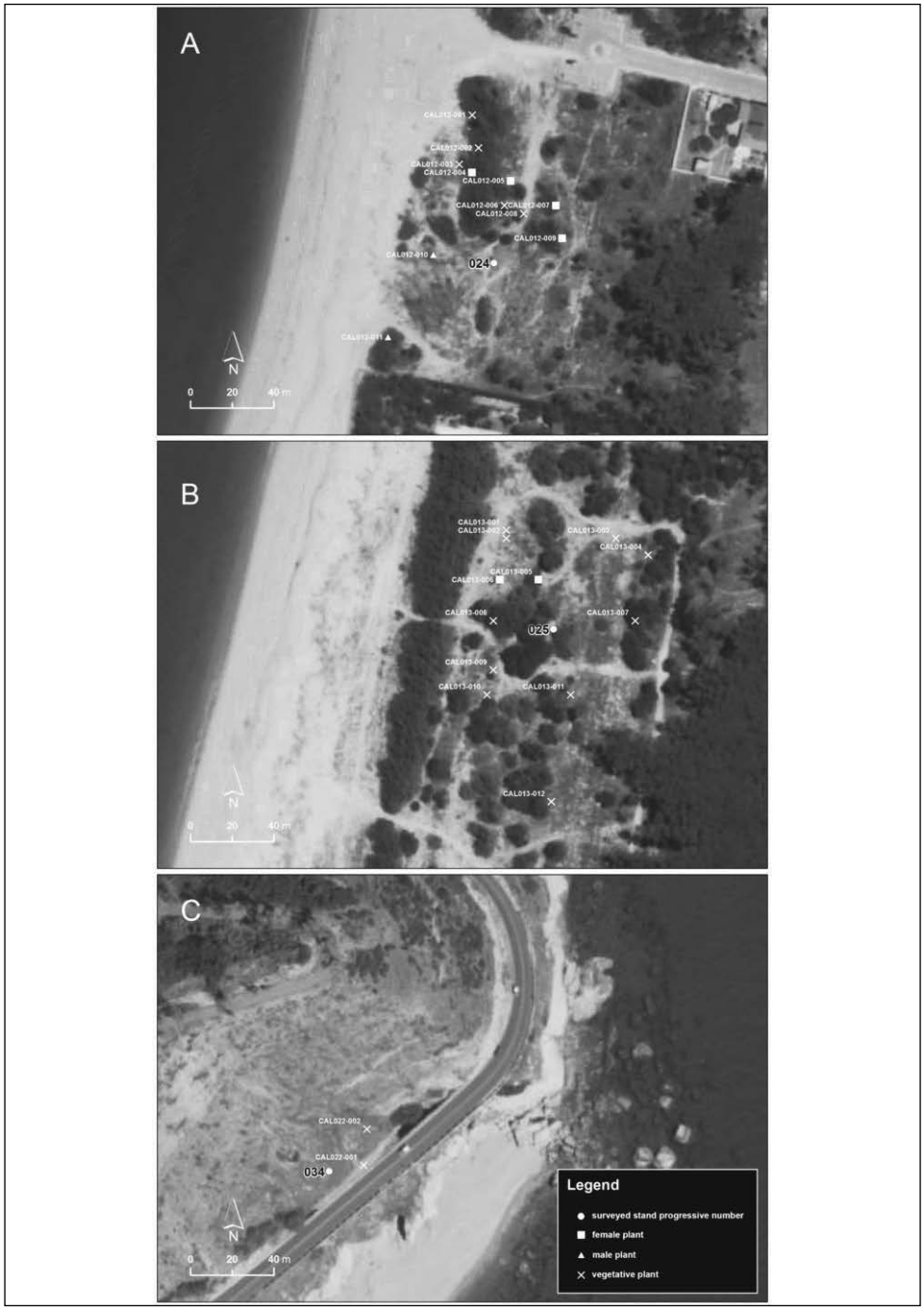


Fig. 3. Distribution of *Ephedra fragilis* plants in continental Italy stands. A = San Ferdinando N #1, B = San Ferdinando N #2, C = Capo Bruzzano.

tifolium (Huds.) Thell., *Lobularia maritima* (L.) Desv., *Lotus creticus* L., *Lygeum spartum* L., *Moricandia arvensis* (L.) DC., *Pancratium maritimum* L., *Phagnalon rupestre* subsp. *illyricum* (H. Lindb.) Ginzb., *Phlomis fruticosa* L., *Pistacia lentiscus* L., *Stachys major* (L.) Bartolucci & Peruzzi, *Rubia peregrina* L., *Scorpiurus muricatus* L., *Sixalix atropurpurea* (L.) Greuter & Burdet, *Smilax aspera* L., *Sulla coronaria* (L.) Medik., *Teucrium flavum* L. subsp. *flavum*, *Urospermum dalechampii* (L.) F.W. Schmidt.

A few threats persist for this plant in the studied area according to IUCN-CMP Unified Classification of Direct Threats (IUCN-CMP, 2013): small numbers of individuals (38), very few sub-populations (3), exiguity of suitable environment, recreative use of the area (1.3 Tourism & Recreation Areas), occurrence of alien invasive plant species such as *Acacia cyanophylla*, *Cestrum parqui*, *Eucalyptus camaldulensis*, *Pinus* sp. (8.1 Invasive Non-Native/Alien Species/Diseases), instability of the landslide slope at Capo Bruzzano (9.3.2 Soil Erosion, Sedimentation; 10.3 Avalanches/Landslides). Because of the persistent threats the species could still be considered highly at risk in the area, so deserving special measures of long-term monitoring and conservation.

Conclusions

The survey carried on along the coasts (and close inland) in selected areas of different regions of Central and Southern Italy, suggests that although the occurrence of *E. fragilis* on continental Italy cannot be categorically excluded, the only known stands of this species are actually located in Southern Calabria, two at San Ferdinando (Tyrrhenian coast), and one at Capo Bruzzano (Ionian Coast). Although numbers are at the moment increasing at San Ferdinando, the species is still locally under real extinction risk.

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Short note

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Kawther Hadj Khalifa & Ridha El Mokni

Vitex trifolia (*Lamiaceae*) a naturalized alien new to the non-native flora of Tunisia and North Africa

Abstract

Hadj Khalifa, K. & El Mokni, R.: *Vitex trifolia* (*Lamiaceae*) a naturalized alien new to the non-native flora of Tunisia and North Africa. — Fl. Medit. 30: 327-332. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

Vitex trifolia (*Lamiaceae*) is recorded for the first time for the non-native vascular flora of Tunisia and North Africa. Morphological description, distribution and habitat, as well as taxonomic notes, are provided. Original discriminant characters and a key of the genus in North Africa are also given.

Key words: aliens, *Lamiales*, new records, Mahdia.

Introduction

In continuation to our ongoing project aiming at updating and improving knowledge about vascular flora of Tunisia (see e.g. El Mokni 2018, 2019, 2020; El Mokni & Domina 2018, 2019, 2020a, 2020b; El Mokni & Iamonico 2018a, 2018b, 2019, 2020; El Mokni & Verloove 2019a, 2019b, 2020; El Mokni & al. 2019, 2020), extensive botanical surveys carried out within the central-eastern of Tunisia (Regions of Hammamet, Monastir, Sousse and Mahdia) allowed in 2015 the discovery of a naturalized population of *Vitex* L., previously non recorded in the country.

Vitex is one of the prominent genera in the family of *Lamiaceae* including about 300 species almost all occurring in the tropics (de Kok 2008), of which *V. agnus-castus* L. (chaste tree) is the only known as abundant taxon within the Mediterranean region and North Africa (WCSP 2020). The Arabian lilac (*Vitex trifolia* L.), a tropical shrub that is widely distributed in tropical countries is here reported for the first time from Tunisia and North Africa as a naturalized alien.

About the discovery

Vitex trifolia L. Sp. Pl. 2: 638. 1753.
≡ *Vitex agnus-castus* var. *trifolia* (L.) Kurz, Forest Fl. Burma 270. 1877.

Lectotype (designated by Moldenke & Moldenke 1983): India, *Herb. Linnaeus* 811/7 (LINN). Lectotype (Moldenke & Moldenke in Dassanayake & Fosberg, Revised Handb. Fl. Ceylon 4: 378. 1983): Herb. Linn. No. 811.7 (LINN).

Brief description

The plant has a shrubby **habit** with 60–220(–300) cm in height; branchlets puberulous; bark brown, slightly smooth (Fig. 1-A). **Leaves** with 1–3 leaflets (Fig. 1-B); petiole up to 30 mm long; leaflets chartaceous, obovate or elliptic, 2.5–7.5 by 1–4 cm, apex and base acute, margin entire; adaxial leaf surface dark green, glabrous, abaxial surface with glands and grey hairs; secondary veins 4–12- paired; petiolule absent. **Inflorescence** terminal in panicle-like cyme (Fig. 1-C), 5–20 cm long; peduncle 2–5 cm long; bracts foliaceous, obovate or oblanceolate, 2–5 by 1–1.5 mm with petiole 1–5 mm long; bracteoles linear, 1–2 mm long. **Calyx** green with pale purple; tube 2–4.5 mm long, outside with short grey hairs, inside glabrous; lobes 5, triangular, 0.3–0.5 mm long (Fig. 1-D). **Corolla** funnel shaped, 8–12 mm long, pale purple; upper lobe 2–3 by 2–3 mm, triangular, one lower lobe 6–7 by 4–6 mm, rounded with entire margin; tube 3–7 mm long, outside with cream short hairs, inside with white hairs (Fig. 1-D). **Stamens** filament glabrous with long whitish hairs at base; short filament 6.5–7.5 mm long; long filament 7.5–8.5 mm long; anthers 1–1.5 mm long, dark purple (Fig. 1-D). **Ovary** globose or ovoid; style 7–13 mm long; stigma 1–1.3 mm long. **Fruits** globose drupes, 5–8 mm in diameter, pale green or green turning to purplish black, black or dark brown when mature (Fig. 1-E). **Seeds** up to 4 per fruit. (de Kok 2007; Chantaranothai 2011)

Phenology

Flowering and fruiting all year round.

Habitat

The plant grows in an extended population in a loam-sandy costal field within Mahdia-City (East Central Tunisia).

Distribution

Widespread from North Australia east to Tahiti and north via Indonesia and the Philippines to China, India and Sri Lanka. Also reported from East Africa (Verdcourt 1992) and introduced on many islands (because of its local medicinal and ornamental use) in the Central Pacific and Hawaii (Wagner & al. 1999). The plant is reported also in Bangladesh, Japan, Vietnam, Malaysia, Brunei, New Guinea, Polynesia (Chantaranothai 2011). *Vitex trifolia* is known only from few European Mediterranean countries (Portugal, Spain and Italy) as cultivated (GBIF 2020; WCSP 2020) and till this work no record for North Africa (APD 2020).

Occurrence in North Africa and status of naturalization

Only one extend population is known in North Africa till now (more than 30 individuals in total) from Tunisia. The population is found in Mahdia region (East Central Tunisia) occupying about 3 ha. This population is observed since 2015 whereas our last observations are in August 2020. Based on this datum, and according to the actual wider area of occupancy noted for the species, we here propose *V. trifolia* as naturalized species in North Africa.

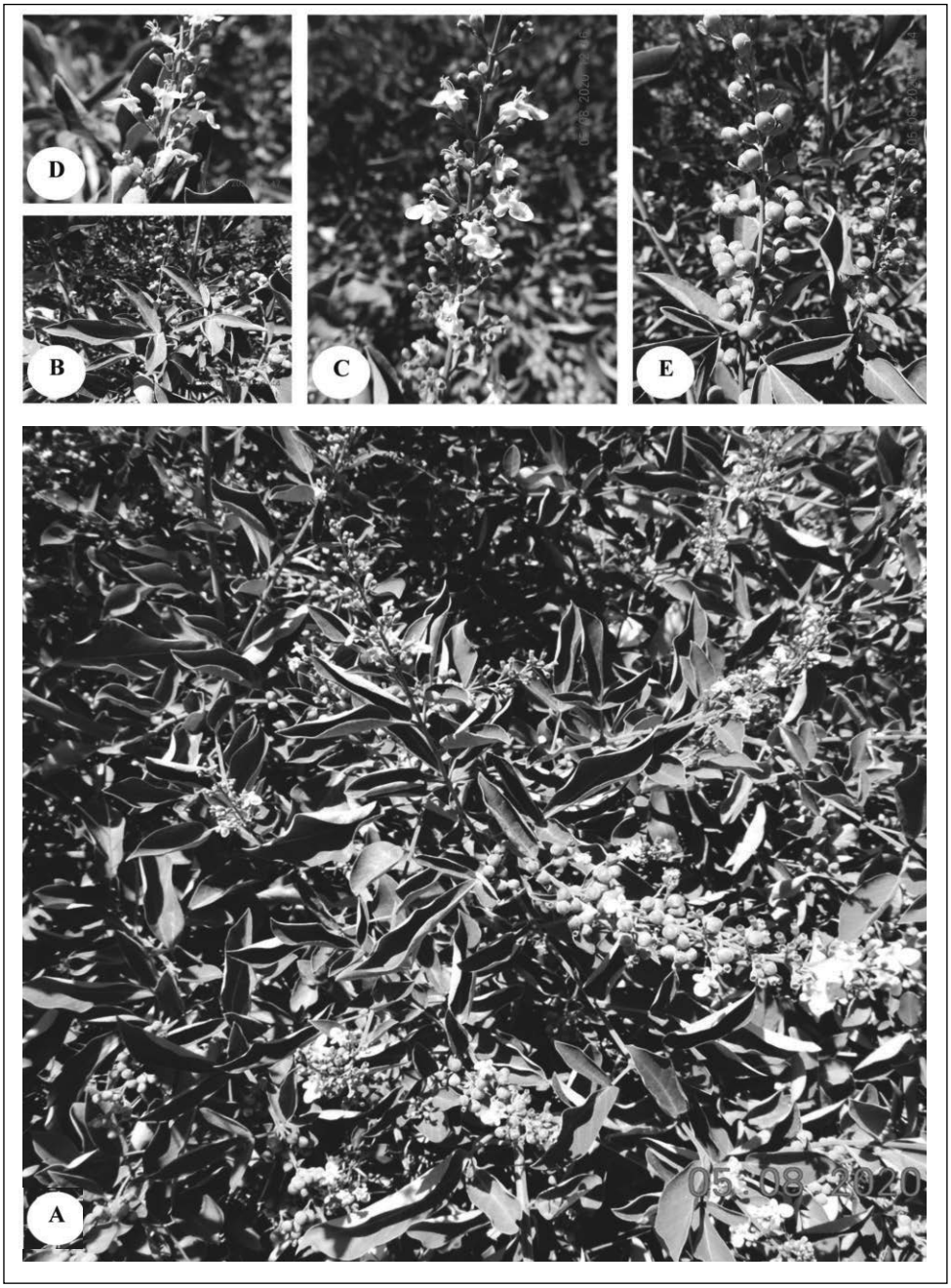


Fig. 1. Morphological features of *Vitex trifolia* in Tunisia: A. Plant habit in its blooming-fruiting period; B. typical three obovate sessile leaflets leaves; C. terminal panicle-like cyme inflorescence; D. flowers in profile view with green pale purple cupuliform calyx, funnel shaped bilabiate corolla, long style and exerted stamens; D. globose, ovoid pale green drupes (Mahdia, 05.08.2020) (Photographs by R. El Mokni).

Taxonomic notes

The species is part of a species complex comprising the Asian *Vitex negundo* L., the Mediterranean *V. agnus-castus* L. [incl. the W-Asian *V. pseudonegundo* (Hausskn.) Hand.-Mazz.] and the Australian *V. trifolia* subsp. *trifolia* [incl. *V. benthamiana* Domin.]. This complex is defined by a unique hair type and similar ecology. *Vitex trifolia* L. [syn. *V. agnus-castus* var. *trifolia* (L.) Kurz] has been confused with *V. negundo* L., which is a native to India but has been introduced into western Malesia. In comparison, *V. negundo* has relatively long leaves and large inflorescences with smaller cymes of flowers, and calyxes with 5 distinct pointed teeth (Singhakumara 1990). Moreover, *V. trifolia* L. differs from *V. negundo* L. in its obovate leaflets with mainly the central one being almost sessile (Chantaranothai 2011).

Examined specimens (new records)

TUNISIA: **Mahdia** (Mahdia-City, CE Tunisia), 35°29’43’’N, 011°03’26’’E, 1-5 m a.s.l., 29 December 2015, *R. El Mokni s.n.* (Herb. Univ. Monastir); *ibidem,* 05 August 2020, *R. El Mokni s.n.* (Herb. Univ. Monastir).

Key to species of *Vitex* L. occurring in the wild in North Africa (incl. Tunisia)
(New taxon in bold)

1. Leaves 1–3 (rarely 5)- foliolate, leaflets often obovate, the central almost sessile. Cymes (panicle-like) lax……..……..……..……. ***V. trifolia***
1. Leaves 5–7- foliolate, leaflets usually lanceolate. Cymes sessile or sub-sessile, forming compact verticillasters in a subcylindrical, narrow inflorescence ..... *V. agnus-castus*



Fig. 2. Occurrence of *Vitex trifolia* (▲) in the Mahdia region, Tunisia.

Acknowledgements

We express our thanks to all colleagues and friends from the RCDA of Mahdia for their help during our field studies.

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Article

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P. P. Ferrer-Gallego, J. Gómez, R. Roselló, E. Laguna & J. B. Peris

Type designation of *Cistus* ×*canescens* Sweet (*Cistaceae*)

Abstract

Ferrer-Gallego, P. P., Gómez, J., Roselló, R., Laguna, E. & Peris, J. B.: Type designation of *Cistus* × *canescens* Sweet (*Cistaceae*). — Fl. Medit. 30: 333-338. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

The typification of the name *Cistus* × *canescens* (*Cistaceae*) is discussed. The designation of the nomenclatural type is based on the assessment of the protologue and the original elements used by the author to describe this plant. The name is lectotypified using an illustration included in the protologue.

Key words: *Cistus*, hybrid, lectotype, nomenclature.

Introduction

Cistus L. (*Cistaceae*) includes about 20 species from the Mediterranean basin, reaching the Caucasus Mountains to the east and the Canary Islands to the west (Warburg 1968; Arrington & Kubitzki 2003). However, its highest diversity is found in the western Mediterranean, with about 14 species occurring in the Iberian Peninsula and northwestern Africa (Guzmán & Vargas 2005). Some taxa of this genus are not well characterized morphologically and are not always easy to identify, such as *C. creticus* L. aggr. (see, e.g., Paolini & al. 2009; Lo Bianco & al. 2017; Pignatti 2017, 2019; Moosmang & al. 2020). In addition, there are several more taxonomically complex hybrids and cultivars (Demoly 1994, 1996).

Species of *Cistus* have been in cultivation for centuries in renowned collections (see Sweet 1825-1830), due to their spectacular blooming and wide variation of hybrid forms that are grown successfully (Demoly 1996). Consequently, some authors, as for example Linnaeus (1753), based many of their descriptions on cultivated material from European botanic gardens, the origin of which was usually uncertain, and their morphology being sometimes anomalous due to cultivation or *in situ* hybridization processes.

The present paper, is a new contribution to the nomenclature in *Cistaceae* (see, e.g., Ferrer-Gallego & Laguna 2012; Ferrer-Gallego & al. 2013a, 2013b, 2020; Ferrer-Gallego 2015a, 2015b; Ferrer-Gallego & Boisset 2015), and the name *Cistus* × *canescens* Sweet, pro species is typified to contribute to the stability of the nomenclature.

Materials and methods

The designation of the type of *Cistus* ×*canescens* is based on the consultation of original elements and the literature cited in the protologue. In typifying name, we strictly followed the International Code of Nomenclature for algae, fungi, and plants (Turland & al. 2018). The identity of the designated type is verified with the current use and traditional concept of the name.

Results and discussion

Cistus ×*canescens* is a hybrid between *C. albidus* L. and *C. creticus* L. (Dansereau 1940; Demoly 1994; Gómez Navarro & Roselló 2008) and was described from cultivated plants from the nursery of Mr. Lee, at Hammersmith (a district of west London, England). The nursery garden founded by James Lee (1715-1795), was one of the most respected and most successful English establishments of ornamental plants, and also one of the oldest in the neighborhood of London, which survived until the early part of the 20th century.

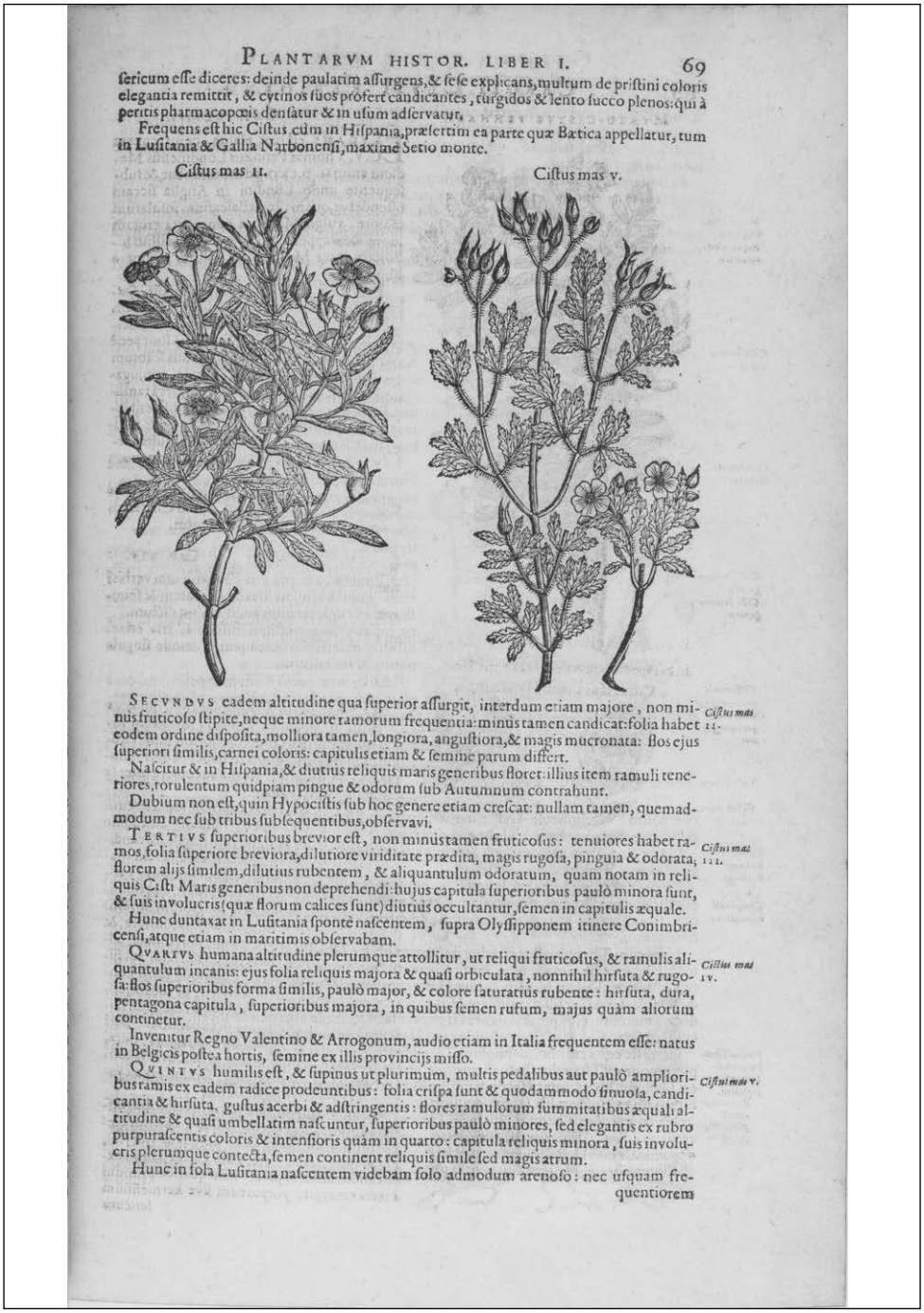
About the year 1760, Mr. James Lee entered into partnership with Mr. Lewis Kennedy, gardener to Lord Bolton, at Chiswick, and commenced a nursery, in what was called The Vineyard, at Hammersmith. Mr. James Lee and his partner established a successful Horticultural Nursery, remarkable for obtaining from distant countries everything rare and beautiful to be obtained. They maintained collector at the Cape of Good Hope, and another in America and enjoyed world-wide celebrity. Every known, rare, or new plant could be obtained there. Along with Linnaeus, Mr. Lee wrote *An Introduction to Botany*, published in 1760 (see Linnaeus & Lee 1760), which went through five editions, and for many years was in the highest repute.

Sweet (1827) described *Cistus canescens* providing a short diagnosis "C. *canescens*, foliis oblongo-linearibus obtusiusculis tomentoso-canescentibus undulatis subtrinerviis sessilibus subconnatis, pedunculis terminalibus unifloris aut subcymosis, sepalis ovatis acutis nervosis stellato-pubescentibus, petalis obovatis distinctis", and followed by three synonyms, the first synonym "Cistus canescens. Sw. hort. brit. p. 468, n. 29" was cited from an earlier work of the author, the second "Cistus mas 2" was cited from Clusius (1601: 69) and the third synonym "Cistus incanus β. foliis linearibus longis" was cited from Candolle (1824: 264). The protologue also includes a complete description of this plant, a vernacular or common name "Narrow-leaved hoary Rock-Rose", and a relevant comment: "Our drawing of this rare and handsome plant was taken at the Nursery of Mr. Lee, at Hammersmith, last Summer. It has generally been considered as a variety of C. *incanus*, but we have no hesitation in giving it as a distinct species, easily distinguishable at first sight from all others, whether in flower or not; as it is a native of the South of Europe, it is rather more tender than some of the other species, and requires a little covering in severe frosty weather, either the covering of a mat, or to be protected by a frame, succeeding well in a light sandy soil. Young cuttings, planted under hand-glasses in August or September, will soon strike root, but they must not remain covered too long, or they will be liable to damp off".

The illustration included in the protologue (Sweet 1827 tab. 45) is an excellent color drawing of this plant, with leaves and flowers (Fig. 1). This element is original of Sweet and a good candidate to be selected as lectotype of *C.* ×*canescens*.



Fig 1. Lectotype of *Cistus* ×*canescens* Sweet, illustration "*Cistus canescens*" in Sweet, Cistineae: tab. 45 (1827).



PLANTARVM HISTOR. LIBER I. 69

sericum esse diceres: deinde paulatim assurgens, & sese explicans, multum de pristini coloris elegantia remittit, & cytinos suos profert candicantes, turgidos & lento succo plenos: qui à peritis pharmacopœis dentur & in usum adservatur.

Frequens est hic Cistus, cùm in Hispania, præsertim ea parte quæ Bætica appellatur, tum in Lusitania & Gallia Narbonensi, maxime Setio monte.

Cistus mas II. Cistus mas V.

SECVNDVS eadem altitudine qua superior assurgit, interdum etiam majore, non minùs fruticoso stipite, neque minore ramorum frequentia: minùs tamen candicat: folia habet eodem ordine disposita, molliora tamen, longiora, angustiora, & magis mucronata: flos ejus superiori similis, carnei coloris: capitulis etiam & semine parum differt. *Cistus mas II.*

Nascitur & in Hispania, & diutius reliquis maris generibus floret: illius item ramuli teneriores, rorulentum quidpiam pingue & odorum sub Autumnum contrahunt.

Dubium non est, quin Hypocistis sub hoc genere etiam crescat: nullam tamen, quemadmodum nec sub tribus subsequentibus, observavi.

TERTIVS superioribus brevior est, non minùs tamen fruticosus: tenuiores habet ramos, folia superiore breviora, dilutiore viriditate prædita, magis rugosa, pinguia & odorata; florem alijs simlem, dilutius rubentem, & aliquantulum odoratum, quam notam in reliquis Cisti Maris generibus non deprehendi: hujus capitula superioribus paulò minora sunt, & suis involucris (quæ florum calices sunt) diutiùs occultantur, semen in capitulis æquale. *Cistus mas III.*

Hunc duntaxat in Lusitania sponte nascentem, supra Olyssipponem itinere Conimbricensi, atque etiam in maritimis observabam.

QVARTVS humana altitudine plerumque attollitur, ut reliqui fruticosus, & ramulis aliquantulum incanis: ejus folia reliquis majora & quasi orbiculata, nonnihil hirsuta & rugosa: flos superioribus forma similis, paulò major, & colore saturatiùs rubente: hirsuta, dura, pentagona capitula, superioribus majora, in quibus semen rufum, majus quàm aliorum continetur. *Cistus mas IV.*

Invenitur Regno Valentino & Arrogonum, audio etiam in Italia frequentem esse: natus in Belgicis postea hortis, semine ex illis provincijs misso.

QVINTVS humilis est, & supinus ut plurimum, multis pedalibus aut paulò ampliorib⁹ ramis ex eadem radice prodeuntibus: folia crispa sunt & quodammodo sinuosa, candicantia & hirsuta, gustus acerbi & adstringentis: flores ramulorum summitatibus æquali altitudine & quasi umbellatim nascuntur, superioribus paulò minores, sed elegantis ex rubro purpurascentis coloris & intensioris quàm in quarto: capitula reliquis minora, suis involucris plerumque contecta, semen continent reliquis simile sed magis atrum. *Cistus mas V.*

Hunc in sola Lusitania nascentem videbam solo admodum arenoso: nec usquam frequentiorem

Fig. 2. Original material of *Cistus* ×*canescens* Sweet, illustration "Cistus mas II" in Clusius *Rariorum plantarum historia* (1601: 69).

In addition, the reference of Clusius (1601: 69) cited in the protologue provided an illustration "Cistus mas II" that can be considered also original material used by Sweet to describe this plant. This drawing illustrates a stem with leaves and flowers (Fig. 2), and was originally published and described by Clusius (1576: 136-137). This illustration could be identified as belonging to *C.* ×*canescens*, and perhaps also to *C. creticus*.

On the other hand, we have not been able to locate any further original material in any consulted herbaria (e.g., at BM, CGE, G, K, L, LINN, MW, P, UPS, etc.). Robert Sweet (1783–1835) was a British horticulturist and botanist, nursery-man at Stockwell (1810-1815), at Fulham (1815–1819) and Chelsea (1819–1826). This author described several taxa from cultivated specimens, and their herbarium is preserved at CGE and MW (see Stafleu & Cowan 1986). However, at CGE and MW there are no specimens of *C.* ×*canescens*.

In conclusion, among the original elements, the Clusius's and Sweet's illustrations, we designate as the lectotype of the name *Cistus* ×*canescens* the excellent drawing "*Cistus canescens*" published by Sweet (1827). This illustration match with the current use and traditional concept of the name (see e.g., Dansereau 1940; Martín Bolaños & Guinea 1949; Demoly 1994; Gómez Navarro & Roselló 2008).

Cistus* ×*canescens Sweet, Cistineae: "45 *Cistus canescens*", tab. 45. 1827 pro. sp. [= *C. albidus* L. × *C. creticus* L.]

Lectotype (designated here): illustration "*Cistus canescens*" in Sweet, Cistineae: tab. 45. 1827 (Fig. 1).

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Article

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Georgi Kunev

Fumana bonapartei and *F. aciphylla* (*Cistaceae*), new additions to the Bulgarian flora

Abstract

Kunev, G.: *Fumana bonapartei* and *F. aciphylla* (*Cistaceae*), new additions to the Bulgarian flora. — Fl. Medit. 30: 339-345. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

The occurrence of *Fumana bonapartei* and *F. aciphylla* in Bulgaria is reported here for the first time. Both species were found together at a single site on serpentine slopes near the village of Zagorichane, East Rhodope Mts. The diagnostic features of each species have been compared with those of other members of the genus already known for the country. An identification key to all four Bulgarian species of *Fumana* has been provided. Population structure and size, and floristic composition at the new sites as well as a preliminary assessment of the conservation status of both species are also presented.

Key words: Balkans, new records, identification key, native species, serpentinophytes.

Introduction

In Bulgaria, *Fumana* (Dunal) Spach has been presented up to date by two taxa (Markova 1979; Assyov & Petrova 2012; Petrova & Vladimirov 2018), namely the widespread *F. procumbens* (Dunal) Gren. & Godr., and *F. arabica* (L.) Spach known from one region only (Velčev & al. 1966). The presence in the country of *F. ericoides* (Cav.) Gand., listed for Bulgarian flora by Raab-Straube (2018), needs confirmation, since it has been neither reported in floristic references (Markova 1979; Kožuharov 1992; Delipavlov & Chesmedzhiev 2011; Assyov & Petrova 2012), nor deposited at any national indexed herbaria (SO, SOM and SOA).

Materials and Methods

On 13.05.2019, a botanical trip was held to a region in East Rhodope Mts., known for its rich and interesting flora (Pavlova & al. 2003; Stoyanov & Marinov 2020). A subsequent careful examination of photos taken during the trip and a review of the relevant literature suggested that an unknown for the Bulgarian flora species of *Fumana* might have been photographed. This encouraged the two consecutive botanical trips in the following

year. As a result, two previously unencountered species of the genus have been found and collected in a single site near the village of Zagorichane, Kardzhali district. During the first trip on 17.05.2020, individuals of both taxa were at the beginning of flowering period; during the second trip on 14.06.2020, individuals of both taxa were at fruiting stage. The diagnostic characters were noted from both living plants and collected specimens after examination under stereomicroscope. Collected materials were deposited at the herbarium of Sofia University "St. Kliment Ohridski" (SO) and that of the Institute of Biodiversity and Ecosystem Research at the Bulgarian Academy of Sciences (SOM). For identification purpose, the key to the genus *Fumana* (Heywood 1968) was used as a main source, and cross-checked with data from Boissier (1867), Maire & Petitmengin (1908), Coode (1965), Markova (1979) and Bogdanović & al. (2012). To verify the identification, the collected specimens were compared with a number of exsiccata, including type materials kept at SO, VAL, K, E, P, MA, WU, MPU and MW. Most of the exsiccata were obtained as scanned or photographic images at GBIF.org (2020) or provided from the collectors after personal communication. The habitat's physical characteristics and floristic composition were noted by the author at the field, and combined with data from previous studies (Pavlova & al. 2003; Stoyanov & Marinov 2020). Climatic conditions are presented according climate model (Climate-Data.org 2020). The numbers of individuals of the reported species were counted in limited parts of the area and after that, their total number for entire site was estimated by assumption.

Results

The detailed morphological analyses confirmed that the studied specimens represent undoubtedly *Fumana bonapartei* Maire & Petitm. and *F. aciphylla* Boiss. This is the first report of the presence of both taxa for the Bulgarian native flora.

F. bonapartei can be distinguished from other species of the genus in Bulgaria by its glandular-viscid inflorescence axis, glabrous, linear to narrowly lanceolate, shortly mucronate leaves, as well as by the fruit capsule, which usually bears six seeds (Fig. 1). *F. bonapartei* is a Balkan endemic and an obligate serpentinophyte, documented until now from Albania, Bosnia-Herzegovina, Montenegro, Serbia (incl. Kosovo), North Macedonia and Greece (Stevanović & al. 2003; Raab-Straube 2018; Carrió & al. 2020). *F. aciphylla* is distinctive by its erect to ascending habitus and glaucous green appearance. Plants are usually glabrous (except scattered cilia on leaf margins), fruit capsule is three seeded and seed surface is shallow broadly pitted (Fig. 2). The species has been known thus far from Asiatic Turkey and Greece (Coode 1965; Greuter & Raus 1984; Babalonas 1989; Tan & Strid 2008; Raab-Straube 2018; Carrió & al. 2020). All of its European localities are confined to areas with serpentine substrates.

Key to the Bulgarian species of *Fumana*

1. Leaves oblong-elliptic to broadly lanceolate, stipulate.....***F. arabica***
1*. Leaves linear to narrowly lanceolate, exstipulate **2**
2. Plants glaucous. Stems erect or ascending, glabrous. Capsule with 3 seeds ..... ***F. acyphilla***
2*. Plants green. Stems procumbent or ascending, pubescent. Capsule with 6–12 seeds **3**



Fig. 1. Habitus (a), terminal inflorescence (b) and seed capsule (c) of *Fumana bonapartei* from the Eastern Rhodopes, Bulgaria. Photos by Georgi Kunev.

3. Indumentum glandular. Flowers few 2–4(–7). Pedicels distinctly longer than adjoining leaves .....***F. bonapartei***

3*. Indumentum eglandular. Flowers solitary. Pedicels equal or shorter than adjoining leaves .....***F. procumbens***

Ecological conditions at the locality. **-** In Bulgaria, *Fumana bonapartei* and *F. aciphylla* are found on open rocky slopes with low to moderate inclination (up to 15 °) surrounded by pine forest plantations. The serpentine outcrops cover up to 70% of the studied area. Soil layer is nearly absent or it is very shallow. The climate is hot-summer Mediterranean (Csa), with mean annual temperature 12.5 °C and precipitation maximum in December. The vegetation is composed by chamaephytes mostly, among which dominate obligate serpentinophytes such as *Convolvulus boissieri* subsp. *compactus* (Boiss.) Stace, and the recently described as new to science *Thymus jalasianus* Stoyanov & Marinov (Stoyanov



Fig. 2. Habitus (a), terminal inflorescence (b) and seed capsule (c) of Fumana aciphylla from the Eastern Rhodopes, Bulgaria. Photos by Georgi Kunev.

& Marinov 2020). Frequent are also *Genista anatolica* Boiss., *Fumana procumbens* (Dunal) Gren. & Godr., *Sedum ochroleucum* Chaix, *Teucrium montanum* L., *Euphorbia myrsinites* L., *Paronychia kapela* (Hacq.) A.Kern., *Cheilanthes marantae* (L.) Domin, *Plantago subulata* L., *Agropyron cristatum* subsp. *pectinatum* (M. Bieb.) Tzvelev, *Chrysopogon gryllus* (L.) Trin., *Asperula purpurea* (L.) Ehrend., *Danthonia alpina* Vest, *Linum tauricum* subsp. *bulgaricum* (Podp.) Petrova. The locality is inhabited by some local or Balkan endemics and species with restricted distribution in the country, such as *Silene fetleri* D. Pavlova, *Aethionema rhodopeum* D. Pavlova, *Saponaria stranjensis* Jordanov, *Onosma kittanae* Strid*, Verbascum humile* Janka, *Silene cretica* L., and *Trifolium globosum* L.

***Population size and structure*. -** The study site is located at 41°22’47.06”N, 25°19’33.74”E, 1.5 km northwest of Zagorichane village, Kardzhali district (Fig. 3). A

total area of 37.5 ha was studied in order to evaluate the distribution, population structure and its size for each of the species. The population of *F. bonapartei* covers the whole study site (i.e. 37.5 ha), consists of about 300 individuals and has mosaic structure: individuals are sparsely distributed across the study site in groups of up to five plants, or solitary. The population of *F. aciphylla*, found at the same site, is more dense and uniform in appearance. It is composed of approximately 350 individuals within an area of 1.5 ha (Fig. 3). Given the small population size and the single known so far locality on the territory of

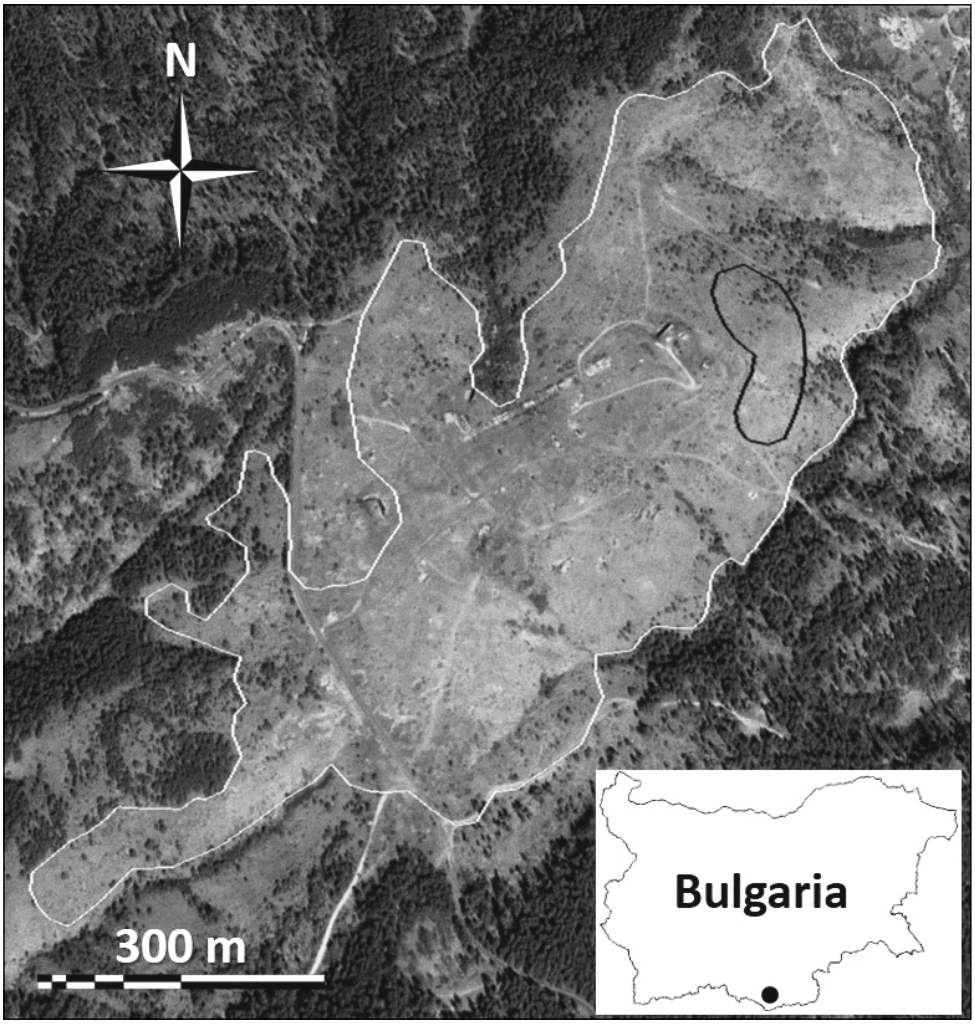


Fig. 3. Area and location of *F. bonapartei* and *F. aciphylla* in Bulgaria. The black dot in the smaller panel is the position of their first known population site in the country. In larger, ortho-photo map, the white contour delineates the population area of *F. bonapartei* (37.5 ha), whereas the area outlined in black presents the population area of *F. aciphylla* (1.5 ha).

Bulgaria, both taxa meet provisionally the national status of 'Critically Endangered' according to the IUCN Red List Criteria (IUCN 2012). However, serpentine sites with suitable habitat conditions for both taxa cover much larger area in Eastern Rhodopes (Kozhoukharova 1984, 1985; Pavlova & al. 2003), thus more locations of *F. bonapartei* and *F. aciphylla* could be expected in a course of future investigations.

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Article

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Contribution to the seed morphology of some Greek *Campanula* species of sect. *Quinqueloculares* (*Campanulaceae)*

Abstract

Liveri, E., Kalachanis, D., Bareka, P., Grammatikopoulos, G. & Kamari, G.: Contribution to the seed morphology of some Greek *Campanula* species of sect. *Quinqueloculares* (*Campanulaceae*) — Fl. Medit. 30: 347-363. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

The seed morphology of 16 Greek taxa of *Campanula* section *Quinqueloculares*, 14 of them are endemic to Greece, is studied using Scanning Electron Microscopy. Data on the size, shape, and colour of the seeds are provided and the seed coat morphology is described. The seed morphology is found to be relatively uniform except the seed coat. Two different patterns are described based on the type of striations on the seed surface. The seed coat morphology of the studied taxa is compared to the Turkish relatives of *C.* sect. *Quinqueloculares* highlighting the variation of the section. Overall, seed morphology was found to be an overlooked feature in Greek *Campanula* taxa. Our study sets, for the first time, a framework for the study of seed morphology in Greek *C.* sect. *Quinqueloculares* and additionally supports their complementary role in *Campanula* taxonomy and systematics.

Key words: *Campanula*, micromorphology, Scanning Electron Microscopy, seed coat.

Introduction

Campanula L. comprises ca. 420 species with circumboreal distribution (Lammers 2007). Eurasia, especially the area from Balkans to eastern Caucasus hosts most of the *Campanula* diversity (Tutin & al. 1976; Oganesian 2008; Castroviejo & al. 2010). The endemism hotspots for *Campanula* are located in Eastern Mediterranean region, Balkan Peninsula, Caucasus and Turkey (Damboldt 1978; Gagnidze 2005; Borsch & al. 2009). Greece represents an intriguing part of the Eastern Mediterranean diversity hotspot including ca. 96 *Campanula* taxa of which ca. 60 are Greek endemics (in Dimopoulos & al. 2013, 2020).

Over half of the Greek endemic *Campanula* taxa belong to *Campanula* section *Quinqueloculares* (Boiss.) Phitos (Liveri & al. 2019). In total, *C*. section *Quinqueloculares* includes ca. 39 species (ca. 47 specific and subspecific taxa) distributed in Greece and coastal Turkey (Phitos 1969, 2016) with the exception of *C. medium* L., growing as native in France and Italy (Castroviejo & al. 2010; Bartolucci & al. 2018), as well as *C. lyrata*



Fig. 1. Representatives of *Campanula* section *Quinqueloculares* from Greece: **A,** *C. pelviformis* growing at roadside banks of New National Road of Agios Nikolaos (Crete), 11.V.2017 and **B,** on rock fissures from Plaka (Crete), 11.V.2017; **C,** *C. nisyria* from Evangelistria (Nisyros), 8.V.2018; **D,** *C. hagielia* on the old walls of castle in Chalki, 5.V.2018; **E,** *C. saxatilis* subsp. *saxatilis* on old walls of Monastery Katholiko (Crete) and **F,** details of the flowers and capsules, 9.V.2017 (Photos by E. Liveri & V. Ketsilis-Rinis).

Lam. and *C. crispa* Lam., of which their distribution extends to the Caucasus and the Middle East (Al-Eisawi 1982; Aghabeigi 1985; Takhtajan 1995; Gagnidze 2005; Aghabeigi & Assadi 2008; Castroviejo & al. 2010).

The species of *Campanula* section *Quinqueloculares* are biennial (monocarpic), or more rarely perennial chasmophytes growing commonly on calcareous cliffs, rock fissures and crevices, old walls (e.g., *Campanula saxatilis* L. subsp. *saxatilis*; Figs 1E, F) (Phitos 1969), and occasionally in rocky places or roadside banks (e.g., *C. pelviformis* Lam.; Figs 1A, B) or schistose rocks cracks (Yıldırım 2013). They are characterized by five-locular ovary, a style with five stigmas, appendages more or less covering the ovary, and a capsule opening with five pores (Phitos 1965, 1969, 2016). Despite the epithet of the section (quinque + loculares = five locules), the number of the ovary locules may vary from three to five (Liveri & al. 2019).

The first mention of this group is found in De Candolle's classic monograph of *Campanulaceae*. De Candolle (1830) divided *Campanula* into two main sections based mainly on calyx morphology: *C*. sect. *Medium* A. DC. and *C*. sect. *Eucodon* A. DC. In his first mentioned section, one subgroup with five locules and five stigmas was recognized including 12 of the known *Quinqueloculares* species. Later, Boissier (1875) also recognized two sections within *Campanula*, almost the same with De Candolle's, but added capsule dehiscence to further define them: *C*. sect. *Medium* and *C*. sect. *Rapunculus* Boiss. For the first time, Boissier (1875) ranked a group of 14 species within *C*. section *Medium* as subsection *Quinqueloculares* Boiss. In 20th century, Charadze (1949) working largely on Caucasian *Campanula* species elevated *Quinqueloculares* to subgenus. Phitos (1963a, 1963b, 1964a, 1964b, 1965, 1969) studied extensively *Quinqueloculares* in Greece and Turkey and established the group as section (in Damboldt 1976). In *Flora of Turkey and the East Aegean Islands*, Damboldt (1978) retained *Quinqueloculares* at sectional level with 10 species, while Oganesian (1995) based on material from Caucasus placed again *Quinqueloculares* at the rank of subgenus.

Campanula section *Quinqueloculares* is characterized by remarkable morphological polymorphism (Fig. 1) as noted by Phitos (1963a, 1963b, 1964a, 1964b, 1965, 1969). His study is based on morphological, phytogeographical and karyological data resulting to the description of 22 new taxa (Phitos 2016; Liveri & al. 2019) and to the identification of three phytogeographically defined groups inside the section (Phitos 1965). Eddie & Ingrouille (1999) tried a phenetic approach to examine the high morphological polymorphism of *C*. sect. *Quinqueloculares* based on leaf and flower features corroborating the extreme morphological variability of the section.

In 21th century, the molecular methods gave new insights into the taxonomy and evolution of this group. The high polyphyly of *Campanula* has been confirmed in many studies (Borsch & al. 2009; Mansion & al. 2012; Crowl & al. 2016; Jones & al. 2017; Yoo & al. 2018; Xu & Hong 2020) presenting two major clusters of *Campanula*: a rapunculoid clade and a *Campanula* s. str. clade (Eddie & al. 2003; Roquet & al. 2008; Cellinese & al. 2009; Haberle & al. 2009). Several species of *C*. sect. *Quinqueloculares* have been included in some of these broader *Campanula* groups (e.g., Roquet & al. 2008; Borsch & al. 2009; Cellinese & al. 2009; Haberle & al. 2009; Mansion & al. 2012; Jones & al. 2017; Silakadze & al. 2019).

According to Liveri & al. (2020), the first phylogenetic study including all the species and subspecies of *C*. sect. *Quinqueloculares* revealed the polyphyly of the traditional section and recovered two strongly-supported clades, which include the majority of species.

Three species (*C. crispa*, *C. medium*, *C. pelia* Bedd.) of *C.* sect. *Quinqueloculares* are resolved outside the main clades, whereas four species from other *Campanula* sections [ie., *C. teucrioides* Boiss. from *C.* sect. *Rupestres* (Boiss.) Charadze] are nested within.

Seed characters, comparing to other plant organs, are considered less affected by changing environmental conditions (Zorić & al. 2010) and thus essential for classification (Barthlott 1981; Bonilla-Barbosa & al. 2000; Eriksson & al. 2000). Netolitzky (1926) was the first to notice that the structure of the seed coat is characteristic of a family in general and has taxonomic value. Takhtajan (1991) also pointed out that, even for phylogenetic correlations between families and genera, the structure of the seed coat might be important. Scanning electron microscopy data may be useful to delimit taxa at the species level, or sometimes as indicators of suprageneric groupings (Barthlott 1981, 1984; Behnke & Barthlott 1983), while variation in seed coat surface sculpturing among taxa could be correlated to ecological aspects (Barthlott 1981).

Studies on seed morphology of *Campanula* and *Campanulaceae* in general are limited. The first systematic studies of seed surface morphology in *Campanulaceae* were made by Eddie (1984, 1997) and concluded to correlation among testa patterns and ecology and may be useful for recognition at species level, but of little value at the generic level. The usefulness of seed morphology as a character in the systematics of *Campanulaceae* was studied in taxa from Europe (Geslot 1980), North America (Shetler & Morin 1986), India (Haridasan & Mukherjee 1988), Turkey (Akcin 2009; Alçitepe 2010), South Africa (Cupido & al. 2011). All the previous studies demonstrated the potential taxonomic value of seed morphology.

The seed morphology of *Campanula* sect. *Quinqueloculares* has been investigated in nine species from Turkey (Akcin 2009; Alçitepe 2010). Akcin (2009), who used *Campanula* species from several sections, states that micromorphological features of seed surface are useful in species delimitation and, also, suggests the broad investigation of the seeds of other *Campanula* taxa, in order to understand if such surface patterns are consistent and can differentiate taxa. Alçitepe (2010) examined the most of *C.* sect. *Quinqueloculares* in Turkey and concluded that seed coat morphology could be used as taxonomic trait in species delimitation but in combination with other morphological traits.

The current study aims to describe the seed morphology of some Greek *Campanula* species of sect. *Quinqueloculares* and evaluate their taxonomic significance.

Material and Methods

During 2016-2018 plant material of *Campanula* section *Quinqueloculares* was collected from Greece and stored in the herbarium of University of Patras (UPA). A list of the 16 collected taxa, collection localities and voucher numbers are provided in Table 1. Approximately 15 mature seeds of each taxon were analyzed. Seeds were taken from mature capsules collected in the field or from herbarium specimens. The seed samples were mounted on SEM stubs using double-sided adhesive tape and sputter coated with gold (Au). Coated seeds were observed with a Scanning Electron Microscope type JSM 6300 of the company JEOL in the Laboratory of Electron Microscopy and Microanalysis of University of Patras (L.E.M.M.). The terminology follows Barthlott (1981) and Simpson (2016). All the measurements were obtained from the SEM microphotographs.

Table 1. List of studied *Campanula* taxa (section *Quinqueloculares*) and specimen information. Greek endemics are indicated with an (*) asterisk.

Taxon	Specimen information
C. anchusiflora Sm.	Greece/Aegean Islands: Isl. Hydra, village Kamini, rock fissures, 10 m., 27 Apr 2016, *E. Liveri & V. Ketsilis-Rinis 189* (UPA 24629)
C. andrewsii subsp. ***hirsutula*** Phitos	Greece/Peloponnisos: Castle of Monemvasia, walls and rock fissures, 0-5 m., 21 May 2016, *E. Liveri & V. Ketsilis-Rinis 225*
C. carpatha Halácsy	Greece/Aegean Islands: Isl. Karpathos, Mertonas, rock fissures, 300 m., 14 May 2017, *E. Liveri, V. Ketsilis-Rinis & N. Cellinese 271*
C. celsii subsp. ***carystea*** Phitos	Greece/Aegean Islands: Isl. Evia, *D. Phitos & G. Kamari 3825*
C. constantinii Beauverd & Topali	Greece/Aegean Islands: Isl. Evia, Mt. Xerovouni, *G. Kofinas s.n.*
C. cymaea Phitos	Greece/Aegean Islands: Isl. Evia, old walls, 115 m., Niochori-Vrysi, 6 May 2017, *E. Liveri, V. Ketsilis-Rinis & N. Cellinese 294*
C. euboica Phitos	Greece/Aegean Islands: Isl. Evia, village Agios Georgios, rock fissures, 5 m., 5 May 2017, *E. Liveri, V. Ketsilis & N. Cellinese 292* (UPA 24639)
C. hagielia Boiss.	Greece/Aegean Islands: Isl. Rodos, Lindos, rock fissures, 5 m., 7 May 2018, *E. Liveri, V. Ketsilis-Rinis & N. Cellinese 306*
	Greece/Aegean Islands: Isl. Chalki, Castle of Chalki, old walls, 5-10 m., 5 May 2018, *E. Liveri, V. Ketsilis-Rinis & N. Cellinese 305*
C. kamariana Kyriak., Liveri & Phitos	Greece/Lakonia: south of village Itilo, castle of Kelefa, 17 Jun 2018, *E. Liveri & V. Ketsilis-Rinis 237*
C. lyrata subsp. ***icarica*** Phitos	Greece/Aegean Islands: Isl. Samos, Marathokampos-Kastania, 12 May 2018, *E. Liveri, V. Ketsilis-Rinis & N. Cellinese 307*
C. merxmuelleri Phitos	Greece/Aegean Islands: Isl. Skyros, Mt. Kochilas, 430 m., 7 May 2017, *E. Liveri, V. Ketsilis-Rinis & N. Cellinese 291* (UPA 24649)
C. nisyria Papatsou & Phitos	Greece/Aegean Islands: Isl. Nisyros, village Evangelistria, 8 May 2018, *E. Liveri, V. Ketsilis-Rinis & N. Cellinese 303* (UPA 24650)
C. pelviformis Lam.	Greece/Aegean Islands: Isl. Crete, 42o km of New National Road Heraklio-Agios Nikolaos, roadside banks, 120 m., 11 May 2017, *E. Liveri, V. Ketsilis-Rinis & N. Cellinese 295*
	Greece/Aegean Islands: Isl. Crete, Plaka-Vrouxas, rock fissures, 190 m., 11 May 2017, *E. Liveri, V. Ketsilis-Rinis & N. Cellinese 296*

Table 1. continued.

C. rupestris Sm.	Greece/Viotia: Livadia, rock fissures, 200-300 m., 5 May 2016, *E. Liveri, A. A. Crowl & N. Cellinese 209* (UPA 24653)
C. saxatilis L. subsp. ***saxatilis***	Greece/Aegean Islands: Isl. Crete, Plakias beach, rock fissures, 0-20 m., 29 May 2016, *E. Liveri & S. Samaropoulou 229*
	Greece/Aegean Islands: Isl. Crete, Akrotiri Peninsula, old walls, 75 m., 9 May 2017, *E. Liveri, V. Ketsilis-Rinis & N. Cellinese 288* (UPA 24654)
C. topaliana subsp. ***delphica*** Phitos	Greece/Phokida: close to Delphi, rock fissures, 450 m., 9 Apr 2017, *E. Liveri & V. Ketsilis-Rinis 258*

Results

All the studied taxa of *Campanula* sect. *Quinqueloculares* show small seeds varying in length from 0.52 to 0.92 mm and width from 0.26 to 0.43 mm. The smallest seed is observed in *Campanula euboica* Phitos both in length and width (Figs 3: 3A, 3B). The longest seed is observed in *C. cymaea* Phitos (Figs 3: 2A, 2B) whereas the widest in *C. topaliana* subsp. *delphica* Phitos (Figs 6: 2A,2 B). Generally, the seeds are glabrous, oblong to elliptic/obelliptic in outline, while the seed colour varies from light to dark brown.

The seed surface cells are elongated with straight and raised boundaries, relatively thick radial walls and an often-distinct lumen, which is essentially linear. These characteristics give a striate appearance to the seed coat. The surface of the outer cell wall (surface of the cuticle) exhibits a micro-ornamentation called striate. The nearness of striations on the seeds' surface varies among the taxa resulting to two seed surface sculpturing patterns: a) regularly striate and b) narrowly striate seed coat pattern. The first seed coat pattern (a) characterizes four species of *Campanula* sect. *Quinqueloculares*: *C. euboica* (Figs 3: 3A, 3B), *C. hagielia* Boiss. (Figs 3: 4A, 4B), *C. kamariana* Kyriak., Liveri & Phitos (Figs 4: 1A, 1B) and *C. nisyria* Papatsou & Phitos (Figs 5: 1A, 1B). The second seed coat pattern (b), which is the most common among the Greek taxa, characterizes eleven taxa: *C. anchusiflora* Sm. (Figs 2: 1A, 2B), *C. andrewsii* subsp. *hirsutula* Phitos (Figs 2: 2A, 2B), *C. carpatha* Halácsy (Figs 2: 3A, 3B), *C. celsii* subsp. *carystea* Phitos (Figs 2: 4A, 4B), *C. constantinii* Beauverd & Topali (Figs 3: 1A, 1B), *C. cymaea* (Figs 3: 2A, 2B), *C. lyrata* subsp. *icarica* Phitos (Figs 4: 2A, 2B), *C. merxmuelleri* Phitos (Figs 4: 3A, 3B), *C. pelviformis* (Figs 5: 2A, 2B), *C. rupestris* Sm. (Figs 5: 3A, 3B) and *C. topaliana* subsp. *delphica* (Figs 6: 2A, 2B). *Campanula saxatilis* subsp. *saxatilis* (Figs 6: 1A, 1B, 1C, 1D) shows both patterns in material from two different populations whereas *Campanula nisyria* (Figs 5: 1A, 1B) shows regular but evidently shallow striations on its seeds.

A summary of the results on seed morphology data of the studied taxa are given in Table 2.

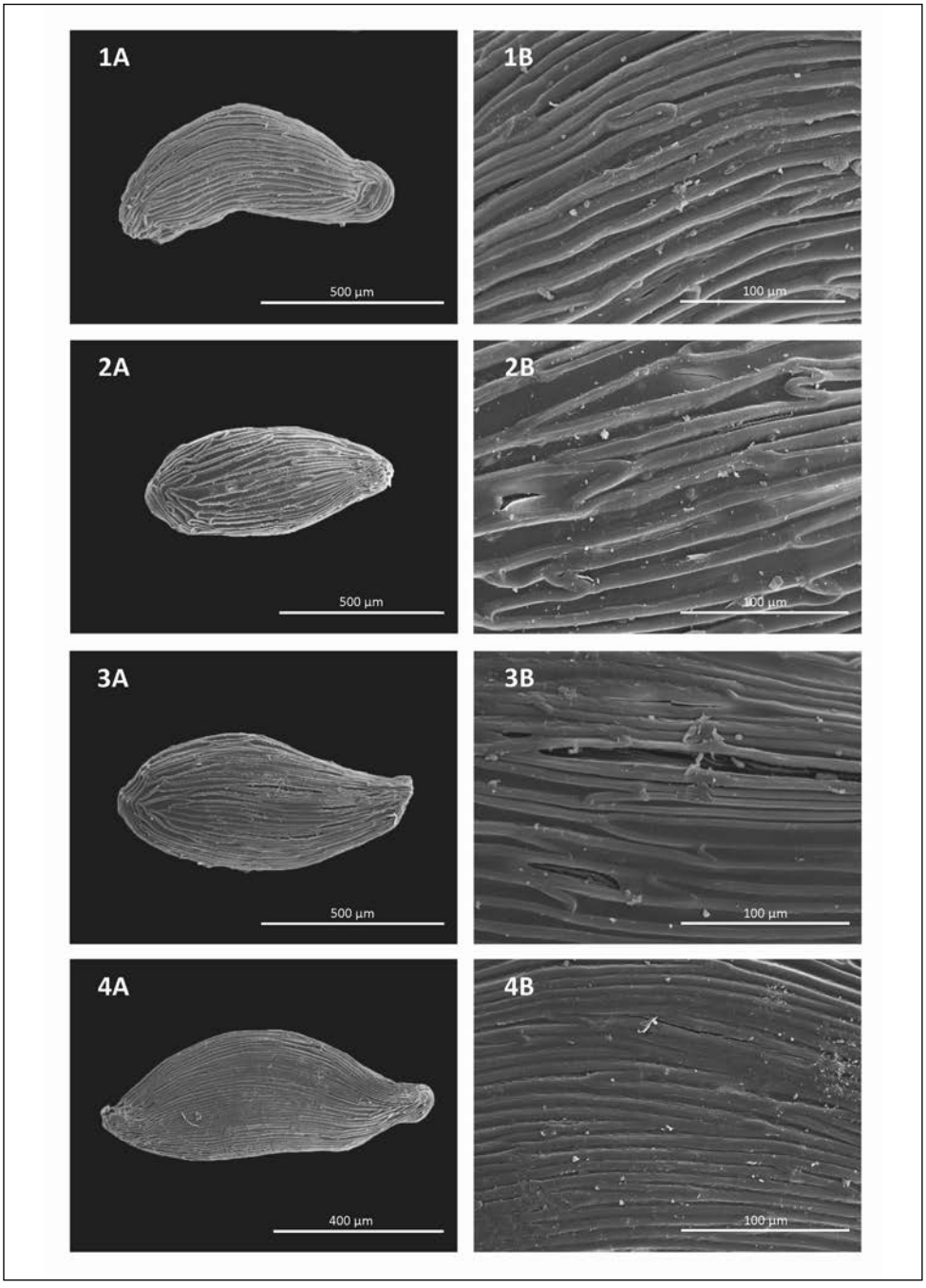


Fig. 2. Seed morphology (A) and seed coat surface (B) of the studied *Campanula* section *Quinqueloculares* taxa in SEM: **1A, B,** *C. anchusiflora*; **2A, B,** *C. andrewsii* subsp. *hirsutula*; **3A, B,** *C. carpatha*; **4A, B,** *C. celsii* subsp. *carystea*.

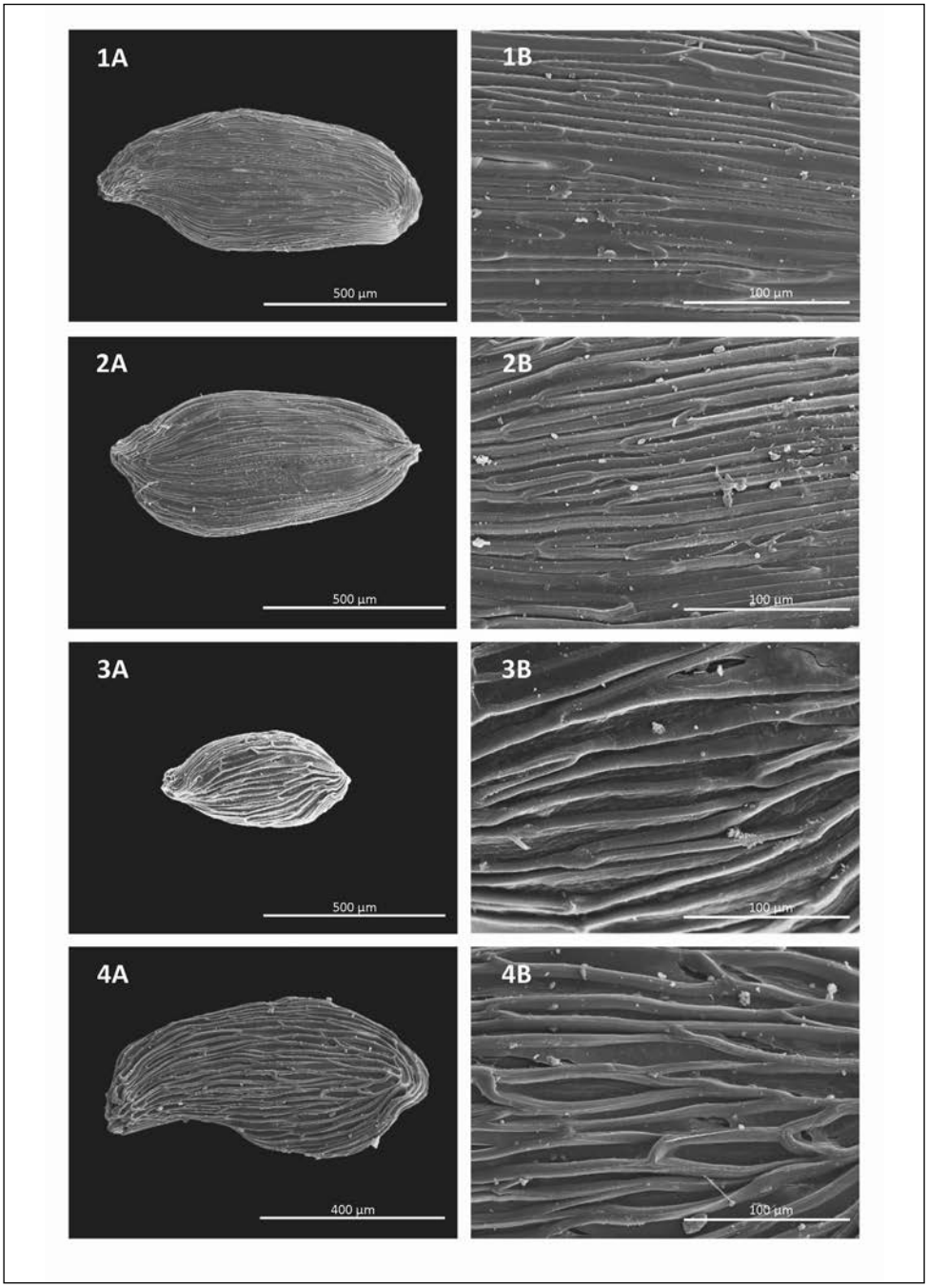


Fig. 3. Seed morphology (A) and seed coat surface (B) of the studied *Campanula* section *Quinqueloculares* taxa in SEM: **1A, B,** *C. constantinii*; **2A, B,** *C. cymaea*; **3A, B,** *C. euboica*; **4A, B,** *C. hagielia.*

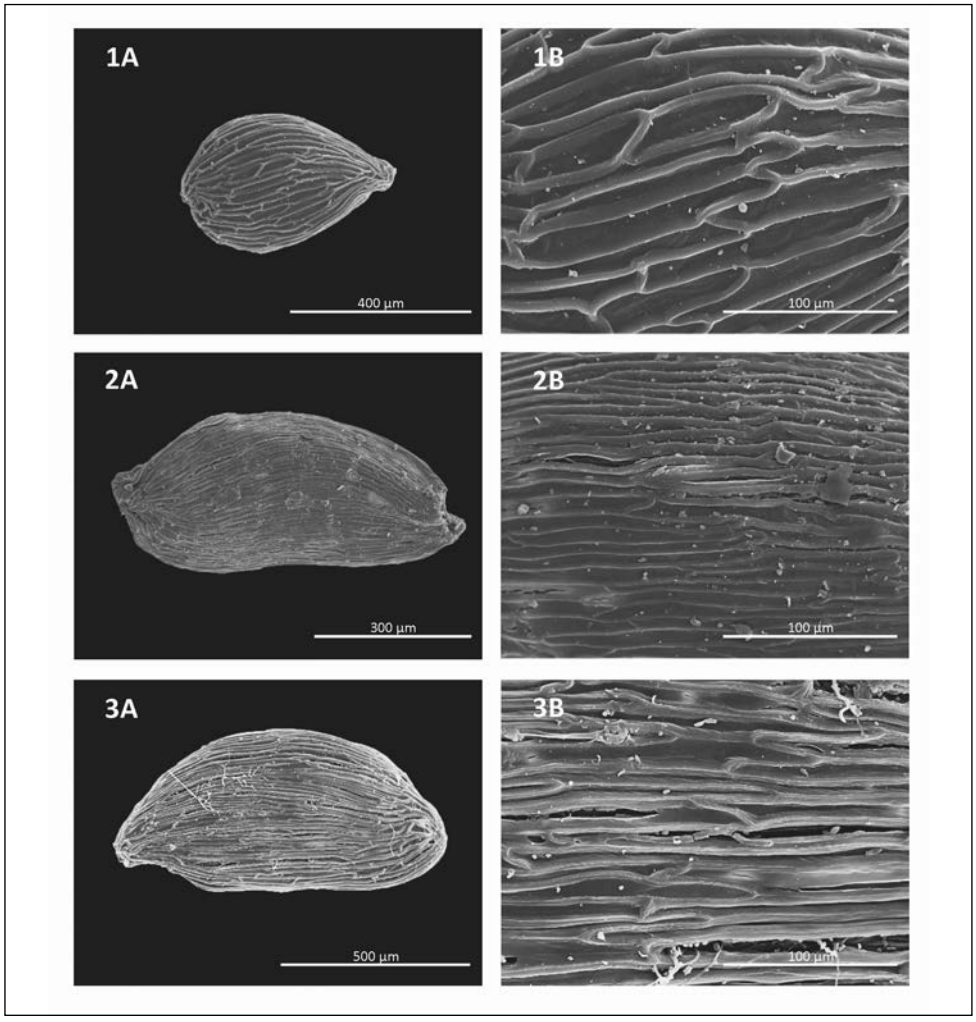


Fig. 4. Seed morphology (A) and seed coat surface (B) of the studied *Campanula* section *Quinqueloculares* taxa in SEM: **1A, B,** *C. kamariana*; **2A, B,** *C. lyrata* subsp. *icarica*; **3A, B,** *C. merxmuelleri*.

Discussion

In the current study, the seed morphology of 16 species and subspecies belonging to *Campanula* section *Quinqueloculares* from Greece are studied for the first time. In general, the seeds of *C.* sect. *Quinqueloculares* are small in size, oblong to elliptic/obelliptic varying in colour from light to dark brown. Although the seed coat morphology is striate in all investigated taxa, two different patterns related to the nearness of striation are revealed: a) regularly striate and b) narrowly striate.

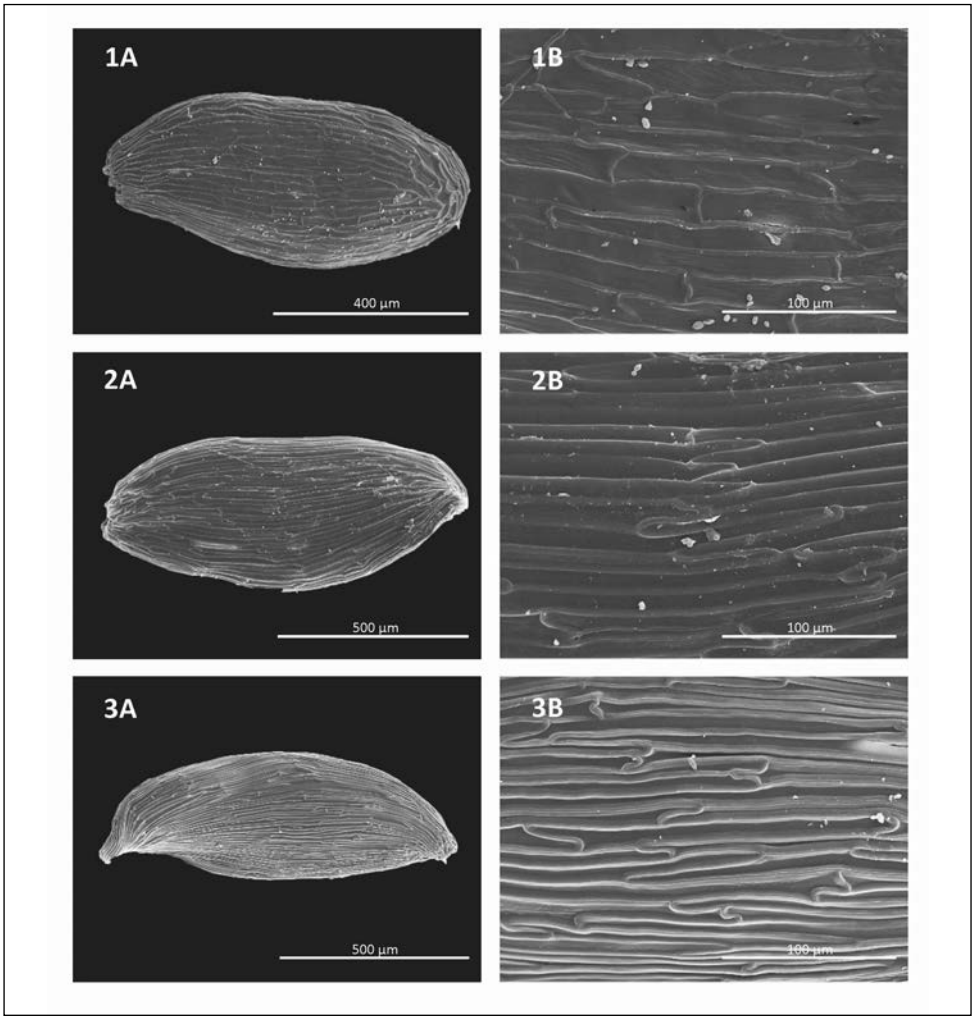


Fig. 5. Seed morphology (A) and seed coat surface (B) of the studied *Campanula* section *Quinqueloculares* taxa in SEM: **1A, B,** *C. nisyria*; **2A, B,** *C. pelviformis*; **3A, B,** *C. rupestris*.

The striate seed coat is common in *Campanula* and particularly in section *Quinqueloculares* from Turkey (Akcin 2009; Alçitepe 2010). This pattern has been recognized by Alçitepe (2010) as Type II including two subtypes (II-a and II-b). The two subtypes coincide with the presented two patterns (a) and (b) in our study. Most of the Turkish *C*. sect. *Quinqueloculares* belong to subtype II-a in contrast to the Greek taxa, which mostly belong to subtype II-b (Table 2). However, Alçitepe (2010) finds one more type of seed coat sculpturing characterized by weakly striate/wavy-striped radial walls presented only in one species, *C. tomentosa* Lam. According to Alçitepe (2010), *Campanula lyrata* subp.

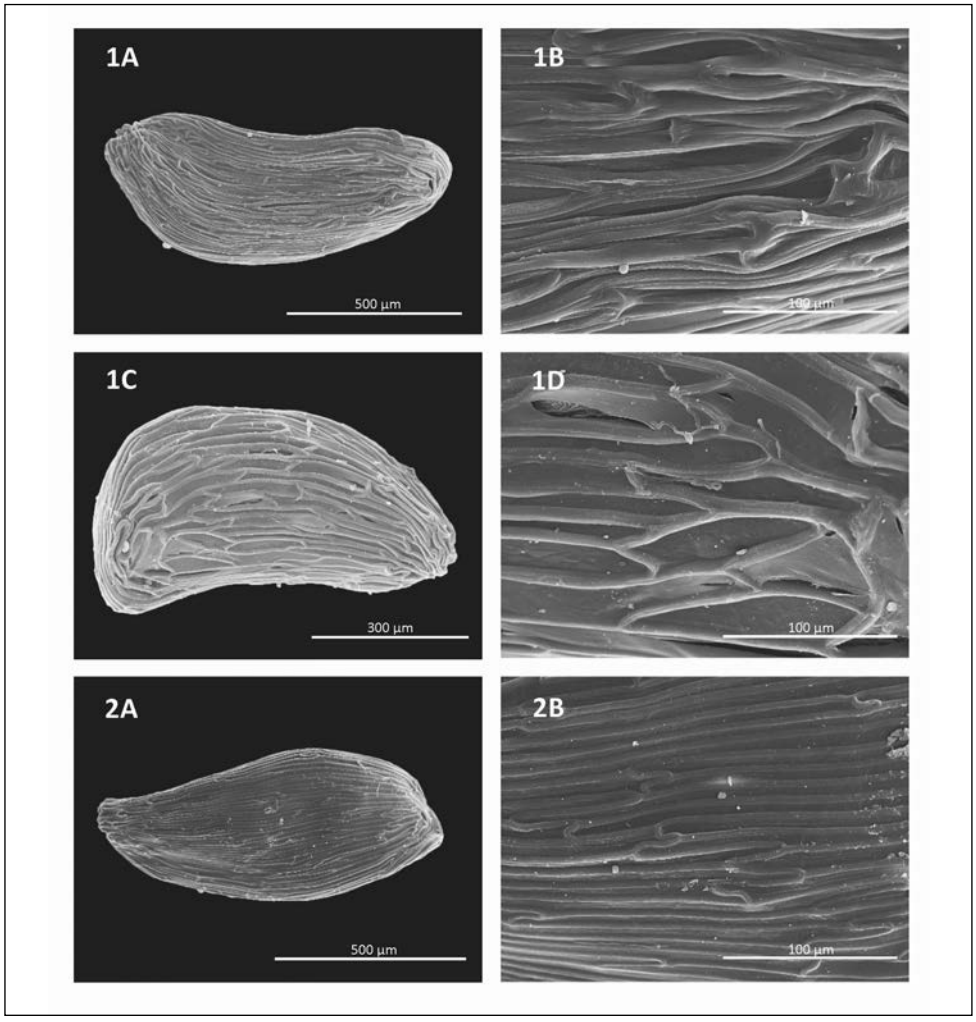


Fig. 6. Seed morphology (A, C) and seed coat surface (B, D) of the studied *Campanula* section *Quinqueloculares* taxa in SEM: **1A, B, C, D,** *C. saxatilis* subsp. *saxatilis*; **2A, B,** *C. topaliana* subsp. *delphica*.

lyrata belong to subtype II-a, but in our study *C. lyrata* subsp. *icarica* (Figs 4: 2A, 2B) falls into the second subtype presenting another difference between the subspecies. Akcin (2009) studies the seed coat morphology of Turkish *Campanula* from five sections belonging to two subgenera but includes only *C. lyrata* subsp. *lyrata* from *C*. sect. *Quinqueloculares* placing it in Type II without mentioning the subtype. Based on the microphotographs of his study (Akcin 2009), we can conclude that it belongs to the second subtype that is in accordance with Alçitepe's (2010) findings.

Table 2. Seed characters of the studied *Campanula* section *Quinqueloculares*. The mean value along with the Standard Deviation (SD) in parenthesis given for length (mm) and width (mm).

Taxon	Length	Width	Shape	Surface	Colour
C. anchusiflora	0.72 (0.12)	0.34 (0.02)	Elliptic to obelliptic	Narrowly striate	Light brown
C. andrewsii subsp. ***hirsutula***	0.70 (0.05)	0.27 (0.02)	Obelliptic to oblong	Narrowly striate	Brown
C. carpatha	0.75 (0.06)	0.39 (0.03)	Elliptic to obelliptic	Narrowly striate	Light brown
C. celsii subsp. ***carystea***	0.74 (0.05)	0.30 (0.03)	Elliptic to obelliptic	Narrowly striate	Brown
C. constantinii	0.87 (0.06)	0.36 (0.03)	Oblong	Narrowly striate	Brown
C. cymaea	0.89 (0.04)	0.43 (0.04)	Oblong	Narrowly striate	Brown
C. euboica	0.52 (0.05)	0.26 (0.04)	Elliptic	Regularly striate	Brown
C. hagielia	0.70 (0.04)	0.30 (0.02)	Oblong	Regularly striate	Light brown
	0.57 (0.03)	0.31 (0.02)	Elliptic	Regularly striate	Light brown
C. kamariana	0.56 (0.06)	0.31 (0.05)	Elliptic to obelliptic	Regularly striate	Brown
C. lyrata subsp. ***icarica***	0.65 (0.1)	0.30 (0.02)	Oblong	Narrowly striate	Light brown
C. merxmuelleri	0.88 (0.8)	0.39 (0.04)	Elliptic to obelliptic	Narrowly striate	Brown
C. nisyria	0.76 (0.03)	0.34 (0.03)	Oblong to elliptic	Regularly striate (shallow striations)	Dark brown
C. pelviformis	0.89 (0.08)	0.39 (0.04)	Oblong to elliptic	Narrowly striate	Brown
	0.54 (0.07)	0.29 (0.05)	Oblong to elliptic	Narrowly striate	Brown
C. rupestris	0.89 (0.06)	0.33 (0.02)	Oblong	Narrowly striate	Light brown
C. saxatilis subsp. ***saxatilis***	0.90 (0.12)	0.42 (0.05)	Oblong	Narrowly striate	Brown
	0.76 (0.11)	0.36 (0.03)	Oblong to obelliptic	Regularly striate	Brown
C. topaliana subsp. ***delphica***	0.92 (0.11)	0.41 (0.05)	Oblong	Narrowly striate	Brown

The studied material of *C.* sect. *Quinqueloculares* from Greece even if seems uniform concerning the size, shape and colour of the seeds, varies considerably in seed coat morphology giving further insights in species relationships. Our findings present the variation characterizing this section from micro-morphological point of view and provide also taxonomic interpretation in some cases. For example, we observe that the striation pattern may even differ within the same subspecies (e.g. the Cretan endemic *C. saxatilis* subsp. *saxatilis*; Figs 6: 1A, 1B, 1C, 1D) emphasizing the need for a more extensive study.

In the case of *C. hagielia* (distributed in East Aegean Islands and coastal Turkey) and *C. nisyria* (one-island endemic), which recently were considered synonyms (Strid 2016), the differences in seed coat sculpturing (Figs 3: 4A, 4B and Figs 5: 1A, 1B, respectively), combined with some other taxonomically important morphological features, support the distinction of these two species (Papatsou & Phitos 1975; Damboldt 1978). Concerning the morphology, *C. nisyria* is a long hirsute/scabrid plant with flowers sessile/subsessile, solitary or 2-3 together, forming a long spike-like inflorescence (Fig. 1C) whereas *C. hagielia* is softly hirsute/pubescent with terminal and axillary, pedicellate flowers (Fig. 1D). Additionally, molecular data place *C. nisyria* more closely related to other Turkish endemics (ie., *C. iconia* Phitos and *C. sorgerae* Phitos) than to *C. hagielia* (Liveri & al. 2020).

In general, the studied material of *C.* sect. *Quinqueloculares* from Greece and Turkey show similarities concerning seed morphology (size, shape, colour). However, the seed coat pattern shows some differences among Greek and Turkish representatives. Firstly, the weakly striate/wavy-striped seed coat is observed in the Turkish endemic *C. tomentosa* and also the newly described endemic Turkish species *C. phitosiana* Yıldırım & Şentürk (Yıldırım & al. 2020). For the rest of *C.* sect. *Quinqueloculares* species, the striate seed coat pattern predominates. However, the seed coat striation of *C. mugeana* Yıldırım shows transition between the weakly striate/wavy-striped seed coat and prominent striate seed coat patterns (Yıldırım 2013). Although, the most common pattern in Turkey is regularly striate (noticed in more than the half studied taxa), whereas the narrowly striate seed coat pattern is observed for nearly 70% of the studied taxa from Greece.

Concluding, the taxonomic significance of seed morphology of *C.* sect. *Quinqueloculares* can be complementary to other morphological characters. However, its importance should not be underestimated. In contrast, the seed morphology of more *Campanula* species should be studied in order to have a better representation of the genus in Greece. The seed coat morphology probably could be the most useful micro-morphological character, compared to the other seed features, in taxonomy and systematics. Nevertheless, the first necessary step is to broaden our knowledge on seed characteristics.

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Short note

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Aaron Rottenberg

The origin of *Vicia faba* (*Fabaceae*): a quest of five decades

Abstract

Rottenberg, A.: The origin of *Vicia faba* (*Fabaceae*): a quest of five decades. — Fl. Medit. 30: 365-368. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

The ancestry of broad bean *Vicia Faba*, one of the most important cultivated legumes, baffled scholars for many years. Until some half-century ago only meager evidence of charred broad bean was unearthed in archaeological excavations. A living putative wild progenitor has been remained obscured. During the last five decades significant archaeobotanical evidence from the Mediterranean basin was accumulated, illuminating the importance of this legume at the dawn of agriculture. Several recent excavations in the Near East revealed large quantities of Neolithic broad bean, suggesting that it was an important part of the crop assemblage of the early farmers some 10,000 years ago. Also, charred seeds found recently suggest that pre-agricultural hunter-gatherers used the same species before its cultivation as early as 14,000 years ago, hence revealing the wild ancestry of this crop.

Key words: broad bean, horse bean, Yiftahel, Ahiud, Neolithic.

The quest for the wild ancestry of *Vicia faba*

Faba bean (broad bean, horse bean, *Vicia faba* L.) with its high protein content is an important crop of the Mediterranean Basin and the northern temperate zone (Bond 1995). The plant is a hardy erect annual and some of the cultivars are resistant to drought. During the thousands years of *V. faba* cultivation many cultivars were bred, most of the large seeds varieties are for culinary consumption. Small seeds cultivars, although popular as food in certain regions are mainly used for other purposes like fodder, green manure and nitrogen fixing rotation crop (Temesgen & al. 2015). A living wild type of this cultivated species is not known and it is possible that it is either extremely restricted in its geographical distribution or that it is extinct.

Until a half-century ago most of the archaeological remains of *V. faba* were recorded mainly from relatively late Bronze Age sites at the Mediterranean Basin and Central Europe. It was only later, mainly through the 1960s and on that earlier *Vicia* seeds were unearthed. These were found mainly in a range of Neolithic sites in the Near East (Hopf 1969; Zohary & Hopf 1988). However, even in these Neolithic sites not only the finds were very little, but it was difficult to tell whether the *Vicia* seeds found there were of true

cultivated faba beans or of the related wild species of the resembling *V. narbonensis* complex (see below). Thus, Zohary & Hopf (1973, 1988) admitted that at that time, identification of Neolithic faba bean was not satisfactory.

Moreover, the wild ancestry of this crop remained elusive. The question as to the identity of the wild progenitor of faba bean puzzled scholars for many decades: On one hand researchers have recognized several related wild species that morphologically resembles *Vicia faba* (Bennett & Maxted 1997), but on the other hand they were all ruled out from its ancestry because of their different genetics. Some of these related wild species are part of the *Vicia narbonensis* complex, e.g. *V. narbonensis* L., *V. hyaenisciamus* Mouterde and *V. galilea* Plitman & Zohary (Plitmann 1965; Bennett & Maxted 1997). Their morphological resemblance to cultivated *V. faba* led researchers to investigate their cytology and to attempts of crossing them with the crop. The results of Schäfer (1973) and Ladizinisky (1975) showed that neither of these related species could be regarded as the wild progenitor of *V. faba* as the chromosome number of these three wild species was found to be $2n=14$ whereas that of *V. faba* is $2n=12$. Accordingly, crossability between the wild species and the crop was practically zero (Schäfer 1973; Ladizinisky 1975). In all, Zohary (1977) concluded that the evidence from archaeobotanical remains and the living plants suggest that the search for the origin of Neolithic faba bean and the obscured progenitor should be focused in the Mediterranean Basin and the Near East.

Indeed, several years later, the first sound evidence of cultivated Neolithic *Vicia faba* was revealed during the excavations at the Neolithic site of Yiftahel, lower Galilee, Israel (Kislev 1985). Here, some 2,600 *V. faba* seeds were found in a PPNB (Pre Pottery Neolithic B) obvious agricultural context: these beans were found along with some 1.4 million (7.5 kg) charred cultivated lentil (*Lens culinaris* Medik.) seeds and their accompanying field weed *Galium tricornutum* Dandy seeds (Garfinkel & al. 1988). These sensational findings were reinforced two decades later during extensive salvage excavations at the same site. This time, more than 1,000 *V. faba* seeds were found (Khalaily & al. 2008). Also, some 250,000 lentil seeds were found along with their infesting weed *Galium tricornutum* as well as several dozens of *Triticum dicoccoides* (Asch. & Graebn.) Schweinf. seeds (Rottenberg, pers. obs.). The seeds were dated to some 10,000 years ago.

Recent findings

Two additional salvage excavations were conducted in the following years around Yiftahel. The first, in nearby Nahal Zippori, where several dozens of faba bean and lentil seeds were found in a Neolithic context (Caracuta & al. 2017). The second Neolithic site, at Ahiud (18 km NW of Yiftahel) revealed large quantities of legumes dated to some 10,200 years ago (Pre Pottery Neolithic B). More than 2,000 *V. faba* seeds and many additional fragments were unearthed. Significantly, in one of the excavation squares, additional seeds of the related *V. narbonensis* were found, and by their more spherical appearance they were clearly distinguished from the true agricultural *V. faba* found there (Caracuta & al. 2017). Several hundred seeds of *Lens*, *Pisum* and *Lathyrus* spp. were found as well. Elsewhere, in both nearby and remoter regions, small quantities of faba bean seeds were

excavated in the meantime at several other sites in the Near East (Tanno & Willcox 2006; Galili & al 2009; and see ref. 9-18 in Caracuta & al. 2017).

Finally, after decades of archaeobotanical pursuit, also the elusive progenitor was found: recently, six charred seeds of pre-agricultural *V. faba*, dated to 14,000 years ago were unearthed in Israel during an ongoing excavation project at El-Wad, Mt. Carmel. The researchers suggested that this wild type progenitor of faba bean was used by the local hunter-gatherers several millennia before domestication (Caracuta & al. 2016).

Conclusion

It was not before the 1960s that faba bean was assigned to as one of the major Neolithic crops. Since then, archaeobotanical evidence have been accumulating, showing that faba beans were cultivated in many parts of the Near East during the very early days of agriculture (Zohary & al. 2012; Caracuta & al. 2017). Significantly, in some of these sites, faba bean was found to be used alongside other legumes in an unmistakable agricultural context of the Pre Pottery Neolithic B some 10,000 years ago. The Large quantities of *V. faba* seeds found in these sites clearly indicate that this legume was of a main importance to the first farmers there.

Although not known today as a living wild species, the recent archaeobotanical evidence suggest that wild *V. faba* existed and was used by hunter-gatherer communities even before agricultural times (Caracuta & al. 2016). In all, faba bean should be regarded as one of the most important and main legumes used at the dawn of agriculture.

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This note is dedicated to the memory of Prof. Daniel Zohary. I thank Dr. Hamoudi Khalaily for his kind invitation to participate in the excavations at Yiftahel, and to Maya and Ohad Rottenberg for their help in examining and scoring the numerous seeds unearthed there.

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Article

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F. M. Raimondo, V. Spadaro & E. Di Gristina

Centaurea heywoodiana (*Asteraceae*), a new species from the Nebrodi Mountains (NE-Sicily)

Abstract

Raimondo, F. M., Spadaro, V. & Di Gristina, E.: *Centaurea heywoodiana* (*Asteraceae*), a new species from the Nebrodi Mountains (NE-Sicily). — Fl. Medit. 30: 369-376. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

A new endemic species of *Centaurea* is here described from the Nebrodi Mountains, in Sicily, and named *Centaurea heywoodiana*. Information on its morphology, distribution, ecology and taxonomic relationship is also provided.

Key words: endemism, Mediterranean flora, taxonomy, plant biodiversity, Nebrodi regional park, Italy.

Introduction

The native vascular flora of Sicily has been well explored in the past (Raimondo 1988) and the Sicilian territory is one of the well-known floristic territories among Italian and Mediterranean regions (Raimondo & al. 2005). However, not all of the regional territory was investigated with the same in-depth level. There are still some areas that have on average explored by scholars and among these, there is the extensive mountain area of the Nebrodi Mountains. This area has become the subject of considerable study only in recent decades by botanists of Catania University and by scholars who work, or have worked, in the botanical institution of Palermo University. About this, please refer to the taxonomic investigations of Raimondo & Schicchi (2004), Raimondo (2008), Marino & al. (2012) and Brullo & al. (2015).

Furthermore, investigations on new vegetation aspects of the same mountains allowed to acquire herbarium specimens, whose study provided us to identify a new taxon in the *Asteraceae* family. In this rich and complex family, some genera are still critical in Sicily, such as *Anthemis* L., *Hieracium* L., *Pilosella* Vaill., *Taraxacum* F. H. Wigg. and *Centaurea* L. Several taxa belonging to these genera have recently been described or rediscovery for the Sicilian flora: *Anthemis pignattiorum* (Guarino & al. 2013); *Hieracium pignattianum* (Raimondo & Di Gristina 2004), *H. madoniense* (Raimondo & Di Gristina 2007), *H. pallidum* subsp. *aetnense* (Gottschlich & al. 2013), *H. hypochoeroides* subsp. *montis-scuderii*

(Di Gristina & al. 2013), *H. busambarense* (Caldarella & al. 2014), *H. schmidtii* subsp. *nebrodense* (Di Gristina & al. 2016a); *Pilosella hoppeana* subsp. *sicula* **(**Di Gristina & al. 2016b); *Taraxacum garbarianum* (Peruzzi & al. 2009); *Centaurea erycina* (Raimondo & Bancheva 2004), *C. saccensis* (Raimondo & al. 2004), *C. giardinae* (Raimondo & Spadaro 2006), *C. sicana* (Raimondo & Spadaro 2008) and *C. aegusae* (Domina & al. 2017). Recent is also the finding in the north-west of the island of *Xeranthemum cylindraceum* Sm. (Costa & Di Gristina 2020).

The new taxon of the Nebrodi Mountains, described below, belongs to the genus *Centaurea.*

Centaurea heywoodiana Raimondo, Spadaro & Di Gristina **sp. nov**. (Fig. 1)

Type – *Holotypus*: Sicilia: Monti Nebrodi, Floresta, pendici sud orientali di Monte Musarra, nei luoghi aperti pascolati, su suolo argilloso-calcareo, 1081 m (s.l.m.), 37°51'39,45" N – 14°54°28,94" E, 27 luglio 2020, *Raimondo* (PAL-Gr) – *Isotypi* in FI and PAL.

Diagnosis. – *Planta perennis, caespitosa. Caulis obliquus, scaber, ramosus et praecipue bifidus ad apicem. Rami secundi ordinis ab primo dimidio caulis, etiam bifidi ad apicem. Folia viridi-glauca: folia rosularia pinnatisecta, folia caulina minora, pinnatifida vel hastata; folia apicis brevi, lineari, mucronata ad apicem. Capitula solitaria, minuta, numerosa; involucrum ovatum; bractae inferiores ovatae-lanceolatae; bractae medianae ventricosae; appendices leviter exsertae, brunneae, fimbriatae. Flosculi purpurei. Fructus glaber, brunneus, minutus, subcostatus, et in longitudinem striatus.*

Description. – Perennial herbaceous plant, bushy, (20) 25–45 (50) cm high. Stems oblique, scabrid, branched and particularly bifurcated at the extremity (Fig. 2); second-order branches starting from the first half of the scape, inserted perpendicularly or at a maximum of 45°, also bifurcated at the end. Leaves glaucous green; basal leaves pinnatisect 7–10 cm, with oblong-lanceolate segments; cauline leaves from pinnatifid to astate, and progressively smaller (1.2–2 cm); apical leaves linear-lanceolate (0.5) 0.6-1 (1.2) cm, mucronate at apex. Capitula solitary; involucre ovoid (0,7) 0.8–1 (1.1) cm in diameter; lower bracts ovate-lanceolate, 5–7 × 3–4 mm; middle bracts ventricose, 8–10 × 1.2–1.5 mm; appendages dark brown, slight exserted, with 5-7 fimbriae on each side. Florets purple. Achenes brownish, glabrescent, 3–3.5 mm, slightly costate, longitudinally striped; pappus 1/3 long of the achene.

Biological form. – hemicryptophyte (H caesp).

Etymology. – The epithet of the name of the new Sicilian species recalls the surname of the illustrious Plant Scientis Vernon Hilton Heywood, professor emeritus of Botany at the University of Reading, co-editor of *Flora Europaea*, founding member of OPTIMA, and for many years, active component of the Executive Council of this Organization.

Phenology. – Flowering in July; fruiting from July to August.

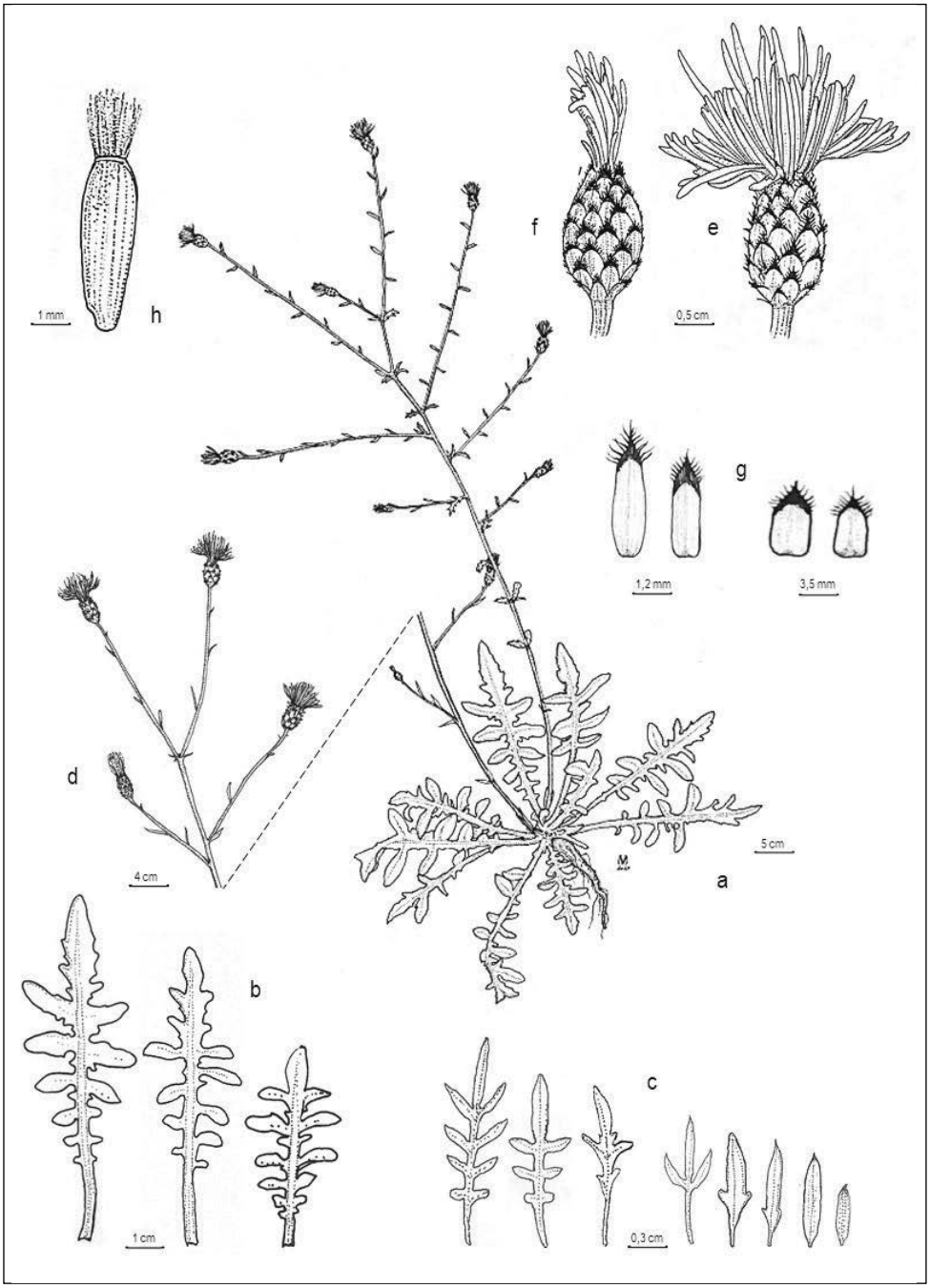


Fig. 1. Iconographic plate of *Centaurea heywoodiana*: a) plant; b) basal leaves; c) cauline (left) and apical leaves of the stem (right); d) particular of the bifurcated extremity of the stem; e) capitulum in flower; f) capitulum after flowering; g) exsternal bracts of the capitulum; h) mature achene with pappus.



Fig. 2. Particular of the stem of *Centaurea heywoodiana,* branched and bifurcated at the extremity.

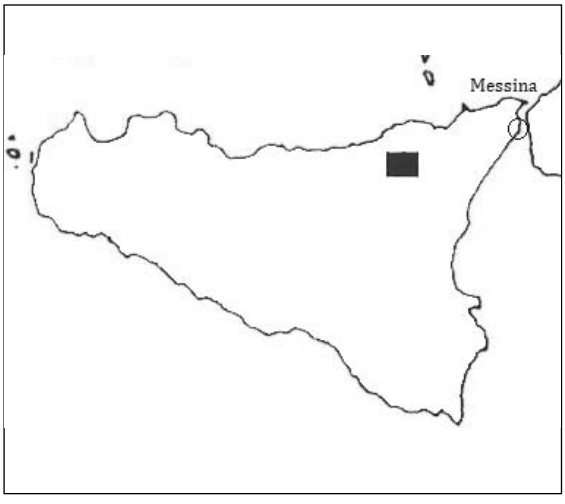


Fig. 3. Localization of the *locus classicus* of *Centaurea heywoodiana* in Sicily.

Distribution and ecology. – *Centaurea heywoodiana* occurs in the eastern sector of the Upper Nebrodi Mountains (see Domina & al. 2018), in Sicily (Fig. 3). As well as on the slopes of Monte Musarra (Floresta) (Fig. 4 a), the species also occurs in the clearings of the degraded *Quercus cerris* L. woods of the northern and western slopes, partly very steep, of the nearby Monte Colla (Fig. 4b). It is assumed that it can also be found in all carbonate soils (Fig. 5) above 1000 of altitude of the basins of the two rivers that originate in this area: the Alcantara and the Flascio rivers. Therefore, it is not a localized species, although its distribution area is always limited to a few hundred hectares.

The area that includes the *locus classicus* and the other nearby stations of C. *heywoodiana* falls within the potential space of deciduous oak forests of *Q. cerris* (*Quercetalia pubescenti-petraea* Klika 1933), which occupy extensive areas on the Nebrodi Mountains. In its habitat, *C. heywoodiana* grows together with *Dianthus siculus* C. Presl, *Thymus spinulosus* Ten., *Brachypodium pinnatum* (L.) P. Beauv., *Origanum vulgare* L., *Eryngium campestre* L., *Rosa canina* L., *R. montana* Chaix, *Sternbergia sicula* Tineo ex Guss., *Asphodelus ramosus* L. subsp. *ramosus*, *Clinopodium nepeta* (L.) Kuntze, *Trifolium ochroleucon* Huds., *Medicago lupulina* subsp. *cupaniana* Guss., *Plantago lanceolata* L., *Leontodon siculus* (Guss.) Nyman, *Carlina nebrodensis* Guss. ex DC., *Cirsium vallis-demonii* Lojac., *Reichardia picroides* (L.) Roth., *Bellis margaritaefolia* Huter, Porta & Rigo, *Galium verum* L., *Asperula cynanchica* L., *Verbascum* sp., *Helianthemum* sp., *Allium* sp., ecc.



Fig. 4. The calcareous slopes of Monte Musarra, *locus classicus* of *Centaurea heywoodiana* (a); north-western slopes of Monte Colla where *Centaurea heywoodiana* also occurs (b).



Fig. 5. *Centaurea heywoodiana* in its calcareous habitat (eastern slopes of Monte Musarra).



Fig. 6. *Centaurea heywoodiana* in flowering (photo taken on 25.07.2020 by F.M. Raimondo): see the terminal cauline leaves, mucronate at apex.

Taxonomic remarks. – Compared to the Sicilian species of *Centaurea* sect. *Dissectae* (Hayek) Dostál, all with late spring flowering, *C. heywoodiana* is the only one to bloom in the middle of summer. Among all, it is a small plant, with linear and mucronate apical leaflets at the end. The capitula are very small and so is the achene. The basal leaves are short and never tomentose. For these characters it is close to *C. sicana* from the center of Sicily; the latter is distinguished by its erect and most scabrid stems, the much more developed cauline leaves, the larger capitula, the bracts with more numerous fimbriae and the longer achene. *C. heywoodiana* differs from *C. giardinae* of nearby Mount Etna, which instead of presents as a very vigorous plant, larger in size, with erect stems and undivided basal leaves; the apical ones never mucronate at the apex; larger capitula and a ribbed achene with short and thin hairs. Compared to *C. parlatoris* Heldr. and to *C. gussonei* Raimondo & Spadaro (*C. parlatoris* var. *tomentosa* Guss.), both species endemic to Sicily, the differences are even more marked: moreover, *C. gussonei* – reported for the Madonie and Peloritani Mountains to Mt Scuderi (Giardina & al. 2007) – is a more robust plant than *C. parlatoris* and it is entirely whitish-tomentose. Finally, for the apical leaves of the mucronate floral stem, the new species has similarities with *C. ambigua* Guss., a critical taxon whose presence in Sicily – although originally described from this island (Dostál 1976) – is excluded, and reported, instead, for the Italian peninsula (Greuter 2008; Bartolucci & al. 2018; Pignatti 2018).

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Article

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The recent neophyte *Opuntia aurantiaca* (*Cactaceae*): distribution and potential invasion in the Iberian Peninsula

Abstract

Gómez-Bellver, C., Laguna, E., Agut, A., Ballester, G., Cardero, S., Deltoro, V., Fàbregas, E., Fos, S., Francisco, S., Guillot, D., Oltra, J. E., Pérez-Prieto, D., Pérez Rovira, P., Senar, R., Ibáñez, N., Herrando-Moraira, S., Nualart, N. & López-Pujol, J.: The recent neophyte *Opuntia aurantiaca* (*Cactaceae*): distribution and potential invasion in the Iberian Peninsula. — Fl. Medit. 30: 377-390. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

The *Cactaceae*, and especially its most emblematic genus, *Opuntia*, is one of the groups of plants with greater invasion potential in the Iberian Peninsula. One of the most recently detected species is *Opuntia aurantiaca*, a small cactus with an enormous capacity of dispersion. Probably native to Argentina and Uruguay, it behaves as a very aggressive invader in Australia and South Africa. In Europe, it only occurs on the Mediterranean coast of the Iberian Peninsula (Catalonia and Valencian Community). In this study, the geographic range of the species is accurately delineated at the peninsular level. Detected firstly at the beginning of the last decade in Navajas (Castelló Province), it has been subsequently observed in other places of Castelló, but also in Valencia, Tarragona and Barcelona, and since 2017 in Girona. With all gathered occurrence data, the potential distribution of *O. aurantiaca* is estimated (for the current climatic conditions as well as for different scenarios of global warming). Despite the fact that the species seems to be spreading, maps of potential distribution do not forecast large expansions to other areas of the Iberian Peninsula, both for the present and for the year 2070.

Key words: alien flora, niche modelling, Spain.

Introduction

Although nearly all cacti (*Cactaceae*) are originally restricted to the New World, many species have become naturalized outside the Americas after having been introduced by man, for instance in Australia, South Africa, Hawaii, and the Mediterranean basin (Verloove & Guiggi 2019). The introduction in these regions was due to their value as ornamental or industrial plants. Initially brought from the Americas by European explorers, probably at early-middle 16th century (Ochoa & Barbera 2017), they soon became common in European collections and gardens (Anderson 2001; Novoa & al. 2015). Since

the 19th century, some of these species rapidly became a major weed problem (e.g. Walters & al. 2011; Chinnock 2015; Novoa & al. 2015). Among cacti, the genus *Opuntia* L., together with *Cylindropuntia* (Engelm.) F. M. Knuth, is the most problematic, having ca. 25 species reported as invasive (Novoa & al. 2015).

The date of the first observation of many of the *Opuntia* spp. and other *Cactaceae* now present in the Iberian Peninsula is, however, very recent. According to Sanz-Elorza & al. (2004), the genus has not spread considerably due to the lack of suitable areas, with the notable exception of *O. ficus-indica* (L.) Mill. Indeed, in *Flora Europaea* (Moore 1968) only five currently recognized species were included, although it should be taken into account that this treatment is over 50 years old. However, in *Flora iberica* (Berthet 1990), albeit published much later, only seven species are recognized. In Catalonia, where at present up to 20 taxa of *Opuntia* are listed (Aymerich & Sáez 2019), in the early 1990s this genus had only two representatives according to Casasayas (1989). Since the 2000s, the number of newly reported species in the Iberian Peninsula has grown exponentially. This remarkable increase in the number of occurrences during the last two decades, which has also been observed for another group of succulent plants (*Agave*; Burguera & al. 2019), might be due to several reasons: (1) the increase of the number of botanists and naturalists interested in the study of the alien flora, with several research groups specialized on alien plants having appeared since late 1990s; apart from the pioneering work of Casasayas (1989), the first lists and catalogues of alien flora in the Iberian Peninsula did not appear until late 1990s/early 2000s (Sanz-Elorza & al. 2001); (2) the enormous habitat fragmentation (especially in coastal areas) linked to the strong economic growth of the Portuguese and Spanish economies after their adhesion to the European Union in 1986; such processes often enhance the introduction of alien plants (Mack & al. 2000); (3) the spread of coastal/suburban second-home settlements thanks to the Spanish real estate bubble of 1995–2008, being composed in most cases of detached and semi-detached villas with private gardens; it is estimated that nearly 2 million of this kind of houses were built during the period 1995–2006 (Pozueta 2015); and (4) the "boom" of xero-gardening in Spain (Aymerich & Sáez 2019), which involved the planting of many succulent alien species [belonging to families including *Agavaceae*, *Asphodelaceae* (where now *Aloe* spp. are included), *Cactaceae*, and *Crassulaceae*] in domestic yards. Additionally, the increase of detections of new populations can be also linked to the more engaged regional policies to fight against biological invasions, establishing protocols for early alert and quick communication of new locations of the most dangerous and expansive alien species. In the case of the Valencian Community, the regional Decree 213/2009 (Generalitat Valenciana 2009) establishes a network of early warning to detect and combat the presence of the most aggressive species, whose introduction in natural areas is fully forbidden. This network allows to provide fine information for species identification, and quick communication protocols to a large network of collaborators (environmental keepers, conservation NGOs, etc.) aiding the regional Wildlife Service to fight against the expansion of invasive species.

Opuntia aurantiaca Lindl. is a small cactus with an enormous capacity for dispersion by means of cladodes and sterile fruits (which can produce sprouts) that detach very easily and adhere to animals, clothing or footwear, and vehicle wheels. Its strong spines can easily penetrate the skin or can stick into the wool or hair of animals (CABI 2020). Its origin is uncertain, but according to Arnold (1977) and van de Venter & al. (1984) it would be a

natural hybrid between *O. discolor* Britton & Rose and *O. salmiana* Pfeiff. [= *Salmonopuntia salmiana* (Pfeiff.) P. V. Heath] originated in South America (Argentina and Uruguay). It was probably first transported to the United Kingdom in 1824 (Moran & al. 1976), and from there it was introduced in Cape Town (South Africa), probably in the 1840s (Moran & Annecke 1979). Used as a garden ornamental and as a barrier plant, it seems that it soon escaped, with eradication activities starting already in the late 19th century but without much success (as it infested ca. 800,000 ha in less than 60 years; Moran & Zimmermann 1991). In Australia, although not much information exists on how and when it was introduced (it was first noted in New South Wales in 1883; DAWE 2020), it is also a very aggressive invader, being considered among the most noxious weeds (CABI 2020), with individual patches of over 1,600 ha (DAWE 2020); for example, in New South Wales alone about 200,000 ha were infested in 1988 (Hosking 2002). *Opuntia aurantiaca* has been declared as a "weed of National Significance" in Australia (DAWE 2020). In recent years it has also been listed as a noxious weed in other two countries of southern Africa (Botswana and Zimbabwe) and in the United States (Novoa & al. 2019). This cactus, in addition to being potentially harmful to people and animals (cattle and dogs), has negative impacts on the local flora (due to its ability to cover the soil densely) and on the economy (because it reduces cultivation and grazing areas). Eradication actions developed against this plant include chemical, mechanical and/or biological control (see Moran & Annecke 1979; Moran & Zimmermann 1991; CABI 2020; DAWE 2020).

In Europe, its presence as a neophyte is only known from Spain (Iberian Peninsula), in Mediterranean coastal areas. This newcomer in the Spanish alien flora has recently been detected in few sites of Catalonia and Valencian Community, where it has established small populations (Guàrdia 2016; Vázquez & Albiach 2016; Verloove & Guiggi 2019; Guardiola & Petit 2020). However, we believe that the species is spreading fast according to our field observations, personal communications, as well as the existence of several unpublished records (or at least not published in standard scientific sources such as articles or books). A proof that this cactus has already become a problem in Spain is the existence of some recent removal actions (e.g. in the Collserola Mountains in Barcelona a few years ago; in the Empordà Plain, in northern Catalonia, in 2019; in Borriol, Castelló Province, in 2015–2018; in El Puig de Santa Maria and Llíria, province of Valencia, in 2015–2019).

The aims of the present study were the following: (1) to delineate accurately the present geographic range of *O. aurantiaca* in the Iberian Peninsula, by gathering and validating all the occurrences, both published in standard publications and available from other sources; and (2) to predict the potential distribution of this species through ecological niche modelling (ENM), both under the present climatic conditions and according to different scenarios of climate change.

Materials & methods

The study species

The typical forms of *Opuntia aurantiaca* are semiprostrate cacti of up to 0.6 m tall, with cladodes of 4–23 × 1–4 cm, deep green to purplish, cylindrical to subcylindrical when mature, and readily detachable (Fig. 1). Areoles contain 2–7 barbed spines (1–4 mm long) with minute

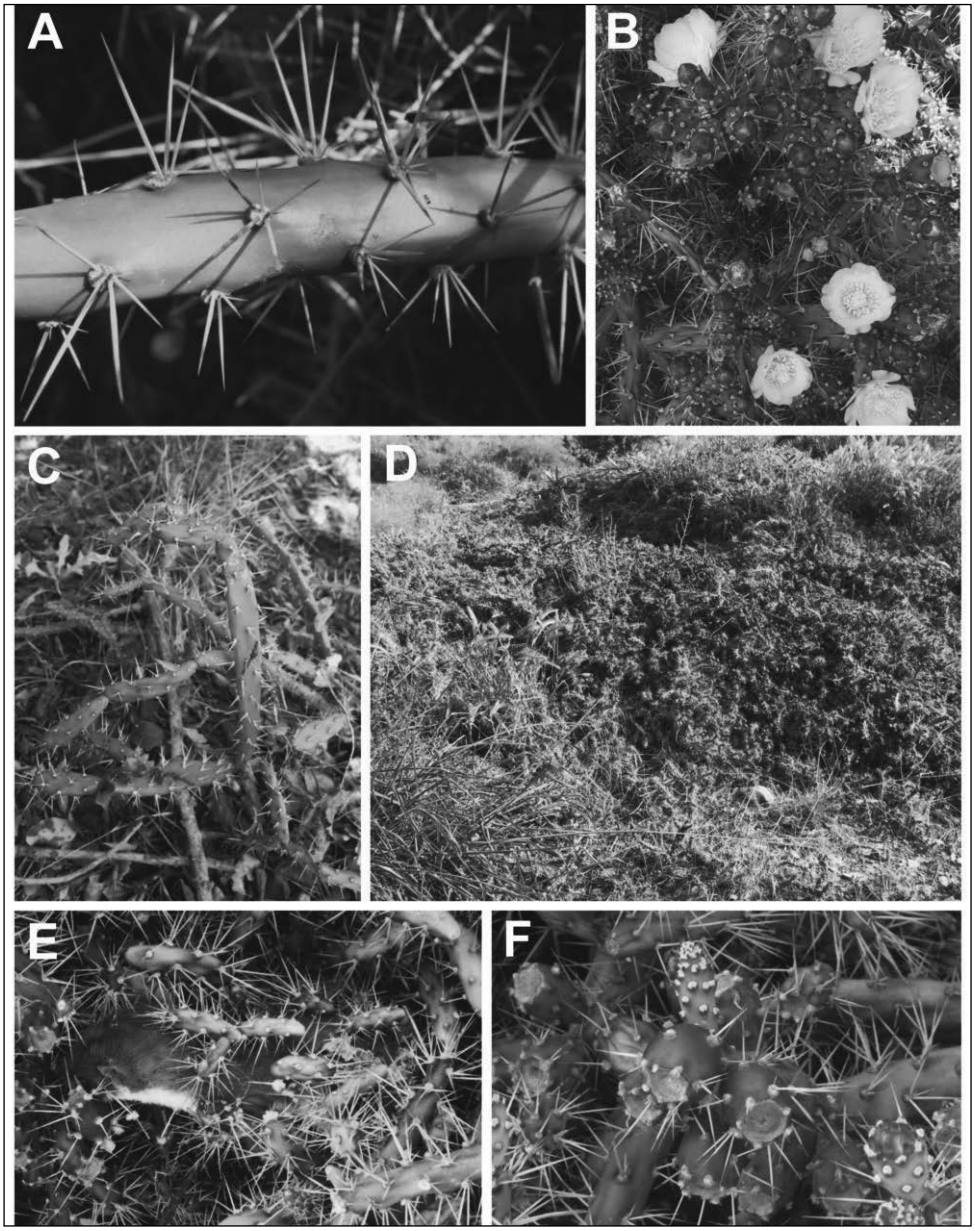


Fig. 1. *Opuntia aurantiaca*, growing in the wild in several locations of the Iberian Peninsula. (A), detail of the areoles and spines of a cladode, from Gavà (Barcelona, 2016); (B) flowering individual in Torreblanca (Castelló 2014), (C), individual from Gavà (Barcelona, 2016); (D), large infestation in Torreblanca (Castelló, 2015); (E), in the same population (Torreblanca, Castelló, 2015), a dead individual of least weasel (Mustela nivalis), probably because it was trapped among the spiny cladodes; (F), fruiting individual in Ulldecona (Tarragona, 2020). Photographs: (A) and (C), C. Gómez-Bellver; (B), P. San Lázaro; (D) and (E), P. Pérez Rovira; (F) S. Cardero.

glochids and trichomes. The flowers are bright yellow, 2.5–6 cm wide, while the sterile, spiny fruits are about 2–3 cm long, pear-shaped, red-purple at maturity (van de Venter & al. 1984; Guàrdia 2016; DAWE 2020). Although it has been reported that *O. aurantiaca* can produce apomictic seeds, these are rarely viable (Archibald 1939); therefore, it spreads mainly thanks to vegetative reproduction, mostly by cladode detachment; stem segments can be dispersed over long distances by animals, humans, vehicles, water or wind (Electronic Supplementary File 1, Fig. S1; Zimmermann & van de Venter 1981; DAWE 2020). According to Moran & Zimmermann (1991), a single individual produces a mean of ca. 170 cladodes. There are four morphotypes of this hybrid, the naturalized one being the typical form (morphotype A2, related to the *O. discolor* parent; Arnold 1977; van de Venter & al. 1984). It is a tetraploid species with $2n = 4x = 44$ (Yuasa & al. 1973). Plants are very long lived (DAWE 2020).

Search for occurrences

The distribution of *Opuntia aurantiaca* in the Iberian Peninsula has been updated and completed using different sources: (1) research articles; (2) global online databases as GBIF (GBIF 2020) or iNaturalist (www.inaturalist.org); (3) regional online databases as the *Banco de Datos de Biodiversidad de la Comunidad Valenciana* (www.bdb.gva.es); (4) grey literature (e.g. technical reports); and (5) herbarium specimens. In addition, an extensive field work has been carried out by the authors of this contribution.

Ecological niche modelling

The maximum entropy algorithm implemented in MaxEnt v.3.4.1 (Phillips & al. 2006) was used to determine the potential distribution for *Opuntia aurantiaca*. For modelling we used all the occurrences detected (see ESF1, Appendix); for some of them, more than one unique geographic coordinate has been considered to cover the total area where the species is found in that locality (e.g. Vilajuiga and Pau populations). As these occurrences were recent and accurate, the resolution used was 30 arc-sec (i.e. ca. 1 km). The 19 bioclimatic variables and altitude, also at 30 arc-sec resolution, were downloaded from the WorldClim website (www.worldclim.org; Hijmans & al. 2005). The Human Footprint (HF) (Sanderson & al. 2002) was also chosen because the establishment and spread of *O. aurantiaca* is related to human disturbance. A small set of eight relatively uncorrelated variables ($r < |0.8|$) were selected (see ESF1, Text S1). Niche models have been developed for both current climatic conditions and different climate change scenarios for the year 2070. For the present conditions, we have built two models, one including the variable HF and the other excluding it. For the future, we used the three widely used general circulation models in two different representative concentration pathways (RCPs), RCP 2.6 and RCP 8.5 (see ESF1, Text S1). Details on the methods of replication, model performance assessment, thresholding, map representation, and calculations on gained/lost areas are in ESF1, Text S1.

Results and Discussion

Current distribution range of* Opuntia aurantiaca *in the Iberian Peninsula

There are no reports of the presence of *Opuntia aurantiaca* in the Iberian Peninsula (and in the whole of Europe) until recently. The first time that it was observed with certainty

(although mistakenly reported as *O. pestifer* Britton & Rose) was in 2002 in the limestone walls around Navajas (Vázquez 2009; see also ESF1, Appendix), a small village in the province of Castelló, about 30 km from the coastline, in the Valencian Community. The second observation of this cactus was not until 2008, from Tivenys, near the Ebro River, in southern Catalonia. However, the number of reports since 2010 quickly increased and, up to date, 36 occurrences have been recorded (ESF1, Appendix), distributed in five Spanish provinces along the Mediterranean coast: Girona, Barcelona and Tarragona of Catalonia, and Castelló and València of the Valencian Community (ESF1, Fig. S2). The largest concentrations of occurrences (and, thus, the potential spread foci) are southern Castelló/northern València, southern Tarragona, and central Barcelona provinces; however, the northernmost locations are particularly worrisome, since these are the largest and the invasion seems to be progressing faster there (see below).

Most reports of *O. aurantiaca* till recently seem to correspond to small populations of a few individuals (typically, less than 50) occupying a few square meters, perhaps escaping from nearby private gardens. For example, in Navajas (the first report of *O. aurantiaca* in Europe, in 2002), just a dozen individuals were observed in a small area of a few square meters (J. R. Vázquez, pers. comm.), whereas in Tivenys (the second report, dating from 2008) the population was not much larger (around or slightly more than 20 individuals in an area of about 25 m^2; S. Pyke, pers. comm.). Other localities observed at the beginning or middle 2010s are also of relatively small size, although with some exceptions (ESF1, Appendix). However, according to the most recent observations (from 2017 onwards), both own and from colleagues, most populations seem to be getting bigger in number of individuals and thus affecting much larger areas. These observations are coinciding with the putative spread of the cactus towards the north (province of Girona and parts of the province of Barcelona; ESF1, Fig. S2). For example, in Vilajuïga there are over 2 ha of land covered by *O. aurantiaca* (Fàbregas 2018), and the species has spread to a nearby village (Pau; ESF1, Appendix). Only a close monitoring of populations, however, could allow to test whether this purported recent expansion is actually occurring. Fortunately, *O. aurantiaca* is not a popular garden plant here, since we have not detected any shop selling it, which may guarantee a certain level of containment.

***Present and future potential distribution of* Opuntia aurantiaca**

The ENM models have been built with occurrence data for 41 cells of 30 arc-sec resolution, a size that is enough for getting reliable results and avoid the need for using jackknife validation (an approach that may produce overoptimistic estimates of predictive power with sample sizes > 25; Pearson & al. 2007). Indeed, both AUC and TSS values indicated that the models performed well (AUC values > 0.990; TSS values > 0.887; ESF1, Table S1). In all models the variables that contributed the most are bio8 (average temperature of the wettest quarter) and altitude (ESF1, Table S1). Given that the low cold-tolerance is one of the most limiting factors of succulent species with a CAM (Crassulacean Acid Metabolism) photosynthetic strategy (Lüttge 2004), the absence of bio6 (minimum temperature of the coldest month) in the list of variables used for modeling may be surprising. For example, bio6 is the most important variable for the ENM in other succulent plants, such as *Dendrocereus nudiflorus* (Engelm. ex Sauvalle) Britton & Rose (*Cactaceae*; Barrios & Mancina 2017) and *Kalanchoe* × *houghtonii* D. B. Ward

(*Crassulaceae*; Herrando-Moraira & al. 2020). However, bio6 is actually represented in our models for *Opuntia aurantiaca* by the variable altitude, as they were highly correlated in our preliminary models (r = -0.85), and we selected the latter because of its higher weight in the model and its better (i.e. more easy to interpret) response curve (ESF1, Figs. S3-S5). In addition, bio11 (mean temperature of the coldest quarter), a variable highly correlated (r = 0.98) with bio6, is also an important variable in our model (ESF1, Table S1).

The most explanatory variable in all models for *O. aurantiaca* is bio8, the average temperature of the wettest quarter. The response curve of this variable is asymptotic, with the probability of occurrence starting to increase at about 2–3ºC and reaching the maximum values at about 16–17ºC (ESF1, Fig. S6). In other words, the species would not be capable to grow in too cold places when the rain season occurs, probably reflecting the climate of the area where the species presumably originated, eastern Argentina (mostly in the Entre Ríos Province) and southwestern Uruguay (Moran & al. 1976); in this region, the rainy season coincides with the austral summer (Inumet 2020; SMN 2020). These climatic constraints for *O. aurantiaca* could be easily explained by the lack of freezing tolerance of most cacti and succulent plants in general. Although some cacti [such as *O. humifusa* (Raf.) Raf.] have the sugar-mediated osmoregulation mechanism to control freeze dehydration (for example, this allows *O. streptacantha* Lem. to tolerate temperatures as low as -24ºC; Goldstein & Nobel 1994), this does not seem to be the case for *O. aurantiaca*; neither the native areas nor invasive ones include cold-weather areas. Such effects of cellular freeze dehydration could be enhanced under a high-precipitation regime, as it produces the lowering of intracellular osmotic pressure, thus promoting the diffusion of intracellular water into the apoplastic spaces where ice crystals are formed. Certainly, the negative effects of freeze dehydration are well-known in succulents gardening—"weather that is most threatening to succulents is rain followed by frost" (Baldwin 2017). Interestingly, such effects were already noted in South Africa by Zimmermann & van de Venter (1981) for *O. aurantiaca*: "The plant does not establish well in winter rainfall areas". In *O. ficus-indica*, which also has the sugar-mediated osmoregulation mechanism (Goldstein & Nobel 1991) but not as effective as in *O. humifusa* (*O. ficus-indica* cannot tolerate temperatures below -10ºC), bio8 was also the most important variable for its niche model built for the Iberian Peninsula (Guillot & al. 2015).

The maps depicting the suitable areas for *O. aurantiaca* at the present time do not show very large differences between them (Fig. 2), although the model incorporating the variable HF recovers somewhat smaller areas (10.444 km^2 vs. 13.617 km^2; Table 1). The most inland areas—those with fewer human activities—have not been considered as suitable in the model with HF (e.g. the Ebro River basin), although a smaller area for models incorporating HF compared to models without HF has already been reported for the succulent *K.* × *houghtonii* (Herrando-Moraira & al. 2020). Despite the fact that *O. aurantiaca* seems to be actively spreading in Catalonia and the Valencian Community, our maps of potential distribution for the present do not predict large expansions to other areas of the Iberian Peninsula (Fig. 2). Although the current occurrences are far to fill all of the predicted distribution, *O. aurantiaca* would hardly colonize regions outside the areas of typical Mediterranean climate (the Csa climate according to the Köppen-Geiger classification; http://koeppen-geiger.vu-wien.ac.at/) on the Mediterranean coast of the eastern part of the Iberian Peninsula (see also AEMET & IM 2011). A similar potential distribution for the



Fig. 2. Potential distribution areas of *Opuntia aurantiaca* in the Iberian Peninsula under present climatic conditions (A) not including Human Footprint (HF) or (B) including HF to perform the models.

Table 1. Extension of suitable predicted areas of *Opuntia aurantiaca* for each model. The overlap area between present (without considering Human Footprint variable; HF) and respective future models, and the lost and gained area for future predictions with respect to present models are also presented.

Model	Predicted area in km²	Difference with present in km² (%)	Overlap with present in km² (%[a]; %[b])	Lost area in the future in km² (%)	Gained area in the future in km² (%)
Present (without HF)	13,617	—	—	—	—
Present (with HF)	10,444	3,174 (−23.31)	10,434 (76.62; 99.91)	—	—
Future 2070 CCSM (RCP 2.6)	14,393	775 (+5.69)	12,341 (90.62; 85.74)	1,277 (9.38)	2,052 (15.07)
Future 2070 CCSM (RCP 8.5)	16,620	3,002 (+22.04)	10,468 (76.87; 62.99)	3,149 (23.13)	6,151 (41.17)
Future 2070 GFDL (RCP 2.6)	11,063	2,555 (−18.76)	10,644 (78.16; 96.22)	2,974 (21.84)	419 (3.07)
Future 2070 GFDL (RCP 8.5)	14,798	1,181 (+8.67)	7,958 (58.43; 53.77)	5,660 (41.57)	6,841 (50.23)
Future 2070 MPI (RCP 2.6)	17,117	3,500 (+25.70)	12,375 (90.87; 72.29)	1,243 (9.13)	4,742 (34.83)
Future 2070 MPI (RCP 8.5)	6,069	7,549 (−55.43)	4,810 (35.32; 79.26)	8,808 (64.68)	1,259 (9.25)

[a]Percentage of overlapped area with respect to the area predicted with first model (present).
[b]Percentage of overlapped area with respect to the area predicted with each assayed model.

Iberian Peninsula was recovered for *O. ficus-indica* (with the exception that a small area in the Portuguese central coast also appeared as suitable; Guillot & al. 2015), which may indicate that the Mediterranean areas of central and southern Iberian Peninsula would not be entirely suitable for the establishment of *Opuntia* species. Among other factors, they are probably too dry in summer; for example, bio18, the precipitation of the warmest quarter (summer), should reach ca. 100 mm for the niche optimum of *O. aurantiaca* according to its response curve (ESF1, Fig. S6), a value of rainfall hardly occurring in the central and southern Iberian Peninsula (www.worldclim.org; AEMET & IM 2011).

There is a high variability for the predicted range of *O. aurantiaca* in the Iberian Peninsula among the models for the different future climate scenarios, although, on average, there is a loss of 2.00% or 274 km² with respect to present scenario data (Table 1). In general, when Figs. 2–3 are observed, no major changes in the predicted area can be observed between the models for the present and the models for the future, with perhaps the only exception of the MPI model under the RCP 8.5 scenario (with a

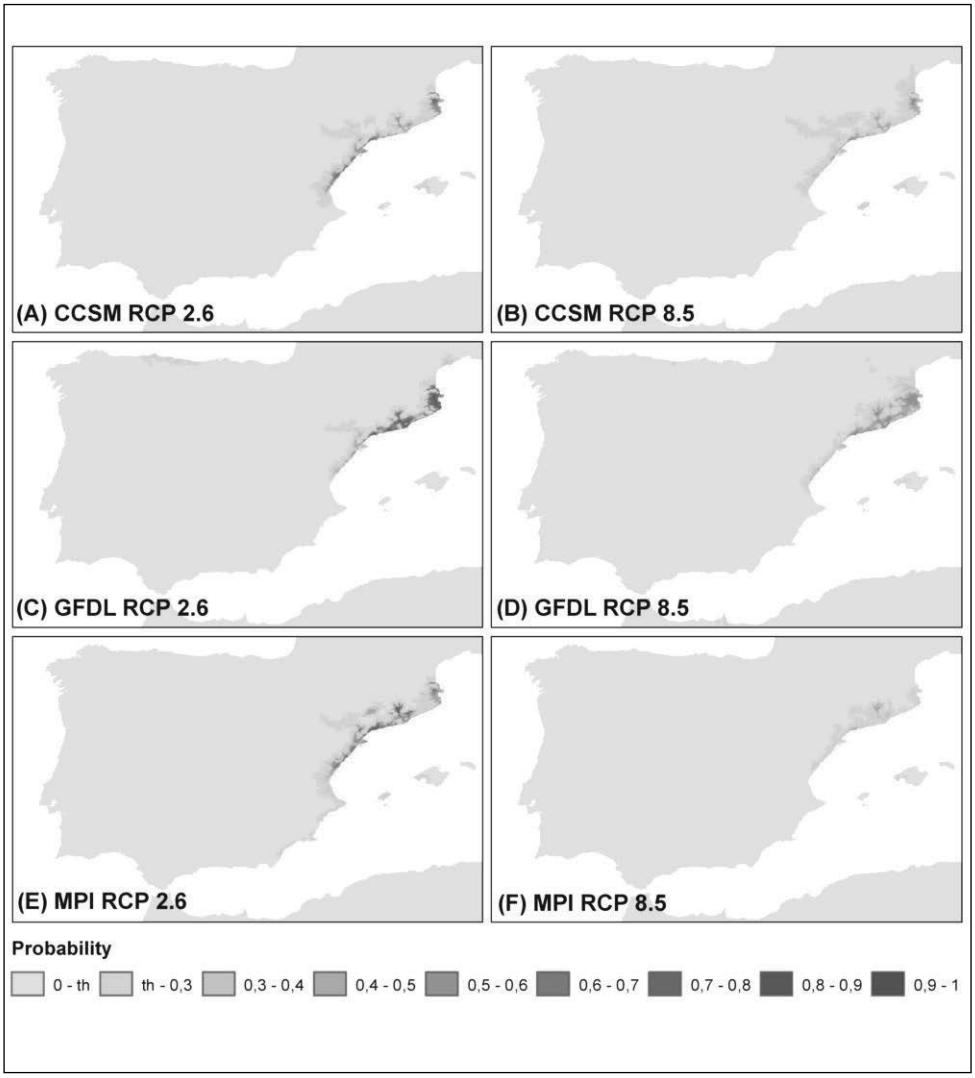


Fig. 3. Potential distribution areas of *Opuntia aurantiaca* in the Iberian Peninsula under future climatic conditions, using the CCSM model for (A) RCP 2.6 and (B) RCP 8.5, the GFDL model for (C) RCP 2.6 and (D) RCP 8.5, and the MPI model for (E) RCP 2.6 and (F) RCP 8.5. The RCP 2.6 scenario represents an increase of 0.3–1.7ºC for ca. 2081–2100, whereas RCP 8.5 forecasts an increase of 2.6–4.8ºC for the same period (see ESF1, Text S1).

considerable loss of suitable area, of up to 55%; Table 1). Such variability between models for the year 2070 for *O. aurantiaca* is not an unexpected result given that the uncertainty of predicting suitable areas using climate forecasts and not real data (e.g. Guevara & al. 2019) is added to the fact that we are only focusing on a part of the

species' world range. For example, in the succulent *Kalanchoe* × *houghtonii* all global models show a reduction in the potential distribution area for the year 2070 with no very large differences between them (mean = 33.5% ± 17.0%), but if we "zoom in" to the Iberian Peninsula (see Fig. 8 in Herrando-Moraira & al. 2020) the differences become very pronounced. It should be taken into account, however, the limitation of our niche model due the use of only Iberian occurrences; one may suppose that the suitable area in the Iberian Peninsula would be larger if all world occurrences are used for modeling, as native occurrences or other introduced areas occurrences could grow under different climatic conditions than the Iberian ones. Although beyond the scope of this study, it would be advisable, thus, to model the niche with all occurrences of *O. aurantiaca*.

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Mediterranean plant germination reports – 2

edited by Sara Magrini & Cristina Salmeri

Abstract

Magrini, S. & Salmeri, C. S. (eds): Mediterranean plant germination reports – 2. — Fl. Medit. 30: 391-437. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

This is the second issue of the series of germination reports from Mediterranean areas (sensu Med-Checklist). It comprises germination protocols for 23 taxa: *Neotinea* from Greece by S. Oikonomidis & al. (No. 23); *Berardia*, *Potentilla*, *Silene*, and *Tephroseris* from North Italy by V. Carasso & al. (Nos. 24-27); *Aethionema*, *Arenaria*, *Iberis*, and *Odontarrhena* from Sicily by F. Carruggio & al. (Nos. 28-31); *Astragalus*, *Erysimum*, *Senecio*, *Silene*, and *Tanacetum* from Sicily by C. Salmeri & M. Castrogiovanni (Nos. 32-36); *Onopordum* from central Italy by S. Zitti & al. (No. 37); *Viola* from central Italy and Sicily by S. Magrini & L. Zucconi (Nos. 38-41); *Hieracium* and *Pilosella* from Sicily and South Italy by E. Di Gristina & al. (Nos. 42-45).

Editorial

This second issue of the series of germination reports from Mediterranean areas (sensu Med-Checklist) comprises seven contributions reporting germination protocols for 23 taxa from Greece, Italy, and Sicily, including 14 endemics. In particular, first germination data for 18 taxa are here reported.

In the first report, Oikonomidis & al. (2020, No. 23) successfully tested several media to improve asymbiotic germination performance in seeds of *Neotinea maculata* (Desf.) Stearn (*Orchidaceae*).

Other five contributions are focused on mountain plants, reporting germination protocols for a total of 18 taxa from Alpine and Mediterranean mountains, most of them endemics. The authors tested the effect of various pre-treatments, like cold stratification, scarification, the addition of gibberellic acid, different temperatures and different photoperiods on germination. In particular, Carasso & al. (2020, Nos. 24-27) reported germination data for four species from North Italy, endemic to the Western Alps, using cold stratification or scarification for dormancy-breaking of: *Berardia lanuginosa* (Lam.) Fiori & Paol. (*Asteraceae*), *Potentilla valderia* L. (*Rosaceae*), *Silene cordifolia*

All. (*Caryophyllaceae*), and *Tephroseris balbisiana* (DC.) Holub (*Asteraceae*). Cold stratification and gibberellic acid were used by Zitti & al. (2020, No. 37) to break physiological dormancy in *Onopordum tauricum* Willd. (*Asteraceae*) from central Italy. Three studies focused on the effects that changes in temperature and photoperiod have on seed germination. Best germination protocols for four pioneer taxa from the Madonie Massif (Sicily) are provided by Carruggio & al. (2020, Nos. 28-31) who tested six different constant temperatures (from 5 to 30°C), both in light/dark and darkness, without pre-treatments: *Aethionema saxatile* (L.) R.Br. subsp. *saxatile* (*Brassicaceae*), *Arenaria grandiflora* L. subsp. *grandiflora* (*Caryophyllaceae*), *Iberis violacea* R.Br. (*Brassicaceae*), and *Odontarrhena nebrodensis* (Tineo) L. Cecchi & Selvi (*Brassicaceae*), endemic to the Madonie Massif. Salmeri & Castrogiovanni (2020, Nos. 32-36) focused on the germination ability of five Sicilian endemics from Mt. Etna (Sicily), using different pre-treatments, like manual/chemical scarification and hydro-priming, and testing four temperatures (from 10 to 25°C), both in light/dark and darkness: *Astragalus siculus* Biv. (*Fabaceae*), *Erysimum etnense* Jord. (*Brassicaceae*), *Senecio squalidus* L. subsp. *aetnensis* (DC.) Greuter (*Asteraceae*), *Silene italica* subsp. *sicula* (Ucria) Jeanm. (*Caryophyllaceae*), and *Tanacetum vulgare* subsp. *siculum* (Guss.) Raimondo & Spadaro (*Asteraceae*). Di Gristina & al. (2020, Nos. 42-45) tested the effect on germination of gibberellic acid and of three constant temperatures (15, 20, 25°C) and alternating temperature (25/15°C) in four endemic *Asteraceae* taxa from mountains of Sicily and South Italy: *Hieracium hypochoeroides* subsp. *cilentanum* Di Grist., Gottschl. & Raimondo, endemic to Mt Cervati (Campania, South Italy), *H. schmidtii* subsp. *nebrodense* (Lojac.) Di Grist., Gottschl. & Raimondo, endemic to the Madonie Mountains, *H. terraccianoi* Di Grist., Gottschl. & Raimondo, endemic to the Pollino Massif, and *Pilosella hoppeana* subsp. *sicula* Di Grist., Gottschl. & Raimondo, endemic to the Madonie and Nebrodi Mountains.

In the last contribution by Magrini & Zucconi (2020, Nos. 38-41), cold stratification, seed hydro- and hormo-priming, and gibberellic acid were used for dormancy-breaking in four species of *Viola* sect. *Melanium* (*Violaceae*) from central Italy and Sicily: *Viola arvensis* Murray subsp. *arvensis*, *V. hymettia* Boiss. & Heldr., *V. kitaibeliana* Schult., and *V. tricolor* L. subsp. *tricolor*.

The "Mediterranean plant germination reports" column could surely become a useful tool for researchers, conservationists, botanists, and other specialists, providing species-specific information on the pre-treatments and key factors to enhance germination of native seeds. Moreover, these germination data will flow into an online, open-access database managed by RIBES association in order to make them available to a wider audience.

For the preparation of the manuscript, please, follow the general instructions for authors of Flora Mediterranea (http://www.herbmedit.org/guide.html) and the specific instructions for the Mediterranean plant germination reports (Magrini & Salmeri 2019; https://www.herbmedit.org/flora/FL29_269-271.pdf). Authors are invited to submit their manuscript in English to one of the editors.

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S. Oikonomidis, K. Koutsovoulou & C. A. Thanos

Germination of *Neotinea maculata* (*Orchidaceae*) in nutrient media and water agar

Abstract

Oikonomidis, S., Koutsovoulou, K. & Thanos, C. A.: Germination of *Neotinea maculata* (*Orchidaceae*) in nutrient media and water agar [In Magrini, S. & Salmeri, C. (eds), Mediterranean plant germination reports – 2]. Fl. Medit. 30: 394-399. 2020. https://doi.org/10.7320/FlMedit30.394

The asymbiotic seed germination of orchids is a complex process with considerable technical difficulties, due to the natural requirement of a plant-fungus symbiotic relationship under field conditions. Only on rare occasions, orchid seeds are known to readily germinate in water. *Neotinea maculata* is a relatively common orchid species with its main distribution around the Mediterranean Sea. Germination of *N. maculata* seeds was tested in both nutrient media and water agar, in asymbiotic culture. Full germination was achieved both in nutrient media (96.1%) and water agar (84.0%) in darkness at 20°C. In this study, apart from presenting the protocols of germination for *N. maculata* in asymbiotic culture, we also furnish data for the other members of the genus *Neotinea*.

Key words: asymbiotic germination, Greece, orchid, photoinhibition.

Introduction

Orchidaceae is one of the richest, in number of species, flowering plant families of the world, comprising about 28,000 species and 800 genera (Govaerts & al. 2019); it is also one of the oldest Angiosperm families in an evolutionary perspective (Givnish & al. 2015). Members of the family can be found almost everywhere, throughout all continents except Antarctica (Christenhusz & al. 2017).

Orchid seeds are among the smallest-sized ones. They consist of a spindle-shaped, thin seed coat that encloses the underdeveloped embryo. Due to the rudimentary structure of the orchid embryo, comprised by just a cluster of undifferentiated cells, there are no well-shaped embryonic organs and thus germination cannot be defined by the concept of radicle emergence from the seed coat. A system of developmental stage evaluation has been put forward for the assessment of orchid seed germination (Zettler & Hofer 1998) and it is commonly used in most relevant studies. Therefore, in this work, according to Zettler & Hofer (1998), germination is considered to take place as soon as the rhizoids have started to develop.

Neotinea maculata (Desf.) Stearn, commonly known as the dense-flower orchid, is a relatively common species with its main distribution around the Mediterranean Basin. In

Greece, it is found growing in numerous small populations, mostly in grassland and coniferous forest habitats, from sea level up to 2000 m of elevation.

N. maculata is one of the four members of the genus *Neotinea*. While the other species (*N. lactea*, *N. tridentata* and *N. ustulata*) are allogamous, relying on insects for pollination, *N. maculata* is an autogamous species with only rare occasions of insect pollination (Claessens & Kleynen 2018).

Regarding seed germination data, the *Neotinea* genus shows a widely diverse picture: on the one end, no records of successful germination for *N. tridentata* and *N. lactea* exist, while minimal germination (1%) has been reported for *N. ustulata* (Ponert & al. 2011); on the other hand, *N. maculata* seeds germinate relatively easily, in asymbiotic nutrient media culture, with percentages ranging between 59% and 80% (Calevo & al. 2017; Ponert & al. 2011). In this work, we further investigated the germination capacity of *N. maculata* seeds both in nutrient media and in water agar (the latter tested for the first time), at a range of constant temperatures under two light regimes; we also compared the relatively easy germination exhibited by *N. maculata* with those of the other genus members.

23. *Neotinea maculata* (Desf.) Stearn (*Orchidaceae*)

Accession data

Gr: Mt. Hymettus (Athens), loc. Aesthetic Forest of Kaisariani (WGS84: 37.96305556°N, 23.79638889°E), 314 m a.s.l., 26 Mar 2017, *S. Oikonomidis* (NKUA/GR-Acc. 0206, Seed Bank of National and Kapodistrian University of Athens).

Germination data

Pretreatments: Disinfection with: **a**) 10% bleach solution (0.5-1% NaOCl) for 15 min followed by three rinses in sterile distilled water, **b**) 5% $Ca(OCl)_2$ + 1% Tween 80 solution for 15 min followed by three rinses in sterilized distilled water, **c**) no pretreatment.

Germination media: **1)** modified (type 1) Malmgren (**Mm**) medium (Malmgren 1996 modified by Kitsaki & al. 2004) consisting of 75 mg/L $(Ca)_3PO_4$, 75 mg/L KH_2PO_4, 75 mg/L $MgSO_4(H_2O)_7$, 10 mg/L sucrose, 50 mL/L coconut water, 6 g/L agar and 0.5 g/L charcoal, at pH 5.8; **2)** modified (type 2) Malmgren (**M+**) medium (Calevo & al. 2017) consisting of 75 mg/L $(Ca)_3PO_4$, 75 mg/L KH_2PO_4, 75 mg/L $MgSO_4(H_2O)_7$, 100 mg/L NH_4NO_3, 10 g/L sucrose, 50 mL/L coconut water, 8 g/L agar and 0.5 g/L charcoal, at pH 5.8; **3)** Murashige & Skoog (**MS**) medium (Murashige & Skoog 1962); **4)** 2% agar (**WA**). All germination media were autoclaved at 0.1 MPa and 121°C for 20 min.

Sample size: 140 seeds (70 × 2 replicates) in nutrient media; 500 seeds (100 × 5 replicates) in water agar.

Germination	Thermoperiod	Pretreatment /Medium	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
96.1%	constant 20°C	a/Mm	0/24h	11	16	54	12

89.3%	constant 20°C	b/M+	0/24h	11	18	66	18
86.6%	constant 20°C	a/M+	0/24h	8	14	42	24
84.0%	constant 20°C	c/WA	0/24h	13	16	50	28

Observations

Mature seed pods were collected in March 2017 from a wild population (26 mature individuals) of *N. maculata* in Mt. Hymettus. A total of 104 seed pods from 13 individuals (8 per plant) were collected and they were taken in the Seed Bank of National and Kapodistrian University of Athens where seeds were extracted and placed in glass vials, in laboratory conditions until the end of the experiments. After the end of the experiments (July 2018), the seeds were deposited for long term storage in the NKUA Seed Bank at -20°C.

N. maculata is a relatively easy species to germinate (Calevo & al. 2017; Ponert & al. 2011). In our study, optimal germination results, higher than previously reported, were reached in three media with two pretreatments. Final germination of seeds pretreated with 10% bleach for 15 min (96.1%) was slightly higher than seeds pretreated with 5% $Ca(OCl)_2$ + 1 Tween 80 (89.3%) in Mm; the same observation was also made in the case of MS where final germination for bleach pretreated seeds was higher (60.8%) than the $Ca(OCl)_2$ pretreated seeds (14%). In the nutrient media experiments, optimal final germination was obtained in Mm (96.1%) and M+ (86.6%) while MS gave the lowest germination (60.8%). Germination of *N. maculata* has been previously tested on Michl-5 by Ponert & al. (2011) and on M+ by Calevo & al. (2017); final germination on Michl-5 was 80% but this medium was not tested in our study. In the present work, final germination in M+, after 15 min of pretreatment with bleach, yielded a considerably higher final germination (86.6%) than previously reported by Calevo & al. (2017) who achieved 59% of germination in the same medium, with seeds pretreated with NaOCl for 20 min, with the main difference being in the shorter duration of the pretreatment.

In addition, it is for the first time that germination of *N. maculata* is observed in water agar. Optimal germination (84.0%) was achieved with no pretreatment at 20°C, when seeds were imbibed on 2% agar (no nutrients added). Regarding temperature, 20°C was found to be optimal for *N. maculata* germination while final germination (similarly without pretreatment) at 10°C, 15°C, 25°C, and 30°C was 39%, 66%, 10%, and 0%, respectively. Pretreating the seeds with NaOCl for 15 min resulted in lower final germination levels compared to untreated seeds (53%, 66%, 61%, 3%, and 0% at 10, 15, 20, 25, and 30°C, respectively).

Despite the fact that germination of small seeds is usually promoted by light, an increasing number of orchids have been reported to have seeds with photoinhibited germination (Carta & al. 2017; Rasmussen 1995). *N. maculata* is an addition to the short list of the *Orchidaceae* species with photoinhibition. Germination of *N. maculata* seeds was fully inhibited by white light (photoperiod of 12/12h) at 20°C.

For the other three species within the genus *Neotinea*, very low germination data for only *N. ustulata* have been reported, so far (Ponert & al. 2011). Therefore, in our lab, we tried to germinate asymbiotically *N. lactea* and *N. tridentata* seeds. Final germination values in Mm were relatively low, 15% and 10% for *N. lactea* and *N. tridentata*, respectively; in both species, seed germination was obtained with longer scarification time: 30 min for the former and 60 min for the latter.

Conclusions

Orchid minuscule seeds with their underdeveloped embryos lack sufficient nutrient to support germination and early seedling development. In most cases, in nature, a fungus symbiont provides nutrients to the seedling in the first stages of its development while in the laboratory, nutrients are provided by the culture media used. Relatively few species of the family *Orchidaceae* can readily germinate in water and the final germination level is usually low (Rasmussen 1995). In this study we present a successful protocol for germination of *N. maculata* which yielded higher final germination than previously reported in nutrient media; we also demonstrate, for the first time, the ability of the species to readily germinate in water agar without any nutrients added, while we additionally reveal the inhibition of seed germination by light for this species. Seeds sown in nutrient media reached a stage 4-5 in the Zettler & Hofer scale (Zettler & Hofer 1998), while seeds imbibed in water agar reached stage 1-2 in the same scale (Fig. 1).

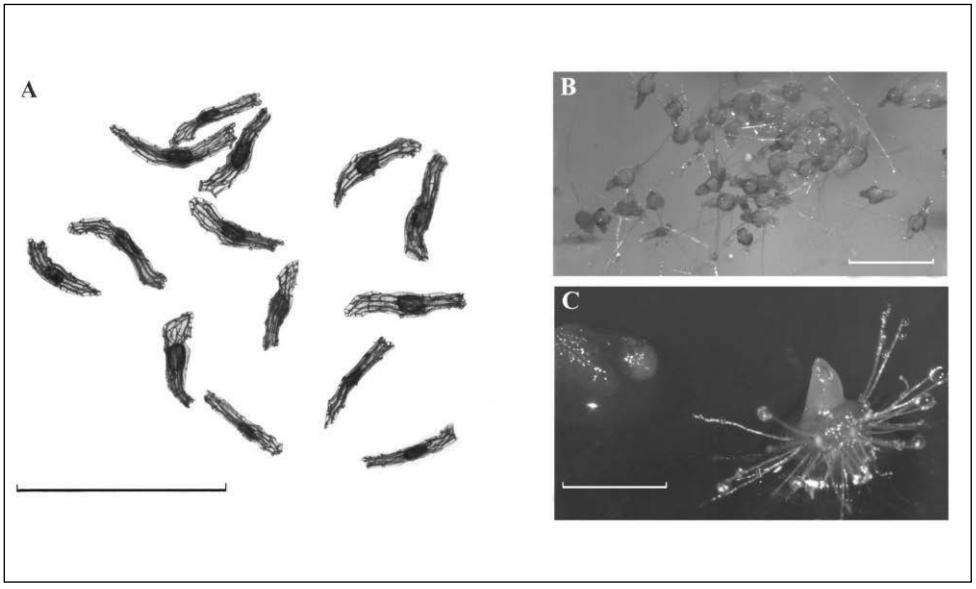


Fig. 1. *Neotinea maculata*. A: dry seeds; B: germinated seeds in water agar (WA) at the developing rhizoids stage; C: germinated seed in modified (type 1) Malmgren (Mm) at the protocorm plus initial shoot stage. Scale bars = 1 mm.

The optimal germination temperature was 20°C and the highest, reported so far, germination (96.1%) was achieved in Mm medium. High germination (84.0%) was also achieved in water agar with no seed pretreatment, a result that seems to indicate the water permeability of the seed testa in this species. *N. maculata* is one of the few orchid species known (Rasmussen 1995) to readily germinate in water with almost full germination. Seeds of *N. maculata* do not require scarification in order to germinate while such a pretreatment, even for a short duration, may lead to negative results in seed viability and subsequent germination.

Comparing the germination behaviour of the four species, we can assume that *N. maculata* is the only member of the genus with a water-permeable testa, while the other species have an impermeable seed coat, which might be the result of the accumulation of water-repelling substances (e.g. lignin, waxes etc.), thus requiring chemical degradation in order for water to be absorbed and the germination process to start.

Species which readily germinate in water like *N. maculata* can be utilized as comparative means for further understanding the germination physiology of species which exhibit hindered germination either in common orchids (e.g. in the genus *Neotinea*) or in rare and endangered ones (e.g. in the genus *Dactylorhiza* where germination in water was also observed in several members of the genus, Rasmussen 1995).

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V. Carasso, B. Gallino & M. Mucciarelli

Seed germination reports of four rare species of the Western Alps

Abstract

Carasso, V., Gallino, B. & Mucciarelli, M.: Seed germination reports of four rare species of the Western Alps [In Magrini, S. & Salmeri, C. (eds), Mediterranean plant germination reports – 2]. Fl. Medit. 30: 400-407. 2020. https://doi.org/10.7320/FlMedit30.400

This study describes germination protocols of four Western Alps endemics. The species studied are: *Berardia lanuginosa, Potentilla valderia, Silene cordifolia*, and *Tephroseris balbisiana*. Seeds were collected in the Maritime Alps (Cuneo, Italy) and conserved for a few days in the herbarium chamber or in the drying room of the seed bank before submitting to germination test. The germination tests were carried out in the Piedmont Germplasm Bank. Our results show a high germination response for all the analyzed species.

Key words: alpine species, *Berardia lanuginosa*, endemic, *Potentilla valderia*, *Silene cordifolia*, *Tephroseris balbisiana*.

Introduction

The Maritime and Ligurian Alps are one of the most important centres of flora diversification of the Mediterranean basin (Casazza & al. 2016). This part of the Alpine chain represented an important refuge for plants during the last glacial maximum, and this is the reason why it hosts a large number of endemic species.

This study investigated the germination response of *Berardia lanuginosa* (Lam.) Fiori & Paol., *Potentilla valderia* L., *Silene cordifolia* All., and *Tephroseris balbisiana* (DC.) Holub. These endemic species show a distribution limited to the Western Alps, with the only exception of *T. balbisiana* which has a disjoint distribution with a few populations on the Northern Apennines.

Seeds were collected in the field at dispersal and immediately transferred to the Piedmont Germplasm Bank (Centro Regionale per la Biodiversità Vegetale, Chiusa di Pesio, CN) where germination tests were carried out. Our results showed high germination percentages in all the species studied, which are presently conserved at the germplasm bank.

24. *Berardia lanuginosa* (Lam.) Fiori & Paol. (*Asteraceae*) (Fig. 1)

Accession data

It: Argentera (Cuneo), loc. Gias Colombart, Vallone di Colombart (WGS84: 44.360433°N, 6.916624°E), calcareous screes, 2350 m a.s.l., 28 Sept 2013, *V. Gosmar* (NA/13/1000, Piedmont Germplasm Bank).

Germination data

Pre-treatments: Manual detachment of the pappus from the seeds. Seed sterilization in a bleach solution (5% of chlorine) for 2 minutes followed by several rinses in sterilized distilled water. Weak scarification of the seed coat with a scalpel in sterile conditions.

Germination medium: agar 1%.

Sample size: 60 seeds (20 × 3 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
91.4%	constant 10°C	0/24h	9.0	12.4	32.0	17.2

Observations

Berardia lanuginosa is an endemic geophyte of the South-western Alps (Casazza & al. 2016; 2017) distributed along the boundary of the Italian and French border (Noble & Diadema 2011). The plant grows exclusively on high-altitude calcareous screes (*Berardietum lanuginosii*) (Corine biotopes 61.2322) with a major distribution on the

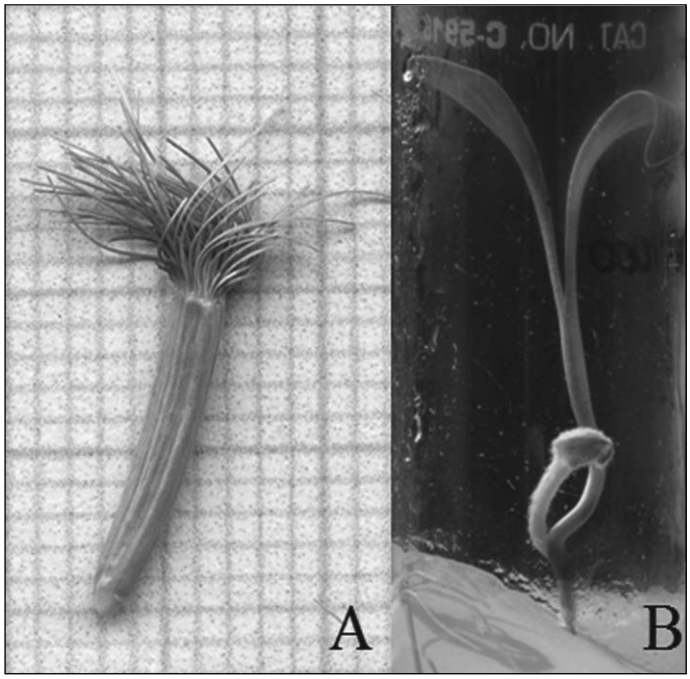


Fig. 1. An achene (A) and a seedling (B) of *Berardia lanuginosa* (photo by V. Gosmar/M. Mucciarelli, 2013).

Maritime, Cottian and Graian Alps and a secondary centre within the Ligurian Alps. The monospecific genus *Berardia* is a paleo-endemic of the alpine flora (Ozenda 2009).

Seeds used for this study were collected in the field at the end of September 2013 and stored for a few days at 15-20°C and 15-20% RH in the drying room of the Piedmont Germplasm Bank.

During the last 15 years, several tests have been carried out on this species in our seed bank, using not only fresh or dry seeds but also germplasm previously frozen at -20°C or conserved in the fridge at 4°C. Among the various methods adopted so far, the results presented in this study refer to the treatment with the highest final germination percentage (91%).

25. *Potentilla valderia* L. (*Rosaceae*) (Fig. 2)

Accession data

It: Vinadio (Cuneo), loc. S. Anna di Vinadio (WGS84: 44.260131°N, 7.121159°E), acidophilous alpine grasslands, 1670 m a.s.l., 24 Aug 2017, *B. Gallino* (NA/17/1996, Piedmont Germplasm Bank).

Germination data

Pre-treatments: Seed sterilization in a bleach solution (4.5% of chlorine) for 5 minutes followed by several rinses in sterilized distilled water. Cold stratification at 4°C for 60 days.

Germination medium: agar 1%.

Sample size: 100 seeds (50 × 2 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
82.0%	alternate 20/10°C	12/12h	7.0	4.7	17.0	8.9

Observations

Potentilla valderia is a strict orophyte endemic to the South-western Alps (Argentera-Mercantour Massif) with distribution at the boundary of the Italian and French border (Noble & Diadema 2011). It is a thermophile and xerophile species which preferably develops on acidophilous alpine grasslands (*Festucion variae,* Corine biotopes 36.33; Biondi & al. 2010), which are typical for this species in the Maritime Alps (*Festuco-Potentilletum valderiae*) (Noble & Diadema 2011).

Seeds used for this study were collected in the field during summer 2017 and were conserved for a few days in the herbarium cold room (10°C and 30% RH).

P. valderia seed germination was optimal at 20/10°C reaching a value of 82% in the presence of a 12h light/12h dark photoperiod. No germination data are currently available via the RBG Kew's Seed Information Database (Royal Botanic Gardens Kew,

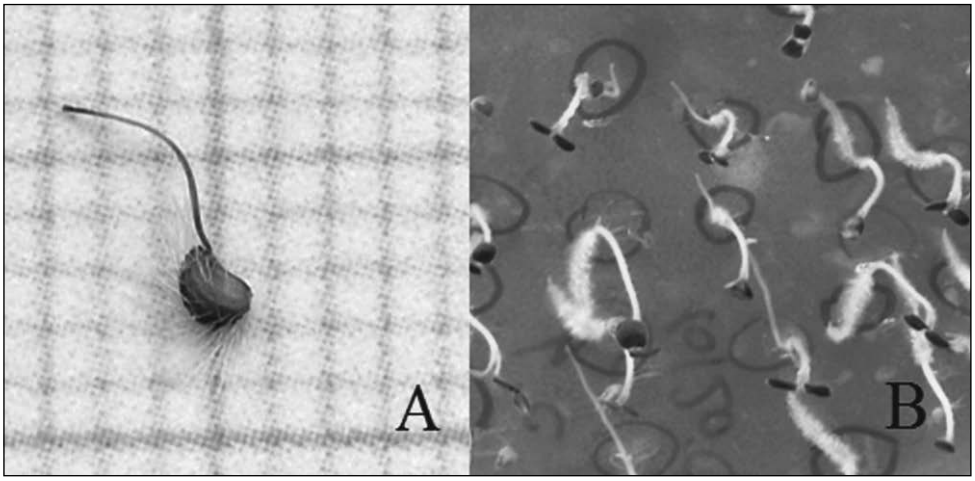


Fig. 2. An achene (A) and several seedlings (B) of *Potentilla valderia* growing on agar 1% (photo by V. Carasso, 2017).

2020) or in ENSCOBASE (2016). Therefore, as far as we know, this is the first report about the germination of this species.

26. *Silene cordifolia* All. (*Caryophyllaceae*) (Fig. 3)

Accession data

It: Vinadio (Cuneo), loc. Vallone S. Anna di Vinadio (WGS84: 44.260131°N, 7.121159°E), siliceous cliffs, 1670 m a.s.l., 24 Aug 2017, *B. Gallino* (NA/17/1992, Piedmont Germplasm Bank).

Germination data

Pre-treatments: Cold stratification at 4°C for 60 days.

Germination medium: 1% agar.

Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
97.0%	constant 15°C	0/24h	7.0	9.2	20.0	12.4

Observations

Silene cordifolia is an orophyte endemic to the Argentera-Mercantour Massif with distribution at the boundary of the Italian and French border (Noble & Diadema 2011). It is a tertiary

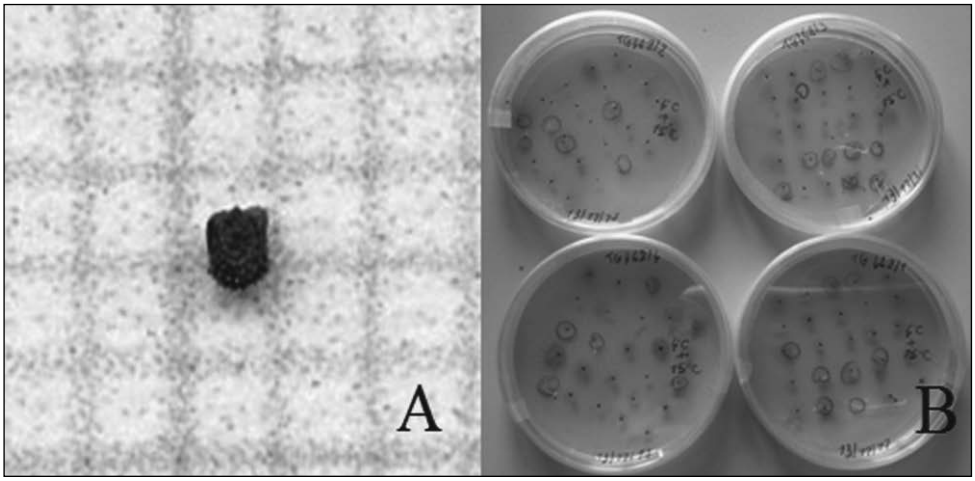


Fig. 3. A seed (A) and seedlings (B) of *Silene cordifolia* (photo by V. Carasso, 2017)

relict of the ancient flora that was present in this area before the onset of the Mediterranean climate regime and subsequent Quaternary glaciations. The plant grows in narrow crevices of the siliceous cliffs between 700 and 3000 m of altitude (Casazza & al. 2016).

The seeds used for this study were collected in the field during summer 2019 and were conserved for a few days in the herbarium cold room (10°C and 30% RH) of the Piedmont Germplasm Bank.

S. cordifolia seed germination was optimal (97%) at 15°C and light insensitive. No germination data are currently available via the RBG Kew's Seed Information Database (Royal Botanic Gardens Kew, 2020) or in ENSCOBASE (2016). Therefore, as far as we know, this is the first report about the germination of this species.

27. *Tephroseris balbisiana* (DC.) Holub (*Asteraceae*) (Fig. 4)

Accession data

It: Valdieri (Cuneo), loc. Pian della Casa, Vallone Gesso della Valletta (WGS84: 44.161267°N, 7.276504°E), meso-hygrophile tall herb communities, 1790 m a.s.l., 13 Jul 2017, *B. Gallino & V. Carasso* (NA/17/1931, Piedmont Germplasm Bank).

Germination data

Pre-treatments: Manual detachment of the pappus from the seeds. Cold stratification at 4°C for 60 days. Manual scarification of the seed coat with a scalpel.

Germination medium: 1% agar.

Sample size: 100 seeds for each test (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
98.0%	constant 25°C	12/12h	6.0	3.1	9.5	6.2
92.0%	constant 25°C	12/12h	5.0	6.9	24.0	10.2
89.0%	constant 25°C	0/24h	6.0	5.2	25.2	10.9
86.0%	constant 25°C	0/24h	8.7	17.0	52.7	24.3
85.0%	constant 25°C	0/24h	5.0	8.2	33.5	13.5

Observations

Tephroseris balbisiana belongs to the alpine and subalpine meso-hygrophile tall herb communities at elevations as high as 2100 m a.s.l. The plant has a disjoint distribution with the main centre on the Mercantour-Argentera Massif at the boundary between the French Department of Alpes-Maritimes, where most of the populations lie and the Ligurian and Maritime Alps (Italy). Further ranges are the Cottian Alps north to Turin, the Ligurian

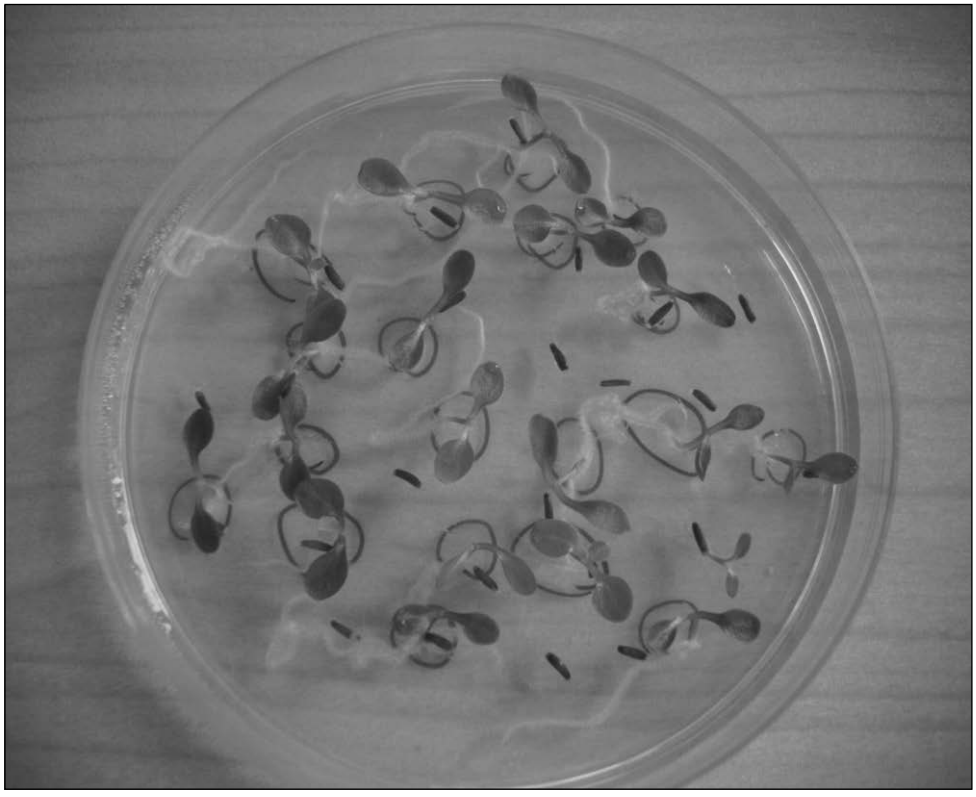


Fig. 4. Twenty days old seedlings of *T. balbisiana* incubated at 25°C and 12h light/12h dark photoperiod (photo by V. Carasso, 2017)

Apennines north to Genoa (Pignatti 1982; Bartolucci & al. 2018) and in Emilia Romagna (Bonafede & al. 2013).

Germination tests were carried out with seeds collected in the field during the summer 2017. Considering the high level of environmental humidity at the time of collecting, seeds were maintained ten days at 15-20°C and 15-20% (RH) in the drying room of the Piedmont Germplasm Bank. Our experimental design consisted of five different treatments to check the effects of light vs. dark incubation in combination with cold stratification and manual scarification.

Although the final germinations were >80% for all the treatments, germination values were slightly higher (98%) when all the pre-treatments were applied to 12h light incubation. To our knowledge, no reports are presently available in the literature on the germination requirements of this species.

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F. Carruggio, M. Castrogiovanni, C. Impelluso & A. Cristaudo

Germinability of pioneer plant species from Mediterranean mountains occurring on screes and debris

Abstract

Carruggio, F., Castrogiovanni, M., Impelluso, C. & Cristaudo, A.: Germinability of pioneer plant species from Mediterranean mountains occurring on screes and debris [In Magrini, S. & Salmeri, C. (eds), Mediterranean plant germination reports – 2]. Fl. Medit. 30: 408-414. 2020. http://dx.doi.org/10.7320/FlMedit30.408

The present work focuses on germination requirements of four pioneer plant species from Mediterranean mountains, mainly occurring on more or less consolidated limestone screes and debris. The study species are *Aethionema saxatile* subsp. *saxatile*, *Arenaria grandiflora* subsp. *grandiflora*, *Iberis violacea*, and *Odontarrhena nebrodensis* subsp. *nebrodensis*. Seeds were collected at the time of natural dispersal, on the Madonie Massif, within an altitudinal range of 1300-1500 m a.s.l. Different germination conditions were tested and the best germination protocols for each species are provided.

Key words: germination protocols, high-mountain habitats, environmental constraints, Madonie Massif.

Introduction

The present study examined the germination behavior of four phytogeographically significant taxa mainly occurring on Mediterranean mountains. More specifically, we provide the first germination data for *Aethionema saxatile* (L.) R. Br. subsp. *saxatile*, *Arenaria grandiflora* L. subsp. *grandiflora*, *Iberis violacea* R. Br., and *Odontarrhena nebrodensis* (Tineo) L. Cecchi & Selvi subsp. *nebrodensis* from the Madonie Massif (Sicily, Italy).

The study taxa are short-lived perennial herbs, usually woody at the base. The distribution range of *I. violacea* and *A. saxatile* subsp. *saxatile* is centered on the Mediterranean basin, extending to continental Europe in the last one, while it is more limited to the western Mediterranean area for *A. grandiflora* subsp. *grandiflora*. Finally, *O. nebrodensis* subsp. *nebrodensis* is an exclusive endemic taxon to the Madonie Massif. These taxa, which are considered rare in Sicily (Giardina & al. 2007), occur in rocky habitats on mountain complexes, acting as pioneer plants on screes and debris together with other sparse xerophytes. Their growing sites undergo harsh environmental conditions, with strong winds and intense solar radiation, as well as stress from both seasonal drought and cold. The resulting patchy vegetation type is included within the 8130 Habitat type, i.e.,

'Western Mediterranean and thermophilous screes', listed under the Annex I of the Directive 92/43/EEC. Specifically, *A. grandiflora* subsp. *grandiflora* and *I. violacea* are characteristic taxa of the *Arenario-Rumicetum scutati* Raimondo 1980 (*Linarion purpureae* Brullo 1984, *Thlaspietea rotundifolii* Br.-Bl. 1948) (Raimondo & al. 2004), while *O. nebrodensis* subsp. *nebrodensis* is a characteristic taxon of the *Cerastio-Astragalion nebrodensis* Pignatti & Nimis ex Brullo 1984 (Brullo 1984).

Seeds were collected in July 2019, between 1300 and 1500 m a.s.l., in the supra-Mediterranean belt. Six different constant temperature conditions were tested (from 5 to 30°C), both in light/dark (L/D, 12/12 h photoperiod) and darkness (D, 0/24 h photoperiod), after eight months from seed collection. After such a dry-storage period at room temperature (22 ± 2°C), seeds proved to be ready to germinate, without any pre-treatment, over different wide thermal ranges according to different species. Such a feature was highlighted as a frequent trait within the high mountain Mediterranean species (Giménez-Benavides & al. 2005). This behavior may envisage, if anything, the presence of non-deep physiological dormancy in conditionally dormant fresh seeds, which gradually is released allowing germination from the autumn following seed dispersal to the next spring. Further studies are needed to validate this hypothesis and to better define the timing of germination in the wild.

28. ***Aethionema saxatile*** (L.) R.Br. subsp. ***saxatile*** (*Brassicaceae*) (Fig. 1a)

Accession data

Si: Polizzi Generosa (Palermo), Serre Quacella (WGS84: 37.847111°N, 14.015573°E), screes and debris, 1351 m a.s.l., 18 Jul 2019, *F. Carruggio*, *M. Castrogiovanni*, *C. Impelluso*, *R. Galesi*, *A. Cristaudo* (SiMaSeed/CT/19/135, Catania Germplasm Bank, BGS-CT).

Germination data

Pre-treatments: no treatment.

Germination medium: 3 sheets of sterilized filter paper (Munktell grade 292, 87 g/m^2), imbibed with 6 ml of sterilized distilled water.

Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
100%	constant 15°C	0/24 h	-	-	-	-
100%	constant 20°C	0/24 h	-	-	-	-
100%	constant 25°C	0/24 h	-	-	-	-
98%	constant 15°C	12/12 h	5.0	4.5	5.0	5.0
94%	constant 25°C	12/12 h	3.0	3.0	4.0	3.5
92%	constant 20°C	12/12 h	3.0	2.5	3.0	3.0

Observations

Seeds used in germination tests were taken from dehiscent siliculae. It was possible to verify the seed surface to be covered by specialized cells, producing mucilage and forming a sticky layer (Karaismailoglu 2018), thanks to which seeds can adhere to soil particles.

Seed germination percentage reached high final values, within the thermal range of 15-25°C, varying from 92 to 100%, regardless of photoperiod conditions. Conversely, outside this thermal range, a negative effect of light on germination was detected at 10°C (66% in L/D vs. 94% in D), while a positive one at 30°C (92% in L/D vs. 52% in D). Both temperatures of 20 and 25°C provided the best germination performance since these temperature regimes showed the lowest T_{50} values, namely ca. 2.5-3 days.

The ability to germinate over a wide thermal range, as observed in *A. saxatile*, is a behavior already detected among high mountain species (Marchand & Roach 1980). Based on our results, field germination by the autumn following seed dispersal cannot be excluded, even if fresh and short-aged seeds (≤ 90 days) were not tested. Autumn germination would take advantage from the low T_{50} values that the species showed since young seedlings could have a longer time period for their establishment before snow arrival.

29. ***Arenaria grandiflora*** L. subsp. ***grandiflora*** (*Caryophyllaceae*) (Fig. 1b)

Accession data

Si: Polizzi Generosa (Palermo), Contrada Quacella (WGS84: 37.852792°N, 14.014092°E), screes and rocky dry grasslands, 1297 m a.s.l., 17 Jul 2019, *F. Carruggio*, *M. Castrogiovanni*, *C. Impelluso*, *R. Galesi*, *A. Cristaudo* (SiMaSeed/CT/19/122, Catania Germplasm Bank, BGS-CT).

Germination data

Pre-treatments: no treatment.

Germination medium: 3 sheets of sterilized filter paper (Munktell grade 292, 87 g/m^2), imbibed with 6 ml of sterilized distilled water.

Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
88%	constant 15°C	12/12 h	9.0	13.0	22.0	14.1
88%	constant 15°C	0/24h	-	-	-	-
84%	constant 10°C	0/24h	-	-	-	-
82%	constant 20°C	0/24h	-	-	-	-
78%	constant 10°C	12/12 h	8.0	9.0	16.0	9.5

Observations

Seeds of *A. grandiflora* subsp. *grandiflora* showed optimal germination values at 10 and 15°C, both under L/D and D conditions, as well as at 20°C under D regime. Otherwise, a photo-inhibition effect was detected at 20°C (54% in L/D vs. 82% in D) and germination was poor or very low above this temperature value (0% in L/D vs. 14% in D at 25°C; 0% at 30°C, regardless of photoperiod).

Our data agree with those of Fernàndez-Pascual & al. (2017) referred to *A. grandiflora* from Cantabrian Mountains (altitude of the collection site: 1600 m a.s.l.). The Authors, applying alternating instead of constant temperature conditions on fresh seeds, identified the 14/4°C regime as the best one compared to 22/12 and 30/20°C. Moreover, obtaining a germination percentage of over 50% during the 12-week cold stratification treatment at 3°C, they suggested the species could have a very low base temperature (T_b) rather than a real need for cold stratification. Overall, based on both our data and those of the Iberian researchers, *A. grandiflora* emerges for its evident 'Mediterranean character' that is planned to protect the species mainly from drought conditions. Further studies are needed to better define the temporal germination window of the species in the wild, assuming that it should be included between autumn and early spring.

30. *Iberis violacea* R. Br. (*Brassicaceae*) (Fig. 1c)

Accession data

Si: Petralia Sottana (Palermo), Contrada Faguara (WGS84: 37.864788°N, 14.038100°E), screes, 1500 m a.s.l., 17 Jul 2019, *F. Carruggio*, *M. Castrogiovanni*, *C. Impelluso*, *R. Galesi*, *A. Cristaudo* (SiMaSeed/CT/19/130, Catania Germplasm Bank, BGS-CT).

Germination data

Pre-treatments: no treatment.

Germination medium: 3 sheets of sterilized filter paper (Munktell grade 292, 87 g/m^2), imbibed with 6 ml of sterilized distilled water.

Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
90%	constant 10°C	12/12h	5.0	15.2	14	5.8
88%	constant 15°C	12/12h	3.0	4.5	16	6.0
84%	constant 20°C	12/12h	3.0	3.4	10	4.0
82%	constant 25°C	12/12h	3.0	4.6	16	6.2

Observations

Seeds of *I. violacea* showed high germination values (> 80%) throughout the range 10-20°C, both under L/D and D conditions. Germination performance slightly decreased under D condition at 25°C (68%) and markedly fell at 30°C (30 and 8%, in L/D and D conditions, respectively). No significant temperature effect on germination speed was detected in the range 15-25°C, within which the lowest T_{50} values were registered (ca. 4 days). Overall, *I. violacea* showed a comparable germination behavior to that of *A. saxatile*, although the species has a lower ceiling temperature.

31. *Odontarrhena nebrodensis* (Tineo) L.Cecchi & Selvi subsp. ***nebrodensis*** (*Brassicaceae*) (Fig. 1d)

Accession data

Si: Polizzi Generosa (Palermo), Contrada Quacella (WGS84: 37.852792°N, 14.014092°E), screes and rocky dry grasslands, 1297 m a.s.l., 17 Jul 2019, *F. Carruggio*, *M. Castrogiovanni*, *C. Impelluso*, *R. Galesi*, *A. Cristaudo* (SiMaSeed/CT/19/124, Catania Germplasm Bank, BGS-CT).

Germination data

Pre-treatments: no treatment.

Germination medium: 3 sheets of sterilized filter paper (Munktell grade 292, 87 g/m^2), imbibed with 6 ml of sterilized distilled water.

Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
98%	constant 15°C	12/12h	1.0	1.3	5	2.0
98%	constant 10°C	12/12h	3.0	3.4	6	4.3
96%	constant 20°C	12/12h	1.0	0.5	6	1.3
94%	constant 25°C	12/12h	1.0	0.5	6	1.1
92%	constant 30°C	12/12h	1.0	0.6	15	2.2
92%	constant 5°C	12/12h	6.0	7.6	16	9.0

Observations

High germination percentage (> 90%) was registered throughout the entire temperature range tested, regardless of photoperiod. The germination process was notably fast within the range 20-30°C (T_{50} < 1 day) but quite fast also at 10-15°C. Such behavior may allow germination to occur from the autumn following seed dispersal to the next spring.

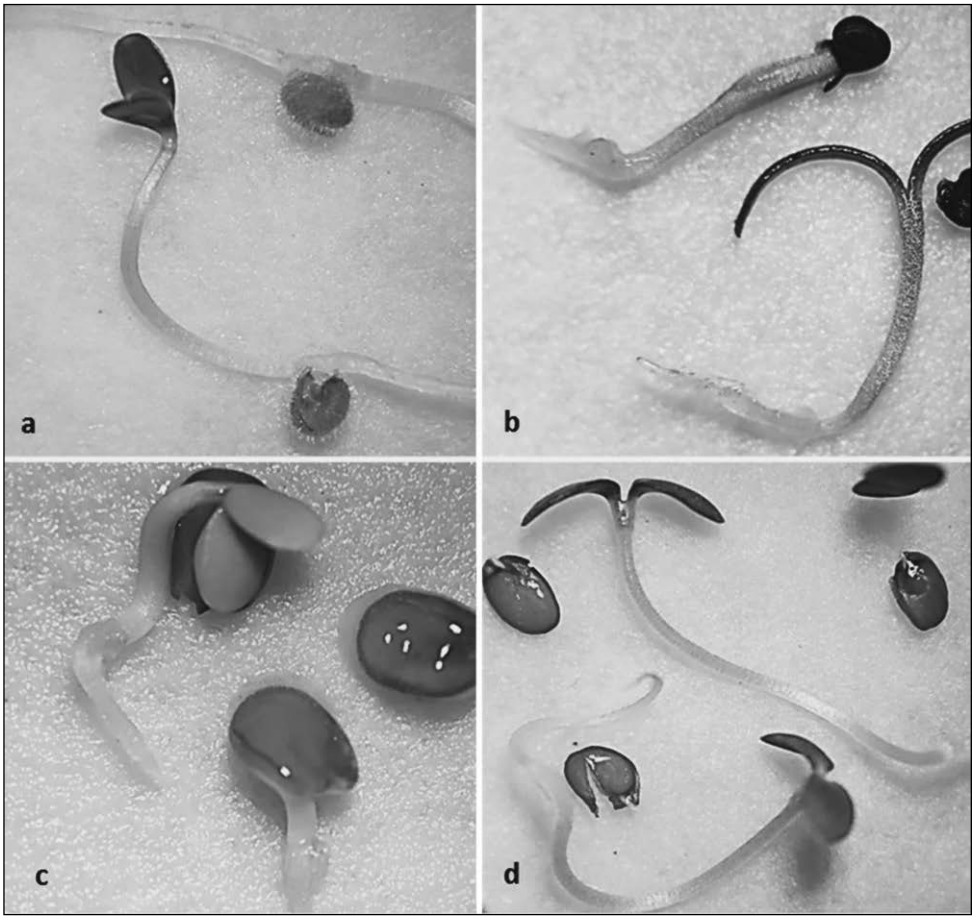


Fig. 1. Germinated seeds and seedlings: **a,** *Aethionema saxatile* subsp. *saxatile*; **b,** *Arenaria grandiflora* subsp. *grandiflora*; **c,** *Iberis violacea*; **d,** *Odontarrhena nebrodensis* subsp. *nebrodensis*.

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Cristina Salmeri & Maria Castrogiovanni

Seed germination reports of high mountain species native to Mount Etna (Sicily)

Abstract

Salmeri, C. & Castrogiovanni, M.: Seed germination reports of high mountain species native to Mount Etna (Sicily) [In Magrini, S. & Salmeri, C. (eds), Mediterranean plant germination reports – 2]. Fl. Medit. 30: 415-420. 2020. http://dx.doi.org/10.7320/FlMedit30.415

The germination ability of five endemic species from the high mountain belt of Mt. Etna were studied; they are *Astragalus siculus*, *Erysimum etnense*, *Senecio squalidus* subsp. *aethnensis*, *Silene italica* subsp. *sicula*, and *Tanacetum vulgare* subsp. *siculum.* Mature seeds were collected in the field, within an elevation range of 1700–2000 m a.s.l. Different experimental conditions were tested and the best methods with optimal germination results are provided and compared for each species. First germination records are given for 4 out of 5 of the investigated taxa.

Key words: *Astragalus siculus*, *Erysimum etnense*, high-mountain endemics, Mt. Etna, *Senecio aethnensis*, *Silene sicula*, *Tanacetum siculum.*

Introduction

Mt. Etna has a rich and diversified flora with a big contingent of endemic taxa. The high mountain zone of Mt. Etna is characterized by the presence of xerophytic thorny cushion communities dominated by the endemic *Astragalus siculus* Biv., which grows on old lava flows and pyroclastic deposits in association with several other typical endemic species of this plain. It represents the most important species for both number of plants and cover abundance, giving the landscape a peculiar physiognomy.

Evidence of temperature increases linked to global climate change has been predicted and reported for the Mediterranean mountain ranges (Giménez-Benavides & al. 2005, 2007). As a consequence, seed germination in some species may be anticipated, thus affecting seedling emergence, growth, and development. Specific germination requirements constitute valuable information for predicting plant survival and ensure a successful plant propagation. Surprisingly, there is almost no published basic information on germination features of most of these key species. In this study, the best protocols for seed germination of five interesting endemic species growing in the high mountain zone of Mt. Etna were assessed and discussed. Names and taxonomic status of investigated taxa follow Bartolucci & al. (2018).

32. *Astragalus siculus* Biv. (*Fabaceae*)

Accession data

Si: Mt. Etna, Milo (Catania), Mt. Concazza (WGS84: 37.766930°N 15.056690°E), orophilous cushion-like shrublands, 1720 m a.s.l., 26 Aug 2004, *A. Restuccia & N. Visalli* (BGS-CT 11AR/NV, Catania Germplasm Bank).

Germination data

Pre-treatments: disinfection with a 4% sodium hypochlorite water solution for 5 minutes followed by 3-4 rinses in sterile distilled water; scarification with **1)** sterile abrasive paper for 5 minutes followed by imbibition in sterile distilled water overnight, **2**) 98% sulfuric acid for 30 minutes.

Germination medium: 3 sheets of sterilized filter paper (Whatman 40).

Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
88% [1]	constant 21°C	0/24h	7.0	9.3	35.0	16.1
87% [2]	constant 20°C	12/12h	3.0	8.7	40.0	13.6

Observations

These are the first germination reports for this taxon. Similarly, to other *Astragalus* species, *A. siculus* has hard seed coats and a resultant physical dormancy. Mechanical scarification provided the best germination percentage; similar values were also reached by chemical scarification not exceeding 30 minutes, above which germination decreased to 53-47% (at 60 and 90 min, respectively), while no germination and embryo death resulted from longer treatments. Other types of scarification, such as warm water (40, 50, 60°C) or boiling water (3, 5, 10 min), allowed no more than 20% of seed germination. Seeds did not result photoblastic since different photoperiod did not significatively affect the final germination percentage.

33. *Erysimum etnense* Jord. (*Brassicaceae*)

Accession data

Si: Mt. Etna, Ragalna (Catania), loc. Piano Vetore, (WGS84: 37.693338°N 14.980555°E), old lava flows, 1740 m a.s.l., 19 Sept 2012, *C. Brullo, S. Brullo & G. Giusso* (UNICT_069, Catania Germplasm Bank).

Germination data

Pre-treatments: disinfection with a 4% sodium hypochlorite water solution for 5 minutes followed by 3-4 rinses in sterile distilled water; imbibition in sterile distilled water for 24 h.

Germination medium: 1% agar.

Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
98%	constant 10°C	0/24h	2.0	2.7	7.0	3.7
94%	constant 15°C	0/24h	1.0	1.5	4.0	2.2

Observations

These are the first germination reports for this taxon. Germination tests carried out on fresh seeds provided successful germination results (> 80%) under different constant temperatures (10, 15, 20 and 25°C) either in full darkness or 12h light/dark photoperiod, with better results at the lower temperatures. Higher temperatures enhanced the germination speed (T_{50} < 1.5, MGT ≤ 2). Seeds showed a negative light sensitivity at lower temperatures, with less germination in 12h light/dark photoperiod (85% at 10°C, 81% at 15°C), while light had positive effects at higher temperatures increasing the germination percentages compared to full darkness (92% *vs* 89% at 20°C, 87% *vs* 84% at 25°C).

34. *Senecio squalidus* subsp. ***aethnensis*** (DC.) Greuter (*Asteraceae*)

Accession data

Si: Mt. Etna, Nicolosi (Catania), loc. Monti Silvestri (WGS84: 37.699166°N 14.999722°E), volcanic sands, 1896 m a.s.l., 26 Jul 2012, *S. Bogdanovič, C. Brullo, S. Brullo & G. Giusso* (UNICT_051, Catania Germplasm Bank)

Germination data

Pre-treatments: disinfection with a 4% sodium hypochlorite water solution for 5 minutes followed by 3-4 rinses in sterile distilled water; imbibition in sterile distilled water for 24 h.

Germination medium: 1% agar.

Sample size: 100 cypselae (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
95%	constant 10°C	12/12h	3.0	3.9	15.0	5.6
90%	constant 20°C	12/12h	2.0	2.3	6.0	2.8

Observations

These are the first germination reports for this taxon. Germination tests carried out on fresh cypselae provided successful germination results, ranging from 81% to 95% under different constant temperatures (10, 15, 20 and 25°C) either in 12h dark/light

photoperiod or full darkness, with enhanced performance at the lowest temperature. Conversely, higher temperatures increased germination speed (T_{50} and MTG < 3). Seeds of *Senecio squalidus* subsp. *aetnensis* resulted somewhat positively photoblastic having higher germination percentages under 12h dark/light photoperiod (95% *vs* 90% at 10°C, 89% *vs* 81% at 15°C, 90% *vs* 83% at 20°C). Light sensitivity reversed at the highest temperature (81% *vs* 86% at 25°C). Similar results of germination (95%, 16°C 12h light/dark) were reported for *Senecio squalidus* by Royal Botanic Gardens Kew (2019).

35. *Silene italica* subsp. ***sicula*** (Ucria) Jeanm. (*Caryophyllaceae*)

Accession data

Si: Mt. Etna, Nicolosi (Catania), loc. Rifugio Sapienza (WGS84: 37.697774°N 14.986665°E), lava flows and basalt outcrops, 1860 m a.s.l., 26 Jul 2012, *S. Bogdanovič, C. Brullo, S. Brullo & G. Giusso* (UNICT_067, Catania Germplasm Bank).

Germination data

Pre-treatments: disinfection with a 4% sodium hypochlorite water solution for 5 minutes followed by 3-4 rinses in sterile distilled water; imbibition in sterile distilled water for 24 h.

Germination medium: 1% agar.

Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
100%	constant 10°C	12/12h	2.0	2.8	8.0	3.8
100%	constant 15°C	12/12h	1.0	1.6	8.0	2.5
100%	constant 20°C	0/24h	1.0	1.5	7.0	2.1
98%	constant 25°C	0/24h	1.0	1.5	14.0	2.7

Observations

Germination tests carried out on fresh seeds provided optimal germination results (98-100%) under different constant temperatures (10, 15, 20 and 25°C), either in 12h dark/light photoperiod or full darkness, revealing the ability of *Silene sicula* seeds to germinate very fast in a wide range of temperature. Best results, with the finest values of both germination percentage and velocity, were achieved at 15-20°C. These data agree with the only existing record for this taxon (100% at 15°C 12h light/dark on 1% agar; Royal Botanic Gardens Kew 2020). Lastly, seed exposure to light condition had an extremely low influence on seed germination, since germination rates in full darkness were almost equivalent.

36. *Tanacetum vulgare* subsp. ***siculum*** (Guss.) Raimondo & Spadaro (*Asteraceae*)

Accession data

Si: Mt. Etna, Sant'Alfio (Catania), loc. Rifugio Citelli (WGS84: 37.765277°N 15.058888°E), orophilous cushion-like shrublands, 1740 m asl, 19 Sept 2012, *C. Brullo, S. Brullo & G. Giusso* (UNICT_065, Catania Germplasm Bank).

Germination data

Pre-treatments: disinfection with a 4% sodium hypochlorite water solution for 5 minutes followed by 3-4 rinses in sterile distilled water; imbibition in sterile distilled water for 24 h.

Germination medium: 1% agar.

Sample size: 100 cypselae (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
87%	constant 20°C	0/24h	1.0	2.5	8.0	4.0
86%	constant 25°C	12/12h	2.0	11.7	38.0	13.6

Observations

These are the first germination reports for this taxon. Germination tests carried out on fresh cypselae, under different constant temperatures (10, 15, 20 and 25°C) either in 12h dark/light photoperiod or full darkness, provided very variable germination percentages (ranging from 1% to 87%). Best results were achieved at higher temperatures, while a drastic fall in germination occurred at the lowest temperature (1% and 6% at 10°C and 12h light/12h dark and 24h dark, respectively).

In general, the absence of light represented a more favourable incubation condition for germination at the different temperatures tested, except for 25°C, when 12h light photoperiod improved the final germination (86% *vs* 65% at 24h dark) while reducing the germination speed (T_{50}: 11.7 *vs* 3.3, MTG: 13.6 *vs* 7).

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S. Zitti, V. Di Cecco, S. Casavecchia, L. Di Martino & L. Aquilanti

Seed germination reports for *Onopordum tauricum* (*Asteraceae*)

Abstract

Zitti, S., Di Cecco, V., Casavecchia, S., Di Martino, L. & Aquilanti, L.: Seed germination reports for *Onopordum tauricum* Willd. [In Magrini, S. & Salmeri, C. (eds), Mediterranean plant germination reports – 2]. Fl. Medit. 30: 421-423. 2020. http://dx.doi.org/10.7320/FlMedit30.421

This study deals with the seed germination for *Onopordum tauricum* (*Asteraceae*). The cypselae were collected from two populations in the Marche and Umbria Region (Italy). The highest germination value (93.6%) was obtained after 24 hours of soaking in a 500 ppm GA_3 solution and then incubated at a constant temperature of 20°C with a 12/12h light-dark photoperiod.

Key words: *Onopordum*, dormancy-breaking, gibberellin, milk-clotting agent.

Introduction

Onopordum tauricum Willd. occurs in uncultivated, ruderal environments and sometimes behaves as a nitrophilic plant. It is native to Eurasia mainly with a Pontian range.

This species has been chosen as candidate wild plant for possible use as milk-clotting agent within the international PRIMA Project "Valorisation of thistle-curled Cheeses in Mediterranean marginal area" (VEGGIE-MED-CHEESES), which is focused on the production of traditional Mediterranean cheeses with non-animal rennet in order to meet the increasing demand of vegetarian and animal rights consumers.

The germination ecology of *O. tauricum* had never been investigated so far. The study is based on germination protocols for similar taxa (Baskin & Baskin 2014; Royal Botanic Gardens Kew 2020).

37. *Onopordum tauricum* Willd. (*Asteraceae*)

Accession data:

It: Umbria. Foligno (Perugia), loc. Colfiorito (WGS84: 43.050304°N 12.912574°E), bordo strada a lato di campi coltivati, 761 m a.s.l., 8 Aug 2019, *S. Casavecchia, S. Zitti, V. Di Cecco, L. Di Martino* (MSB VEGGIE19A02, Majella Seed Bank).

It: Marche. Visso (Macerata), loc. Cupi (WGS84: 42.999108°N 13.114858°E), bordo strada nei pressi di una stalla, 979 m a.s.l., 8 Aug 2019, *S. Casavecchia, S. Zitti, V. Di Cecco, L. Di Martino* (MSB VEGGIE19A01, Majella Seed Bank).

Germination data

Pre-treatments: soaking in water for 24h, sterilization with a solution of 3% sodium hypochlorite plus Tween 20 for 5 minutes followed by 3 rinses in sterile distilled water. 1) Soaking in a 500 ppm GA_3 solution for 24 hours; 2) soaking in a 250 ppm GA_3 solution for 24 hours; 3) vernalization for 50 days at 5°C.

Germination medium: 1% agar.

Sample size: 80 seeds (20 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]	Accession code
93.6%(1)	constant 20°C	12/12h	3.8	5.3	8.0	5.8	19A02
86.7%(1)	alternate 25/10°C	12/12h	3.3	4.2	7.5	4.5	19A02
84.7%(2)	constant 20°C	12/12h	3.8	5.4	7.8	5.9	19A02
80.3%(3)	constant 20°C	12/12h	3.5	7.2	9.8	7.4	19A01

Observations

Cypselae of *O. tauricum* have a fairly thick pericarp, but its breakage/scarification does not increase the final germination percentage. The tests showed the presence of a physiological dormancy. Vernalization or pre-treatment with GA_3 broke dormancy, allowing high final germination rates. Other tested protocols showed high germination rates: with 500 ppm GA_3 and alternating temperature of 25/10°C (12/12 light-dark) the final percentage was 86.7%, lowering the concentration of GA_3 to 250 ppm at 20°C (12/12 light-dark) the final percentage remains high (84.7%). Exposing the cypselae to vernalization at 5°C in a moist environment for 50 days and then incubating at 20° C with a photoperiod of 12/12 light-dark, a final per-



Fig. 1. Germinated seed of *Onopordum tauricum.*

centage of 80.3% was recorded. All the other tests investigated several variables such as scarification, substrate, and temperature, showing final germination percentages lower than 80%. The viability of the non-germinated seeds at the end of each test was estimated by cutting test. No statistically significant differences between the two investigated populations were detected for all tested conditions.

As the species often grows in nitrified areas, soils added of nitrogen compounds and humic acids were also tested. The percentage of germination on these substrata, compared with the un-nitrified control under the same conditions, was lower than 23%. The seeds became infected very easily and were difficult to sterilize.

Acknowledgement

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This paper is dedicated to the memory of our dear co-worker Silvia Zitti, who passed away while this paper was being peer-reviewed. Silvia was respected and loved by all whose lives she touched – her more senior advisors and mentors, her peers, and her students and junior colleagues. She was kind and available with all, and she had a positive intensity and infectious enthusiasm for her research and teaching, which was exceeded only by her dedication to her family. We will miss her very much.

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Sara Magrini & Laura Zucconi

Seed germination of the endangered *Viola kitaibeliana* and other Italian annual pansies (*Viola* Section *Melanium, Violaceae*)

Abstract

Magrini, S. & Zucconi, L.: Seed germination of the endangered *Viola kitaibeliana* and other Italian annual pansies (*Viola* Section *Melanium, Violaceae*) [In Magrini, S. & Salmeri, C. (eds), Mediterranean plant germination reports – 2]. Fl. Medit. 30: 424-430. 2020. http://dx.doi.org/10.7320/FlMedit30.424

Here, successful germination protocols for the following four annual pansies are presented: *Viola arvensis* subsp. *arvensis*, *V. hymettia, V. kitaibeliana,* and *V. tricolor* subsp. *tricolor*. Seeds were collected mainly in Central Italy (Tuscany, Umbria, and Latium) and in Sicily. The germination ability was tested at the Tuscia Germplasm Bank (BGT) using several methods for dormancy-breaking. Our results show high germination percentages and germination rate for the tested species.

Key words: cold stratification, dormancy, priming, *Viola arvensis, Viola hymettia, Viola tricolor*.

Introduction

The Sect. *Melanium* DC. ex Ging. of the genus *Viola* (the so-called pansies) is a derived, monophyletic and morphologically well-defined group comprising 125 species, both perennials and annuals (Marcussen & al. 2015). The genus is basically myrmecochorous but different selective pressures, especially seed predation, have produced a clear divergence in dispersal systems. Particularly, in the Sect. *Melanium* diplochory is exhibited by most species which have evolved a system combining ballistic and ant seed dispersal (Beattie & Lyons 1975; Beattie 1985). Seeds are brown to dark brown (only immature ones are pale brown), ovoid to obovoid in shape, all with an elaiosome in the micropylar area and a conspicuous raphe (Scoppola & Magrini 2019).

Pansy seeds have a physiological dormancy (Baskin & Baskin 1995; 2014), so pretreatments for dormancy-breaking like cold stratification and/or hormones are required for germination. Elaiosome removal from seeds functions as a germination cue in many ant-dispersed plant species (e.g., Horvitz 1981; Blois & Rockwood 1985; Lobstein & Rockwood 1993; Ohkawara 2005). Elaiosome is also known to inhibit seed germination due to the presence of water-soluble inhibitory substances (Sasidharan & Venkatesan 2019). On the other hand, its removal did not improve germination success in *Viola striata* Aiton (Lobstein & Rockwood 1993), *Viola pedata* L. (Gehring & al. 2013), and *Viola pedunculata* Torr. & A. Gray. (Franklin & al. 2017), so in our research elaiosomes were not removed from seeds.

This paper is part of a larger research on the Sect. *Melanium* in Europe (e.g. Magrini & Scoppola 2015a,b,c; Magrini 2019; Scoppola & Magrini 2019). Particularly, research focused on germination ecology of annual pansies are carried out at the Tuscia Germplasm Bank (BGT) where seed accessions collected mainly in Central Italy are long term preserved. Here we present successful germination protocols of four closely related European pansies occurring in Italy: first data for *V. kitaibeliana* Schult. and *V. hymettia* Boiss. & Heldr., and new data for Italy for *Viola arvensis* Murray subsp. *arvensis* and *V. tricolor* L. subsp. *tricolor*.

38. *Viola arvensis* Murray subsp. ***arvensis*** (*Violaceae*) (Fig. 1a)

Accession data

It: Tuscany. Sarteano (Siena), Mt. Cetona (WGS84: 42.931109°N, 11.875547°E), edge of stony path on calcareous substrate, 1100 m a.s.l., 17 May 2012, *A. Scoppola* (BGT-A-29512, Tuscia Germplasm Bank).

It: Umbria. Norcia (Perugia), Forca d'Ancarano (WGS84: 42.819999°N, 13.117497°E), margin of cultivated field, 1013 m a.s.l., 25 May 2012, *A. Scoppola* (BGT-A-29612, Tuscia Germplasm Bank).

It: Latium. Monte San Giovanni in Sabina (Rieti), Mt. Tancia (WGS84: 42.315850°N 12.744658°E), stony grassland on calcareous soil, 1180 m a.s.l., 20 May 2014, *A. Scoppola* (BGT-A-28614, Tuscia Germplasm Bank).

It: Latium. Tivoli (Roma), Acque Albule (WGS84: 41.963056°N, 12.714722°E), dry grassland on a travertine outcrop, 66 m a.s.l., 20 May 2014, *S. Magrini* (BGT-A-28913, Tuscia Germplasm Bank).

Germination data

Pre-treatments: sterilization with a solution of 5% sodium hypochlorite + Tween 20 for 5 minutes, followed by 3 rinses in sterile distilled water. Cold-moist stratification for 1 month at 5°C.

Germination medium: 1% agar + 250 mg/l GA_3.

Sample size: 100 seeds for each test (20 × 5 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]	Accession code
100%	constant 20°C	12/12h	6.0	12.2	24.0	12.3	BGT-A-28614
100%	constant 20°C	12/12h	7.0	10.6	30.0	17.3	BGT-A-29512
100%	constant 20°C	12/12h	8.6	13.6	21.3	14.3	BGT-A-29612
95.2%	constant 20°C	12/12h	5.0	9.6	21.7	11.3	BGT-A-28913

Observations

Viola arvensis subsp. *arvensis* (field pansy) is a Mediterranean-Eurasiatic winter annual pansy widespread throughout Europe and SW Asia as a weed in cultivated

fields, in synanthropic habitats, and open shrublands (Scoppola & Magrini 2019).

Germination tests were carried out with or without cold stratification. The effect of both hydro- and hormo-priming was tested, soaking seeds, respectively, in distilled water and in a solution of gibberellic acid (250 mg/l) for 24 h at 20°C in darkness. Seeds were sown on water-agar with or without the addition of gibberellic acid. No germination was recorded without cold stratification nor for primed seeds, contrarily to results for hydro-priming (ca. 40%) reported by Rajabalipour & al. (2013). High germination (> 95%) was obtained at 20°C only with the combination of both cold stratification and the addition of GA_3 to the substrate, in accordance with results reported by Royal Botanic Gardens Kew (2020). Moreover, seeds were sorted into two colour fractions, pale (immature) and dark brown (mature), to assess seed maturity effect on germination. Both germination percentage and rate were higher for dark than pale brown seeds (100% vs 6.7% and T_{50}: 9.9 vs 20.0, respectively), confirming that seed maturity also affects *V. arvensis* seed germination, as reported for *V. wittrockiana* Gams (Agnieszka & Holubowicz 2008).

39. *Viola hymettia* Boiss. & Heldr. (*Violaceae*)

Accession data

It: Latium. Viterbo (Viterbo), loc. Asinello (WGS84: 42.401150°N, 12.072031°E), dry grassland on volcanic soil, 276 m a.s.l., 18 Apr 2018, *L. Cracco* (BGT-A-48318, Tuscia Germplasm Bank).

Si: Piazza Armerina (Enna), Cannarozzo (WGS84: 37.409167°N, 14.380556°E), clearing in a pine forest, 730 m a.s.l., 21 Mar 2019, *R. Galesi* (BGT-A-68619, Tuscia Germplasm Bank).

Germination data

Pre-treatments: sterilization with a solution of 5% sodium hypochlorite + Tween 20 for 5 minutes followed by 3 rinses in sterile distilled water.

Germination medium: 1% agar + 250 mg/l GA_3.

Sample size: 100 seeds for each test (20 × 5 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]	Accession code
88.7%	constant 15°C	12/12h	6.8	12.4	22.3	13.1	BGT-A-48318
84.9%	constant 15°C	12/12h	6.0	8.8	24.3	11.7	BGT-A-68619

Observations

Viola hymettia is an annual pansy widespread in the southern Balkans and the Aegean Islands, quite rare in central and southern Italy and Sicily, linked to stony pas-

tures, dry open habitats and shrub fringes, mostly on sub-acid soils (Scoppola & Magrini 2019).

Here we report the first germination data for *Viola hymettia*. Cold stratification was not required in accordance with results for *V. calaminaria* (Ging.) Lej. (Godefroid & Van de Vyver 2020). The effect of both hydro- and hormo-priming was tested, soaking seeds, respectively, in distilled water and in a solution of gibberellic acid (250 mg/l) for 24 h at 20°C in darkness and sowing them on water-agar medium. Not primed seeds were sown on water-agar with the addition of gibberellic acid (250 mg/l). High germination (> 84%) was obtained at 15°C only for not primed seeds on the substrate with the addition of GA_3. Very low germination was recorded for both hydro- and hormo-primed seeds of all the tested accessions (0-2% and 8-9%, respectively).

40. *Viola kitaibeliana* Schult. (*Violaceae*) (Fig. 1b)

Accession data

It: Latium. Nespolo (Rieti), Cerreta (WGS84: 42.162784°N 13.080031E), open grassland on calcareous soil, 1000 m a.s.l., 16 Jun 2010, *A. Scoppola* (BGT-A-14710, Tuscia Germplasm Bank).

It: Latium. Varco Sabino (Rieti), Mt. Navegna (WGS84: 42.234799°N 12.992089°E), stony grassland on calcareous soil, 1184 m a.s.l., 2 Jun 2014, *A. Scoppola* (BGT-A-28714, Tuscia Germplasm Bank).

It: Umbria. Norcia (Perugia), Forca d'Ancarano (WGS84: 42.819651°N 13.117618°E), stony meadow between fields on calcareous soil, 1010 m a.s.l., 11 May 2012, *A. Scoppola* (BGT-A-29712, Tuscia Germplasm Bank).

Germination data

Pre-treatments: sterilization with a solution of 5% sodium hypochlorite + Tween 20 for 5 minutes followed by 3 rinses in sterile distilled water.

Germination medium: 1% agar + 1) 250 mg/l GA_3 and 2) 500 mg/l GA_3.

Sample size: 100 seeds for each test (20 × 5 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]	Accession code
100%[1]	constant 20°C	12/12h	6.0	12.2	19.0	12.3	BGT-A-28714
100%[2]	constant 20°C	12/12h	8.0	11.7	17.3	12.1	BGT-A-14710
93.3%[1]	constant 20°C	12/12h	7.0	11.6	21.7	12.2	BGT-A-14710
80.3%[1]	constant 20°C	12/12h	6.0	5.8	24.7	9.8	BGT-A-29712

Observations

Viola kitaibeliana is a winter annual small-flowered pansy extremely rare in Europe where it is a component of early stages of grasslands, stony slopes, and other open places

(Randal 2004; Magrini & Scoppola 2015a, 2015b). In particular, it has a highly fragmented distribution in Italy, where it is endangered. Here we report the first germination data for this species.

Germination tests were carried out after 0 and 1 month of cold stratification at 5°C. Seeds were sown on water-agar with the addition of gibberellic acid. No germination was recorded without cold stratification. High germination (> 80%) was obtained at 20°C only with the combination of both cold stratification and the addition of GA_3 to the substrate.

41. *Viola tricolor* L. subsp. ***tricolor*** (*Violaceae*)

Accession data

It: Latium. Vejano (Viterbo), loc. Acquaforte (WGS84: 42.218919°N 12.110024°E), shrubby grassland, 353 m a.s.l., 14 May 2017, *S. Buono* (BGT-A-41517, Tuscia Germplasm Bank).

Germination data

Pre-treatments: sterilization with a solution of 5% sodium hypochlorite + Tween 20 for 5 minutes followed by 3 rinses in sterile distilled water.

Germination medium: 1% agar + 250 mg/l GA_3.

Sample size: 100 seeds for each test (20 × 5 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
83.1%	constant 15°C	12/12h	7.0	13.3	24.5	13.6

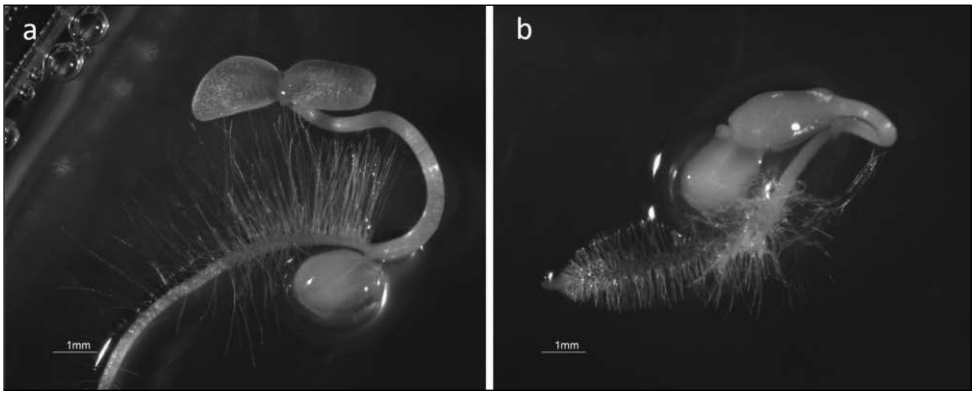


Fig. 1. Germinated seeds of: **a,** *Viola arvensis* subsp. *arvensis* and **b,** *V. kitaibeliana*.

Observations

Viola tricolor subsp. *tricolor* is a pansy occurring in habitats linked to woodlands and semi-natural lands in south Europe (Scoppola & Magrini 2019).

Following Godefroid & Van de Vyver (2020), cold stratification was not required. The effect of both hydro- and hormo-priming was tested, soaking seeds, respectively, in distilled water and in a solution of gibberellic acid (250 mg/l) for 24 h at 20°C in darkness and sowing them on water-agar medium. Not primed seeds were sown on water-agar with the addition of gibberellic acid. High germination (> 83%) was obtained at 15°C only for not primed seeds on the substrate with the addition of GA_3, in accordance with results reported by Royal Botanic Gardens Kew (2020). Lower germination was recorded for both hydro- and hormo-primed seeds (4% and 16%, respectively).

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Seed germination data of three *Hieracium* and one *Pilosella* (*Asteraceae*) from Sicily and southern Italy

Abstract

Di Gristina, E., Varshanidze, D. & Domina, G.: Seed germination data of three *Hieracium* and one *Pilosella* (*Asteraceae*) from Sicily and southern Italy [In Magrini, S. & Salmeri, C. (eds), Mediterranean plant germination reports – 2]. Fl. Medit. 30: 431-437. 2020. http://dx.doi.org/10.7320/FlMedit30.431

This work reports the first seed germination data of three *Hieracium* and one *Pilosella* (*Asteraceae*) taxa from Sicily and southern Italy. The studied taxa are: *Hieracium hypochoeroides* subsp. *cilentanum*, endemic to Campania, *H. schmidtii* subsp. *nebrodense*, endemic to Sicily, *H. terraccianoi*, endemic to Calabria and *Pilosella hoppeana* subsp. *sicula*, endemic to Sicily. The obtained results showed that the investigated taxa produce non-dormant seeds, with a high percentage of germination at all tested thermoperiods (15°C to 25°C and the alternating temperature of 25/15°C). Germination tests carried out in gibberellic acid (GA_3) provided similar germination percentages. The data presented in this paper provides useful information for the conservation of these endemic taxa.

Key words: apomixis, conservation, endemics, sexuality, taxonomy.

Introduction

Hieracium L. s. str. and *Pilosella* Vaill. (*Asteraceae*) are two of the largest angiosperm genera notorious for their taxonomic complexity caused by widespread interspecific hybridization, polyploidy, apomixis and sexuality (see, e.g., Krahulcová & al. 2000; Mráz & al. 2019). Many *Hieracium* and *Pilosella* taxa have a very restricted distribution and are punctual endemics. In southern Europe there are only local populations and most of them seem to be relict (Mráz & al. 2019). Therefore, their biological, phytogeographical and taxonomical relevance requires specific actions of *ex situ* and *in situ* protection. To this regard, the knowledge of the seed germination behaviour is an important contribution to the conservation of these taxa.

The taxonomy and distribution of *Hieracium* and *Pilosella* in southern Italy are currently under review. Recent studies resulted in the description of new endemic taxa with very local distributions (Brullo & al. 2001; Raimondo & Di Gristina 2004, 2007; Caldarella & al. 2014; Gottschlich & al. 2013, 2015; Di Gristina & al. 2013a, 2014, 2015a, 2015b, 2016a, 2016b, 2018, 2019). Also, little-known taxa were rediscovered (Di Gristina & al. 2016c; Gottschlich & al. 2017b) or reported as new to the Italian flora (Gottschlich & al. 2017a).

In this study, we present the seed germination data of four endemic hawkweed from Sicily and southern Italy: *Hieracium hypochoeroides* subsp. *cilentanum* Di Grist., Gottschl. & Raimondo, *H. schmidtii* subsp. *nebrodense* (Tineo ex Lojac.) Di Grist., Gottschl. & Raimondo, *H. terraccianoi* Di Grist., Gottschl. & Raimondo, and *Pilosella hoppeana* subsp. *sicula* Di Grist., Gottschl. & Raimondo

42. *Hieracium hypochoeroides* subsp. ***cilentanum*** Di Grist., Gottschl. & Raimondo (*Asteraceae*)

Accession data

It: Campania. Sanza (Salerno), Mt Cervati (Parco Nazionale del Cilento e Vallo di Diano) (WGS84: 40.290336°N, 15.477447°E), carbonate rocks, 1.860 m a.s.l., 09 Jul 2015, *E. Di Gristina* (PAL 102652).

Germination data

Pre-treatments: No treatment. Only manual removal of pappus.

Germination medium: Petri dishes with 2 sheets of sterilized Whatman 40 filter papers, imbibed in sterilized distilled water or in 10^{-3} M gibberellic acid (GA_3) water solution(1).

Sample size: 80 seeds for each test (20 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
94%	constant 20°C	0/24h	6.0	12.4	21.0	12.8
95%(1)	constant 20°C	0/24h	5.0	11.8	22.0	12.8

Observations

Hieracium hypochoeroides subsp. *cilentanum* is a chasmophytic hawkweed endemic to Mt Cervati (Campania, S Italy) (Di Gristina & al. 2016a). The collective species *H. hypochoeroides* s. l. is a young aggregate of many apomictic microtaxa which have evolved probably during the post-glacial period (Di Gristina & al. 2015a). Many of the taxa so far described have a very restricted distribution and are punctual endemics (Di Gristina & al. 2013a, 2015b). In southern Europe there are only local populations, and most of them seem to be relict (Di Gristina & al. 2015b). *H. hypochoeroides* subsp. *cilentanum* matures and disperses seeds in July (Di Gristina & al. 2016a).

Germination tests were carried out 3 months after seed harvesting, using the constant temperatures of 15°C, 20°C, 25°C, and the alternating temperature of 25/15°C (16h/8h), in continuous darkness. The obtained results showed that *H. hypochoeroides* subsp. *cilentanum* produces non-dormant seeds, with a high percentage of germination at all tested thermoperiods. This can be due to a strategy aimed at allowing populations living in unfavourable ecological conditions, such as chasmophytic environments, to increase the probability of dispersal and affirmation of the progeny. The optimal ger-

mination temperature was 20°C (94%). Germination tests carried out in 10^{-3} M gibberellic acid (GA_3) provided similar germination percentages. No germination data are present in literature for this taxon nor for the *H. hypochoeroides* aggregate.

43. *Hieracium schmidtii* subsp. ***nebrodense*** (Tineo ex Lojac.) Di Grist., Gottschl. & Raimondo

Accession data

Si: Polizzi Generosa (Palermo), Monte Cavallo (Monti Madonie) (WGS84: 37.831973°N, 14.037852 E), quartzarenitic rocks, 1.400 m a.s.l., 28 Jun 2015, *E. Di Gristina* (PAL 102631).

Germination data

Pre-treatments: No treatment. Only manual removal of pappus.

Germination medium: Petri dishes with 2 sheets of sterilized Whatman 40 filter papers, imbibed in sterilized distilled water or in 10^{-3} M gibberellic acid (GA_3) water solution(1).

Sample size: 80 seeds for each test (20 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
90%	constant 20°C	0/24h	6.0	11.5	21.0	13.1
95%(1)	constant 20°C	0/24h	5.0	12.5	20.0	11.7

Observations

Hieracium schmidtii subsp. *nebrodense* is a chasmophytic hawkweed endemic to the Madonie Mountains (Sicily, Italy) (Di Gristina & al. 2016c). This taxon has been recently rediscovered after almost two centuries since its first and single collection made in 1830 and reclassified as a subspecies of the collective species *H. schmidtii* (Di Gristina & al. 2016c). This aggregate in Sicily is also represented by another taxon endemic to the Madonie Mountains, *H. schmidtii* subsp. *madoniense* (Raimondo & Di Grist.) Greuter (syn. *H. madoniense*, see Raimondo & Di Gristina 2007). *H. schmidtii* subsp. *nebrodense* matures and disperses seeds in June and July (Di Gristina & al. 2016c).

Germination tests were carried out 3 months after seed harvesting, using the constant temperatures of 15°C, 20°C, 25°C and the alternating temperature of 25/15°C (16h/8h), in continuous dark. In water, high percentage of germination was obtained at all tested thermoperiods, the highest (90%) and with high germination speed (T_{50}: 11.5, MTG: 13.1) at the constant temperature of 20°C. Germination tests carried out in 10^{-3} M gibberellic acid (GA_3) provided a bit higher germination percentage (95%). Here we report the first germination data for this taxon and for the *H. schmidtii* aggregate.

44. *Hieracium terraccianoi* Di Grist., Gottschl. & Raimondo (*Asteraceae*)

Accession data

It: Calabria, Morano Calabro (CS), Scala di Gaudolino (Parco Nazionale del Pollino) (WGS84: 39.900303° N, 16.169194°E), carbonate rocky slopes, 1.350 m a.s.l., 12 Jul 2014, *E. Di Gristina* (PAL 101239).

Germination data

Pre-treatments: No treatment. Only manual removal of pappus.

Germination medium: Petri dishes with 2 sheets of sterilized Whatman 40 filter papers, imbibed in sterilized distilled water or in 10^{-3} M gibberellic acid (GA_3) water solution(1).

Sample size: 80 seeds for each test (20 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
90%	constant 15°C	0/24h	7.0	14.9	19.0	15.0
90%(1)	constant 15°C	0/24h	6.0	13.4	19.0	14.0

Observations

Hieracium terraccianoi is a pseudorosulate hemicryptophytic hawkweed endemic to the Pollino National Park (S Italy) (Di Gristina & al. 2014). This species belongs to a complex of similar morphotypes which have been grouped together in *H.* sect. *Grovesiana* (Gottschlich & al. 2013). *H. terraccianoi* matures and disperses the seeds in June and July (Di Gristina & al. 2014).

Germination tests were carried out 3 months after seed harvesting, using the constant temperatures of 15°C, 20°C, 25°C and the alternating temperature of 25/15°C (16h/8h), in continuous dark. The seeds of *H. terraccianoi* showed no dormancy and the highest germination (90%) at the temperature of 15°C. High germination was also obtained at 20°C reaching a value of 84%, while the alternating temperature of 25/15°C only reached a maximum of 65%. These results suggest that the seeds of *H. terraccianoi* prefer constant, cool or medium temperatures, for germination. Tests carried out in 10^{-3} M gibberellic acid (GA_3) provided similar germination percentages. Our germination tests are the first for this species and for the *H.* sect. *Grovesiana*.

45. *Pilosella hoppeana* subsp. ***sicula*** Di Grist., Gottschl. & Raimondo (*Asteraceae*)

Accession data

Si: Polizzi Generosa (Palermo), Monte Scalone (Monti Madonie) (WGS84: 37.841030°N 14.018628°E), quartzarenitic rocky slopes, 1.510 m a.s.l., 15 Jun 2011, *E. Di Gristina* (PAL 101238).

Si: Nicosia (Enna), Monte Sambughetti, (Monti Nebrodi) (WGS84: 37.820000°N 14.385000°E), quartzarenitic rocky slopes, 1.420 m a.s.l., 20 Jun 2011, *E. Di Gristina* (PAL 100473).

Germination data

Pre-treatments: No treatment. Only manual removal of pappus.

Germination medium: Petri dishes with 2 sheets of sterilized Whatman 40 filter papers, imbibed in sterilized distilled water or in 10^{-3} M gibberellic acid (GA_3) water solution(1).

Sample size: 80 seeds for each test (20 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]	Herbarium Id no.
85%	constant 20°C	0/24h	5.0	9.2	18.0	10.0	PAL101238
87%(1)	constant 20°C	0/24h	5.0	9.1	17.0	9.9	PAL101238

Observations

Pilosella hoppeana subsp. *sicula* is a rosulate hemicryptophytic hawkweed endemic to the Madonie and Nebrodi Mountains (Sicily, Italy) (Di Gristina & al. 2016b). The *P. hoppeana* (Schult.) F.W. Schultz & Sch. Bip. aggregate includes widespread taxa and also very localized ones (Di Gristina & al. 2013b). In Sicily the group is represented by the widely spread *P. hoppeana* subsp. *macrantha* (Ten.) S. Bräut. & Greuter and *P. hoppeana* subsp. *sicula*, recently described on the basis of an integrated morphological, karyological and isoenzymatic study (Di Gristina & al. 2013b). The two populations of *P. hoppeana* subsp. *sicula* from the Madonie and Nebrodi Mountains were investigated. This taxon matures and disperses seeds in June and July (Di Gristina & al. 2016b).

Germination tests were carried out 3 months after seed harvesting, using the constant temperatures of 15°C, 20°C, 25°C and the alternating temperature of 25/15°C (16h/8h), in continuous dark. The examined populations of *P. hoppeana* subsp. *sicula* showed no seeds dormancy and 20°C as optimal germination temperature. However, the germination rates were different between the two populations: the Madonie one showed the highest percentage (85%) with a high germination speed (T_{50}: 9.25, MTG: 10), while the seed germination value of the Nebrodi population only reached 75%, with lower speed (T_{50}: 14.5, MTG: 15.4). Tests carried out in 10^{-3} M gibberellic acid (GA_3) provided similar or slightly higher germination percentages. These are the first germination data for this taxon and for the *P. hoppeana* aggregate.

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Mediterranean plant karyological data – 30

edited by G. Kamari, C. Blanché & S. Siljak-Yakovlev

Abstract

Kamari, G., Blanché, C. & Siljak-Yakovlev, S. (eds): Mediterranean plant karyological data – 30. — Fl. Medit. 30: 439-460. 2020. — ISSN: 1120-4052 printed, 2240-4538 online.

This is the thirty of a series of karyological data from Mediterranean area, peri-Alpine communities and the Atlantic Islands, in English or French language. It comprises contributions on 15 taxa: *Campanula* from Crete, East Aegean Islands and Greece by E. Liveri, P. Bareka & G. Kamari (Nos 1982-1993); *Crepis* from Bosnia, France, Italy and Slovenia by S. Siljak-Yakovlev (Nos 1994-1996).

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E. Liveri, P. Bareka & G. Kamari

Karyosystematic study of some taxa from *Campanula* section *Quinqueloculares* (*Campanulaceae*). I.

Abstract

Liveri, E., Bareka, P. & Kamari, G. 2020: Karyosystematic study of some taxa from *Campanula* section *Quiqueloculares* (*Campanulaceae*). I. [In Kamari, G., Blanché, C. & Siljak-Yakovlev, S. (eds), Mediterranean plant karyological data-30]. – Fl. Medit. 30:440-455. http://dx.doi.org/10.7320/FlMedit30.440

Chromosome numbers and karyotypes are given for 12 taxa of *Campanula* section *Quinqueloculares*. All the examined taxa are distributed in Greece including the phytogeographical regions of Crete and Karpathos, Cyclades and East Aegean Islands. The chromosome number $2n = 2x = 34$ is found in all examined taxa with the exception of *C. laciniata* ($2n = 4x = 68$), which is a new chromosome number for the taxon from Crete. Their karyotypes are symmetrical comprising of mostly metacentric and submetacentric chromosomes, small in size, but they differ in the presence and the size of satellites. The chromosome count ($2n = 34$) and karyotype morphology of *C. topaliana* subsp. *delphica* is given for first time. New populations of *C. cymaea*, *C. kamariana*, *C. pelviformis*, and *C. topaliana* subsp. *cordifolia* were karyologically investigated confirming the previous references. The karyotype morphology of *C. anchusiflora*, *C. andrewsii* subsp. *hirsutula*, *C. kamariana*, *C. lavrensis*, *C. merxmuelleri*, *C. nisyria*, and *C. rupestris* is given for first time. Additionally, microphotographs are firstly provided hereby for all investigated taxa.

Keywords: Chromosome number, distribution, endemism, Greece, karyomorphology.

Introduction

Campanula L. section *Quinqueloculares* (Boiss.) Phitos encompasses ca. 39 species mostly distributed in Greece and/or W Turkey (Liveri & al. 2019). Only two of the species (*C. crispa* Lam., *C. lyrata* Lam.) extend their distribution to Transcaucasia, Armenia, Iran and Jordan, whereas one species (*C. medium* L.) is restricted to Italy and France (Castroviejo & al. 2010). Greece and W Turkey harbor 24 and 12 species, respectively, in addition to 2 species (*C. hagielia* Boiss. and *C. lyrata*) which occur both in East Aegean Islands and the adjacent Turkish coastline.

The species of *Campanula* sect. *Quinqueloculares* are characterized by an extreme morphological polymorphism, which renders their identification hard, or even dubious in some cases (Phitos 1965, 1969, 2016; Eddie & Ingrouille 1999). In general, they are biennial (monocarpic) or, more rarely, perennial plants, mostly chasmophytic, featured by a 5-locular ovary, style with 5 stigmas, capsule opening with 5 pores, and calyx

appendages more or less covering the ovary (Phitos 1965, 1969; Liveri & al. 2019, 2020). However, in some species, the number of the ovary locules varies from 3 to 5 (Liveri & al. 2019, 2020). A small group of six species with a predominantly trilocular ovary has been recognized by Phitos (1963a) and referred to as "*Campanula rupestris* group" or "trilocular *Campanula* species" (Phitos 1964a) or "*Triloculares*" (Phitos 2016). Recently, the first phylogenetic study of *C.* sect. *Quinqueloculares* based on molecular data was performed revealing the polyphyletic origin of the traditionally circumscribed section (Liveri & al. 2020).

Karyological studies of 28 species belonging to *Campanula* sect. *Quinqueloculares* resulted in a consistent chromosome count ($2n = 2x = 34$) for all of them (Marchal 1920; Phitos 1963a, b, 1964a, b, 1965, 1969; Contandriopoulos 1964, 1970; Gadella 1964; Zhukova 1967; Tornadore & al. 1974; Papatsou & Phitos 1975; Phitos & Kamari 1984; Montmollin 1986; Runemark & Phitos 1996; Strid 2015; Kyriakopoulos & al. 2017). The chromosome number $2n = 2x = 32$ given in *C. medium* (Chen & al. 2003), is questionable.

Polyploidy is not common in *C.* sect. *Quinqueloculares.* So far, the only known polyploidy number is $2n = 6x = 102$ in *C. laciniata* L. (Sugiura 1942).

Although the chromosome number for the majority of the species has been given in the past, the karyotype morphology of most species is still unknown.

The current karyological study provides chromosome number, ploidy level, type of symmetry and average maximum and minimum length of chromosomes. For each taxon, karyotype microphotograph is also provided and karyotype morphology is discussed.

1982. *Campanula anchusiflora* Sm. **—** $2n = 2x = 34$ (Figs 1a, 2a & 2b).

Gr: Isl. Hydra: W side of the port, on the coastal road from the port towards Kamini village, alt. 6-10 m., 37° 21' 5'' N, 23° 27' 51'' E, 27 Apr 2016, leg. *E. Liveri & V. Ketsilis-Rinis 188* (Herb. Phitos & Kamari in UPA).

Campanula anchusiflora (Fig. 1a) is a typical quinquelocular species restricted in Hydra island (Argosaronikos Gulf). However, morphologically deviating forms can be found on the adjacent mainland in Peloponnisos (Phitos 1965, 1969).

One population of *Campanula anchusiflora* in material from Hydra has been studied karyologically resulted to the chromosome number $2n = 34$ (Phitos 1963a, 1969).

The chromosome number $2n = 34$ for *Campanula anchusiflora* in material from Hydra is confirmed in our study. The karyotype is diploid and symmetrical, consisting of mostly metacentric (m) and submetacentric (sm) chromosomes which vary in size between 1.00-1.55 μm (Fig. 2a; Table 1). In several karyotypes of the examined material, two submetacentric (sm) chromosomes are observed, bearing large satellites, similar in size to the short (s) arm (Fig. 2b). Due to the heterochromatin structure and the long distance from the short arm caused by the squashing technique, these satellites can be considered as B-chromosomes. The given chromosome number is confirmed by previous studies (Phitos 1963a, 1969); microphotographs of the karyotype are presented here for the first time (Figs 2a, b).



Fig. 1. Some taxa of *Campanula* section *Quinqueloculares*: **a,** *C. anchusiflora* (Hydra); **b,** *C. merx-muelleri* (Skyros); **c,** *C. laciniata* (Crete); **d,** *C. topaliana* subsp. *delphica* (Delphi); **e,** *C. andrewsii* subsp. *hirsutula* (Monemvasia); **f,** *C. nisyria* (Nisyros). – Photos by E. Liveri.

1983. *Campanula andrewsii* subsp. ***hirsutula*** Phitos **—** 2*n* = 2x = 34 (Figs 1e & 2c).

Gr: Prov. Lakonia: Castle of Monemvasia, alt. 0-5 m., 36° 41' N, 23° 03' E, 21 May 2016, leg. *E. Liveri & V. Ketsilis-Rinis 225* (Herb. Phitos & Kamari in UPA).

Campanula andrewsii is distributed in eastern Peloponnisos. It comprises of two subspecies: 1) the typical subsp. *andrewsii*, mostly growing in northeastern Peloponnisos (Argolis peninsula, Korinthos); and 2) subsp. *hirsutula* (Fig. 1e), which was originally described from the castle of Monemvasia (*locus classicus*) and it is also found in southeastern Peloponnisos (Phitos 1965, 1969; Fedorov & Kovanda 1976) and in a single locality of northeastern Peloponnisos, in Methana peninsula (Kougioumoutzis & al. 2012a). *C. andrewsii* subsp. *hirsutula* differs morphologically from the typical subspecies mainly in its indumentum (hirsute calyx), corolla (shorter tube) and calyx appendages (very short and acuminate) (Phitos 1965, 1969; Fedorov & Kovanda 1976).

The chromosome count 2*n* = 34 has been recorded in material from the *locus classicus* (Phitos 1965, 1969). Additionally, Contandriopoulos (1964) reports the same chromosome number and provides a karyotype drawing for *C. andrewsii* s.l. in material from Mt. Parnassos, but most probably refers to a different taxon.

The examined material of *C. andrewsii* subsp. *hirsutula* shows a diploid, symmetrical karyotype comprised of 2*n* = 2x = 34 chromosomes, mainly metacentric (m) and submetacentric (sm), varying in size between 1.02 and 1.45 μm; one submetacentric (sm) chromosome pair bears large satellites (Fig. 2c; Table 1). Previous karyological references confirm the same chromosome number (Phitos 1965, 1969); although, the karyotype morphology and microphotograph are presented here for first time.

1984. *Campanula cymaea* Phitos **—** 2*n* = 2x = 34 (Fig. 2d).

Gr: Isl. Evia: village Vrysi, 15 km SW of the town Kymi, alt. 115 m., 38° 33' 06.56'' N, 24° 02' 38.57'' E, 6 May 2017, leg. *E. Liveri, V. Ketsilis-Rinis & N. Cellinese 294* (Herb. Phitos & Kamari in UPA).

Campanula cymaea is a representative of "*Triloculares*", endemic to eastern part of central Evia, especially around the town of Kymi (Phitos 1969; Phitos & Kamari 1995). It is included in the first *Red Data Book of Rare and Threatened Plants of Greece* as Rare (R), according to IUCN (1994) criteria (Phitos & Kamari 1995) and in the Greek Presidential Decree 67/1981.

The chromosome count 2*n* = 2x = 34 has been reported in material from two localities (Kymi and Potamia) accompanied with a karyotype drawing indicating one pair of large SAT-chromosomes (Phitos 1964a, 1969). Phitos (1964a) notices structural heterozygosity in the satellited pair in most individuals of the second population.

The examined material of *Campanula cymaea* is also diploid (2*n* = 2x = 34) and has a symmetrical karyotype which includes mostly metacentric (m) and submetacentric (sm) chromosomes; one submetacentric (sm) chromosome pair bears satellites (Fig. 2d). The average maximum and minimum chromosome length equals to 0.86 μm

and 1.25 µm, respectively (Table 1). The chromosome count and karyotype morphology of the newly examined subpopulation of *C. cymaea* is in accordance with previous studies (Phitos 1964a, 1969), but a microphotograph of the karyotype is provided for the first time (Fig. 2d).

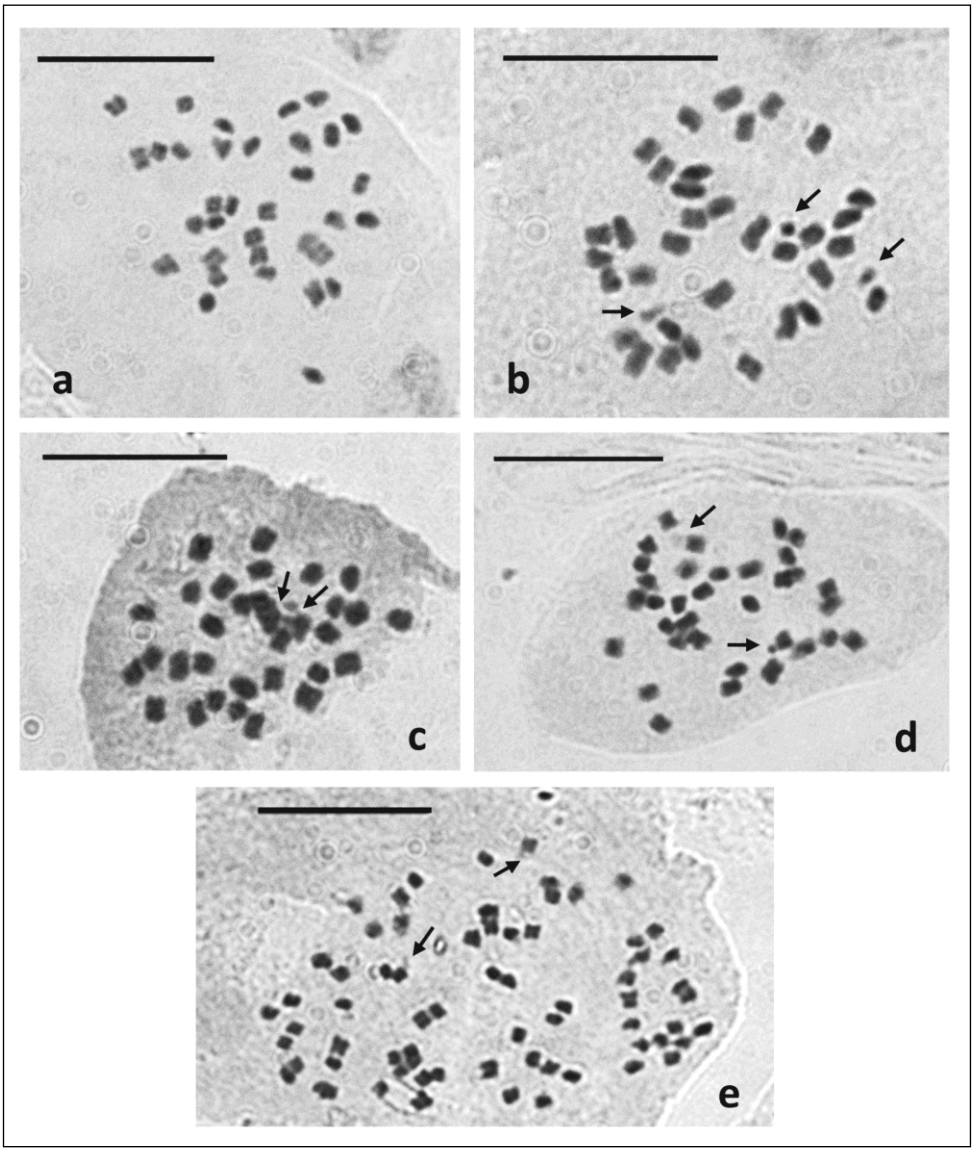


Fig. 2. Microphotographs of mitotic metaphase plates of *Campanula* section *Quinqueloculares*: **a,** and **b,** *C. anchusiflora*, 2*n* = 34; **c,** *C. andrewsii* subsp. *hirsutula*, 2*n* = 34; **d,** *C. cymaea*, 2*n* = 34; **e,** *C. laciniata*, 2*n* = 68. – Arrows indicate satellites. Scale bars = 10 µm.

1985. *Campanula kamariana* Kyriak., Liveri & Phitos **—** 2*n* = 2x = 34 (Fig. 3a).

Gr: Prov. Lakonia: south of village Itilo, castle of Kelefa, alt. 230 m., 36° 42' 4.385'' N, 22° 23' 47.327'' E, 17 Jun 2018, leg. *E. Liveri & V. Ketsilis-Rinis 237* (Herb. Phitos & Kamari in UPA).

Campanula kamariana is a recently described species of *C.* sect. *Quinqueloculares*, which is easily distinguished from the other species of the section mostly by its strongly lacerate, sparsely pubescent to glabrescent rosette leaves with long, sparsely lobed petioles (Kyriakopoulos & al. 2017). Up to now, it is found in the description locality, i.e. Limeni, a small village closes to the town Areopolis (Messinian Bay - southern Peloponnisos) and a second locality firstly mentioned in the current study, i.e. the castle of Kelefa.

Concerning karyology of *Campanula kamariana* from the *locus classicus*, Kyriakopoulos & al. (2017) mention the chromosome number 2*n* = 34 and a symmetrical karyotype including mostly metacentric (m) chromosomes.

The examined material of *Campanula kamariana* shows also a diploid and symmetrical karyotype (2*n* = 2x = 34) comprised of mostly metacentric (m) and submetacentric (sm) chromosomes, varying in size from 0.73 to 2.05 μm (Fig. 3a, Table 1). One submetacentric (sm) chromosome pair is predominantly observed bearing large satellites. The chromosome number of *C. kamariana* is confirmed from a new subpopulation with the addition of a microphotograph. The presence of satellited chromosomes is firstly mentioned hereby (Fig. 3a).

1986. *Campanula laciniata* Lam. **—** 2*n* = 4x = 68 (Figs 1c & 2e).

Cr: Prov. Chania: Aradaina gorge, alt. 70 m., 35° 12' 22.410'' N, 24° 3' 12.084'' E, 10 May 2017, leg. *E. Liveri, V. Ketsilis-Rinis & N. Cellinese 289* (Herb. Phitos & Kamari in UPA).

The large, broadly campanulate flowers and the laciniate, rather thick rosette leaves render *C. laciniata* (Fig. 1c) among the most showy and distinct members of *Campanula* sect. *Quinqueloculares* (Phitos 1965, 1969, 1995a; Cellinese & al. 2009; Strid 2016a, 2016b; Liveri & al. 2020). *Campanula laciniata* is distributed in the extended Cretan area (Crete and Karpathos), the southern Cyclades (Amorgos, Anafi, Folegandros, Kardiotisa, Sifnos, Sikinos), and Dodekanissos islands (Astypalea) (Phitos 1964b, 1965, 1969; Greuter 1973; Fedorov & Kovanda 1976; Phitos & Kamari 1984; Fielding & Turland 2005; Cellinese & al. 2009; Kougioumoutzis & al. 2012b; Strid 2016a, 2016b; Liveri & al. 2020). The populations of *C. laciniata* are scattered, consisting of a few individuals. This species is included in the first *Red Data Book of Rare and Threatened Plants of Greece* as Rare (R), according to IUCN (1994) criteria (Phitos 1995a), as well as in the Greek Presidential Decree 67/1981.

Diploid and hexaploid populations have been reported for *Campanula laciniata*: 2*n* = 2x = 34 chromosomes are reported in material from Folegandros (Phitos 1964b) and Karpathos (Phitos & Kamari 1984); while Sugiura (1942) reports an hexaploid karyotype with 2*n* = 6x = 102 chromosomes, from Greek material of an unknown locality.

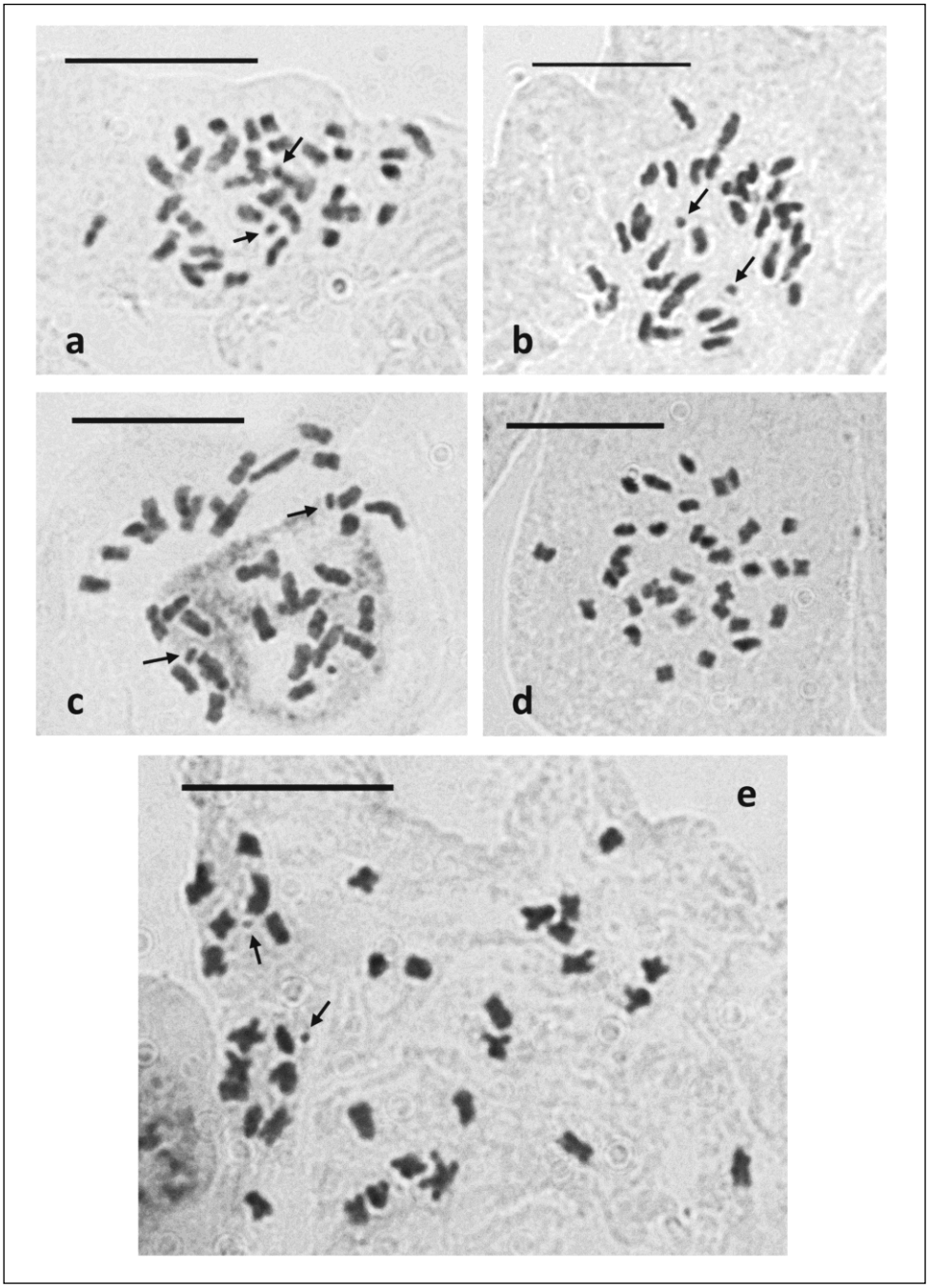


Fig. 3. Microphotographs of mitotic metaphase plates of *Campanula* section *Quinqueloculares*: **a,** *C. kamariana*, 2*n* = 34; **b,** *C. lavrensis*, 2*n* = 34; **c,** *C. merxmuelleri*, 2*n* = 34; **d,** *C. pelviformis*, 2*n* = 34; **e,** *C. nisyria*, 2*n* = 34. – Arrows indicate satellites. Scale bars = 10 μm.

Our results reveal a new ploidy level for *Campanula laciniata* in material from Crete, which is studied karyologically for the first time here. The tetraploid chromosome count for the species is $2n = 4x = 68$ chromosomes. The karyotype is symmetrical including mainly metacentric (m) and submetacentric (sm) chromosomes; four chromosomes have small spherical satellites, not all of them always visible (Fig. 2e). The chromosome size ranges from 0.78 to 1.29 μm (Table 1). The chromosome morphology of the Cretan population is similar to that given for diploid population in material from Folegandros (Phitos 1964b). According to the karyotype drawing for the latter material, four SAT-chromosomes are observed (Phitos 1964b), in accordance with our results. The karyotype of *C. laciniata* is depicted for the first time with a microphotograph here (Fig. 2e).

1987. *Campanula lavrensis* (Tocl & Rohlena) Phitos — $2n = 2x = 34$ (Fig. 3b).

Gr: Prov. Chalkidiki: Athos peninsula, Moni Megistis Lavras, alt. 154 m., 40° 10' 14.23'' N, 24° 23' 2.88'' E, 5 Jun 2018, leg. *A. Karydas s.n.* (UPA 24662).

The northest distribution limit of *Campanula* sect. *Quinqueloculares* is Athos peninsula, or commonly known in Greece as the Agion Oros, where *Campanula lavrensis* occurs (Phitos 1969; Fedorov & Kovanda 1976). This species grows on the cliffs and old walls of the numerous monasteries located in this area. Due to its morphological variability, two varieties have been recognized: 1) var. *lavrensis*; and 2) var. *breueri* Phitos (Phitos 1965). According to Strid (2016a, b), material from Samothraki island also belongs to *C. lavrensis*, which previously was referred to as *C. rupestris* (Ade & Rechinger 1938; Stojanov & Kitanov 1944).

The only chromosome count given for *Campanula lavrensis* is $2n = 34$ in material from the *locus classicus*, i.e. Moni Megistis Lavras, which is the largest and oldest monastery in Athos peninsula (Phitos 1965, 1969).

The material of *Campanula lavrensis* examined here has a diploid ($2n = 2x = 34$) and symmetrical karyotype with metacentric (m) and submetacentric (sm) chromosomes, ranging from 1.06 to 1.99 μm (Fig. 3b; Table 1). One pair of submetacentric (sm) chromosomes bears large satellites. The chromosome count confirms previous studies (Phitos 1965, 1969), but the karyotype morphology and a microphotograph are provided for first time.

1988. *Campanula merxmuelleri* Phitos — $2n = 2x = 34$ (Figs 1b & 3c).

Gr: Isl. Skyros: Mt. Kochilas, Monastery Agios Artemios, alt. 430 m., 38° 51' 04.76'' N, 24° 35' 39.72'' E, 7 May 2017, leg. *E. Liveri, V. Ketsilis-Rinis & N. Cellinese 291* (UPA 24649).

One of the most distinct members of *Campanula* sect. *Quinqueloculares* is *Campanula merxmuelleri* (Fig. 1b), characterized by its glabrous and fleshy leaves combined with the entire petiole and elliptic-spathulate lamina (Phitos 1963b, 1965, 1995b; Phitos & Kamari 2009; Liveri & al. 2020). *C. merxmuelleri* is distributed in

Skyros and adjacent small islands, as well as in Psara island (eastern Aegean) (Phitos & Kamari 2009; Baliousis 2016). It is noteworthy that the first specimen from Psara island was collected by P. Saliaris in 2007 (kept in Herb. Phitos & Kamari). Due to its peculiar distribution, it is considered as a relict endemic of the Aegean region (Phitos 2016). It is included in the *Red Data Books of Rare and Threatened Plants of Greece* as Vulnerable (VU), according to IUCN (1994, 2003) criteria (Phitos 1995b; Phitos & Kamari 2009) and in the Greek Presidential Decree 67/1981.

The only chromosome count given for *C. merxmuelleri* is $2n = 34$ in material from the *locus classicus*, ie. Monastery Agios Artemios in Mt. Kochilas (Phitos 1963b, 1969). In the karyotype drawing of the species two SAT-chromosomes are indicated (Phitos 1969).

According to our data, *Campanula merxmuelleri* has $2n = 2x = 34$ chromosomes, metacentric (m) and submetacentric (sm) in morphology, ranging in size between 1.18

Table 1. Chromosome data of the examined taxa of *Campanula* section *Quinqueloculares*. MAX and MIN correspond to average maximum and minimum length of chromosomes, respectively. SAT corresponds to the maximum number of observed SAT-chromosomes. All measurements are given in μm. Standard Deviation (SD) is given in parenthesis.

Taxon	Chromosome number	SAT	MIN	MAX
C. anchusiflora	$2n = 2x = 34$	2	1.00 (0.08)	1.55 (0.13)
C. andrewsii* subsp. *hirsutula	$2n = 2x = 34$	2	1.02 (0.12)	1.45 (0.12)
C. cymaea	$2n = 2x = 34$	2	0.86 (0.05)	1.25 (0.08)
C. kamariana	$2n = 2x = 34$	2	0.73 (0.16)	2.05 (0.38)
C. laciniata	$2n = 4x = 68$	4	0.78 (0.05)	1.29 (0.24)
C. lavrensis	$2n = 2x = 34$	2	1.06 (0.34)	1.99 (0.50)
C. merxmuelleri	$2n = 2x = 34$	2	1.18 (0.31)	2.49 (0.72)
C. nisyria	$2n = 2x = 34$	2	0.91 (0.08)	1.95 (0.19)
C. pelviformis	$2n = 2x = 34$	0	0.88 (0.11)	1.61 (0.30)
C. rupestris	$2n = 2x = 34$	2	1.02 (0.20)	1.95 (0.16)
C. topaliana* subsp. *cordifolia	$2n = 2x = 34$	2	0.85 (0.17)	1.73 (0.39)
C. topaliana* subsp. *delphica	$2n = 2x = 34$	2	0.83 (0.10)	1.17 (0.33)

and 2.49 μm (Fig. 3c, Table 1). The karyotype is symmetrical and diploid whereas two large satellites are observed in most karyotypes. Our findings are in accordance with previous studies (Phitos 1963b, 1969). Additionally, a microphotograph is provided here for first time (Fig. 3c).

1989. *Campanula nisyria* Papatsou & Phitos **—** 2*n* = 2x = 34 (Figs 1f & 3e).

AE: Isl. Nisyros: Evangelistria, alt. 170 m., 36° 36' 22.331'' N, 27° 8' 41.394'' E, 8 May 2018, leg. *E. Liveri, V. Ketsilis-Rinis & N. Cellinese 303* (UPA 24650).

Campanula nisyria (Fig. 1f) is endemic to the volcanic island Nisyros (Papatsou & Phitos 1975). Nisyros is the easternmost active volcano of the South Aegean Volcanic Arc (Sachpazi & al. 2002; Higgins 2009; Kougioumoutzis & Tiniakou 2014). Additionally, it is the only oceanic island in the Aegean; i.e. it has never been connected to a continental landmass (Tibaldi & al. 2008). After the first description of *C. nisyria*, Burton (1991) referred that it is an extreme isolated form of *C. lyrata*, while Strid (2016a) considered it as a synonym of *C. hagielia.* However, recent molecular data (Liveri & al. 2020) reveal that *C. nisyria* belongs to a well-supported clade together with five Turkish endemics, whereas *C. lyrata* and *C. hagielia* form a different clade; both clades though are included in a larger clade comprised of *Campanula* taxa distributed in southeastern Aegean and Anatolia.

The only chromosome record (2*n* = 34) for *Campanula nisyria* originates from the *locus classicus* (Papatsou & Phitos 1975).

The karyotype of *Campanula nisyria* examined here is diploid (2*n* = 2x =34), symmetrical, consisting of mostly metacentric (m) and submetacentric (sm) chromosomes; two of them bearing small spherical satellites which are rarely found in this size in the section (Fig. 3e). The chromosome length varies from 0.91 μm to 1.95 μm (Table 1). The chromosome count is in accordance with the previous study by Papatsou & Phitos (1975). However, the karyotype morphology and a microphotograph are provided here for first time (Fig. 3e).

1990. *Campanula pelviformis* Lam. **—** 2*n* = 2x = 34 (Fig. 3d).

Cr: Prov. Heraklio: New national road Iraklio-Agios Nikolaos, 42° km, close to Malia, alt. 100-120 m., 35° 18' 24.563'' N, 25° 22' 43.745'' E, 11 May 2017, leg. *E. Liveri, V. Ketsilis-Rinis & N. Cellinese 295* (Herb. Phitos & Kamari in UPA).

Campanula pelviformis is endemic to Crete, growing mainly in the eastern part of the island (Phitos 1965; Fedorov & Kovanda 1976; Fielding & Turland 2005; Strid 2016a, b). Except from inhabiting calcareous cliffs and rocky slopes like the most of *Campanula* sect. *Quinqueloculares* species, *C. pelviformis* is also found growing along steep, rocky, roadside banks (Fielding & Turland 2005; Cellinese & al. 2009).

Phitos (1964b) reports the chromosome number 2*n* = 34 for *C. pelviformis* in material from Crete of unknown locality and provides a karyotype drawing indicating two satellites.

The same chromosome count has been also mentioned for the species in material of unknown origin by Sugiura (1938, 1942).

The examined material of *Campanula pelviformis* has a diploid ($2n = 2x = 34$) and symmetrical karyotype consisting of mostly metacentric (m) and submetacentric (sm) chromosomes (Fig. 3d). The chromosome length varies from 0.88 μm to 1.61 μm (Table 1). Our findings confirm previous studies (Sugiura 1938, 1942; Phitos 1964b), however, no SAT-chromosomes are observed in the material examined here. The karyotype is firstly presented with a microphotograph hereby (Fig. 3d).

1991. *Campanula rupestris* Sm. **—** $2n = 2x = 34$ (Fig. 4a).

Gr: Prov. Viotia: Springs Krya, alt. 300-400 m., 38° 25.908' N, 22° 52.540' E, 5 May 2016, leg. *E. Liveri, A. A. Crowl & N. Cellinese 209* (UPA 24653).

Campanula rupestris is characterized by a consistently trilocular ovary with three stigmas, which is also found in other five species of the section; in total six species comprising the "*C. rupestris* group" (Phitos 1963a, 1964a). The species was discovered by Sibthorp, based on material from "Livadia" (Sterea Hellas) and was consequently described by Smith (Sibthorp & Smith 1819). The exact *locus classicus* of *C. rupestris* was enigmatic since no more details of the locality were known, until Phitos re-discovered it in 1962 (see Phitos 1964a, 1995c, 2016). Before 1964, various *Campanula* taxa were erroneously referred to C. *rupestris* in literature causing much confusion due to the lack of herbarium material and the morphological variability of "*C. rupestris* group". Most likely, the species is also extended to Mt. Elikon (Phitos 1964a, 1995c). Eddie & Ingrouille (1999) studied four populations of *C. rupestris*; two of them should be re-examined because of possible confusion with *C. topaliana* Beauverd subsp. *delphica* Phitos, while for one population the mentioned locality is rather unclear (Phitos 2016).

C. rupestris is recognized according to IUCN (1994) criteria as Vulnerable (VU) in the first *Red Data Book of Rare and Threatened Plants of Greece* (Phitos 1995c) and it is also included in the Greek Presidential Decree 67/1981.

The karyological study of *Campanula rupestris* from its *locus classicus* revealed $2n = 34$ chromosomes, accompanied with a karyotype drawing indicating one pair of SAT-chromosomes (Phitos 1964a). There are also two more references reporting the same chromosome number for *C. rupestris* in material from Peloponnisos (Phitos 1963a; Contandriopoulos 1964); most probably these references are related to *C. topaliana* subsp. *cordifolia* Phitos. Gadella (1964) also gives the same chromosome count for cultivated material of *C. rupestris* originated from England and the former Soviet Union.

The examined material of *Campanula rupestris* was also collected from the *locus classicus* and shows the same chromosome number and morphology. *C. rupestris* has diploid ($2n = 2x = 34$) and symmetrical karyotype, consisting of mostly metacentric (m) and submetacentric (sm) chromosomes with one pair of SAT-chromosomes (Fig. 4a). The chromosome length ranges from 1.02 μm to 1.95 μm (Table 1). Microphotograph is firstly provided hereby (Fig. 4a).

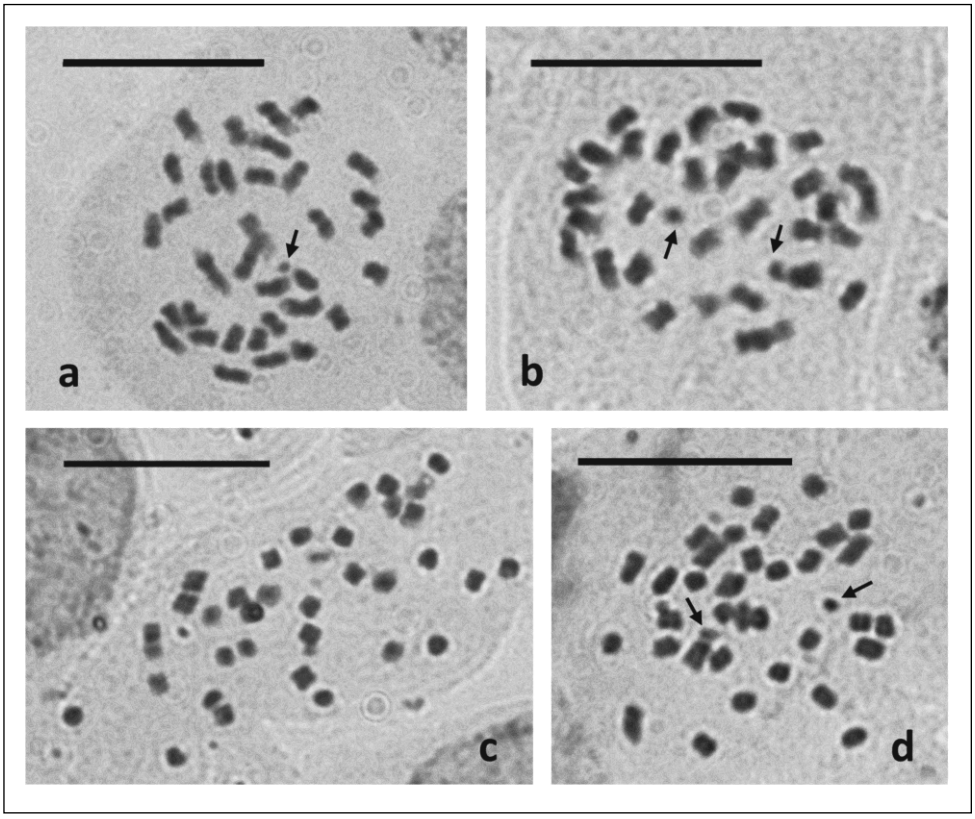


Fig. 4. Microphotographs of mitotic metaphase plates of *Campanula* section *Quinqueloculares*: **a,** *C. rupestris*, 2*n* = 34; **b,** *C. topaliana* subsp. *cordifolia*, 2*n* = 34; **c,** and **d,** *C. topaliana* subsp. *delphica*, 2*n* = 34. – Arrows indicate satellites. Scale bars = 10 μm.

1992. *Campanula topaliana* subsp. ***cordifolia*** Phitos **—** 2*n* = 2x = 34 (Fig. 4b).

Gr: Prov. Ilia: Thermal springs of Kaiafas, alt. 0-5 m., 37° 30’ 52.49’’ N, 21° 36’ 54.94’’ E, 8 Apr 2017, leg. *E. Liveri & V. Ketsilis-Rinis 266* (Herb. Phitos & Kamari in UPA).

Campanula topaliana is a variable species which includes three subspecies *sensu* Phitos (1965): 1) subsp. *topaliana*, distributed in a very restricted region between Kalavryta and Monastery Agia Lavra (Prov. Achaia); 2) subsp. *cordifolia*, which occurs in the most part of Peloponnisos (Prov. Achaia, Argolida, Arkadia, Korinthia, Lakonia, Messinia); and 3) subsp. *delphica*, growing in Delphi (Prov. Fokida) and the nearby area. The three subspecies mainly differ in the shape of basal leaves and the size of corolla (Phitos 1965, 1969; Fedorov & Kovanda 1976).

The chromosome count from a new population studied here is in accordance with previous reports (Phitos 1965, 1969) in material from *locus classicus* (Zachlorou near

Kalavrita). The examined material shows a diploid ($2n = 2x = 34$), symmetrical karyotype, consisting of mostly metacentric (m) and submetacentric (sm) chromosomes; two large satellites are observed in most karyotypes (Fig. 4b). The chromosome length ranges from 0.85 µm to 1.73 µm (Table 1). Karyotype morphology and a microphotograph are given for first time here (Fig. 4b).

1993. *Campanula topaliana* subsp. ***delphica*** Phitos **—** $2n = 2x = 34$ (Figs 1d, 4c & 4d).

Gr: Prov. Fokida: close to Delphi, alt. 450 m., 38° 29' 15.21'' N, 22° 28' 11.37'' E, 9 Apr 2017, leg. *E. Liveri & V. Ketsilis-Rinis 258* (Herb. Phitos & Kamari in UPA).

Campanula topaliana subsp. *delphica* (Fig. 1d) differs from the other subspecies in its grayish-sericeous basal leaves, long racemose to paniculate stems and their long, thin branches (Phitos 1965; Fedorov & Kovanda 1976).

Our results show that *C. topaliana* subsp. *delphica* has also a diploid ($2n = 2x = 34$), symmetrical karyotype comprised of mostly metacentric (m) and submetacentric (sm) chromosomes (Fig. 4c); one pair of submetacentric (sm) SAT-chromosomes is observed in most metaphase plates (Fig. 4d). The chromosome size varies between 0.83 and 1.17 µm (Table 1). To our knowledge, these are the first chromosome data for the subspecies.

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Sonja Siljak-Yakovlev

Karyological study of diploid and tetraploid *Crepis aurea* (*Asteraceae*)

Abstract

Siljak-Yakovlev, S. 2020: Karyological study of diploid and tetraploid *Crepis aurea* (*Asteraceae*) [In Kamari, G., Blanché, C. & Siljak-Yakovlev, S. (eds), Mediterranean plant karyological data-30]. – Fl. Medit. 30:456-460. http://dx.doi.org/10.7320/FlMedit30.456

Chromosome numbers and karyotypes were studied in eight populations of *Crepis aurea* from Alps, Dinaric Alps and Apennines. The populations from Alps and Apennines exhibit diploid chromosome number ($2n = 10$) while the populations from Central Dinaric Alps and one population from Julian Alps were tetraploid ($2n = 4x = 20$). For this reason, a detailed comparative analysis of the two cytotypes was undertaken. The hypothesis of auto-polyploidy seems to be the most plausible one. Additionally, it was interesting to deal with the taxonomic status of *Crepis aurea* var. *bosniaca* growing in Central Dinaric Alps and whose populations are tetraploid.

Keywords: Chromosome number, *Crepis aurea* subsp. *aurea*, *C. aurea* subsp. *glabrescens*, *C. aurea* var. *bosniaca*, karyomorphology, polyploidy.

Introduction

Crepis aurea (L.) Cass. belongs to the *Asteraceae* family (sub-family *Cichorioideae* Chevall., 1828; tribe *Cichoriae* Lam. & DC., 1806; sub-tribe *Crepidinae* Cass., 1827). This is a perennial hemicryptophyte growing in grass and on rocky slopes of the subalpine and alpine regions of South European mountains (from 1000 to 2900 m). This species has often changed its taxonomic status, which explains the existence of many synonyms: *Leontodon aureus* L., 1759; *Hieracium aureum* (L.) Scop., 1772; *Apargia aurea* (L.) F.W.Schmidt, 1795; *Calliopea aurea* (L.) D.Don, 1829; *Geracium aureum* (L.) Rchb., 1831; *Crepis kitaibelii* Froel., 1838; *Aracium aureum* (L.) D.Dietr., 1847; *Brachyderea aurea* (L.) Sch.Bip., 1866; *Hieracioides aureum* (L.) Kuntze, 1891. Currently this species comprises three accepted subspecies: *Crepis aurea* (L.) Cass. subsp. *aurea*, mainly located in the Alps, *Crepis aurea* subsp. *glabrescens* (Caruel) Arcang. located in Apennines, Apuan Alps and mountains of Southwest Balkans, and *Crepis aurea* subsp. *olympica* (K. Koch) Lamond which is limited to Turkey.

Of the eight populations studied, four had the diploid ($2n = 10$) and four the tetraploid ($2n = 4x = 20$) chromosome numbers. This led us to make a comparative karyological study of two ploidy levels and to try to understand the origin of polyploidy within *Crepis aurea* species. Two of these seven populations (one diploid - Col de Galibier and one tetraploid – Mt. Jahorina) are used for karyomorphological analyses. In addition, given that Bosnian populations are all tetraploid, the question arises regarding the real taxonomic status of *Crepis aurea* var. *bosniaca* described by Maly (1906).

1994. ***Crepis aurea*** (L.) Cass. subsp. ***aurea*** **—** 2*n* = 10 (Figs 1a & 1b).

Fr: French Alps: Aussois, near to the village, alt. 1450 m, Sept 1980, leg. *S. Siljak-Yakovlev*, *s.n*.
— Col de Galibier, alt. 2200 m, Sept 1980, leg. *S. Siljak-Yakovlev*, *s.n.*
— Col de Balme, alt. 2190 m, Aug 1981, leg. *D. Cartier & S. Blaise*, *s.n.*

The material from the Col de Galibier population was used for the fine analysis of the diploid karyotype and construction of a karyogram and idiogram which presents the mean value of the five metaphases belonging to the different individuals (Figs 1, 1a & 1b). Chromosome types were determined according to the usual recommendation and nomenclature of Levan & al. (1964).

Karyotype was composed of two metacentric pairs (pairs 4 and 5), one submetacentric (pair 2) and one satellite subtelocentric pair (pair 3). The karyotype formula was as follows: 2*n* = 4m + 2sm + 2sm-st + 2st-SAT = 10 chromosomes (Table 1).

Several chromosome counts of 2*n* = 10 were previously reported for this taxon (Siljak-Yakovlev 1981, 1982; Lippert & Heubl 1988; Gemeinholzer 2005; Lippert 2006; Enke & al 2011).

Table 1. Numerical data of chromosome set for diploid *Crepis aurea* s. s.

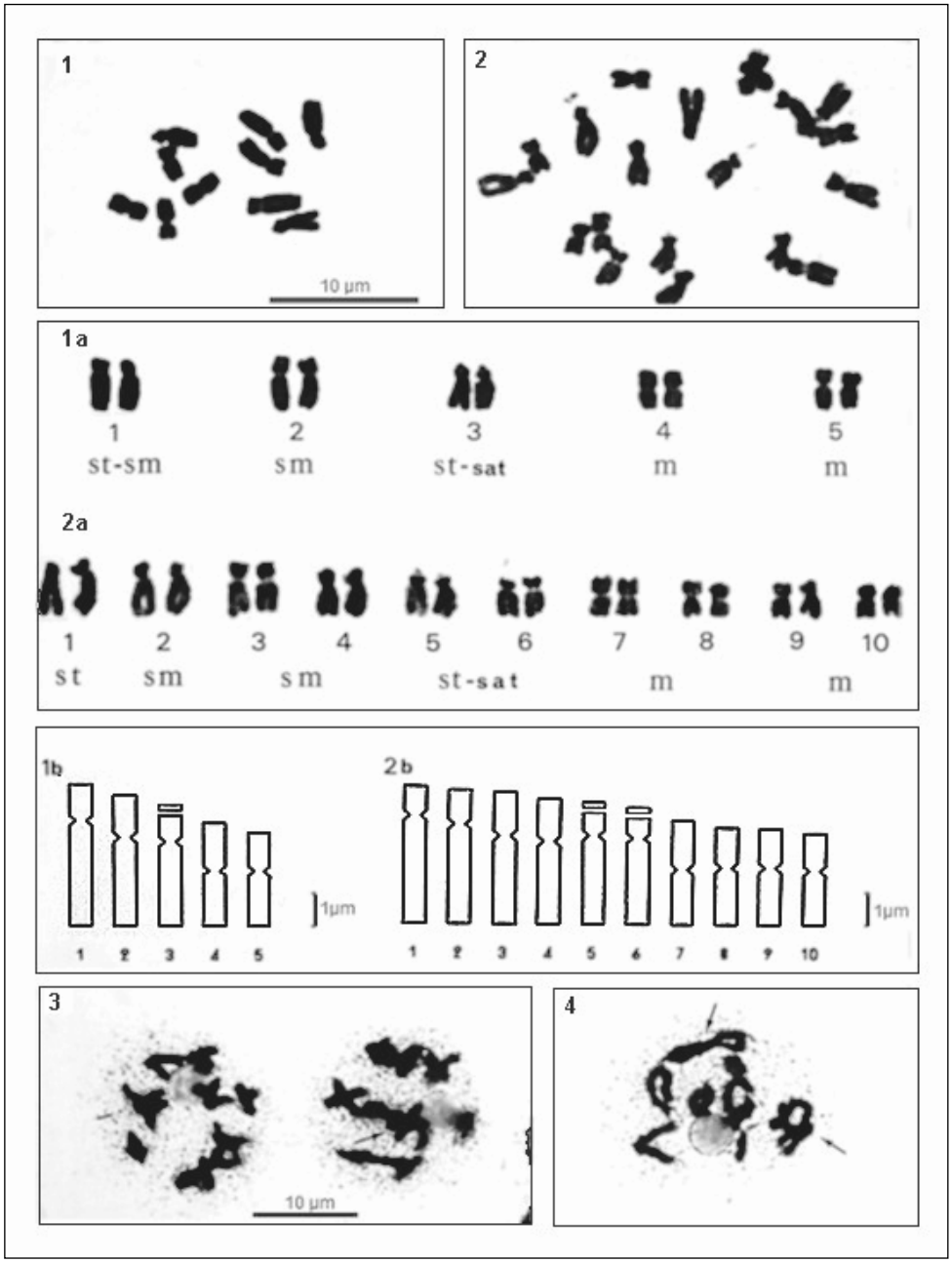
Chrom. pair	L (in µm)	S (in µm)	TL (in µm)	RL	Rapport L/S	Centromeric index	Chrom. type
1	3.10 (0.10)*	1.02 (0.04)	4.12	242.73	3.02	24.86	sm-st
2	2.60 (0.09)	1.23 (0.05)	3.83	225.31	2.11	32.11	sm
3	2.47 (0.12)	0.77 (0.07)	3.24	190.97	3.19	23.89	st-SAT
4	1.64 (0.08)	1.39 (0.09)	3.03	178.12	1.18	45.80	m
5	1.63 (0.06)	1.14 (0.08)	2.77	162.86	1.43	41.11	m

*Standard deviation; L = Long arm; S = Short arm; TL = Total length; RL = Relative length

1995. ***Crepis aurea*** subsp. ***glabrescens*** (Caruel) Arcang. **—** 2*n* = 2x = 10.

It: Apennins: Peisey Nancroix, alt. 1700 m, 1983, *material from Botanical garden*, *s.n*.

The chromosomal number of 2*n* = 10 already reported (Chichiricc & al. 1979, 1981; Siljak-Yakovlev 1985) has been confirmed again in this work for the population from Apennins.



Figs 1-4: **1,** Mitotic metaphase chromosome plate of diploid, 2*n* = 10, *Crepis aurea* subsp. *aurea* from French Alps (Galibier), corresponding karyogram (**1a**) and ideogram (**1b**); **2,** Metaphase chromosome plate of tetraploid, 2*n* = 4x = 20, *C. aurea* var. *bosniaca* from Central Dinaric Alps (Mt. Jahorina), corresponding karyogram (**2a**) and idiogram (**2b**); **3** and **4,** Meiotic chromosome plates of tetraploid *C. aurea* var. *bosniaca* in diakinesis stage. – The rare tetravalents are indicated by arrows.

1996. *Crepis aurea* var. ***bosniaca*** Maly **—** 2*n* = 4x = 20 (Figs 2a, 2b, 3 & 4).

BH: Central Dinaric Alps of Bosnia: Mt. Jahorina, alt. 1600 m, Aug 1979, leg. *S. Siljak-Yakovlev, s.n*.
— Central Dinaric Alps of Bosnia: Mt. Treskavica, alt. 1600 m, Aug 1979, leg. *S. Siljak-Yakovlev, s.n*.
— Central Dinaric Alps of Bosnia: Mt. Vlasic, alt. 1500 m, Aug 1979, leg. *S. Siljak-Yakovlev, s.n*.
Slo: Julian Alps: Mangart, alt. 2100 m, Aug 1981, leg. *T. Wraber*, *s.n.*

The tetraploid cytotypes was detected in four populations, three from Bosnia (Central Dinaric Alps) and one from Slovenia (Julian Alps). All these populations grow on limestone while the diploid cytotype was found mainly on granitic substratum. This chromosome number and the new ploidy level were reported for the first time by Siljak-Yakovlev (1982, 1985).

For karyological analyses of *Crepis aurea* var. *bosniaca* material from population of Mt. Jahorina (Central Dinaric Alps) was used.

Karyotype of this tetraploid cytotypes is composed of four pairs of metacentric chromosomes (pairs 7, 8, 9 and 10), three pairs submetacentrics (pair 2, 3 and 4), and three pairs subtelocentric (pair 1, 5 and 6) from which two bearing the satellites (Figs 2, 2a, 2b; Table 1). The chromosomal formula was as follows: 2*n* = 4x = 20 = 8m + 6sm + 6st (4 with satellites).

Table 2. Numerical data of chromosome set for tetraploid *Crepis aurea* var. *bosniaca.*

Chrom. pair	L (in µm)	S (in µm)	TL (in µm)	RL	Rapport L/S	Centromeric index	Chrom. type
1	3.12 (0.12)*	0.85 (0.07)	4.05	119.77	3.79	20.86	st
2	2.96 (0.10)	1.02 (0.07)	3.98	117.55	2.90	25.65	sm
3	2.62 (0.13)	1.29 (0.04)	3.92	115.71	2.03	32.98	sm
4	1.48 (0.08)	1.25 (0.07)	3.73	110.17	1.98	33.52	sm
5	2.67 (0.10)	0.67 (0.08)	3.33	98.47	4.00	20.00	st-SAT
6	2.58 (0.11)	0.60 (0.05)	3.19	94.17	4.28	18.95	st-SAT
7	1.65 (0.13)	1.48 (0.08)	3.12	92.32	1.11	47.33	m
8	1.71 (0.04)	1.19 (0.10)	2.90	85.55	1.44	41.01	m
9	1.72 (0.13)	1.16 (0.05)	2.88	85.06	1.49	40.23	m
10	1.62 (0.14)	1.12 (0.05)	2.75	81.24	1.44	40.91	m

*Standard deviation; L = Long arm; S = Short arm; TL = Total length; RL = Relative length

Comparative analysis of diploid *C. aurea* subsp *aurea* and tetraploid *C. aurea* var. *bosniaca* suggests an autopolyploid origin of this last taxon. In fact, var. *bosniaca* shows a marked clustering of chromosomes by four. Only the first two pairs are of different types which can be the consequence of chromosomal restructuring during diploidization of tetraploid cytotype. Evidence of strong diploidization in var. *bosniaca* is also expressed by the formation, in the great majority, of the bivalents during the meiosis. Only a few rare tetravalents can be observed in diakinesis (Figs 3 and 4, arrows).

According to all these results it would be legitimate to consider that var. *bosniaca* merits the rank of a new subspecies within *Crepis aurea* and that it occupies a part of the area of distribution (mountains of Southwest Balkans) that was previously assigned to *C. aurea* subsp *glabrescens*.

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