

Investigations of *Melissa* L. (Lamiaceae) from Istria: SEM and morphological characteristics

Ioana-Marcela Padure, Sanja Šimić & Walter K. Rottensteiner

Summary: The genus *Melissa* consists of two taxa in Istria: *M. officinalis* ssp. *officinalis* and *M. romana* (syn. *M. officinalis* subsp. *altissima*). This study presents macro- and micromorphological characteristics of nutlets, pollen, leaves and calyx, including type of trichomes and exocarp pattern. Pollen and fruit macro- and micromorphological characteristics of the Istrian taxa were examined using scanning electron microscope (SEM). The results showed that in *Melissa* pollen grains are radially symmetrical, isopolar, hexacolpate and have a medium size. Pollen grain shape is elliptic to circular in equatorial view and circular in polar view. The exine ornamentation is bireticulate. Nutlets sculpturing pattern is psilate to reticulate. This study clarified that both pollen and nutlet micromorphological characters are significant features in taxonomic classification of the genus *Melissa*. Our research presents the Istrian distribution of *Melissa* along with ecological, chorological, macro- and micromorphological characteristics of vegetative and generative organs that differentiate the species.

Keywords: *Melissa officinalis*, *Melissa romana*, Istria, Krk, SEM study, macromorphology, micromorphology, chorology

Melissa belongs to Lamiaceae, an important plant family that consists of 250 genera and more than 7000 species. The largest genera of this family are *Nepeta*, *Salvia*, *Scutellaria*, *Stachys*, *Teucrium* and *Thymus*. Many species inhabit different ecosystems and have a great diversity with a cosmopolitan distribution (STANKOVIC 2020).

Melissa officinalis subsp. *officinalis* originally comes from the Middle East and probably is native to parts of the eastern Mediterranean, too. Because of the scent and the medicinal properties, it is used as culinary herb and as medicinal plant in different countries. In the Mediterranean area to the northern edge of the Alps (Austria, Switzerland) it grows firmly naturalized in ruderal locations, hedges or walls up to the colline altitudinal zone. In addition to *Melissa officinalis*, there exist three other species of the genus in East Asia: *M. axillaris* (Benth.) Backh. f., *M. flava* Benth. and *M. yunnanensis* C.Y. Wu & Y.C. Huang. *Melissa romana* occurs in South Europe, but it is also reported as naturalized in New Zealand (DAWSON et al. 1988). It is native in damp locations at altitudes up to 1000 m a. s. l., populating quite different habitat types. Thus, it grows in gardens, at field margins, in shady places, banks of streams that maintain moisture, on the shores of lakes, but the optimum growth occurs in mountainous and hilly areas. Populations, which are usually scattered among locations, vary from abundant to moderate or little (BUCH & JAGEL 2011; BOŽOVIĆ et al. 2018). *Melissa romana* is growing in humid locations and its fragrance is described as herbal, fruity and powdery or even unpleasant for humans.

In the past, *Melissa romana* (high balm) was considered a variety or subspecies of *Melissa officinalis* (lemon balm) and catalogued as *Melissa officinalis* subsp. *altissima*. MONTELUCCI (1953) considered it as a case of stabilized polyploidy (*Melissa romana*: $2n = 64$; *Melissa officinalis*: $2n = 32$), as it does not generate any offspring and it has an intermediate aspect, when it grows next to *Melissa officinalis* (DAWSON et al. 1988; MICELI et al. 2006; PIGNATTI 2018, 2019).



Figure 1. *Melissa romana*, a new species for Island of Krk: A, B – Dolovo SE Kras, on the gravel road to Garica (01.06.2019); C – Njivice, on the beach (02.06.2019). Photos: Ioana M. Padure.

The genus *Melissa* (Salviinae) (MOON et al. 2009) is represented by two species in Istria, *Melissa officinalis* L. subsp. *officinalis* and *Melissa romana* Mill. [syn. *Melissa altissima* Sm., *Melissa bicornis* Klokov, *Melissa hirsuta* Hornem., *Melissa officinalis* var. *villosa* Benth., *Melissa officinalis* subsp. *inodora* Bornm.] (ROTTENSTEINER 2014, 2018; STARMÜHLER 2011). *Melissa romana* was recorded on the Island of Krk for the first time: SE Kras in June 2019 (Dolovo), shortly thereafter also at the west coast near Njivice (PADURE 2019), on the gravel road (Fig. 1). New locations were found in Njivice and Vrbnik (PADURE et al. 2021).

The Island of Krk with an area of 405.78 km² presents a very rich flora (1677 species) including some very special, rare and unique taxa (ROTTENSTEINER et al. 2020). This island is covered by the typical vegetation of the submediterranean zone (mixed *Quercus pubescens* woods and Šibljak), just at the east coast north of Vrbnik and in the southernmost parts around Baška and Stara Baška with transitions to eumediterranean vegetation. The distribution maps of *Melissa officinalis* and *Melissa romana* in Istria are shown in Fig. 2.

Plant morphology

Melissa officinalis subsp. *officinalis* is a perennial herb, 30–90 cm tall, with a fragrant smell of lemon. Rhizome horizontal; stems erect, richly branched in the region of inflorescence, with patent, 6–13 mm long hairs at the corners, forming white tufts at the nodes, the other parts glabrous; leaves dark green, sparsely hairy, with a 2–3 cm long stalk and an ovate blade measuring 3–4 × 4–5 cm, obtuse at base (the lowest ones often heart-shaped, the upper ones ± cuneate), the

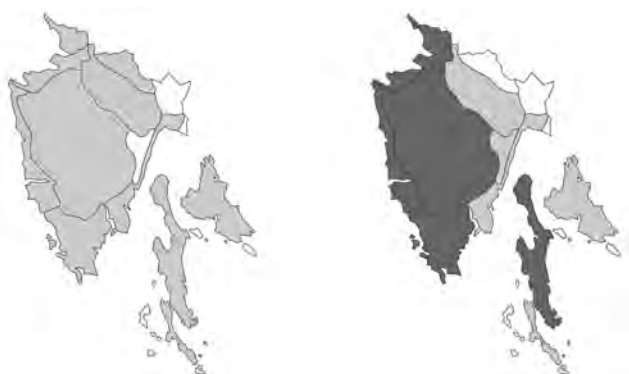


Figure 2. Distribution maps of *Melissa officinalis* (left) and *Melissa romana* (right) on the Island of Krk (ROTTENSTEINER 2018).

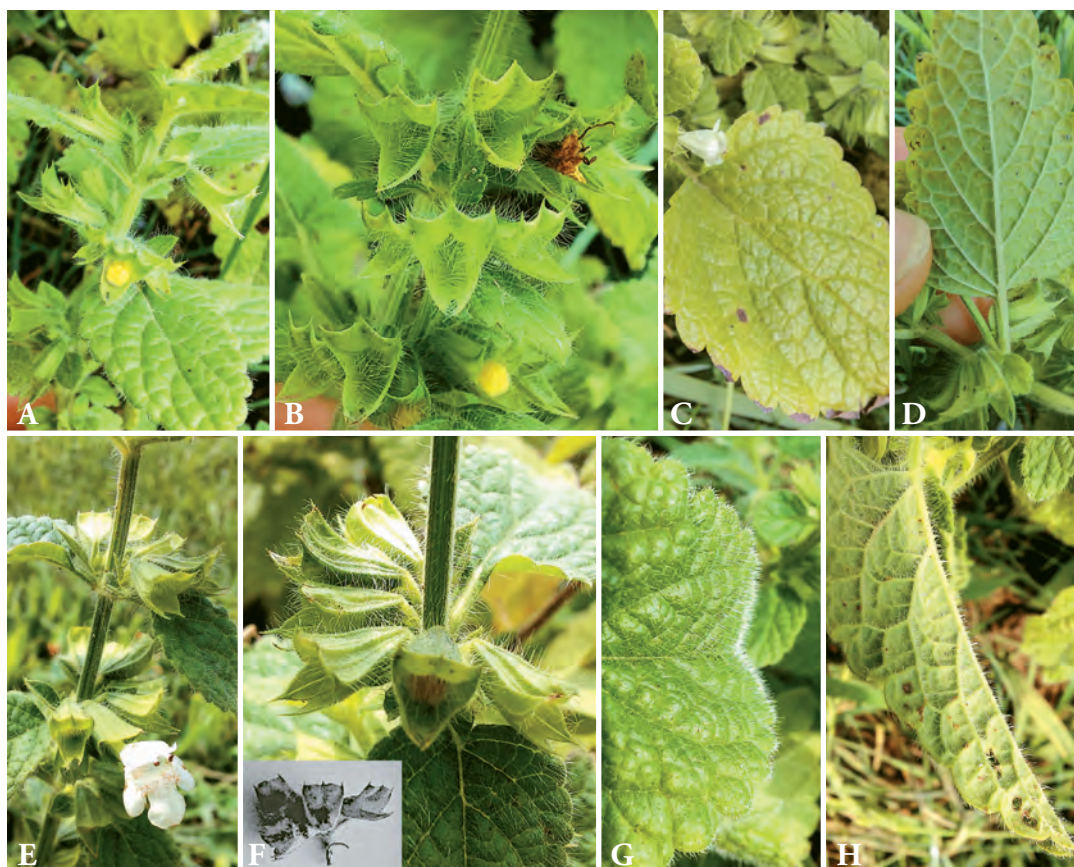


Figure 3. Macromorphological characteristics of calyx and leaves in *Melissa officinalis* (A–D) and *Melissa romana* (E–H): A, B, E, F – calyx type; C, G – leaf adaxial side; D, H – leaf abaxial side. Photos: Ioana M. Padure.

margin with 4–14 rounded teeth on each side, usually gland-dotted below (peltate glands); leaf venation is almost glabrous, abaxially; flowers arranged in whorls of 2 at the axils of normal leaves; bracteoles lanceolate, 1.5–2 × 3–7 mm, entire; flower pedicels 2–4 mm long; flowers nutant; calyx 6–9 mm long, at fructification with a well developed central tooth on the upper lip, with patent long hairs on the tube, the teeth generally glabrous; upper lip 3-denticulate, obviously undulate, teeth straight, evenly spaced; corolla yellowish, turning white or pink after pollination, 10–12 mm long; lower lip hairless or with a few hairs at the mouth only; nutlets brown to blackish, slightly lustrous, prolonged obovate, dorsal side convex, ventral sides flat and roof-like with longitudinal rib, 1.7–1.9 × 0.9–1.1 mm; dirty-white areole zone, horseshoe-shaped with abscission scar at the basal ventral side without expanded area. Flowering period May to August (Fig. 3A–D.).

Melissa romana is a perennial herb, 40–150 cm tall, with a foul-smelling scent, usually more densely hairy to lanate, with erect, branched, shortly glandular puberulent stems, with sparse or dense, long, patent, eglandular trichomes or glabrescent. The indumentum presents capitate glands and short protective hairs on the stem sides and long protective hairs at the corners; leaves are 2–9 cm long and 1.5–7 cm wide, broadly ovate to rhombic, obtuse or acute, more or less deeply crenate, except at the base, leaves bright green, most of them (incl. floral bracts) truncate or cordate at base, hairy on both sides, ± greyish-tomentose beneath, at the margin with 6–13 triangular teeth on each side, usually very hairy below; leaf venation (primary and secondary)

is very hairy abaxially; verticils are 4–12-flowered, ovate to linear bracteoles are entire and up to 5 mm long; calyx is covered with long, patent, eglandular and short glandular hairs, up to 9 mm; teeth of the lower lip are lanceolate-triangular, at fruiting time densely hirsute (glandular trichomes) on tube and teeth, the upper lip is characterized by a much-reduced central tooth, inconspicuous, truncate or emarginate, the line between two teeth of calyx is straight, sometimes the central tooth is $\pm$ visible; corolla with a faint violet hue, the lower lip with patent hairs on the upper face; nutlets brown to black, prolonged obovate, dorsal side convex, ventral sides flat and roof-like with a prominent long rib; white areole zone, almost circular, the abscission scar at the basal ventral side without expanded area. Flowering period June to November (Fig. 3E–H).

Materials and methods

Specimina visa. The macromorphological investigations were carried out on stem and leaf indumentums, leaf petiole, leaf margins and calyx. All characteristics were investigated with a standard stereomicroscope. The herbarium specimens of *Melissa* species preserved at the Carinthian Botanic Center in Klagenfurt [KL] were investigated. Material was collected from newly discovered locations of the Island of Krk and also deposited at KL-Herbarium-Istriacum. The Istrian localities and collection data are listed below:

Melissa officinalis L. subsp. *officinalis*: Lovrana; 01.07.1900; leg. Evers [GZU-261090, GZU-261091]. – Kroatien, Istrien (Istria, Istra), Quarner Bucht, Insel Lussin (isola di Lussino, otok Lošinj), Lussingrande (Veli Lošinj), N 44°31.097', E 14°30.267', 15 m alt.; Ödland; 09.08.1997; leg. W. Starmühler & J. Walter [GZU, KL-Herbarium-Istriacum]. – Kroatien, Istrien (Istria, Istra), Golf von St. Veit (Golfo di Fiume, Riječki zaljev), SW Abbazia (Opatija), W Ville d'Icici (Ičići), Pogliane del Carnaro (Poljane), N 45°18.92', E 14°16.51', 110 m alt.; Schibliaksaum; 26.09.1999; leg. W. Starmühler & J. Walter [GZU, KL-Herbarium-Istriacum]. – Kroatien, Istrien, Kvarner/Carnaro/Quarner Bucht, otok Krk/isola di Veglia/Insel Vögl, NW Vrbnik/Verbenico/Vörbnick, am Weg vom polje Lug/valle Jas/Hainfeld nach N, SW Risika/Réssica; Waldrand; 14.08.2020; leg. Ioana M. Padure, Marica & Walter K. Rottensteiner [GJO, KL-Herbarium-Istriacum, LI, NHMR, WHB, ZA].

Melissa romana Mill.: Pola; s.d.; leg. Pelikan [GZU-261407]. – Istria, costa orientalis inter Abbazia et Icici ad vias; 05.07.1898; leg. Evers [GZU-261360, GZU-261409]. – Flora von Istrien, Pola, Hecken am Prato grande; 26.07.1899; leg. K. Untchj [GZU-261361]. – Istrien, Umgebung v. Pola; buschige Wegränder; 08.[1]905; leg. Arbesser [GZU-029942]. – Istrien, Abbazia; buschige Orte; 07.[1]916; leg. Arbesser [GZU-029943]. – Kroatien, Istrien, Zapadna obala/Costa occidentale/West-Küste, etwa 3,5 km NW Rovinj/Rovigno/Rofein, „Monsena-Gebiet“; an einem Graben, größere Gruppe; 20.09.1981; leg. F. Richter [KL-Herbarium-Istriacum]. – Kroatien, Istrien (Istria, Istra), Gebiet des Monte Maggiore (Učka gora), WSW Berschez (Bersezio, Brseč), M. Sissol (Sisol), NE-Hang, N 45°10.51', E 14°12.70', 530 m alt.; *Pinus nigra*-Waldrand; 06.07.2000; leg. U. & W. Starmühler [KL-Herbarium-Istriacum]. – Kroatien, Istrien, Insel Lošinj/Lussino/Lussin, am Weg von Neresine, 35 m alt.; Ruderal; 20.06.2003; leg. U. & W. Starmühler [GZU, KL-Herbarium-Istriacum, MBM, ZA]. – Kroatien, Istrien, Južna Istra/Istria meridionale/Süd-Istrien, SSE Pula/Pola, am Weg von Premantura/Promontore zum Rt Kamenjak/Kap Promontore, 30 m alt.; Macchiensaum; 28.06.2003; leg. M. Münch & W. Starmühler [GZU, KL-Herbarium-Istriacum, ZA]. – Kroatien, Istrien, Zapadna obala/Costa occidentale/Westküste, Poreč/Parenzo, auf dem Hügel Sv. Marko/S. Marco am östlichen Stadtrand, 20 m alt.; lichter *Pinus halepensis*-Mischwald; 27.09.2004; leg. P. Vergörer [GZU, KL-Herbarium-Istriacum, ZA]. Kroatien, Istrien (Istria, Istra), Gebiet des Monte

Maggiore (Učka gora), WSW Berschez (Bersezio, Brseč), M. Sissol (Sisol), NE-Hang, N 45°10.51', E 14°12.70', 530 m alt.; *Pinus nigra*-Waldrand; 06.07.2000; leg. U. & W. Starmühler [KL-Herbarium-Istriacum]. – Kroatien, Istrien, Insel Lošinj/Lussino/Lussin, am Weg von Neresine, 35 m alt.; Ruderal; 20.06.2003; leg. U. & W. Starmühler [GZU, KL-Herbarium-Istriacum, MBM und ZA]. – Kroatien, Istrien, Južna Istra/Istria meridionale/ Süd-Istrien, SSE Pula/Pola, am Weg von Premantura/Promontore zum Rt Kamenjak/Kap Promontore, 30 m alt.; Macchiensaum; 28.06.2003; leg. M. Münch & W. Starmühler [GZU, KL-Herbarium-Istriacum, ZA]. – Kroatien, Istrien, Zapadna obala/Costa occidentale/Westküste, Poreč/Parenzo, auf dem Hügel Sv. Marko/S. Marco am östlichen Stadtrand, 20 m alt.; lichter *Pinus halepensis*-Mischwald; 27.09.2004; leg. P. Vergörer [GZU, KL-Herbarium-Istriacum, ZA]. – Kroatien, Istrien, Zapadna obala/Costa occidentale/West-Küste, SE Rovinj/Rovigno/Rofein, am Weg von der Buschenschank „Arka“ nach W zur Uvala Cisterna/Valle Cisterna/Zisternen-Bucht, N 45°02'34.35", E 13°42'42.88", 48 m alt.; Schibliaksaum; 04.06.2011; leg. G. Heber & W. Starmühler [GZU, KL-Herbarium-Istriacum, MBM, ZA]. – Kroatien, Istrien, Zapadna obala/Costa occidentale/West-Küste, NNE Rovinj/Rovigno/Rofein, etwa 0,2 km ENE der Ruine der Sv. Toma/S. Tommaso/ Hl. Thomas-Kirche, N 45°06'40.06", E 13°39'49.16", 47 m alt.; Brache; 11.06.2011; leg. E. Schalk & W. Starmühler [CLF, GZU, KL-Herbarium-Istriacum, M, W, WHB, ZA]. – Kroatien, Istrien, Kvarner/Carnaro/Quarner Bucht, otok Krk/isola di Veglia/Insel Vögl, SE Kras/Carso, am Weg vom aufgelassenen Gehöft Dolovo nach SE nach Garica/S. Antonio, N 45°06'28.69", E 14°37'10.24", 228 m alt.; Schotterweg; 01.06.2019; leg. Ioana M. Padure, Marica & Walter K. Rottensteiner [KL-Herbarium-Istriacum]. – Österreich, Steiermark, Graz; kultiviert. Herkunft: Kroatien, Istrien, Kvarner/Carnaro/Quarner Bucht, otok Krk/isola di Veglia/Insel Vögl, SE Kras/Carso, am Weg vom aufgelassenen Gehöft Dolovo nach SE nach Garica/S. Antonio, N 45°06'28.69", E 14°37'10.24", 228 m alt.; Schotterweg; 01.06.2019; 17.09.2020; leg. Ioana M. Padure [KL-Herbarium-Istriacum]. – Kroatien, Istrien, Kvarner/Carnaro/Quarner Bucht, otok Krk/isola di Veglia/Insel Vögl, Westküste, Njivice/Gnivizze/Sniewitz; 02.08.2021; leg. Ioana M. Padure [KL-Herbarium-Istriacum].

SEM of dry leaves, calyx, nutlets and pollen. For scanning electron microscopy (SEM) investigation the specimens were coated with a thin layer (5–10 nm) gold / palladium for electrical conductivity. SEM analysis was performed using an SEM Zeiss Ultra 55 at 5.00 kV. Secondary electron imaging (SE) was performed using an Everhart-Thornly detector.

Mixocarpy. For the investigations of mixocarpy, at least five nutlets were treated with distilled water, and the thickness of the mucous layer was measured under light microscope. The measurements were taken every 15 minutes during the first hour, and then after each hour during 8 hours. No mucilage production after 8 hours was taken to indicate the absence of mucilage reaction (RYDING 1992).

Results and discussion

The comparative macro-and micromorphological characteristics of *Melissa* species are presented in Table 1.

Macromorphological characters

Stem indumentum. Pubescent in *Melissa officinalis* and hirsute to villous in *Melissa romana*. The indumentum consists of uniseriate and multicellular eglandular and glandular trichomes (capitate and peltate type).

Table 1. Macro- and micromorphological characteristics in the genus *Melissa*.

Species	<i>Melissa officinalis</i>	<i>Melissa romana</i>
Pollen grains	Hexacolpate	Hexacolpate
Size Px _E (µm) / P/E ratio (dry pollen)	34–38 × 21–25 / prolate	31–36 × 24–28 / spheroidal to subprolate
Polar view (PV)	Outline in PV: elliptic to circular; three wider mesocolpi might alternate with three narrower ones.	Outline in PV: elliptic; colpi are distributed symmetrically.
Equatorial view (EV)	Mesocolpi 5–7 µm wide.	Mesocolpi 10–11 µm wide.
Exine type	Bireticate	Bireticate
Lumen shape / primary reticulum (PR)	Polygonal / muri of PR thicker than secondary muri; lumen of PR contains fewer than three units of secondary lumen.	Polygonal / muri of PR thicker than secondary muri; lumen of PR contains fewer than five units of secondary lumen.
Exocarp sculpture	± Reticulate exocarp, the abscission scar rounded and white without an extended area of outer layer of pericarp.	
Nutlets	Brown to blackish, prolonged obovate, dorsal side convex, ventral sides flat and rooflike with longitudinal rib.	Brown to black, prolonged obovate, dorsal side convex, ventral sides flat and rooflike with a prominent long rib.
Calyx macro- and micromorphology	Calyx 6–9 mm at fruiting time, with a well-developed central tooth on the upper lip (mucron), with patent hairs on the tube, the teeth generally glabrous. The line between two teeth of calyx is obviously convex.	Calyx 6–7 mm at fruiting time, densely hirsute on tube and teeth, the upper lip with a much-reduced central tooth. The line between two teeth of calyx is straight.
Plant and leaf characters	Fragrant smell of lemon, leaves sparsely hairy to glabrous, peltate glands abaxial, with a 2–3 cm long stalk and an ovate lamina, obtuse at base (the lowest ones often heart-shaped), margin with 4–14 rounded teeth on each side.	Foul-smelling, usually more densely hairy, capitate glands abaxial, with a 1–2 cm long stalk. Most leaves (incl. floral bracts) truncate or heart-shaped at base, grey-tomentose beneath, margin with 6–12 ± triangular teeth on each side.

Leaf morphology. Leaves are pubescent abaxially in *Melissa officinalis* and almost glabrous adaxially. *Melissa romana* is very hairy on both sides, the midvein presents long protective hairs.

Nutlet size, shape and colour. The pericarp is smooth, slightly lustrous, fine granulate (BOJNANSKÝ & FARGAŠOVÁ 2007) and not becoming mucilaginous upon wetting. For nutlet length and width, 10–20 samples per specimen of each taxon were measured. Nutlets are brown to black, prolonged to ovoidal, dorsal side convex, ventral sides ± flat, slight lustrous to fine granulate, ± glabrous 1.6–2.0 × 0.8–1.1 mm, smaller sized in *Melissa romana*, brown to black, areole zone rounded, white and without an extended area of outer layer of pericarp. The nutlets are bilaterally symmetric based on the position of the abscission scar. The apex shape is round, but truncate apices also occur in *Melissa romana*. The colour of nutlets is first greenish and turns to brownish black to black at maturity in *Melissa officinalis* and to black in *Melissa romana*. The shape of transversal section is slightly trigonous in *Melissa officinalis* and trigonous in *Melissa romana*.

The veins' anastomosis in calyx can help to differentiate the species in Lamiaceae (PADURE 2006). The primary and secondary veins are differently anastomosed on the upper lip of calyx. The primary calyx veins protrude at the abaxial epidermis and are more prominent at the *Melissa romana* calyx.

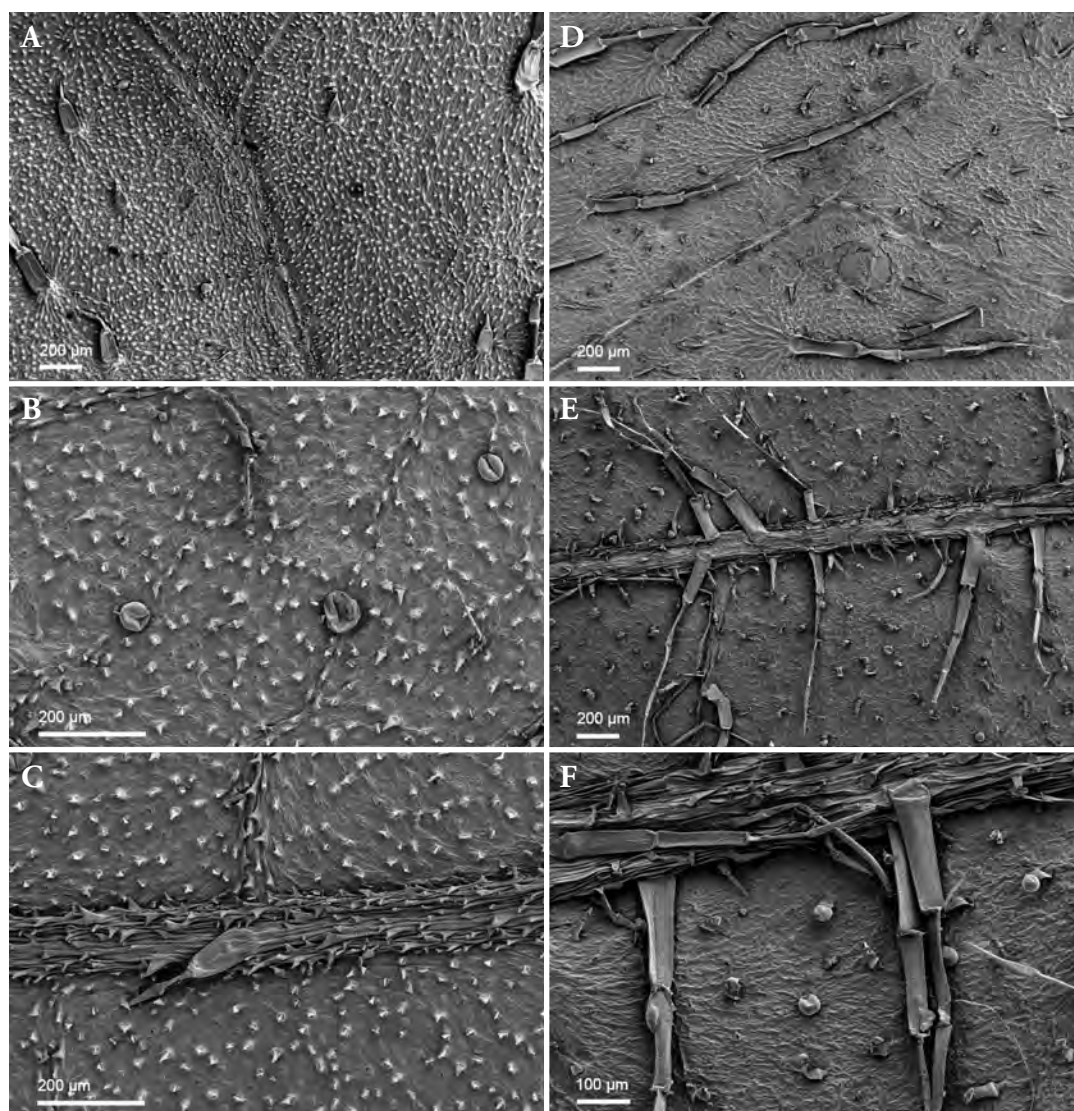


Figure 4. SEM images of leaves in *Melissa officinalis* (A–C) and *Melissa romana* (D–F): A, D – leaf adaxial side; B, E – leaf abaxial side; C, F – midvein with protective (C) long hairs or glandular trichomes (F), abaxially. Photos: Sanja Šimić.

Mixocarpy. Mucilage production on the nutlets upon wetting ($\pm$) very weak reaction in *Melissa officinalis* and (–) absent in *Melissa romana*.

Pollen grains. Shapes of pollen grains are very similar: isopolar, elliptic to oblong, medium sized.

Leaves indumentum and trichome types. Hairs are typical of Lamiaceae. Protective hairs short (subulate) or long, 2–4-celled. The glandular trichomes are capitate or peltate, with abaxial distribution. The primary and secondary venation is abaxially very hairy in *Melissa romana*.

Trichome types and morphology of the indumentum have taxonomic values in Lamiaceae (METCALFE & CHALK 1972; CANTINO 1990; CHWIL et al. 2016; NGUYEN et al. 2017). Trichomes on leaves and calyx are typical of Lamiaceae: peltate and capitate glands (short-stalked or with 2-celled stalk) or eglandular, which may be simple, short/long; calyx lacinia in *Melissa romana* are with glandular trichomes (Figs 4, 5).

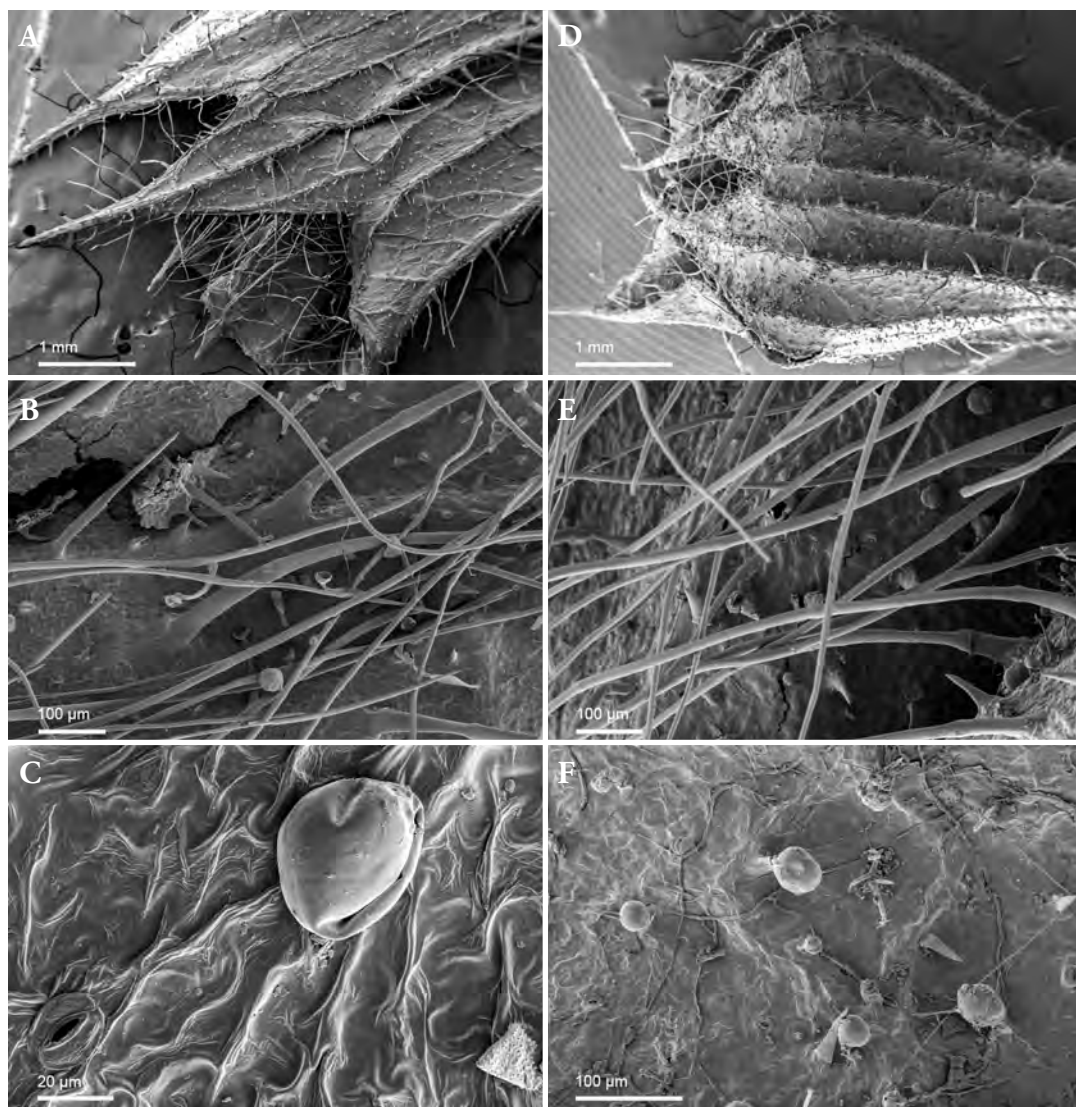


Figure 5. SEM images of calyx and trichome types in *Melissa officinalis* (A–C) and *Melissa romana* (D–F): A, D – calyx morphology, general view; B, E – protective hair types; C, F – calyx epidermis with glandular trichomes: peltate gland (C) and capitate trichomes (F). Photos: Sanja Šimić.

Micromorphological characters

SEM micrographs of leaves. The images from above show the distribution and trichome types.

SEM micrographs of calyx. Calyx is potent, with prominent venation in *Melissa romana*. The primary and secondary venation is obviously stronger in *Melissa officinalis*.

Pollen grains. The pollen is isopolar, hexacolpate, inoperculate, prolate-spheroid to subprolate with bireticulate exine (Fig. 6A, B, E, F. *Melissa officinalis* P/E ratio: prolate, 34–38 × 21–25 µm, *Melissa romana* P/E ratio: 31–36 × 24–28 µm. The outline of pollen in polar view is circular to elliptic, with three wider mesocolpi (5–7 µm wide) which can alternate with three narrower ones in *Melissa officinalis*. In *Melissa romana*, the outline is elliptic, colpi are distributed symmetrically, mesocolpi 10–11 µm wide.

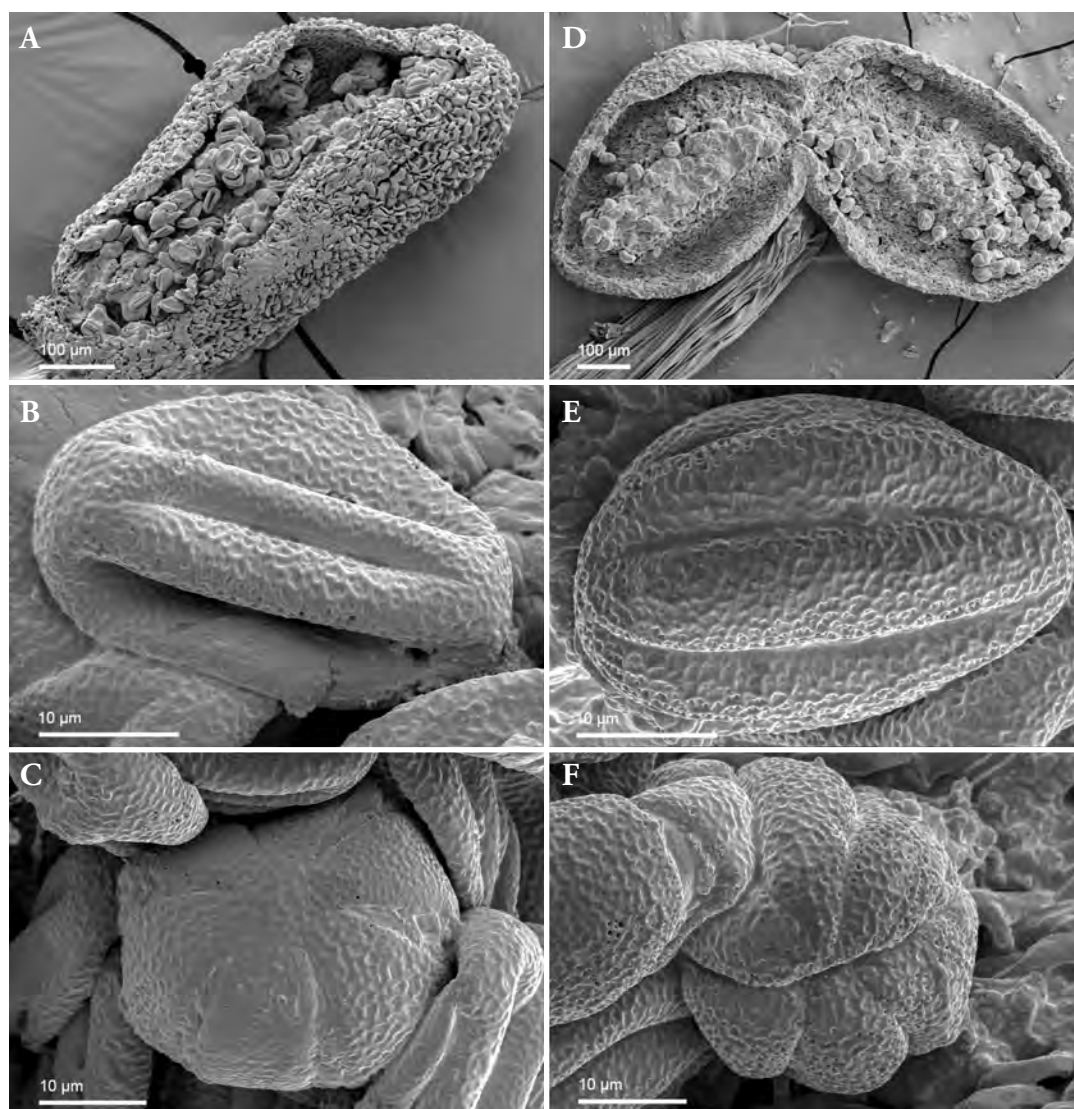


Figure 6. SEM images of stamens and pollen grains in *Melissa officinalis* (A–C) and *Melissa romana* (D–F): A, D – mature stamens with pollen, general view; B, E – pollen in polar view; C, F – pollen in equatorial view. Photos: Sanja Šimić.

Nutlet sculpture. The exocarp type is psilate to reticulate, with similar characteristics for both species. The external surface is rather smooth lacking any particular ornamentation, sometimes slightly undulate-cellular type (*Melissa romana*) or ± reticulate in *Melissa officinalis* (Fig. 7D–F, A–C). Non-glandular or glandular trichomes were not observed.

Conclusions

Pollen and seed macro- and micromorphological features of leaves, calyx, nutlets and pollen grains of *Melissa officinalis* and *M. romana* from Istria were examined for the first time using scanning electron microscope (SEM). Macromorphological aspects of leaf base and margins, the shape of the calyx upper lip and dimension and position of the teeth can be used as taxonomic characters to differentiate between both species.

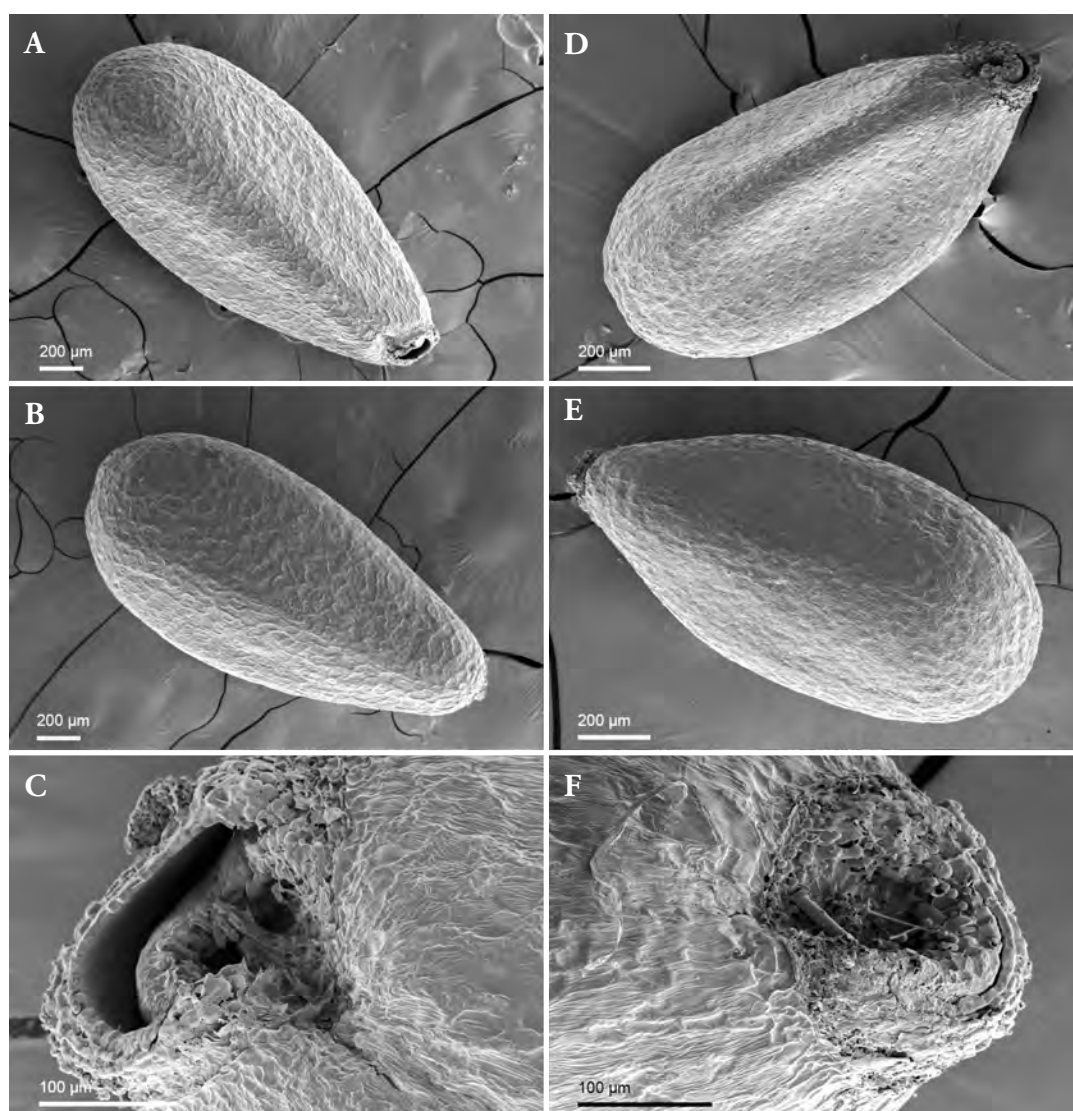


Figure 7. SEM images of nutlets in *Melissa officinalis* (A–C) and *Melissa romana* (D–F): A, D – ventral side with a long rib; B, E – dorsal side; C, F – showing detail abscission scar. Photos: Sanja Šimić.

In *Melissa officinalis* subsp. *officinalis*, SEM characteristics of pollen grains are mostly in agreement with previous studies (ULRICH 2005, 2016; ULRICH & AUER 2020). No studies about *Melissa romana* are available. The width of mesocolpi and their distribution can be used as a valuable taxonomic character regarding the interspecific differentiation.

The nutlets are $\pm$ glabrous, lustrous, very similar in general shape, exocarp sculpture or the shape of abscission scar, but smaller sized in *Melissa romana*.

Concerning mixocarp of the nutlets, it is well known that plants growing in moist habitats have more often non-mucilaginous nutlets than those growing in drier habitats. Germinating is almost absent in natural habitats due to the hardness of pericarp, especially in *Melissa romana* (mixocarp is absent). Sporadically, in garden conditions the seed of *Melissa officinalis* can germinate and produce seedlings.

References

- BOJNANSKÝ V. & FARGAŠOVÁ A. (2007): *Melissa* – In: Atlas of seeds and fruits of Central and East-European flora; The Carpathian Mountains region. – Dordrecht: Springer.
- BOŽOVIĆ M., GARZOLIC S., BALDISSEOTTO A., ROMAGNOLI C., PEPIC F., CESAC S., VERTUANID S., MANFREDINI S. & RAGNO R. (2018): *Melissa officinalis* L. subsp. *altissima* (Sibth. & Sm.) Arcang. essential oil: Chemical composition and preliminary antimicrobial investigation of samples obtained at different harvesting periods and by fractionated extractions. – *Industr. Crops Prod.* **117**: 317–321.
- BUCH C. & JAGEL A. (2011): *Melissa officinalis* – Melisse (Lamiaceae). – *Jahrb. Bochumer Bot. Vereins* **2**: 220–225.
- CANTINO P.D. (1990): The phylogenetic significance of stomata and trichomes in the Labiatae and Verbenaceae. – *Arnold Arbor.* **7**: 323–370.
- CHWIL M., NURZYŃSKA-WIERDAK R., CHWIL S., MATRASZEK R. & Neugebauerová J. (2016): Histochemistry and micromorphological diversity of glandular trichomes in *Melissa officinalis* L. leaf epidermis. – *Acta Sci. Polon. Hort. Cult.* **15**(3): 153–172.
- DAWSON B.S.W., FRANICH R.A. & MEDER R. (1988): Essential oil of *Melissa officinalis* L. subsp. *altissima* (Sibth. et Smith) Arcang. – *Flav. Fragr. J.* **3**: 167–170.
- METCALFE R. & CHALK L. (1972): Anatomy of the dicotyledons, Vol. 2: 1041–1053. – Oxford: Clarendon Press.
- MICELI A., NEGRO C. & TOMMASI L. (2006): Essential oil of *Melissa romana* Miller grown in South Apulia, Italy, – *J. Essential Oil Res.* **18**: 473–475.
- MONTELUCCI G. (1953): La vegetazione del Monte Terminillo (Appennino centrale). – *Webbia* **9**: 49–359.
- MOON H.-K., HONG S.-P., SMETS E. & HUYSMANS S. (2009): Micromorphology and Character Evolution of Nutlets in Tribe Mentheae (Nepetoideae, Lamiaceae). – *Syst. Bot.* **34**(4): 760–776.
- NGUYEN T.H.Y., YAKOVLEVA O.V. & TERNINKO I.I. (2017): Comparative morphological and anatomical studies of two herbal drugs: *Nepeta cataria* L. and *Melissa officinalis* L. – *J. Pharm. Sci. Res.* **9**(12): 2463–2467.
- PADURE I.M. (2006): Morpho-anatomy of flower and inflorescence in *Nepeta* L. (Lamiaceae, Nepetoideae). – *Analele Ști. Univ. „Al. I. Cuza” Iași, Ser. Nouă, 2.a, Biol. Veget.* **53**: 19–29.
- PADURE I.M. (2019): Revidierte Belege aus dem „Herbarium Istriacum“. – In: Rottensteiner W.K.: Notizen zur „Flora von Istrien“, Teil V. – *Joannea Bot.* **16**: 101–105.
- PADURE I.M., ŠIMIĆ S. & ROTTENSTEINER W.K. (2021): Distribution, ecology and macro- and micromorphology of the genus *Melissa* in Istria and on the islands of the Kvarner Bay. – 19. Österreichische Botanik-Tagung: 23.–25. September 2021: 67. – Krems: Edition Donau-Universität Krems. doi: 10.48341/wr38-dj17
- PIGNATTI S. (2018): *Melissa*. – In: Flora d'Italia 3 [2nd ed.]: 259–260. – Milano: Edagricole.
- PIGNATTI S. (2019): *Melissa*. – In: Flora d'Italia 4 [2nd ed.]: 737. – Milano: Edagricole.
- ROTTENSTEINER W.K. (2014): *Melissa* – In: ROTTENSTEINER W.K.: Exkursionsflora für Istrien: 557. – Klagenfurt: Naturwissenschaftlicher Verein für Kärnten.
- ROTTENSTEINER W.K. (2018): *Melissa*. – In: Die Pflanzen Istriens in ihren natürlichen Lebensräumen: 259. – Klagenfurt: Verlag des Naturwissenschaftlichen Vereins für Kärnten.
- ROTTENSTEINER W.K., ZERNIG K., JAKELY D. & SCHEUER C. (2020): Beiträge zur Flora von Istrien VI: Eine kommentierte Prüfliste der Gefäßpflanzen als Grundlage für eine „Flora und Vegetation der Insel Krk (Veglia/Vögl) in der Quarner Bucht“. – *Fritschiana (Graz)* **95**: 1–75.
- RYDING O. (1992): The distribution and evolution of mixocarpy in Lamiaceae – In: HARLEY R. & REYNOLDS T. [eds]: Advances in Labiatae science: 85–96. – Kew: Royal Bot. Garden, Kew.

- STANKOVIC M. [ed.] (2020): Lamiaceae species. Biology, ecology and practical uses. – Plants. Special issue: 1–142. – Basel: MDPI. doi: 10.3390/books978-3-03928-419-1
- STARMÜHLER W. (2011): Beiträge zur Flora von Istrien I: Die Lamiaceae. – Fritschiana (Graz) **68**: 1–85.
- ULRICH S. (2005): *Melissa officinalis*. – In: PalDat - A palynological database. – https://www.paldat.org/pub/Melissa_officinalis/109578
- ULRICH S. (2016): *Melissa officinalis*. – In: PalDat - A palynological database. – https://www.paldat.org/pub/Melissa_officinalis/300526
- ULRICH S. & AUER W. (2020): *Melissa officinalis*. – In: PalDat - A palynological database. – https://www.paldat.org/pub/Melissa_officinalis/304445+

Adresses of the authors:

Ioana-Marcela Padure
Universalmuseum Joanneum, Studienzentrum Naturkunde
Weinzöttlstraße 16
8045 Graz, Austria
E-mail: ioanapadure@yahoo.com

Sanja Šimić
Graz Centre of Electron Microscopy (ZFE)
Steyerergasse 17
8010 Graz, Austria
E-mail: sanja.simic@felmi-zfe.at

Walter K. Rottensteiner (corresponding author)
Klosterwiesgasse 12
8010 Graz, Austria
E-mail: wk.rottensteiner@gmail.com

ZOBODAT - www.zobodat.at

Zoologisch-Botanische Datenbank/Zoological-Botanical Database

Digitale Literatur/Digital Literature

Zeitschrift/Journal: [Wulfenia](#)

Jahr/Year: 2022

Band/Volume: [29](#)

Autor(en)/Author(s): Padure Ioana-Marcela, Simic Sanja, Rottensteiner Walter Karl

Artikel/Article: [Investigations of Melissa L. \(Lamiaceae\) from Istria: SEM and morphological characteristics 103-114](#)