New records of nonmarine Ostracoda (Crustacea) from Gran Canaria (Canary Islands), with an updated checklist of the nonmarine Ostracoda of the Canary Islands

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Abstract. In January 2014, seven species of nonmarine Ostracoda were collected from the island of Gran Canaria, the third largest of the Canary Islands. Notes on species and scanning electron micrographs of the valves and carapaces of all species collected are presented. The first record of *Sarscypridopsis lanzarotensis* (Mallwitz, 1984) from Morocco, and the African continent in general, is provided. An updated checklist of the nonmarine ostracods of the Canary Islands is given and their geographic origin is briefly discussed.

Key words. Freshwater and brackish water Ostracoda, Gran Canaria, Canary Islands.

1. Introduction

Ostracoda are small crustaceans, mostly around one millimetre in length, the body of which is totally enclosed within a bivalved carapace. Worldwide, ostracods are found living in virtually any type of aquatic environments, from marine to brackish, from freshwater to semi-terrestrial habitats. Globally, some 2100 free-living species have been described from nonmarine waters (Martens & Savatenalinton 2011).

The Canary Islands are located 100-500 km west of Morocco in the Atlantic Ocean (Fig. 1). The archipelago includes, from largest to smallest, seven major islands: Tenerife, Fuerteventura, Gran Canaria, Lanzarote, La Palma, La Gomera, and El Hierro. The entire archipelago is volcanic in origin, being placed above the so-called Canary hot spot (Hoernle & Carracedo 2009, Schminke & Sumita 2010, van den Bogaard 2013).

Zoogeographically speaking, the Canary Islands belong to the Palaearctic region (Holt et al. 2013) and form, together with the Azores, Madeira, the Cape Verde and Selvagens Islands the Macaronesian ecoregion (Francisco-Ortega et al. 2009).

Studies of the nonmarine ostracod fauna of the Canaries started in 1984 with the description of a new species, *Cypridopsis lanzarotensis* Mallwitz 1984 collected, as indicated by its name, from the island of Lanzarote. The species was later transferred to the genus *Sarscypridopsis* (Meisch & Broodbakker 1990). The investigations continued in the 1990s with contributions by Meisch & Broodbakker (1993), Meisch et al. (1995), Baltanás & García-Avilés (1993), Beyer & Meisch (1996), Beyer et al. (1997), and Malmqvist et al. (1997).

The aim of the present study is to report on the freshwater ostracods collected by one of us (B.S.) in January 2014 on the island of Gran Canaria. Scanning electron micrographs and notes on each of the species are given. Additionally, an updated checklist of the nonmarine ostracods from the Canaries is provided and the geographic origin of the nonmarine Canarian ostracods is briefly discussed.

2. Study sites and methods

In January 2014, B. S. recovered living and subrecent (subfossil) nonmarine ostracods from the island of Gran Canaria (Fig. 1 and Table 1). The samples were collected using a net with a 200 µm mesh width and then sieved with a 5 mm mesh size to remove the coarse sediment and keep the fine fraction. Each evening, the ostracods were separated from the sediment using the so-called blowing method (Scharf & Viehberg 2014) and afterwards picked up from the fine remaining sediment under low magnification of the stereomicroscope. To obtain open carapaces, the ostracods were narcotized for about 30 minutes in low concentrated ethanol to be then preserved in 96% ethanol. The animals are stored in the ostracod collection of B.S.

To make visible the calcareous structure of the inner valve margins in the SEM, subrecent adult valves, devoid of any membranous parts, were used in most cases. An alternative method was also performed with success: the entire animal was placed for about 6 hours in a 7% KOH solution (see Matzke-Karasz 1995). After that treatment, the membranous inner lamella could easily be removed with a brush.

At each sampling site, the temperature of the water was measured with a standard

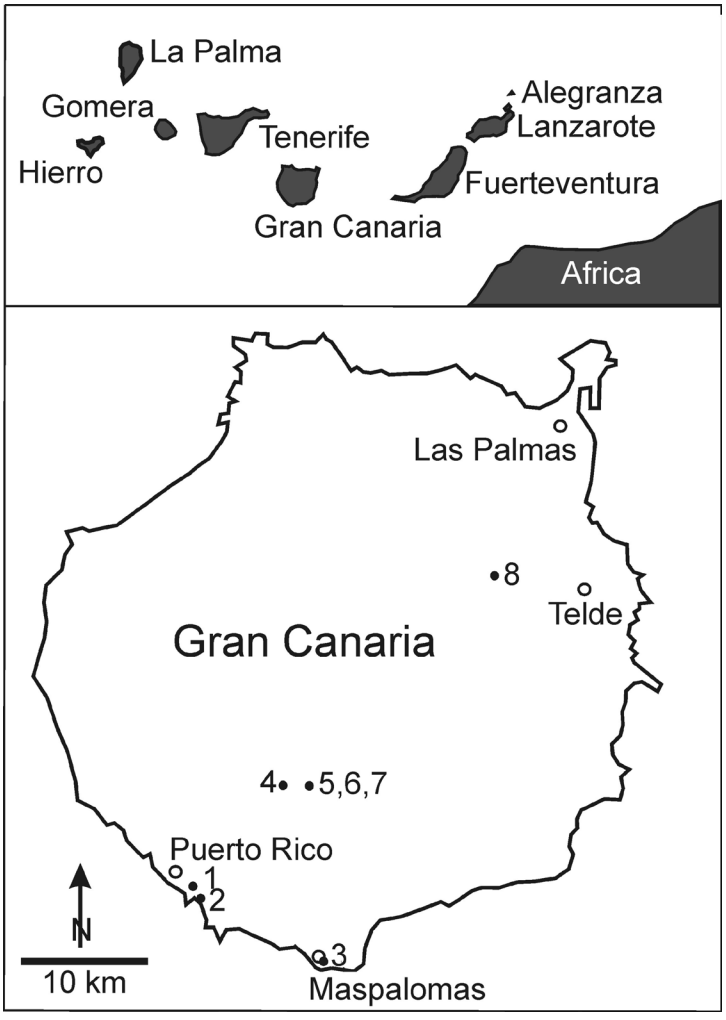


Fig. 1. Map of Gran Canaria with sampling sites.

Table 1. Sampling sites on Gran Canaria. The site numbers correspond to those in Fig. 1.

Sampling site	Water body	Coordinates	Temperature [°C]	Salinity [‰]	Remarks
1	helocrenic spring	27°47'08" N 15°42'12" W		3	at the basis of a steep rocky slope, close to the road, the water runs over the sidewalk, ostracods collected in the thick layer of algae on the sidewalk
2	helocrenic spring	27°46'31" N 15°42'07" W		4	c. 5 m over the sea, at the basis of a rocky steep slope, c. 5 cm deep rockpools
3	shallow lake	27°44'16" N 15°35'40" W	20	60	the lake is situated between Maspalomas and the dune area, at the shore, clay, separated from the sea by a dune (after strong rain connected with the sea)
4	basin in Palmitos Park	27°50'03" N 15°36'60" W			butterfly house, filamentous algae
5	stream pool with spring	27°50'59" N 15°36'26" W	20	1	standing water, sand with a layer of reed detritus, macrozoobenthos: water slug (*Limnea* sp.), larvae of dragonflies and chironomids
6	stream	27°50'50" N 15°36'29" W	19	8	slowly flowing water among big stones, odour of H_2S, frogs present
7	stream	27°50'45" N 15°36'28" W	17	4	shallow, slowly flowing water, algae, biogenicly precipitated chalk, macrozoobenthos: frogs, larvae of Chironomidae and Ephemeroptera
8	spring (Fuenta Peňa),	27°59'56" N 15°28'41" W	15	3	the spring flows into a cement basin (c. 10 x 10 m), standing water, macrozoobenthos: Cnidaria (*Hydra* sp.), Hydracari, larvae of Culicidae and Chironomidae, leeches.

mercury thermometer, the salinity with the refractometer REF 211 (Arcarda® GmbH), and the geographic coordinates were taken with a Garmin GPSmap76 (WGS 84).

Additionally to those from the Canaries, two samples with ostracods collected from the interstitial habitat of two brooks (oueds) of the Haut Atlas in Morocoo were taken into account, this because both of them contained individuals of *Sarscypridopsis lanzarotensis*, a species which was so far unknown from Africa: (1) Haut Atlas, Khang el Ghar, Oued Guir, 1175 m, 32°01'26" N, 03°59'25" W, 07.04.1999, leg. R. Gerecke; (2) Haut Atlas, Boudenib, Oued Guir near Tazouguerte, 08.04.1999, leg. R. Gerecke.

For the distinction of marine and nonmarine ostracods we rely on the taxonomic indices published by Kempf (1980, 1986, 1995, 1997, 2008).

The following abbreviations are used in text and figures: L = length, LV = left valve, RV = right valve.

3. Results

Seven species of nonmarine ostracods were collected from eight localities - springs, streams and a shallow lake - on the isle of Gran Canaria (Tables 1 and 2). Seven of the eight sampling sites presented slightly salty conditions, from 1 to 8 ‰ salt content, which concentrations correspond to the oligohaline (0.5-5 ‰) and mesohaline (5-18 ‰) ranges. The salinity reached 60

Table 2. Recent nonmarine ostracods collected on Gran Canaria in January 2014. The sampling site numbers correspond to those in Fig. 1. Abundance: I = 1-3 individuals per sample; II = 4-10 ind.; III = 11-25 ind.; IV = 26-100 ind.; V = >100 ind.; () = only empty carapaces and valves found.

Sampling site	1	2	3	4	5	6	7	8
Salinity [‰]	3	4	60		1	8	4	3
Cypretta seurati Gauthier, 1929					II	I		
Cyprideis torosa (John, 1850)			V					
Cypridopsis vidua (O.F. Müller, 1776)				III		III	I	
Herpetocypris chevreuxi (Sars, 1896)						( )		V
Heterocypris incongruens (Ramdohr, 1808)			( )					
Heterocypris salina (Brady, 1868)			( )		III	I	III	
Sarscypridopsis lanzarotensis (Mallwitz, 1984)	V	V						

‰ in a shallow lake close to the sea (site 3), which corresponds to the hyperhaline range (> 40 ‰) (Meisch 2000: 34) (Tables 1 and 2). Only *Cyprideis torosa* was found living there, together with valves and empty carapaces of *Heterocypris incongruens* and *Heterocypris salina.*

Notes on species

Phylum Arthropoda von Siebold, 1848
Class Ostracoda Latreille, 1802
Subclass Podocopa G.O. Sars, 1894
Order Podocopida G.O. Sars, 1866
Suborder Cypridocopina Jones, 1901
Superfamily Cypridoidea Baird, 1845
Family Cyprididae Baird, 1845
Subfamily Cyprettinae Hartmann, 1971

Genus *Cypretta* Vávra, 1895

Cypretta seurati Gauthier, 1929 (Fig. 2 A-C)

C. seurati was recovered from a pool fed by a spring and from a stream (Tables 1 and 2). Only females were collected.

In the Canaries, *C. seurati* was previously known from the island of La Gomera (Meisch & Broodbakker 1993). It is here reported for the first time from Gran Canaria (Table 3).

First described from the central Sahara (Gauthier 1929), *Cypretta seurati* is presently known to be widely distributed throughout the circumtropical regions and the warm areas of the temperate zones, e.g. in Spain, southern France, Italy, the Balkans, and the circum-Mediterranean regions in general (Meisch et al. 2007). No males of *C. seurati* have ever been found.

C. seurati is tolerant to a rather wide range of ecological conditions, having been collected from (rock)pools, streams, the hyporheic (interstitial) habitat included, springs, rice fields, and lakes, although the rare specimens reported from the latter tend to indicate that they are not among the preferred habitats of the species.

Subfamily Cypridopsinae Kaufmann, 1900

Genus *Sarscypridopsis* McKenzie, 1977

Sarscypridopsis lanzarotensis (Mallwitz, 1984) (Fig. 2 G-J)

More than 200 individuals of this species were collected from a helocrenic spring and several rockpools fed by a spring. The water at both sites was slightly salty (Tables 1 and 2).

First described from the isle of Lanzarote (Mallwitz 1984), *S. lanzarotensis* is now known to be the most wide-spread freshwater ostracod in the Canaries, having been recorded in large numbers from all the seven major islands of the archipelago (Table 3).

In general, *S. lanzarotensis* colonizes springs, waters flowing from springs, streams, isolated pools, and rice fields. For data on the ecology of the species, see Mezquita et al. (2001, 2005).

Up to the mid-1990s, *S. lanzarotensis* was unknown from outside the Canary Islands,

Table 3. Updated checklist of nonmarine ostracods of the Canary Islands. Updated from Malmqvist et al. 1997. a: Reported from Fuerteventura as *Herpetocypris* cf. *helenae* G.W. Müller by Baltanás & García-Avilés (1993).

	Tenerife	Fuerteventura	Gran Canaria	Lanzarote	La Palma	La Gomera	El Hierro	Alegranza
Candonidae								
Cypria ophtalmica (Jurine, 1820)						●		
Pseudocandona albicans (Brady, 1864)	●					●	●	
Ilyocyprididae								
Ilyocypris bradyi Sars, 1890		●	●			●		
Ilyocypris gibba (Ramdohr, 1808)		●						
Cyprididae								
Bradleycypris obliqua (Brady, 1868)	●							
Cypretta seurati Gauthier, 1929			●			●		
Cypridopsis lusatica Schäfer, 1943	●					●	●	
Cypridopsis vidua (O.F. Müller, 1776)		●	●		●	●	●	
Cypridopsis vidua f. *obesa* (Br. & Rob., 1869)						●		
Cypris bispinosa Lucas, 1849			●					
Cypris pubera O.F. Müller, 1776	●		●					
Herpetocypris brevicaudata Kaufm., 1900		●				●		
Herpetocypris chevreuxi (Sars, 1896)	●	●	●			●		
Herpetocypris cf. *helenae* G.W. Müller, 1908		●				●		
Heterocypris incongruens (Ramdohr, 1808)	●	●	●			●	●	
Heterocypris salina (Brady, 1868)	●	●	●			●		
Plesiocypridopsis newtoni (Brady & Rob., 1870)	●	●		●			●	●
Potamocypris arcuata (Sars, 1903)		●					●	
Potamocypris mastigophora (Methuen, 1910)						●	●	
Syn.: *Potamocypris producta* (Sars, 1924)								
Potamocypris pallida Alm, 1914						●		
Potamocypris villosa (Jurine, 1820)	●					●		
Sarscypridopsis aculeata (Costa, 1847)		●					●	
Sarscypridopsis lanzarotensis (Mallwitz, 1984)	●	●	●	●	●	●	●	
Strandesia vinciguerrae (Masi, 1905)						●		
Trajancypris clavata (Baird, 1838)	●							
Limnocytheridae								
Limnocythere inopinata (Baird, 1843)		●						
Cytherideidae								
Cyprideis torosa (Jones, 1850)		●	●					
Numbers of valid species recorded	11	13	10	2	2	15	9	1

but has since been repeatedly reported in Spain (Mezquita et al. 1999, 2001, 2005, Valls et al. 2014) and Italy (Madoni & Uluhogian 1997).

Recently, one of us (C.M.) identified *S. lanzarotensis* in a sample of ostracods collected from the interstitial habitat of a brook (oued) in the Haut Atlas in Morocco (leg. Dr R. Gerecke). This is the first published record of the species from North Africa, and the African continent in general.

Cypridopsis vidua (O.F. Müller, 1776) (Fig. 2 D-F)

This species was collected from two shallow slow streams and a basin inside a butterfly house (Tables 1 and 2). Only females were found.



Fig. 2. *Cypretta seurati.* Adult females (A-C). **A**: LV, int. view. **B**: RV, int. view, same individual as in A. **C**: RV, dorsal view. *Cypridopsis vidua*. Adult females (D-F). **D**: carapace, dorsal view. **E**: LV, int. view. **F**: RV, int. view, same individual as in E. *Sarscypridopsis lanzarotensis*. Adult females (G-J). **G**: LV, int. view. **H**: RV, int. view. **I**: carapace, dorsal view. **J**: RV, ext. view. The arrows point to the anterior end of the animals. Scale bar: 0.50 mm.

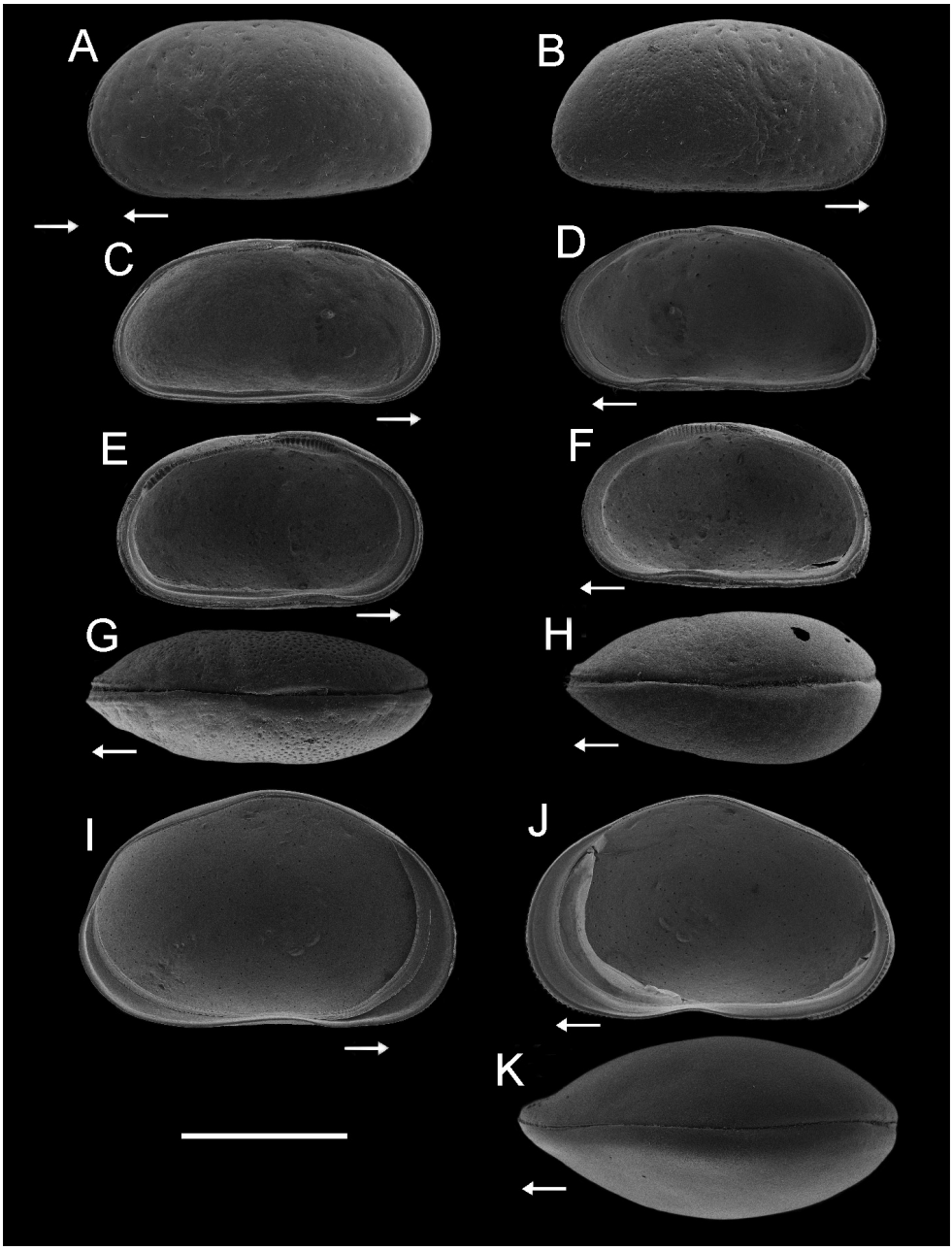


Fig. 3. *Cyprideis torosa*. Adult males (A-D, G) and females (E, F, H). **A**: LV, ext. view. **B**: RV, ext. view, same individual as in A. **C**: LV, int. view. **D**: RV, int. view. **E**: LV, int. view. **F**: RV, int. view, same individual as in E. **G**: carapace, dorsal view. **H**: carapace, dorsal view. *Heterocypris salina*. Adult females (I-K). **I**: LV, int. view. **J**: RV, int. view. **K**: carapace, dorsal view. The arrows point to the anterior end of the animals. Scale bar: 0.50 mm.

C. vidua is here reported for the first time from Gran Canaria. It is presently also known from Fuerteventura, La Gomera and El Hierro (Table 3). Given the almost ubiquitous presence of this species in sunny water bodies with rich vegetation, *C. vidua*

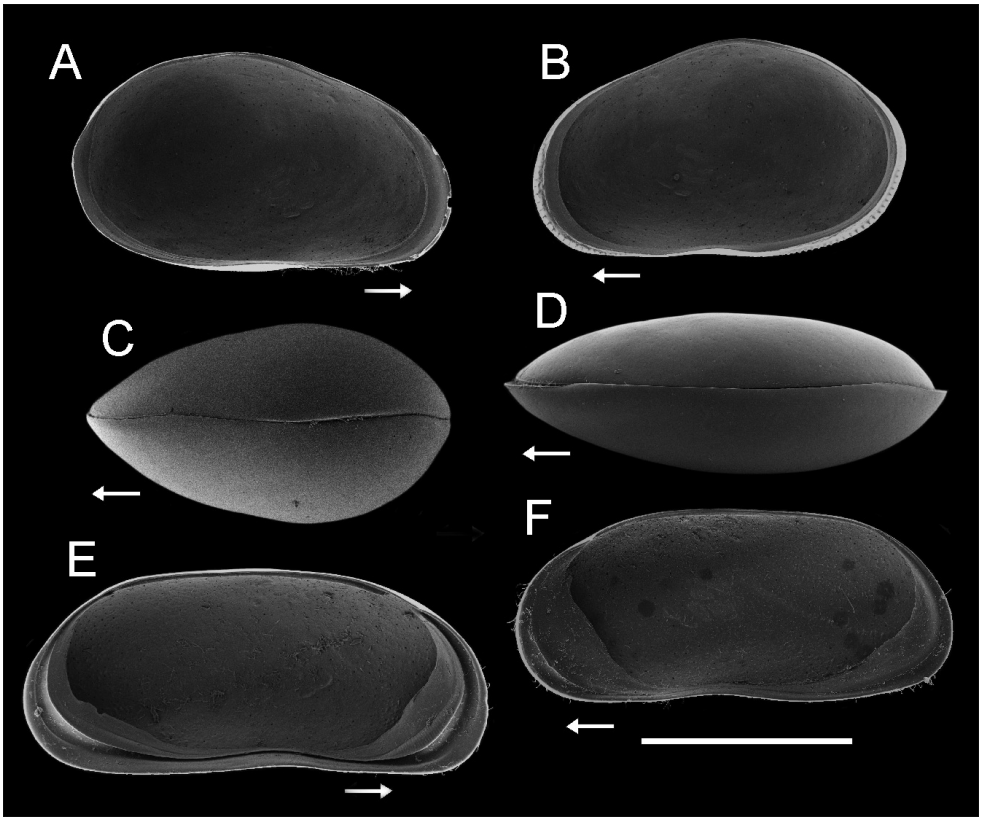


Fig. 4. *Heterocypris incongruens*. Adults (A-C). **A**: LV, int. view. **B**: RV. int. view. **C**: carapace, dorsal view. *Herpetocypris chevreuxi*. Adult females (D-F). **D**: carapace, dorsal view. **E**: LV, int. view. **F**: RV, int. view, same individual as in E. The arrows point to the anterior end of the animals. Scale bar: 1.0 mm.

is expected to occur on all the islands of the archipelago.

Cypridopsis obesa (Brady & Robertson, 1869) was generally considered an intraspecific form of *C. vidua* (review in Meisch 2000: 377). Beyer & Meisch (1996) redescribed *C. obesa* from La Gomera and reassessed the taxonomic validity of the species. The main differentiating characters put forward were the carapace size (0.70-0.77 mm; 0.45-0.65 mm in *C. vidua*) and the uniform greenish colour of the carapace. Meisch (2000) mentioned the finding of animals with transitional characters and therefore reassigned *C. obesa* the status of an intraspecific variety of *C. vidua*, a view which is adopted here (Table 3).

C. vidua has a cosmopolitan distribution. It prefers permanent and stagnant or slowly flowing water bodies, of all sizes, with rich vegetation (Meisch 2000). The males of *C. vidua* remain unknown, except if the bisexual populations of *Cypridopsis okeechobei* Furtos, 1936 from North and Central America are considered conspecific with *C. vidua* (Martens & Savatenalinton 2011, Karanovic 2012).

Subfamily Cyprinotinae Bronstein, 1947

Genus *Heterocypris* Claus, 1892

Heterocypris incongruens *(*Ramdohr, 1808) (Fig. 4 A-C)

Single valves and empty carapaces of this species were found in a small hypersaline lake (60‰ salt content) close to the sea shore. Although *H. incongruens* is known to tolerate, at least temporarily, an increase in

salinity up to around 16‰ (Meisch 2000), it certainly cannot survive in pure marine water and the less so in hypersaline conditions. It is suggested here that the valves and carapaces were washed in from a nearby freshwater habitat; alternatively, they could be the remains of a population that lived here under distinctly lower saline conditions.

The species had previously been reported from Gran Canaria by Malmqvist et al. (1997). It is presently known from five of the major Canarian Islands (Table 3).

Heterocypris incongruens has a cosmopolitan distribution. Males are presently only known from the circum-Mediterranean regions (Meisch 2000).

Heterocypris salina (Brady, 1868) (Fig. 3 I-K)

This species was found living in a pool fed by a spring and two slowly flowing streams with oligohaline to mesohaline conditions (Tables 1 and 2). Single valves and empty carapaces were collected from a lake with hypersaline conditions (> 60‰). For an explanation of the presence of those remains see the remark under *H. incongruens*.

H. salina had already been reported from Gran Canaria by Beyer & Meisch (1993) and Malmqvist et al. (1997). It is presently known from four islands of the Canaries (Table 3).

Heterocypris salina is reported from both pure freshwater and slightly saline coastal and inland waters, with, however, a clear preference for the latter habitats. *H. salina* has a holarctic distribution, with introductions into the southern hemisphere (Meisch 2000).

Herpetocypridinae Kaufmann, 1900

Genus *Herpetocypris* Kaufmann, 1900

Herpetocypris chevreuxi (Sars, 1896) (Fig. 4 D-F)

This species was abundantly collected from a man-made basin fed by a spring. Additionally, a small number of empty carapaces and valves were retrieved from a stream. The total salt content was slightly increased at both sites (3‰ and 8‰, respectively) (Table 2).

H. chevreuxi was previously recorded from Gran Canaria by Malmqvist et al. (1997). It is presently known from four of the Canarian Islands (Table 3).

H. chevreuxi has *H. helenae* G.W. Müller, 1908 as a close relative (Gonzalez Mozo et al. 1996). There is one uncertain record, as *H.* cf. *helenae,* from the Canaries (Baltanás & García-Avilés 1993). Meisch (2000) mentions the findings of animals with transitionals characters, both in carapace shape and soft part features, thus blurring the distinction between the two species. *H. helenae* is here considered an intraspecific form of *H. chevreuxi*.

Though also occurring in pure freshwater, *H. chevreuxi* prefers waters with slightly saline conditions (Meisch 2000). The findings of the species on Gran Canaria concur with that observation. The species is distributed throughout the Holarctic and Neotropical regions (Martens & Savatenalinton 2011).

Suborder Cytherocopina Baird, 1850
Superfamily Cytheroidea Baird, 1850
Family Cytherideidae Sars, 1925
Subfamily Cytherideinae Sars, 1925

Genus *Cyprideis* Jones, 1857

Cyprideis torosa (Jones, 1850) (Fig. 3 A-D, G)

Hundreds of individuals of this species were recovered from a shallow hypersaline lake (Tables 1 and 2) separated with a dune from the sea shore. The very high salinity of 60 ‰ at this site is most probably due to sea water evaporation, the lake being only intermittently replenished, during stormy weather, with sea water. All the animals collected possessed unnoded valves. Both sexes were found.

C. torosa is here recorded for the first time from Gran Canaria (Table 3). In the Canaries, it is presently known from two islands (Table 3). Given the near ubiquity of the species in brackish marine waters it is expected to be widely distributed along the Canarian coasts.

C. torosa is a characteristic inhabitant of the coastal marine brackish waters of Western Europe, the Baltic Sea included, the circum-Mediterranean regions, and West Africa (see Wouters 2002 for a review of the global dis-

tribution of the species). *C. torosa* tolerates wide variations in salt content, from freshwater to fully marine and even hypersaline waters (>60‰) (Meisch 2000).

The carapaces of *C. torosa* come in two extreme forms: one with conspicuous nodes (or tubercles), and another one with unnoded valves. Transitionally noded carapaces are also found. Noded carapaces are common in slightly saline waters, but beyond the threshold of c. 5‰ salt content, unnoded carapaces largely predominate (review in Meisch 2000). The unnoded carapaces collected from the hypersaline coastal lake on Gran Canaria obviously concur with that 'rule' (Fig. 3 A-D, G). Keyser (2005) convincingly showed that nodes in *C. torosa* develop as a result of 'failed' osmoregulation in the inner valve lamella under low salinity conditions.

4. Updated checklist of the nonmarine Ostracoda of the Canary Islands

The first checklist of nonmarine ostracods of the Canary Islands, the Azores, Madeira, the Cape Verde and the Selvagens Islands, was provided by Meisch & Broodbakker (1993). Their list mentions 8 species of ostracods from the Canary Islands, only one of which, i.e. *Heterocypris salina*, had been collected from Gran Canaria.

Published three years later by Baltanás et al. (1996), the checklist of nonmarine ostracods of the Iberian Peninsula, the Balearic and Canary Islands lists 20 species for the Canaries (out of 84 species in all for the area considered).

The third checklist, by Malmqvist et al. (1997), reports 22 nonmarine ostracod species from the Canaries, of which 7 are listed for Gran Canaria.

To our best knowledge, no new records of ostracods from the Canaries have been published since 1997. The updated checklist presented here includes the records of the seven species mentioned from Gran Canaria in the present work (Table 3), all of which were already known from the Canarian archipelago. Our updated list includes 25 species (26 if the uncertain record of *Herpetocypris helenae* is included). Three species, *Cypridopsis vidua, Cypretta seurati* and *Cyprideis torosa* are new to the island of Gran Canaria.

5. Discussion

The Canarian Islands have never been connected to the African mainland (Francisco-Ortega et al. 2009) and one must therefore admit that all Canarian ostracods colonised the archipelago through passive immigration from the Iberian Peninsula and/or northwestern Africa, or from elsewhere.

All 25 taxonomically certain species of the Canaries, with the exception of *Potamoypris pallida*, are known to occur on the Iberian Peninsula (Baltanás et al. 1996). The percentage of shared Canarian and Iberian ostracod diversity amounts to 100% if *P. pallida,* which has been recorded from the French Pyrenees close to the Spanish frontier (Meisch 1984: 50), is considered to occur also in Spain.

A look at the list of nonmarine ostracod species known in Morocco, Mauretania, Algeria and Tunisia (Martens 1984; Zaibi et al. 2013) reveals that those countries are home to 20 out of the 25 known Canarian species, the species 'missing' in northwestern Africa being *Cypridopsis lusatica*, *Limnocythere inopinata, Pseudocandona albicans, Strandesia vinciguerrae*, and *Potamocypris mastigophora*. This is, however, a biased view because of the poor current knowledge about the ostracod fauna of northwestern Africa.

From Table 3 it appears that there is no clear relation between the surface area of the different islands and the diversity of their ostracod fauna as presently known. This is perfectly illustrated by the island of La Gomera, the second smallest of the major islands (15 species recorded), and Tenerife and Fuerteventura, the two largest islands (11 and 13 species, respectively). The explanation for La Gomera's relative ostracod richness relies on the rather extensive investigations carried out on that island in the 1990s (Beyer & Meisch 1996, Beyer et al. 1997). The present state of knowledge about Canarian ostracods reflects the relative sam-

pling efforts on the different islands rather than their real faunistic diversity.

The Canaries are well known for their impressive number of endemic species: c. 40% of the native flora and c. 50% of all terrestrial invertebrates are endemics (Triantis & Whittaker 2009). As ostracods are concerned, all the nonmarine species so far reported from the Canaries are known from the Iberian Peninsula and northern Africa, or elsewhere. In conclusion, no endemic nonmarine ostracod species is presently known from the Canary Islands.

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