Stenocypria fischeri (Lilljeborg, 1883), a poorly known freshwater ostracod (Crustacea, Ostracoda)

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Abstract. *Stenocypria fischeri* (Lilljeborg, 1883) is redescribed from females collected from the environs of Bremen, northern Germany, and individuals of both sexes sampled from several sites in Turkey. An amended diagnosis of the genus *Stenocypria* is presented. Parthenogenetically reproducing populations of *S. fischeri* occur throughout the entire Palaearctic realm. Bisexual populations are so far known only from Turkey, with one historic population from an unspecified locality in the central dry steppe of Anatolia and one recently discovered population in the province of Muş. The sinuous posterior inner margin of the female valves of *S. fischeri* results from a lobe-shaped expansion of the calcified inner lamella, this calcified lobe being absent from the males. A similar but more or less reduced expansion is seen in at least part of the specimens of *Stenocypris major* (Baird, 1859), the type species of the related genus *Stenocypris* (Sars, 1889). The significance of this variation remains unknown. Relying on the examination of *S. fischeri* and various other species, it is shown that the sexual dimorphism of the cypridoid male antennae involves the reinforcement of the outermost structures (setae z1, z2 and Gm) into strong claws, while the innermost structures (the claws G1, G3 and GM) are reduced in strength, these modifications most likely having a functional role during copulation.

Keywords. Taxonomy, distribution, geographic parthenogenesis, Palaearctic, *Stenocypris major*.

1. Introduction

Ostracods are small, mostly 0.5-3.0 mm long crustaceans, the body of which is entirely enclosed within a carapace consisting of two valves. They are found living in almost every type of aquatic habitats, from marine to brackish and fresh waters, with a small number of species inhabiting semi-terrestrial environments (Horne et al. 2019).

The subfamily Herpetocypridinae of Cyprididae, to which the genus *Stenocypria* belongs, includes 15 genera with a total of 72 species (Meisch et al. 2019a).

Although the identification of *Stenocypria fischeri* (Lilljeborg, 1883), the single species of its genus, is unproblematic, most other aspects of its morphology, ecology and life history remain poorly known.

This is the more so surprising as the species has a wide distribution across almost the entire northern Palaearctic zoogeographical realm, from where it was recorded up to now by quite a number of authors since it was first properly identified in the late 19th century (Lilljeborg 1883).

For example, parts of the appendages of the female have so far never been illustrated; the single illustration of the female second antenna, which carries important taxonomic characters, goes back to the original

description of the species by Fischer (1851; misidentified by that author as *Cypris fasciata* O.F. Müller, 1776).

Except for the populations recorded from two sites in Turkey (Schäfer 1952, Külköylüoğlu et al. 2020) all other populations of *S. fischeri* were reported to consist of females only and are therefore inferred to reproduce parthenogenetically.

Here we present (1) a re-description of *S. fischeri* (both sexes) based on new material from Germany and Turkey; (2) new records of *S. fischeri* from Germany (all-female populations) and Turkey (parthenogenetic and bisexual populations); (3) an updated diagnosis of the genus *Stenocypria*; (4) a review of the taxonomy, distribution, ecology, and life history of *S. fischeri*.



Fig. 1. Records of *Stenocypria fischeri* in Germany. G1 and G2, this study; G3 near Greifswald (G.W. Müller 1900, Klie 1938); G4 near Berlin (Hartwig 1894).

2. Material and methods

2.1. Material examined

The material studied was collected from two sites in northern Germany, here designated as G1 and G2, and 12 others, designated as T1-12, in the provinces of Ağrı and Muş in Turkey.

From 2009 to 2018, dead specimens with macerated soft parts of *S. fischeri* were collected by the first author from two water bodies located north of Bremen in the floodplain of the river Weser in northern Germany (Fig. 1): (a) a small reservoir situated within the 'Alte Weser', an ancient arm of the river Weser (Table 1), here designated as G1, and (b) an abandoned clay pit, here designated as G2. The two sites are located at a distance of c. 8 km from each other. Fig. 2 shows photos of the two localities. The German material consists of females only.

The soft bodies of all the German specimens being partly decayed (Fig. 3), the study of the appendages of these animals was not possible. Therefore, the description and drawings of the female and male appendages were made from the Turkish material sampled from the unnamed pond T5 (Ağrı province) and shallow Lake Derik T12 (Muş province), respectively (Figs 4-6). SEM-images of the carapaces and valves were taken from both the German and Turkish animals.

In Turkey, *S. fischeri* was collected by the team of OK from 12 localities, here designated as T1-T12 (Fig. 4 and Table 1).

For the study of the sexually dimorphic chaetotaxy of the A2, the following material (both sexes) was examined:

(a) *Sclerocypris venusta* (Vávra, 1897): 21 slides with dissected individuals of both sexes deposited in Museum für Naturkunde, Berlin; these were the slides from which Martens (1987; Fig. 1A,B,D and Fig. 2) made the drawings of the diagrams of the two terminal A2-segments of both sexes (BS);

(b) *Neglecandona altoides* (Petkovski, 1961), as described in Meisch et al. (2019b): southern France, Germany and North Macedonia (CM and BS);

(c) *Neglecandona neglecta* (Sars, 1887): Germany and Luxembourg (BS and CM);

(d) *Candona candida* (O.F. Müller, 1776): Germany (BS);

(e) *Eucypris virens* (Jurine, 1820): Spain and France (BS and CM);

(f) *Heterocypris barbara* (Gauthier & Brehm, 1928): Tunisia and Hungary (BS and CM);

(g) *Apatelecypris schultzei* (Daday, 1913): Namibia (BS).

Table 1. New records of extant females and males of *Stenocypria fischeri,* with geographical coordinates and physical parameters from Germany and Turkey. Abbreviations: Cp, carapace(s); V, valve(s); roadside wb, roadside water body, small (c. 1-3 m²) and shallow (up to 50 cm deep).

Site number	Coordinates		Date	Water temp. [°C]	pH	Conduct. [µS/cm]	*Stenocypria fischeri*
G1	Ancient river arm 'Alte Weser' near Rade, Germany						
	53°15'51.5"N	08°30'44.0"E	30.09.2012	13.7	8.0	1439	2 Cp
	"		04.08.2013	22.5	8.5	1214	2 Cp, 4 V
	"		05.08.2014	23.0	7.5	1241	-
	"		24.07.2017	19.5	7.5	1148	-
	"		21.05.2018	19.7	7.5	1310	3Cp, 1 V
G2	Abandoned pit near Bremen-Farge, Germany						
	53°11'21.8"N	08°31'00.3"E	13.12.2009	5		1277	1 V
	"		18.04.2010	18		1453	1 V
	"		04.09.2010	17.3		1260	-
	"		24.07.2017	20.2	8.7	1102	3 V
	"		12.08.2018	19.9	8.0	1402	-
T1	Ağrı province, Doğubeyazıt county, Gölyüzü lake, Turkey						
	39°35'57.2"N	44°08'43.9"E	14.05.2014	10.6	8.4	997	15 ♀, 2 V
T2	Ağrı province, Merkez county, Center, stream, Turkey						
	39°44'47.9"N	43°01'20.2"E	16.05.2014	18.1	8.5	505	1 ♀
T3	Ağrı province, Eleşkirt county, Akyumak village way, spring, Turkey						
	39°52'56.4"N	42°51'19.6"E	16.05.2014	23.0	8.4	586	42 ♀♀
T4	Ağrı province, Tutak County, Isaabat village way, roadside wb, Turkey						
	39°36'51.2"N	42°46'04.9"E	17.05.2014	26.8	8.7	374	77 ♀♀
T5	Ağrı province, Tutak county, Esmer village, pond, Turkey						
	39°31'14.4"N	42°42'37.2"E	17.05.2014	22.2	8.6	192	>15 ♀♀
T6	Ağrı province, Tutak county, Ocakbaşı village, stream, Turkey						
	39°22'30.5"N	42°41'38.1"E	16.05.2014	20.3	8.6	808	103 ♀♀
T7	Ağrı province, Tutak county, Burnubulak-Tutak way, roadside wb, Turkey						
	39°22'50.6"N	42°45'17.3"E	17.05.2014	28.2	9.7	701	7 ♀♀
T8	Ağrı province, Tutak county, Köşkköy village, roadside wb, Turkey						
	39°26'00.1"N	42°45'50.7"E	17.05.2014	22.8	8.2	678	1♀
T9	Ağrı province, Patnos county, Doğansu way, pond, Turkey						
	39°10'13.2"N	42°45'49.9"E	17.05.2014	18.1	8.1	466	209 ♀♀
T10	Ağrı province, Patnos county, Doğansu way, pool, Turkey						
	39°09'35.8"N	42°45'22.5"E	17.05.2014	21.8	9.8	553	12 ♀♀
T11	Ağrı province, Patnos county, Gençali village, slough, Turkey						
	39°03'25.3"N	42°52'05.9"E	17.05.2014	18.6	8.4	556	1 ♀
T12	Muş province, Derik wetland, shallow Lake Derik, Turkey						
	39°02'51.4"N	41°43'51.9"E	19.08.2013	17.2	6.8	489	12 ♂♂ 59 ♀♀ 7 Cp, 3 V

The material under (b)-(g) is kept in the collections of BS and CM.

2.2. Methods

The first author collected water samples in Germany at depths of c. 20 cm from a shallow, c. 2 m deep reservoir (site G1) and an abandoned clay pit (site G2) with a maximum depth of c. 1 m (Table 1). Water temperature and electrical conductivity were measured with TESTR 35 (Co. EUTECH Instruments OAKTON) while pH was determined with a liquid pH-indicator RF1.09175 (pH 4-10,

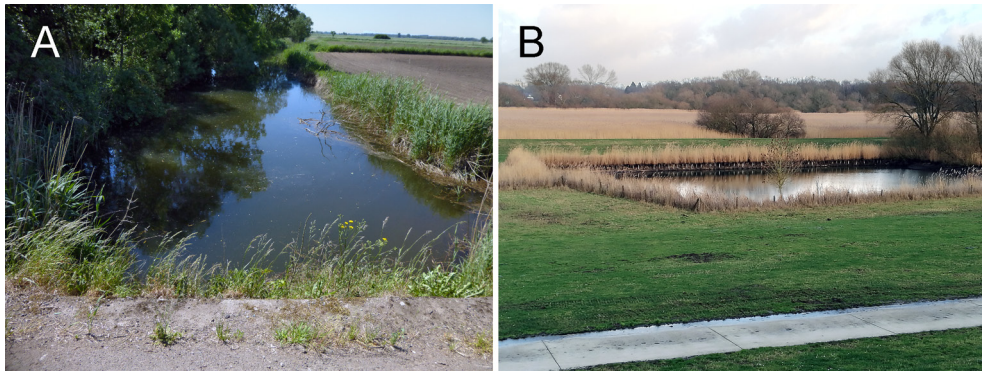


Fig. 2. A, site G1, a small reservoir upstream of a dam within the 'Alte Weser' near Rade. B, site G2, an abandoned clay pit near Bremen-Farge. Photos: B. Scharf

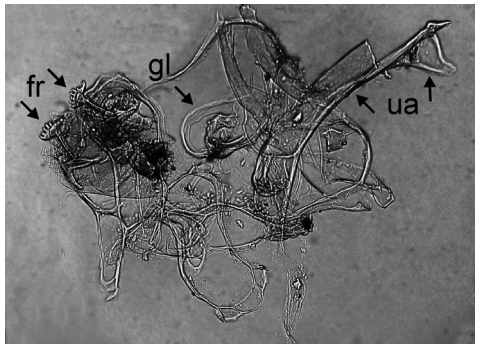


Fig. 3. Macerated female soft parts of *Stenocypria fischeri* from site G1. Arrows point to the food rakes (fr), the female genital lobe (gl), and the uropodal attachment with the basal triangle (ua).

with 0.5 steps, Co. Merck). The geographical coordinates of the sampling sites G1 and G2 were taken with a Garmin GPS map 76 (WGS 84). The ostracods were collected with a hand net (200 µm mesh size) among submersed macrophytes and from the upper part of the sediment. The animals were separated from the sediment as described by Scharf et al. (2014). HydroMatrix® was used for the preparation of permanent slides.

Site G1 in Germany was sampled five times: on September 30, 2012, August 4, 2013, August 5, 2014, July 24, 2017, and May 21, 2018. Site G2 was sampled on December 13, 2009, April 18, 2010, September 4, 2010, July 24, 2017, and August 12, 2018.

When needed, closed carapaces were opened for separation of the valves with an expanding gas bubble under lowered air pressure (Scharf et al. 2016).

The Turkish team collected the ostracods with a hand net (200 µm mesh size) from shallow waters (c. 100 cm of depth). The samples were kept in 70 % ethanol in plastic bottles. In the laboratory, each sample was individually washed through a series of standard sieves (2.0, 1.5, 1.0, and 0.5 mm mesh size) and kept in 70 % ethanol. Dissections of soft parts were done in the lactophenol mixture under an Olympus ACH 1X stereomicroscope and examined under an Olympus BX-51 light microscope. All samples and slides are stored in the Limnological Laboratory of the Department of Biology of the Bolu Abant İzzet Baysal University, Bolu, Turkey. pH, water temperature and electrical conductivity were recorded at each sampling site (Table 1). Geographical information (e.g., coordinates, elevation) was gathered with a geographical positioning system (GARMIN Etrex Vista H GPS). YSI Multi Professional Plus was used to record the environmental variables mentioned above.

The Turkish sites were sampled as follows. Unnamed pond T5 in Ağrı province: May 17, 2014; shallow Lake Derik T12 in Muş province on August 19, 2013 (Figs 4-6); for the remaining Turkish sites see Table 1.

Stenocypria fischeri and the ostracod species co-occurring with *S. fischeri* in both the German and Turkish sites were identified with the taxonomic keys of Meisch (2000).

The valves and the macerated soft parts from the German sites G1 and G2 as well as 6 slides



Fig. 4. *Stenocypria fischeri*: Sampling sites T1 – T12 in Turkey.

each with one dissected female from the Turkish site T5 are kept in the personal collections of BS. All the remaining Turkish material is deposited in the Biology Department of the Bolu Abant İzzet Baysal University in Bolu.

Abbreviations used in text and figures. A1, antennule; A2, antenna; Md, mandible; Mx1, maxillule; T1 (L5), first thoracopod (maxilliped); T2 (L6), second thoracopod (walking leg); T3 (L7), third thoracopod (cleaning

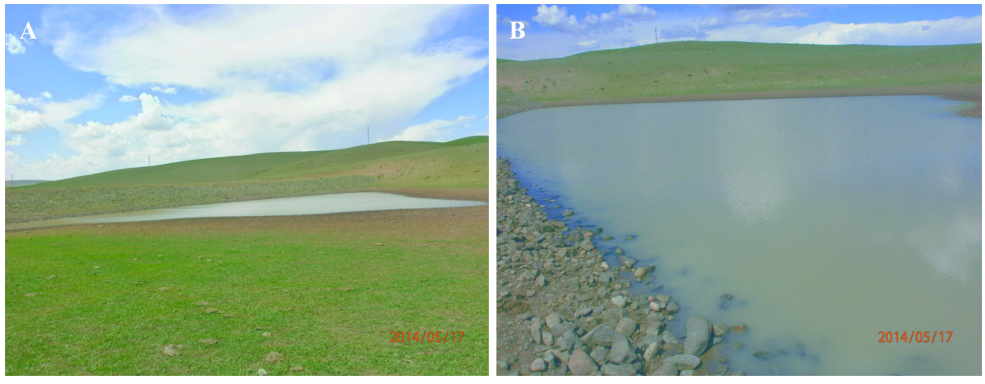


Fig. 5. Site T5, an unnamed pond in Ağrı province, Turkey. A, overview. B, shore. May 17, 2014. Photos: O. Külköylüoğlu.

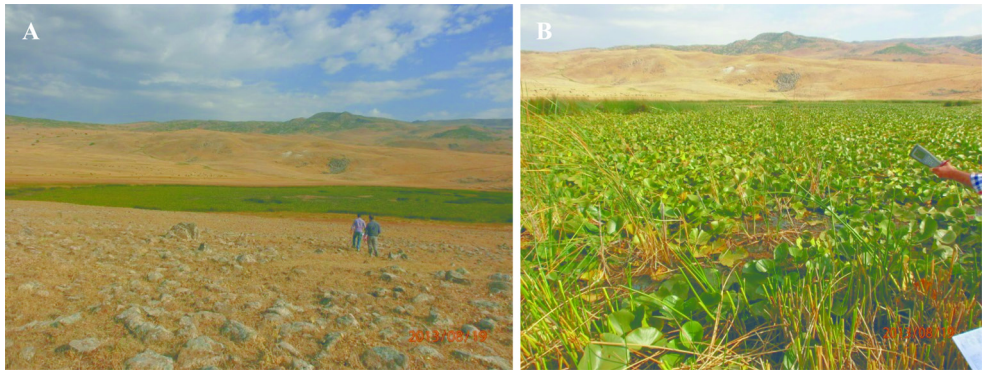


Fig. 6. Site T12, shallow Lake Derik in Muş province, Turkey. A, overview. B, detail of vegetation. August 19, 2013. Photo O. Külköylüoğlu.

leg); u-rami, uropodal rami; Cp, carapace; L, length of carapace; LV, left valve; RV, right valve. Authors' names are abbreviated with their initials (BS, etc.).

Authors' contributions. BS and the team of OK collected the material from the German and Turkish sites, respectively. BS and CM organized and wrote the first draft of the manuscript. The drawings of the appendages of the Turkish females and males were made by BS, OK, and MY. All four authors read the manuscript and contributed with improvements.

3. Results

3.1. Systematic position of *Stenocypria fischeri* (Lilljeborg, 1883)

Class Ostracoda Latreille, 1802
Subclass Podocopa Sars, 1866
Order Podocopida Sars, 1866
Suborder Cypridocopina Baird, 1845
Superfamily Cypridoidea Baird, 1845
Family Cyprididae Baird, 1845
Subfamily Herpetocypridinae Kaufmann, 1900
Tribe Stenocypridini Ferguson, 1964
Genus *Stenocypria* G.W. Müller, 1901

Type species: *Cypris fischeri* Lilljeborg, 1883.

Type locality: Russia, surroundings of Sergiefskoje; modern name: Sergievka, a palace and park near Peterhof Palace, 59°53'N, 29°50'E (Saint Petersburg Encyclopaedia).

Repository of type material unknown, this material probably lost (Matzke-Karasz & Damkaer 2011, also pers. comm. to BS by Dr Renate Matzke-Karasz, July 2020).

3.2. Amended diagnosis of *Stenocypria* G.W. Müller, 1901 (based on Meisch 2000 and Martens 2001; updated for the males).

Female: Valves elongated and laterally compressed, L=1.4-2.3 mm; both valves without selvages and inner lists; fused zones narrow at both ends, marginal septa absent; anterior calcified inner lamella wide, posteriorly narrow but with a conspicuous lobe-shaped expansion, the posterior inner margin therefore appearing conspicuously sinuous. LV overlaps RV on all sides. Rome organ on A1 short. Natatory setae of A2 long, reaching tips of terminal claws or slightly longer. Distal segment of Mx1-palp rectangular, c. 1.45 x as long as broad. Setae d1 and d2 of walking leg (T2) relatively short, subequal in length. Uropodal rami (sub)symmetrical, posterior margin with a dense row of spinules; posterior seta sp well developed. Basal triangle of uropodal attachment well developed.

Male: Carapace without the conspicuous calcified lobe-shaped expansion of the posterior inner lamella. A2: setae z1 and z2 transformed into stout claws, z3 a long seta; Gm-claw comb-shaped; GM a long and thin claw. Zenker organ with c. 60 rings of spines. Penis: medial shield distally conical; medial lateral shield distally inflated; dorsal lateral shield conical; ventral lateral shield conspicuously short.

3.3. Description

The descriptions and drawings were made from females and males collected from the Turkish localities T5 (Ağrı province) and T12 (Muş province) (Table 1; Figs 7-13).

Female. Carapace elongate in lateral view, laterally compressed in dorsal view; LV overlaps RV at both ends. Calcified inner lamella: anteriorly broad, antero-dorsally with a small sinuosity; this lamella posteriorly narrow, except for a conspicuous lobe-shaped expansion, the inner margin therefore appearing distinctly sinuous (Fig. 7).

A1 (Fig. 8A). 7-segmented. Apical natatory setae slightly longer than the combined segments 1-7. Natatory setae, especially those arising from segment 6, delicately feathered (not shown in Fig. 8A). Aesthetasc ya as long as the combined distal segments 5-7. Apical seta of terminal segment slightly reinforced. Rome organ present, Wouters organ not seen.

A2 (Fig. 8B). Basal segment proximally with a seta of medial length, ventro-distally with two other setae of equal length. Second segment with one long seta. Exopodite with one long and two short setae. Aesthetasc Y relatively short. Four t-setae present, the longest reaching tip of Gm, seta z1 shorter than z2 and z3, but longer than G3, z2 and z3 extending beyond tip of G1. Terminal claws G1 and G3 as long as penultimate A2-segment. G2

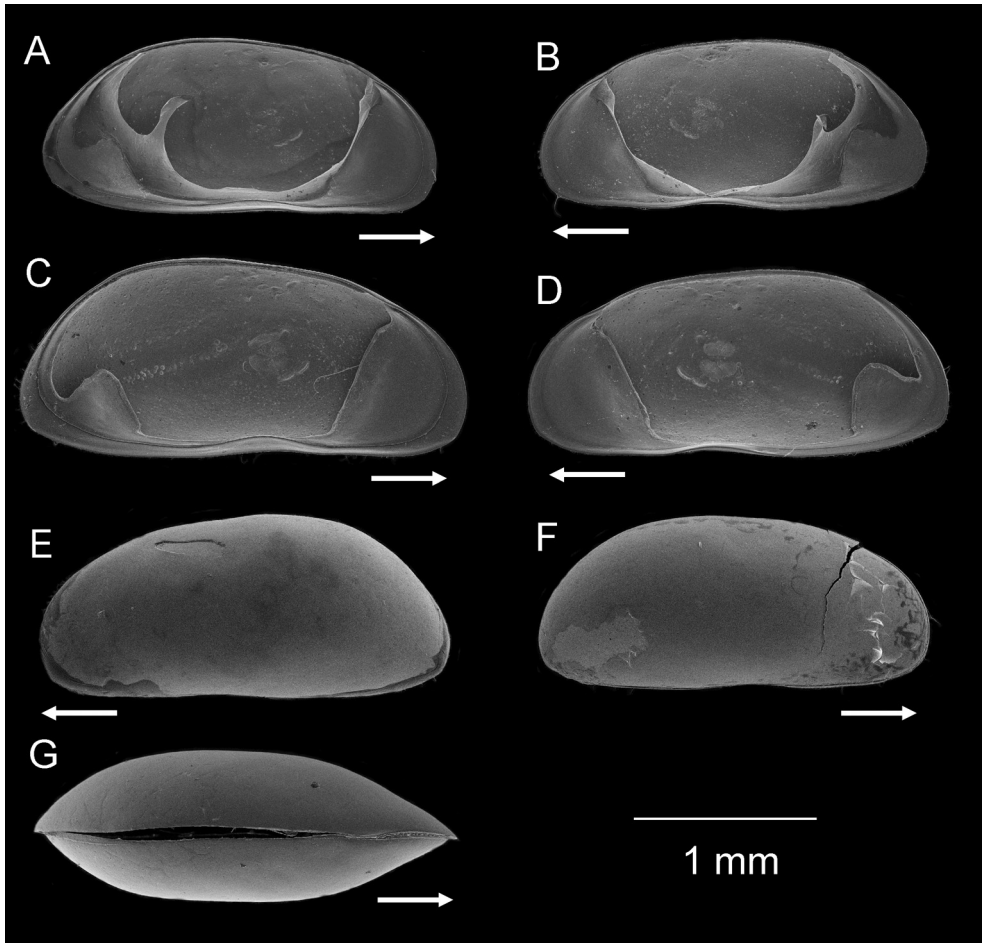


Fig. 7. *Stenocypria fischeri.* Female. A and C, LV, internal view. B and D, RV, internal view. E, LV, external view. F, RV, external view. G, dorsal view. A, B, and G from site T5. C-F from site G2.

slightly reduced in size. GM c. 3x the length of the distal A2-segment. Gm about half as long as GM. Aesthetasc y3 basally fused with a short seta (the latter not being the seta g; Fig. 8C). Natatory setae 1-5 well developed, reaching tips of terminal claws or slightly beyond.

Md-palp (Fig. 9A). S1 and S2 on first segment well developed, equally long. Setal group on 2nd segment with four setae; alpha- and beta-setae present; gamma-seta thick and feathered. Vibratory plate distally with five long and one short filaments, basally and in the middle with a short and a long filament.

Lower lip as in Fig. 8D. Food-rakes each with eight denticles.

Mx1 (Fig. 8E). Palp two-segmented, terminal segment slightly longer than broad, with three long and three shorter setae, one of the short setae with setulae. Both teeth bristles of third masticatory process serrated.

T1 (Fig. 9B,C). Palp one-segmented, distally with setae h1-3. Setae a, b, and d present, seta c absent. Vibratory plate with six filaments.

T2, walking leg (Fig. 9D). d1 and d2 present, (sub)equal in length. Basal segment with a complex chitinous skeleton. This leg otherwise without special characters.

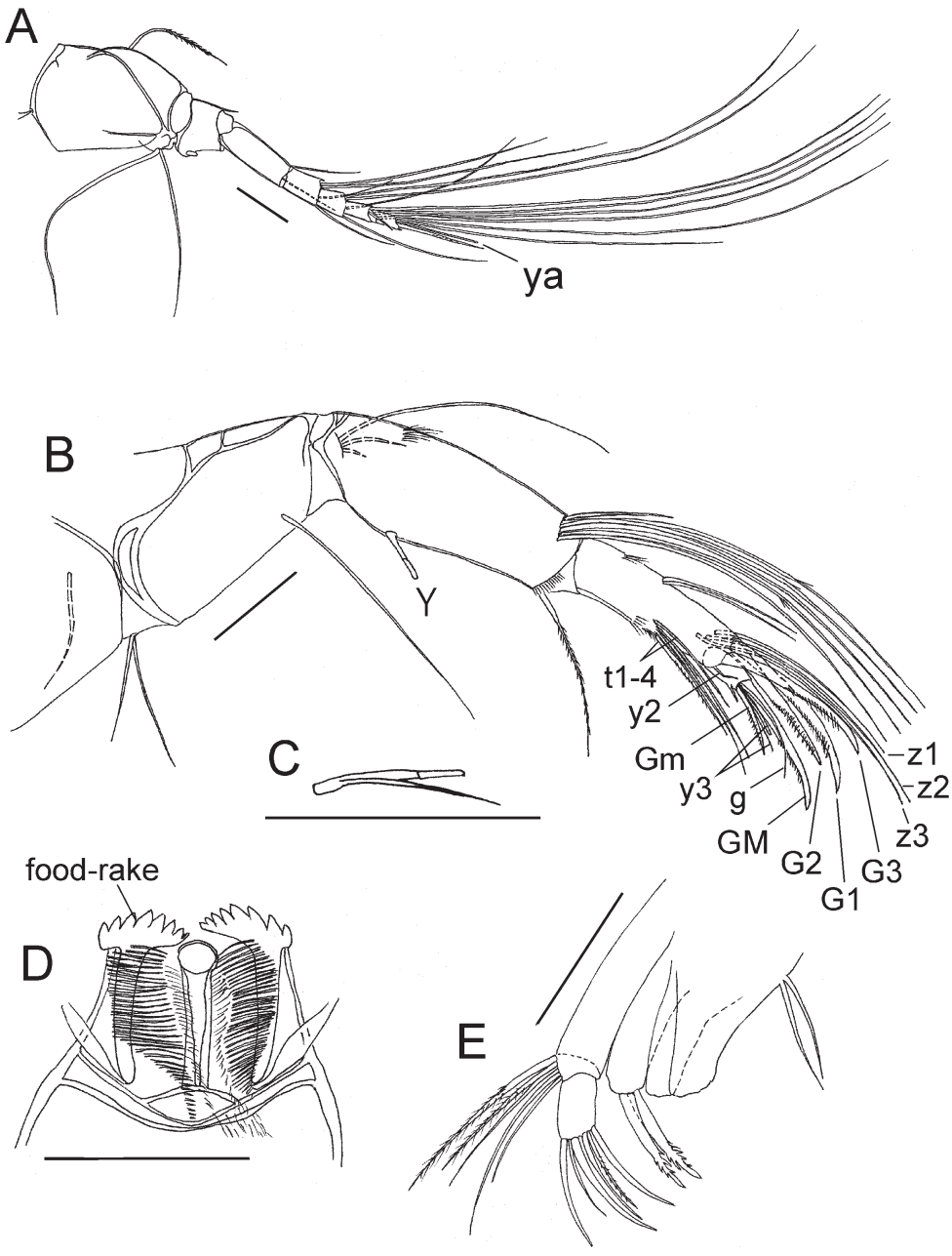


Fig. 8. *Stenocypria fischeri*. Female, site T5. A, antennule A1. B, left antenna A2, internal view. C, aesthetasc y3. D, lower lip with food-rakes. E, maxillula. Scale bars: 100 µm.

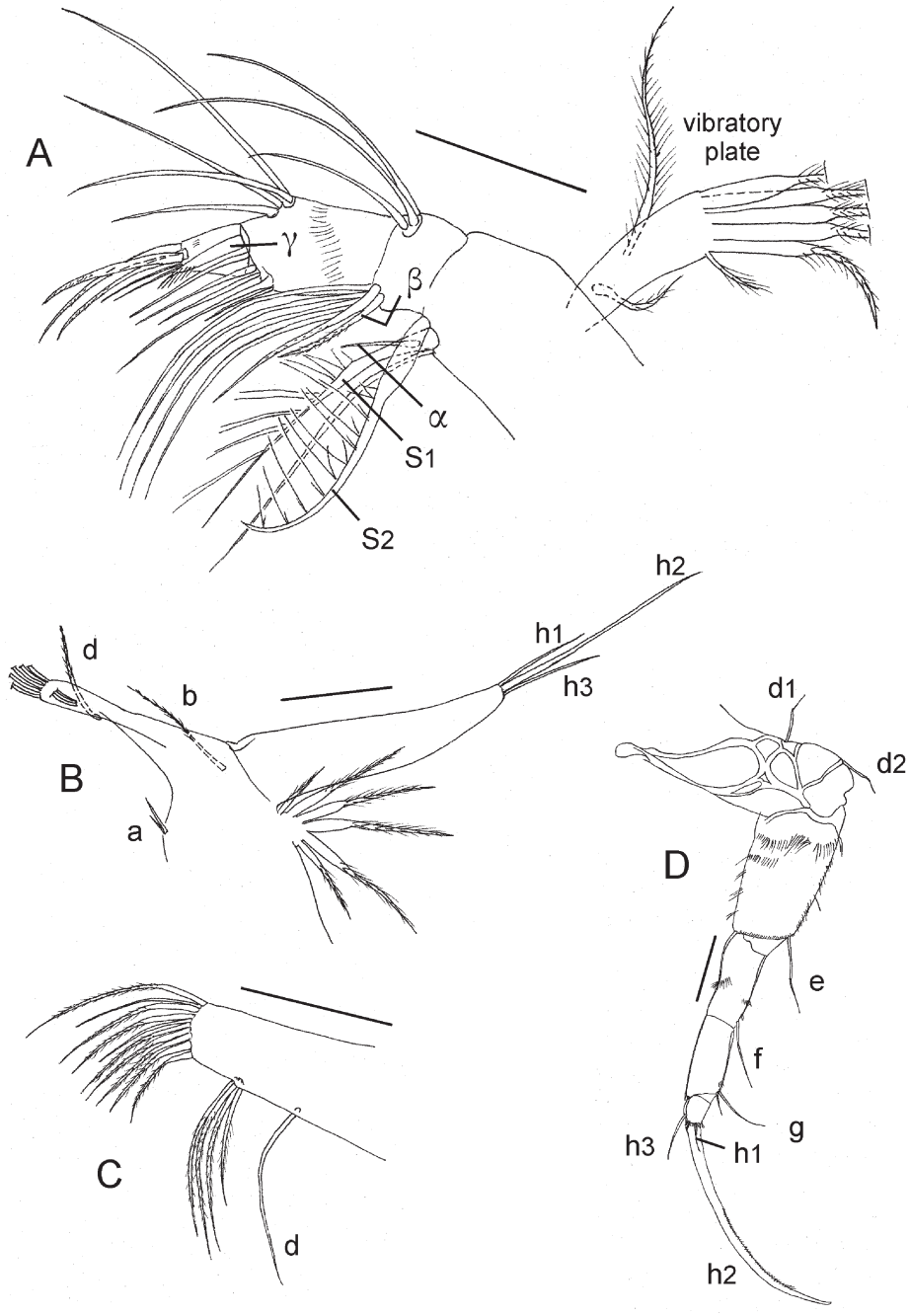


Fig. 9. *Stenocypria fischeri*. Female, site T5. A, mandibular palp. B, maxilliped (T1). C, anterior part of maxilliped. D, 2nd thoracopod (walking leg). Scale bars: 100 µm.

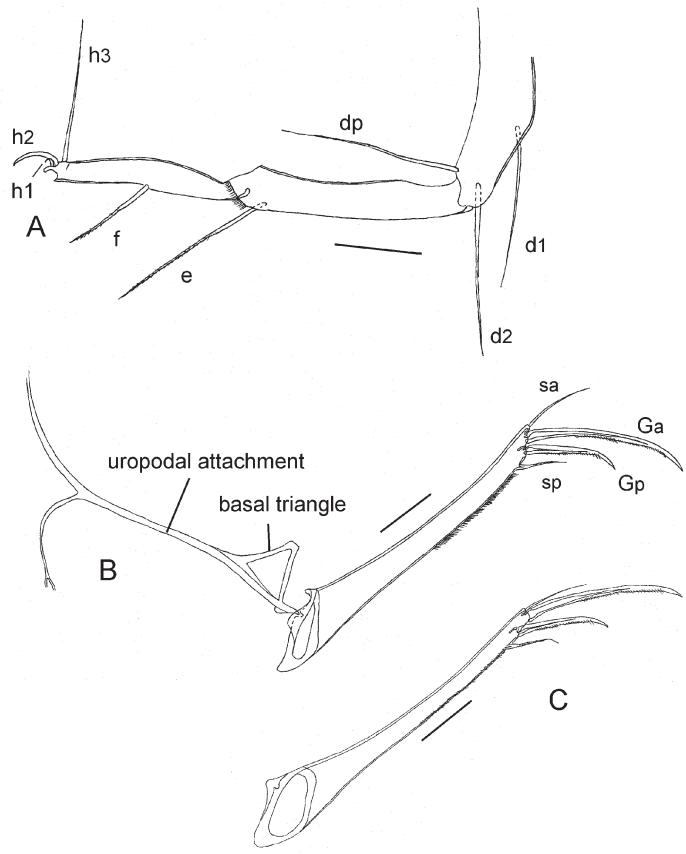


Fig. 10. *Stenocypria fischeri*. Female, site T5. A, third thoracopod (cleaning leg). B, right uropod with uropodal attachment. C, left uropod. Fig. 10B, C from the same animal. Scale bars: 100 µm.

T3, cleaning leg (Fig. 10A). Basal segment with setae d1, d2, and dp. Setae e, f, and h1-3 present. Distal pincer organ well developed.

U-ramus (Fig. 10B,C). Seta sp short but well developed, sitting close to the base of the distal claw Gp. Distal third of the ramus with a row of setulae. Uropodal attachment with a chitinous basal triangle. Left ramus weakly curved, right ramus almost straight.

Male (Figs 11-13). Carapace similar to that of the female but internal posterior margin narrow, regularly rounded, approximately parallel to the posterior valve margin, lacking the lobe-shaped expansion (Fig. 11).

A2 (Fig. 12) sexually dimorphic, setae z1 and z2 transformed into powerful claws, seta z3 untransformed; G1- and G3-claws reduced. GM a thin claw, Gm reinforced into a strong, comb-shaped claw.

Clasping organs of T1 asymmetrical, right finger large and swollen (Fig. 13A), left finger short, thinner, and curved at right an angle (Fig. 13B).

Zenker organ (Fig. 13C) with c. 60 whirls of spines.

Penis (Fig. 13D). Medial shield ms cuneiform, lateral medial shield mls club-shaped, ventral lateral shield vls very small, dorsal lateral shield dls small, attached at about mid-length of the penis.

Size of females and males 1.4-2.3 mm (usually 1.9-2.1 mm). Colour light to dark bluish green.

3.4. Taxonomic history (mainly based on G.W. Müller 1912, Kempf 1980, Meisch 2000)

1776 Non *Cypris fasciata* n. sp. O.F. Müller: 53; pl. 4: 1-3.

1851 *Cypris fasciata* O.F. Müller – Fischer: 151; pl. 5: 9-19; pl. 6: 1-2.

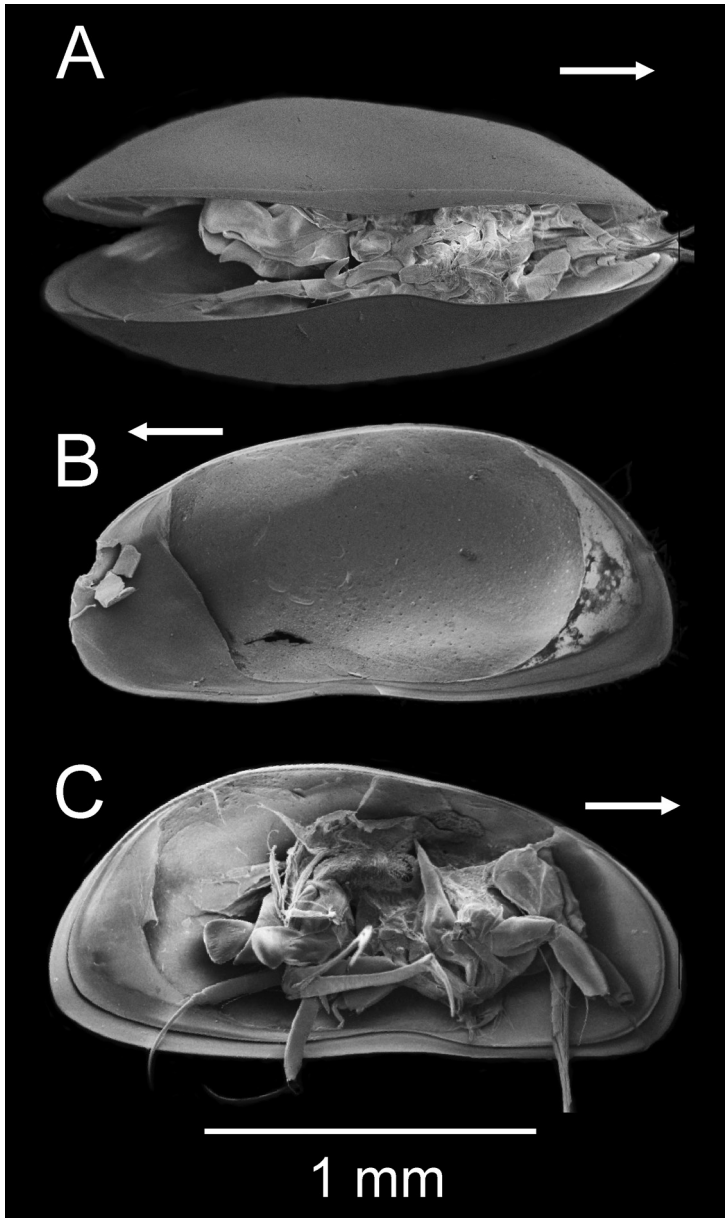


Fig. 11. *Stenocypria fischeri*. Male, site T12. A, ventral view. B, RV internal view, C, LV internal view.

1883 *Cypris fischeri* nom. nov. Lilljeborg, 1883: 146.
1891 *Cypris* (*Eucypris*) *fischeri* (Lilljeb.) comb. nov. Vávra: 94; fig. 31.
1894 *Stenocypris fischeri* (Lilljeb.) comb. nov. Croneberg: 301; pl. 7: 17.
1901 *Stenocypria fischeri* (Lilljeb.) comb. nov. G.W. Müller: 572.

Stenocypria fischeri was originally misidentified and therefore erroneously described as *Cypris fasciata* O.F. Müller, 1776 by Fischer (1851). The latter species is presently known as *Dolerocypris fasciata* (O.F. Müller, 1776). Lilljeborg (1883) recognized that Fischer's (op. cit.) description actually applies to a so far undescribed species for which he (Lilljeborg op. cit.) introduced the new name *Cypris fischeri*, with-

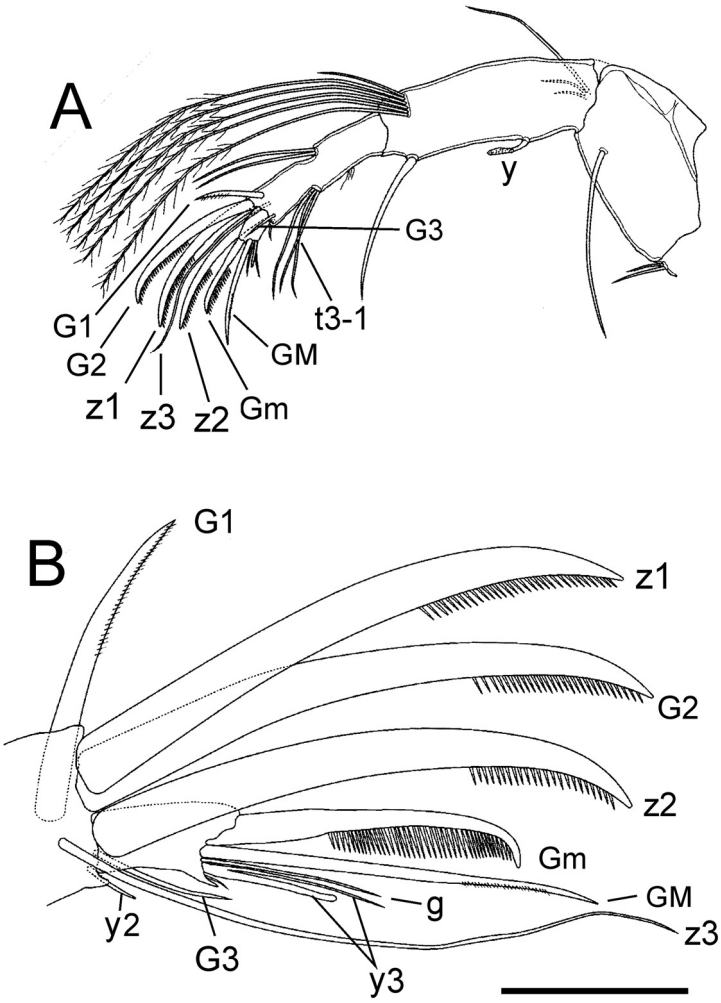


Fig. 12. *Stenocypria fischeri*. Male, site T12. A, right A2, inner view. B, distal part of right A2, exterior view. Scale bars: 100 µm for A, 25 µm for B.

out, however, providing a redescription of the species. The species was thereafter successively transferred to the genera *Eucypris* and *Stenocypris* until G.W. Müller (1901) transferred it to the newly erected genus *Stenocypria* to which it is currently still assigned.

3.5. Ecology and life history

Stenocypria fischeri was mostly recorded from streams, the littoral zone of lakes and ponds, less often from springs, fountains, thermal waters, temporary water bodies, and still others with a slight increase in salt content.

The original findings of *S. fischeri* were from slowly flowing streams in the environs of Saint-Petersburg, Russia, and Tallin, Estonia (Fischer 1851).

The species is widespread in Anatolia, the Asian part of Turkey. It was collected from streams in the provinces of Erzincan and Ağrı (Akdemir & Külköylüoğlu 2014, Külköylüoğlu et al. 2019a). Records of the species from Turkish lakes were presented by Külköylüoğlu et al. (2010, 2019a; Lake Sünnet, Bolu province, and Ağrı province). Yavuzatmaca (2020) mentioned the species as being common in both streams and lakes in the western provinces of Turkey.

Elsewhere, the occurrence of the species in lakes was reported from Sweden (Alm 1915, small numbers of individuals always)

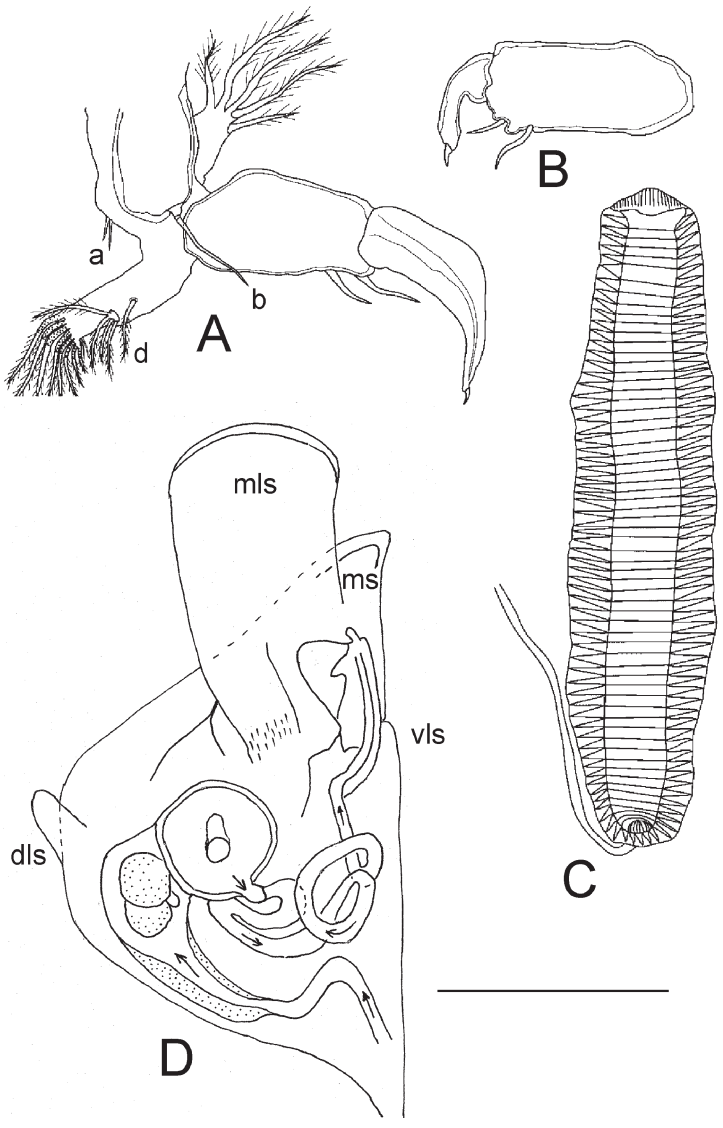


Fig. 13. *Stenocypria fischeri*. Male, site T12. A, right clasping organ. B, left clasping organ. C, Zenker organ. D, penis. Scale bar: 100 µm.

and France (Paris 1920, réservoir Panthier, one single individual) and lake Kara-gel in the Caucasus (Bronstein 1947). The maximum depth colonised by *S. fischeri* in lakes remains unknown.

There are many records of *S. fischeri* from ponds and similar small water bodies, e.g. in the Czech Republic (Vávra 1891), in Hungary (Daday 1892), in northern Germany (Müller 1900), the European part of Russia (Bronstein 1947), in Austria (Löffler 1961), Turkey (Margaritora et al. 1977), and Iran (Löffler 1959). Remarkably, the two bisexual populations reported from Turkey were found in small ponds (Schäfer 1952, Külköylüoğlu et al. 2020).

The historic occurrence in thermal waters of the Lukács Baths in Budapest, Hungary, is most noteworthy. Toth (1863; see also Daday 1892, 1900) reports on the presence of 'billions of individuals' of *S. fischeri* in a pond fed by the waters of a nearby hot spring, at temperatures of 20-24° on the Réaumur scale (25.0-30.0 °C). Two years later, this

Species \ Localities	G1 Alte Weser	G2 Clay pit	T1 A28	T2 A74	T3 A73	T4 A114	T5 A110 pond	T6 A93	T7 A108	T8 A109	T9 A105	T10 A106	T11 A103	T12 L. Derik
Candona candida (O.F. Müller, 1776)	I,III	I,II												
Candonocypris novaezelandiae (Baird, 1843)		I												
Candonopsis sp.		I												
Cyclocypris ovum (Jurine, 1820)	I													
Cypria ophtalmica (Jurine, 1820)	I,II,II,III	I,I,III,III,IV											I	I
C. subsalsa Redeke, 1936	I													
Cyprideis torosa (Jones, 1850)	I	I,II,III,V,V												
Cypridopsis vidua (O.F. Müller, 1776)	I,II,III	I,I,II,III,IV								I	I		I	I
Cypris pubera O.F. Müller, 1776	I,I,I,II,III	II,III											II	I
Darwinula stevensoni (Brady & Robertson, 1870)	I	I,II												
Eucypris virens (Jurine, 1820)	II,II,III	I												
Fabaeformiscandona fabaeformis (Fischer, 1851)					III								I	
Fabaeformiscandona holzkampfi (Hartwig, 1900)	I													
Herpetocypris chevreuxi (Sars, 1896)		I												
H. reptans (Baird, 1835)	I,I,II	I,III,III												
Heterocypris incongruens (Ramdohr, 1808)			IV	I	IV	IV			I			I		
Ilyocypris bradyi Sars 1890		I,I,II			V									
I. decipiens Masi, 1905	I,III	I,II,II	II					IV			II			
I. getica Masi, 1901										IV				
I. monstrifica (Norman, 1862)	I,II,II	II,IV												
Isocypris beauchampi (Paris 1820)	I,I,II,II	I												
Limnocythere inopinata (Baird, 1843)	I	I						I						
Neglecandona neglecta (Sars, 1887)	I,II,II,IV	III,IV,IV,V,V			I					I				
Notodromas monacha (O.F. Müller, 1776)	I,II,II	I,I,I												
Paralimnocythere relicta (Lilljeborg, 1863)											I			
Physocypria kraepelini G.W. Müller, 1903	III	I,I,II,IV,V												
Plesiocypridopsis newtoni (Brady & Robertson 1870)	I	II	I											
Potamocypris arcuata (Sars, 1903)								II						I
Potamocypris variegata (Brady & Norman, 1889)			IV								I			
Prionocypris zenkeri (Chyzer & Toth, 1858)		I,I												
Pseudocandona compressa (Koch, 1838)	I,I,II													
Pseudocandona insculpta (G.W. Müller, 1900)	III (1)													
Pseudocandona pratensis (Hartwig, 1901)	I													
Sarscypridopsis aculeata (Costa, 1847)	II,II,II													
Stenocypria fischeri (Lilljeborg, 1883)	I,I,II,II,III	I,I	III	I	IV	IV	IV	V	II	I	V	III	I	IV
Trajancypris serrata (G.W. Müller, 1900)								V						
Number of species	24	22	5	2	5	3	2	6	2	4	5	2	5	5

← Table 2. Ostracods found co-occurring with *Stenocypria fischeri*. Abundance: I = 1-3 individuals/sample, II = 4-10, III = 11-25, IV = 26-100, V = > 100 ind./sample. Example: I,III means that this species was found two times with the abundances of I and III at a given locality. A28 etc., refer to the identification numbers of the Ağrı-sampling sites in the database of OK.

remarkable population had become extinct after the pond had been converted into a public swimming pool. In contrast, Daday (1892) collected only three individuals of *S. fischeri* in the nearby pond of the botanical garden in Budapest.

A few records are from ditches in Germany (Hartwig 1894), Poland (Namiotko 1990), and Turkey (Külköylüoğlu et al. 2019a, Ağrı province). There is one record from a fountain (Külköylüoğlu et al. 2012a, Kahramanmaraş province) and another one from a spring (Külköylüoğlu et al. 2019a, Ağrı province), both sites being located in Turkey.

S. fischeri has repeatedly been recorded from temporary water bodies, e.g. in Turkey (Rasouli et al. 2014, Külköylüoğlu et al. 2019a) and Crete (Marrone et al. 2019), where it was reported to co-occur with ostracods which are characteristic inhabitants of that type of habitats, such as, e.g., *Eucypris virens*, *Heterocypris incongruens*, and *Tonnacypris lutaria* (Table 2).

S. fischeri shows a relatively wide tolerance towards (a) elevation, having been recorded from sea level (northern Germany, this paper) to 1717 m asl in Turkey (Yavuzatmaca 2020); 2350 m in the Caucasus (Lake Kara-gel, Bronstein 1947), and 2800 m asl in Iran (Löffler 1959), and (b) an increase of the salt content of its habitats: up to 3 g/L total salt content (oligohaline range) in samples from Algeria (Blanchard 1891, Moniez 1891). See Table 1 for the ranges of further environmental variables in Turkish waters.

The life history of *S. fischeri* remains poorly known. It is generally considered a summer form with adults being present in the warm season, from May to September, and with two generations in the year (Klie 1938, Bronstein 1947).

3.6. Sexual and asexual reproduction

The first males of *S. fischeri* were discovered in a sample collected from 'a pond (pool) located in the central dry (arid) steppe in Turkey', with no further information on the locality having been available to the author (Schäfer 1952); the sample contained four male juveniles belonging to the last juvenile stage (A-1). Interestingly enough, among other species, Schäfer's (1952) sample also contained females and males of *Cypris pubera* O.F. Müller, 1776, these males being the first ones of that species ever recorded.

The very recent finding of a bisexual population of *S. fischeri* in the shallow Lake Derik in the Turkish province of Muş, where 12 males and 59 females (new analysis of the *S. fischeri* material from Lake Derik by OK and MY) were collected, is the second record of males of this species (Külköylüoğlu et al. 2020).

As presently known, *S. fischeri* reproduces parthenogenetically throughout its vast Palaearctic distribution area, with the exception, however, of two bisexual populations known from Turkey. Special attention should be paid in the future to the finding of males of this species.

3.7. Distribution

The literature tells us that *S. fischeri* has a wide distribution throughout the entire northern Palaearctic realm, from China across Asia to the Middle East, to continental Europe and North Africa.

The Asian records come from northeastern and central eastern China (Yu et al. 2009), central and East Asia (Afghanistan, Hartmann 1964; Tian Shan, Schornikov 2007; Altai mountains, Semenova 2007), southwestern Siberia (environs of Novosibirsk, Bronstein 1947, Semenova 2007), Turkey, and the Middle East (Iran, Rasouli et al. 2016).

The records from the European part of Russia are from the environs of Saint-Petersburg (Fischer 1851), Moscow, Perm, Saratow, the basins of the rivers Donets and Volga, the Ural Mountains (Kungursky region), and North Caucasus (Bronstein 1947, Semenova 2007).

Further records from southeastern Europe are from the South Caucasus (Lake Karagel, 2350 m asl, Bronstein, 1947) and from Ukraine (environs of Kharkov and Kiev, Bronstein 1947, Semenova 2007). In Poland, the species was reported from three sites (environs of Gdańsk and Poznań, Namiotko 1990, Sywula & Namiotko 1997).

In Germany, previously to the findings reported here from the environs of Bremen, the species was recorded from the environs of Berlin and Greifswald (Hartwig 1894, Müller 1900); both authors mention that *S. fischeri* was not found there again after the first finding. Viehberg (2001) mentioned the absence of the species in his samples, as well as those of Stammer (1928) from the Greifswald area.

Further European records are from Estonia (environs of Tallin, Fischer 1851), Sweden (environs of Uppsala and Säbysjön, and the isle of Öland, Lilljeborg 1883, Alm 1915), Denmark (Jensen 1903), Czechia (central Bohemia, Vávra 1891), Austria (Lower Austria, Löffler 1961, 1963), Hungary (Daday 1900, Farkas 1958, review in Meisch & Forró 1998), and France (one single record, Côte-d'Or department, Paris 1920, Meisch et al. 1990).

In southern Europe, there are records from Greece (Crete, one site, Marrone et al. 2019), Italy (northern and central Italy and Sardinia, Pieri et al. 2015), and northeastern Spain (province of Gerona, Baltanás et al. 1996). Interestingly enough, there is presently no record from the Balkans.

In North Africa, there is a record from one site in Algeria (Blanchard 1891, Moniez 1891). The record from Madeira is here considered somewhat doubtful (Schodduyn 1927).

The occurrence of *S. fischeri* in Turkey deserves a closer look because (a) the species appears to be rather widespread in Anatolia, where it has been reported from 10 of the 81 provinces, from West to East: Bolu (Külköylüoğlu et al. 2010, 2017), Ankara (Yavuzatmaca 2020), Konya (Rasouli et al. 2014), Kırşehir (Külköylüoğlu et al. 2019b), Kahramanmaraş (Külköylüoğlu et al. 2012a), Erzincan (Akdemir & Külköylüoğlu 2014), Diyarbakır (Margaritora et al. 2017, Rasouli et al. 2014), Ağrı (Külköylüoğlu et al. 2019a), Van (Külköylüoğlu et al. 2012b), and Muş (Külköylüoğlu et al. 2020), and (b) it is the only country from where bisexual populations have been reported.

To our best knowledge, the species is unrecorded from outside the Palaearctic and, in particular, it has so far not been reported from subtropical and tropical regions.

4. Discussion

4.1. The genus *Stenocypria* G.W. Müller, 1901

As testified by the presence of a basal triangle on the uropodal attachment (Fig. 10), *Stenocypria* clearly belongs to the subfamily Herpetocypridinae of Cyprididae. This triangle is, indeed, a diagnostic character of the entire subfamily (Triebel 1953, Martens 2001, Shearn et al. 2017).

Within its subfamily, *Stenocypria* belongs to the tribe Stenocypridini Ferguson, 1964, which comprises five genera (Meisch et al. 2019a). A diagnosis of the tribe was provided by Martens (2001) and needs not to be repeated here. *Stenocypria* comes most close to *Stenocypris* Sars, 1889 from which it differs mainly in the characters shown in Table 3.

The genus *Stenocypria* is presently monospecific, comprising the single *Stenocypria fischeri* (Meisch et al. 2019a).

We agree with Martens (2001: 299) that *S. fischeri* – and therefore also the genus *Stenocypria* – sits ‚uncomfortably' in Stenocypridini, as it is the only species in its tribe with (sub)symmetrical u-rami, the latter each with a well developed posterior seta sp.

4.2. Sexual dimorphism of the A2 of *S. fischeri* and the Cypridoidea in general

We successfully used the diagrams by Martens (1987: 187), as reproduced in Meisch (2000: 13) for the identification of the apical claws and setae of the A2 of the adults of both sexes of *S. fischeri*, except, however, for the GM- and Gm-claws of the terminal segment of the male.

Table 3. Differential diagnosis of the genera *Stenocypria* and *Stenocypris*.

	Stenocypria G.W. Müller, 1901	*Stenocypris* Sars, 1889
Valve margins	without septa	with conspicuous septa
Inner posterior valve margin of females	this margin strikingly sinuous	this margin 'normally' rounded (but see Discussion)
Uropodal rami	(sub)symmetrical in shape	distinctly asymmetrical
Posterior margins	each with a row of short setae	one ramus with spines, the other one with short setae
Posterior seta sp	sp well developed	sp missing

We agree with Martens (1987) that the setae and claws keep their exact relative position, when, in the last moult of the male, the sexually dimorphic process involves the transformation of some setae into claws and vice-versa. According to Martens (1987) – and this was apparently accepted by the majority of subsequent authors (e.g., Meisch 2000, Horne et al. 2019, Smith & Chang 2020) – the GM- and Gm-claws remain untransformed in the adult male. Contrary to that observation, we found that in the male of *S. fischeri* the GM-claw is modified into a slender claw, while Gm has become a powerful claw with a comb-like serration (Fig. 12). A similar observation was already made by Karanovic (2006, 2012).

In order to verify the general correctness of that transformation, the first two authors examined the antennae of both adult males and females of six additional species belonging to the Cyprididae and Candonidae (see Material examined). We found that in all these species, the GM-claw of the males was reduced into a slender short claw, while Gm had become a powerful claw. These observations tend to indicate that this sexually dimorphic modification is a general character of the males throughout the Cypridoidea.

In general, we conclude that in the cypridoid male antennae the outermost structures (setae z1, z2 and Gm) are reinforced into claws, while the innermost structures (the claws G1, G3 and GM) are reduced in strength. We agree with Martens (1987) that these modifications most likely have a functional role during the copulation.

Remark. When working on the redescription of *Neglecandona altoides* (Petkovski 1961), the first two authors (CM and BS) were not aware of the sexual dimorphism of the GM- and Gm-claws in the male as corrected here, and therefore the designation of GM and Gm has to be interchanged in the corresponding illustration (Meisch et al. 2019b: Fig. 11A,B).

4.3. Aesthetasc y3 of A2

Upon examining the terminal segment of the A2 of both sexes at high magnification, we could see that the aesthetasc y3 is basally fused with a so far unnamed seta, longer than y3, but which is not the seta g (Fig. 8C). This combined structure was illustrated for *Candona dancaui* Danielopol, 1973 (syn.: *Candona sanociensis* Sywula, 1971) by Danielopol (1978: 40, Fig. 7) but, to our best knowledge, it was not illustrated nor described by any subsequent author. The presence of this structure in a species of the Candonidae as well as the Cyprididae tends to indicate that it is a common feature of the entire Cypridoidea.

4.4. Sexual dimorphism of the posterior inner calcified lamellae

The conspicuous sinuous posterior inner margin of the female valves of *S. fischeri* is due to the lobe-shaped expansion of the posterior inner calcified lamella. This is generally considered a unique and therefore diagnostic feature of the genus *Stenocypria* (Meisch 2000, Martens 2001).

It came therefore as a surprise to us that the valves of the males of *S. fischeri* completely lack that character, as the inner margin narrowly runs 'in parallel' to the outer margin (Fig. 11).

We interprete this dimorphism to be related to the anatomy and/or function of the copulatory organs of the two sexes. A similar dimorphism apparently also exists in other cypridoid ostracods, for instance in *Cryptocandona vavrai* Kaufmann, 1900 (Meisch 2000: Fig. 80B,C), but this needs further investigation.

The question arises whether the lobe-shaped expansion described above also exists in other species of the Herpetocypridinae. As the systematic investigation of this character is beyond the scope of the present work, we restrict our analysis to *Stenocypris major* (Baird, 1859), the type species of the genus *Stenocypris* Sars, 1889, which occurs worldwide in the circum-tropical and warm temperate zones (Martens & Behen 1994, Meisch et al. 2007). Males of *S. major* have so far never been found (Moonchaisook & Savatenalinton 2020).

The screening of the literature for the structure of the valves of *Stenocypris major* revealed the following results. The illustrations of most authors present valves with a narrow inner posterior calcified lamella (e.g., Lowndes 1930: pl. 1: 1-2; Triebel 1953, pl. 1: 1-2); Fox 1965: Fig. 1: g). However, we also found illustrations of valves with (a) a wide lobe-shaped expansion of the inner lamella similar to that seen in *S. fischeri*, e.g., in Ferguson (1969: Fig. 3: 1) and Moonchaisook & Savatenalinton (2020: Figs 1E,G, 9A-D), as well as (b) with a very small calcified expansion, less than 1/3 as wide as the one seen in *S. fischeri* (Victor & Fernando 1979: Figs 196-197).

We presently do not know if this variation in *Stenocypris major* expresses the variability of one given species or if it rather points towards the existence of 'forms' that should be separated at the specific level. Given the world-wide distribution of *S. major* and its clonal composition due to parthenogenesis, we rather tend to adhere to the first hypothesis. An alternative explanation would be that calcification of the posterior inner lamella would continue to develop after the last moult has occurred. Already Klie (1932) and more recently Moonchaisook & Savatenalinton (2020) drew the attention to the fact that, in *Stenocypris major*, freshly moulted individuals show marginal valve zones – the area with the marginal septa – that differ in their structure from those of older adults. This might also be the case of the calcification of the posterior inner valve lamella of *S. major,* a process that would only be completed some time after the last moult has occurred.

5. Conclusion

Within Herpetocyprinae *Stenocypria fischeri* is readily recognized by the following combined characters: the absence of marginal septa, the (sub)symmetrical shape of the u-rami, and the conspicuous lobe-shaped expansion of the calcified posterior lamella of the female. This expansion is missing in the male.

A similar but less wide expansion is also seen in at least part of the individuals of *Stenocypris major* (Baird, 1859), the type species of the genus *Stenocypris* (G.W. Müller, 1912), described in the literature. The taxonomic significance of this variation remains unknown.

Stenocypria fischeri is confirmed to belong to the separate, monospecific genus *Stenocypria*, which, however, stands somewhat aside in the tribe Herpetocypridini because of the characters mentioned above.

Stenocypria fischeri reproduces through geographical parthenogenesis, with all-female populations occurring throughout the entire Palaearctic and two bisexual populations so far recorded from Turkey. More sexually reproducing populations are expected to occur in Turkey, and probably also in the Middle East.

In addition to the male bristles (transformed t2- and t3-setae), the sexual dimorphism of the male antenna of *Stenocypria fischeri,* and the Cypridoidea in general, involves the reinforcement of the distal outermost structures: setae z1 and z2 become powerful claws, while the innermost structures, the claws G1, G3 and GM are reduced in strength. These modifications most likely have a functional role during copulation.

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