New bisexual form of *Cavernocypris subterranea* (Wolf, 1920) (Crustacea, Ostracoda) from Idaho

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NEW BISEXUAL FORM OF CAVERNOCYPRIS SUBTERRANEA (WOLF, 1920) (CRUSTACEA, OSTRACODA) FROM IDAHO

Okan Kulkanlioglu and Gary L. Vinyard

ABSTRACT.—Males of Cavernocypris subterranea were found for the first time in an Idaho spring. The bisexual form is described based on soft body parts and valves. The genus Cavernocypris now includes 2 bisexual and 1 parthenogenetic species.

Key words: Cypridopsinae, Cavernocypris subterranea, crenobiont, bisexual form, ecology, Idaho.

A recent revision of the genus Cavernocypris Hartmann (Ostracoda, Cypridopsinae) by Marmonier et al. (1989) suggested that this genus contains 3 species: Cavernocypris subterranea (Wolf 1920), C. coreana (McKenzie 1972), and C. wardi Marmonier, Meisch, and Danielopol, 1989. Of these, only C. coreana and its subspecies C. coreana elongata in South Korea have been reported to exist in bisexual populations (McKenzie 1972, Marmonier et al. 1989). Parthenogenetic populations of C. subterranea are known from Europe and central Asia, and parthenogenetic C. wardi has been reported from the western United States (Marmonier et al. 1989, Forester 1991, Ward et al. 1994). An undescribed species, Cavernocypris, n. sp., has also been reported from Arizona (Danielopol et al. 1994).

This study presents the first report of the bisexual form of Cavernocypris subterranea and provides the first description of males of the species.

MATERIALS AND METHODS

We collected 25 individuals (8 males and 17 females) on 4 August 1993 from Head Spring, near Brush Creek, in Malad City, Snake Valley, Bannock County (T11S, R38E, Sec 7), Idaho. Specimens were collected using a hand dip-net with a mesh size approximately 1 mm², preserved in 10% formalin, and subsequently stored in 70% ethanol. After isolating ostracods from the samples, we dissected specimens and mounted them in lactophenol. Species identification is based both on soft body parts and valves. Ecological and physical data collected from the collection site are shown in Table 1. All materials have been retained in the Department of Biology, University of Nevada, Reno, except for 7 specimens deposited at the Musée National d'Histoire Naturelle, Luxembourg, by Dr. Claude Meisch.

DESCRIPTION

In general, modern ostracods are described based on their soft body parts and valves. Detailed information about the terminology and more description of the parts can be found in Moore (1961) and Van Morkhoven (1962).

MALE.—Shell, viewed dorsally, is elongate and the width less than half the length. There is no double-folded inner list on the posterior margin of the left valve (LV, and LV (range, 0.67–0.73 mm) is slightly longer than the right valve (RV; range, 0.63–0.73 mm). Height (H) is less than half the length (L; range, 0.26–0.34 mm) and approximately equal to the width (W; range, 0.27–0.33 mm). In lateral view (Figs. 1A, 1B), valves are elongate and LV overlaps RV both anteriorly and posteriorly. The posterior end is slightly narrower than the anterior, but both are rounded in dorsal view. The fused zone of the inner lamella is wider at the ends and broader anterioventrally. Valves are whitish-opaque and smooth. In some European specimens the valves may have a dorsa-median band with pits. Some individuals may lack this band (C. Meisch, Luxembourg, personal communication).
TABLE 1. Ecological and physical data collected from the study site.

<table>
<thead>
<tr>
<th>Name and location</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Elevation</th>
<th>Water temperature</th>
<th>Conductivity</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head Spring, Malad City, Snake Valley, Bannock County, Idaho; T11S, R38E, Sec 7</td>
<td>42°48'43&quot; N</td>
<td>112°06'09&quot; W</td>
<td>1842 m</td>
<td>9.6°C</td>
<td>528 μS/cm</td>
<td>7.73</td>
</tr>
</tbody>
</table>

communication). In our specimens decalcification has destroyed this pitted area if it was present.

The 1st antenna (Fig. 1C) or antennula (a1) has 7 segments (joints) with long natatory setae (as in females). Numbers of setae on each segment of a1 are 3:1:1–2:3:4–5:4:4. Unlike females, there is no row of delicate setae on the 1st segment of a1 of male specimens. The rima organ (r) is poorly developed.

The 2nd antenna (a2) is 4-segmented (Fig. 1D). Swimming setae of a2 on the 2nd segment are reduced to 6 small setae, 5 of which

Fig. 1. Cavernocypris subterranea: A, left valve of male (inner view); B, right valve of female (inner view); C, 1st antenna (antennula) (a1); D, last 3 joints of 2nd antenna (a2) (2nd joint bears 5 short and 1 longer setae); E, mandibula; F, mandibular palp; G, rake-like organ with 7 teeth.
barely extend to the proximal margin of the penultimate joint or podomere (3rd segment). The 1st dorsally located natatory seta extends halfway up the penultimate joint (as in females). All sensory clubs “aesthetasc” (Y, y₁, y₂, y₃) are present. The aesthetasc Y is 1-segmented and its length equal to 33% of the dorsal edge of the 2nd segment and 37% of the ventral edge of the 2nd segment. The t and z setae are reduced on the 3rd segment. Claws G₁ and G₂ are about equal in length, 2/3 longer than G₃ and 5/12 longer than the 2nd segment. Claws are serrate. Length of the GM claw on the 4th segment is about equal to G₃ and 38% longer than the claw Gm that is about the same size as or slightly longer than y₃.

The mandibula (Fig. 1E) ends with 6 teeth and 3 small setae, 1 hairy and 2 smooth. There are also 2 other setae, k₁ and k₂. The position of k₁ is between the 1st and 2nd teeth, and k₂ is between the 2nd and 3rd.

The mandibular palp (Mdₚ) is 4-segmented with a respiratory plate (Fig. 1F). The α, β, and γ setae are present on the 1st, 2nd, and 3rd segments, respectively. The 1st segment also carries 1 long seta and S₁ seta, but the S₂ seta is reduced or absent. The β seta on the 2nd segment and the γ seta on the 3rd segment are feathery while the α seta is small and smooth. There are also 2 small and 2 long setae on the 2nd segment, which reach almost to the tips of the claws. The 3rd segment has 2 groups of setae, 8 total. In the 1st (dorsal) group are 2 small and 2 medium setae, whereas the 2nd (ventral) group has 4 setae, all similar in size. The 4th segment has 2 claws and 2 setae.
The maxilla (Max) is formed as left and right prehensile palps with 10–12 medium-sized apical setae placed on the opposite end of the endopodite. Right prehensile palp (Fig. 2A) is slightly larger than left (Fig. 2B). The subterminal segment of the left palp has 2 small, clawlike setae (1 on the right palp). Two feathery branchial filaments are seen on the exopodite plate, a diagnostic character of the species. Two small setae (2a) are also seen on the opposite side.

The maxillula (MaxI) (Fig. 2D) bears 3 masticatory processes and 1 maxillular palp (the 4th joint). The terminal segment of the palp is rectangular in outline with 5–6 setae, 1 of which is always small. The length of the 2nd segment of the palp is twice its width. The outer (3rd) masticatory process of the maxillula has 2 spinelike setae and is scarcely toothed.

The 1st thoracopod (T1, walking leg) has a long, faintly toothed distal claw (Fig. 3A), its length nearly equal that of all 4 segments. The distal seta of the penultimate segment is long and well developed. In addition to the distal claw, the 4th segment bears 1 small seta. The 2nd thoracopod (T2) with 4 segments is ended with 1 pincer organ, 1 well-developed seta (or 2 small setae), and 1 beaklike claw (Fig. 3B). No serrate setae occur.

A flagellum-like furca is absent in males but present in females. A small hook-shaped seta is located on the proximal part of the furca. The rake-shaped organ (Fig. 1G) is T-shaped and has 7 teeth.

The Zenker organ has 11 spinous whorls (Fig. 2E), and 1 specimen of 3 shows 3 Zenker organs rather than 2. The hemipenis (Fig. 2F) is of cypridopsine type and subtriangular in shape. The base of the lateral shield (Is) of the peniferum is straight, the medial shield rounded.

**FEMALE.**—Shape and surface structure of the valves are as in males (Fig. 1B). Mean length and width of the shell of 12 females were smaller than that of males: L = 0.67–0.69 mm, H = 0.20–0.30 mm, W = 0.20–0.26 mm. A row of delicate setae is found on the 1st segment of a1. The 3rd segment has 2 setae (1 is reduced in males). Claws G1, G2, and G3 on a2 are subequal. The maxilla is shaped normally and not formed into palps (Fig. 2C). Flagellum-like furca is present (Fig. 2G). Other appendages are similar to those reported by Marmonier et al. (1989).
TABLE 2. Comparison of males of the species C. coreana and C. subterranea.

<table>
<thead>
<tr>
<th>Character</th>
<th>C. coreana</th>
<th>C. subterranea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>0.66 mm (elongata)</td>
<td>0.70 mm</td>
</tr>
<tr>
<td>a1</td>
<td>6-segment</td>
<td>7-segment</td>
</tr>
<tr>
<td>G3 claw</td>
<td>short seta</td>
<td>normal</td>
</tr>
<tr>
<td>t and z setae</td>
<td>present</td>
<td>reduced/absent</td>
</tr>
<tr>
<td>Aesthetasc Y</td>
<td>long. 2-segment</td>
<td>1-segment</td>
</tr>
<tr>
<td>Maxilla</td>
<td>with 4 filaments</td>
<td>2 filaments</td>
</tr>
<tr>
<td>Zenker organ</td>
<td>6–8 whors (elongata)</td>
<td>11 whors</td>
</tr>
<tr>
<td>Lateral shield</td>
<td>duck-head shaped</td>
<td>spatula shaped</td>
</tr>
<tr>
<td>Habitat</td>
<td>cave waters</td>
<td>cold springs, rivers, caves, mountain lakes</td>
</tr>
</tbody>
</table>

Fig. 4. Cavernocypri$ coreana elongata (male): A, right valve; B, right prehensile palp; C, left prehensile palp; D, right hemipenis, inner view (from Marmonier et al. 1989 with permission of Dr. Claude Meisch).

DISCUSSION

Determination of sexual dimorphism in Cavernocypris subterranea is based on the occurrence of reproductive organs and furca, size of the shell, shape of the maxilla, and differences in the length of claws (G1, G2, G3). The description of females of C. subterranea by Marmonier et al. (1989) also included descriptions of 2 additional species. Of these, C. coreana is bisexual. The males of these 2 species (Table 2) can be compared as follows: (1) C. coreana (Fig. 4A) is smaller than C. subterranea; (2) a1 is 7-segmented in C. subterranea, but 6-segmented in C. coreana; (3) the G3 claw on the antenna is reduced to a tiny, short seta in C. coreana, but G3 is normal and clawlike in C. subterranea. The t and z setae are reduced in C. subterranea while C. coreana has 2 t and 2 z setae; (4) C. subterranea has 2 branchial filaments on the exopodite plate of the maxilla, but C. coreana has 4 branchial filaments (Fig. 4B, 4C); (5) the lateral shield of the hemipenis (Fig. 4D) is duck-head shaped in C. coreana but spatulate shaped in C. subterranea; (6) Zenker organ 11
whorled in *C. subterranea*, but 8–9 whorls in *C. coreana coreana*, and 6–8 in *C. coreana elongata*, which can also bear 12 whorls (Marmonier et al. 1989). Although 1 of our specimens had 3 Zenker organs, this is considered aberrant and is not used for comparison of these 2 species. However, this characteristic may be important if the condition is found to be common. Morphological and anatomical anomalies of some freshwater ostracods (C. Meisch personal communication) were reported from Sweden and Poland after the Chernobyl accident (B. Scharf, Germany, personal communication), but the presence of 3 Zenker organs was not observed. Further studies are needed to assess causal factors for this anomaly. Habitats of these 2 species are different. *C. coreana* is known only from the cold limestone cave waters in Korea, while *C. subterranea* is crenobiont and occupies a wider range of environments including cold spring waters, river and alluvial bed sediments, caves, and the littoral zone of mountain lakes (Marmonier et al. 1989).

Based on these differences, we propose that the bisexual form of *C. subterranea* is congeneric with the bisexual forms of *C. coreana*, but not conspecific. They constitute 2 distinct species.

**CONCLUSIONS**

Twenty-five (8 males and 17 females) individuals of the species *Cavernocypris subterranea* were examined. The bisexual form of *C. subterranea* was found in a cold water spring in Idaho and is described for the first time. Description of the males is based on valves, soft body parts, and comparison with the other known bisexual form, *C. coreana*. Differences of morphological characters, structures, and ecological parameters indicate that males of *C. subterranea* are different from males of *C. coreana*, but the same as parthenogenetic females of *C. subterranea* found in Europe.

**ACKNOWLEDGMENTS**

We thank Dr. Claude Meisch (Musée National d’Histoire Naturelle, Luxembourg) for his help, comments, and encouragement as we prepared this study. Thanks are also given to Dr. Dinger Gülen and his colleagues at the University of Istanbul (Turkey) for their comments and assistance obtaining the camera lucida, to Dr. Burkhard Scharf (Department of Inland Water Research, Germany) for personal communication, and to Robert Schroeter (University of Nevada–Reno, USA) for his review of an early draft of this manuscript.

**REFERENCES**


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