



## A new stygobitic genus and species of Cyclopinae (Crustacea, Copepoda, Cyclopoida), from the epikarst of Scrivilleri Cave, Sicily (Italy)

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### Abstract

A new genus and species of Cyclopinae, *Korecyclops alpha* **gen. nov. sp. nov.**, is described based on specimens retrieved from the epikarstic drip collecting in a rimstone pool of a Sicilian cave (Southern Italy). The new monotypic genus is characterized by the number of spines and setae on second segments of Exp P1–P4: 3.3.3.2, and 5.5.5.5, respectively; and by the number of spines and setae on second segments of Enp P1–P4: 1.1.1.1 and 4.5.5.4, respectively. *Korecyclops alpha* **gen. nov. sp. nov.** is an epikarstic, stygobitic species whose morphological characters associated with the size and oligomerisation of the appendages, relate it to the *Microcyclops* group Pesce 1996, as recently discussed by Boonyanusith *et al.* (2018), to the *Metacyclops* complex Karanovic *et al.* 2011, and to *Pseudohesperocyclops* Brancelj, Boonyanusith & Sanoamuang 2024. The strongest morphological affinities of the new species are with the genus *Pseudohesperocyclops*, but the two genera differ in the spinal formula of P1–P4 exp-2 and in the setal formula of P1–P4 enp-2, in the position and length ration of the ornamentation of P5 exopodal seta and spine, in the body shape and spermatophore shape. *Korecyclops alpha* **gen. nov. sp. nov.** represents a contribution to the knowledge of the diversity and of the low-range endemism of the groundwater taxa of the Sicilian karst; the discovery of this new genus reinforces the need of further investigating and protecting the epikarstic and karstic habitats. Some peculiar morphological and ethological adaptations of copepod fauna to life and colonization of the epikarst are presented and discussed. The existing species list of Sicily is updated by presenting unpublished data on the crustacean populations of groundwater of Sicily and some circum-Sicilian islands.

**Key words:** Sicilian fauna, new genus, crustacean stygofauna, *Korecyclops*, epikarst, *Metacyclops*, *Pseudohesperocyclops*

### Introduction

Sicily, the largest Mediterranean island, covering an area of approximately 25.832 km<sup>2</sup>, has a long and complex geological history: more than 20% of the island surface is classified as karst, and the karstification process has created numerous caves in the carbonatic and in the evaporitic rock. Due to the presence of Mount Etna, which is an active volcano, numerous lava caves are also present in the area surrounding the volcano, which contribute to increasing the geological diversity of the island. These numerous and diverse subterranean environments sustain a remarkable biodiversity; the species that inhabit them are quite numerous and often endemic, but the study of the different characteristics of the Sicilian subterranean fauna, including those aimed at the protection and conservation of terrestrial and aquatic fauna and related habitats, is challenging. Indeed, despite the island catalogue of cavities lists about 1170 caves (in carbonatic, evaporitic, volcanic substrates), the existing records of troglobitic and stygobitic species are currently limited to roughly 200 surveyed cavities.

Our research group has been studying and exploring Sicilian caves for several years, paying particular attention to aquatic arthropods, especially copepods. Indeed, we have been investigating the vadose zone, or epikarst, of four Sicilian caves and also, to improve the biogeographical interpretation, of five caves in Calabria (Southern Italy) (Cottarelli *et al.* 2012; Bruno *et al.* 2017, 2020, 2023). The research carried out to date in Sicily, albeit fragmentary, has already provided information on the diversity of groundwater habitats and of the low-range endemisms of the groundwater taxa of the island (Bruno *et al.* 2023). Although the core of our research in Sicily is devoted to collecting and studying copepod stygofauna, the hyporheic habitat of some Sicilian watercourses has also been explored and sampled (Cottarelli, unpublished data). The copepod fauna of groundwater aquifers, accessible from wells, was studied in relatively recent times by Pesce (1987), Pesce & Galassi (1987, 1988), Pesce *et al.* (1987, 1988). A checklist and distribution of the crustacean fauna of Sicilian groundwater was recently published (Pendino *et al.* 2024), and it includes details on the distribution of all the known Sicilian groundwater copepods.

Our research in Sicily has so far contributed several studies focused specifically on epikarstic harpacticoids, although we also reported and discussed the first discovery of the stygobitic *Speocyclops italicus* Kiefer 1938 from Molara Cave in Cottarelli *et al.* (2012). The present paper is the first one exclusively addressed to the study of cyclopoids: we describe and discuss one new species belonging to a new genus: *Korecyclops alpha* **gen. nov., sp. nov.** This stygobitic genus and species is endemic to Sicily and colonizes the epikarst, having been collected in the percolating waters of the Scrivilleri Cave, a well-known cavity in the Climiti Mountains in the province of Siracusa, whose copepod fauna was collected and studied for the first time by our research group (Bruno *et al.*, 2023): the new species is indeed cited as *Metacyclops* sp. in Bruno *et al.* (2023) and in Pendino *et al.* (2024).

The new monotypic genus described here, *Korecyclops alpha* **gen. nov., sp. nov.**, is represented by an epikarstic, stygobitic species whose morphological characters, such as those related to the size and oligomerisation of the appendages, relate it, as it will be discussed below, to the *Microcyclops* group Pesce 1996, to the *Metacyclops* complex Karanovic *et al.* 2011, and to the genus *Pseudohesperocyclops* Brancelj, Boonyanusith & Sanoamuang 2024. The new genus in our opinion, and in agreement with Brancelj (2009), belongs to the large group of taxa that, thanks to particular adaptations “are frequent in unsaturated zones of karst, especially in epikarst in temperate zones”.

We therefore aim to:

- 1) describe the new genus and species, define and specify its taxonomic position;
- 2) identify and discuss the morphological adaptations to the epikarstic habitat of the new species, with particular attention to its distinctive features;
- 3) present unpublished records of groundwater crustaceans from our personal, still unpublished, research (e.g., faunistic records from the small islands of Marettimo and Favignana), to complete and correct the recent checklist of the groundwater crustacean fauna from Sicily compiled by Pendino *et al.* (2024).

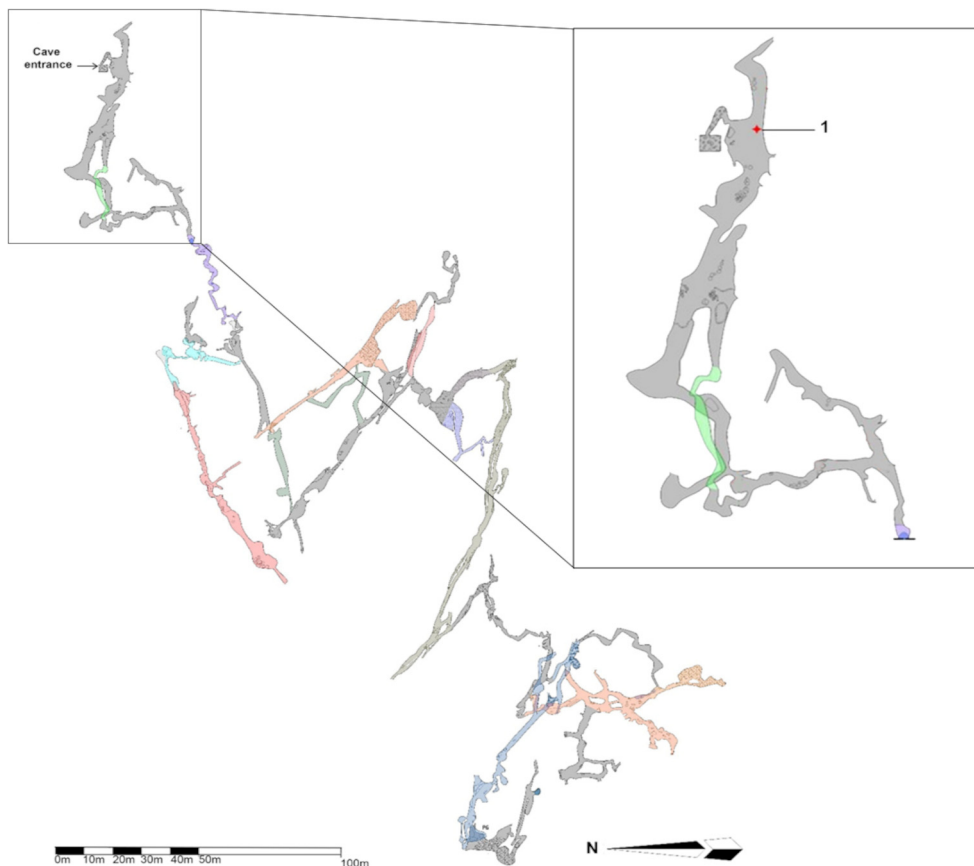
## Materials and Methods

### Site description and sampling methods

The “Grotta Scrivilleri” (Scrivilleri Cave, cadastral number: SI SR 7003) is one of the largest Sicilian limestone caves, located in the municipality of Priolo Gargallo, Province of Siracusa, opening at 4.2 km from the coast. The area is characterized by karst morphologies and horizontal caves, created by the oscillations of the sea level and the modification of the coastline which occurred during the Quaternary (Cavallaro 1998); the cave develops for 2.2 km, mainly in the horizontal direction (Figure 1). A detailed description of morphology and geology of Scrivilleri cave is provided in Bruno *et al.* (2023). The area is characterized by a Mediterranean climate with hot, dry summers and mild to cool, wet winters with usually low or no precipitation period extending from the end of May to the end of August, corresponding to a strong increase in air temperature; most of the streams are temporary and during rainfall events most of the water quickly infiltrates into the karstic system due to the high permeability of the limestone layer.

In Scrivilleri Cave there are no subterranean streams, and all the water originates from the surface (during rainfall events and/or, as it is the case of Scrivilleri Cave, crop irrigation), percolates into the epikarst, and drops to saturate the soil of the cave floor. Specimens were collected from one pool (reported as pool 1 in Bruno *et al.* 2023)

(Figure 1); the cave was sampled four times but pool 1 was filled with water dripping from the epikarst only on 23/VIII/2020, when the pool had a surface area of approximately 4 m<sup>2</sup> and water depth of approximately 1 cm. In the subsequent sampling events (08/XII/2020, 20/II/2021, 06/VIII/2021) the pool was dry, but on 06/VIII/2021 water was present in some “micro-pools” 2–3 cm wide and 2 cm deep, formed by the water drops falling from the ceiling because of the irrigation of the cropland above the cave. All the water present in the pool or in the micro-pools was collected with a syringe following Brancelj (2003). Samples were stored in cooled containers and transported to the laboratory where they were sorted within 48 hours.



**FIGURE 1.** Full planimetry of the Scrivilleri Cave; insert: detail of the first branch of the cave, and location of the sampling pool. Source: topographical survey 1996–2013, Centro Speloelologico Etneo (G. Giudice), Gruppo Speleologico Sircusano (G. Spitaleri, C. Bongiorno), Speleo Club Ibleo (F. Zaccaria). Modified with permission of the Speleo Club Ibleo.

## Morphological methods

All specimens were sorted alive under a stereomicroscope, placed individually in 70% ethanol, and stored refrigerated. Before morphological analyses, specimens were rinsed in distilled water, dissected and mounted in Faure’s medium solution between two cover slips to allow observations from both sides. Illustrations were made at different magnifications up to a maximum of 1250 X, using drawing tubes mounted on a Zeiss Axioskop® phase-contrast microscope and a Polyvar Reichert-Jung® interferential-contrast microscope.

Specimens of the type series are deposited at La Specola Museum of Natural History, Zoology Section Florence, Italy (MZUF). The taxonomic descriptions and the authority of the new species are the sole responsibility of VC and MCB. Authorship of the new species should be cited as “Cottarelli & Bruno” in Cottarelli *et al.*, 2026 (following the International Commission on Zoological Nomenclature, Recommendation 51E).

The following abbreviations are used throughout the text and figures: ae = aesthetasc; enp: endopod; enp-1 (2) = proximal (distal) segment of endopod of swimming legs; exp: exopod; exp-1 (2) = proximal (distal) segment of exopod of swimming legs; A1: antennule; A2: antenna; Pd1–Pd6: pedigers 1–6; P1–P6: first to sixth pereopod; seta I–VII = first to seventh caudal setae (seta I = anterolateral accessory seta; seta II = anterolateral seta; seta III =

postereolateral seta; seta IV = outer terminal seta; seta V = inner terminal seta; seta VI = terminal accessory seta; seta VII = dorsal seta)

The nomenclature and descriptive terminology follow Huys & Boxshall (1991); the terminology and homologisation of maxillary and maxillipedal structures follow Ferrari & Ivanenko (2001, 2008).

## Taxonomic Results

### Subclass Copepoda H. Milne Edwards

### Order Cyclopoida Burmeister 1834

### Family Cyclopidae Dana 1846

### Subfamily Cyclopinae Burmeister 1834

#### *Korecyclops*, new genus

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Synonyms: *Metacyclops* sp. in Bruno *et al.* 2023, Pendino *et al.* 2024.

Diagnosis. Female: small Cyclopinae, with typical cyclopoid habitus; body slightly elongated, greatest width at posterior margin of cephalothorax. Antennule 11-segmented, short, not reaching posterior margin of cephalothorax. Genital double somite wider than long; incision between anterior and posterior half of segment dorsally and ventrally visible. P5 composed of baseoendopod completely fused to Pd5 to form protopod carrying a well-developed outer basal seta, and one-segmented exopod, separated from Pd5, cylindrical and as short as wide, carrying one spine and one long seta apically; spine and seta not adjacent. P6 inserted lateroventrally, represented by a rectangular plate carrying one strong triangular tip and two short setae of different length on the distal margin. Anal operculum strongly developed, rectangular in shape but with rounded distal corners, margin smooth. Caudal rami short, approximately rectangular, armed with six setae and longitudinal dorsal keel. Antenna four-segmented, coxobasis of antenna with short seta representing exopodite remnant and two abexopodal elements. Mandibular palp with two very long plumose setae and short, bare seta. Intercoxal sclerites of P1–P4 without ornamentation. Coxae of P1–P4 with plumose seta on inner corner. Inner (median) corner of P1 basis with well-discernible round apophysis ornamented with hair; inner (median) corners of P2–P4 basis with pointed apophysis and transversal row of fine hair. P1–P4 with 2-segmented Exp and Enp, similar in length. Number of spines and setae on second segments of Exp P1–P4: 3.3.3.2, and 5.5.5.5, respectively; number of spines and setae on second segments of Enp P1–P4: 1.1.1.1 and 4.5.5.4, respectively. P1 Enp-2 with strong apical spine bent at almost 90°.

Male: Habitus similar to the female but proportionally smaller; caudal rami as in female. A1 16-segmented, digeniculate, suture between 2 distalmost articles still discernible. Shape of the basis inner (median) corner of P1–P4, armature and ornamentation of P1–P5 as in female except for the distal spine of P4 enp-2 which is proportionally longer than in female. Genital somite round, wider than long; P6 a small triangular plate fused to the somite, armed with strong spine and slightly longer seta. Spermatophore quadrangular with short, thin neck.

Type species: *Korecyclops* **sp. nov.** (by original designation)

Etymology. The generic name is derived from Kore (Greek Κόρη), one of the names of the goddess Persephone, a divinity of the underworld in ancient Greece and Magna Graecia, and therefore worshipped in Sicily: it was believed that in the meadows of Enna, a well-known Sicilian city, the goddess returned every six months to her mother Demeter, thus making the earth flourish again. The genus name is masculine, composed of “Kore” and the existing generic name *Cyclops* O. F. Muller, 1776.

***Korecyclops alpha* sp. nov.**

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Type locality. Sicily, Siracusa Province (Italy), Scrivilleri Cave (37°08'29"N, 15°09'36"E), pool 1.

Type material. Holotype: adult female, dissected, mounted on one slide labelled: *Korecyclops alpha*, holotype female (MZUF 747), pool number 1, 06/VIII/2021. Allotype: adult male, dissected, mounted on one slide labelled: *Korecyclops alpha*, allotype male (MZUF 748), pool number 1, 06/VIII/2021. Paratypes: four females, dissected, each mounted on one slide labelled: *Korecyclops alpha*, paratype female (MZUF 749, 750, 751, 752), pool number 1, 06/VIII/2021; two females, undissected, each mounted on one slide labelled: *Korecyclops alpha*, paratype female (MZUF 754, 755), pool number 1, 23/VIII/2020; one female, dissected, mounted on one slide labelled: *Korecyclops alpha*, paratype female (MZUF 753), pool number 1, 23/VIII/2020; four males, undissected, each mounted on one slide labelled: *Korecyclops alpha*, paratype male (MZUF 756, 757, 758, 759), pool number 1, 23/VIII/2020.

All material collected by Rosario Grasso, Maria Teresa Spena, Daniele Vincenzo Caccamo, and Diana Sapuppo.

Etymology. The species epithet is the name of the first letter of the Greek alphabet, because this is the first species described for the genus.

Description of female. Habitus as in Figures 2A, 10A. Preserved specimens colourless, naupliar eye not discernible. Total body length (of specimen in Figure 2A) measured from tip of rostrum to posterior margin of caudal rami, 631 µm (mean: 632 µm; n= 6); prosome to urosome length ratio about 1.2 (Figure 2A). Total body length to width ratio about 2.3. Cephalothorax slightly shorter than wide, representing 35% of body length, with the greatest width at the posterior margin. Integument covered with small circular pores (Figures 2A, 3A, 3D), not strongly chitinized, without cuticular windows. Hyaline free margins of Pd1–Pd3 dorsally smooth. First two free urosomites (urosomites 3 and 4) with serrated hyaline free margin (Figures 2A, 10A, 10E). Genital double somite about 1.4 times as wide as long, tapering posteriorly, with trace of ancestral division discernible ventrally and dorsally (Figures 3A, 3B, 3C, 3D, 10C, 10E, 10F), with hyaline free margin ventrally slightly serrated (Figures 3A, 10C, 10E). Copulatory pore small, opening at 1/2 the length of somite (Figures 3A, 3B, 10C, 10E, 10F). Seminal receptacle large; discernible only in posterior segment, roundish, extended laterally in two lobes (Figure 3C).

Anal somite (Figures 3E, 3F, 10C): distal margin laterally serrated, with rows of denticles extending from the sides of the operculum laterally.

Anal operculum (Figures 3E, 3F): well developed, rectangular with rounded corners, free margin smooth, with two basal sensilla.

Caudal rami (Figures 3E, 3F, 10C): longer than anal somite, slightly enlarged proximally and slightly divergent, about 2.1 times as long as wide, with dorsal keel (Figure 3F) and ventral integumental pore near the insertion of ramus (Figure 3E). Anterolateral accessory seta (I) apparently absent. Anterolateral seta (II) inserted at 2/3 length of caudal ramus, seta/caudal ramus length about 0.5. Posterolateral seta (III) robust, bipinnate, seta/caudal ramus length about 1.35. Outer terminal seta (IV) plumose, about 4.0 times as long as caudal ramus, without breaking plane. Inner terminal seta (V) plumose, without breaking plane, 5.5 times the caudal ramus length. Terminal accessory seta (VI) slim, seta/caudal ramus length about 0.7. Dorsal seta (VII) articulated, inserted near base of inner terminal seta (V), seta/caudal ramus length about 1.1.

Rostrum (Figure 4B): triangular, small, with rounded tip, with two latero-basal sensilla and two dorsal papillae.

Antennule (Figure 4A): 11-segmented, not reaching posterior margin of cephalothorax (Figure 2A). Armature formula: 1-[9], 2-[4], 3-[5], 4-[2], 5-[2+I], 6-[2], 7-[3], 8-[2+ae], 9-[3], 10-[3], 11-[7+ae]. Segments 2, 4 and 5 short; segment 5 with spiniform seta on distal corner (arrowed in figure 4A). Aesthetascs on segments 8 and 11 small, shorter than the adjacent setae; distal acrothek on segment 11.

Antenna (Figure 2C): four-segmented, composed of coxobasis, and three-segmented endopod. Coxobasis bearing two abexopodal smooth setae of different length; exopodal seta present, pinnate, short, approximately as long as enp-1. Enp-1 with seta inserted at about ¾ of the inner margin; enp-2 about 1.5 times as long as wide, with five inner setae: one inserted at midsegment, the longest one, geniculate, inserted on distal inner corner and the remaining three near its base; enp-3 as long as enp-2 but thinner, with seven terminal setae, the two apical ones long ad strong. All endopodal segments with outer longitudinal spinule row.

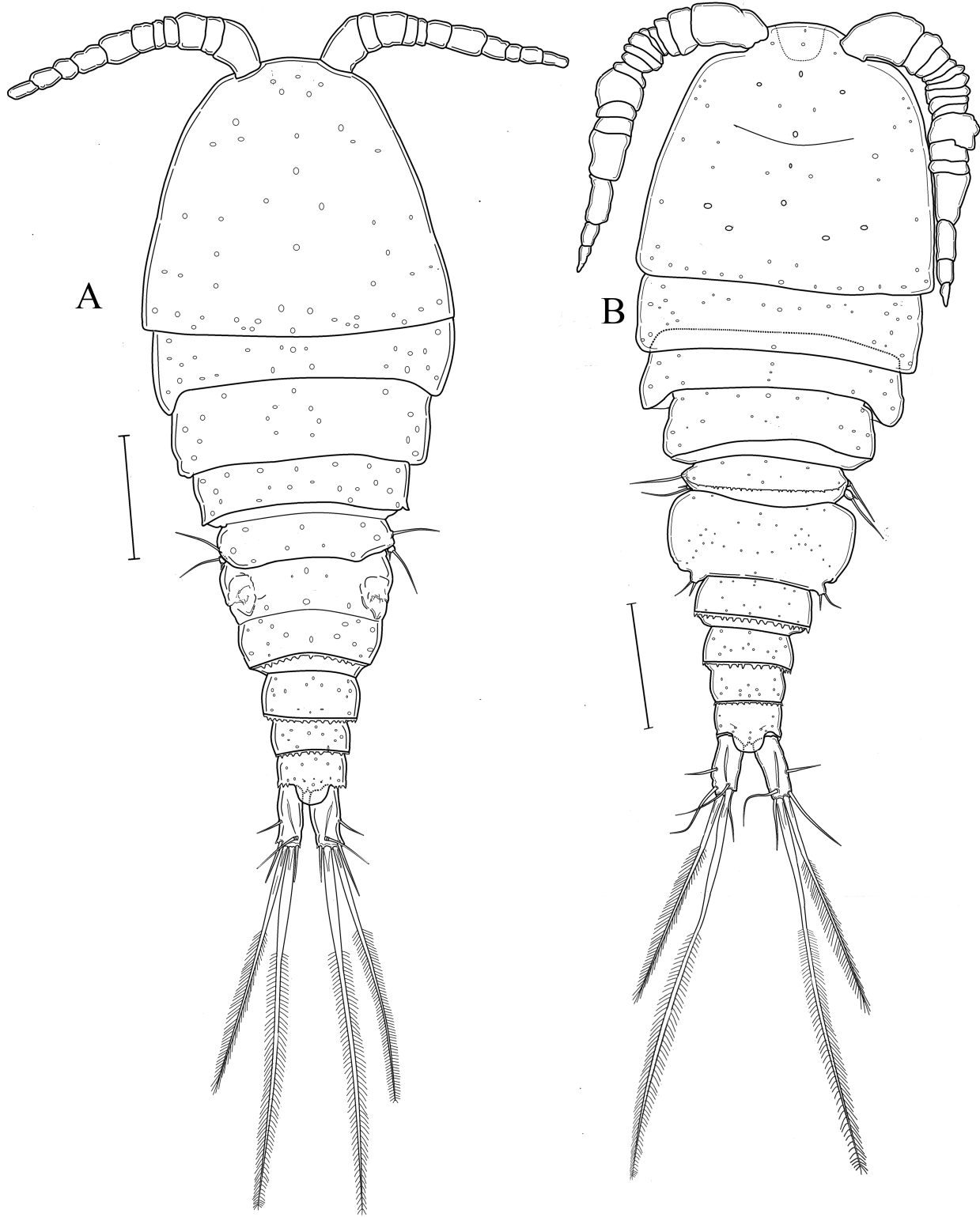
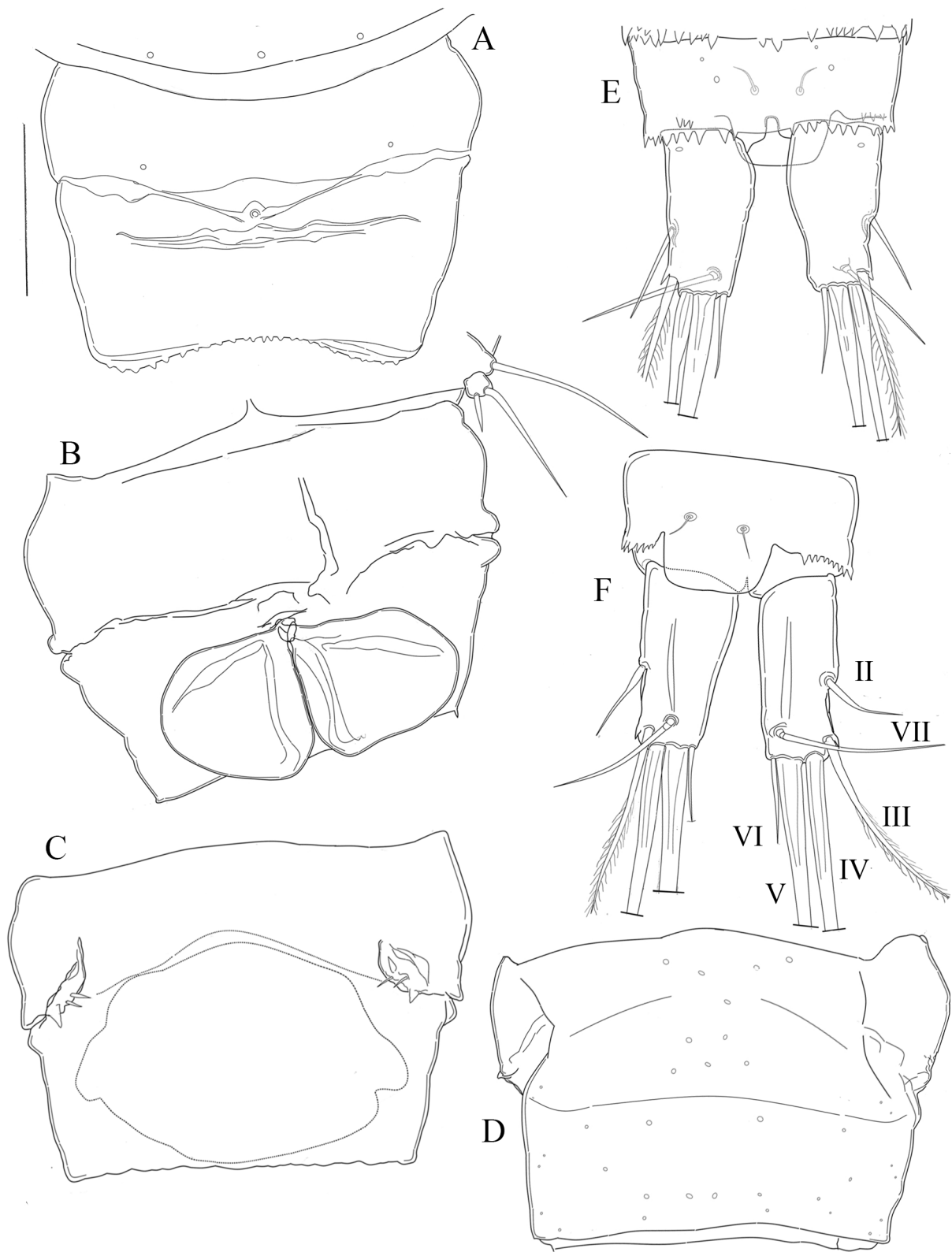
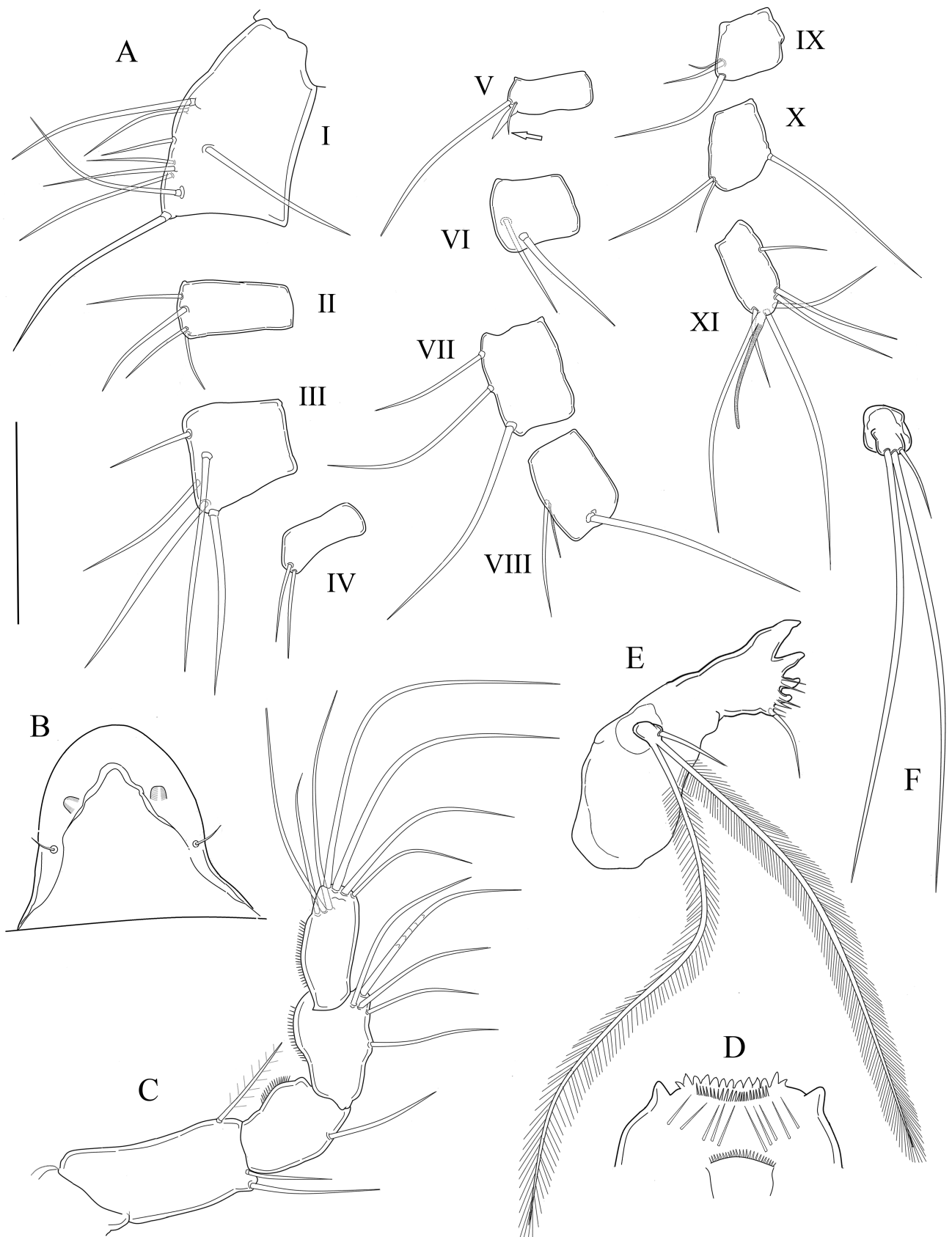


FIGURE 2. *Korecyclops alpha* sp. nov. A) female, habitus, dorsal view; B) male, habitus, dorsal view. Scale bar: 100 micrometers.



**FIGURE 3.** *Korecyclops alpha* sp. nov. Female. A) genital double somite, genital field, ventral view; B) genital double somite, copulatory pore, spermatophores, P5, ventral view; C) genital double somite, seminal receptacle, P6, dorsal view; D) genital double somite, dorsal view; E) anal somite, anal operculum and caudal rami, ventral view; F) anal somite, anal operculum and caudal rami, dorsal view; Scale bar: 50 micrometers.



**FIGURE 4.** *Korecyclops alpha* sp. nov. A–E: female; F :male. A) antennule, disarticulated, dorsal view (antennular segments marked with roman numerals); B) rostrum; C) antenna; D) labrum; E) mandible; F) mandibular palp (schematic). Scale bar: 50 micrometers.

Labrum (Figure 2D): trapezoidal, ventrally ornamented with (basal to distal) one transversal row of spinules, one transversal row of few, long setulae, one transversal row of larger spinules at the base of the cutting edge. Cutting edge almost straight, with 13 large and more or less sharp teeth between sharply produced lateral corners.

Mandible (Figure 4E): coxa strong and curved. Gnathobase with four strong, pointed and chitinized teeth, the ventral one the largest, the remaining ones decreasing in size, and curved seta on lateral outer corner; six thin, straight needle-like setae aligned from the insertion of the third tooth to the outer corner. Basis reduced to small mandibular palp armed on distal end with two very long pinnate setae representing exopod; endopod reduced to short (about 1/9 the length of the exopodal setae), smooth seta.

Maxillule (Figures 5A, 5B): composed of well-developed, quadrangular praecoxa (Figure 5A) and two-segmented palp (Figure 5B). Arthrite of praecoxa with three strong and smooth apical claw-like spines of subequal length completely fused to praecoxa and one strong lateral spine; seven pointed lateral spines, the two distal-most bare and of similar shape and length, the three middle one small and thin; the subproximal one sparsely pinnate, the proximal one slightly curved in an S-shape. Palp (Figure 5B): coxobasis armed laterally with one smooth exopodal seta and apically with two pinnate and one scarcely unipennate setae; endopod laminar, with three smooth apical setae of subequal lengths. Palp somewhat shorter than arthrite of praecoxa.

Maxilla (Figure 5D, 5E, 5F): five-segmented. Praecoxa and coxa not fused (Figure 5D, 5E); praecoxa robust, with one endite carrying two pinnate setae of same length; coxa with two endites, the proximal one with two thin bare seta, the distal one cylindrical, with three apical setae: two of same length, one bare and geniculate, the second one one-side scarcely pinnate, third seta, longest, geniculate and bare. Allobasis (Figure 5E) with strong claw-like basal endite ornamented with a group of five smaller, and three larger spiniform tips inserted proximally at about 1/3 the length of the claw on the concave side. Two setae inserted near the claw base (Figure 5E): one strong, slightly shorter than the claw, and modified (first 1/3 scarcely pinnate, second 1/3 denticled), one small and bare. Endopod (Figure 5F) 2-segmented, proximal segment with one long and strong pinnate seta; distal segment with two long geniculate apical setae, accompanied subapically by two shorter setae: one bare, one very scarcely pinnate.

Maxilliped (Figure 5I): four-segmented, composed of syncoxa, basis and 2-segmented Enp. Syncoxa with one distal endite carrying two long setae of different length, the shortest one bare, the longest one bipinnate; ornamentation represented by a longitudinal row of setulae along the inner margin, and a transversal spinular row inserted below the endite. Basis with two apical setae of different length on the inner distal margin, the longest one bipinnate; ornamentation represented by longitudinal row of setulae along the inner margin below the seta insertion, and two transversal spinular rows on the outer margin. Enp-1 with one long, pinnate seta, one shorter bare seta, setular row along inner margin; enp-2 with one long apical bare seta and two shorter subapical ones, one bipinnate, one unipinnate. Armature formula: 2.2.1.3.

P1–P4: intercoxal sclerites (Figures 5J, 5K, 5L, 6F) with concave distal margin, rounded projections overreaching distal margin; P4 sclerite with several groups of spinules; remaining sclerites unornamented. Coxae (Figures 6A, 6D, 6E, 6F) quadrangular, with seta on inner distal corner, ornamentation as shown in Figures 6A, 6D, 6E, 6F. Exp and Enp P1–P4 two-segmented; most setae on Exp-2 and Enp-2 as long or slightly longer as ramus bearing them, soft, plumose. Exp-2 spines/setae formula: 3.3.3.2 / 5.5.5.5, respectively. Enp-2 spines/setae formula: 1.1.1.1 / 4.5.5.4, respectively. All setae plumose even if drawn as smooth for a clear interpretation of the armature position and size. Complete armature of P1–P4 reported in Table 1.

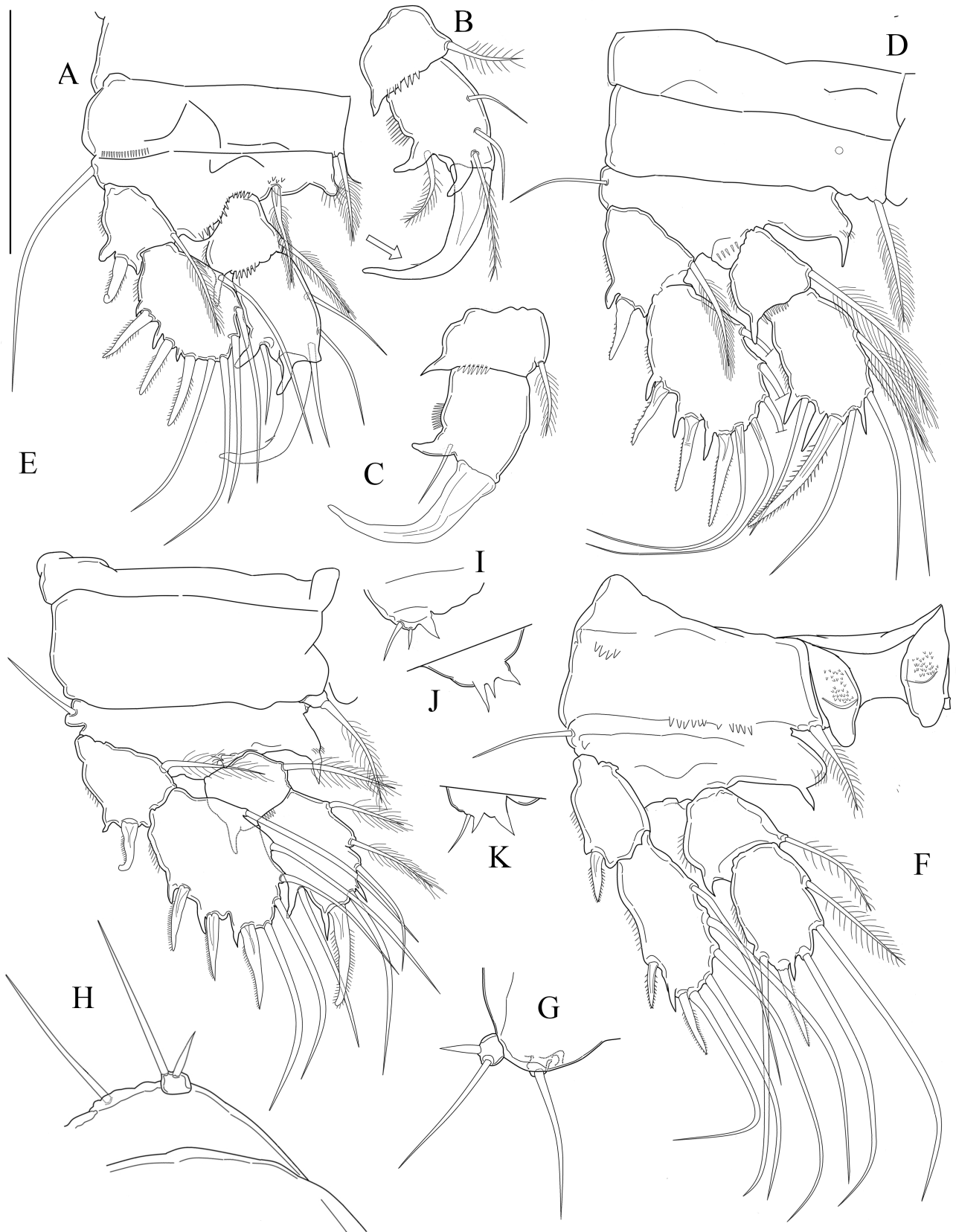
**TABLE 1.** Armature of P1–P4 in *Korecyclops alpha* sp. nov. (Roman numerals = spines; Arabic numerals = setae; inner-outer, inner-apical-outer).

	COXA	BASIS	EXP-1	EXP-2	ENP-1	ENP-2
P1	1-0	1-1	1-I	3-2-III	1-0	3-I-1
P2	1-0	0-1	1-I	4-1,I-II	1-0	4-I-1
P3	1-0	0-1	1-I	4-1,I-II	1-0	4-I-1
P4	1-0	0-1	0-I	4-1,I-I	0-1	3-I-1

P1–P4 basis (Figures 6A, 6D, 6E, 6F): approximately trapezoidal, with bare seta on outer corner; inner distal corner produced in a round apophysis ornamented with a transversal row of hair at its inner base.



**FIGURE 5.** *Korecyclops alpha* sp. nov. A–B, D–L: female, C: male. A) maxillular precoxa; B) maxillular palp; C) maxillula; D) maxillar coxa and praecoxa E) maxillar allobasis; F) maxillar endopod; G) maxillar allobasis endopodal claw (variability); H) maxillar allobasis endopodal claw (variability); I) maxilliped; J) P1, intercoxal sclerite; K) P2, intercoxal sclerite; L) P3, intercoxal sclerite. Scale bar: 50 micrometers.



**FIGURE 6.** *Korecyclops alpha* sp. nov. Female. A) P1: coxa, basis, endopod, exopod; B) P1: endopod (arrow pointing at spinule along the inner margin of enp-1 apical spine); C) P1: endopod (variability); D) P2: coxa, basis, endopod, exopod; E) P3 coxa, basis, endopod, exopod; F) P4: intercoxal sclerite, coxa, basis, endopod, exopod; G) P5, ventral view. H) P5, dorsal view; I) P6; J) P6 (variability); K) P6 (variability). Scale bar: 50 micrometers.

P1 (Figure 6A). Coxa with distoventral spinular row near outer corner. Basis with one long and thin plumose spiniform seta near enp insertion, reaching 1/3 the length of enp-2, with four spinules at the insertion; one spinular row along the endopod insertion. Exp-1 small, slightly longer than wide; inner distal corner with plumose seta as long as enp-2; outer distal corner with pinnate spine with characteristically bent apex. Exp-2 twice the length of exp-1 (length/width: 1.5). Enp-1 as long as large, inner distal corner with plumose seta; enp-2 1.7 times the length of enp-1, apical spine very strong, the last 1/3 bent outwards at almost 90° (Figure 6B), 1.2 times the length of enp-2, in some specimens the concave margin carries a spinule, arrowed in figure 6B.

P2 (Figure 6D): basis with pore. Exp-1 small, slightly longer than wide (length/width:1.2); inner distal corner with plumose seta reaching past the end of enp-2. Exp-2 about twice the length of exp-1 (length/width: 1.7); two outer spines of same length, apical spine about ½ the length of exp-2. Enp-1 as long as wide, inner distal corner with long plumose seta; enp-2 twice the length of enp-1, length/width: 1.8; apical spine long, slightly bent outwards, 1.2 times the length of enp-2.

P3 (Figure 6E). Exp and Enp similar to those of P2 in size and armature but setae slightly shorter and apical spine of enp-2 almost straight, 0.9 times the length of the segment.

P4 (Figure 6F). Coxa with one apical and one distal row of spinules on ventral side. Exp-1 longer than wide (length/width:1.5); inner distal corner without seta; exp-2 narrow and strongly elongated (length/width:3.3), with two spines, the apical one ¼ the length of exp-2. Enp-1 as long as large, inner distal corner with plumose seta as long as enp-2; enp-2 elongated (length/width: 1.7), with five elements, apical spine 0.7 times the length of enp-2.

P5 (Figures 3B, 6G, 6H, 10F): baseopod completely fused to Pd5 to form protopod; exp round, as short as wide, with one spine and one long seta apically (length seta/length spine: 4.3); spine and seta inserted not adjacent, separated by a space equal to ¼ the length of the exp. Baseopodal seta inserted dorsally to exp (on the lateral margin of the somite, visible in dorsal view, see Figure 2A) and as long as the exopodal apical seta.

P6 (Figure 6I) inserted lateroventrally (Figure 10F), represented by a semicircular plate carrying one strong outer triangular tip and two short inner setae of different length on the distal margin.

Description of male. Habitus as in Figures 2B, 10B. Preserved specimens colourless, naupliar eye not discernible. Slightly smaller than female, total body length, measured from tip of rostrum to posterior margin of caudal rami, 617 µm (mean: 616 µm; n= 5). Total body length to width ratio 2.64; prosome to urosome length ratio about 1.3 (Figure 2B). Rostrum, cephalothorax, Pd1–Pd4 similar to those of female. Cephalothorax representing 33% of body length, with the greatest width at the posterior margin. Integument covered with small circular pores (Figures 2B, 10B), not strongly chitinized, without cuticular windows. Hyaline free margins of Pd1–Pd4 dorsally smooth, margin of Pd5 slightly serrated (Figure 2B).

Genital somite (Figures 2B, 7A, 10D) large and round (length/width/length: 0.52), representing 23% the length of urosome (measured to the tip of caudal rami), dorso-lateral surface with distinct pore pattern. Spermatophore quadrangular with short, thin neck (Figures 3B, 10C). Urosomites 2–4 shorter and narrower than genital somite, with irregularly serrated free hyaline margin posteriorly (Figures 7A, 2B).

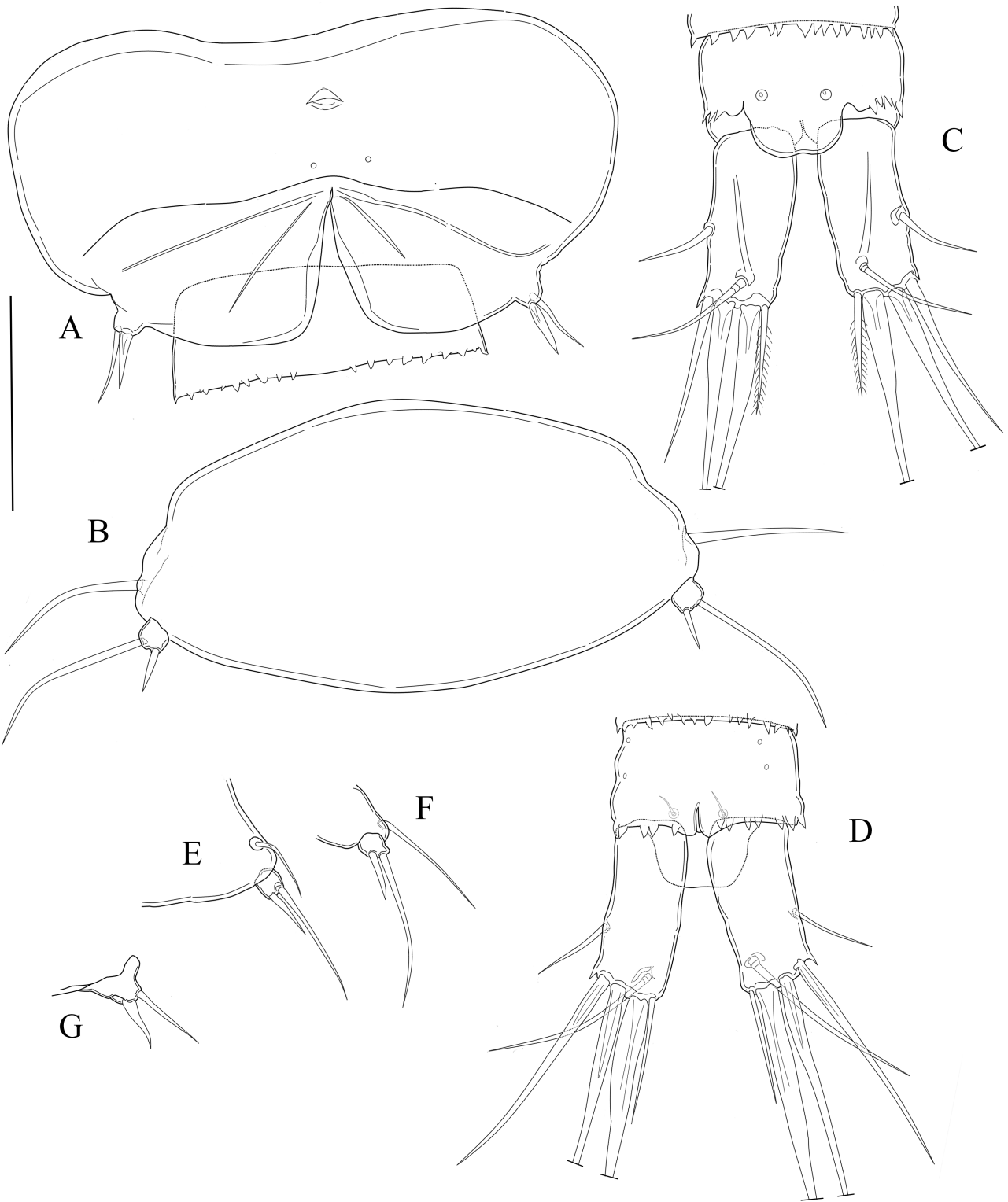
Anal somite and anal operculum similar to those of female (Figures 7C, 7D, 10D).

Caudal rami (Figures 7C, 7D). Slightly narrower than those of female, about 2.0 times as long as wide, with dorsal keel. Anterolateral accessory seta (I) absent. Anterolateral seta (II) bare, inserted below the first ½ of ramus, seta/caudal ramus length about 0.5. Posterolateral seta (III) bipinnate, seta/caudal ramus length about 1.4. Outer terminal seta (IV) plumose, about 3.6 times as long as caudal ramus, with breaking plane. Inner terminal seta (V) longest, plumose, with breaking plane, 6 times the caudal ramus length. Terminal accessory seta (VI) slim, straight and spiniform, seta/caudal ramus length about 0.7 length. Dorsal seta (VII) articulated, bipinnate, inserted near base of inner terminal seta (V), seta/caudal ramus length about 1.2.

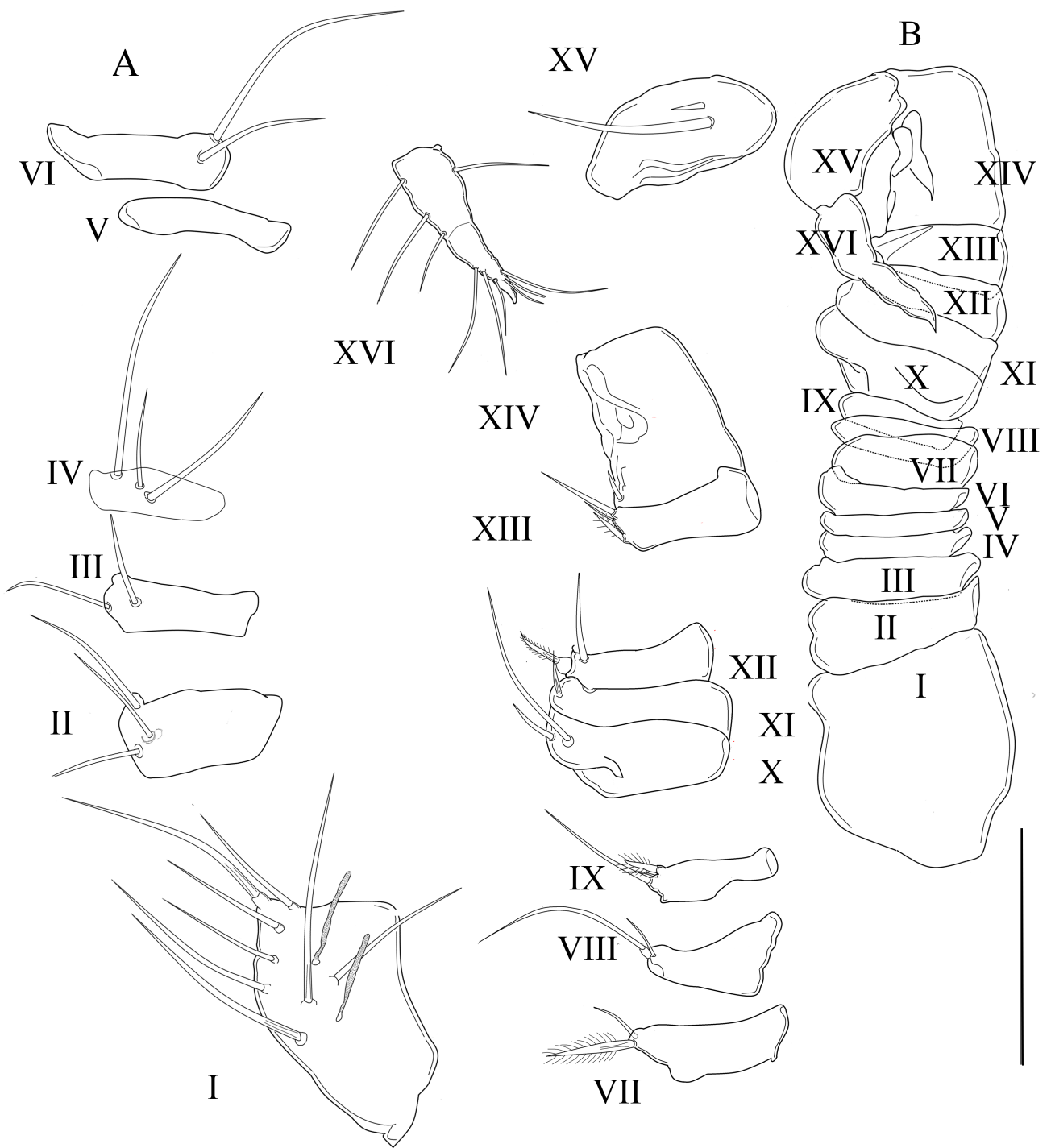
Rostrum as in female.

A1 (Figures 8A, 8B, 10B): Slightly longer than cephalothorax, 16-segmented (but vestigial subdivision of segments 16 and 17 still visible), digeniculate. Terminal segment with acrothec; short spine on eighth segment. Seta on ninth and eleventh segments robust, spiniform; one seta on ninth, tenth, eleventh and twelfth segments very short. Armature formula: 1-[8+2ae], 2-[3], 3-[2], 4-[3], 5-[0], 6-[2], 7-[2], 8-[1+ae], 9-[2+I], 10-[2], 11-[1], 12-[1+I], 13-[2+I], 14-[1], 15-[1+I], 16-[9+ae].

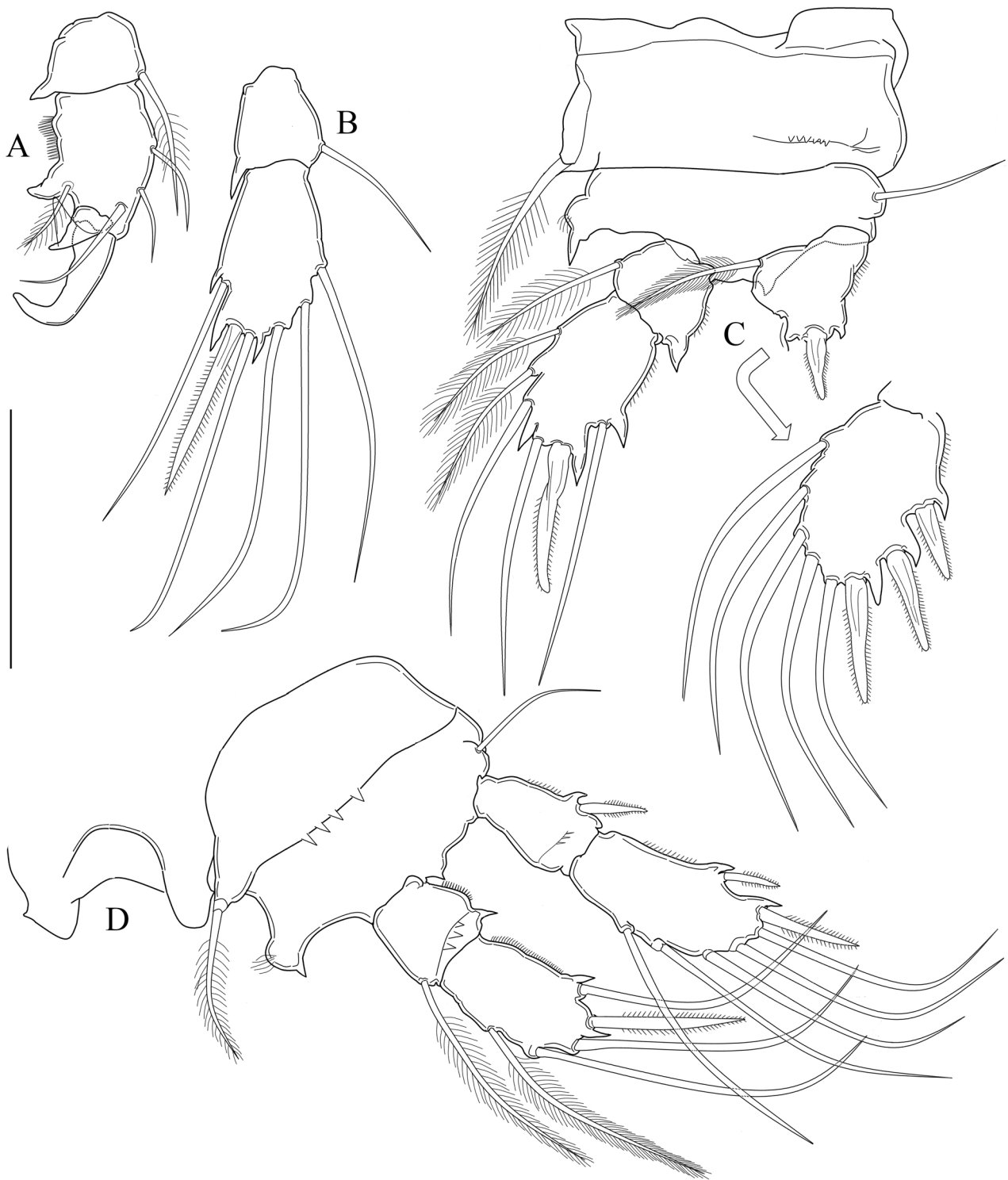
A2, labrum, mx1 (Figure 5C), mx2, mxpd as in female. Mandible similar to those of female, but mandibular palp setae shorter (Figure 4F).



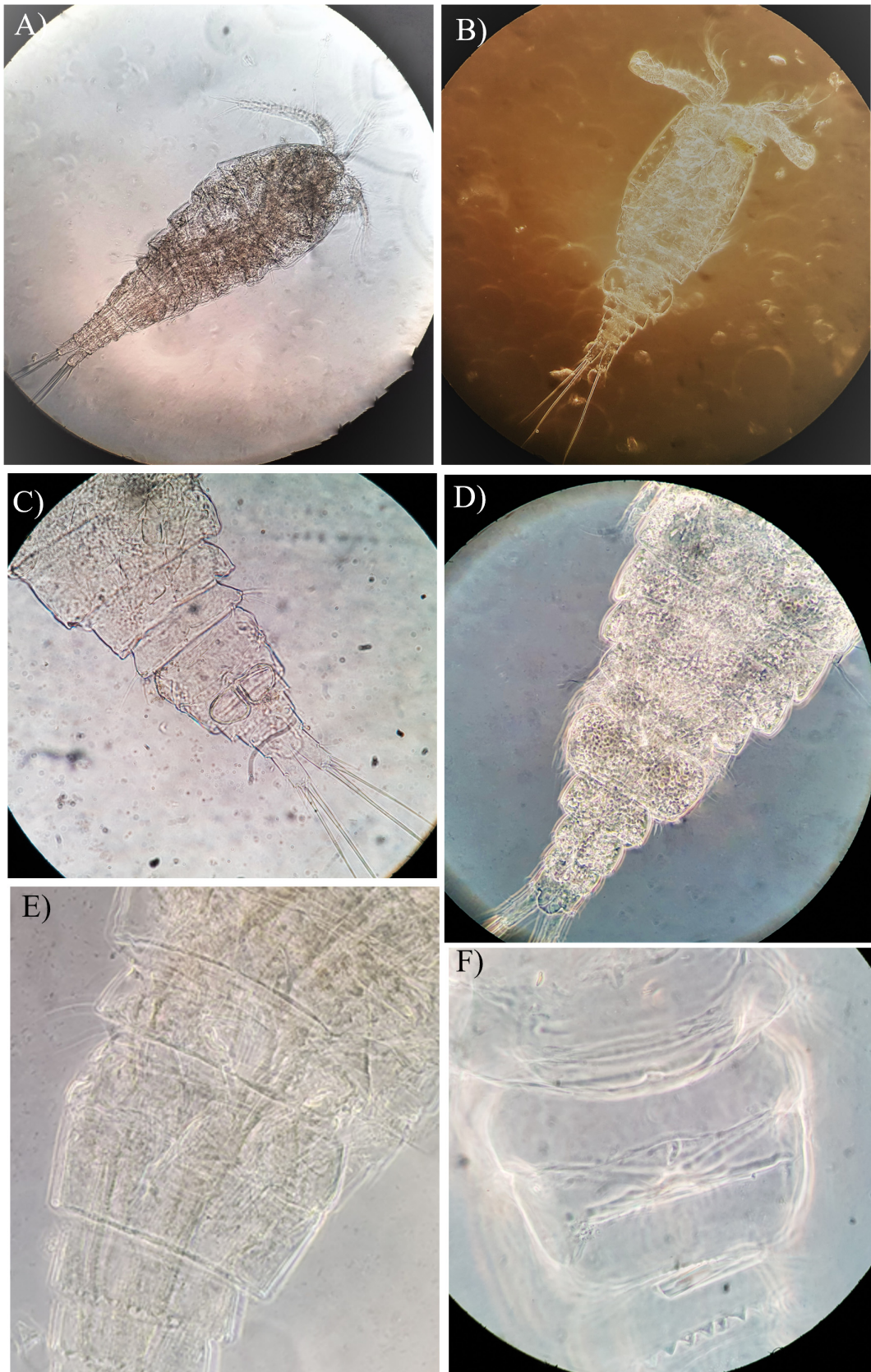
**FIGURE 7.** *Korecyclops alpha* sp. nov. Male. A) Genital somite, P6, urosomite 2, ventral view; B) Pd5 and P5; ventral view; C) anal somite, anal operculum and caudal rami, dorsal view; D) anal somite, anal operculum and caudal rami, ventral view; E) P5, dorsal view; F) P5, ventral view; G) P6, dorsal view. Scale bar: 50 micrometers.



**FIGURE 8.** *Korecyclops alpha* sp. nov. Male. A) antennule, disarticulated (antennular segments marked with roman numerals); B) antennule, schematic (armature not depicted, antennular segments marked with roman numerals). Scale bar: 50 micrometers.



**FIGURE 9.** *Korecyclops alpha* sp. nov. Male. A) P1: endopod; B) P2: endopod; C) P3: coxa, basis, endopod, exopod (second segment disarticulated); D) P4: intercoxal sclerite, coxa, basis, endopod, exopod. Scale bar: 50 micrometers.



**FIGURE 10.** Figure 8. *Korecyclops alpha* sp. nov. Microscope pictures taken at different magnification/light; not in scale. A, C, E, F: female; B, D: male. A) habitus, ventral view; B) habitus, ventral view; C) Pd5, Pd6, genital field with spermatophores attached to genital pore; urosomites, anal somite and caudal rami, dorsal view; D) pedigerous somites, urosomites, anal somite, anal operculum and caudal rami, dorsal view; E) Pd5, Pd6, genital somite, dorsal view; F) Pd5, Pd6, P5, P6, genital field, ventral view.

Intercoxal sclerites, coxae and basis P1–P4, and P1–P3 exopods and endopods (Figures 9A, 9B, 9C) as in female.

P4 (Figure 9D): exopod and endopod similar to those of female; enp-2 apical spine 1.05 times the length of enp-2.

P5 (Figures 7B, 7E, 7F): as in female, but length spine/length seta: 3.2.

P6 (Figures 2B, 7A, 7G): inserted ventrally; represented by a cuticular plate with one outer seta and one inner spine (length spine/length seta: 0.6).

## Variability

Females: the total body length slightly differs among specimens (as expected); the ornamentation of the maxillar allobasis endopodal claw of two female paratypes differs from the holotype: in one specimen (Figure 5G) the ornamentation is represented by two large spiniform tips, and in another female by two thin tips followed by a stronger one (Figure 5H). The P1 enp-2 of one female specimen lacks the two outer setae (Figure 6C); the P6 has three tips (Figure 6J) or two tips and one seta (Figure 6K) in two different female specimens.

## Discussion

### Taxonomic definition of the new genus

The Cyclopinae most closely related to *Korecyclops* **gen. nov. sp. nov.** are stygobitic, of small or medium-small size, and characterized by peculiar morphological and bio-ecological adaptations; the most relevant shared characters are related to the reduced segmentation of the female A1 and of the P1–P4 endopods and exopods, and the fusion of the P5 proximal segment with the somite. More specifically, affinities could be searched within the following groups of genera or species: 1) the “*Metacyclops* complex” formally defined by Karanovic *et al.* (2011) as those Cyclopinae with ovipores situated in the anterior half of the genital double-somite; 11-segmented (or rarely 10-segmented) female A1; two-segmented P1–P4 endopods and exopods, without sexually dimorphism; P5 with protopod of P5 completely fused to the somite, except outer seta, and free exopod armed apically with two armature elements (most usually an inner spine and an outer seta). The complex includes species (mainly Australian) in the genera *Allocyclops* Kiefer 1932, *Anzycyclops* Karanovic, Eberhard & Murdoch 2011, *Apocyclops* Lindberg 1942, *Pilbaracyclops* Karanovic 2006, *Fimbricyclops* Reid 1993, *Goniocyclops* Kiefer 1955, *Hesperocyclops* Herbst 1984, *Menzeliella* Lindberg 1954, *Meridiecyclops* Fiers 2001, *Metacyclops* Kiefer 1927, *Muscocyclops* Kiefer 1937, *Psammophilocyclops* Fryer 1956; 2) The *Microcyclops*-group of Pesce (1996) was recently discussed by Boonyanusith *et al.* (2018) who included in this group 25 genera and subgenera of Cyclopinae characterized by 10–11 segmented A1 in females; P1–P4 with 2-segmented exp (exceptionally P3–P4 exp 3-segmented) and 1–2 -segmented enp; P5 with one segment (i.e., the exp) free or partly fused with the Pd5, with or without baseoendopodal seta. Boonyanusith *et al.* (2018) remark how most of these characters represent morphological adaptations for life in subterranean habitats. Among the 25 genera, those with 2 setae/spines on the P5 exp, as typical of *Korecyclops* **gen. nov.**, are: *Anzycyclops*, *Apalachocyclops* Fiers, 2011, *Apocyclops*, *Cochlacocyclops* Kiefer 1955, *Dussartcyclops* (*Barrowcyclops*) Karanovic, Eberhard & Murdoch 2011, *Fierscyclops* Karanovic 2004, *Fimbricyclops*, *Goniocyclops*, *Graeteriella* (*Paragraeteriella*) Rylov 1948, *Hesperocyclops* Herbst 1984, *Itocyclops* Reid & Ishida 2000, *Menzeliella*, *Meridiecyclops*, *Metacyclops*, *Microcyclops* Claus 1893 (in this genus, the inner spine is strongly reduced and inserted on the inner corner, or it is completely lost), *Muscocyclops*; *Pescecyclops* Karanovic, Eberhard & Murdoch 2011, *Pilbaracyclops*, *Psammophilocyclops* Fryer 1956, *Rheocyclops* Reid & Strayer 1999, *Teratocyclops* Pleša 1981 and *Speocyclops* Kiefer 1937. Interestingly, most of these genera represent also the *Metacyclops* complex. Recently, Sanoamuang *et al.* (2019) described the monotypic genus *Pseudograeteriella* Sanoamuang, Boonyanusith & Brancelj 2019 from a Vietnamese cave, and Brancelj *et al.* (2024) described *Pseudohesperocyclops* Brancelj, Boonyanusith & Sanoamuang 2024 from Thailand with three species: the type species *P. loeiensis* Brancelj, Boonyanusith & Sanoamuang 2024, *P. cushae* (Reid 1991), and *P. thailandicus* (Brancelj, Boonyanusith & Sanoamuang 2018). Both genera can be included in the above mentioned *Microcyclops*-group *sensu* Boonyanusith *et al.* (2018).

Based on the characters listed above for the two groups of genera, and the affinities due to the segmentation

of the female A2 and the P1–P4, and the general morphology of the P5, *Korecyclops* **gen. nov.** could easily be classified in both the *Microcyclops* group *sensu* Boonyanusith *et al.* (2018) and the *Metacyclops* complex. However, *Korecyclops* **gen. nov.** is notably characterised by a unique combination of features that distinguish it from the most related genera of Cyclopinae included in the *Microcyclops* group and *Metacyclops* complex. Specifically, the rare apomorphic spine formula 3.3.3.2 of *Korecyclops* **gen. nov.** is a primary discriminating feature, found also other genera (Table 2): i) *Cochlacocyclops ateles* Kiefer 1955, the only species of the genus, found only once in Madagascar and incompletely described from a single female, has the same spine formula as *Korecyclops* **gen. nov.**, and additional similar characters: two-segmented P1–P4 limbs, 11-segmented A1, and a single apical spine on P4 end-2. However, this species differs from *Korecyclops* **gen. nov.** by having a dorsoventrally flattened body and smaller body size, the genital somite longer than wide, a different shape and size of the seminal receptacle, of the anal operculum, of the median corner of P4 basis, an unornamented P4 intercoxal sclerite, the P4 enp-2 with four elements. Unfortunately, *C. ateles* was not completely described and the morphology of the A2, the armature of A1 and of the mouthparts are unknown. ii) The three known species of the genus *Goniocyclops* share with *Korecyclops* **gen. nov.** the spine formula 3.3.3.2, and a similar size and ornamentation of caudal rami. However, *Goniocyclops* differs from the new genus for its very smaller body size, the shape of the anal operculum, which is semicircular rather than rectangular; the shape and size of the genital somite and seminal receptacle; the rectangular P5 exp; the P4 enp-2 with four armature elements and the apical spine longer than the segment; the A2 without exopod; the male P6 with three armature elements; iii) The genus *Pilbaracyclops* comprises two Australian species, *P. supersensus* (Karanovic 2006) and *P. frustratio* (Karanovic 2006); both species are known only from male specimens. *P. frustratio* shares with the male of *Korecyclops* **gen. nov.** the spine formula 3.3.3.2., a similar size, the male A1 16-segmented, the P1 enp-2 with a robust and curved apical spine. However, *P. frustratio* has a shorter anal operculum, mxpd formula 2.2.1.2, A2 without exopod, P5 with considerable space between distal spine and seta, P4 enp-2 with one apical spine and one spine plus four other spines, median corner of basis P1–P4 not protruding and with rounded margin, P6 with three armature elements, caudal rami with similar shape and size, but lacking the keel, and different length and position of the caudal setae; iv) The genus *Siamcyclops* Boonyanusith, Sanoamuang & Brancelj 2018, which presently includes two species (Watiroyram & Koompoot 2024) has some other morphological characteristics in common with the new genus; however, *Siamcyclops* belongs to the *Bryocyclops* species-group *sensu* Boonyanusith *et al.* (2018), whose members exhibit a characteristic sexual dimorphism in the apical spine of P3 enp-2 and therefore it is not closely related phylogenetically to *Korecyclops* **gen. nov.** In addition to the morphological affinities, all the above-discussed genera are recorded from zoogeographical regions different from the Palearctic one of *Korecyclops* **gen. nov.** and, in this respect, they would seem to be scarcely related with it.

*Metacyclops* is as well a genus which could have accommodated *Korecyclops* **gen. nov.**: in fact, *Metacyclops* is one of the oldest and best-known genera of the subfamily Cyclopinae; it is also a fairly large genus, with 60 named species and subspecies (Walter & Boxshall 2026). The systematic of the genus is complex and not entirely stable and considered polyphyletic in some respects (Karanovic *et al.* 2011; Boonyanusith *et al.* 2018). Several of the *Metacyclops* species were revised on several occasions (Da Rocha & Bjorneberg 1987; Galassi & Pesce 1992; Karanovic *et al.* 2011; Boonyanusith *et al.* 2018) and transferred to other “related” genera that already existed, or to new genera which are included in the *Microcyclops* group of Boonyanusith *et al.* (2018). A rather variable spine formula has been accepted for the genus, which groups, or grouped, taxa with very different spine formulae such as 3.4.4.3, 3.4.4.2, 3.3.3.3 (Lindberg 1961; Reid 1987, 1991; Herbst 1988; Karanovic 2004a, 2004b; Karanovic *et al.* 2011); based on such existing spine number variability within *Metacyclops*, the genus could have included *Korecyclops* **gen. nov.** by emending the generic diagnosis to include the 3.3.3.2 formula. However, we reject this possibility to avoid further use of the genus *Metacyclops* as a polyphyletic repository of taxa. Indeed, within the large group of species of *Metacyclops* with spine formula 3.4.4.3, there are 16 species with most characteristics in common with the new species: the 11-segmented female A1, P4 enp-2 with one apical spine, caudal rami with seta III shorter than seta VI, and male P6 with 2 armature elements (see Stoch 1987; Lee & Chang 2015; Athibai *et al.* 2022). However, the spine on the terminal segment of P1 in this group of *Metacyclops* is thin, short and almost straight, quite different from the large, long (longer than enp-2), and strongly curved spine of *Korecyclops* **gen. nov.** The genital somite in the same group of *Metacyclops* species is 2–3 times longer than wide, and the seminal receptacle has an elongated posterior lobe, while in *Korecyclops* **gen. nov.** this segment is wider than long, and the seminal receptacle consequently has a shortened posterior lobe. The P5 exopod is rectangular, longer than wide in these *Metacyclops*, while it is rounded, at least as wide as it is long, in the new genus. Consequently, the new genus can not be attributed to *Metacyclops* (see also Reid 1991; Athibai *et al.* 2022; Brancelj *et al.* 2024).

**TABLE 2.** Main characters of *Korecyclops* **gen. nov.**, *Cochlacocyclops*, *Goniocyclops*, *Pilbaracyclops*.

	<i>Korecyclops</i>	<i>Cochlacocyclops</i>	<i>Goniocyclops</i>	<i>Pilbaracyclops</i>
Spinal formula	3.3.3.2	3.3.3.2	3.3.3.2	3.3.3.2
P1–P4	2-segmented	2-segmented	2-segmented	2-segmented
A1	Female: 11-segmented; male: 16-segmented	Female: 11-segmented; male: unknown	Female: 11-segmented; male: undescribed	Female: 11-segmented; male: 16-segmented
N. apical spines on P4 end-2	1	1	1	1
Body length, $\mu\text{m}$ (from tip of rostrum to posterior margin of caudal rami)	Female: 632 $\mu\text{m}$ ; male: 616 $\mu\text{m}$	Female: 365 $\mu\text{m}$	<i>G. arenicola</i> , female: 320 $\mu\text{m}$ ; male: 320–330 $\mu\text{m}$ ; <i>G. primus</i> , female: 400–500 $\mu\text{m}$ , male: 330 $\mu\text{m}$	<i>P. supersensus</i> , male: 752–904 $\mu\text{m}$ , female: undescribed; <i>P. frustratio</i> , male: 579 $\mu\text{m}$ ; female unknown
Body shape	“Normal”, elongated	Dorso-ventrally flattened	Normal	Normal
Genital somite shape	Wider than long	Longer than wide	<i>G. arenicola</i> : wider than long; <i>G. primus</i> : longer than wide	Wider than long
Genital double somite incision	Visible dorsally and ventrally	Unknown	<i>G. arenicola</i> : visible dorsally and ventrally; <i>G. primus</i> : not mentioned but possibly visible, as the proximal part of the double segment is angularly and wider than the last thoracic segment	Not present
P4 intercoxal sclerite	With several groups of spinules	Unornamented	Unknown	Unornamented
Number of elements on P4-enp-2	4 setae, 1 spine	3 setae, 1 spine	<i>G. arenicola</i> : 2 setae, 2 spines; <i>G. primus</i> : 3 setae, 1 spine	5 setae, 1 spine
Anal operculum	Long, rectangular, rounded distal corners, distal margin smooth	Short, trapezoidal, rounded distal corners, distal margin smooth	Long, rectangular, rounded distal corners, distal margin smooth	Vshort and convex, distal margin smooth
P6 armature	Female: one strong outer triangular tip and two short inner setae of different length; male: one outer seta and one inner spine	Unknown	<i>G. arenicola</i> , female: apparently missing; male: 2 short spinules and 1 seta; <i>G. primus</i> , female: 1 outer triangular tip and 1 short median seta (or spine/tip?) and longer inner seta; male: 93 pinnate setae of similar length	<i>P. frustratio</i> , male: 1 bipinnate spine and 2 plumose setae; <i>P. supersensus</i> , male: 1 bipinnate spine and 2 setae; female: 2 smooth spines and 1 smooth, much longer seta; median spine distinct, other one completely fused to leg and much larger

After removing the possibility of allocating the new species to one of the genera discussed above, the highest number of affinities occur between *Korecyclops* **gen. nov.** and *Pseudohesperocyclops*, a genus which includes two Thai species and one Holarctic species from Louisiana, North America. In *Pseudohesperocyclops* the female A1 is 11-segmented, and the P1–P4 are two-segmented, the seta representing the A2 exopod is similar in length to that of the new genus, and the number of setae on the maxilliped also coincides (i.e., 2.2.1.3). There is no diagnosis of the male of *Pseudohesperocyclops* at the genus level, since only the male of *P. cushae* has been described; nonetheless, besides the non-sexually dimorphic characters, the males of the two genera also share the 16-segmented A1 and the P6 with two armature elements. The two genera, however, differ in some major and micro characters (Table 3): the males and females of *Pseudohesperocyclops* and *Korecyclops* **gen. nov.** have a similar size, but not the habitus,

which is slimmer in the former: L/W (width measured at the largest part of the cephalothorax, length measured from the tip of the rostrum to the end of the caudal rami, setae excluded) measures 2.64 and 2.30 in the males and females of *Korecyclops* **gen. nov.**, respectively, 3.02 and 3.43 in *Pseudohesperocyclops* (for the females of the latter, the ratio is calculated averaging the values of the females of the three known species); in the females, the genital somite is wider than it is long in both genera, but the dorsal suture between anterior and posterior half of the segment is clearly visible in *Korecyclops* **sp. nov.** and is not present in *Pseudohesperocyclops*; the seminal receptacle differs between the two genera (with the lower half wider and shorter in the new genus). The anal operculum of the two genera is similar in shape and size but in the new genus it is slightly longer, and the furcal branches are similar but they are shorter and wider in the proximal part; the caudal rami of *Korecyclops* **gen. nov.** have a dorsal keel (a keel is present only in the type species of *Pseudohesperocyclops*) and the length ratios of the setae to caudal rami differ between the two genera. The intercoxal sclerites of P1–P4 are similar in shape and size in the two genera and they are unornamented except for the two groups of spinules on the P4 sclerite of the new genus; the median (inner) corner of the basis P1 extends in both genera into a rounded process bearing a group of fine hairs, and the median corner of the P2–P4 basis have apophyses with sharp tips, but the P3 and P4 tips are longer and more developed in *Korecyclops* **gen. nov.**, which also bears a transverse row of hair aligned below the tip, which are absent in *Pseudohesperocyclops*. The endopod P1 is similar in the two genera, being armed with a strong and robust spine which, however, is strongly hooked and longer than the P1 enp-2 in *Korecyclops* **gen. nov.**, while it is straight (or hook-shaped in *P. cushae*) and as long as the P1 enp-2 in *Pseudohesperocyclops*. The spine formula of P1–P4 exp-2 differs by being 3.4.3.3 in *Pseudohesperocyclops* and 3.3.3.2 in the new genus, the setal formula of the P1–P4 endopods also differs, being 4.5.5.4 for *Korecyclops* **gen. nov.** versus 5.6.6.4 for *Pseudohesperocyclops*. The exopod P5 is as wide as it is long in both taxa, but the exopodal seta and spine are more widely spaced in the new genus, and the length ratios between these two elements also differ. The P6 are semicircular, and armed with two short spines and longer seta in *Pseudohesperocyclops*, while they are rectangular, with one strong triangular tip and two short setae of different length in *Korecyclops* **gen. nov.** Finally, the spermatophores of *P. cushae* are rounded and provided with remarkably wide neck, quite different from those of the new genus, which are quadrangular with a short, thin neck. These differences, and notably those related to the reproductive system (genital somite, spermatophore), and the very scarce variability in the armature (only one female reported with one of the P1 enp-2 lacking two setae) of all the examined specimens, suggests that the specimens analyzed are indeed representatives of a new genus rather than phenetic variation of a species of *Pseudohesperocyclops*.

**TABLE 3.** Summary of differences between the genera *Pseudohesperocyclops* and *Korecyclops* **gen. nov.** \* not in the generic diagnosis of *Pseudohesperocyclops*.

Character in females	<i>Pseudohesperocyclops</i>	<i>Korecyclops</i> <b>gen. nov.</b>
Length/Width	Males: 3.02; females: 3.43	Males: 2.64; females: 2.30
Genital somite	As long a wide or slightly shorter	Wider than long
Genital somite	Incision between anterior and posterior half of segment not well developed	Incision between anterior and posterior half of segment dorsally (and ventrally) visible
Insertion of P5 exopodal segment apical seta and spine	Close to each other	Not adjacent
P6	Small semicircular plate located dorsolaterally, armed with two short spines and longer seta	Rectangular plate carrying one strong triangular tip and two short setae of different length
Caudal rami*	<i>P. loeiensis</i> : 2.4 times longer than wide, dorsal keel; <i>P. thailandicus</i> : 2.6 times, no keel; <i>P. cushae</i> : 3 times, no keel	2.1 times longer than wide longitudinal dorsal keel
Spine formula on terminal segments of Exp P1–P4	3.4.3.3	3.3.3.2
Setae formula on terminal segments of Enp P1–P4	5.6.6.4	4.5.5.4
P1 Enp-2 apical spine	Normal, straight or ( <i>P. thailandicus</i> ) blunt, hook-shaped spine apically.	Strong, bent at almost 90°
Spermatophore	Rounded and provided with remarkably wide neck	Quadrangular with short, thin neck.

Based on the above-discussed affinities among genera, we can affirm that *Korecyclops* **gen. nov.** represents a new stygobitic cyclopoid, morphologically characterised by a set of features that clearly distinguish it from other genera of Cyclopinae, and indicate that the greatest correlations are with *Pseudohesperocyclops*. However, we consider this proposal for a new genus of Cyclopinae to be subject to future changes because, as has been remarked by various authors, some descriptions of older taxa are incomplete or imprecise, making the necessary comparisons difficult, and several taxa have been described on the basis of one or a few specimens or of only one sex. Furthermore, while studying *Korecyclops alpha* **gen. nov. sp. nov.**, we have not been able to use a biomolecular approach or even resort to SEM, the latter being an important method for the identification of micro-characters. Further difficulties arise from the fact that specialised taxa that are not closely related phylogenetically may have similar morphological characteristics as a result of convergence phenomena caused by strong, “oriented”, evolutionary pressures.

### Accompanying fauna

The harpacticoids *Elaphoidella elaphoides* (Chappuis 1924) and *Stammericaris similior* Bruno & Cottarelli 2023 were collected together with *Korecyclops alpha* **gen. nov. sp. nov.** In the same cave, a different pool hosts a *Diacyclops* sp. belonging to the *crassicaudis* complex (Reid 1992), wrongly listed as *Diacyclops crassicaudis lagrecai* Pesce & Galassi 1987 in Bruno *et al.* 2023.

### Remarks on the epikarstic habitat and colonization processes

A primary challenge of this study was the rarity of *Korecyclops alpha* **sp. nov.**: over two years, specimens were collected only twice, from one single station. These specimens were typically recovered from ‘micro-pools’ fed by dripping water during the August drought period in Sicily. The drip water derived from the prolonged irrigation of the fields above the cave. This unnatural supply of surface water likely facilitated the transport of *Korecyclops alpha* **sp. nov.** specimens via the increased water flow documented during sampling. Interestingly, *Korecyclops alpha* **sp. nov.** was never collected in the other stations of the cave (see Bruno *et al.* 2023), some of which characterized by a greater presence of water all year around, where other stygobitic species such as *Stammericaris similior*, *Diacyclops* sp., *Elaphoidella* sp. appeared to thrive. Interestingly, the cave is almost horizontal and develops at a shallow depth (about -35 m), the epikarstic layer is thin and therefore prone to water shortages. Hence, water can probably persist by capillarity for a long period of time only in the network of those micro-channels which are not vertical, which could be the ones that host and allow this population of cyclopoids to persist.

It is now known that the stygobitic microcrustaceans fauna includes a contingent of species which are specialised in colonising and inhabiting the epikarst (e.g., Rendoš *et al.* 2025). Studies on the biology and ecology of these organisms are complicated, given the difficulties of access to this particular ecotone, and observations in nature can only be indirect. However, it is sometimes possible to identify peculiar morphological features that could represent relevant adaptations, as it has been observed and proposed for various taxa of harpacticoids (Brancelj 2009, 2011; Cottarelli *et al.* 2012; and Bruno *et al.* 2023, for *Stammericaris similior* from the same Scrivilleri Cave). Reid & Strayer (1994) gave an accurate overview of the distinctive morphological “interstitial features” (i.e., adapted to dwell in small interstitial spaces) of Cyclopinae, emphasising, among other things, the general reduction in size, but not that of the genital somites, which remain proportionally large, and the simplification of the body appendages, which tend to decrease in number and length of the segments and of their spines and setae. In some cases, a marked tendency towards an “harpacticoid habitus” can also be observed, see, for example, *Rybocyclops defayae* Rao Totakura & Ranga Reddy 2015, or *Haplocyclops (Kiefercyclops) fiersi* Karanovic & Ranga Reddy 2005, the latter is in fact the smallest free-living cyclopoid known to date. The presence of a supplementary pseudo-somite has also been reported, e.g., in the hyporheic *Haplocyclops henrii* Brancelj, 2015, and *Rheocyclops carolinianus* Reid 1999; the supplementary pseudo-somite is inserted between the fifth podomere and the genital somite and may serve to increase the flexibility of the body, a useful ability in the hyporheic environment. *Korecyclops* **gen. nov.** is fairly small in size, with proportionally large genital somite, short pereopods, and rather simplified armature and ornamentation. It is likely that the adaptations evolved for life in unconsolidated substrates such as the hyporheic or psammic habitats, are also useful for moving and living in the network of microfractures and microchannels of the

epikarst, and are therefore also found in its colonisers. Another morphological adaptation for life in the epikarst is the particular structure of the P1 endopod, which in the new genus is massive, with a particularly robust and curved apical spine: such morphology could serve to ensure better anchorage or, at least, stability, in microchannels that are often vertical and/or strongly inclined, where the animals need to avoid drifting when the water flow becomes stronger, as in the case of heavy rainfall on the surface above. Interestingly, a similar P1 exists in *Pilbaracyclops frustratio*, which inhabits groundwater, and an even almost identical P1 is found in *Siamacyclops*, a phylogenetically distant but ecologically comparable genus, since it is also a typical coloniser of the epikarst (Boonayusith *et al.*, 2018).

The typical and primary habitat of *Koreacyclops alpha* **gen. nov. sp. nov.** therefore could be the complex of particularly small microchannels and microfractures, with limited and discontinuous water flow and subsequent percolation, populated by cyclopoids of at least relatively small size, such as the new genus described here, and by harpacticoids, also small in size and with a narrow, cylindrical body, an even more advantageous condition (as it is the case, for example, of *Stammericaris similior*, collected together with *Koreacyclops alpha* **sp. nov.**).

## Unpublished records of groundwater crustaceans of Sicily and surrounding islands (to complete the recent checklist of Pendino *et al.*, 2024)

Below are the additions to the aforementioned list by Pendino *et al.* (2024), including data from unpublished research by Grasso, Spena, and Cottarelli in various caves as well as hyporheic and phreatic habitats of Sicily and the Aegadian islands (Favignana and Marettimo). (PA = Palermo, AG = Agrigento, SR = Siracusa, ME = Messina, RG = Ragusa, TP = Trapani, CT = Catania). The cadastral number was retrieved from the National Cave Registry of Italy, freely accessible and downloadable from the WISH -Web Information System Hyperlink project (<https://speleo.it/catastogrotte/wish/home.en.html>).

### 1) Order Cyclopoida

#### Family Cyclopidae Rafinesque 1815

##### 1a) Amendments to Pendino *et al.* (2024)

Pendino reports the presence of *Diacyclops crassicaudis lagrecai* (Pesce & Galassi, 1988) and *Metacyclops* sp., in Scrivilleri Cave, as stated in Bruno *et al.* (2023). Subsequent investigations, still ongoing, indicate that the identification of *D. crassicaudis lagrecai* is incorrect and that this is instead a different stygobitic species of *Diacyclops*. Furthermore, the record of *Metacyclops* sp. should be discarded as it refers to *Koreacyclops* **sp. nov.** described in the present study

##### 1b) Additional taxa records

*Diacyclops* Kiefer 1927: the genus was collected, likely with different stygobitic species, in Gapparrone Cave (AG, cadastral number SI AG 2033, 37°25'24"N, 13°26'49"E), Totino Cave (AG, no cadastral number, 37°26'44"N 13°22'43"E), and Burritta Cave (SR, SI SR 7139, 36°58'18"N, 15°00'13"E); in a well on the Miraglia property, near Lake Biviere in the municipality of Cesarò (ME), *Diacyclops* occurs with two species (females with A1 12 and 17 segmented, respectively).

*Acanthocyclops* Kiefer 1927: *Acanthocyclops* sp. was collected from dripping waters in Monte Santa Venera Cave (SR, no cadastral number, 37°09'06"N, 14°55'07"E).

*Microcyclops* Claus 1893: *Microcyclops varicans* (Sars G.O. 1863) was collected in the hyporheic zone of the Alcantara River, in the municipality of Moio (ME), where it coexists with *Speocyclops* sp.

## 2) Order Harpacticoida

### 2a) Amendments to Pendino *et al.* (2024)

#### Family Leptopontiidae Lang 1948

The record of *Psammopsyllus maricae* Cottarelli, Saporito & Puccetti 1983 at the mouth of the Cerasella River should be corrected to “mouth of the Nocella stream,” near Terrasini (PA): the incorrect toponym was used by Cottarelli *et al.* (2008) in the original description of the species and, consequently, also by Pendino *et al.* (2024)

#### Family Parastenocarididae Chappuis 1940

The record of *Cottarellicariss luciae* (Cottarelli, Bruno & Berera 2008) at the mouth of the Cerasella River should be corrected to “mouth of the Nocella stream,” near Terrasini (PA): the incorrect toponym was used by Cottarelli *et al.* (2008) in the original description of the species and, consequently, also by Pendino *et al.* (2024)

#### Family Phyllognathopodidae Gurney 1932

*Phyllognathopus viguieri* (Maupas 1892): Bruno *et al.* (2017), report the presence of the species in the Entella Cave; this record was not cited in Pendino *et al.* (2024).

### 2b) Additional taxa records

#### Family Miraciidae Dana 1846

*Schizopera* Sars 1905: *Schizopera* sp. was collected in a well on the island of Favignana (TP).

#### Family Ameiridae Boeck 1864

*Nitocrella* Chappuis, 1924: *Nitocrella stammeri* Chappuis 1938, was collected in the Gapparrone (AG), Totino (AG), Burritta and Monte S. Venera (SR) caves.

*Parapseudoleptomesochra* Lang, 1965: a troglobitic and likely new species was collected in a water reservoir near the ruins of the Punta Troia Castle on the Marettimo Island (first record of the genus for the Sicily Region).

#### Family Canthocamptidae Brady 1880

*Attheyella* Brady 1880: *Attheyella* (*Attheyella*) *crassa* (Sars G.O. 1863) is abundant in Pipistrelli Cave (SR, cadastral number SI SR 7009, 37°08'28"N, 15°01'50"E); the species was also collected in Totino Cave (AG) and in the hyporheic habitat of Tellesimo Stream, Hyblaean Mountains (RG).

*Bryocamptus* Chappuis 1929: *Bryocamptus* spp. were collected in the Gapparrone (AG), Pipistrelli (SR), Burritta (SR), and S. Venera (SR) caves.

*Elaphoidella* Chappuis 1929: *Elaphoidella* sp. was collected in the Mortaio Cave (SR, cadastral number SI SR 7044, 37° 08' 20" N, 14° 57' 30" E) and in Totino Cave (AG), and in the hyporheic habitat of Tellesimo Stream, Hyblaean Mountains (RG).

*Epactophanes* Mrázek 1893: *E. richardi richardi* Mrázek 1893, which would constitute a species complex according to Bruno & Cottarelli (1999) and Boxshall & Halsey (2004) was collected in Tellesimo Stream, Hyblaean Mountains (RG); first record for Sicily.

## Family Arenopontiidae Martinez Arbizu & Mura 1994

*Phreatipontia* Sak, Karaitug & Huys 2024: *Phreatipontia* cf. *phreatica* (Cottarelli, Bruno & Venanzetti 1994) was collected in the interstitial habitat on the shoreline near the mouth of the Platani River (AG). This record is ecologically significant as it represents an example of continental interstitial water colonization by originally marine forms.

## Family Leptopontiidae Lang 1948

*Bereraia* Huys 2009: *Beraria* sp., very likely a new species, currently under advanced study, was collected in the shoreline interstitial habitat near the mouth of Belice River (TP). The genus, new to Sicily, is, as far as is currently known, an Italian endemic comprising seven taxa from peninsular Italy and Sardinia. Members of this genus also represent an example of colonization similar to that previously observed for *Phreatipontia*. The species was used as an outgroup for the phylogenetic analysis of Parastenocarididae in Bruno *et al.* (2017, 2020).

*Psammopsyllus* Nicholls 1995: specimens of *Psammopsyllus* cf. *operculatus* Nicholls 1945, new record for Sicily, were collected at the previously mentioned stations near the mouths of the Belice and Platani rivers. *Psammopsyllus maricae* Cottarelli, Saporito & Puccetti 1983 was collected in the interstitial habitat on the shore at the mouth of the Simeto River (CT).

## Fam. Parastenocarididae Chappuis 1940

*Cottarellicaris* Schminke 2013: *Cottarellicaris* sp. was collected in the shoreline interstitial habitat near the mouth of Belice River (TP), where it coexists with *Bereraia* sp. and *Psammopsyllus* cf. *operculatus*.

*Stammericaris* Jakobi 1872: a single female of *Stammericaris* sp. was collected in dripping water of the Pipistrelli Cave (SR).

## 3) Order Bathynellacea

### 3a) Amendments to Pendino *et al.* (2024)

#### Family Bathynellidae Grobben 1905

*Meridiobathynella* Serban, Coineau & Delamare Deboutteville 1971: Pendino *et al.* (2024) erroneously report the existence of *Meridiobathynella* sp. in the Conza Cave (PA, cadastral number SI PA 0060, 38°11'09"N, 13°16'54"E); the species was instead found in the Entella Cave (PA, cadastral number SI PA 0310, 37°46'38"N, 13°06'47"E), as reported by Bruno *et al.* (2017)

### 3b) Additional taxa records

#### Family Bathynellidae Grobben 1905

*Meridiobathynella* sp.: a second species, different from the one reported for Entella Cave, was collected in a well on Favignana Island.

## Conclusions

The research we have been conducting in the Scrivilleri Cave shows that this site deserves a high level of attention and protection. As regards microcrustaceans, we now know that the epikarst of this cave is home to exclusive stygobitic endemisms such as *Stammericaris similior* for the harpacticoids, and, for cyclopoids, *Korecyclops alpha* **gen. nov. sp. nov.** and a probably new species of *Diacyclops* Kiefer 1927, currently still under study. Research has

so far only focused on the initial section of the cave: when the remaining explorable section of the caves will be investigated for stygofauna, it is very likely that new and interesting taxa will be discovered, thus furthering our understanding of the specialized and endangered fauna of Sicilian groundwater.

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