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The *Eophreatoicus* Nicholls, 1926 species flock from Kakadu and Arnhem Land, with a description of a new genus of Amphisopidae (Crustacea : Isopoda : Phreatoicidea)

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GEORGE D.F. WILSON & CHRISTOPHER L. HUMPHREY

THE *EOPHREATOICUS* NICHOLLS, 1926 SPECIES FLOCK FROM KAKADU AND ARNHEM LAND, WITH A DESCRIPTION OF A NEW GENUS OF AMPHISOPIDAE (CRUSTACEA : ISOPODA : PHREATOICIDEA)

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Table of Contents

Table of Contents . . . 3
Abstract . . . 4
Introduction . . . 4
Ecological Observations . . . 5
Habitats . . . 5
Seasonal movements, recruitment and other behavior . . . 5
Associated surface water quality . . . 7
Methods . . . 9
Sampling . . . 9
Images . . . 9
Data Sources . . . 10
Diagnostic Morphological Characters . . . 10
Phylogenetic analysis . . . 16
Name sources and Abbreviations . . . 18
Results of the phylogenetic analyses . . . 18
Taxonomy . . . 22
Amphisopidae Nicholls, 1943 . . . 22
Keys to the species of ***Eophreatoicus*** Nicholls, 1926 and ***Kakadubeh*** gen. nov . . . 23
Key to adult males . . . 24
Key to adult females . . . 26
Kakadubeh gen. nov. . . . 27
Kakadubeh rangemyahwurd sp. nov. . . . 28
Eophreatoicus Nicholls, 1926 . . . 39
Eophreatoicus kershawi Nicholls, 1926 . . . 40
Eophreatoicus mok sp. nov. . . . 50
Eophreatoicus kudjamarndi sp. nov. . . . 59
Eophreatoicus bodmemurrngkudji sp. nov. . . . 68
Eophreatoicus kurdabeyhmay sp. nov. . . . 77
Eophreatoicus gudjangah sp. nov. . . . 86
Eophreatoicus indjangarlwurr sp. nov. . . . 96
Eophreatoicus karrkkanj sp. nov. . . . 105
Eophreatoicus ngarradj sp. nov. . . . 114
Eophreatoicus binjdjarrang sp. nov. . . . 128
Eophreatoicus djirrinjbal sp. nov. . . . 134
Eophreatoicus boywek sp. nov. . . . 141
Eophreatoicus sp. Zi . . . 148
Eophreatoicus sp. Zu . . . 149
Eophreatoicus kudjaldordo sp. nov. . . . 150
Eophreatoicus sp. J1 . . . 158
Eophreatoicus sp. J3 . . . 158
Eophreatoicus djurrukunja sp. nov. . . . 160
Eophreatoicus warnbi sp. nov. . . . 167
Eophreatoicus kurrih sp. nov. . . . 174
Eophreatoicus galunggul sp. nov. . . . 182
Eophreatoicus nawurlandja sp. nov. . . . 190
Gulunggul Creek population of ***Eophreatoicus nawurlandja*** sp. nov. . . . 198
Eophreatoicus korokoro sp. nov. . . . 206
Eophreatoicus gubara sp. nov. . . . 213
Eophreatoicus namarrkon sp. nov. . . . 224
Eophreatoicus namimminya sp. nov. . . . 231
Eophreatoicus namarden sp. nov. . . . 238
Eophreatoicus barrkmarlam sp. nov. . . . 245
Eophreatoicus balbun sp. nov. . . . 256
Eophreatoicus sp. 03DJ . . . 264
Eophreatoicus warddebarrarn sp. nov. . . . 266
Eophreatoicus wurrkbaba sp. nov. . . . 273
Discussion . . . 281
Consequences of ***Eophreatoicus*** Life History . . . 281
Species Richness . . . 282
Conservation of phreatoicidean isopods in the Northern Territory . . . 283
Acknowledgments . . . 284
References . . . 284

Appendices 288
APPENDIX 1. Water quality data (based on laboratory analyses) for several sites associated with sandstone springs, seeps and streams of the western Arnhem Land sandstone massif and outliers. 288
APPENDIX 2. ***Eophreatoicus* & *Kakadubeh*** gen. nov. specimens and sequences. 289
APPENDIX 3. ***Eophreatoicus* & *Kakadubeh*** gen. nov. genetic distances between described species. 292
APPENDIX 5. Morphological characters. 297
APPENDIX 6. 18S primers and protocol 303

Abstract

We present descriptions of 28 new species of Amphisopidae from Arnhem Land and Kakadu National Park of Australia's Northern Territory. We identified five additional species that are not yet fully characterized and are not provided with formal species recognition. This is the first taxonomic treatment highlighting the high species richness within the Phreatoicidea that occur in Australia and likely elsewhere. We document each species fully with scanning electron and light micrographic images, diagnoses, detailed descriptions, keys to identification and justification of each species using parsimony analysis of their morphological and genetic characters. The distributional data show that all species, except for one, have microendemic distributions, with some sibling species occurring within a few kilometers of each other. Because of the age of this group of species, they appear to have spread throughout the region of the Arnhem sandstone plateau and then back-colonized the same habitats so that as many as three morphologically and genetically distinct species may co-occur syntopically. Our research has uncovered a new genus-level taxon of the family Amphisopidae, *Kakadubeh* gen. nov. This new genus is unlike *Eophreatoicus*, not only in its general appearance, but also in having an inferred reproductive strategy different from most of the other members of the family. While *Eophreatoicus* species have males that are much larger than the females and practice precopula, a form of pre-insemination mate guarding, males of the new species, *Kakadubeh rangemyahwurd* sp. nov., are much smaller than females. In addition, males of this species have a fourth walking leg that is not specialized for holding females, suggesting that they have a reproductive strategy that does not involve precopula of the form seen in *Eophreatoicus* and *Eremisopus* Wilson & Keable, 2002a. Most of our research has been undertaken in Kakadu National Park, although recent collections have been made in Arnhem Land, yielding additional distinctive species. Given the size of unexplored territory around the Arnhem Plateau and the geographic frequency of discovering new species, we predict that the diversity of this group in the Northern Territory may be many more than the ~35 species described here. At this time, these microendemic isopods appear to be unthreatened by human activities, largely owing to the environmental protection afforded by Kakadu National Park and Arnhem Land, and their cryptic habits during the dry season. Because they are dependent on small springs of permanent groundwater, future changes in hydrology owing to water use and climate change, as well as invasive introduced species, may present risks to populations and species.

Keywords: Malacostraca, Peracarida, Amphisopidae, microendemism, groundwater dependent fauna, systematics

Introduction

Isopod crustaceans of the suborder Phreatoicidea are known from Paleozoic fossils (Hessler 1969; Schram 1970, 1974) and new information about their Mesozoic distribution in Gondwanan habitats is accumulating (Ball *et al.* 1979; Wilson & Edgecombe 2003; Wilson 2008b). The apparent similarity of these fossils to modern taxa (Wilson & Edgecombe 2003; Fu *et al.* 2009) is a striking aspect of these new data. Phreatoicideans are frequently encountered in stable, long-term groundwaters around Australia and, despite the apparent ongoing evolutionary diversification of the group (Gouws *et al.* 2007, 2013; Gouws 2008; Wilson *et al.* 2009), they nevertheless remain largely similar to these ancient fossils. The genus *Eophreatoicus* Nicholls, 1926 (family Amphisopidae) is one such group (Wilson *et al.* 2009). Prior to our research, the genus was represented only by the type species, *E. kershawi* Nicholls, 1926 from northwestern Arnhem Land, but we have discovered a large number of new species in Kakadu National Park (Wilson *et al.* 2009) and nearby regions. Since Wilson *et al.*'s (2009) paper, additional species have come to light from Myra Springs and from the Liverpool River catchment of Arnhem Land. All species were found during surveys carried out by one of the authors (CLH) and Environmental Research Institute of the Supervising Scientist (ERISS) colleagues since the 1990s, and were found to be all distinct new species during anatomical comparisons with the accumulating collections of *Eophreatoicus.* We were assisted in this study by the animals themselves, in that multiple species (as many as 3) were found syntopically at several locations. A comparison of the differing forms in these samples

revealed many details of their external morphology that allowed distinguishing species, including the separation of females and juveniles. These data were entered into a taxonomic database of distinguishing features each species in detail. Wilson *et al.* (2009) confirmed the putative species identities during the process of describing these species, which is the subject of this paper. Although we had good taxonomic information on these species initially, more effort was needed to completely characterize them because of their overriding morphological similarity across the genus. Although we see reports of "lack of taxonomic differentiation", "morphological stasis" and "cryptic species" among molecular-based papers (e.g., Gouws *et al.* 2004, 2005), studies of anatomy confirm that most groups can indeed be identified by field workers without recourse to a molecular laboratory. Admittedly, we are assisted by the anatomical diversity that can be found in arthropod cuticles, a fact that almost certainly explains why we have so many species of insects. Crustaceans have their own freshwater biodiversity 'standouts', such as freshwater shrimps (e.g., *Caridina*, Short *et al.* 2019) and the Amphipoda (Väinölä *et al.* 2008), but freshwater taxa in general are understudied with respect to the attention to detail observed mainly in the entomological literature. With further investigation, we believe that isopods will be found to be highly diverse (e.g., Wilson 2008a, 2017). This paper presents new data on these microendemic crustaceans with the description of 30 phreatoicidean species in the genus *Eophreatoicus* and a new genus *Kakadubeh*, with a study of their relationships using combined molecular and morphological data. Relevant background information to aid the understanding of these new species follows.

Ecological Observations

Habitats

Eophreatoicus Nicholls, 1926 and *Kakadubeh* gen. nov. species are found in ground or surface waters associated with springs or seeps emerging from sandstone escarpments and outliers (Fig. 1). *Eophreatoicus kershawi* Nicholls, 1926 was originally found in a sandstone ridge pool of the King River region of Arnhem Land (White 1917); CLH and colleagues searched this region and found a narrow cave in a sandstone escarpment (Fig. 1A–C) with what we have determined to be the same species. Similarly, *E. mok* sp. nov. was found abundantly in a cave in the Liverpool River catchment (Fig. 1D). Some localities consist of spring-fed streams flowing from sandstone cliffs, such as the waterfall and pool at Lightning Dreaming (Fig. 1E), type locality of *E. namimminya* sp. nov. and *E. namarden* sp. nov., or from the base of the cliff, such as Cannon Hill (Fig. 1G), type locality of *E. karrkkanj* sp. nov. *Eophreatoicus* species may occur in more unusual habitats, such as *E. bodmemurrngkudji* sp. nov. at the Myra radiogenic springs (Fig. 1F). Springs may also emerge some distance from the base of the sandstone ridges; one such spring (Fig. 1H) is a site near Gunbalanya (also known as Oenpelli). Leichhardt Springs, the location of *Kakadubeh bininjkukyahwurd* gen. et sp. nov. is an exception: these springs emerge some distance from the main escarpments and are unlike other springs in Kakadu and western Arnhem Land in that they are thermal, having a constant year-round temperature of 30°C at the head of the spring and indicating a water source from deep faults rather than flowing from the base of sandstone ridges (Short *et al.* 2019). The isolation of these springs and constancy of temperature may explain why this species is so different.

Many streams and seeps associated with the sandstone habitats described above cease to flow and dry out during the dry season. During these months, species retreat to the interstitial groundwaters associated with these seasonally-available, surface water habitats.

Seasonal movements, recruitment and other behavior

Wilson *et al.* (2009) reported on wet season movements and behavior of isopods. Expanding upon this previous description, adult isopods become particularly active after the first rains of the wet season, typically in October and November. For those populations obliged to seek dry season refuge in interstitial waters retained in underlying sediments, rock crevices or in shallow groundwater aquifers, re-wetting and flooding of surface waterholes or water courses invariably results in the immediate appearance of large numbers of active adults. Even for populations resident year-round in permanent surface waters, activity and abundance may be much greater following early wet season rains. For example, sampling conducted in upper Gulunggul Creek in October 1999 after early wet season rains resulted in the collection of large numbers of individuals along the creek course, particularly at seep and spring



FIGURE 1. Selected localities showing habitat types where *Eophreatoicus* Nicholls, 1926 and *Kakadubeh* gen. nov. species can be found. A–C, King River Region, type locality of *Eophreatoicus kershawi* Nicholls, 1926: A, Sandstone escarpment; B, CLH and colleagues approaching base of escarpment; C, cave pool where presumptive topotypes were collected. D, cave pool in Liverpool catchment, type locality of *E. mok* sp. nov. E, Lightning Dreaming, type locality of *E. namimminya* sp. nov. and *E. namarden* sp. nov. F, Julie Hanley collecting at Myra Springs, type locality of *E. bodmemurrngkudji* sp. nov. G, Collecting from spring-fed stream flowing away from Cannon Hill, type locality of *E. karrkkanj* sp. nov. H, CLH at an escarpment stream south of Gunbalanya, type locality of *E. kurdabeyhmay* sp. nov. I, Stream near source of Leichhardt Springs, type locality of *Kakadubeh rangemyahwurd* sp. nov.

points exhibiting recent water flow. Follow-up collections in July 2000 in the same permanent waters resulted in far fewer animals collected (CLH, pers. observations). In other permanent surface waters, however, including sites containing *Eophreatoicus namimminya* sp. nov and *Eophreatoicus namarden* sp. nov. (Lightning Dreaming Creek), isopods may be observed and collected in large numbers year-round. These sites are often free of predatory fishes (Wilson *et al.* 2009). For locations where predatory fish are present, however, isopods may be cryptic and seek refuge under rock and amongst aquatic plant material (e.g., *E. korokoro* sp. nov.).

With reconnection of watercourses during the early wet season, large numbers of both adult and juvenile isopods disperse limited distances (a few km) downstream. In small, seasonally-flowing watercourses, mass upstream migrations of adult isopods to dry season refugia have been observed during the mid to late wet seasons (Wilson *et al.* 2009), demonstrating localized homing behavior. Such migrating swarms of isopods have been observed in a tributary of Gulunggul Creek draining Mt Brockman (near Radon Springs and Blue Tongue Dreaming) and small streams draining Nourlangie Rock (Fig. 2). Isopods are also efficient climbers over moist substrates and, in general feeding behavior and in migrations just mentioned, have been observed on the walls of near-vertical crevices and waterfalls (Wilson *et al.* 2009).



FIGURE 2. Mass upstream migration of adult *Eophreatoicus nawurlandja* sp. nov. to dry season refugia during the mid to late wet season in the Nourlangie Creek catchment (location 12°51'59.65"S, 132°49'07.11"E, 16 March 2000). A, habitat upstream from road and culvert. B–C, isopods clustering at the downstream margin of culvert.

Associated surface water quality

In the upland seeps, springs and stream sections of permanent flow where isopods occur, water quality of surface waters during both the wet and dry seasons is relatively uniform and reflects the highly-leached nature of the sandstone catchments and the characteristics of wet season rain waters. Water quality data (Appendix 1) have been gathered for Magela Creek, a tributary of the East Alligator River, upstream of the Ranger mine site since 1980, for the period of flow (usually December to June). This water quality is indicative also of regional dry season water quality in upland surface waters of permanent flow. In particular, surface waters are acidic (arithmetic mean pH 6.2), the result of the natural acidic quality of the rain, poor buffering capacity of the catchment rocks and soils, and the presence of organic acids from (mainly) decaying leaf litter. Electrical conductivity of the waters is low (5–26 μScm^{-1}), together with concentrations of suspended materials (suspended solids, 4–59 mg L^{-1}), major ions,

nutrients and trace metals. Waters are also extremely soft with low buffering capacity and have relatively high temperatures (mean ~28°C during the summer wet season). These characteristics are exemplified in water quality data acquired for several sites from which isopods have been collected (Appendix 1).

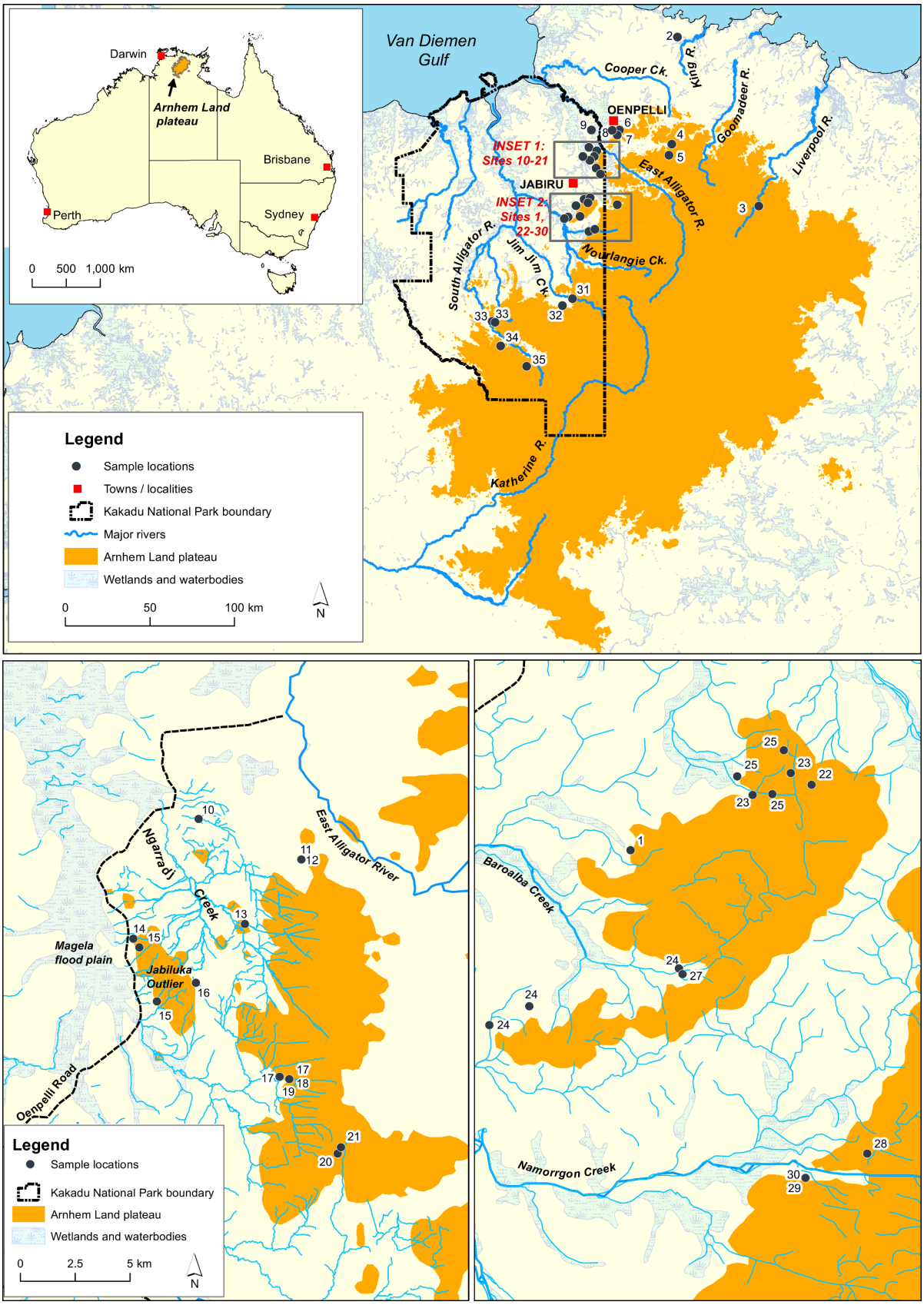

FIGURE 3. Map of collecting localities from Arnhem Land and Kakadu National Park, Northern Territory, Australia with 2 enlargement insets. See Appendices 2 and 4 for species number labels.

Appendix 1 also contains data from two sites in the seasonally-flowing Rockhole Mine Creek (RMC), a small, narrow, cobble-bedded, second-order tributary arising on a sandstone outlier of the Arnhem Land plateau and draining into the South Alligator River (site 40, Fig. 3). For the past 50 years, the lower sections of RMC have received acid water, enriched in heavy-metals, emanating from the adit of an abandoned uranium mine. In experimental manipulations conducted by Faith *et al.* (1995), macroinvertebrate communities were sampled from artificial substrates across a full gradient of mine water exposure, including uncontaminated upstream water. *Eophreatoicus warddebarrarn* sp. nov., common in the creek, was indifferent to the contaminated creek waters and, over a seven-week exposure period, occurred in slightly higher abundances in the creek downstream of the source of mine waters than upstream (mean of 11.7 versus 8.2 individuals per weekly sample, respectively; Student-t test not significant) (Dostine *et al.* 1993). For most of the exposure period, water quality in the creek downstream of the mine-water input was worse than that shown in Appendix 1 (column RMC "polluted"); at the prevailing pH, the Australian and New Zealand Water Quality Guidelines for protection of freshwater ecosystems of high conservation value (ANZECC & ARMCANZ 2000) are exceeded for Ni, Cu, Zn and Al, while U measured at this site exceeds a local ecotoxicologically-derived water quality limit (Hogan *et al.* 2005). By the end of the exposure period, isopods were still observed in polluted water of pH 3.3 (Dostine *et al.* 1993).

Methods

Sampling

Eophreatoicus specimens (see Appendices 2–3 for sites and accession numbers, Fig. 3 for mapped distribution of the sites and species) were collected from streams and springs using small sieves or sweep nets. Most specimens were collected by CLH and ERISS staff, except for visits by the first author (GDFW) to the Kakadu region in 1994 and 1999. Most specimens were preserved in either 70% ethanol with 5% glycerin added or in 95% ethanol. Some initial samples for several species were also preserved in formaldehyde solution and could not be used for molecular sequencing. We did not succeed in obtaining sequences from *E. warddebarram* sp. nov and *E. gubara* sp. nov. and so these species are not represented in the genetic data.

Images

All specimens were examined using light microscopy and scanning electron microscopy (SEM). The holotype and multiple paratypes were photographed using a digital camera and the resulting images processed into plates and used for measurements. The light microphotographs were taken with digital cameras (ranging from Nikon 990, Canon Powershot S5IS to, most recently, Canon EOS 6D) and from Wild or Leica stereo microscopes. The resulting images of preserved specimens have lost some pigment, especially green and red pigments; as a result, the coloration in the habitus photographs should be used mainly as a guide to chromatophore distribution and density.

To enhance the depth of field, multiple images were taken at evenly spaced series of focal levels, aligned using the Hugin software tool (http://hugin.sourceforge.net/) align_image_stack (settings "-v -m -a") and then merged using the Hugin software tool enfuse (based on Mertens *et al.* 2009, settings "-v --exposure-weight=0 --saturation-weight=0 --contrast-weight=1 --hard-mask -contrast-window-size=5"). Some light microphotographs, such as those from an Olympus BH2 microscope, were decomposed into color channels and the clearest channel was used as a gray scale image. Transmitted light images of mouth parts were taken with an Olympus BH2 microscope with a green band pass filter, which gave the highest contrast as gray scale images.

For SEM, limbs from types were dissected in ethanol using a razor blade fragment held in a clamp. Sonication for 3–5 seconds was performed to remove debris and epibionts. Not all epibionts were removed; loricate peritrichs (family Lagenophryidae; e.g., Clamp & Kane 2003) are commonly seen in the images. These appear as small ovoid domes with a single opening and can be quite common on some specimens (e.g., on the pleotelson on the female specimen of *E. karrkanj* sp. nov., Fig. 81). The specimens were dehydrated in 100% ethanol and critical-point dried. Individual parts were vertically mounted on stubs at the cut edge using adhesive carbon spots. For efficient imaging, multiple parts were placed on each stub so they could be viewed without obscuring other parts. The stubs were then

gold-palladium sputter coated and examined using an Evo LS15 Carl Zeiss SEM microscope. The SEM stubs are retained at the Australian Museum (see 'Materials Examined' for each species).

Figures were prepared using GIMP (versions 2.6.6 to 2.8.22, http://Gimp.org). Backgrounds were deleted from each image, gray levels adjusted for a consistent contrast and, if appropriate, sharpened using the GIMP filter "unsharp mask". Color images, which were obtained under many different lighting conditions and from different cameras, often needed adjustment of colors for consistency and accuracy of appearance. Because all specimens were preserved, the colors do not represent those of live animals in the wild, which range from reddish brown to yellowish green to grey.

Data Sources

Measurements were made on digital images of specimens using a graphics tablet (Wacom Co., Inc.) or a mouse and the Java application ImageJ (Wayne Rasband, http://rsbweb.nih.gov/ij/). The data were entered into a DELTA database (Dallwitz 1980, Dallwitz *et al.* 2000). This database was used to generate the key and descriptions, which were edited subsequently for clarity. Entries in the database are descriptive text, unordered multistate characters, integers and real numbers. In the case of the latter two data types, ranges typically were given that may also include a third median value in the cases where multiple individuals were measured. Because multiple individuals were used for scoring, a parenthetic comment may indicate which specimen was used for the data. In the descriptions, diagnostic characters and differences between taxa were found using the INTKEY application, which is part of the DELTA system (Dallwitz *et al.* 2000).

The mitochondrial 16S ribosomal RNA sequences (16S) and the cytochrome c oxidase subunit 1 (COI) sequences are from GenBank (sources and sequencing methods in Wilson *et al.* 2009) and generated in several laboratories (Australian Museum, Sydney; Smithsonian Institution, Washington DC, USA; Griffith University, Brisbane, Australia), using the same methods as described in Wilson *et al.* (2009). These data ranging from 1–10 COI and 1–9 16S sequences per species-level taxon, with most having at least 2 sequences of each marker except 2 species where sequences were not obtained. Although insufficient to be used for analysis, three nuclear 18S ribosomal RNA (18S) sequences were obtained at the Australian Museum (Appendix 6). The data were aligned using MUSCLE (Edgar 2004), using default parameters, and a two amino acid gap (a gap of six contiguous bases) in the COI data (Wilson *et al.* 2009) was adjusted to match the amino acid boundaries. The species, accession numbers, voucher information and localities are listed in Appendices 2 and 4.

Diagnostic Morphological Characters

External features allowed us to distinguish species of *Eophreatoicus* prior to obtaining results from the genetics. These features were discovered because some localities had two or three co-occurring species in the same sample and because these features stood out as being relatively constant within a group of individuals but consistently different from other individuals in the same sample. These determinations were confirmed subsequently by the molecular data analyses (Wilson *et al.* 2009). Once species were identified, we added many other more difficult to observe features to the database that are also diagnostic for each species. The following discussion, however, covers those characters that can be observed with a dissecting microscope.

Eyes (Fig. 4). The size of the eyes compared to the basal article of the antenna proved to be a useful categorical character to separate species. This was first noticed when identifying species in samples from tributaries and springs around Gulunggul Creek. The difference in the approximate area of the eyes also can be seen in the figure comparing *Eophreatoicus nawurlandja* sp. nov. and *E. galunggul* sp. nov. (area in image 0.03 mm^2 vs 0.06 mm^2, respectively). Four separate features were chosen as diagnostic: eye profile, whether they were fully sessile, bulging dorsolaterally or projecting anteriorly (seen in fossil taxa); eye height compared to the width of the base of the antenna, where small is less than, medium is subequal to and large is greater than the width of basal articles; eye height in lateral view relative to length; and, the degree that the eyes project from the head in dorsal view.

Cervical groove on posterior margin of head. In lateral view, a groove marks the boundary between the cephalon and the first thoracosomite, the maxillipedal segment. It can extend from just above the anterolateral margin of pereonite 1 (e.g., Fig. 126G, *cg*) to extending nearly to dorsal margin of head (e.g., Fig. 54A C, *cg*).

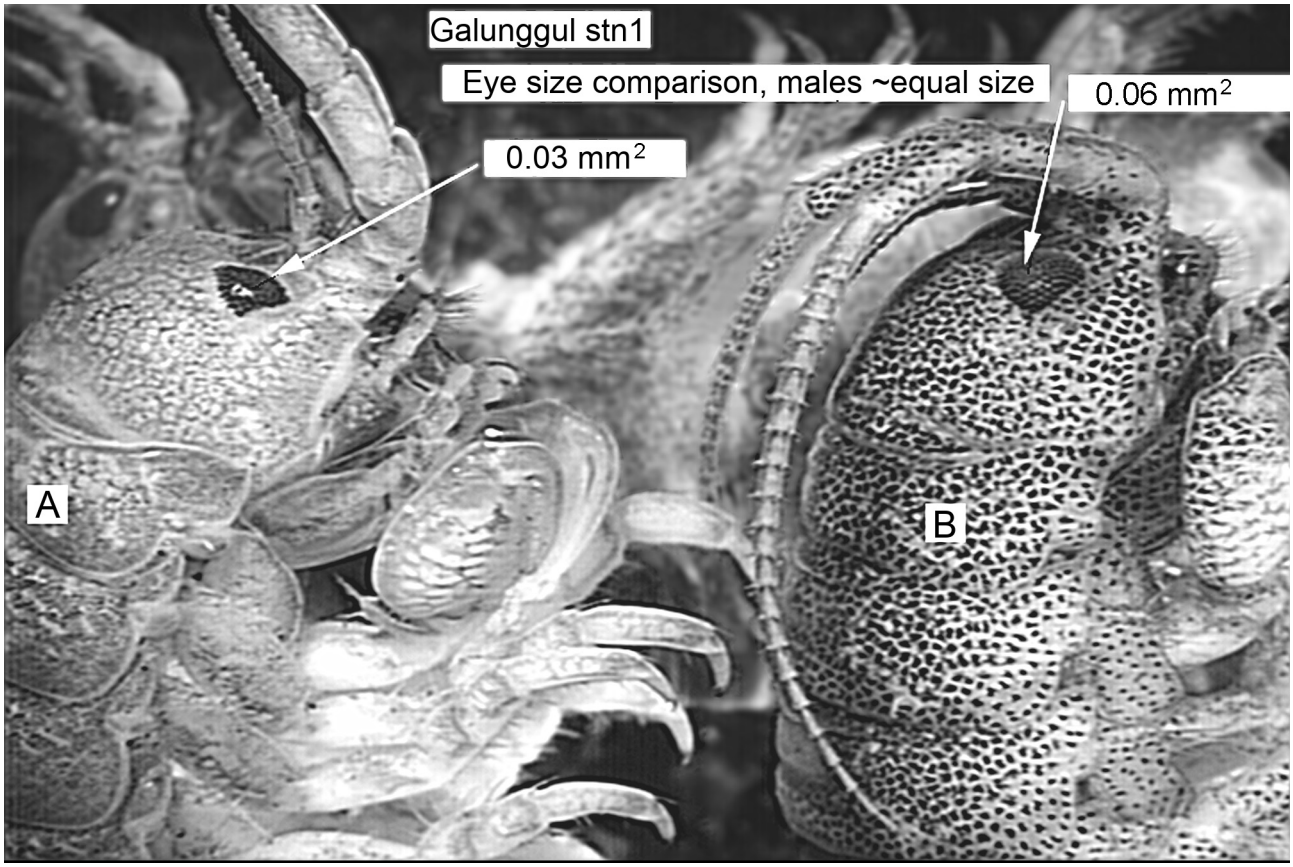

FIGURE 4. Eye size comparison of co-occurring species at Gulunggul Ck Station 1. Two same-sized specimens in a mixed species sample with a measure of eye size measured in pixels in the image. A, *Eophreatoicus nawurlandja* sp. nov., eye height subequal to antenna basal article width. B, *E. galunggul* sp. nov., eye height larger than antenna basal article width.

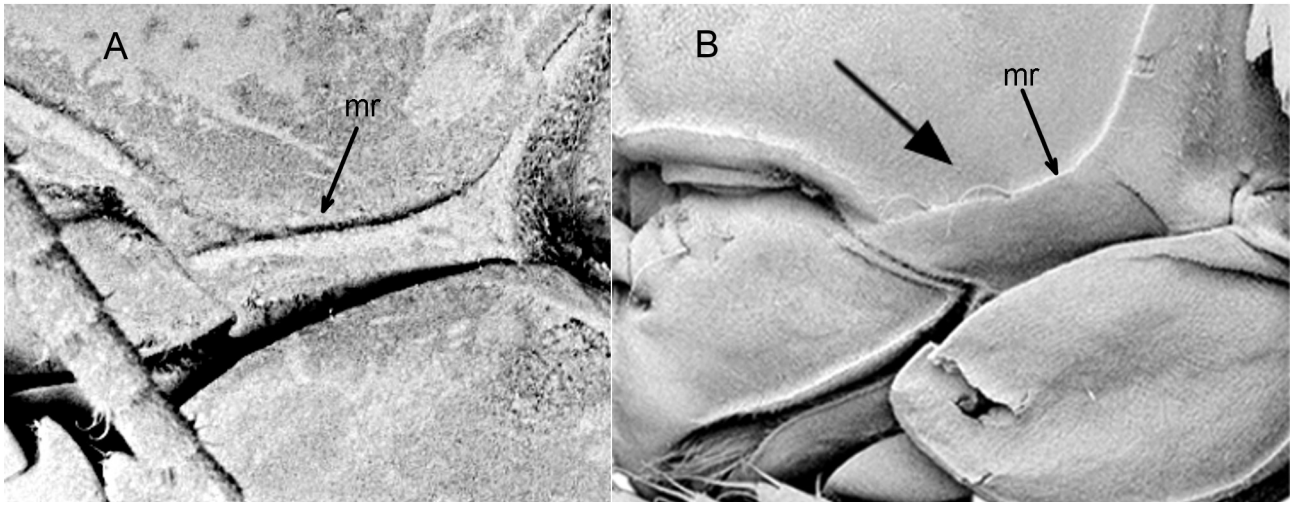

FIGURE 5. Maxillipedal ridge on head. A, *E. gudjangah* sp. nov, no setae on maxillipedal ridge. B, *E. binjdjarrang* sp. nov, large arrow indicating one of two setae, small arrows indicating the maxillipedal ridge, mr.

Maxillipedal ridge (Fig. 5). The head is covered ventrally by the maxillipeds that extends to its lower margin. A cuticular ridge is directly dorsal to where the epipod contacts the head. The cuticle below the ridge is smooth, probably allowing the epipod to slide easily over it. The ridge itself is a fold, projecting dorsally, that begins above the posterior condyle of the mandible and continues to the posterior margin of the head, where it then angles dorsally and becomes a flange where the head attaches to the first pereonite. The dorsal part of the angle cannot be seen in an intact specimen. The ridge may have a relatively sharp margin, be rounded or not expressed at all. It may have

tiny denticles visible in the SEM images, but might be difficult to see in a dissecting microscope. It also has setae of various sizes in the groove that extends along the ventral head margin from the maxilliped, curving up toward the clypeal notch. Females tend to have more and longer setae. The "without setae" state (Fig. 5A) ignores tiny setae that might be seen only in SEM images. Several dorsally-projecting setae (Fig. 5B) are generally short and may be difficult to see, especially in damaged specimens. Elongate setae are easy to see and are generally curled and projecting both dorsally and laterally.

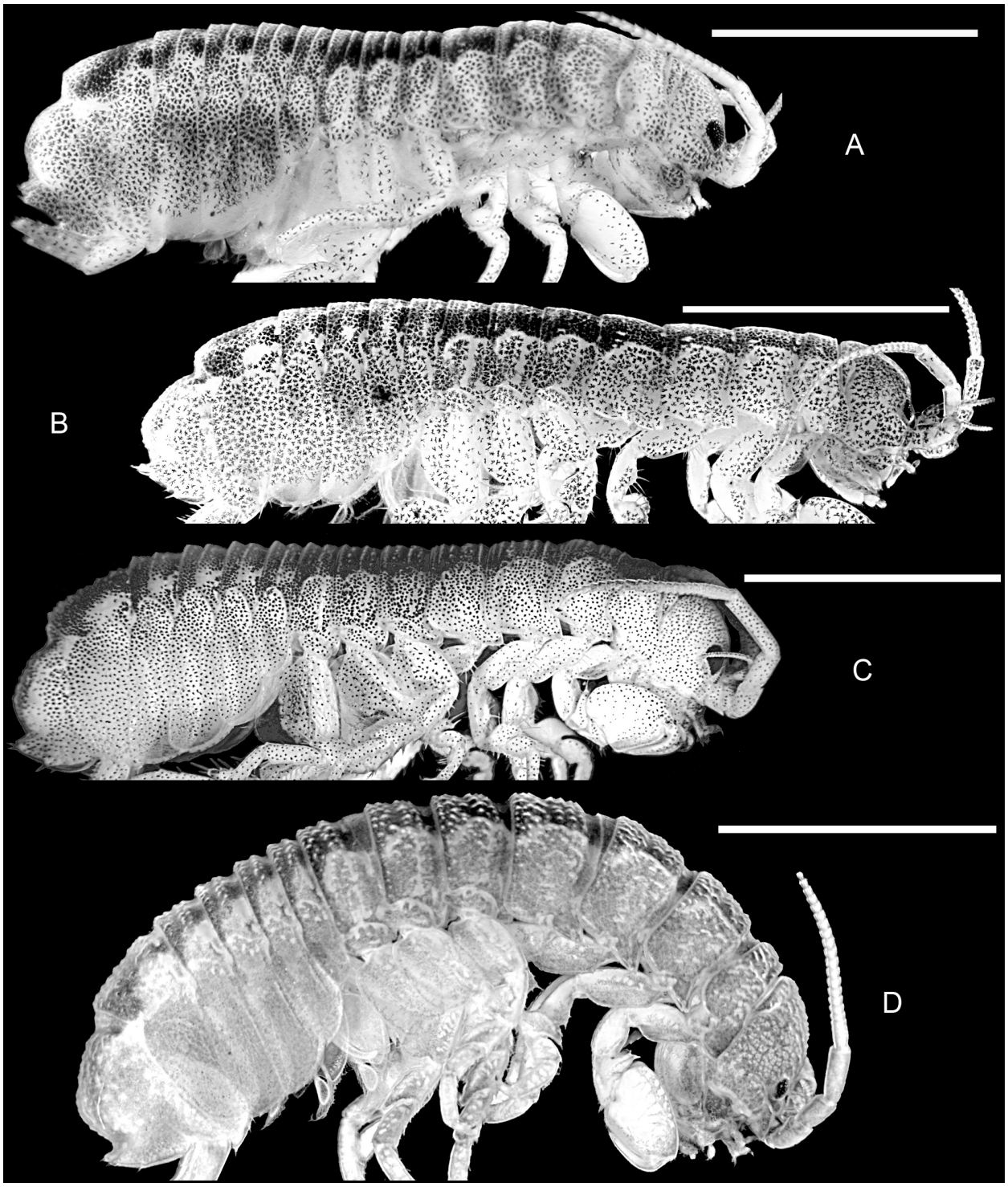

FIGURE 6. Pereon and pleonites cuticular structure. A, *Eophreatoicus kershawi* Nicholls, 1926, male, AM P.72630; transverse ridges anteriorly rounded to carinate posteriorly. B, *E. mok* sp. nov. holotype male, AM P.86059; transverse ridges not expressed anteriorly to low without trough posteriorly. C, *E. indjangarlwurr* sp. nov. holotype male, AM P.76314; transverse ridges anteriorly rounded to carinate posteriorly. D, *E. namarden* sp. nov. holotype male, AM P.72624; without ridges but with transverse trough; note tuberculate dorsal surface. See text for explanation. Scales 5 mm.

Pereon and pleon cuticular structure: dorsal transverse ridges and cuticular rugosity (Fig. 6). The dorsal cuticular surface can have a variety of scales, roughness or tubercles, ranging from smooth (without roughness or tubercles) to strongly tuberculate in all life stages. In addition, transverse ridges on each segment can be carinate with a sharp edge facing posteriorly or they can be low and rounded. These ridges may be accompanied by a transverse trough behind the ridge. These features occur in different degrees on the anterior four pereonites, the posterior three pereonites and the pleonites, so they are treated separately.

Structures of the pleotelson (Figs. 7–8). Cuticular ornamentation of the pleotelson (Fig. 7) in *Eophreatoicus* is one of the key features differentiating species. Ornamentation may appear as low tubercles and ridges of various forms, ranging from rounded tubercles and elongate ridges to irregular patches of rugosity. These structures are best observed with a light source parallel to the microscope stage to enhance shadows of the tubercles. Several different character states are recognized. Rounded tubercles (Fig. 7 **rt**) are approximately round, but may appear oval in some views; typically, these are not as prominent as ridges or oblong tubercles. Oblong tubercles (Fig. 7 **ot**) are longer than wide, but more oval with their length less than twice their width. Ridges (Fig. 7 **ert**) are irregularly elongate tubercles, decidedly longer than wide by approximately twice or more. "Ridge" here is a smaller cuticular feature that does not include median or dorsolateral ridges, the latter seen in *Eremisopus* Wilson & Keable 2002a. Irregular rugose regions, which hardly project above the cuticular surface, are distinct patches of roughness. In *Eremisopus*, these patches appear regularly spaced. Several species, including *Kakadubeh* gen. nov., have no ornamentation at all. The dorsal surface may also have a posteromedial ridge that can be a smoothly rounded continuous ridge (Fig. 7 **spr**) or that can have several posteromedial tubercles not merging into a continuous ridge (Fig. 7 **tpr**). This ridge is often accompanied by concave surfaces to either side.

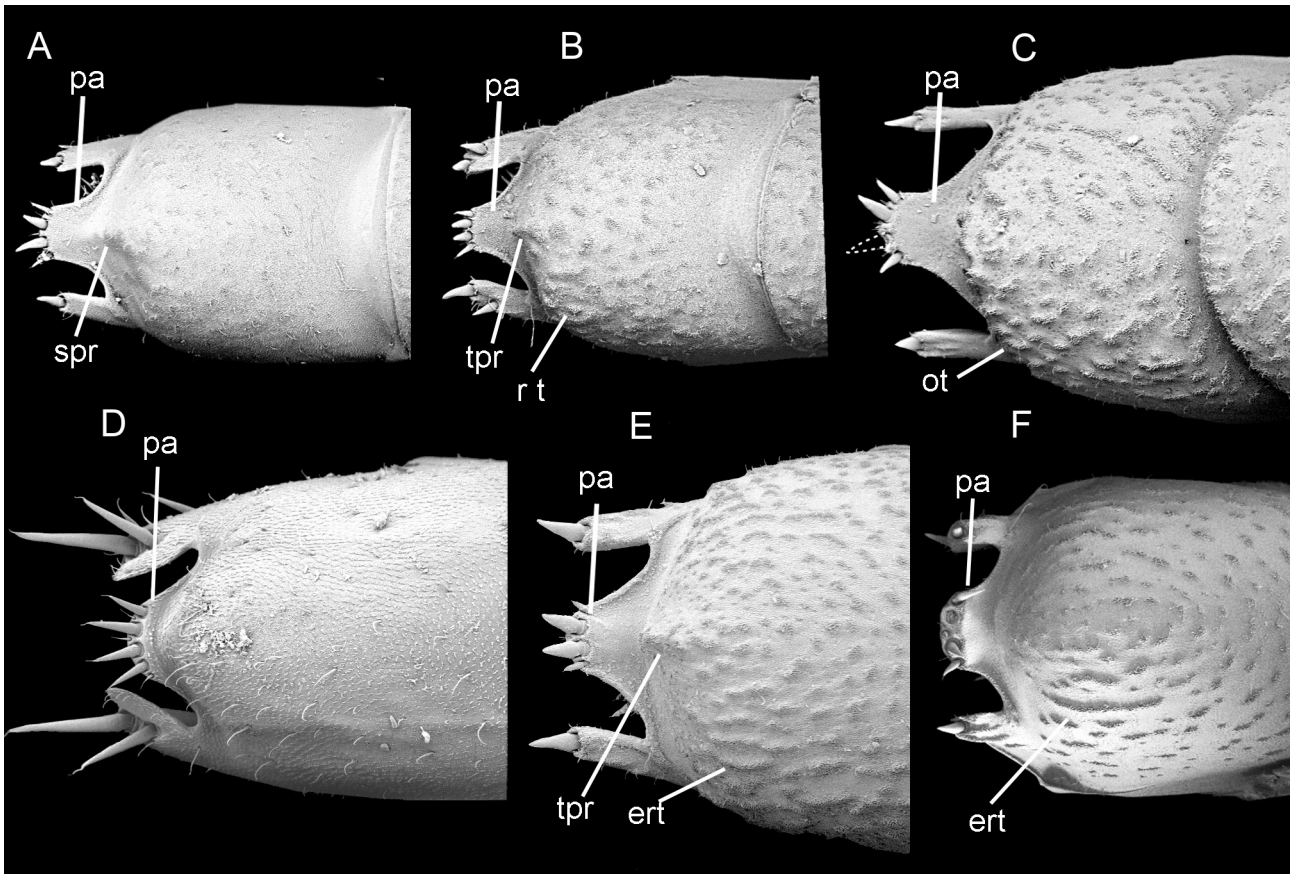

FIGURE 7. Pleotelson dorsal cuticular structure and posterior apex (**pa**). A, *E. galunggul* sp. nov., without tubercles, with smooth posteromedial ridge (**spr** in figure). B, *E. warnbi* sp. nov. with rounded tubercles (**rt** in figure), with tuberculate posteromedial ridge (**tpr**). C, *E. gubara* sp. nov. with oblong tubercles (**ot**), without posteromedial ridge. D, *Kakadubeh rangemyahwurd* gen. nov. sp. nov. smooth cuticle without posteromedial ridge. E, *E. barrkmarlam* sp. nov. with elongate ridge-like tubercles (**ert** in figure), with tuberculate posteromedial ridge (**tpr**). F, *Eophreatoicus mok* sp. nov. with elongate ridge-like tubercles (**ert** in figure), without tuberculate posteromedial ridge.

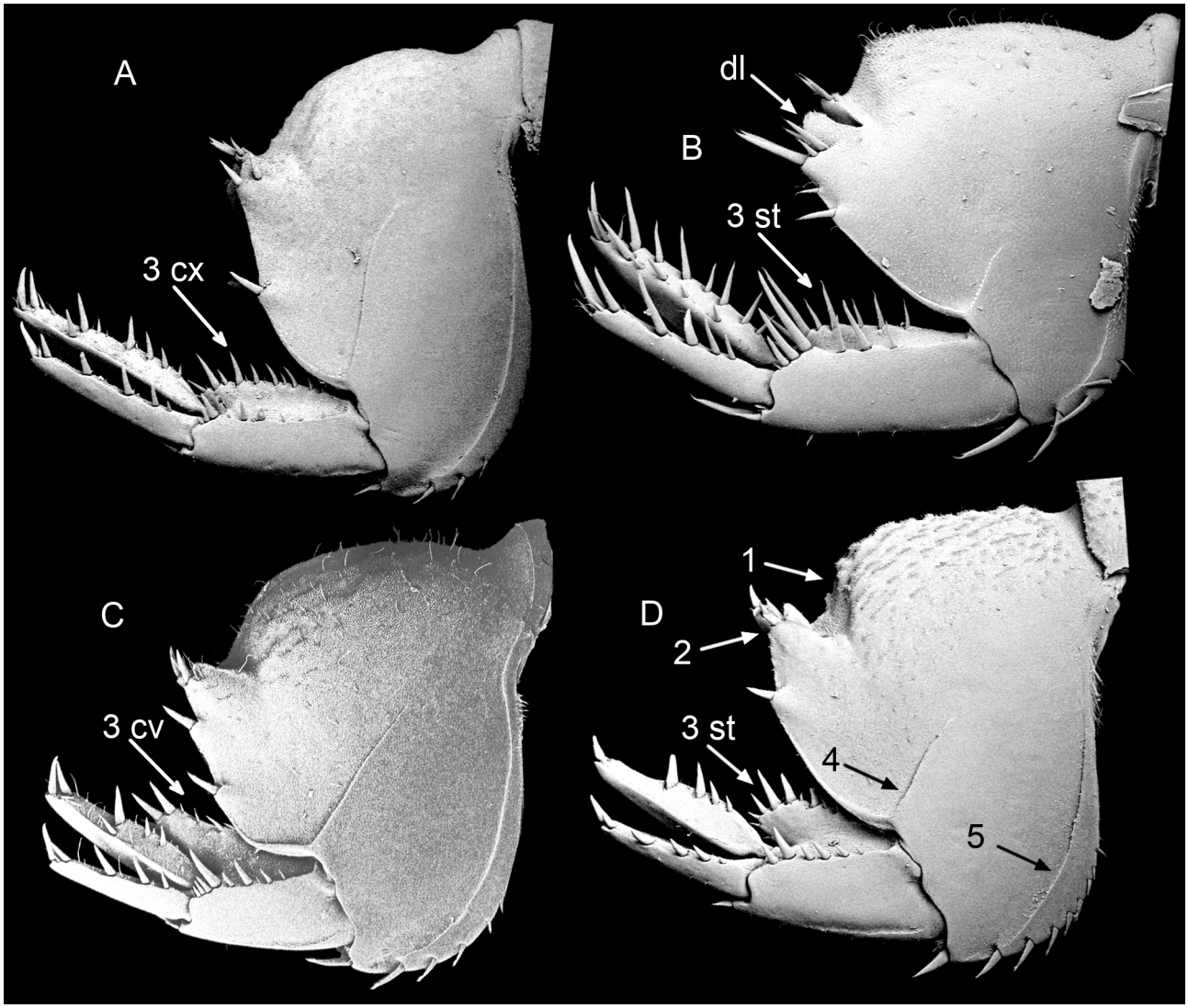

FIGURE 8. Pleotelson (lateral view) and uropods. A, *Eophreatoicus kershawi* Nicholls, 1926, male, AM P.72631. B, *Kakadubeh rangemyahwurd* gen. nov. sp. nov., female, AM P.72635. C, *E. wurrkbaba* sp. nov., male, AM P.76284. D, *E. gubara* sp. nov., male, AM P.76472. Annotations: 1, dorsal inflection; 2, posterolateral plate, dorsal seta position (one seta, no lobe), **dl** dorsal lobe on posterolateral plate; 3, dorsomedial ridge of the uropodal protopod; **cx** ,convex, **cv** concave, **st** straight; 4, lateral uropodal ridge; 5, pleonite ridge.

The pleotelson posterior apex (Fig. 7 **pa**) has several useful diagnostic features. The posterior apex varies from whether its tip is visible in lateral view or obscured by the posterolateral margin. The apex may be distinctly narrow distally in lateral view or it may have the dorsal and ventral surfaces approximately parallel. Setae ornament the apex of most phreatoicideans. In this group, the apex may have two pairs of setae of varying sizes or two pairs with a central fifth seta that is usually smaller. Ordinarily, scoring this is obvious, but in some individuals an intercalating fine seta may be promoted to a robust seta of varying sizes and positions. In such cases, bilateral symmetry is broken, so multiple individuals should be inspected to discover the general score for a particular species. These larger robust setae may have interdigitating fine setae in the same row as robust setae or fine setae above and below the robust setae; these fine setae are absent in some species. The pleotelson ventral surface (postanal region), another important feature, has varying numbers of robust setae from four (Fig. 22E) to as many as 27 (e.g., Fig. 201H) robust setae on a postanal ridge.

The posterior half of the pleotelson is strongly reflexed ventrally (in lateral view), forming a dorsal inflection (Fig. 8D 1). This feature varies significantly among the Phreatoicidea, but is largely similar with a strong ventral inflection among species of *Eophreatoicus* and *Kakadubeh* gen. nov. In lateral view, this inflection varies within these two genera by either being concave anteriorly, linear or posteriorly convex.

The lateral uropodal ridge (Fig. 8D 4) is a carinate ridge that varies considerably in shape and setation among the Phreatoicidea. In *Eophreatoicus*, it curves strongly and extends posteriorly from the uropods on the pleotelson margin; in *Kakadubeh* gen. nov., it terminates at the pleotelson margin above the uropods. Among species of the Amphisopidae, the posterolateral margin is a laterally flattened plate (Fig. 8D 2) that forms a chamber on either side of the anus and is ornamented with several groups of setae. In *Eophreatoicus* or *Kakadubeh* gen. nov., the dorsal setal position on the posterolateral plate (Fig. 8D 2) may have 1–3 robust setae. Notably, in *Kakadubeh rangemyahwurd* gen. et sp. nov., these setae are especially elongate. Medial and dorsal to these setae, the margin may form a large plate as in *Kakadubeh* (Fig. 8B **dl**) a short rounded or angular lobe or may not be present at all.

Antennal podomeres. The length of article 5 of the antenna (assuming that the basal podomere is counted, but not expressed in phreatoicideans) varies with respect to article 4 and can be longer , shorter or subequal (e.g., Figs. 53E, 60D, 68E).

Pereopod I. Although the first pereopod (second thoracopod) has many characters that appear in the description that require high magnification to view, the cuticle of the dactylus might be somewhat easier to see. The ventrodistal margin of the pereopod I dactylus of males and females may be modified with a row of spines. If a species has this feature, it may be expressed as one or two rows of thin scale-like spines, most often in females (Fig. 41A–C), but sometimes without any spines on the ventral dactylar margin (Fig. 40H–I).

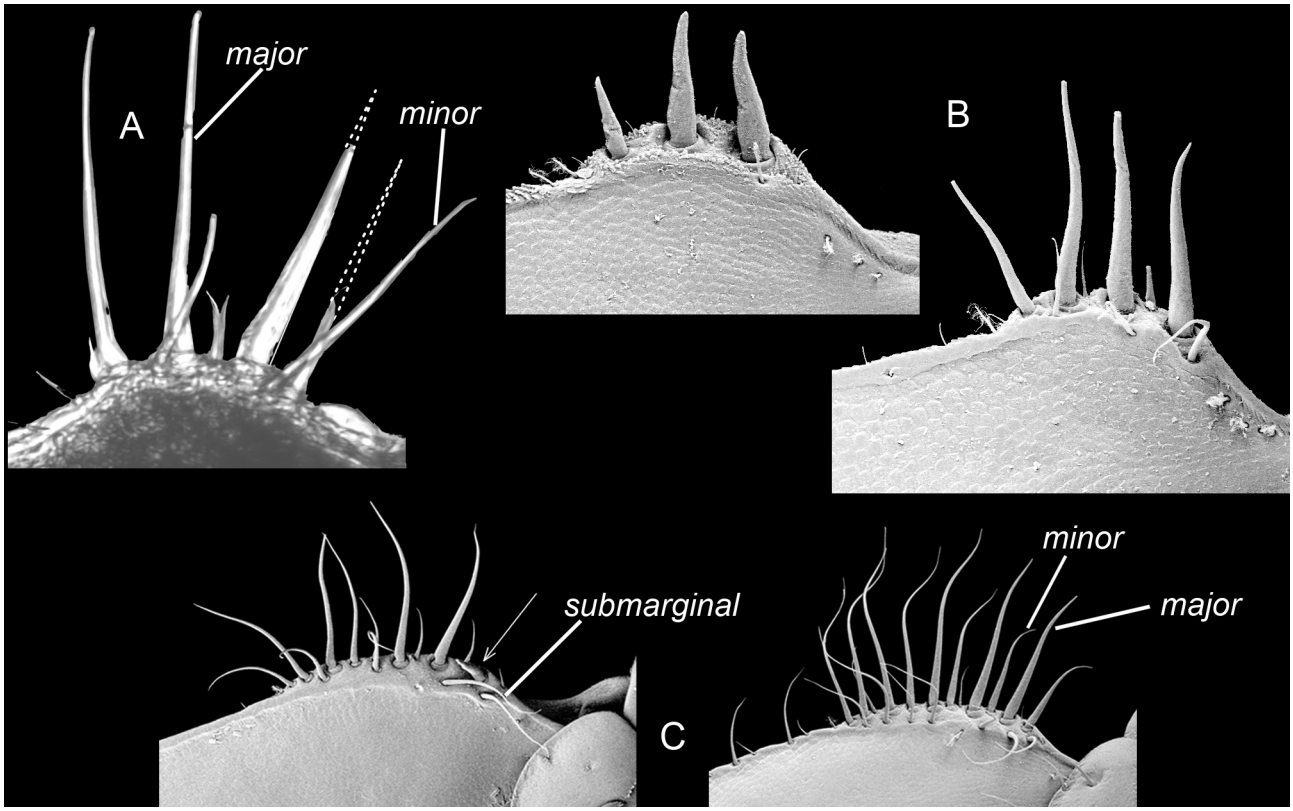

FIGURE 9. Pereopod II basis epaulet major setae, proximal right. A, *Eophreatoicus kershawi* Nicholls, 1926, female, transmitted light photograph, 4 major setae, several broken tips indicated by dotted lines. B, *E. balbun* sp. nov. male and female, SEM image, 3 and 4 major setae, respectively. C, *E. djirrinjbal* sp. nov. male and female, SEM image, 6 (arrow indicating damaged seta) and 7 major setae, respectively, 3 shorter setae not counted.

Pereopod II epaulet (Fig. 9). The epaulet is an enlarged and setose projection on the proximal dorsal margin of the basis of pereopods II–IV and to a lesser extent on pereopod I. The setation of the epaulet proved to be one of the best characters for differentiating species of *Eophreatoicus*. This structure is also found in *Eremisopus* Wilson & Keable, 2002a and *Kakadubeh* gen. nov. It varies in length along the basis between the species. Pereopod II was chosen as the benchmark for each species, even though the epaulet occurs on other limbs, because the setation was similar across pereopods II–IV. The epaulet is located where one would expect to find the exopod (Nicholls 1943), although it does not exist in adult isopods (an exopod rudiment has been reported in this location on embryos of oniscideans: Milatovic *et al.* 2010; Wolff 2010). We have not evaluated the embryology of *Eophreatoicus* species,

so Nicholls' (1943) inference remains only hypothetical. Of more relevance is that this structure is one of the key features to distinguish species of *Eophreatoicus*. The size of the epaulet is its length compared to the length of the basis, using the position of the epaulet basal inflection as a landmark. The epaulet, in its most developed form, has two rows of setae: a main row on the dorsal margin of the epaulet and an adjacent submarginal row ("*submarginal*" in Fig. 9). The setae have two forms, major setae and fine setae ("*major"* and "*minor"* in Fig. 9). The major setae on the main row, which might be normal elongate and curved setae or short and robust, are the longest setae. These major setae often alternate with shorter setae that vary from tiny to those that approach the major setae in relative robustness. Viewed under a microscope, the major setae on intact specimens are easier to see because they catch the light. This character was surveyed by an assistant who provided indicative values as ranges (in larger samples a median was given) in the sample for the setation in all named species. These values were checked against specimens, light and SEM images. In the SEM images, some setae may be missing owing to damage during processing, although their presence can be inferred by the socket or proximal shaft that remained.

Pereopod IV. Males of *Eophreatoicus* have, like most phreatoicideans, a sexually dimorphic pereopod IV with a distinct prehensile palm in adult males (e.g., Fig. 28A–B), while *Kakadubeh* gen. nov. does not (Fig. 20A–B). Where it is so modified, the propodus may have a proximal rounded angular projection. The propodal margin, with or without the projection, typically has two or more distinctly robust or robust-based setae. Additionally, males may have a dactylus that varies from being longer to shorter than the palm margin of the propodus.

Pereopod V–VII. The posterior three pereopods have ridges or broad flanges on the dorsal margin of the basis and less projecting ones on the ischium (e.g., Figs. 139D, 140A, 180C, F–G). In these species, the plate of the basis does not vary as much as the ischium whose width may vary from greater to less than the width of the shaft of the ischium.

Uropod (Fig. 8). The uropodal protopod varies in length from not extending beyond the pleotelson apex to being clearly longer. Most Amphisopidae have a distinct dorsal plate on the dorsomedial margin of the protopod (Fig. 8D 3), furnished with varying sizes and numbers of robust setae. This dorsomedial ridge is a key feature to separate species. It projects above the shaft to varying degrees and has distinctly differing marginal shapes (concave, convex or linear) and differing sizes of the setae on the most dorsal part of the ridge.

Phylogenetic analysis

The characters in the Delta database currently include 840 descriptive characters from 138 species of Phreatoicidea, although data were used only from the taxa listed above. Many characters include scored meristic features and ratios, as well as simple textual descriptive characters, so many characters were excluded from these analyses, which used only discrete characters (treated as unordered). In a few cases, integer or real number characters that were especially useful for distinguishing species in the key, such as the number of setae on pereopod II basis epaulet, were gap coded for the analysis. Because many species had a variable number of setae in adult males and females, the setae were coded into the smallest ranges possible. Possible codings were inspected in a spread sheet for the smallest number of overlaps of categorical characters to minimize polymorphic species in the dataset. The morphological data included 160 characters (Appendix 5), of which 115 were parsimony informative.

The DELTA database was used to generate a Nexus data file with these 36 taxa was processed to include full character descriptions and then read into Mesquite version 3.6 (Maddison & Maddison 2018) for analyses. In addition to organizing the data and generating files for analysis, Mesquite was used for calculating tree indices, taxon instability values and an uncorrected P-distance matrix (Appendix 3).

TNT files generated by Mesquite were analyzed using TNT64, version 1.5 for LINUX (Goloboff & Catalano 2016). The intent of the analyses was to combine the molecular data with the morphological data, for which no useful likelihood model exists (contra Lewis 2001). Although many researchers follow Tuffley & Steel (1997) in equating parsimony with the "no common mechanism model", as modified by Lewis (2001) for morphological analysis, the ordinal equivalence of the two approaches has not been shown (e.g., Sober 2004, 2008). Moreover, the assumptions of Lewis (2001) and papers using his model are unrealistic for morphological data because we have no way to estimate transition probabilities. In most cases, weighted parsimony outperforms model-based analyses (Goloboff *et al.* 2018), so model-based analyses were not considered useful for this project.

Both equal weights and implied weights parsimony (Goloboff 1993; Goloboff *et al.* 2008), using the concavity

value of K=12 as suggested by Goloboff *et al.* (2018), were performed on all data sets, yielding a pair of results for each data set. This concavity value does not penalize homoplasy as highly as the default TNT value of K=3. Lower values of K (homoplasy heavily down weighted) tended to break apart known sister species, such as *E. balbun* sp. nov. and *E. barrkmarlam* sp. nov., whereas trees from higher values of K showed few differences compared to K=12 trees. Group support was evaluated using symmetric resampling jackknifing (probability 33%; Goloboff *et al.* 2003). The data were analyzed using the TNT64 commands " hold 4000; drift:fitd 2 rfitd 0.1; sect:slack 20; xmu = verbose replic 10 hit 10 drift 10 ratchet 10;" for the main part of the analysis, and "resample [mu1=ho1;] prob 33 rep 1000 sym frequency from 0" for symmetric resampling. The second analysis for each pair was the same but with an initial command "piwe=12" to activate implied weights. Branches with poor support, set at a nominal value 10%, were collapsed; this is necessary because implied weights analyses produce only single trees under most circumstances because lengths are real numbers. Because of the loss of a 1:1 relationship between the magnitude of steps and characters in the implied weights analyses, the tree lengths and other statistics are reported without the implied weights to allow comparison. The data files are deposited in TreeBase (http://purl.org/phylo/treebase/phylows/study/TB2:S26181), including analyses and resultant trees.

Species of *Kakadubeh* gen. nov. and *Eophreatoicus* Nicholls, 1926 used in the analyses are listed in with voucher accession numbers (Appendix 2) and locality data (Appendix 4) including numbers on map in Figure 3. Five poorly-characterized species, that were not given formal species status, were not included in the first pair of morphology-only analyses but were used in the combined morphology and16S-COI analyses. In the first pair of analyses, additional amphisopid taxa that shared characters with *Kakadubeh* gen. nov. and *Eophreatoicus* and that were fully scored in the DELTA database were chosen from the Amphisopidae Nicholls, 1943. These include *Amphisopus lintoni* (Nicholls, 1924) and *Amphisopus annectens* Nicholls, 1943, which have the same sex-related size differences of *Kakadubeh*, a unique apomorphy (mature females are much larger than mature males) not found in *Eophreatoicus* or *Eremisopus*. Also included are *Paramphisopus palustris* (Glauert, 1924), *Eremisopus beei* Wilson & Keable, 2002a and a species of *Phreatomerus* Sheppard, 1927 from Deadwoman Springs that we originally assumed (e.g., in Wilson 2002b) was *Phreatomerus latipes* (Chilton, 1922). Guzik *et al.* (2012) found that multiple distinct genetic lineages (presumptive species) are present in the South Australian Mounds Springs region. The specimens of *Phreatomerus* from Dead Woman Springs differ morphologically from the types of *Phreatomerus latipes* from Hergott Springs, Marree, South Australia (SAM C431) and topotypes (SAM C2922), so this population is designated "*Phreatomerus* sp." *Mesamphisopus capens*is (Barnard, 1914), Mesamphisopidae Nicholls, 1943, is included as an outgroup. A second pair of morphological analyses was performed using only described species of *Kakadubeh* gen. nov. and *Eophreatoicus* Nicholls, 1926 to provide a detailed view of the relationships between the species of this clade. These analyses had 30 taxa with 160 characters, including both equal weights and implied weights parsimony, with group support values from symmetric resampling jackknifing (probability 33%).

For the third pair of analyses, the 16S and COI sequences were concatenated using Mesquite, eliminating individuals that were missing one or another marker. Data from *Kakadubeh* gen. nov. and species of *Eophreatoicus* were included. The sequences and GenBank accession numbers for these data are listed in Appendix 2. To reduce the number of terminal taxa in the molecular data, which have multiple sequences (putative haplotypes) per species, to match those in the morphological data, sequences from multiple specimens were merged into a single species-level sequence, using the Mesquite "merge selected taxa" tool. Where haplotypes differed at a particular sequence site, the relevant polymorphism was inserted. The two data sets were concatenated in Mesquite and were exported to a TNT format file. These data included five unnamed species for which we have mtDNA (Wilson *et al.* 2009) data, but insufficient morphological data. Two species, *E. gubara* sp. nov. and *E. warddebarrarn* sp. nov. that have no mtDNA data were excluded. The combined mtDNA data were analyzed using TNT64 with both equal weighted data and implied weights parsimony (K=12). Group support was found using symmetric jackknifing support, with groups having symmetric jackknife support below 10% collapsed for the final trees.

The fourth pair of analyses used morphology and 16S-COI data concatenated into a single matrix. These data were analyzed in TNT64 with equal weights and implied weights, as before. The data included 927 characters: 160, 227 and 540 characters, respectively, of which 394 were parsimony informative. These analyses used all described species of *Kakadubeh* gen. nov. and *Eophreatoicus* as well as the five unnamed species that were included in the mtDNA analyses. The taxon instability index (Maddison & Maddison 2018) was used in these analyses to identify those taxa with highly variable positions among trees.

Name sources and Abbreviations

Deciding on the names for these new species was an important part of this monograph. Because most species are virtually identical under casual inspection, we have decided to use the local place names, or toponyms, used by the owners of the lands from which the species were collected. The traditional owners of Kakadu and Arnhem Land do not have a name for phreatoicideans, probably owing to these isopods living in and around springs, only appearing briefly in streams during the short period of monsoonal rains and to having no dietary amenity. Although taxonomic names are generally adjectives that agree with in gender with the associated generic names, we have chosen all species names to be "nouns in apposition", which is allowed under the International Code for Zoological Nomenclature (ICZN 1999). Using nouns has two positive outcomes: the distinctive names honor the languages and places of the people from which the names came, and should any of the generic names change in the future, the species name will remain unambiguous. We did not arrive at these names ourselves; we consulted with local traditional owners and with Murray Garde, an anthropologist and linguist, who assisted us in finding the relevant toponyms (Garde 2014; details in Acknowledgments).

The order of descriptions of *Eophreatoicus* follows a westward trending north to south pattern starting with *Eophreatoicus kershawi*, the type species, so that nearby-occurring species are placed next to one another in the text. This pattern has two advantages over the standard alphabetical arrangement: geographically nearby species will be found in the same part of the text so that field workers can compare their specimens with the text figures and descriptions; and species that are more related to one another are more likely to be found in the same part of the text (but with important exceptions, discussed below in the species accounts). This order also respects the places where these species are found.

Abbreviations used in text are as follows: M<number> or F<number>, specific male or female specimen used for a measurement; H, holotype; bl, body length; Ma, million years ago; CI consistency index; RI retention index. Measurements, unless parenthetically indicated otherwise, were taken from the holotype. Institutions: AM, Australian Museum, Sydney; MAGNT, Museum and Art Gallery of the Northern Territory, Darwin; MNHN, Museum national d'Histoire Naturelle, Paris; SAM, South Australian Museum, Adelaide; VIC, Museum Victoria, Melbourne, Australia; TMAG, Tasmanian Museum and Art Gallery; WAM, Western Australian Museum, Perth. In the following Results section, the new taxonomic status is assumed for all taxa listed in Appendices 2–3.

Results of the phylogenetic analyses

The morphology data with four Amphisopidae and *Mesamphisopus* (Mesamphisopidae) outgroups had a total of 36 taxa and 160 characters, of which 115 were parsimony informative. This first pair of analyses (of four) included all species of *Eophreatoicus*, except those that were not well characterized and were not given species status. The analysis using equal weights found 12 trees (length 523 steps, CI 0.403, RI 0.546) with poor resolution between taxa of *Eophreatoicus* (consensus in Fig. 10A). The analysis with implied weights (concavity constant K=12) found a single tree (unweighted length 523, CI 0.403, RI 0.546) where poorly supported branches (symmetric jackknife probability 10% and below) were collapsed (Fig. 10B). *Kakadubeh* was clearly distinct from *Eophreatoicus* in both analyses with strong support.

For the second pair of analyses, *Kakadubeh* was used as outgroup for the remaining analyses to find relationships within *Eophreatoicus*. The equal weights analysis with 30 taxa found four trees (length 355, CI 0.392, RI 0.461), but with low symmetric jackknife support for most nodes (Fig. 11A). The low levels of support indicate the relatively high levels of homoplasy in the morphological data. The implied weights analysis (concavity constant K=12; Fig. 11B) found one tree (unweighted length 362, CI 0.384, RI 0.444) with similarly low support, but with some differences. The positions of *E. gubara*, *E. kershawi*, *E. korokoro*, *E. djurrukunja* and *E. galunggul* caused disagreement in the trees. The taxon instability index among trees (median value 0.361) indicated that *E. gubara* was most variable (maximum value 0.793) in its position. The best supported group, as expected, was *E. nawurlandja* and its Gulunggul Creek population, whereas *E. kurrih*, which showed identical mtDNA to *E. nawurlandja* (see below), was placed on the basal polytomy. The remaining clades showed weak support; inspection of the character distributions and a Bremer support analysis (not shown) found that most clades were supported by only 1–2 characters with substantial contradictory evidence. This result may be typical for a set of closely related species where variable characters are

not filtered by a long phylogenetic period. Between genera, such as the outgroups in the first analysis, the results are more certain.

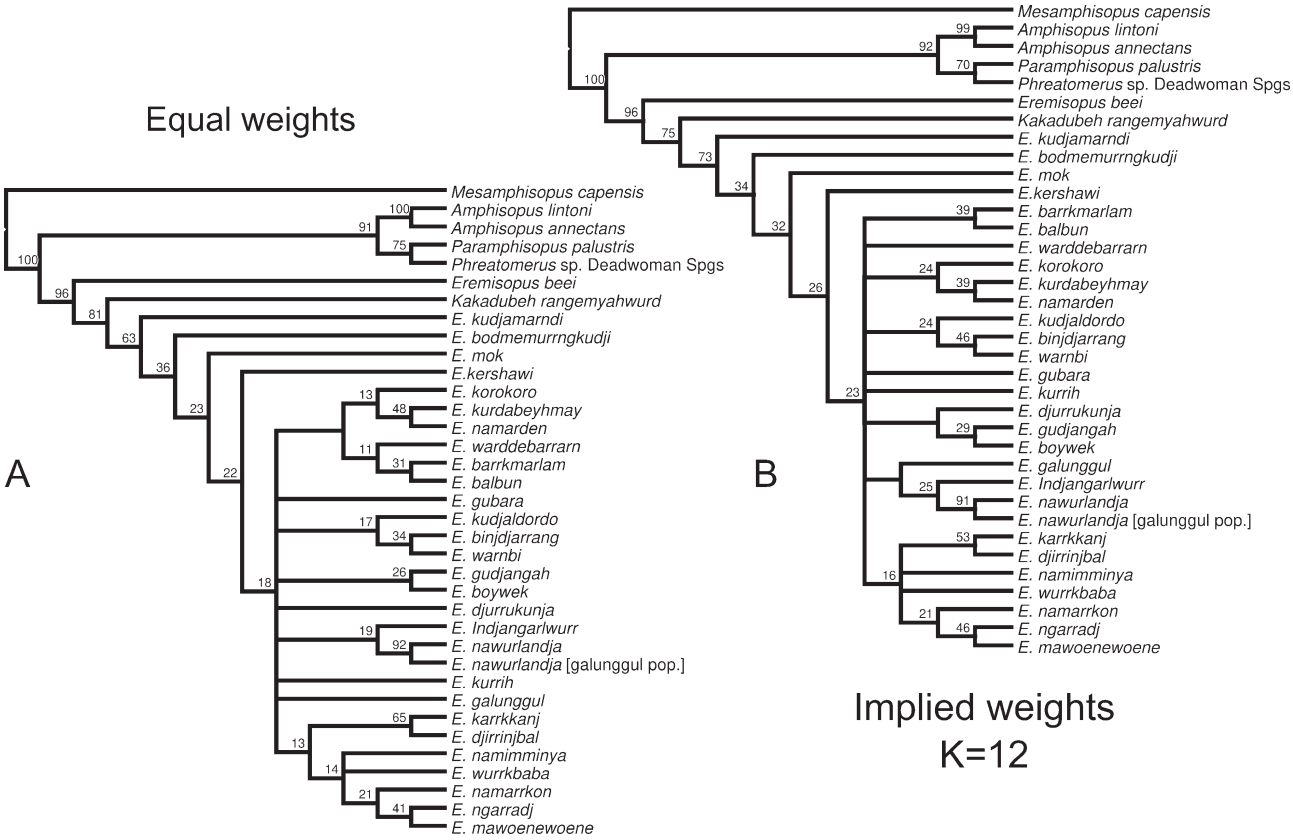

FIGURE 10. Parsimony analysis of Mesamphisopidae and Amphisopidae, including *Kakadubeh rangemyahwurd* gen. nov. sp. nov. and 29 described species of *Eophreatoicus*, using morphological data (see Appendix 5, character list). A, equal weights analysis. B, Implied weights analysis with concavity constant = 12. Numbers on branches indicate probability in a 33% symmetric jackknife analysis, 1000 replications. Branches with p=10 or less were collapsed.

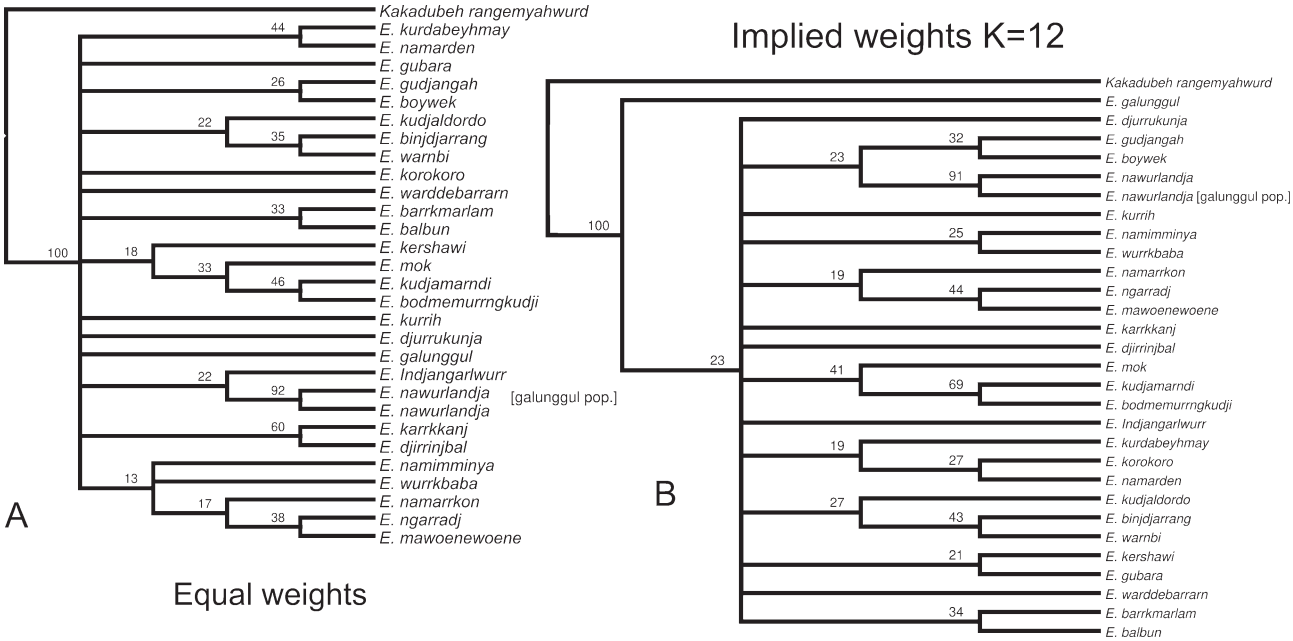

FIGURE 11. Parsimony analysis of *Kakadubeh rangemyahwurd* gen. nov. sp. nov. and 29 described species of *Eophreatoicus*, using morphological data (see Appendix 5, character list). A, equal weights analysis. B, Implied weights analysis with concavity constant = 12. Numbers on branches indicate probability in a 33% symmetric jackknife analysis, 1000 replications. Branches with p=10 or less were collapsed.

The third pair of analyses of 16S and COI mtDNA data employed sequences that were merged within species. This data matrix had 33 taxa of *Eophreatoicus,* including five poorly characterized species that were not given species status, and was rooted on *Kakadubeh rangemyahwurd*. Two species without mtDNA data, *E. gubara* and *E. warddebarrarn* were excluded. These data included 926 characters of which 16S had 142 (of 227) parsimony informative characters and COI had 89 (of 608). The equal weights analysis (tree length 1732, CI 0.433, RI 0.605) found four trees (Fig. 12A–B). The implied weights analysis (concavity constant K=12; Fig. 12C) found well-defined branches for most terminal species relationships (unweighted tree length 1732, CI 0.433, RI 0.605), except for the clade containing *E. nawurlandja*, its Gulunggul Creek population and *E. kurrih.* The positions of the poorly known taxa E. sp. Zi and E. sp. J1 differed between the two trees. The identity of the sequences of *E. kurrih* and *E. nawurlandja* may indicate that the source of introgression discussed in Wilson *et al.* (2009) was between these two populations and not the wide-spread Gulunggul Creek population of *E. nawurlandja*. When poorly-supported branches (symmetric jackknifing probability less than 10%) were collapsed, both trees retained most deeper clades with most with support exceeding 50%.

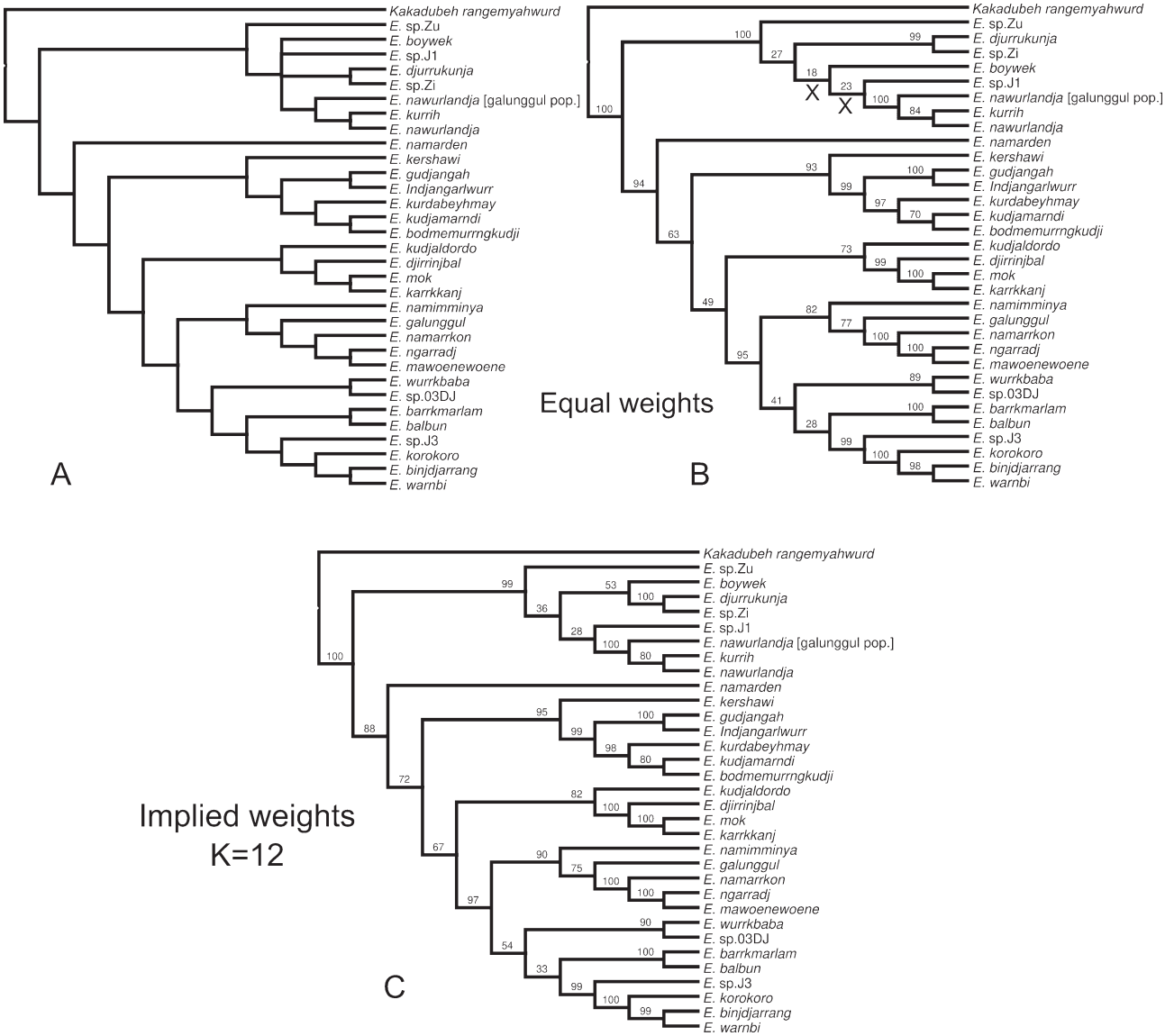

FIGURE 12. Parsimony analysis of *Kakadubeh rangemyahwurd* gen. nov. sp. nov., 27 described species and 5 undescribed species of *Eophreatoicus* using concatenated 16S and COI data (see Appendix 2, species list and GenBank accession numbers). A, equal weights analysis, strict consensus of 4 trees. B, equal weights analysis, X marking branches that did not appear in the strict consensus. C, Implied weights analysis with concavity constant = 12. Numbers on branches of B and C indicate probability in a 33% symmetric jackknife analysis, 1000 replications.

A strict consensus (not shown) between trees resulting from the second morphological analysis and the third 16S-COI analyses (implied weights K=12 or equal weights), removing unnamed species and species without sequence data, found four clades in common: *E. balbun*+*E. barrkmarlam*, *E. binjdjarrang*+*E. warnbi*, *E. bodmemurrngkudji*+*E. kudjamarndi* and *E. namarrkon*+*E. mawoenewoene*+*E. ngarradj*. The group *E. mok*+*E. karrkkanj*+*E. djirrinjbal* was in some trees, but not all, thus not appearing in the consensus. The support for most branches in the morphological analysis was low, owing to several taxa moving in position: *E. kershawi*, *E. gubara* and *E. namarden*. Because *E. kurrih* differs morphologically from *E. nawurlandja* and its Gulunggul Creek population, which differ by only a few characters, this group did not appear in the consensus. In the morphological analysis, *E. kurrih* is basal in some trees to the clade including *E. djurrukunja*, although with low support, so this topology does not survive in the collapsed morphology trees (Fig. 11).

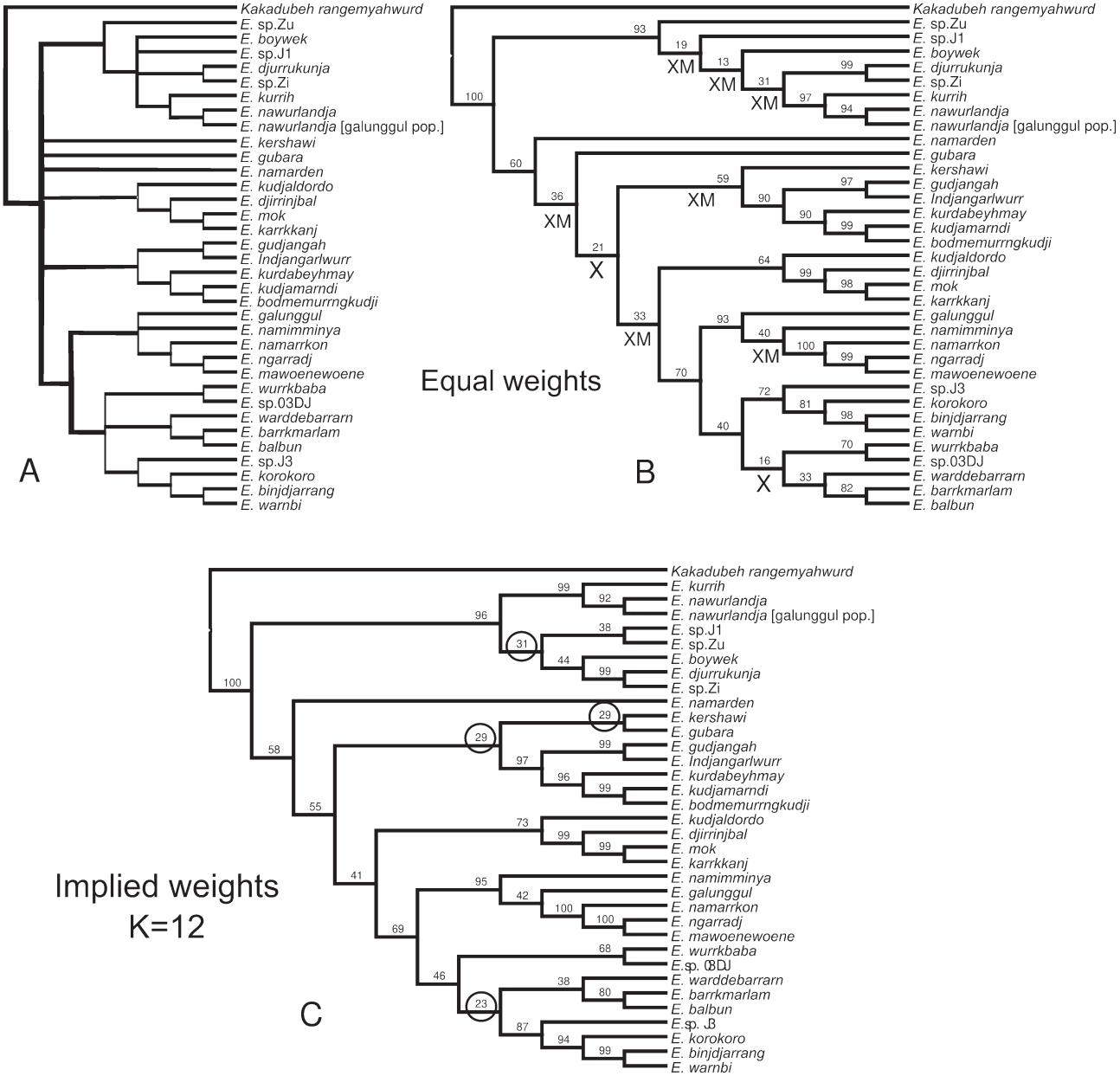

FIGURE 13. Parsimony analysis of *Kakadubeh rangemyahwurd* gen. nov. sp. nov., 29 described species and 5 undescribed species of *Eophreatoicus* using concatenated morphology, 16S and COI data. A, equal weights analysis, strict consensus of 16 trees. B, equal weights analysis, X marking branches that did not appear in the consensus, M marking branches that appeared in the majority rule consensus. C, Implied weights analysis with concavity constant = 12, circles indicating branches that have poor support (<33% group frequency). Numbers on branches indicate probability in a 33% symmetric jackknife analysis, 1000 replications.

The fourth pair of analyses combined morphology and mtDNA data and included all known taxa of *Eophreatoicus,* including five unnamed species, and *Kakadubeh rangemyahwurd* as the outgroup. These data had 927 characters total, of which morphology had 62 (of 160) parsimony informative characters, while 16S had 142 (of 227) and COI had 128 (of 540) parsimony informative characters. Owing to the greater quantity of informative sequence data, the results (Fig. 13) are dominated by the 16S+COI data. The equal weights analysis found 16 trees (Fig. 13A–B; length 2127, CI 0.418, RI 0.571), which are more trees than the initial separate analyses, owing to conflict between morphological and sequence data. The taxon instability index among trees (median value 7.617) found that *E. gubara* was the most variable in its position among the trees (maximum value 30.769). One might expect that *E. warddebarrarn* that also has no sequence data would also have a high instability index but its value is close to the median value. Apparently, the homoplasy in the morphological data is driving this pattern. All branches have more than the nominal 10% symmetric jackknife support, although many branches do not appear in the strict consensus (Fig. 13A). Most branches that were not in the strict consensus ("X" in Fig. 13B) appear in the 50% majority rule consensus ("M" in Fig. 13B), indicating that these branches have some support. To assist interpretation of the symmetric jackknife analysis in the implied weights analysis, support for branches that were not present in either the majority rule or strict consensus had a maximum value of 21% and one of the branches present in the majority rule consensus had a marginal value of 56%. Comparing these results with the symmetric jackknife support suggests that a conservative minimum support level of >36% might be a useful threshold value for evaluating the implied weights analysis, which has only one tree owing to continuous tree length values. The implied weights analysis (unweighted length 2129, CI 0.418, RI 0.571) shows a similar topology (Fig. 13C); circles indicate those branches that have poor support based on the threshold value above. These analyses show several well supported major clades of species that should be useful for evaluations of the regional evolution of *Eophreatoicus* species. The comparative details of the topologies will be discussed in the Remarks for each species.

Taxonomy

Amphisopidae Nicholls, 1943

Amphisopidae Nicholls, 1943: 25–26, 28–29 (broad composition).
Mesamphisopodidae.—Poore *et al.* 2002: 79 (part).
Amphisopodidae.—Poore *et al.* 2002: 64 (part).— Wilson & Keable 2002a: 43; 2002b: 462.
urn:lsid:zoobank.org:act: D85898E5-98C5-4D62-BCEB-9AD9DC515A8C

Type genus. *Amphisopus* Nicholls, 1926.

Taxa included. *Amphisopus* Nicholls, 1926; *Paramphisopus* Nicholls, 1943; *Phreatomerus* Sheppard, 1927; *Eophreatoicus* Nicholls, 1926; *Kakadubeh* gen. nov.; *Eremisopus* Wilson & Keable, 2002a; *Peludo* Wilson & Keable, 2002a; *Platypyga* Wilson & Keable, 2002a.

Diagnosis. *Head.* Mandibular, clypeal, antennal notches present (except for *Paramphisopus* Nicholls, 1943). Antennal notch shallow, without posterior extension (except for *Peludo* Wilson & Keable, 2002a: deep). Anterior margin of males above antennal notch not projecting dorsolaterally with antennal notch closed and slit-like. Mouth field angling ventrally, mandibular insertion axis in lateral view nearly level, line projected anteriorly along mandibular insertion passing below base of antenna; mouth field adjacent to posterior margin of head and anterior margin of pereonite 1 in terminal males. *Pereon.* Pereonite 1 dorsal margin in lateral view shorter than on pereonite 2 in both sexes, in dorsal view medially shorter than width. Pereonites 2–7 in dorsal view wider than long. Sternal processes absent. Hindgut caecae absent. *Pleonites.* In lateral view large pleurae much deeper than pereonites and basal region of pleopods not visible; pleonite 1 pleurae distinctly shallower than pleurae of pleonites 2–5. *Pleotelson.* Vaulted (lateral fields vertical). Dorsal surface anterior width near posterior width, not wider posteriorly, lateral length less than depth. Ventral surface anterior to uropods strongly concave; margin anterior to uropods in lateral view convex, medial side of main row without setae. Postanal ventral surface present. Lateral uropodal ridge present. Posterolateral margin forming vertical plate (except *Platypyga* Wilson & Keable, 2002a), with robust setae. *Antennula.* No articles divisible into one large or two small articles. Article 3 second flagellum absent. Article 4 shorter than article 3. Terminal article distally oblique with 2 or more groups of aesthetascs. Penultimate article length not greater than other articles, not inflated, width not greater than ante-penultimate article width. *Antenna.* Article 1 absent, article

3 scale absent, article 5 longer than article 4. *Mandible.* Mandible palp present. Palp article 3 relatively linear, with more than 5 setae on medial-distal margins. Palp article 2 longitudinal row of setae present. Incisor processes broad, width greater than thickness. Left lacinia mobilis with three cusps. Right incisor process with four cusps. Right lacinia mobilis well separated and distinct from remainder of spine row, with two dentate plates (smaller plate on anterior surface of larger plate). Spine rows with bifurcate spines, on projecting ridge between incisor and molar, forming strongly convex arc in ventral view, protruding medially, basal insertions crossing dorsally and then abruptly angling posteriorly. Molar process triturating surface heavily ridged. *Maxillula.* Lateral lobe present; ventral face with plumose setae. *Maxilla.* Medial lobe proximal and distal setal rows continuous. *Pereopod I.* Of male and female, distal articles subchelate. Propodal palm margin of male without spines, without composite spines, without stout denticulate setae, setal ridge absent, lateral group of elongate distally thick setae with more than one row, medial rugose cuticular pad absent. Propodal palm margin of female without spines, without composite spines, medial rugose cuticular pad absent, setal ridge absent. Dactylus dorsal margin dense group of elongate setae absent; lateral surface with row of fine setae along axis; ventral margin proximal projection absent. Dactylus in both sexes with distal accessory claw. *Pereopods.* Pereopods I–VII coxae ring-like, without projections. Pereopods II–III propodus articular plate present; propodus ventral margin setae robust-based. Pereopod II dactylus of male lateral spine absent. Pereopod IV carpus ventral margin not flattened laterally; propodus with articular plate on posterior side of limb. Pereopod VI–VII basis produced and forming distinct plate, dorsal ridge with no large setae. Pereopods V–VII propodus with articular plate on posterior side of limb, dactylus with accessory claw ventral to primary claw. *Penes.* Curved posteriorly; setae absent. *Pleopods.* Exopods II–V biarticulate, I uniarticulate, II–V proximal article distolateral lobes shorter than distal article. Endopods unilobed. Protopods III–V lateral epipods lobe-like. Pleopod I exopod of female ventral surface flat; protopod length subequal to that of other pleopods. Pleopod II endopod appendix masculina present, curved, proximal half of shaft broadly concave in cross-section, forming elongate channel, distal tip margins smooth (without denticles); exopod distal segment longer than wide. *Uropod.* Protopod dorsomedial ridge produced dorsally, plate-like (except *Platypyga* Wilson & Keable, 2002a), dorsally directed, margin without multiple denticles, in dorsal view parallel to ventral margin, setae on margin robust and simple. Protopod dorsolateral margin setae present; distomedial margin without robust spinose setae. Rami distal tips rounded, cross-sectional shape flattened on dorsal surface only (except pointed and rounded in *Peludo* Wilson & Keable, 2002a). Endopod subequal or longer than exopod; linear (not especially curving); spine on dorsal margin absent. Exopod shorter than pleotelson; distal tip of male without tuft of multiple elongate setae.

Remarks. Nicholls (1943) originally conceived this family as being the counterpart to the Phreatoicidae, with five subfamilies that included the genera of the current Mesamphisopidae, Hypsimetopidae and Phreatoicopsidae and one genus from the Phreatoicidae, *Uramphisopus* Nicholls, 1943. *Eophreatoicus* was originally placed in the Phreatoicopsinae, along with *Uramphisopus, Protamphisopus, Synamphisopus* and *Phreatoicopsis*. The definition above excludes Phreatoicopsinae, Hypsimetopinae, Phreatoicidae and Mesamphisopinae as originally defined and transfers *Eophreatoicus* to the Amphisopidae. Poore *et al.* (2002) changed Nicholls' family names to the correct Latin formulation by adding "od" (e.g., Amphisopodidae) but our preference has been to use the original spellings (cf. ICZN 1999: article 29.4).

A north-south division of the clades of the Amphisopidae was a secondary outcome of the phylogenetic analysis with the outgroup genera. *Amphisopus, Paramphisopus* and *Phreatomerus*, the taxa that Sheppard (1927) included in the first genus, have distinctive modifications of the first pereopod that are not present in the northern taxa, *Eophreatoicus*, *Kakadubeh* gen. nov. and *Eremisopus*. Also, these taxa do not have the unique deletion in the cytochrome oxidase subunit I seen in the northern taxa. The genera *Peludo* and *Platypyga,* which were not included in the analysis, are peculiar outliers not related to any of the other Amphisopidae (see exceptions in diagnosis).

Keys to the species of *Eophreatoicus* Nicholls, 1926 and *Kakadubeh* gen. nov

These keys to the males and females assume that adults are being identified. Juveniles may be identifiable, although the sexually dimorphic features may not be developed and the setal counts may be fewer. Couplets have up to four characters to allow for variation or lack of data. Figures 4–9 and accompanying text on diagnostic morphological characters should be consulted for character descriptions.

Key to adult males

1 Pleotelson lateral uropodal ridge curving strongly and extending posteriorly from uropods on pleotelson margin; pleotelson posterolateral margin with two positions defined by major robust setae without intermediate setae anteriorly and posteriorly . . . . . 2 (*Eophreatoicus* Nicholls, 1926)

– Pleotelson lateral uropodal ridge terminating at pleotelson margin above uropods; pleotelson posterolateral margin with more than two positions defined by major robust setae with intermediate setae anteriorly and posteriorly to these . . . . . ***Kakadubeh rangemyahwurd* gen. et sp. nov.**

2(1) Pereopod IV propodus ventral margin with projection 3

– Pereopod IV propodus ventral margin without projection 20

3(2) Pleotelson dorsal surface lacking posteromedial ridges or median groups of tubercles 15

– Pleotelson dorsal surface with posteromedial ridges or median groups of tubercles 4

4(3) Pleotelson dorsal surface with smoothly rounded posteromedial ridge . . . . . ***Eophreatoicus galunggul* sp. nov.**

– Pleotelson dorsal surface with several posteromedial tubercles, not merging into ridge 5

5(4) Uropod protopod dorsomedial ridge in lateral view approximately straight 7

– Uropod protopod dorsomedial ridge in lateral view curving either dorsally or ventrally 6

6(5) Uropod protopod dorsomedial ridge concave, in lateral view distal part distinctly curving dorsally 9

– Uropod protopod dorsomedial ridge convex, in lateral view distal part distinctly curving ventrally 10

7(5) Pleotelson dorsal surface with rounded tubercles; pleotelson ventral margin in lateral view anterior to uropods with one row of distally denticulate robust setae . . . . . ***Eophreatoicus warnbi* sp. nov.**

– Pleotelson dorsal surface with oblong or ridge-like tubercles; pleotelson ventral margin in lateral view anterior to uropods without distally denticulate robust setae 8

8(7) Pleotelson dorsal surface with elongate ridge-like tubercles; pleotelson ventral margin in lateral view anterior to uropods with single row of simple robust setae grading anteriorly to fine setae . . . . . ***Eophreatoicus barrkmarlam* sp. nov.**

– Pleotelson dorsal surface with oblong tubercles; pleotelson ventral margin in lateral view anterior to uropods with single row of simple robust setae . . . . . ***Eophreatoicus balbun* sp. nov.**

9(6) Pleotelson dorsal surface with elongate ridge-like tubercles; pleotelson postanal ventral surface with 19 or more robust setae on ridge; pereopod VII ischium dorsal ridge plate subequal to shaft width; uropod protopod dorsomedial ridge distinctly elongate posteriorly with posterior margin not exposed but extending posteriorly . . . . . ***Eophreatoicus wurrkbaba* sp. nov.**

– Pleotelson dorsal surface with small irregular rugose regions; pleotelson postanal ventral surface with 8 to 18 robust setae on ridge; pereopod VII ischium dorsal ridge plate greater than shaft width; uropod protopod dorsomedial ridge distinctly projecting dorsally with posterior margin exposed above shaft . . . . . ***Eophreatoicus warddebarrarn* sp. nov.**

10(6) Pleotelson posterior apex with two pairs of robust setae 11

– Pleotelson posterior apex with one median robust seta and two pairs of robust setae 12

11(9) Pereopod II basis dorsal ridge epaulet main setal row with 6–8 major setae; pleotelson dorsal surface in lateral view proximal to posterior apex with anterior inflection, margin below dorsal inflection concave; uropod protopod dorsomedial ridge distal margin with 2 adjacent robust setae distinctly larger than others; pereon pereonites 5–7 with low transverse dorsal ridges without transverse trough . . . . . ***Eophreatoicus ngarradj* sp. nov.**

– Pereopod II basis dorsal ridge epaulet main setal row with 9 or more major setae; pleotelson dorsal surface in lateral view proximal to posterior apex without anterior inflection, margin below dorsal inflection linear; uropod protopod dorsomedial ridge distal margin with all robust setae approximately same size; pereon pereonites 5–7 without transverse dorsal ridges . . . . ***Eophreatoicus namarrkon* sp. nov.**

12(10) Pleotelson dorsal surface with elongate ridge-like tubercles; pleotelson posterolateral margin dorsal setal position with one robust seta; uropod protopod extending posteriorly subequal to pleotelson apex; uropod protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed 13

– Pleotelson dorsal surface with small irregular rugose regions; pleotelson posterolateral margin dorsal setal position with two robust setae; uropod protopod extending posteriorly beyond pleotelson apex; uropod protopod dorsomedial ridge distinctly projecting dorsally with posterior margin exposed above shaft . . . . . ***Eophreatoicus namimminya* sp. nov.**

13(12) Uropod protopod dorsomedial ridge distal margin with 2 adjacent robust setae distinctly larger than others; pereon dorsal cuticular surface with tubercles and small scales, increasing posteriorly, less so in younger stages; pereopod I dactylus longer than palm or length subequal to palm; antenna article 5 longer than article 4 14

– Uropod protopod dorsomedial ridge distal margin with 2 robust setae distinctly larger than others, separated by shorter seta; pereon dorsal cuticular surface scaly or tuberculate, increasing posteriorly, apparent on all life stages; pereopod I dactylus shorter than palm; antenna article 5 length subequal to article 4 . . . . . ***Eophreatoicus indjangarlwurr* sp. nov.**

14(13) Pereopod I merus distodorsal margin with 1 or 2 robust simple setae; pereopod II basis dorsal ridge epaulet length subequal to one-quarter basis length . . . . . ***Eophreatoicus nawurlandja* sp. nov. (Gulunggul Creek population)**

– Pereopod I merus distodorsal margin with few elongate simple setae; pereopod II basis dorsal ridge epaulet length greater than one-quarter basis length . . . . . ***Eophreatoicus nawurlandja* sp. nov.**

15(3) Pereopod II basis dorsal ridge epaulet main setal row with up to 3 major setae 17

– Pereopod II basis dorsal ridge epaulet main setal row with more than 3 major setae 16

16(15) Pereopod II basis dorsal ridge epaulet main setal row with 4–5 major setae . . . . . ***Eophreatoicus kershawi* Nicholls, 1926**

– Pereopod II basis dorsal ridge epaulet main setal row with 6–8 major setae 18

17(16) Pleotelson posterolateral dorsal margin forming lobe medial to seta; pleotelson dorsal surface with small irregular rugose regions; pleotelson posterolateral margin dorsal setal position with one robust seta; uropod protopod extending posteriorly

subequal to pleotelson apex . . . . . ***Eophreatoicus kurdabeyhmay*** **sp. nov.**

– Pleotelson posterolateral dorsal margin not projecting dorsal to seta; pleotelson dorsal surface with rounded tubercles; pleotelson posterolateral margin dorsal setal position with two robust setae; uropod protopod extending posteriorly beyond pleotelson apex. . . . . ***Eophreatoicus korokoro*** **sp. nov.**

18(16) Pleotelson posterior apex with two pairs of robust setae; pleotelson posterolateral margin dorsal setal position with two robust setae; pleotelson dorsal surface in lateral view proximal to posterior apex with anterior inflection, margin below dorsal inflection concave; uropod protopod dorsomedial ridge distal margin with 2 adjacent robust setae distinctly larger than others . . . . . ***Eophreatoicus mawoenewoene*** **sp. nov.**

– Pleotelson posterior apex with two pairs of robust setae and one median robust seta; pleotelson posterolateral margin dorsal setal position with one robust seta; pleotelson dorsal surface in lateral view proximal to posterior apex without anterior inflection, margin below dorsal inflection linear; uropod protopod dorsomedial ridge distal margin with 2 robust setae distinctly larger than others, separated by shorter seta 19

19(18) Pleotelson dorsal surface with elongate ridge-like tubercles; pleotelson posterior apex obscured by posterolateral margin in lateral view; pereopod I basis without dorsal setae; uropod protopod distoventral margin without spinose setae . . . . . ***Eophreatoicus djirrinjbal*** **sp. nov.**

– Pleotelson dorsal surface with oblong tubercles; pleotelson posterior apex visible in lateral view; pereopod I basis with dorsal setae; uropod protopod distoventral margin with spinose setae . . . . . ***Eophreatoicus karrkkanj*** **sp. nov.**

20(2) Pleotelson posterior apex with two pairs of robust setae 21

– Pleotelson posterior apex with two pairs of robust setae and one median robust seta 24

21(20) Pleotelson dorsal surface with several posteromedial tubercles, not merging into ridge; pereopod II basis dorsal ridge epaulet main setal row without shorter setae; pereopod IV propodus articular plate on posterior side of limb longer than dactylar claw; pereopod I dactylus longer than or subequal to palm. 22

– Pleotelson dorsal surface lacking posteromedial ridges or median groups of tubercles; pereopod II basis dorsal ridge epaulet main setal row with shorter setae; pereopod IV propodus articular plate on posterior side of limb shorter than dactylar claw; pereopod I dactylus shorter than palm 23

22(21) Pleotelson dorsal surface with elongate ridge-like tubercles; pleotelson posterolateral margin dorsal setal position with one robust seta; pereopod VII ischium dorsal ridge plate greater than shaft width; pereon pereonites 1–4 without transverse dorsal ridges . . . . . ***Eophreatoicus kudjaldordo*** **sp. nov.**

– Pleotelson dorsal surface with oblong tubercles; pleotelson posterolateral margin dorsal setal position with two robust setae; pereopod VII ischium dorsal ridge plate subequal to shaft width; pereon pereonites 1–4 transverse dorsal ridges rounded expressed as transverse trough only . . . . . ***Eophreatoicus binjdjarrang*** **sp. nov.**

23(21) Pereopod VII ischium dorsal ridge plate greater than shaft width; uropod protopod dorsomedial ridge convex, in lateral view distal part distinctly curving ventrally; head maxillipedal ridge region without obvious setae; pereon pereonites 1–4 without transverse dorsal ridges . . . . . ***Eophreatoicus bodmemurrngkudji*** **sp. nov.**

– Pereopod VII ischium dorsal ridge plate subequal to shaft width; uropod protopod dorsomedial ridge in lateral view approximately straight; head maxillipedal ridge region with several setae projecting dorsally; pereon pereonites 1–4 transverse dorsal ridges rounded, expressed as transverse trough only . . . . . ***Eophreatoicus gubara*** **sp. nov.**

24(20) Pereopod II basis dorsal ridge epaulet main setal row with up to 3 major setae . . . . . ***Eophreatoicus namarden*** **sp. nov.**

– Pereopod II basis dorsal ridge epaulet main setal row with more than 3 major setae 25

25(24) Pereopod II basis dorsal ridge epaulet main setal row with 4 to 5 major setae 26

– Pereopod II basis dorsal ridge epaulet main setal row with 6 to 8 major setae . . . . . ***Eophreatoicus kurrih*** **sp. nov.**

26(25) Pleotelson dorsal surface with elongate ridge-like tubercles; head maxillipedal ridge region without obvious setae; antenna article 5 longer than article 4 27

– Pleotelson dorsal surface with oblong tubercles; head maxillipedal ridge region several setae projecting dorsally; antenna article 5 shorter than article 4 29

27(26) Pereon pereonites 5–7 without transverse dorsal ridges; pereon dorsal cuticular surface smooth (without roughness or tubercles); pleonites 1–4 without transverse dorsal ridges. . . . . ***Eophreatoicus kudjamarndi*** **sp. nov.**

– Pereon pereonites 5–7 with transverse dorsal ridges; pereon dorsal cuticular surface with roughness or tubercles; pleonites 1–4 with transverse dorsal ridges 28

28(27) Pereon pereonites 5–7 transverse dorsal ridges carinate with transverse trough; pereon dorsal cuticular surface scaly or tuberculate, increasing posteriorly, apparent on all life stages; pleonites 1–4 transverse dorsal ridges well developed with transverse trough . . . . . ***Eophreatoicus djurrukunja*** **sp. nov.**

– Pereon pereonites 5–7 transverse dorsal ridges low without transverse trough; pereon dorsal cuticular surface with scattered small scales or roughness; pleonites 1–4 transverse dorsal ridges low without transverse trough on pleonites 1–4. . . . . ***Eophreatoicus mok*** **sp. nov.**

29(26) Pereopod VII ischium dorsal ridge plate greater than shaft width; pleotelson dorsal surface in lateral view proximal to posterior apex without anterior inflection, margin below dorsal inflection linear; pereopod II basis dorsal ridge epaulet main setal row with shorter setae; pereopod IV propodus articular plate on posterior side of limb longer than dactylar claw. . . . . ***Eophreatoicus gudjangah*** **sp. nov.**

– Pereopod VII ischium dorsal ridge plate subequal to shaft width; pleotelson dorsal surface in lateral view proximal to posterior apex without anterior inflection, margin below dorsal inflection convex; pereopod II basis dorsal ridge epaulet main setal row without shorter setae; pereopod IV propodus articular plate on posterior side of limb subequal in length to dactylar claw . . . . . ***Eophreatoicus boywek*** **sp. nov.**

Key to adult females

1 Pleotelson lateral uropodal ridge curving strongly and extending posteriorly from uropods on pleotelson margin; pleotelson posterolateral margin with two positions defined by major robust setae without intermediate setae anteriorly and posteriorly . . . . . 2 (*Eophreatoicus* Nicholls, 1926)

– Pleotelson lateral uropodal ridge terminating at pleotelson margin above uropods; pleotelson posterolateral margin with more than two positions defined by major robust setae with intermediate setae anteriorly and posteriorly to these . . . . . ***Kakadubeh rangemyahwurd* sp. nov.**

2(1) Eyes bulging in dorsal view, projecting from head in distinct arc 3

– Eyes slightly protruding in dorsal view, projecting from head in low or flattened arc 10

3(2) Pleotelson dorsal surface without posteromedial ridges or median groups of tubercles 9

– Pleotelson dorsal surface with posteromedial ridges or median groups of tubercles. 4

4(3) Pleotelson dorsal surface with smoothly rounded posteromedial ridge . . . . . ***Eophreatoicus galunggul* sp. nov.**

– Pleotelson dorsal surface with several median tubercles, not merging into ridge 5

5(4) Pleotelson posterior apex with two pairs of robust setae; pereopod I propodal palm margin convex; pereopod II basis dorsal ridge without major setae distally. 6

– Pleotelson posterior apex with two pairs of robust setae and one median robust seta; pereopod I propodal palm margin straight; pereopod II basis dorsal ridge with major setae distally . . . . . ***Eophreatoicus nawurlandja* sp. nov.**

6(5) Pereon pereonites 5–7 without transverse dorsal ridges. . . . . ***Eophreatoicus namarrkon* sp. nov.**

– Pereon pereonites 5–7 with transverse dorsal ridges 7

7(6) Pereon pereonites 5–7 transverse dorsal ridges carinate with transverse trough . . . . . ***Eophreatoicus warnbi* sp. nov.**

– Pereon pereonites 5–7 transverse dorsal ridges low without transverse trough. 8

8(7) Pereopod II basis dorsal ridge epaulet main setal row with 4 to 5 major setae; pleotelson posterolateral margin dorsal setal position with one robust seta; uropod protopod dorsomedial ridge in lateral view approximately straight; pleotelson posterior apex without fine setae . . . . . ***Eophreatoicus balbun* sp. nov.**

– Pereopod II basis dorsal ridge epaulet main setal row with 6 to 8 major setae; pleotelson posterolateral margin dorsal setal position with two robust setae; uropod protopod dorsomedial ridge convex, in lateral view distal part distinctly curving ventrally; pleotelson posterior apex with interdigitating fine setae in same row as robust setae. . . . . ***Eophreatoicus ngarradj* sp. nov.**

9(4) Pleotelson posterolateral dorsal margin forming lobe medial to seta; pleotelson dorsal surface with oblong tubercles; pleotelson posterior apex visible in lateral view; uropod protopod extending posteriorly subequal to pleotelson apex . . . . . ***Eophreatoicus mawoenewoene* sp. nov.**

– Pleotelson posterolateral dorsal margin not projecting dorsal to seta; pleotelson dorsal surface with rounded tubercles; pleotelson posterior apex obscured by posterolateral margin in lateral view; uropod protopod extending posteriorly beyond pleotelson apex. . . . . ***Eophreatoicus korokoro* sp. nov.**

10(3) Pleotelson dorsal surface with small irregular rugose regions and without tubercles 27

– Pleotelson dorsal surface with tubercles. 11

11(10) Pleotelson dorsal surface with elongate ridge-like tubercles 12

– Pleotelson dorsal surface with oblong tubercles 20

12(10) Uropod protopod dorsomedial ridge distinctly elongate posteriorly with posterior margin not exposed but extending posteriorly. . . . . ***Eophreatoicus wurrkbaba* sp. nov.**

– Uropod protopod dorsomedial ridge projecting dorsally 13

13(12) Uropod protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed 14

– Uropod protopod dorsomedial ridge distinctly projecting dorsally with posterior margin exposed above shaft 18

14(13) Pereon pereonites 5–7 without transverse dorsal ridges; pleonites 1–4 without transverse dorsal ridges. . . . . ***Eophreatoicus kudjamarndi* sp. nov.**

– Pereon pereonites 5–7 with transverse dorsal ridges; pleonites 1–4 with transverse dorsal ridges 15

15(14) Pereon pereonites 5–7 transverse dorsal ridges carinate with transverse trough; pleonites 1–4 transverse dorsal ridges well developed with transverse trough. 16

– Pereon pereonites 5–7 transverse dorsal ridges low without transverse trough; pleonites 1–4 transverse dorsal ridges low without transverse trough on pleonites 1–4. 17

16(15) Pleotelson dorsal surface with several posteromedial tubercles, not merging into ridge; uropod protopod dorsomedial ridge convex, in lateral view distal part distinctly curving ventrally; head maxillipedal ridge region with several setae projecting dorsally; pereopod I propodal palm margin straight . . . . . ***Eophreatoicus indjangarlwurr* sp. nov.**

– Pleotelson dorsal surface lacking posteromedial ridges or median groups of tubercles; uropod protopod dorsomedial ridge in lateral view approximately straight; head maxillipedal ridge region without obvious setae; pereopod I propodal palm margin convex. . . . . ***Eophreatoicus djurrukunja* sp. nov.**

17(13) Uropod protopod extending posteriorly beyond pleotelson apex; head maxillipedal ridge region without obvious setae; pleopod protopod II lateral epipod lobe-like; uropod protopod lateral face without ventrolateral ridge. . . . ***Eophreatoicus mok* sp. nov.**

– Uropod protopod extending posteriorly subequal to pleotelson apex; head maxillipedal ridge region with several setae projecting dorsally; pleopod protopod II lateral epipod absent; uropod protopod lateral face with ventrolateral ridge. . . . . ***Eophreatoicus djirrinjbal* sp. nov.**

18(13) Pereopod II basis dorsal ridge epaulet main setal row with up to 3 major setae; pleotelson posterior apex with two pairs of robust setae; pleotelson posterior apex obscured by posterolateral margin in lateral view; pereopod II basis dorsal ridge without major setae distally 19

– Pereopod II basis dorsal ridge epaulet main setal row with 6–8 major setae; pleotelson posterior apex with two pairs of robust setae and one median robust seta; pleotelson posterior apex visible in lateral view; pereopod II basis dorsal ridge with major setae distally . . . . . ***Eophreatoicus kurrih* sp. nov.**

19(18) Uropod protopod dorsomedial ridge in lateral view approximately straight; head maxillipedal ridge region with several setae projecting dorsally; pleopod protopod II lateral epipod lobe-like; pereopod I merus distodorsal margin with numerous elongate simple setae . . . . . ***Eophreatoicus barrkmarlam* sp. nov.**

– Uropod protopod dorsomedial ridge convex, in lateral view distal part distinctly curving ventrally; head maxillipedal ridge region without obvious setae; pleopod protopod II lateral epipod absent; pereopod I merus distodorsal margin with few elongate simple setae . . . . . ***Eophreatoicus kudjaldordo* sp. nov.**

20(11) Pleotelson posterior apex with two pairs of robust setae 21

– Pleotelson posterior apex with one median robust seta and two pairs of robust setae 24

21(20) Pleotelson posterolateral margin dorsal setal position with one robust seta 22

– Pleotelson posterolateral margin dorsal setal position with two robust setae 23

22(21) Pereopod VII ischium dorsal ridge plate greater than shaft width; uropod protopod dorsomedial ridge convex, in lateral view distal part distinctly curving ventrally; head maxillipedal ridge region without obvious setae; pereon pereonites 5–7 transverse dorsal ridges low without transverse trough. . . . . ***Eophreatoicus bodmemurrngkudji* sp. nov.**

– Pereopod VII ischium dorsal ridge plate subequal to shaft width; uropod protopod dorsomedial ridge in lateral view approximately straight; head maxillipedal ridge region with several setae projecting dorsally; pereon pereonites 5–7 transverse dorsal ridges carinate with transverse trough. . . . . ***Eophreatoicus gubara* sp. nov.**

23(21) Pereopod II basis dorsal ridge epaulet main setal row with up to 3 major setae; pleotelson dorsal surface with several posteromedial tubercles, not merging into ridge; pereopod VII ischium dorsal ridge plate subequal to shaft width; uropod protopod dorsomedial ridge distinctly projecting dorsally with posterior margin exposed above shaft . . . . . ***Eophreatoicus binjdjarrang* sp. nov.**

– Pereopod II basis dorsal ridge epaulet main setal row with 4 to 5 major setae; pleotelson dorsal surface lacking posteromedial ridges or median groups of tubercles; pereopod VII ischium dorsal ridge plate greater than shaft width; uropod protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed. . . . . ***Eophreatoicus kershawi* Nicholls, 1926**

24(20) Pereopod II basis dorsal ridge epaulet main setal row with up to 3 major setae; uropod protopod dorsomedial ridge distal margin with only 1 robust seta distinctly larger than others. . . . . ***Eophreatoicus namarden* sp. nov.**

– Pereopod II basis dorsal ridge epaulet main setal row with more than 3 major setae; uropod protopod dorsomedial ridge distal margin with 2 adjacent robust setae distinctly larger than others. 25

25(24) Pereopod II basis dorsal ridge epaulet main setal row with 4–5 major setae; uropod protopod dorsomedial ridge distal margin with 2 adjacent robust setae distinctly larger than others. . . . . ***Eophreatoicus boywek* sp. nov.**

– Pereopod II basis dorsal ridge epaulet main setal row with 6–8 major setae; uropod protopod dorsomedial ridge distal margin with 2 robust setae distinctly larger than others, separated by shorter seta 26

26(25) Pleotelson posterior apex visible in lateral view; pereon pereonites 5–7 transverse dorsal ridges low without transverse trough; pereopod I propodal palm margin straight; pereon pereonites 1–4 transverse dorsal ridges absent . . . . . ***Eophreatoicus karrkkanj* sp. nov.**

– Pleotelson posterior apex obscured by posterolateral margin in lateral view; pereon pereonites 5–7 transverse dorsal ridges carinate with transverse trough; pereopod I propodal palm margin convex; pereon pereonites 1–4 transverse dorsal ridges rounded expressed as transverse trough only . . . . . ***Eophreatoicus gudjangah* sp. nov.**

27(10) Pereopod II basis dorsal ridge epaulet main setal row with up to 3 major setae; pleotelson dorsal surface lacking posteromedial ridges or median groups of tubercles; uropod protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed; head maxillipedal ridge region without obvious setae. . . . . ***Eophreatoicus kurdabeyhmay* sp. nov.**

– Pereopod II basis dorsal ridge epaulet main setal row with 4–5 major setae; pleotelson dorsal surface with several posteromedial tubercles, not merging into ridge; uropod protopod dorsomedial ridge distinctly projecting dorsally with posterior margin exposed above shaft; head maxillipedal ridge region with several setae projecting dorsally 28

28(27) Pleotelson posterolateral dorsal margin forming lobe medial to seta; pleotelson posterior apex with two pairs of robust setae; pleotelson posterolateral margin dorsal setal position with one robust seta; uropod protopod extending posteriorly subequal to pleotelson apex. . . . . ***Eophreatoicus warddebarrarn* sp. nov.**

– Pleotelson posterolateral dorsal margin not projecting dorsal to seta; pleotelson posterior apex with two pairs of robust setae and one median robust seta; pleotelson posterolateral margin dorsal setal position with two robust setae; uropod protopod extending posteriorly beyond pleotelson apex . . . . . ***Eophreatoicus namimminya* sp. nov.**

Kakadubeh gen. nov.

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Type species. *Kakadubeh rangemyahwurd* sp. nov.

Etymology. The new genus is named *Kakadubeh* meaning "from Kakadu". In the Kundjeyhmi language, a suffix "-beh" that means "from" is attached to the general locality name, which gives this genus its name. The final "h" is a glottal stop, a sudden cut off sound that does not exist in English. Gender masculine.

Diagnosis. Body length of largest male less than body length of largest female. *Pereon.* Lateral tergal plates of pereonites 2–4 not extended over basis. Coxal articulation to pereonites 5–7 free. *Pleotelson.* Dorsal surface in lateral view with distinct dorsal inflection. Dorsal surface median ridge absent, lateral ridges absent, without ridges or tubercles. Lateral surface anterior to uropods with pleonite ridge extending to ventral margin anterior to penultimate robust seta. Postanal ventral surface with ridge parallel to anal opening (slight, adjacent to anus). Lateral uropodal ridge terminating at pleotelson margin above uropods, without setae. Posterolateral margin vertical plate inner margin in dorsal view projecting strongly toward apex (gap between them only small slit), with robust setae, with more than two positions defined by major robust setae with intermediate setae anteriorly and posteriorly to these, dorsal setal position with three robust setae, two anterior setae adjacent, projecting laterally and medially, dorsal major seta much longer than other seta, dorsal margin forming large plate dorsal to seta (large flat plate with cuticular combs), seta near inflection point absent, robust setae on dorsolateral surface absent. Posterior apex projecting in dorsal view, free (not strongly reflexed and flattened against dorsal surface with ventral surface exposed). *Mandible.* Palp article 1 easily visible. Left spine row with first spine separated from remaining spines. Left molar process triturating surface ridges directed transversely to mandibular axis, originating distally to dorsal condyle. Right molar process dorsal surface cuticular hairs sparse. *Pereopod I.* Propodus sexually dimorphic, female propodus broader than of male. Merus of female distodorsal margin projection in cross-section U-shaped and curving over carpus around proximal dorsal margin of propodus. Propodal palm margin of male cuticular fringe weakly developed, with groups of elongate distally thick setae on either side of palm margin. Propodal palm margin of female without stout denticulate setae. *Pereopods II–III.* Basis dorsal ridge in cross-section forming distinct plate (low compared to *Eophreatoicus*). *Pereopod II.* Basis lateral face without longitudinal carina, with ventral carina, complete (extending along basis margin). Basis dorsal ridge proximal margin with epaulet. *Pereopod IV.* Not sexually dimorphic (without palm, not prehensile). Basis dorsal ridge in cross-section produced and forming distinct plate (low compared to *Eophreatoicus*). *Pereopods V–VII.* Basis lateral face central longitudinal carina present; ventral carina present, without fine setae. *Pleopods.* Pleopod II endopod appendix masculina not forming tube, groove open distally, length more than endopod length, distal length approximately half endopod proximal margin length, distal tip acutely rounded; setae continuous around margin; without elongate stiff (rod-like) setae. *Uropod.* Protopod dorsomedial ridge with setae on margin. Protopod dorsolateral margin with robust setae. Protopod ventrolateral margin without longitudinal row of setae; ventral margin without transverse rows of simple setae. Rami distal tips rounded, cross-sectional shape flattened on dorsal surface only. Endopod ventral margin in medial view convex or straight proximally.

Kakadubeh rangemyahwurd sp. nov.

(Figs 7D, 8B, 11, 12, 14–20)

urn:lsid:zoobank.org:act: 7FD36627-A18F-411B-B2E4-6E2F44A50B2C
Eophreatoicus sp. "21".—Wilson *et al.* 2009: 362.

Type material. Holotype male, bl 8.4 mm, AM P.86061, coll. C. Humphrey & party, 14.v.2003. Paratypes collected with holotype: male (M5), bl 7.3 mm, AM P.74564, SEM stubs AW650–655; female (F1), bl 11.4 mm, AM P.72633; female (F2), AM P.74563, DNA E01-E04 Genbank COI EU263163 16S EU263235; brooding female, 7.3 mm, AM P.74568, DNA from embryos E05 Genbank COI EU263164 16S EU263236; female, AM P.72638, DNA E57 Genbank COI EU263166 16S EU263237; female (F3), bl 10.8 mm, AM P.72635, SEM stubs AW638–640; female, bl ~10 mm, AM P.72636; 4 male inds, AM P.74569; 8 male inds, AM P.74565; 38 female inds, AM P.74566; 14 female inds, AM P.74567; 22 inds, AM P.72637; 2 inds, MAGNT Cr018560. Additional paratypes, CH20150518: female, bl 9.3 mm, AM P.103501, photographed, dissected mouthparts and pleopods; male, bl 5.6 mm, AM P.103502, photographed, dissected pleopod II; 3 females, 2 males (male bl 6.1 mm photographed), AM P.103503.

Type locality. Australia, Northern Territory, Kakadu National Park, Leichhardt Springs: 12°46.65'S, 132°51.50'E, coll. C. Humphrey & party, 14.v.2003. Sites adjacent to type locality with additional paratypes: CH20150518, 12°46.558'S, 132°51.395'E, coll. C. Humphrey, 18.v.2015.

Etymology. The species name "rangemyahwurd" means "small male" in the Kundjeyhmi dialect; it is derived from the word for male "na-rangem", but omitting "na" as a redundant masculine prefix, and the elided word for small "yahwurd". The name is pronounced "rung-em-ya-woord".



FIGURE 14. *Kakadubeh rangemyahwurd* gen. et sp. nov., habitus. Holotype male, AM P.86061: A, lateral; B, pleotelson; C, Paratype male, AM P.74564, lateral. Scales 5 mm.

Diagnosis. *Head.* Eyes bulging dorsolaterally, height small, in lateral view less than width of basal antennal articles, height subequal to length in lateral view, not protruding in dorsal view, spread-out, surface confluent with head surface. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with indistinctly rounded margin, region without obvious setae. *Pereon.* Dorsal cuticular surface smooth (without roughness or tubercles); pereonites 1–4 transverse dorsal ridges not expressed; pereonites 5–7 transverse dorsal ridges not expressed. *Pleonites.* 1–4 transverse dorsal ridges not expressed. *Pleotelson.* Dorsal surface in lateral view margin

below dorsal inflection concave. Dorsal surface without tubercles or short ridges, lacking posteromedial ridges or median groups of tubercles. Posterior apex in lateral view visible. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae, with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin smooth. *Pereopod II.* Basis of male dorsal ridge epaulet length less than quarter length of basis (very weak projection), main setal row with 4 major setae. Basis of female dorsal ridge epaulet length less than quarter length of basis, main setal row with 5 major setae. *Pereopod IV.* Not sexually dimorphic (without palm, not prehensile). Propodus of male ventral margin without projection. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate less than shaft width. *Uropod.* Protopod of female extending posteriorly beyond pleotelson apex (M only). Protopod dorsomedial ridge not especially projecting dorsally with plate low above shaft, in lateral view approximately straight; distal margin with 2 adjacent robust setae distinctly larger than others.

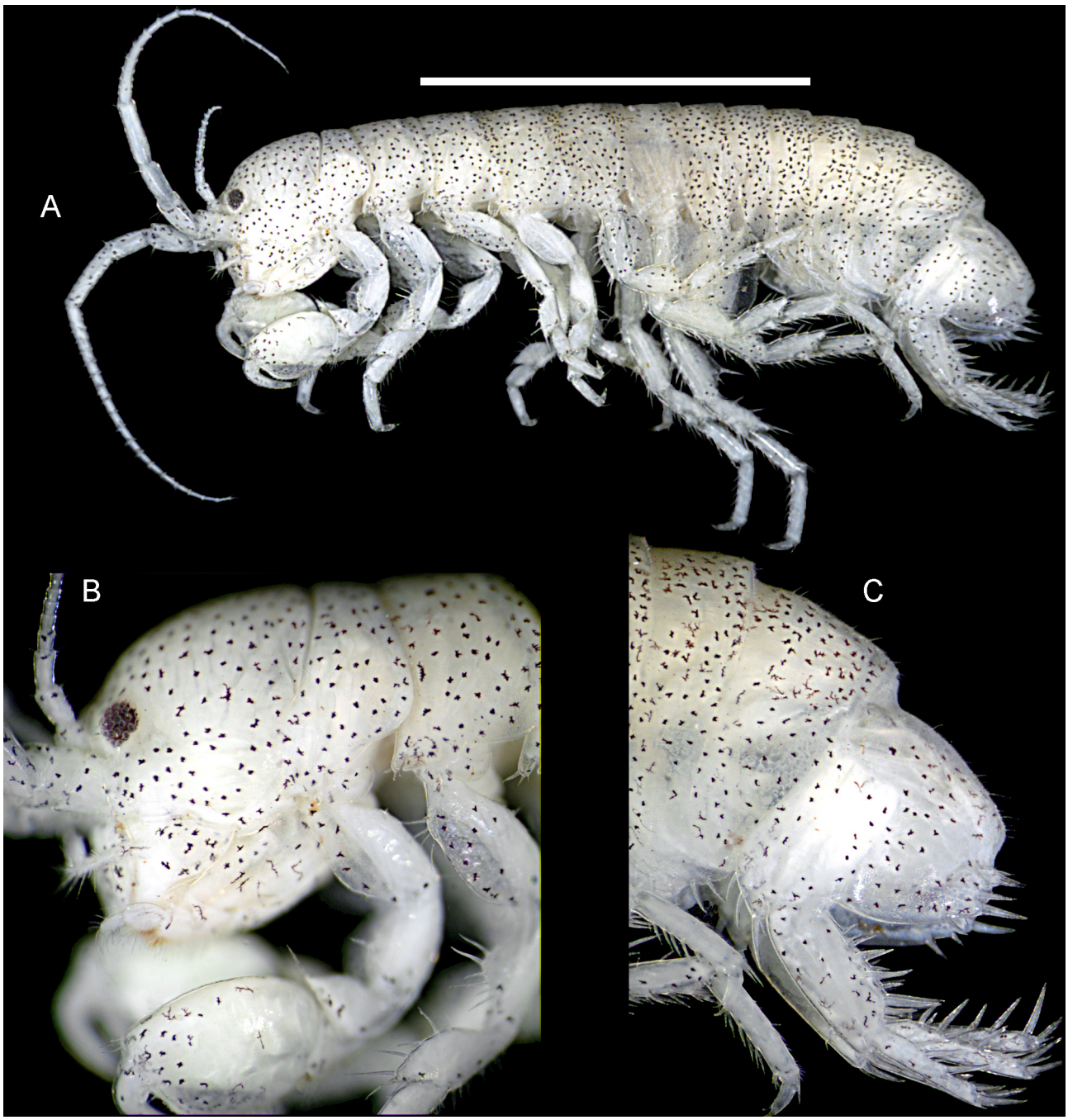

FIGURE 15. *Kakadubeh rangemyahwurd* gen. et sp. nov., habitus, paratype female, AM P.74563. A, lateral. B, head. C, pleotelson. Scale 5 mm.

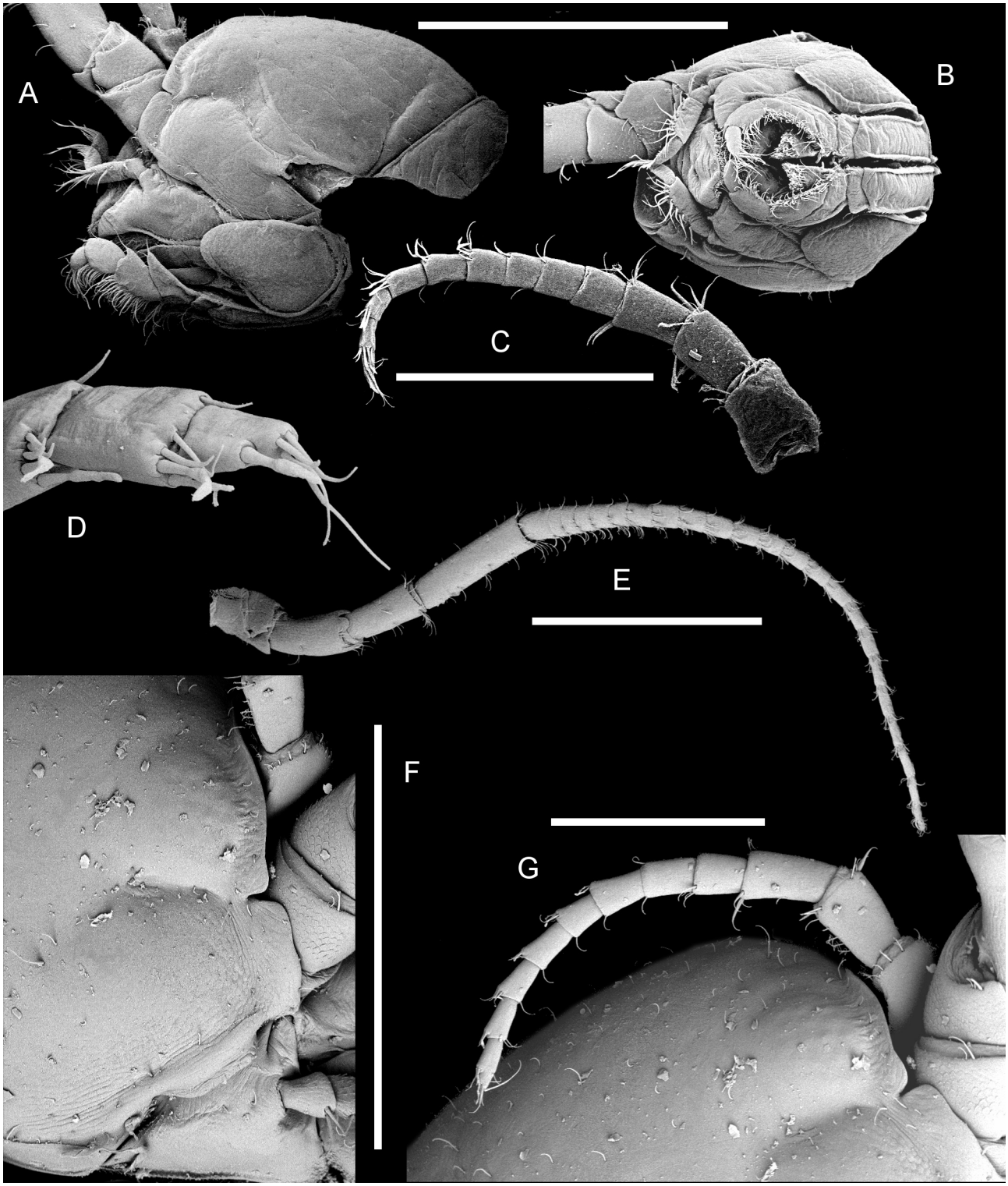

FIGURE 16. *Kakadubeh rangemyahwurd* gen. et sp. nov., head and antennae. Paratype male, AM P.74564: A–B, head lateral and ventral; C–D, antennula with enlargement of tip; E, antenna. Paratype female, AM P.72600. F, head lateral showing eye region; G, antennula and eye region of head. Scales: A–B, E–F, 1 mm; C, G, 0.5 mm.

Description. Body pigmentation light with scattered thin chromatophores (expanded in some individuals); length of largest male 8.4 mm, length of largest male less than body length of largest female, length of largest preparatory female 11.4 mm, length of largest brooding female 7.3 mm (probably bigger ones can be found).

Head. Length greater than width in dorsal view; lateral profile of dorsal surface smoothly curved. Width 1.00 pereonite 1 width. Dorsal surface smooth; setae tiny and sparse, setae fine. Eyes approximately round, maximum

diameter 0.18–0.23–0.26 head depth (F3, H, M5), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view sigmoidal. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with indistinctly rounded margin, region without obvious setae.

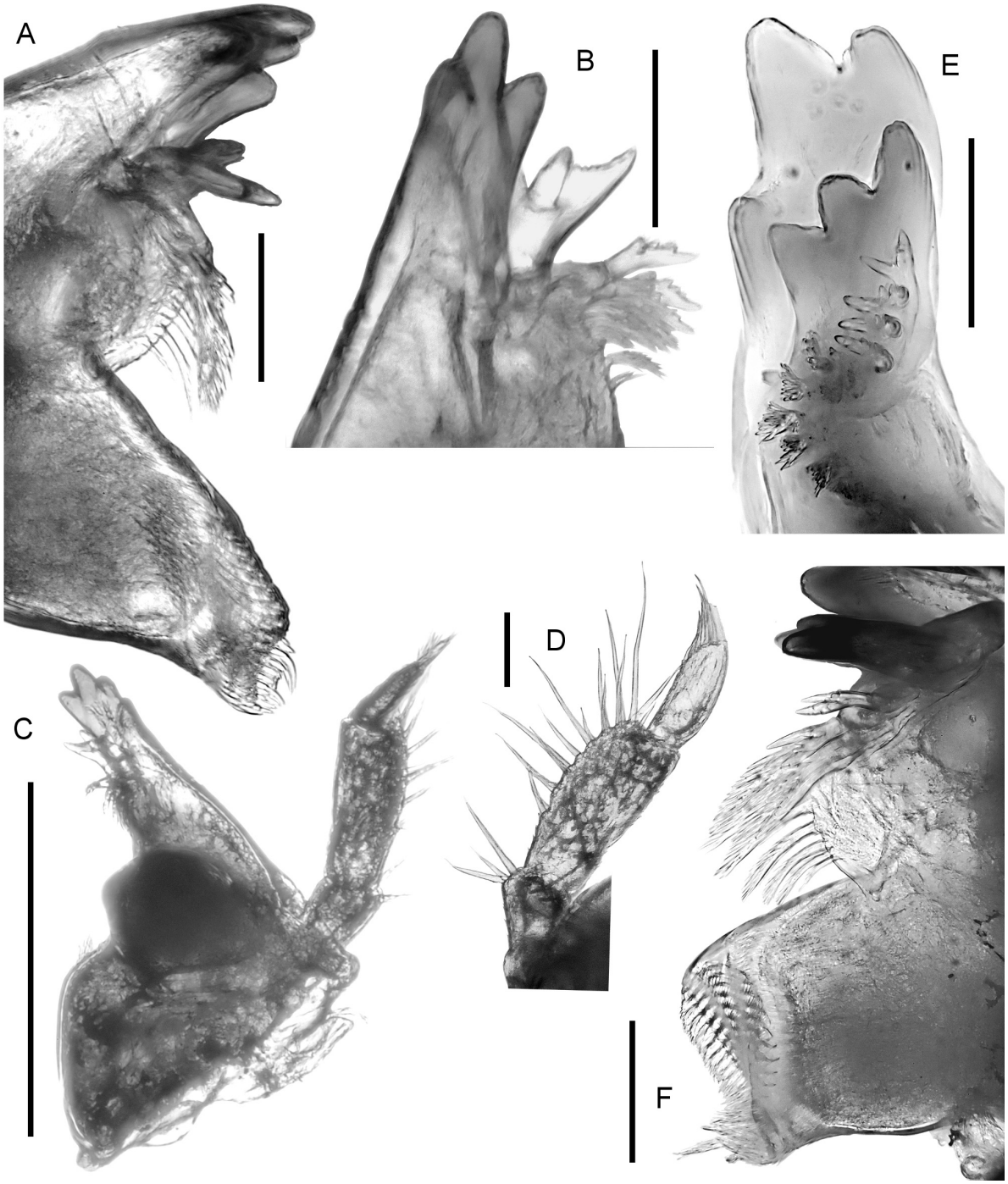

FIGURE 17. *Kakadubeh rangemyahwurd* gen. et sp. nov., mandibles, paratype female, AM P.103501. Right mandible: A, gnathal edge; B, incisor, lacinia mobilis and spine row; C, entire, posterior; D, palp in plan view. Left mandible: E, incisor, lacinia mobilis and spine row; F, gnathal edge. Scales: all 0.1 mm except for C, 0.5 mm.

Pereon. Width near head width. Setae on dorsal surface scattered (tiny compared to body depth), fine. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2 in dorsal view length less than 0.5 pleonite 5 length, 3–4 respective lengths more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth: pereonite 7 depth 1.20 pleonite 1 (H, F1), 1.30–1.50 pleonite 2 (H, F1), 1.50–1.60 pleonite 3 (F1, H), 1.50 pleonite 4 (H, F3), 1.30 pleonite 5 (H, F1).

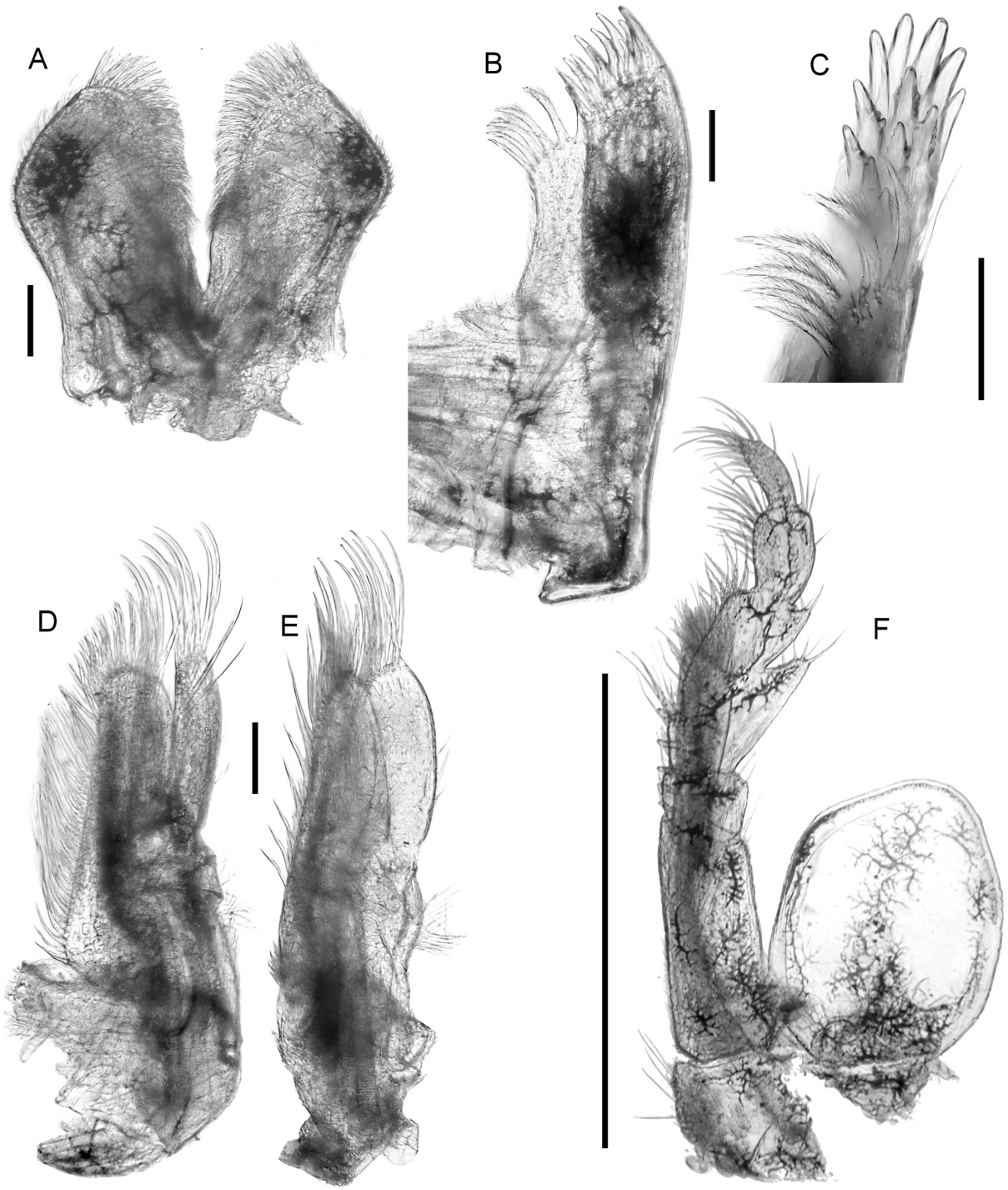

FIGURE 18. *Kakadubeh rangemyahwurd* gen. et sp. nov., mouthparts, paratype female, AM P.72600. A, paragnaths. B–C, maxillula with medial enlargement of distal setation. D–E, maxilla in ventral and ventromedial aspects. F, maxilliped. Scales: all 0.1 mm except for F, 1 mm.

Pleotelson. Dorsal surface length 1.50 width in dorsal view (M5). Dorsal surface sparsely covered with setae. Depth 1.20 pereonite 7 depth (H, F1). Lateral length less than depth, in male 0.75 depth (H), in female 0.73 depth. Lateral length 0.11–0.12–0.13 body length (M5, H, F3). Lateral surface anterior to uropods with pleonite ridge following curve of ventral margin. Ventral margin in lateral view anterior to uropods subequal to width of uropodal insertion (F3, M5), length 0.95–0.98 width of uropodal insertion (F3, M5), with one row of distally denticulate robust setae, including 5 robust setae altogether (F3, M5), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.18–0.22 pleotelson total length (H, F3), dorsal setal position marginal seta larger than

submarginal seta. Posterior apex length less than width, long. Posterior apex 0.13 pleotelson total length, width 0.50 pleotelson width (F3). Posterior apex in lateral view forming an angle of 68–87° with immediately anterior dorsal surface (F3, H), angled 145–169° from horizontal (F3, H).

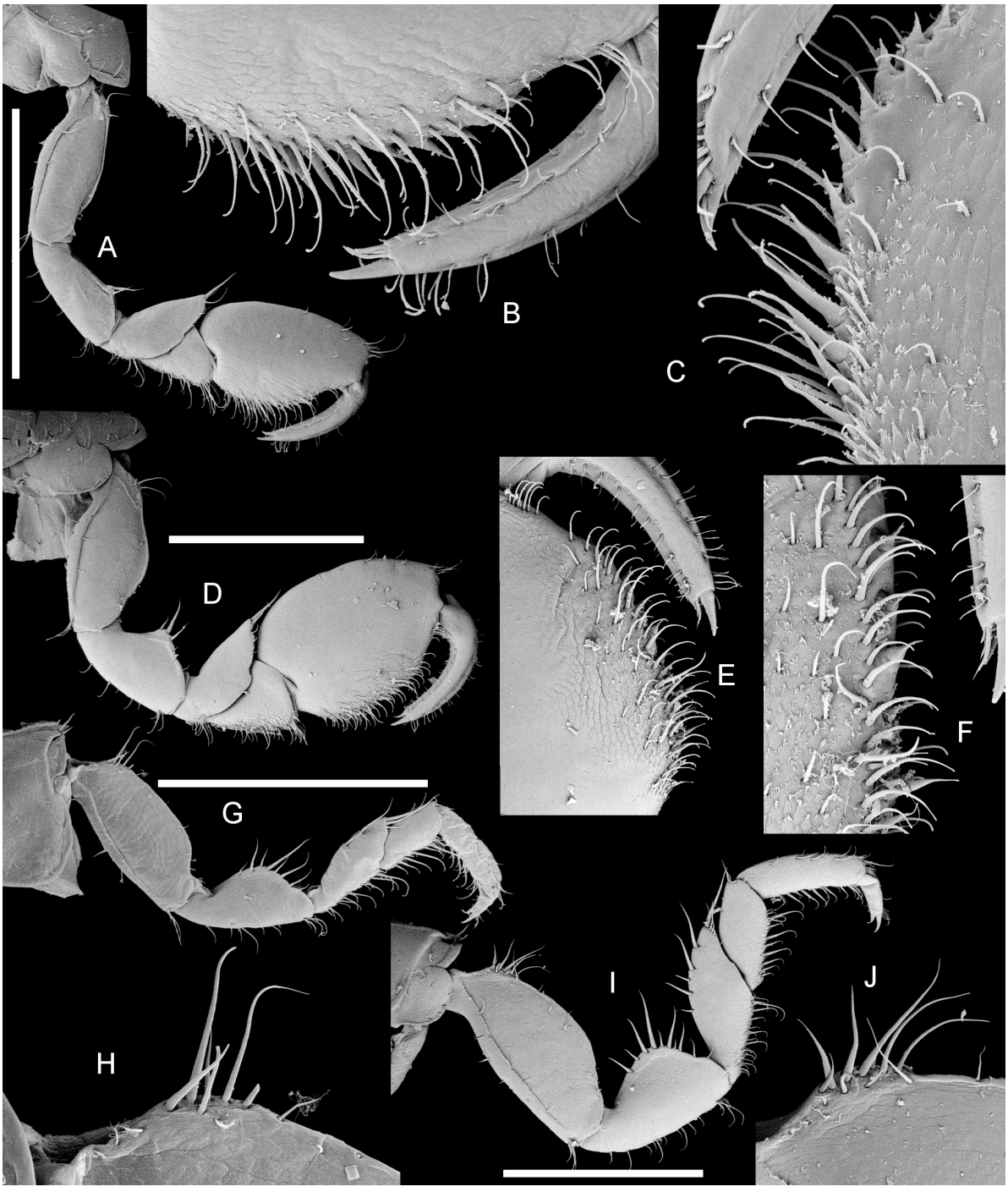

FIGURE 19. *Kakadubeh rangemyahwurd* gen. et sp. nov., pereopods I–II. Paratype male, AM P.74564: A–C, pereopod I with enlargements of the palm and palm setae; G–H, pereopod II with enlargement of epaulet on basis. Paratype female, AM P.72600. D–F, pereopod I with enlargements of the palm and palm setae; I–J, pereopod II with enlargement of epaulet on basis. Scales 1 mm.

Antennula. Length 0.17 body length in male (H), 0.14 body length in female (F3), with 12 articles in male (M5), with 12 articles in female (F3). Article 5 length 1.50–2.00 width (F3, H). Article 6 length 1.30–1.40 width (H, F3). Aesthetascs small (1–3) on distal margins. Terminal article shorter than penultimate article (articulation between articles not expressed), length 1.00 width (F3), length 0.03 antennula total length (F3). Distal articles oval in cross-section.

Antenna. Length 0.65 body length in male (H), 0.54 body length in female (F3). Flagellum length 0.70 total antenna length in male (H), 0.63 total antenna length in female (F3), with 24 articles in male (H), with 24 articles in female (F3), proximal articles surface smooth, proximal articles distal margin with groups of elongate setae.

Mouthfield. Clypeus width 0.42 head width (F3).

Mandible. Palp length 0.71 mandible length. Palp article 3 with 8 setae, setae on margin without setules, medial surface with additional setae, medial surface without setules, surface lacking cuticular hairs, without surface cuticular combs. Palp article 2 with distal group of setae (3). Palp article setae article 1 with 3 setae. Left incisor process with two distal cusps and one on dorsal margin. Left spine row with 12 spines, 8 of which bifurcate. Right spine row with 9 spines, 5 of which bifurcate. Left molar process triturating surface posterodorsal ridge projecting, complex setulate spines forming posterior row. Right molar process longer than wide, without row of complex spines adjacent to triturating ridges, dorsal surface with ciliated spine row, 7 members altogether.

Maxillula. Medial lobe length 0.84 lateral lobe length; width less than lateral lobe, width 0.86 lateral lobe width; with 6 pappose setae; with simple accessory setae, between central pappose setae, with 1 short weakly setulate setae on distal tip. Lateral lobe distal margin distal setal row with 11 robust setae, with 7 denticulate robust setae, with 5 smooth robust setae. Lateral lobe ventral face with 2 plumose setae, setae closely spaced, without additional plumose seta.

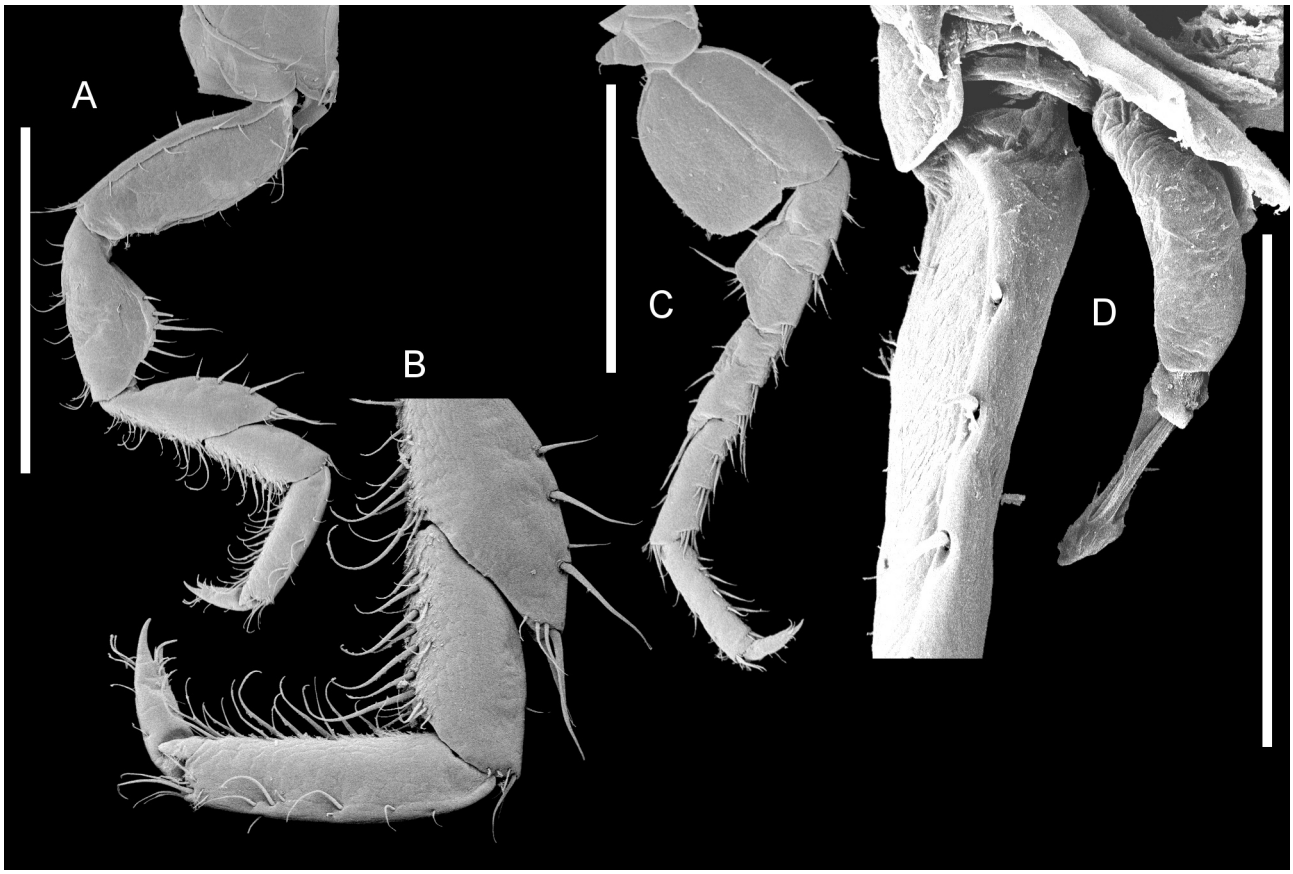

FIGURE 20. *Kakadubeh rangemyahwurd* gen. et sp. nov., pereopods IV and VII. Paratype male, AM P.74564. A–B, pereopod IV with enlargement of distal segments. C, pereopod VII. D, penes. Scales: A C, 1 mm; D, 0.5 mm.

Maxilla. Medial lobe width 0.92 outer lateral lobe width; proximal portion without inflection with distal portion. Outer lateral lobe length subequal to inner lateral lobe, wider than inner lateral lobe. Outer lateral lobe distal margin setal row curving and extending proximally along medial margin, both lateral lobes with bidenticulate setae on distal tips and on medial margin, with 15 long bidenticulate setae, inner lateral lobe with 15 long bidenticulate setae.

Maxilliped. Epipod distal tip broadly pointed, length 1.30 width. Endite length 0.43 total basis length, medial margin with 6 coupling hooks on right side (5 large, proximal 1 small); medial margin with 6 coupling hooks on left side (5 large, proximal 1 small). Endite distal margin fine setae, in fringe, with fine cuticular combs. Palp insertion on basis without lateral margin plumose setae, without medial margin plumose setae. Palp insertion on basis ventral

surface with 2 subdistal smooth setae, without ventral surface subdistal biserrate setae. Palp length 1.10 basis length (F3); width across articles 2–3 1.90 endite width. Palp article 4 shape elongate-oval, length 2.30 width (F3). Palp article 5 length 2.70 width (F3), 0.80 article 4 length (F3).

Pereopod I. Length:body length 0.33 male (M5), 0.34 female (F3). Basis of male length 2.70 width (M5), female length 2.10 width (F3); dorsal setae positioned proximally, 2 dorsal setae altogether (M5); female dorsal setae positioned proximally, female 5 dorsal setae altogether (F3); ventrodistal margin with 3 elongate setae (M5), female with 2 elongate setae (F3), elongate setae longer than ischium. Ischium of male dorsal margin with 2 simple setae (M5), setae not robust. Ischium of female dorsal margin with 3 simple setae (F3), setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with few elongate simple setae, dorsal surface with setae along dorsal axis (1 robust simple); female distodorsal margin with few elongate simple setae, female dorsal surface with setae along dorsal axis (1 robust simple). Propodus length:pereopod length 0.21 male (M5), 0.25 female (F3). Propodus length:width 1.40 male (M5), 1.20 female. Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 5 setae altogether (excluding distal group) (M5), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally inflated setae, stout robust setae articulated, 10 altogether (M5). Propodal palm of female margin convex, with stout robust conical setae, 8 altogether (F3). Dactylus of male shorter than palm, length:palm length 0.88 (M5), female shorter than palm, female length:palm length 0.81 (F3). Dactylus claw length:dactylus length 0.16 male (M5), 0.16 female (F3). Dactylus of male ventral to primary claw, claw length 0.46 (M5) length of primary claw.

Pereopods II–III ratios. Pereopod II. Length:body length 0.33–0.36 male (M5, H), 0.34 female (F3). Basis length:pereopod length 0.26–0.29 male (H, M5), 0.29 female (F3); length:width 2.20–2.70 male (H, M5), 2.40 female (F3). Carpus length:pereopod length 0.12 male (H, M5), 0.12 female (F3); length:width 1.70–2.10 male (M5, H), 1.90 female (F3). Propodus length:pereopod length 0.15–0.17 male (H, M5), 0.17 female (F3); length: width 3.00–3.50 male (H, M5), 3.40 female (F3). Dactylus length:propodus length 0.48 male (M5), 0.48 female (F3); primary claw length:dactylar length 0.31 male (M5), 0.32 female (F3). *Pereopod III.* Length:body length 0.35 male (H), 0.30–0.31 female (F1, F3). Basis length:pereopod length 0.28 male (H), 0.28–0.32 female (F3, F1); length:width 2.40 male (H), 2.40–2.80 female (F3, F1). Carpus length:pereopod length 0.13 male (H), 0.10–0.12 female (F3, F1); length:width 2.40 male (H), 1.50–2.00 female (F3, F1). Propodus length:pereopod length 0.17 male (H), 0.15 female (F1); length:width 4.00 male (H), 4.20 female (F1). *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, carpus and propodus. Ischium II–IV of male dorsal margin with 8 simple setae (M5 pereopod II, pereopod IV), none robust. Dactylus ventral to primary claw, 0.33–0.35 length of primary claw, with scales on ventral margin.

Pereopod II. Basis lateral face with 6 simple setae along margin in both sexes. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 1 minor seta, submarginal setal row with 1 setae, without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 2 minor setae, submarginal setal row with 2 setae (F3), without major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 5 setae (M5), dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 8 setae (M5). Carpus of male ventral margin with simple setae only. Carpus of female ventral margin with simple setae. Propodus of male distal width 0.93 maximum width (M5), setae on ventral margin simple, shorter than dactylar claw (M5, 0.94). Dactylus of male distal accessory claw approximately 0.33 primary claw length (M5). *Pereopod IV ratios.* Length:body length 0.30–0.32 male (M5, H), 0.29 female (F1). Basis length:width 2.20–2.70 male (H, M5), 2.30 female (F1). Carpus length:pereopod length 0.11 male (H, M5), 0.10 female (F1). Propodus length:pereopod length 0.15–0.16 male (M5, H), 0.15 female (F1). Propodus length:width 3.00–3.40 male (H, M5), 3.50 female (F1).

Pereopods V–VII ratios. Pereopod V. Length:body length 0.27–0.36 male (M5, H), 0.33 female (F1). Basis length:width 1.60 male (H, M5), 1.50 female (F1). Carpus length:pereopod length 0.15 male (H, M5), 0.16 female (F1). Propodus length:pereopod length 0.16 male (H, M5). Dactylus claw length:dactylar length 0.29 male (M5). *Pereopod VI.* Length:body length 0.44 male (H), 0.44 female (F1). Basis length:width 1.40 male (H). Carpus length: pereopod length 0.16 male (H), 0.15 female (F1). Propodus length:pereopod length 0.18 male (H), 0.17 female (F1). *Pereopod VII.* Length:body length 0.39–0.43 male (M5, H). Basis length:width 1.30 male (M5). Carpus length:

pereopod length 0.27 male (M5). Propodus length:pereopod length 0.16 male (M5). Dactylus claw length:dactylar length 0.28 male (M5).

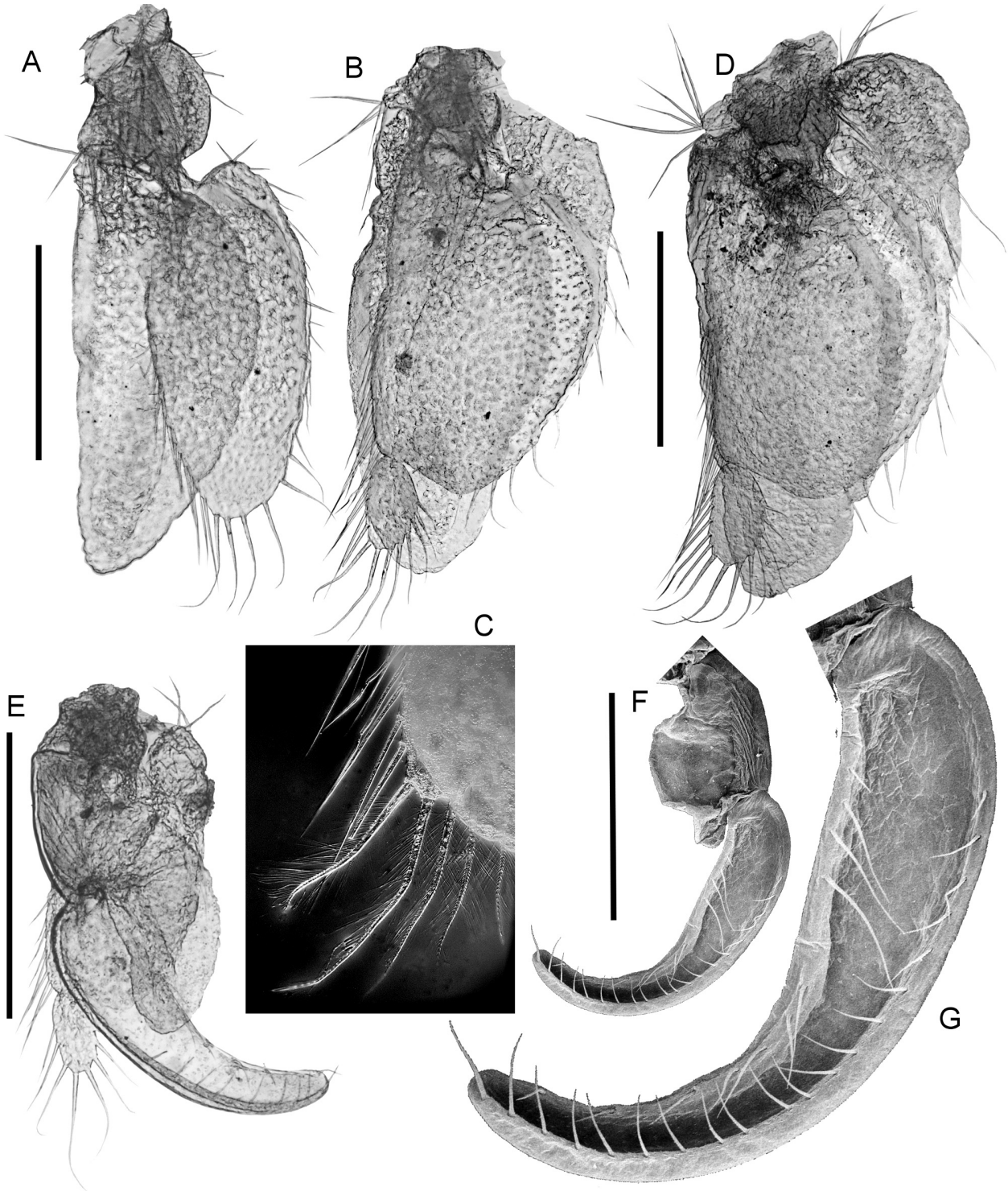

FIGURE 21. *Kakadubeh rangemyahwurd* gen. et sp. nov., pleopods. Paratype female, AM P.103501: A–D, pleopods I–III with enlargement (C) of exopod distal article setation. E, entire pleopod II with appendix masculina, paratype male [2], AM P.103502. F–G, appendix masculina (SEM image), paratype male, AM P.74564. Scales all 0.5 mm.

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming obtuse angle with axis of basis. V–VII ischium of male dorsal margin with 2 setae (M5 pereopod VII, pereopod V). Propodus distal margins with 3 elongate robust or robust-based setae (M5 pereopod V, pereopod VII). Dactylus accessory claw 0.53 primary

claw length (M5 pereopod VII). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, dorsal margin with 2 setae (4 setae in M5).

Penes. Distally tapering; distal tip truncate.

Pleopods. Exopods I with lateral proximal lobe, without medial proximal lobes of pleopod I. Protopods medial margins I–V with large projections, of male medial margins with simple setae only, of female medial margins with simple setae only; protopod I lateral epipod lobe-like, protopod II lateral epipod lobe-like.

Pleopod I exopod of male broadest at midlength, distal margin rounded, medial margin convex, divergent from lateral margin proximally, dorsal surface lacking setae. Pleopod II endopod of male appendix masculina length 0.84 pleopod length, basal musculature pronounced, distal length 2.20 endopod proximal margin length; 31 setae altogether (M5).

Uropod. Of male total length 1.40–1.70 pleotelson length (M5, H); protopod of male length 0.46–0.49 uropod total length (H, M5). Uropod of female total length 1.30 pleotelson length (F3), protopod length 0.48 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.65–0.66 male (H, M5), 0.69 female (F3). Protopod of male dorsolateral margin longer than dorsomedial margin setae (elongate); of female dorsolateral margin longer than dorsomedial margin setae (elongate). Protopod distoventral margin with 3 robust setae, with spinose setae (M5 with single spinule only, F3), 3 robust spinose setae (M5), 3 robust simple setae (F3). Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 14 altogether (M5); female dorsal margin with 16 robust setae (F3). Exopod length:endopod length 0.77 male (H, M5), 0.89 female (F3). Exopod length:protopod length 0.77 male, 0.77 female. Exopod of male dorsal margin with 8 robust setae (M5), female 9 robust setae (F3).

Distribution. Australia, Northern Territory, Kakadu National Park, Leichhardt Springs (Burdulba Creek tributary), South Alligator River, about 1 km west of a large sandstone outlier.

Habitat. Amongst leaf litter and fibrous roots of riparian trees and ferns in a sequence of pools with clean, quartzite sand substrate interspersed by swift-flowing runs and riffles of gravel and cobble. The stream edges are in extensive rainforest vegetation associated with permanent spring-fed flow. Water temperature 30°C.

Remarks. *Kakadubeh rangemyahwurd* sp. nov. is placed in the new genus for multiple reasons. The difference in the reproductive strategy between this species and most other Amphisopidae is most compelling. Typical amphisopid males are substantially larger than the females and engage in precopula with mature females. This species, however, has adult females that are substantially larger than males, ranging from 1.2 to 2 times larger than adult males. The females even have secondary sexual features that are typical for males of other amphisopids, such as an enlarged propodus relative to that of the other sex. This sexual size difference is also observed, ironically enough, among species of *Amphisopus*, a feature that contributes to *K. rangemyahwurd* gen. et sp. nov. appearing basally to the species of *Eophreatoicus* in the phylogenetic analysis.

Although we have no information on the behavior of *K. rangemyahwurd* gen. et sp. nov., we suspect that the males do not engage in precopula owing to the size difference. Supporting this idea is the observation that the males have appendices masculinae that are substantially enlarged relative to body size or to the pleopod II exopod. In most amphisopids, the appendix masculina is near the same size as or shorter than the exopod, but in this species it is ~12% longer than the exopod. In intact specimens, the appendix masculina projects substantially below the pleurae of the pleonites. This enlarged intromittent organ presumably may facilitate copulation with the much larger females.

In addition to the sex-linked differences mentioned above, the differences between *K. rangemyahwurd* gen. et sp. nov. and species of *Eophreatoicus* (features parenthetically) amount to 30 distinct characters, some of which are autapomorphies of the new genus. Some of these include: cuticle of the pereon and pleon without ridges or tubercles (varying degrees of transverse ridges and rugosity); the pleotelson ventral postanal ridge has only 4 robust setae (more than 6); the pleotelson posterior apex is elongate so that it appears in lateral view beyond the posterolateral margin (not visible, except for *E. mawoenewoene* sp. nov.); the posterolateral margin curves medially so that the posterior apex is separated only by a narrow gap (gap is broad and well separated); the posterolateral margin is marked by 3 setal positions, with the most dorsal seta being much more elongate than the others (2 setal positions, all setae around the same size); the antenna flagellum proximal articles distal margin has groups of setae that are longer than half article width (rosettes of setae shorter than half article width); pereopod VII ischium dorsal ridge width less than shaft width (equal to or larger than shaft width).

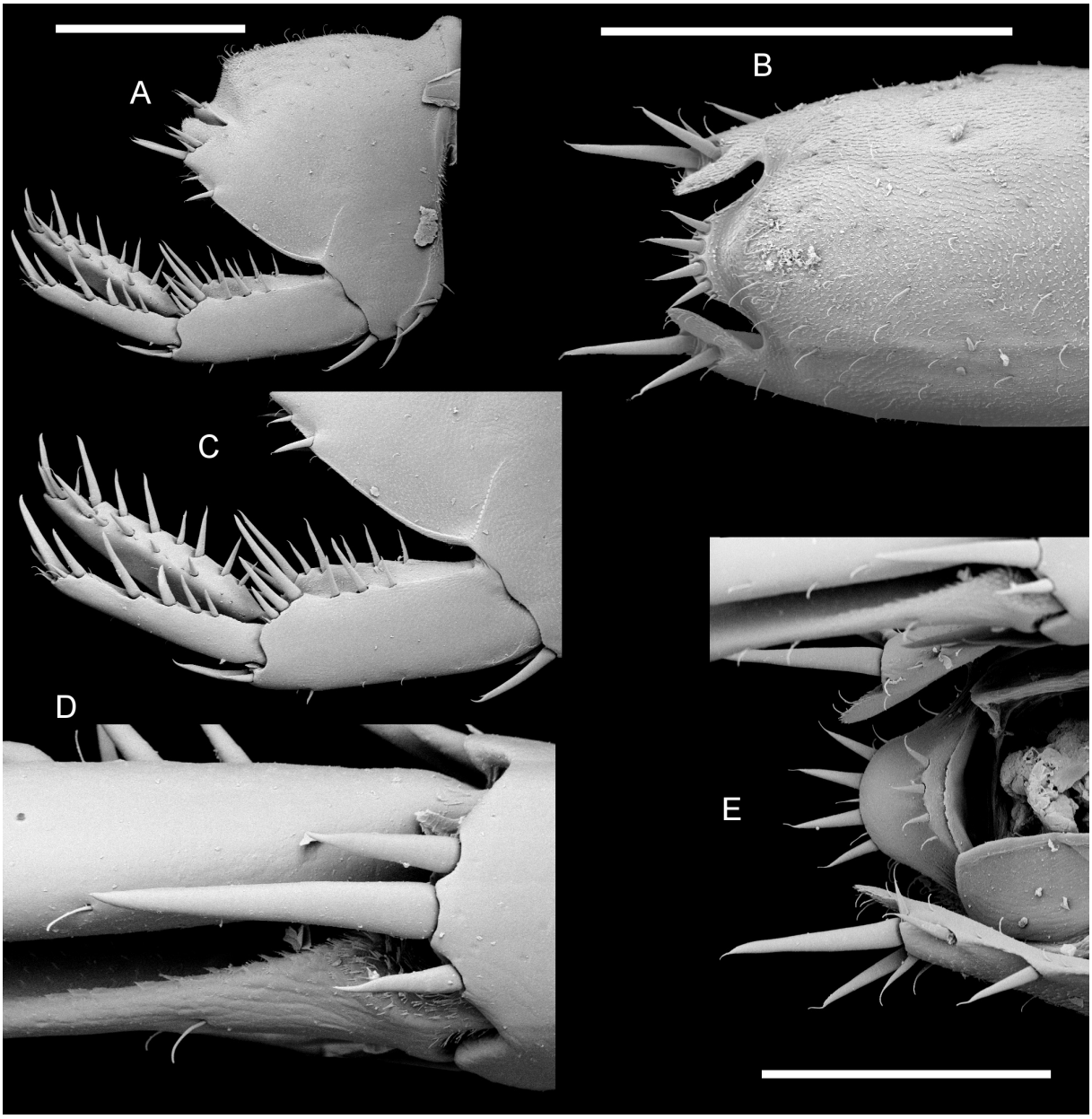

FIGURE 22. *Kakadubeh rangemyahwurd* gen. et sp. nov., pleotelson and uropods, paratype female, AM P.72600. A–B, pleotelson, lateral and dorsal. C–D, uropod with enlargement of protopod distoventral setae. E, pleotelson apex, ventral. Scales: A–B, 1 mm; E, 0.5 mm.

Eophreatoicus Nicholls, 1926

Eophreatoicus Nicholls, 1926: 190.— Nicholls, 1943: 102.— Poore *et al.*, 2002: 79.

Type species. *Eophreatoicus kershawi* Nicholls, 1926, by monotypy.

Taxa included. *Eophreatoicus kershawi* Nicholls, 1926, *E. balbun* sp. nov., *E. barrkmarlam* sp. nov., *E. binjdjarrang* sp. nov., *E. bodmemurrngkudji* sp. nov., *E. boywek* sp. nov., *E. djirrinjbal* sp. nov., *E. djurrukunja* sp. nov., *E. galunggul* sp. nov., *E. gubara* sp. nov., *E. gudjangah* sp. nov., *E. kurdabeyhmay sp. nov.*, *E. indjangarlwurr* sp. nov., *E. karrkkanj* sp. nov., *E. korokoro* sp. nov., *E. kudjaldordo* sp. nov., *E. kudjamarndi* sp. nov., *E. kurrih* sp. nov., *E. mawoenewoene* sp. nov., *E. mok* sp. nov., *E. namarden* sp. nov., *E. namarrkon* sp. nov., *E. namimminya* sp. nov., *E. nawurlandja* sp. nov., *E. ngarradj* sp. nov., *E. warddebarrarn* sp. nov., *E. warnbi* sp. nov., *E. wurrkbaba* sp. nov. (28 species).

Diagnosis. Body length of largest male greater than body length of largest female. *Pereon*. Lateral tergal plates of pereonites 2–4 not extended over basis. Coxal articulation to pereonites 5–7 free. *Pleotelson*. Dorsal surface in lateral view with distinct dorsal inflection. Dorsal surface without median ridge, without lateral ridges, rugose. Lateral surface anterior to uropods with pleonite ridge extending to ventral margin anterior to penultimate robust seta. Postanal ventral surface with ridge parallel to anal opening. Lateral uropodal ridge curving strongly and extending posteriorly from uropods on pleotelson margin (almost angled rather than curved), without setae. Posterolateral margin vertical plate, inner margin in dorsal view projecting posteriorly relative to apex, with robust setae, with two positions defined by major robust setae without intermediate setae anteriorly and posteriorly, dorsal setal position with 1–2 robust setae, dorsal major seta near length of other seta, dorsal margin forming lobe medial to seta (rounded plate), without seta near inflection, without robust setae on dorsolateral surface. Posterior apex projecting in dorsal view, free (not strongly reflexed and flattened against dorsal surface with ventral surface exposed). *Mandible*. Palp article 1 easily visible. Left spine row with first spine not separated from remaining spines. Left molar process triturating surface ridges directed diagonally to mandibular axis, in line with dorsal condyle. Right molar process dorsal surface cuticular hairs dense, extending along margin from larger ciliated spines. *Maxilliped*. Palp insertion on basis without medial margin simple setae. *Pereopod I*. Propodus sexually dimorphic, male propodus more robust than in females. Merus distodorsal margin projection in cross-section in female U-shaped in cross-section and curving over carpus around proximal dorsal margin of propodus. Propodal palm margin in male with cuticular fringe weakly developed, with groups of elongate distally thick setae on either side of palm margin. *Pereopods II–III*. Basis dorsal ridge in cross-section forming distinct plate. *Pereopod II*. Basis lateral face without longitudinal carina, with ventral carina, complete (extending along basis margin). Basis dorsal ridge proximal margin with epaulet. *Pereopod IV*. Sexually dimorphic, with distinct prehensile palm in adult males, with major hinges on dactylus to carpus. Basis dorsal ridge in cross-section produced and forming distinct plate. Propodus distal width in male less than palm width. *Pereopods V–VII*. Basis lateral face with central longitudinal carina, with ventral carina, without fine setae. *Pleopods*. Pleopod II endopod appendix masculina not forming tube, groove open distally, length more than half endopod length, distal length approximately subequal to endopod proximal margin length, distal tip broadly rounded; setae continuous around margin; stiff elongate setae on apex. *Uropod*. Protopod dorsomedial ridge with setae on margin. Protopod dorsolateral margin with robust setae. Protopod ventrolateral margin without longitudinal row of setae; ventral margin without transverse rows of simple setae. Rami distal tips rounded, cross-sectional shape flattened on dorsal surface only. Endopod ventral margin in medial view convex or straight proximally.

Remarks. The genus *Eophreatoicus* Nicholls, 1926 is now substantially enlarged (but see Discussion section on species richness). Remarkably, all species are fairly similar, mostly with differences in cuticular rugosity, setation and pleotelson form. Five species, additional to the list above, had insufficient information for formal description but are included as informal taxa indicated only by alphanumeric tags. *Eophreatoicus*, *Eremisopus* Wilson & Keable, 2002a and *Kakadubeh* gen. nov. form a subgroup of the family Amphisopidae: all have similar first pereopods and uropods. Additionally, they share a unique two amino acid deletion from the mitochondrial cytochrome oxidase subunit I gene that is not found in any other isopod. These three genera are also only found in Northwestern Australia, from Arnhem Land, Northern Territory, to the Western Kimberley of Western Australia.

Eophreatoicus kershawi Nicholls, 1926

(Figs 6A, 8A, 9A, 23–29)

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Eophreatoicus kershawi Nicholls, 1926: 190, figs 17–39.—Nicholls, 1943: 102, fig. 25.— Poore *et al.*, 2002: 79. — Wilson *et al.*, 2009: 361.

Type material. Syntypes. WAM C11815 (old number 223–74) 6 slides labeled "Nicholls Coll." (I, 4 cover slips: antennula, antenna, 2 mandibles, 2 maxillae; II, 3 cover slips: 2 maxillulae, paragnath, 2 maxillipeds; III, 4 cover slips: pereopod I, pereopod II?, pereopod III?, pereopod VII; IV, 3 cover slips: pereopod IV, pereopod V, pereopod VI; V, 3 cover slips: pleopod I, 2 pleopod II with appendix masculina + pleonite epimera, 2 pleopod III? + pleonite epimera; VI, 3 cover slips: 2 pleopod IV? + pleonite epimera, 2 pleopod V? + epimera, pleotelson + uropod; WAM C 11816 (old number 224–74) 7 slides labeled "Nicholls Coll." not numbered, 1 slide with 2 cover slips: frons, maxillae + maxillula + part of paragnath?; 2 slides each with pleopods I–V including appendix masculina, 1 slide with pereopods V–VII, 1 slide with 2 mandibles, 1 slide with 2 cover slips = uropod, pleopod I (in 2 parts), 1 slide

with 2 cover slips: maxilliped (in 2 parts) + maxilla, antennula + antenna; WAM C11817 (old number 225–74) 6 slides labeled "Nicholls Coll., male right side" (I, 3 cover slips: antennula + antenna, maxilliped, maxilliped; II, 3 cover slips: 2 mandibles + frons, 2 maxillae, 2 maxillulae; III, 4 cover slips: paragnath, pereopod I, pereopod IV, pereopod II or III; IV, 4 cover slips: pereopod II or III, pereopod V, pereopod VI, pereopod VII; V, 4 cover slips: 2 pleopod II with appendix masculina, 2 pleopod I, pleopod III?, pleopod III? (used for pleopod illustrations); VI, 2 cover slips: 2 pleopod IV? + 2 pleopod V?, pleotelson + uropod); NMV J12923 6 males, 2 females (including male 15.3 mm, female 16 mm used for redescription, male 16.4 mm used for whole animal illustration).

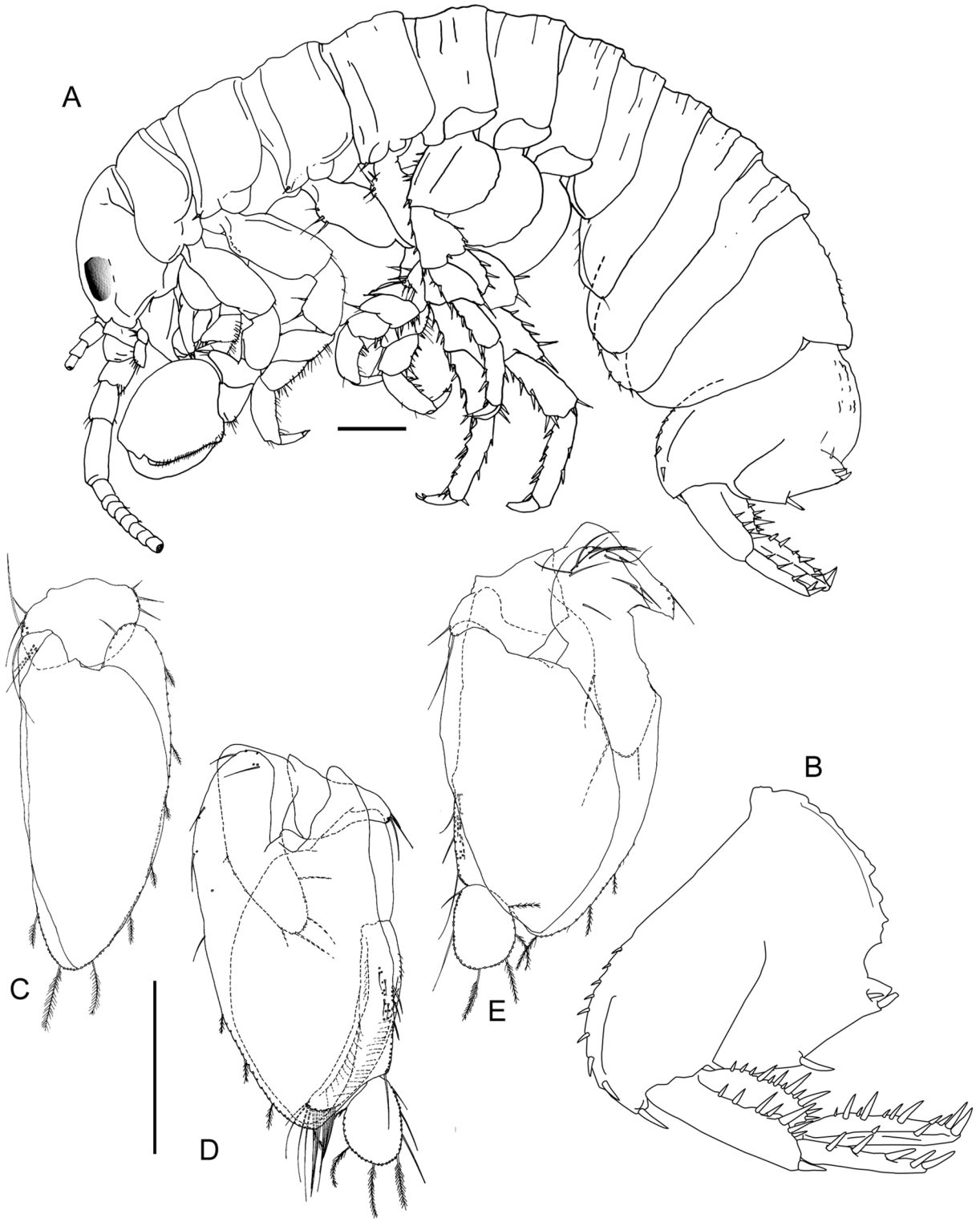

FIGURE 23. *Eophreatoicus kershawi* Nicholls, 1926. A–B, NMV J12923, syntype male, habitus with enlargement of pleotelson. C–E, WAM C11817, syntype male pleopods I–III. Scale 1 mm.



FIGURE 24. *Eophreatoicus kershawi* Nicholls, 1926. A–C, male, AM P.72631, with enlargement of pleotelson and anterior body. D, male, AM P.72630, lateral. E, female, AM P.102180. Scale 5 mm.

Remarks on the Type material. The illustrations of Nicholls (1926, 1943) show no specimens unequivocally represented in the material examined. As a result of this uncertainty, we have not named a lectotype. The antennula and antenna from WAM C11816 are, however, close to illustrations of Nicholls (1943) for these appendages. Nicholls (1926, p. 192 and 181) states "the collection of close upon a hundred specimens...was presented to the Museum [Museum Victoria]". "I was...allowed to remove certain of these...for examination". Nicholls (1943, p. 109) also notes "About a hundred specimens were taken of which about three-fourth were male; no mature females were represented in the collection." Nicholls (1926, p.192) also records "about 25 per cent showed no male organ". Nevertheless, two preparatory females were found in NMV J12923. These syntype specimens were divided among several institutions, as described above.

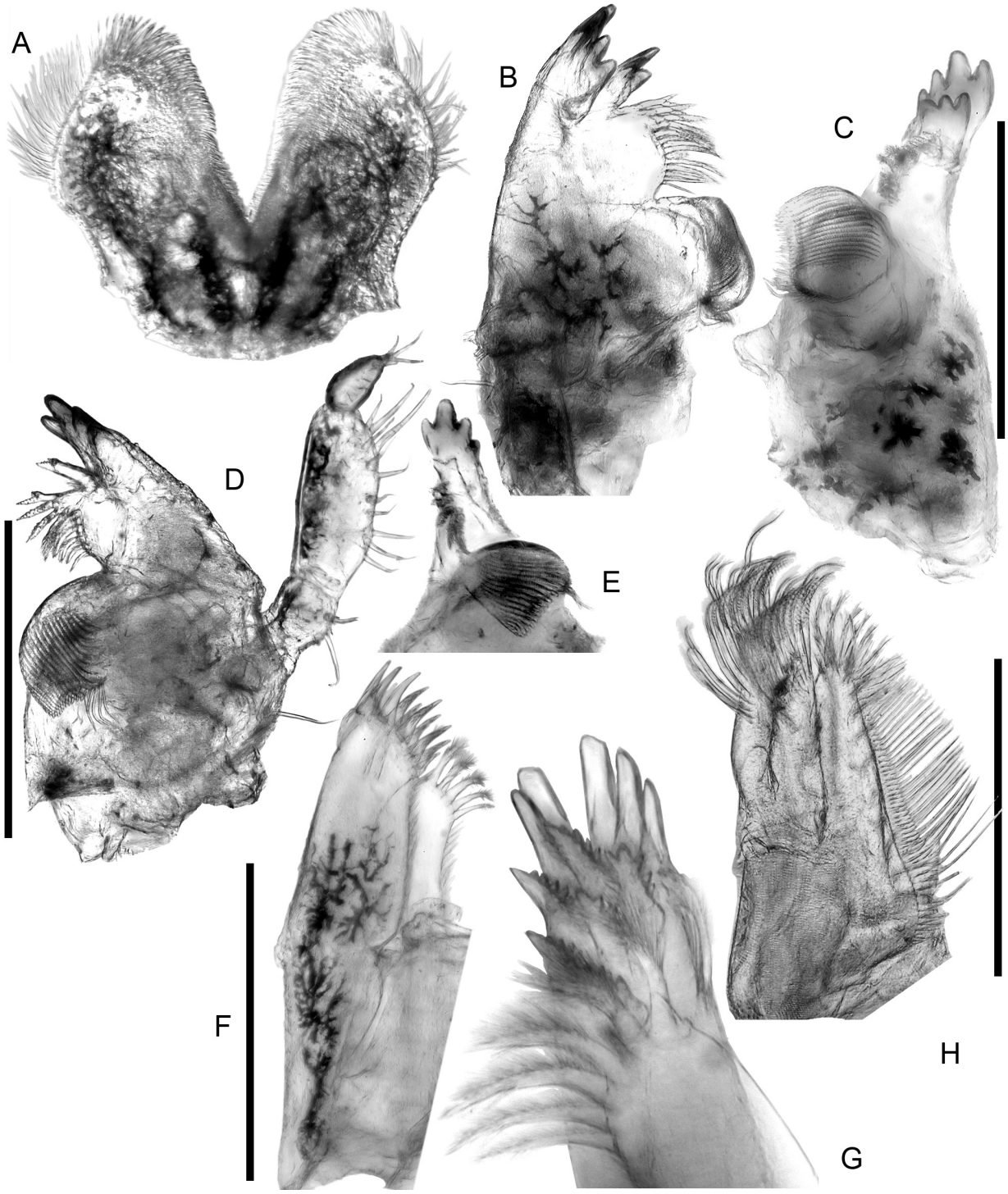

FIGURE 25. *Eophreatoicus kershawi* Nicholls, 1926, female, AM P.102180, mouthparts. A, paragnaths. B–C, left mandible, dorsal and medial. D–E, right mandible, dorsal and medial. F–G, maxillula dorsal and medial. H, maxilla, ventral. Scales 0.5 mm.

Data were taken mostly from syntype male, bl 15.3 mm NMV J13923, but also from syntype slides WAM C 11816 (old number 224–74) and from descriptions by Nicholls (1926, 1943), where noted (particularly for mouthparts, antennulae and antennae, and pleopods). Syntype slides labeled "Nicholls collection" WAM C11815 (old number 223–74) 6 slides, C 11816 (old number 224–74) 7 slides, and C11817 (old number 225–74) 6 slides were also examined. Additional non-type specimens from near the type locality were used for DNA and SEM.

Type locality. Australia, Northern Territory, Sandstone Bluff, near Wellington Hills, small pool/rock hole of clear, cool water, 12°S 133°30'E (estimated by Nicholls 1926), coll. W. M'Lennan, 23.xi.1915. This position,

however, is well south of the King River estuary in a low relief area, whereas White (1917:138) reports that the collector (M'Lennan) obtained the specimens from a sandstone range north of the King River estuary. A locality north and west of the estuary was sought for a 2004 visit to the locality (see Other Material Examined).

Other material examined. Arnhem Land, NT, Australia, Sandstone Outlier north and west of King River Estuary (presumed type locality); cave in crevice of sandstone cliff, coll. 15.xi.2004, C. Humphrey & company, 11°52.62'S 133°23.69'E: juvenile female, AM P.74570, 9.1 mm, DNA E65 Genbank COI EU263136 16S EU263206; juvenile, AM P.74571, bl 8.3 mm, DNA E66 Genbank COI EU263137 16S EU263208; juvenile, AM P.74572, 6.9 mm, DNA E67 Genbank COI EU263138 16S EU263207; male, AM P.72630, bl 14.7 mm; male (M2), AM P.72631, bl 18.1 mm, SEM stubs AW628–633, DNA GW104 Genbank Genbank COI MK967231 16S MK961104; female, P.102180, 8 mm, dissected; female 7.8 mm, AM P.102181; 18 inds, AM P.72632.

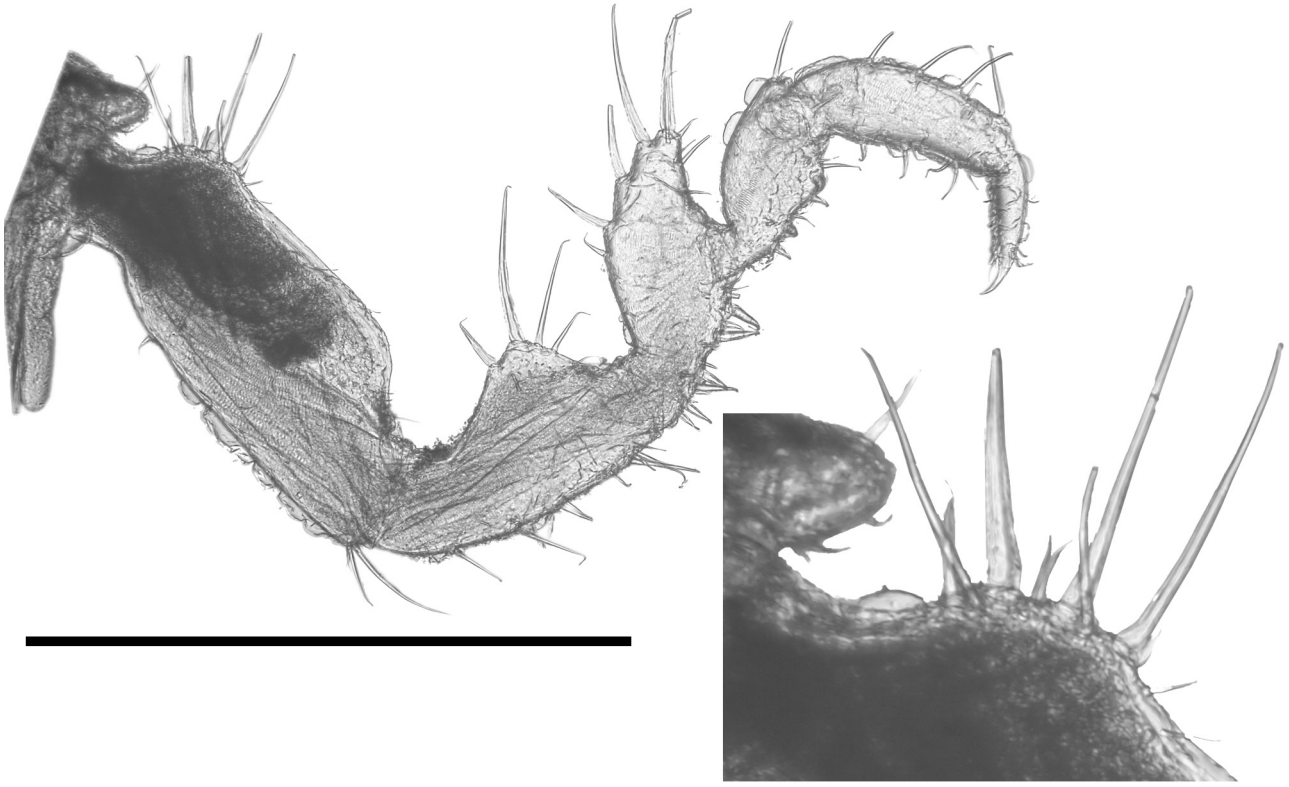

FIGURE 26. *Eophreatoicus kershawi* Nicholls, 1926, female, AM P.102180, pereopod II with enlargement of epaulet. Scale 1 mm.

Other material not examined. WAM 245–74 1 specimen, unavailable, not returned from previous loan (M. Hewitt, pers. comm. August 2002); NMV J12923 6 males, 2 females; TMH G855 2 males.

Etymology. "[T]he species being named in compliment to Mr. Kershaw" (Nicholls 1926), who apparently assisted Nichols with information relating to the new species.

Diagnosis. *Head.* Eyes bulging dorsolaterally, height large, in lateral view greater than width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region without obvious setae. *Pereon.* Dorsal cuticular surface with scattered small scales or roughness; pereonites 1–4 transverse dorsal ridges rounded, expressed as transverse trough only; pereonites 5–7 transverse dorsal ridges carinate with transverse trough. *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection convex. Dorsal surface rugose, with oblong tubercles (angled laterally), lacking posteromedial ridges or median groups of tubercles. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae, with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth. *Pereopod II.* Basis of male dorsal ridge epaulet length subequal to quarter basis length, main setal

row with 4 major setae (M2). Basis of female dorsal ridge epaulet length less than quarter length of basis, main setal row with 4 major setae. *Pereopod IV.* Propodus of male ventral margin with projection, with 5 robust setae on ventral margin. Dactylus of male length subequal to propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 robust setae distinctly larger than others, separated by shorter seta.

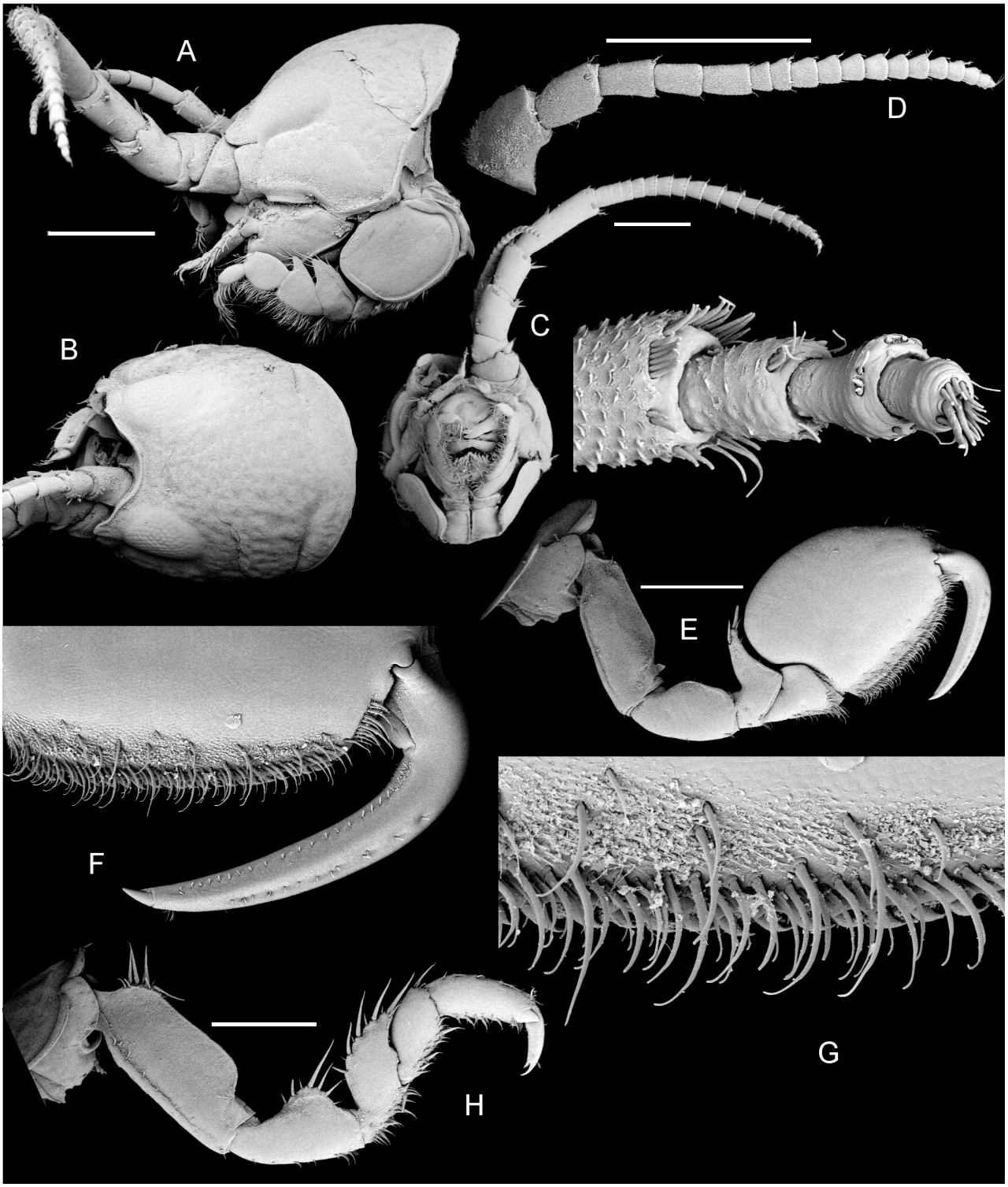

FIGURE 27. *Eophreatoicus kershawi* Nicholls, 1926. Male, AM P.72631. A–B, head, left lateral and dorsal. C, head and left antenna with enlargement of antennal tip. D, right antennula. E, right pereopod I; F, enlargement of propodal palm; G, setation of palm. H, right pereopod II. Scale 1 mm.



FIGURE 28. *Eophreatoicus kershawi* Nicholls, 1926. Male, AM P.72631. A, right pereopod IV; B, enlargement of dactylus and propodus. C, right pereopod V. D, right pereopod VII, distal parts missing. E, pereopod VII pene, sperm bundles protruding from opening. F, pleopod II appendix masculina. Scale 1 mm.

Description. Body pigmentation cream with gray chromatophores scattered regularly over entire body and appendages visible in lateral view (in alcohol). Nicholls (1926: 192) states "In spirit, yellowish-gray. The body generally is yellow tinted, with black dendritic spots scattered sparsely along the sides and still more sparsely upon the extremities of the limbs. In mid-dorsal line and on either side dorsally, these spots are closely aggregated to form three dark interrupted lines. In the peraeon, these may be continuous and almost merge into one another, the marking then, in that region, may be described as consisting of a paired dark dorso-lateral line separated by a light median yellow line bearing a dark spot at the middle of each segment. Laterally (externally) the dark bands may be defined by a thin and wavy yellow line." Topotypic material collected in 2004 matches this description; length of largest male 18.1 mm, length of largest preparatory female 8.3 mm.

Head. Length shorter than width in dorsal view (0.92); lateral profile of dorsal surface smoothly curved. Width 0.78 pereonite 1 width (M2). Dorsal surface pitted; setae tiny and sparse. Eyes dorsal margin convex, ventral margin concave (posteroventral margin concave), orientation of longest axis vertical, maximum diameter 0.31 head depth (M2), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view smoothly curved. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region without obvious setae.

Pereon. Width exceeding head width. Setae on dorsal surface not visible. Pereonite 1 length:width ratio in dorsal view 0.19 in male. Pereonites 2–7 length:width ratios in male 0.45, 0.37, 0.31, 0.29, 0.24, 0.19. Coxal articulation to pereonites 2–4 fused (almost complete but with weak lateral suture).

Pleonites. Pleonites 2–3 in dorsal view respective lengths less than 0.5 pleonite 5 length, pleonite 4 length more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior, 1–4 width 0.78 composite length in dorsal view. Pleonites 1–5 of male dorsal length:maximum pleonite width ratios: 0.20, 0.22, 0.27, 0.29, 0.58. Pleonites depth:pereonite 7 depth 1.40 pleonite 1, 1.90 pleonite 2, 2.20 pleonite 3, 2.10 pleonite 4, 2.10 pleonite 5.

Pleotelson. Dorsal surface length 1.27 width in dorsal view. Dorsal surface sparsely covered with setae; lacking cuticular combs on tubercles. Depth 1.74 pereonite 7 depth. Lateral length less than depth, in male 0.67–0.68 depth (M2), in female 0.62 depth. Lateral length 0.13 body length. Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.50 width of uropodal insertion, with single row of simple robust setae grading anteriorly to fine setae (although described by Nicholls (1943) as toothed), including 9–12 robust setae altogether (9 in material examined, up to 12 according to Nicholls (1943)), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.14 pleotelson total length, dorsal setal position posterior seta subequal to submarginal seta. Posterior apex length approximately subequal to width, long. Posterior apex 0.12 pleotelson total length, width 0.16 pleotelson width. Posterior apex in lateral view forming an angle of 92° with immediately anterior dorsal surface, angled 138° from horizontal.

Antennula. Length 0.12 body length in male (based on male 16.1mm NMV J13923), 0.09 body length in female, with 15–17 articles in male (WAM C11816, WAM C11815), with 13 articles in female. Article 5 length 1.60 width. Article 6 length 0.77 width. Aesthetascs tiny (1–2) on articles 7 (WAM C11816), 8 (WAM C11815) or 10 (WAM C11816, although most proximal possibly missing) to terminal article. Terminal article length 1.00 width, 0.02 antennula total length. Distal articles oval in cross-section (based on male 16.1mm NMV J13923).

Antenna. Length 0.33 body length in male (Nicholls 1926; less than 1/3 bl Nicholls 1943), 0.29 body length in female. Flagellum length 0.57 total antenna length in male (WAM C11816), 0.64 total antenna length in female, with 15–22 articles in male (15 WAM C11816, 20 WAM C11815, 22 in Nicholls 1926), with 16 articles in female, proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Mouthfield. Clypeus consisting of broad bar rounded laterally at mandibular fossae, asymmetrical, broader on left side, width 0.29 head width. Labrum ventrally semicircular in anterior view, asymmetrical, broader on right side. Paragnaths with distolaterally rounded lobes, having medial and lateral setal rows and thickened medial base covered with cuticular spinules.

Mandible. Palp length 0.70 mandible length (WAM C11817). Palp article 3 with 12–18 setae (WAM C11816 =12, WAM C11817 =18), setae on margin finely setulate, medial surface with additional setae, medial surface covered in cuticular combs, surface lacking cuticular hairs, with surface cuticular combs. Palp article 2 without distal group of setae. Palp article setae with long setae on dorsolateral margins, additional short setae on article 2. Left spine row with 16 spines (WAM C11816), 3 of which bifurcate (WAM C11816, AM P.102180). Right spine row with 9 spines (WAM C11816, AM P.102180), 3 of which bifurcate (WAM C11817). Left molar process triturating surface posterodorsal ridge not projecting, complex setulate spines forming posterior row. Right molar process with row of complex spines adjacent to triturating ridges, dorsal surface with ciliated spine row, 5 members altogether.

Maxillula. Medial lobe length 0.88 lateral lobe length (WAM C11817); width subequal to lateral lobe, width 0.83 lateral lobe width (WAM C11817); with 7–9 pappose setae (WAM C11815 =8–9, C11816 =7, C11817 =8); with simple accessory setae, 2 altogether, on distolateral margin and between distolateral pappose setae, with 1 short weakly setulate setae on distal tip. Lateral lobe distal margin distal setal row with 4 robust setae, with 5–7 denticulate robust setae, with 6–7 smooth robust setae. Lateral lobe ventral face with 2 plumose setae, setae closely spaced, additional plumose seta among proximal distal robust setae (clearly apparent on C11817, also illustrated and noted by Nicholls (1943)).

Maxilla. Medial lobe width 0.65–0.77 outer lateral lobe width (WAM C11815 0.65, WAM C11817 0.77); proximal portion without inflection with distal portion; setae in ventral basal rows weakly setulate, setae in dorsal basal row with distinct base and smooth shaft, setae in distal row with row of teeth and row of fine setules, although some plumose and without teeth. Outer lateral lobe length subequal to inner lateral lobe, wider than inner lateral lobe. Outer lateral lobe distal margin setal row with two angles transverse to lateral margin and oblique on medial margin, both lateral lobes with bidenticulate setae on distal tips and on medial margin, with 10 long bidenticulate setae, inner lateral lobe with 10 long bidenticulate setae.

Maxilliped. Epipod distal tip truncate, length 1.03 width (WAM C11817). Endite medial margin with 4–5

coupling hooks on right side (WAM C11816 with 4; Nicholls (1926) states 4 or 5 coupling hooks and his illustration appears to show 5 on the right side); 3–4 coupling hooks on left side (WAM C11815, C11817 with 3; WAM C11816 with 4). Endite distal margin simple setae, in fringe, without fine cuticular combs, 30–41 subdistal biserrate setae on ventral surface (WAM C11816). Endite dorsal ridge with 18–22 large distally denticulate plumose setae (WAM C11816, 18 setae; WAM C11815 & C11817, approximately 22 setae). Palp insertion on basis lateral margin with 4 plumose setae, without medial margin plumose setae. Palp insertion on basis ventral surface without subdistal smooth setae, without ventral surface subdistal biserrate setae. Palp article 4 shape elongate-oval, length 1.20 width. Palp article 5 length 1.80 width, 0.70 article 4 length.

Pereopod I. Length:body length 0.39 male. Basis of male length 2.50 width; dorsal setae positioned proximally, 1 dorsal seta altogether (M2); female dorsal setae positioned proximally; ventrodistal margin lacking elongate setae, female with 1 elongate seta, elongate setae shorter than ischium. Ischium of male dorsal margin with 1 simple seta, setae robust. Ischium of female dorsal margin with 1 simple seta, setae robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (2 robust); female distodorsal margin with numerous elongate simple setae, female dorsal surface with setae along dorsal axis. Propodus length:pereopod length 0.23 male, 0.21 female. Propodus length:width 1.00 male, 1.50 female. Propodus of male dorsal margin setae in several groups between proximal and distal margin (1 subdistal group of 2 short setae in WAM C11817, otherwise absent), with 2 setae altogether (excluding distal group) (small, when present), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae articulation not expressed, 24–29 altogether (WAM C11817 with 26; WAM C11815 with 29). Propodal palm of female margin convex (weakly, almost straight), stout denticulate setae serrate, 10 altogether, with stout robust conical setae, 22 altogether. Dactylus of male shorter than palm, length:palm length 0.89 (WAM C11817), female shorter than palm (just), female length:palm length 0.93. Dactylus claw length:dactylus length 0.10 male, 0.13 female. Dactylus of male positioned ventrally, 0.34 (M2) length of primary claw.

Pereopods II–III ratios. Pereopod II. Length:body length 0.36 male, 0.32 female. Basis length:pereopod length 0.33 male, 0.34 female; length:width 2.90 male, 2.50 female. Carpus length:pereopod length 0.12 male, 0.12 female; length:width 1.50 male, 1.20 female. Propodus length:pereopod length 0.17 male, 0.18 female; length:width 2.90 male, 3.30 female. Dactylus length:propodus length 0.51 male, 0.61 female; primary claw length:dactylar length 0.28 male, 0.26 female. *Pereopod III.* Length:body length 0.29 male, 0.30 female. Basis length:pereopod length 0.35 male; length:width 2.80 male. Carpus length:pereopod length 0.11 male; length:width 1.30 male. Propodus length:pereopod length 0.16 male; length:width 2.70 male. Dactylus length:propodus length 0.64 male; primary claw length:dactylar length 0.20 male. *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, carpus and dactylus; basis dorsal ridge with setae forming 2 rows on proximal projection. Ischium II–IV of male dorsal margin with 7 simple setae (M2 pereopod II), none robust. Carpus II of male with 7 robust based setae. Carpus II of female with 5 robust based setae. Dactylus length 0.44 primary claw length, with scales on ventral margin; 20 altogether (M2 pereopod II, approx).

Pereopod II. Basis lateral face with 2–3 simple setae. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 2 minor setae, submarginal setal row with 1 seta, without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 2 minor setae, submarginal setal row with 2 setae, without major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge setae positioned proximally, of female dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 5 setae (M2). Carpus of male ventral margin setae in several groups, with simple setae only. Carpus of female ventral margin with simple setae. Propodus of male distal width 0.63 maximum width, setae on ventral margin robust-based, 2 distinctly larger than remainder, longer than dactylar claw (just). Propodus of female posterior side of limb articular plate subequal in length to dactylar claw. Dactylus of male distal accessory claw approximately 0.33 primary claw length (M2,0.41). *Pereopod IV ratios.* Length:body length 0.32 male. Basis length:width 2.60 male. Carpus length:pereopod length 0.12 male. Propodus length:pereopod length 0.16 male. Propodus length:width 2.20 male.

Pereopods V–VII ratios. Pereopod V. Length:body length 0.34 male, 0.32 female. Basis length:width 1.10 male, 1.40 female. Carpus length:pereopod length 0.16 male. Propodus length:pereopod length 0.18 male. Dactylus claw

length:dactylar length 0.31 male. *Pereopod VI.* Length:body length 0.35 male, 0.40 female. Basis length:width 1.50 male, 1.20 female. Carpus length:pereopod length 0.17 male. Propodus length:pereopod length 0.19 male. *Pereopod VII.* Length:body length 0.37 male, 0.43 female. Basis length:width 1.40 male, 1.30 female. Carpus length:pereopod length 0.17 male.

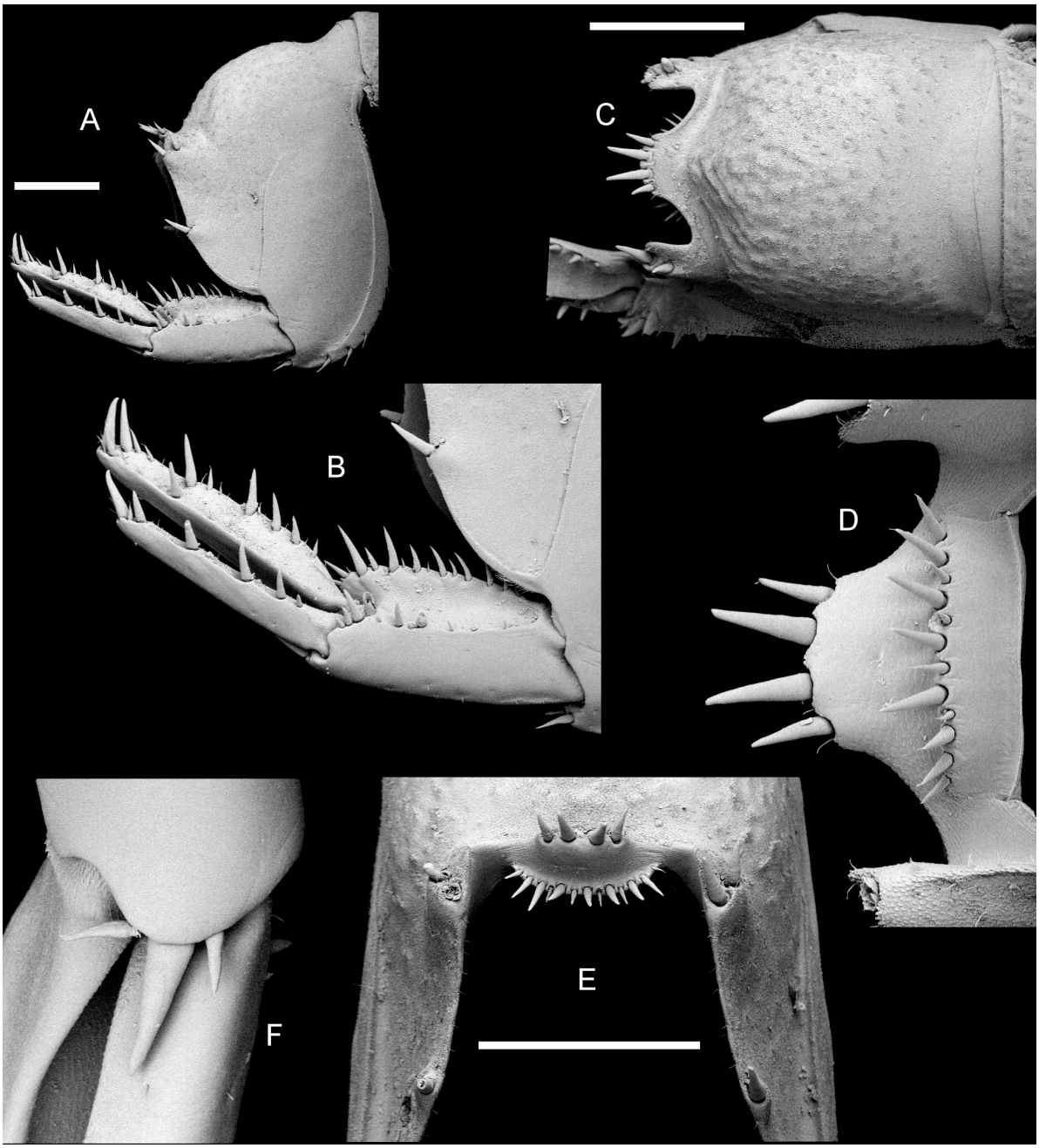

FIGURE 29. *Eophreatoicus kershawi* Nicholls, 1926. Male, AM P.72631: A–C, pleotelson, lateral and dorsal; D–E, terminal apex, ventral and posterior. F, uropod protopod distal margin setae. Scale 1 mm.

Pereopods V–VII. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 4–6 setae (M2 pereopod V, pereopod VII). Propodus distal margins with 4 elongate robust or robust-based setae (M2 pereopod V). Accessory claw length 0.34 primary claw length (M2 pereopod V). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with no setae, dorsal margin with 6 setae (M2 pereopod VII).

Penes. Length 0.28 body width at pereonite 7, extending to midline; cuticle smooth (Nicholls (1926) stated "bearing a few setae on its anterior (more convex) border and with evident serrated margin" but fine denticles would not be obvious in light microscope); distal tip truncate.

Pleopods. Length:body length male pleopod I 0.13, II 0.14, III 0.15. Exopod length:width male pleopod I 2.20, II 2.00, III 1.40. Exopod length of distal article:exopod length male pleopod II 0.22, III 0.30. Endopod length:width male pleopod I 2.00, II 2.30, III 1.90. Endopod length:exopod length male pleopod I 1.00, II 0.81, III 1.10. Exopods I with lateral proximal lobe, with medial proximal lobes of pleopod I. Protopods medial margins II–V with large projections, of male medial margins with minutely serrate setae, of male medial margins pleopod I, II, III–V with 7, 8, 9–11 setae respectively, of female medial margins with simple setae only, of female medial margins multiple on I–V; protopod II lateral epipod lobe-like, epipod III length 2.22 width, epipod V length 2.27 width, in male pleopod II lateral epipod with 16 minutely serrate or simple setae, pleopod V with ~31 minutely serrate or simple setae.

Pleopod I exopod of male broadest proximally, distal margin rounded, medial margin convex, divergent from lateral margin proximally, dorsal surface lacking setae; protopod of male significantly wider than long. Pleopod II endopod of male appendix masculina length 0.51 pleopod length, basal musculature pronounced, distal length 1.80 endopod proximal margin length; distally with 11 setae; 48 setae altogether (M2).

Uropod. Of male total length 1.20 pleotelson length; protopod of male length:width 2.35, length 0.41 uropod total length. Uropod of female total length 1.20 pleotelson length, protopod length 0.39 uropod total length. Protopod dorsomedial ridge length:endopod length 0.70 male, 0.62 female. Protopod of male dorsolateral margin shorter than dorsomedial margin setae; of female dorsolateral margin subequal to dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, without spinose setae, 3 robust simple setae. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 9–10 altogether (approximately, some small additional setae also present); female dorsal margin with 6–16 robust setae (variable on either side, 6–7 large, 3–10 small). Exopod length:endopod length 0.90 male, 0.89 female. Exopod length:protopod length 1.00 male, 0.91 female. Exopod of male dorsal margin with 8 robust setae, female 6 robust setae.

Distribution. Australia, Northern Territory, North Eastern Arnhem Land: Sandstone Bluff near King River Estuary and Wellington Hills (Nicholls 1926). New collections: Arnhem Land, Sandstone Outlier north and west of King River Estuary.

Habitat. Pool in rock hole, possibly spring fed from cave, "a fine rock-hole of clear, cool water" (M'Lennan in White 1917: 138); new collection taken from pool inside cave in crevice of sandstone cliff (Fig. 1), on and under gravel and small stones in shallow pools.

Remarks. Topotypes of *Eophreatoicus kershawi* Nicholls, 1926 were collected during a November 2004 trip that found the approximate type locality to provide material for molecular characterization of this species. Specimens were found in a narrow cave at the base of a sandstone outlier in a pool of water (Fig. 1C), similar to Nicholls' (1926) report on the account of the collector M'Lennan (White 1917). The new material was found to be the same as this species, so we assign the molecular data collected to *E. kershawi*.

Eophreatoicus kershawi can be recognized by having weakly rugose and maculate cuticle with pleotelson cuticular ridges that cross the dorsal midline. The pleotelson is among the shortest in the genus, with a lateral length that is less than 68% of the depth. Phylogenetic analysis places *E. kershawi* basal to a clade of species from Arnhem Land (Fig. 12) that includes the *E. kudjamarndi* sp. nov., *E. gudjangah* sp. nov., *E. bodmemurrngkudji* sp. nov., and *E. kurdabeyhmay* sp. nov. In some analyses, *E. kershawi* was sister to *E. gubara* sp. nov., although the affinities of this latter species are uncertain owing to its high instability index. *Eophreatoicus kershawi* also has large eyes, whereas the other species have only small to medium eyes. *Eophreatoicus kershawi* has a submarginal robust seta on pleotelson posterolateral plates, i.e., two robust setae are in the dorsal position. Of the Arnhem Land species, this feature is shared only with *E. kudjamarndi* sp. nov. as well as several other species in Kakadu National Park, but not *E. gubara*. *Eophreatoicus kudjamarndi* sp. nov. has five major setae on the pereopod II epaulet, whereas *E. kershawi* has only four. *Eophreatoicus kudjamarndi* sp. nov has a longer pleotelson relative to the depth in lateral view and the uropodal protopod dorsal plate is distinctly projecting, while *E. kershawi* has a much lower plate.

Eophreatoicus mok **sp. nov.**

(Figs 6B, 7F, 30–36)

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Type material. Holotype male (coll. 15.xii.2008), bl 15.5 mm, AM P.86059. Paratypes collected with holotype (coll. 15.xii.2008): male, bl 16.6 mm, AM P.81110, carcass and SEM stubs, DNA GW094 Genbank 18S MK961118

COI (2 independently obtained sequences) MK967228 and MK967229 16S MK961106; male, AM P.86065, bl 17.7 mm, DNA GW103 COI MK967230 16S MK961105; 6 male paratypes, AM P.86064. Additional Paratypes (coll. 1.v.2009): 6 ind., AM P.97196.



FIGURE 30. *Eophreatoicus mok* sp. nov. A, Holotype male, AM P.86059. B–C, paratype male, AM P.81110: B, lateral; C, pereopods II–III basis showing epaulet. Scales 5 mm.

Remarks on the Type material. No females were collected. The precision of the locality data has been downgraded at the request of the traditional owners, the Kabulwarnamyo Community.

Type locality. Australia, Northern Territory, East Arnhem Land, "Cold Cave", south of Kabulwarnamyo Creek, Liverpool River catchment, southwest of Kabulwarnamyo Community, 12°46'S, 133°50'E, coll. Peter Cooke, Emilie-Jane Ens & Dean Yibarbuk, 15.xii.2008, 1.v.2009.

Etymology. The Kabulwarnamyo Community requested that the name of the landowning clan, "Mok", be used (language group Kundedjnjenghmi).



FIGURE 31. *Eophreatoicus mok* sp. nov. Paratype male, AM P.81110, head limbs. A, antennula with enlargements of basal and distal ends. B, antenna with enlargement of flagellar articles, showing scaly surface. C, labrum. D, paragnaths. E, maxillula with enlargement of distal setae. F, maxilla. G, maxilliped. Scales 1 mm.

Diagnosis. *Head.* Eyes bulging dorsolaterally, height medium, in lateral view subequal to width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region without obvious setae. *Pereon.* Dorsal cuticular surface with scattered small scales or roughness; pereonites 1–4 transverse dorsal ridges not expressed; pereonites 5–7 transverse dorsal ridges low without transverse trough (pereonite 7 only). *Pleonites.* 1–4 transverse dorsal ridges low without transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection linear. Dorsal surface rugose (cuticular surface also scaly in SEM), with elongate ridge-like tubercles, lacking posteromedial ridges or median groups of

tubercles. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae and one median robust seta, with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth. *Pereopod II.* Basis of male dorsal ridge epaulet length subequal to quarter basis length, main setal row with 5 major setae. *Pereopod IV.* Sexually dimorphic. Propodus of male ventral margin without projection, with 4 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly beyond pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 robust setae distinctly larger than others, separated by shorter seta.

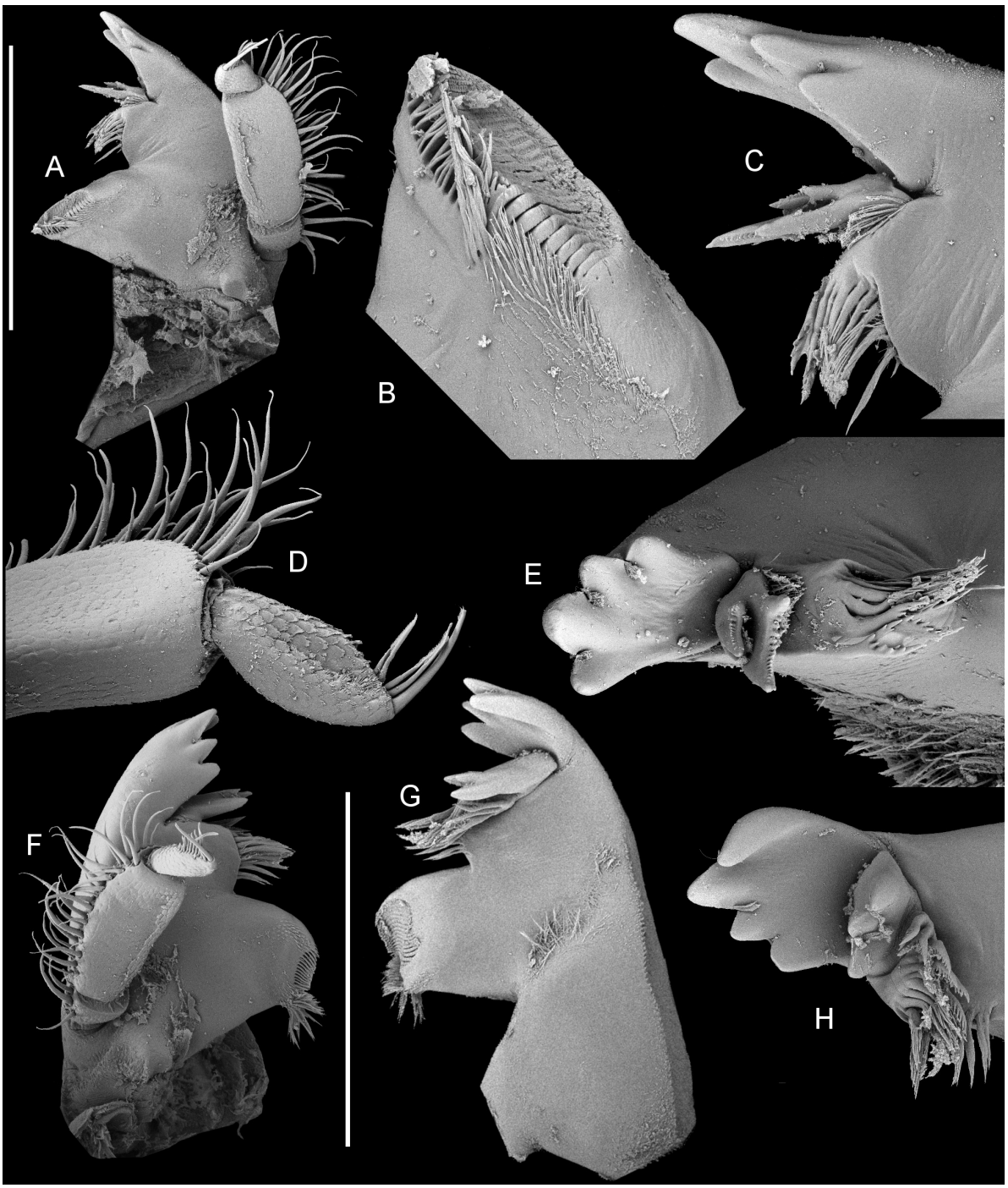

FIGURE 32. *Eophreatoicus mok* sp. nov. Paratype male, AM P.81110, mandibles. A–E, right mandible: A, dorsal; B, molar process; C, E, distal tip, dorsal and medial; D, palp distal articles, anterior; F–G, left mandible: F, dorsal; G, ventral; H, distal tip, medial. Scales 1 mm.

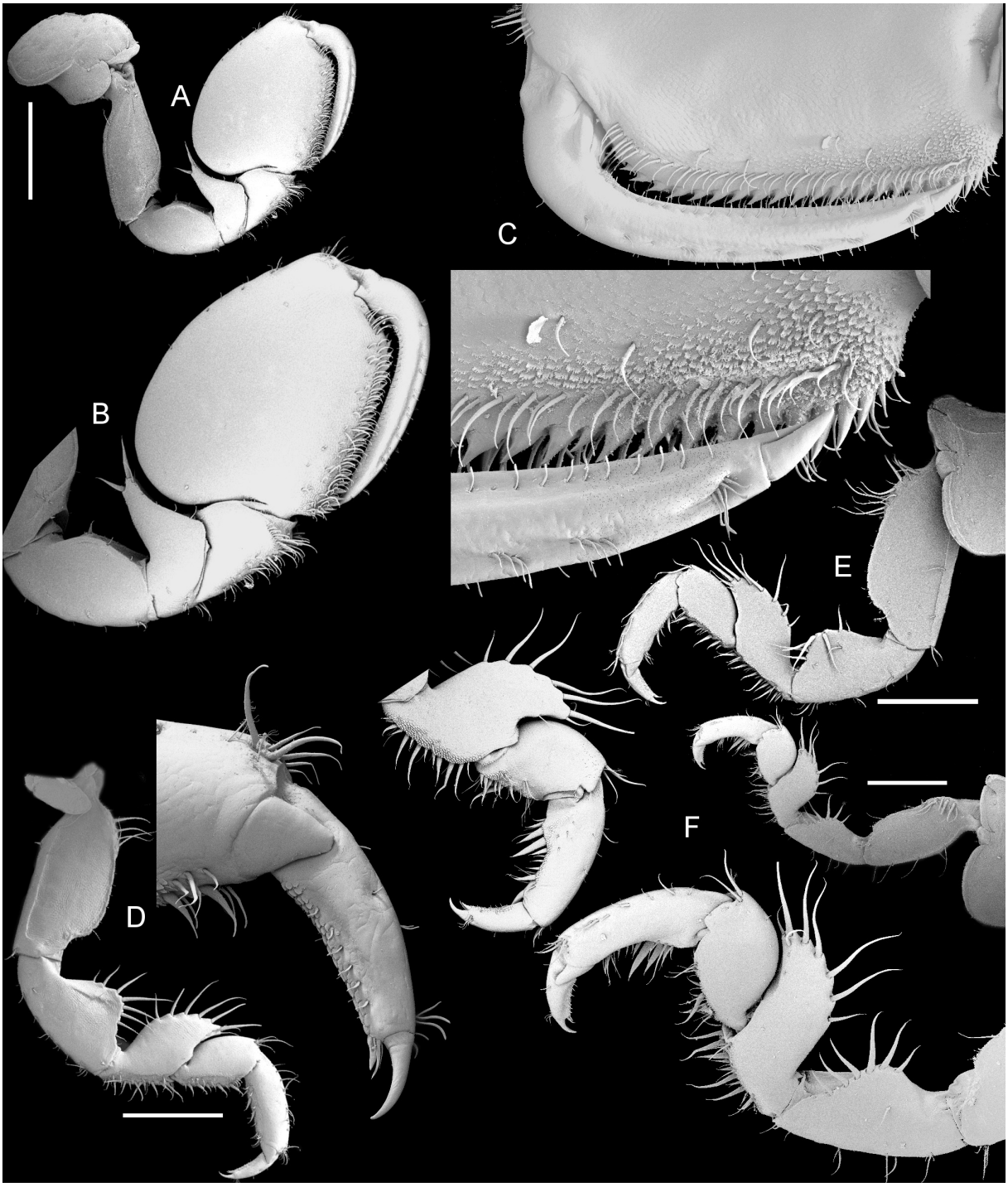

FIGURE 33. *Eophreatoicus mok* sp. nov. Paratype male, AM P.81110, anterior pereopods. A–C, pereopod I: A, lateral; B, distal segments; C, propodal palm and dactylus, medial with enlargement of palm and dactylar setae. D, pereopod II with enlargement of articular plate and dactylus. E, pereopod III. F, pereopod IV with enlargement of distal articles, lateral and medial. Scales 1 mm.

Description. Body pigmentation dorsal surface with dark brown dense chromatophores; head, lateral sides and limbs with diffuse dendritic chromatophores; length of largest male 17.7 mm, length of largest male greater than body length of largest female (assumed).

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Dorsal surface pitted; setae tiny and sparse. Eyes dorsal margin convex, ventral margin straight, orientation of longest axis vertical, maximum diameter 0.25 head depth, ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view sigmoidal. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region without obvious setae.

Pereon. Width near head width. Setae on dorsal surface not visible. Coxal articulation to pereonites 2–4 fused.

Pleonites. Pleonites 2–4 in dorsal view respective lengths equal to or more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.40 pleonite 1, 1.90 pleonite 2, 2.30 pleonite 3, 2.30 pleonite 4, 2.00 pleonite 5.

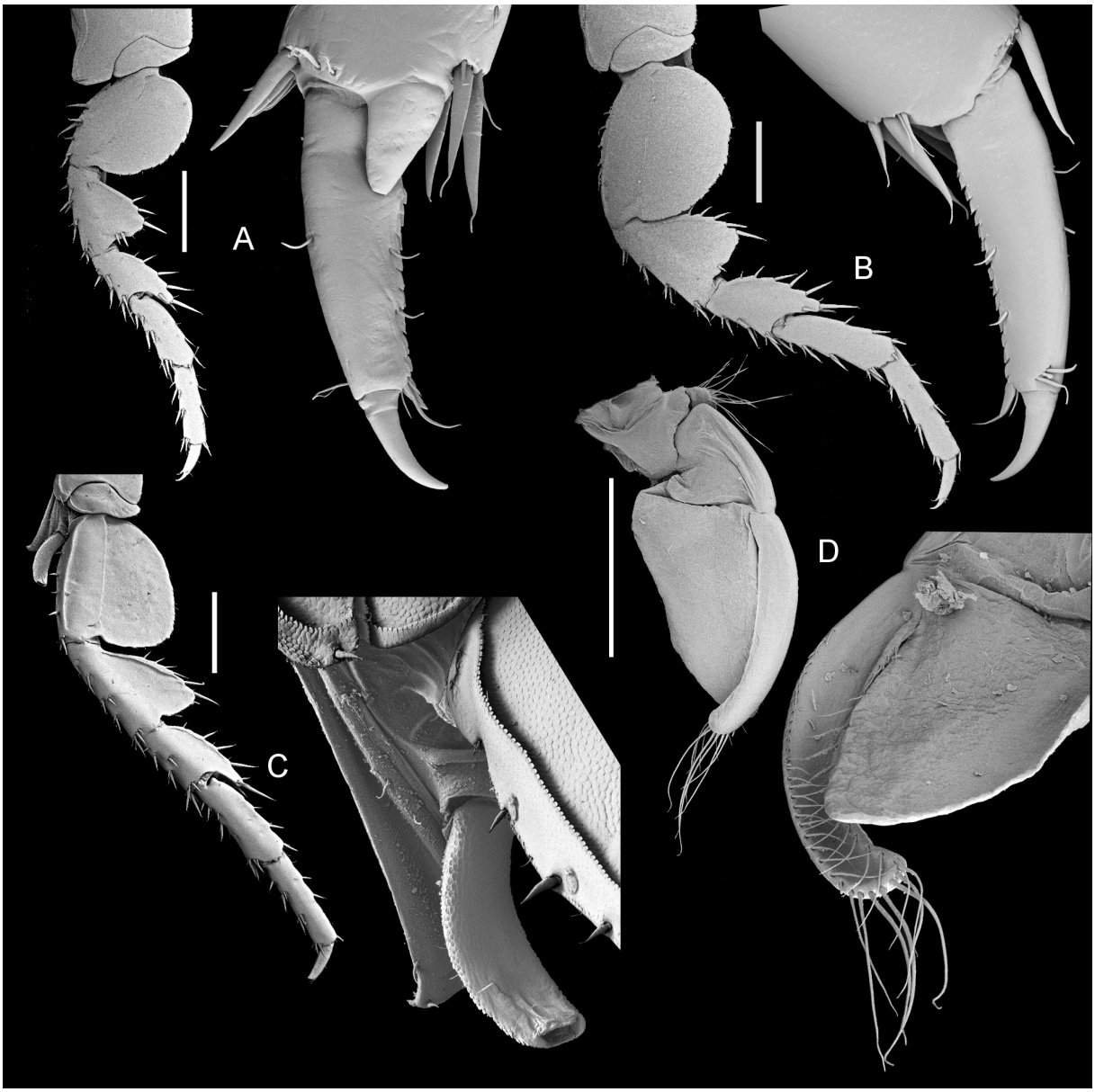

FIGURE 34. *Eophreatoicus mok* sp. nov. Paratype male, AM P.81110, posterior pereopods and pleopod II appendix masculina. A, pereopod V with enlargement of articular plate and dactylus. B, pereopod VI with enlargement of articular plate and dactylus. C, pereopod VII with enlargement of penes. D, pleopod II endopod in both ventral and dorsal. Scales 1 mm.

Pleotelson. Dorsal surface length 1.40 width in dorsal view. Dorsal surface sparsely covered with setae; lacking cuticular combs on tubercles. Depth 1.70 pereonite 7 depth. Lateral length less than depth, in male 0.77 depth. Lateral length 0.14 body length. Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 2.00 width of uropodal insertion, with single row of simple robust setae grading anteriorly to fine setae (distal denticulations tiny, visible only in SEM), including 4 robust setae altogether (+3 more anterior simple setae), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.62 pleotelson total length. Posterior apex length less than width, long. Posterior apex 0.17 pleotelson total length, width 0.47 pleotelson width. Posterior apex in lateral view forming an angle of 70–72° with immediately anterior dorsal surface, angled 140° from horizontal.

Antennula. Length 0.12 body length in male, with 16 articles in male. Article 5 length 1.30 width. Article 6

length 0.79 width. Aesthetascs on dorsal surface from article 5 distally in transverse rows of 3–5 per segment. Terminal article length 0.92 width, 0.20 antennula total length. Distal articles oval in cross-section.

Antenna. Length 0.42 body length in male. Flagellum length 0.58 total antenna length in male, with 25–28 articles in male, proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.



FIGURE 35. *Eophreatoicus mok* sp. nov. Paratype male, AM P.81110. A–E, pleopods I–V. Scales 1 mm.

Mouthfield. Clypeus consisting of broad bar concave laterally at mandibular fossae. Labrum ventrally somewhat angular in anterior view with groups of setules laterally and ventrally. Paragnaths with distolaterally rounded lobes, having medial and lateral setal rows with thickened medial base.

Mandible. Palp length 0.64 mandible length. Palp article 3 with 10 setae, coarsely spinulate and widely

separated setae on margin only, medial surface without additional setae, medial surface without setules, surface lacking cuticular hairs, without surface cuticular combs. Palp article 2 without distal group of setae. Palp article setae with 2 lateral rows of elongate setae. Left spine row with 12 spines, 6 of which bifurcate. Right spine row with 11 spines, 5 of which bifurcate. Left molar process triturating surface posterodorsal ridge projecting, complex setulate spines forming posterior row. Right molar process longer than wide, with row of complex spines adjacent to triturating ridges, dorsal surface with ciliated spine row, 6 members altogether.

Maxillula. Medial lobe length 0.86 lateral lobe length; width subequal to lateral lobe, width 0.97 lateral lobe width; with 7 pappose setae; with simple accessory setae, 2 altogether, one on distolateral margin and one between central pappose setae, without short weakly setulate seta on distal tip. Lateral lobe distal margin distal setal row with 4 robust setae, with 4 denticulate robust setae, with 6 smooth robust setae. Lateral lobe ventral face with 2 plumose setae, setae widely spaced, without additional plumose seta.

Maxilla. Medial lobe width 1.10 outer lateral lobe width; proximal portion distinctly angled to distal portion; setae in ventral basal rows with ventral dense elongate setules, setae in dorsal basal row with dense distally setulate curved setae, setae in distal row with dense ventral setules below stiff elongate setae. Outer lateral lobe length subequal to inner lateral lobe, width subequal to inner lateral lobe. Outer lateral lobe distal margin setal row with two angles, transverse to lateral margin and oblique on medial margin, both lateral lobes with bidenticulate setae on distal tips and on medial margin, with 16 long bidenticulate setae, inner lateral lobe with 13 long bidenticulate setae.

Maxilliped. Epipod distal tip rounded, length 1.20 width. Endite length 0.36 total basis length. Endite distal margin simple setae, in fringe, without fine cuticular combs, 34 subdistal biserrate setae on ventral surface. Endite dorsal ridge with 18 large distally denticulate plumose setae. Palp insertion on basis without lateral margin plumose setae, without medial margin plumose setae. Palp insertion on basis ventral surface without subdistal smooth setae, without ventral surface subdistal biserrate setae. Palp length 1.20 basis length; width across articles 2–3 0.42 endite width. Palp article 4 shape elongate-oblong, length 1.10 width. Palp article 5 length 2.10 width, 1.10 article 4 length.

Pereopod I. Length:body length 0.39 male. Basis of male length 2.70 width; absent; ventrodistal margin with 1 elongate seta, female ventrodistal margin lacking elongate setae. Ischium of male dorsal margin with 1 simple seta, setae robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (2 robust). Propodus length:pereopod length 0.23 male. Propodus length:width 1.10 male. Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 7 setae altogether (excluding distal group), proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae proximally on margin articulated, grading distally to articulation not expressed, 22 altogether. Dactylus of male shorter than palm, length:palm length 0.90. Dactylus claw length:dactylus length 0.12 male. Dactylus of male appearing as spine without basal articulation.

Pereopods II–III ratios. Pereopod II. Length:body length 0.39 male. Basis length:pereopod length 0.30 male; length:width 2.30 male. Carpus length:pereopod length 0.13 male; length:width 1.60 male. Propodus length: pereopod length 0.15 male; length:width 1.60 male. Dactylus length:propodus length 0.64 male; primary claw length:dactylar length 0.26 male. *Pereopod III.* Length:body length 0.39 male. Basis length:pereopod length 0.32 male; length:width 2.30 male. Carpus length:pereopod length 0.13 male; length:width 1.60 male. Propodus length: pereopod length 0.16 male; length:width 3.10 male. Dactylus length:propodus length 0.53 male; primary claw length:dactylar length 0.30 male. *Pereopods II–III.* Penicillate setae on propodus distodorsal margin; basis dorsal ridge with around 7 fine setae along thickened ridge. Ischium II–IV of male dorsal margin with 8 simple setae, none robust. Carpus II of male with 8 robust based setae, largest length 0.3 carpus length, large alternating with small, occurring evenly along margin, III of male with 6 robust based setae, III of male occurring evenly along margin, III of male largest length 0.3 carpus length, large alternating with small. Propodus of male robust-based setae respectively with 6, 6 altogether, II of male 3 larger proximally, length 0.18 propodus length, large alternating with small, II of male occurring evenly along margin, III of male 2 largest at positions 2 & 3, length 0.18 propodus length, large alternating with small, III of male occurring evenly along margin. Dactylus length 0.34 primary claw length, with scales on ventral margin.

Pereopod II. Basis lateral face with 2 long simple setae proximally and 1 seta distally in male. Basis of male

dorsal ridge epaulet with 2 rows of setae, main setal row with 2 minor setae, submarginal setal row with 3 setae, without major setae distal to epaulet.

Pereopod IV. Penicillate setae in both sexes, of male occurring on anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 1 seta, of male dorsal ridge setae positioned distally. Ischium of male dorsal margin with 6 setae. Carpus of male ventral margin with single setal row, with robust-based setae in addition to simple, with 7 robust-based setae, 3 distinctly larger than others. Propodus of male distal width 0.84 maximum width, setae on ventral margin robust-based, 2 distinctly larger than remainder, longer than dactylar claw. Propodus of female posterior side of limb articular plate longer than dactylar claw. Dactylus of male distal accessory claw approximately 0.25 primary claw length. *Pereopod IV ratios*. Length:body length 0.31 male. Basis length: width 3.00 male. Carpus length:pereopod length 0.14 male. Propodus length:pereopod length 0.17 male. Propodus length:width 2.60 male.

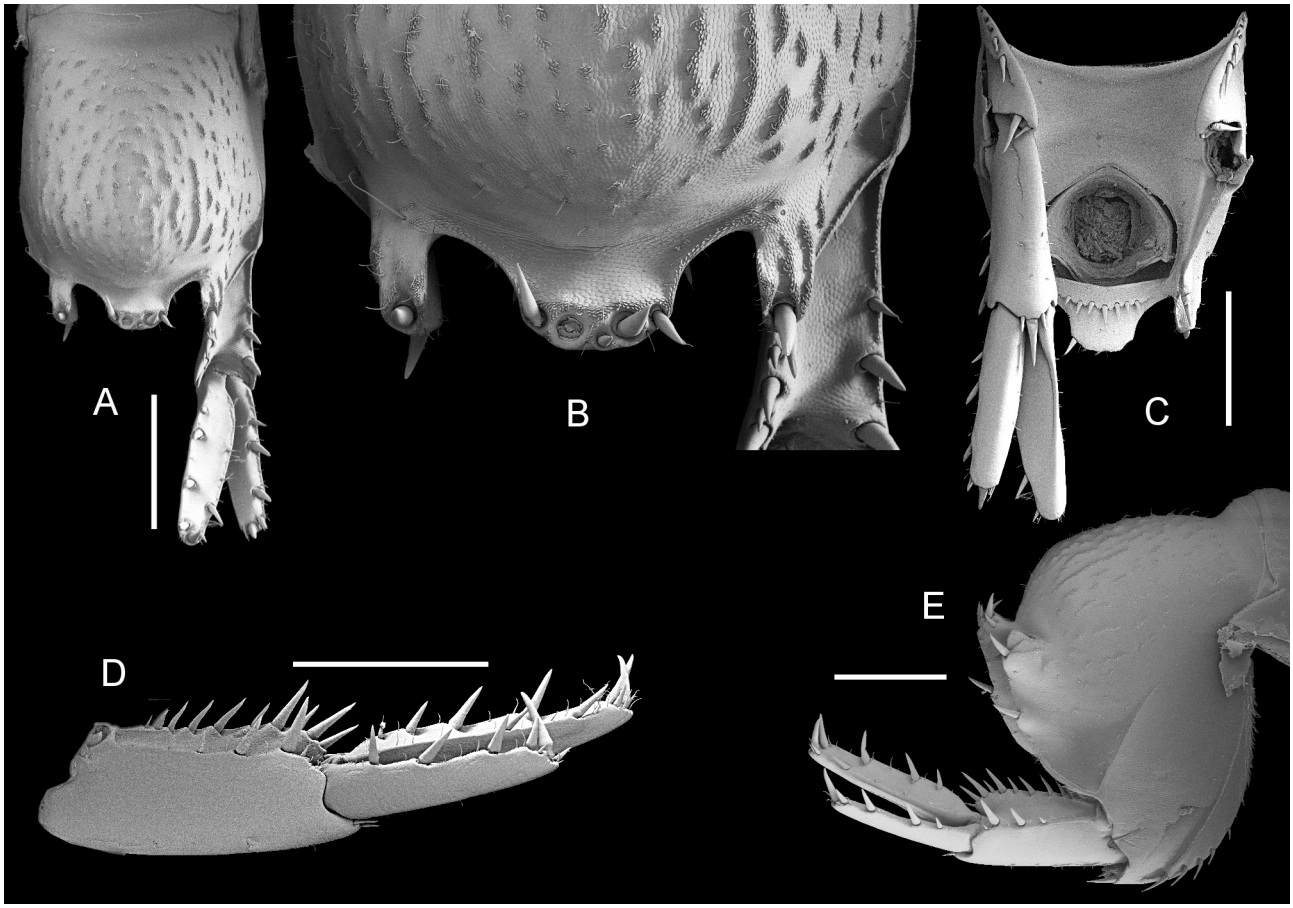

FIGURE 36. *Eophreatoicus mok* sp. nov. Paratype male, AM P.81110, pleotelson and uropods. A–C, E, pleotelson, dorsal, terminal apex, ventral and lateral. D, uropod, lateral. Scales 1 mm.

Pereopods V–VII ratios. *Pereopod V.* Length:body length 0.35 male. Basis length:width 1.25 male. Carpus length:pereopod length 0.19 male. Propodus length:pereopod length 0.17 male. Dactylus claw length:dactylar length 0.31 male. *Pereopod VI.* Length:body length 0.48 male. Basis length:width 1.24 male. Carpus length:pereopod length 0.18 male. Propodus length:pereopod length 0.18 male. Dactylus claw length:dactylar length 0.30 male. *Pereopod VII.* Length:body length 0.44 male. Basis length:width 1.09 male. Carpus length:pereopod length 0.20 male. Propodus length:pereopod length 0.17 male. Dactylus claw length:dactylar length 0.33 male (estimate).

Pereopods V–VII. V–VII penicillate setae not on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 3–6 setae. Propodus distal margins with 3–4 elongate robust or robust-based setae. Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with 1 seta, dorsal margin with 6 setae.

Penes. Extending near midline; shaft denticulate; distally tubular; distal tip truncate.

Pleopods. Exopod length:width male pleopod I 2.16, II 1.96, III 1.73, IV 1.60, V 1.72. Exopod length of distal article:exopod length male pleopod II 0.23, III 0.21, IV 0.25, V 0.27. Endopod length:width male pleopod I 2.44, II 1.60, III 1.93, IV 1.60, V 1.17. Endopod length:exopod length male pleopod I 2.44, II 0.77, III 0.76, IV 0.82, V 0.74. Endopod length:exopod length female pleopod I 0.90. Exopods I with lateral proximal lobe, with medial proximal lobes of pleopod I. Protopods medial margins II–V with large projections, of male medial margins with simple setae only, of male medial margins 11–16 elongate thin setae; protopod II lateral epipod lobe-like, epipod III length 1.80 width, epipod V length 1.40 width, in male with ~20–30 elongate thin setae on lateral and distal margins of epipods.

Pleopod I exopod of male broadest at midlength, medial margin convex, divergent from lateral margin proximally. Pleopod II endopod of male appendix masculina length 0.49 pleopod length, basal musculature pronounced, distal length 1.70 endopod proximal margin length; 50 setae altogether.

Uropod. Of male total length 1.06 pleotelson length; protopod of male length:width 2.20, length 0.47 uropod total length. Protopod dorsomedial ridge length:endopod length 0.69 male. Protopod of male dorsolateral margin subequal to dorsomedial margin setae; of female dorsolateral margin subequal to dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, without spinose setae, 3 robust simple setae. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 7 altogether. Exopod length:endopod length 0.83 male. Exopod length:protopod length 1.00 male. Exopod of male dorsal margin with 5 robust setae.

Distribution. Australia, Northern Territory, Arnhem Land, southwest of Kabulwarnamyo Community, in the Kabulwarnamyo Creek region, Liverpool River catchment.

Habitat. Shallow pool with tree roots in cave.

Remarks. Similar to the habitat of *Eophreatoicus kershawi*, *E. mok* sp. nov. occurs in narrow caves set into the sandstone plateau of Arnhem Land, in the Liverpool catchment in this case. The cuticle of *E. mok* sp. nov. is maculate and moderately rugose, especially on the pleotelson dorsal surface that has elongate ridge-like tubercles, unlike *E. kershawi* that has oblong tubercles. This species also differs from *E. kershawi*, which is similarly maculate, in having a distinctly smaller eye, the pereopod II epaulet having 5 major setae (vs. 4 major setae), and the uropodal protopod extending posteriorly beyond pleotelson apex (vs. subequal). *Eophreatoicus mok* sp. nov. is the sister taxon (Fig. 12) to *E. karrkkanj* sp. nov. from Cannon Hill and Hawk Dreaming sites in Kakadu National Park. This species differs from *E. karrkkanj* sp. nov. by being less turbiculate with only small scales on the pereon dorsal surface and in having elongate ridge-like tubercles on the pleotelson dorsal surface (oblong) and pleotelson postanal ventral ridge with nine robust setae (10–15 setae). Females were not in the type collection, so their characters are unknown.

Eophreatoicus kudjamarndi sp. nov.

(Figs 37–43)

Zoobank LSID. EA843B09-4110-4D9E-AC7F-A36441682BF8

Type material. Holotype male, bl 24.1 mm, AM P.98672. Paratypes collected with holotype: female, bl 10.4 mm, AM P.98673; male, bl 25.9 mm, AM P.98674, dissected for SEM (pin MI1712, stubs MI1701–MI1711), DNA GW106 Genbank COI MK961107 16S MK961108; female, bl. 13.2 mm, AM P.98675, dissected for SEM stubs MI1713–1715, DNA GW107 Genbank COI MK967233 16S MK961107; 11 males, AM P.103506; 13 specimens (4 females, 9 juveniles), AM P.103507; female, bl 10.9, AM P.103508, used for measurements; male, bl 25.2 mm, AM P.103509, used for pleopod measurements.

Type locality. Australia, West Arnhem Land, Myra Radiogenic Springs, ERISS site 3, Spring/seep, collected from riffle, rocky/sandy substrate, 12°26.8536'S, 133°22.0800'E, coll. J. Hanley, A. George and M. Ellis, 28.viii.2014.

Etymology. This species name derives from the nearby Myra Falls called "Kudjamarndi" (language group Kunwinjku) by the Kunwinjku clan. This is pronounced "goo-ja-marn-dee", where the syllable "marn" rhymes with North American pronunciation of "barn" (i.e., the "rn" sound is a retroflex nasal sound).

Diagnosis. *Head.* Eyes bulging dorsolaterally, height small, in lateral view less than width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending just above anterolateral margin of pereonite 1. Maxillipedal ridge with distinct dorsal edge, region without obvious setae. *Pereon.* Dorsal cuticular surface smooth (without

roughness or tubercles); pereonites 1–4 transverse dorsal ridges not expressed; pereonites 5–7 transverse dorsal ridges not expressed. *Pleonites.* 1–4 transverse dorsal ridges not expressed. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection convex. Dorsal surface rugose (cuticular surface also scaly in SEM), with elongate ridge-like tubercles, lacking posteromedial ridges or median groups of tubercles. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae and one median robust seta, with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with single row of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length less than quarter length of basis, main setal row with 5 major setae. Basis of female dorsal ridge epaulet length less than quarter length of basis, main setal row with 3 major setae. *Pereopod IV.* Propodus of male ventral margin without projection, with 6 robust setae on ventral margin. Dactylus of male length subequal to propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate subequal to shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 robust setae distinctly larger than others, separated by shorter seta.

Description. Body pigmentation dorsum with broad dark brown mottled stripe, head and sides pale greenish or yellow, chromatophores brown dendritic and contracted body appearing spotted or expanded body appearing brownish; length of largest male 25.9 mm, length of largest preparatory female 13.2 mm.

Head. Length subequal to width in dorsal view; lateral profile of dorsal surface smoothly curved. Width 0.88 pereonite 1 width. Dorsal surface pitted; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin straight, orientation of longest axis between horizontal and vertical, maximum diameter 0.22 head depth, ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view sigmoidal. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region without obvious setae.

Pereon. Width near head width. Setae on dorsal surface not visible. Pereonite 1 length:width ratio in dorsal view 4.00 in male. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–3 in dorsal view respective lengths less than 0.5 pleonite 5 length, pleonite 4 length more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.20 pleonite 1, 1.50 pleonite 2, 1.70 pleonite 3, 1.70 pleonite 4, 1.50 pleonite 5.

Pleotelson. Dorsal surface length 1.60 width in dorsal view. Dorsal surface sparsely covered with setae; lacking cuticular combs on tubercles. Depth 0.83 pereonite 7 depth. Lateral length less than depth, in male 0.88–0.90 depth (M2, H), in female 0.84 depth. Lateral length 0.15 body length. Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.20 width of uropodal insertion, with single row of simple robust setae grading anteriorly to fine setae (distal denticulations tiny, visible only in SEM), including 5–6 robust setae altogether, posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.19 pleotelson total length, dorsal setal position marginal seta larger than submarginal seta. Posterior apex length less than width, short. Posterior apex 0.14 pleotelson total length, width 0.40 pleotelson width. Posterior apex in lateral view forming an angle of 90° with immediately anterior dorsal surface, angled 134° from horizontal.

Antennula. Length 0.12 body length in male, 0.12 body length in female, with 18 articles in male, with 13–14 articles in female. Article 5 length 0.88–1.10 width (F, M). Article 6 length 1.00–1.04 width (F, M). Aesthetascs occurring ventromedially on distal margin in groups of ~5. Terminal article length subequal to penultimate article length, length 1.95 width, length 0.05 antennula total length. Distal articles oval in cross-section.

Antenna. Length 0.49–0.54 body length in male, 0.50 body length in female. Flagellum length 0.70 total antenna length in male, 0.59 total antenna length in female, with 40 articles in male, with 25–29 articles in female, proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Mouthfield. Clypeus width 0.57–0.59 head width. Labrum dorsal margin narrower than clypeus. Paragnaths with distolateral lobes projecting laterally from narrower proximal margin, group of elongate fine seta laterally and dense distomedial group of setae.

Mandible. Palp length 0.73 mandible length. Palp article 3 with 17 setae, setae on margin finely setulate, medial surface without additional setae, medial surface covered in cuticular combs, surface covered with cuticular hairs, with surface cuticular combs. Palp article 2 without distal group of setae. Palp article setae dense double row of ~

32 robust and simple setae. Left spine row with 14 spines, 6 of which bifurcate. Right spine row with 10 spines, 5 of which bifurcate. Left molar process triturating surface posterodorsal ridge projecting. Right molar process length subequal to width, without row of complex spines adjacent to triturating ridges, dorsal surface without ciliated spine row.

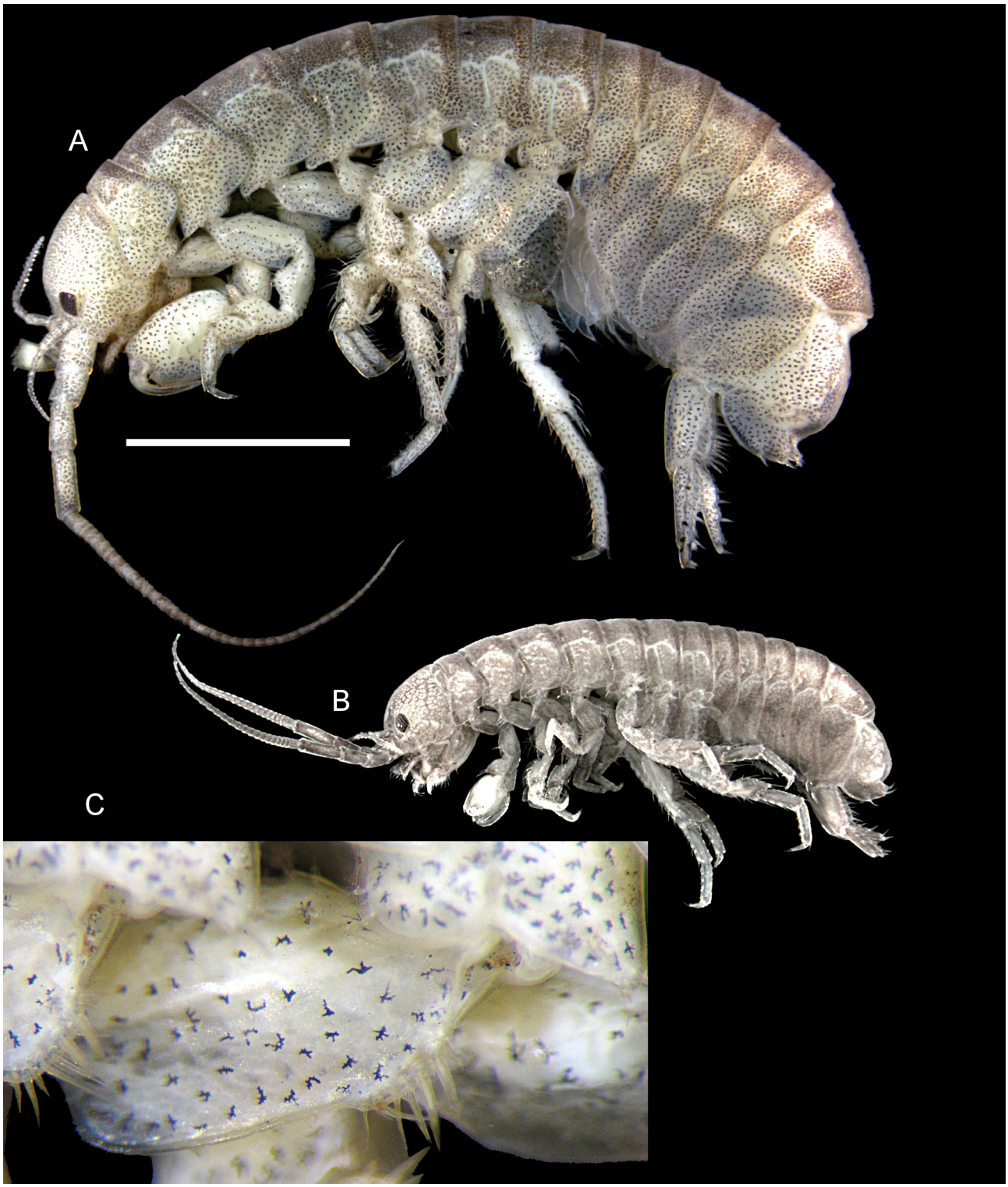

FIGURE 37. *Eophreatoicus kudjamarndi* sp. nov., habitus. A, Holotype male, AM P.98672, color morph with contracted chromatophores. B. paratype female, AM P.76385, color morph expanded chromatophores. C, pereopods II–III basis showing epaulet on proximal margin. A, B scale 5 mm.

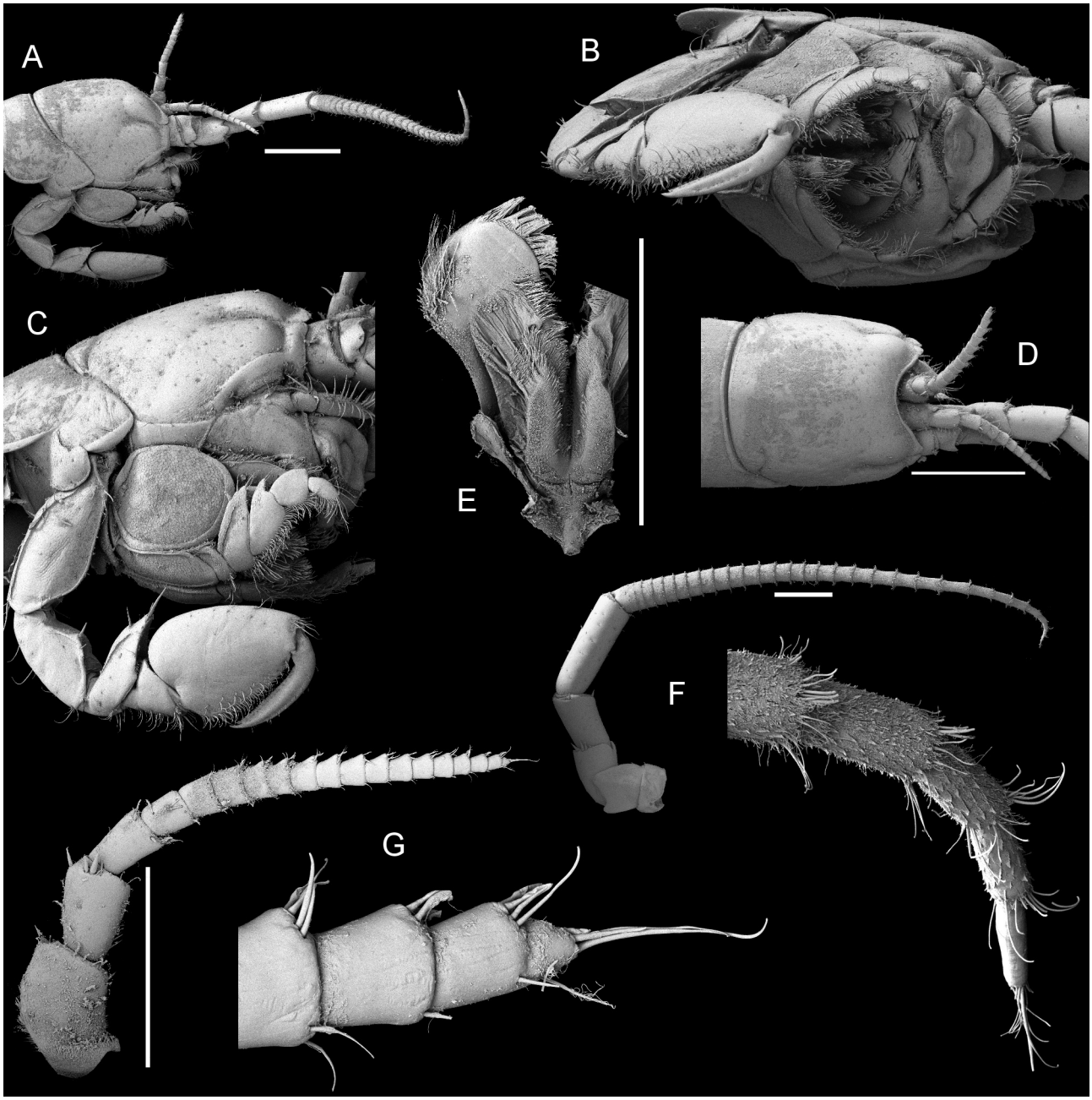

FIGURE 38. *Eophreatoicus kudjamarndi* sp. nov., anterior limbs. Paratype female, AM P.98675, head and pereonite 1: A, lateral; B, ventral, C, ventral oblique, showing pereopod I and mouthparts, D, dorsal. Paratype male, AM P.98674: E, paragnaths, ventral; F, antenna with enlargement of distal tip; G, antennula with enlargement of distal tip. Scales 1 mm.

Maxillula. Medial lobe length 0.89 lateral lobe length; width less than lateral lobe, width 0.77 lateral lobe width; with 6 pappose setae; with distally denticulate accessory setae, 2 altogether, one between central pappose setae and one between distomedial pappose setae, without short weakly setulate seta on distal tip. Lateral lobe distal margin distal setal row with 4 robust setae, with 4 denticulate robust setae, with 9 smooth robust setae. Lateral lobe ventral face with 3 plumose setae, setae closely spaced, additional plumose seta among proximal distal robust setae.

Maxilla. Medial lobe width 0.88 outer lateral lobe width; proximal portion distinctly angled to distal portion; setae in ventral basal rows elongate and simple extending to distal row, setae in dorsal basal row dense and setulose, setae in distal row continuation of basal rows. Outer lateral lobe length subequal to inner lateral lobe, wider than inner lateral lobe. Outer lateral lobe distal margin setal row with two angles, transverse to lateral margin and oblique on medial margin, both lateral lobes with bidenticulate setae on distal tips and on medial margin, with 16 long bidenticulate setae, inner lateral lobe with 14 long bidenticulate setae.

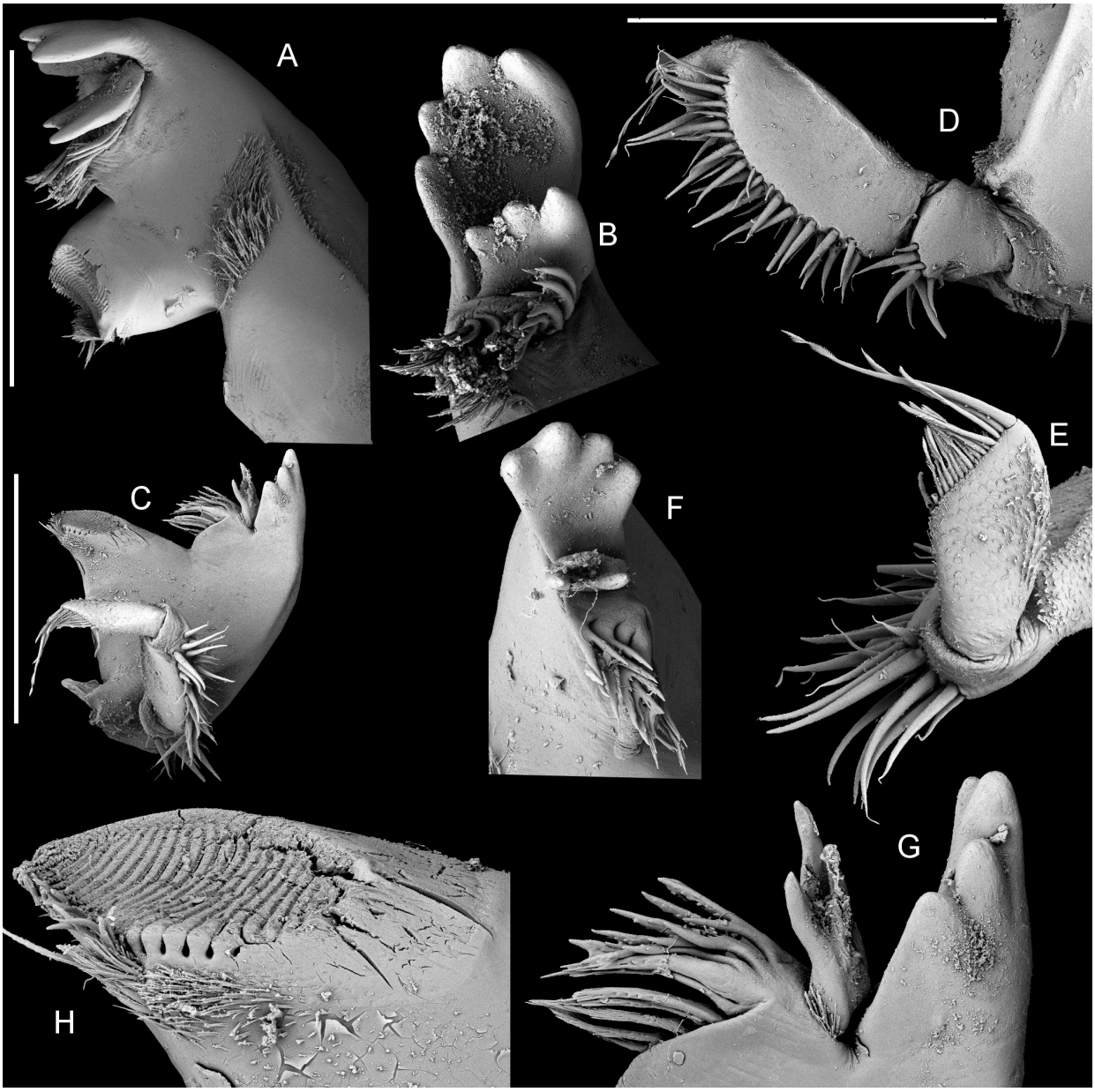

FIGURE 39. *Eophreatoicus kudjamarndi* sp. nov., mandibles. Paratype male, AM P.98674, mandibles. Left mandible: A, ventral; B, distal gnathal margin, medial. Right mandible: C, entire dorsal; D–E, palp, medial and dorsomedial; F–G, distal gnathal margin, medial and dorsal; H, molar process, dorsal. Scales, 1 mm.

Maxilliped. Epipod distal tip rounded, length 1.20 width. Endite length 0.48 total basis length, medial margin with 3 coupling hooks on right side. Endite distal margin simple setae, in fringe, 34 subdistal biserrate setae on ventral surface. Palp insertion on basis without lateral margin plumose setae, without medial margin plumose setae. Palp insertion on basis ventral surface without subdistal smooth setae, without ventral surface subdistal biserrate setae. Palp length 1.00 basis length; width across articles 2–3 1.80 endite width. Palp article 4 length 1.00 width. Palp article 5 length 0.99 width, 2.60 article 4 length.

Pereopod I. Length:body length 0.33 male, 0.31 female. Basis of male length 2.34 width, female length 2.17 width; dorsal setae positioned proximally, 1 dorsal seta altogether; female dorsal setae positioned along ridge, female 5 dorsal setae altogether; ventrodistal margin lacking elongate setae, female ventrodistal margin lacking elongate setae. Ischium of male dorsal margin with 2 simple setae, setae not robust. Ischium of female dorsal margin with 2 simple setae, setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (2 robust); female distodorsal margin with few elongate simple setae, female dorsal surface with

setae along dorsal axis (2 robust). Propodus length:pereopod length 0.26 male, 0.24 female. Propodus length:width 1.14 male, 1.49 female. Propodus of male dorsal margin setae confined to single group at distal margin, proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin convex, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae proximally on margin articulated, grading distally to articulation not expressed, 30 altogether. Propodal palm of female margin convex, with stout robust conical setae, 23 altogether (proximal setae elongate). Dactylus of male shorter than palm, length:palm length 1.10, female shorter than palm, female length:palm length 1.00. Dactylus claw length:dactylus length 0.07 male, 0.16 female. Dactylus of male sharp and around half length of dorsal claw. Dactylus of female sharp and around half length of dorsal claw.



FIGURE 40. *Eophreatoicus kudjamarndi* sp. nov., mouthparts. Paratype male, AM P.98674, mouthparts and pereopod I. A–B, maxillula, ventral and distomedial. C–D, maxilla, ventral and distomedial. E–F, maxilliped, ventral and distomedial. G–I, pereopod I: lateral; H–I, palm, medial and lateral. Scales, 1 mm.

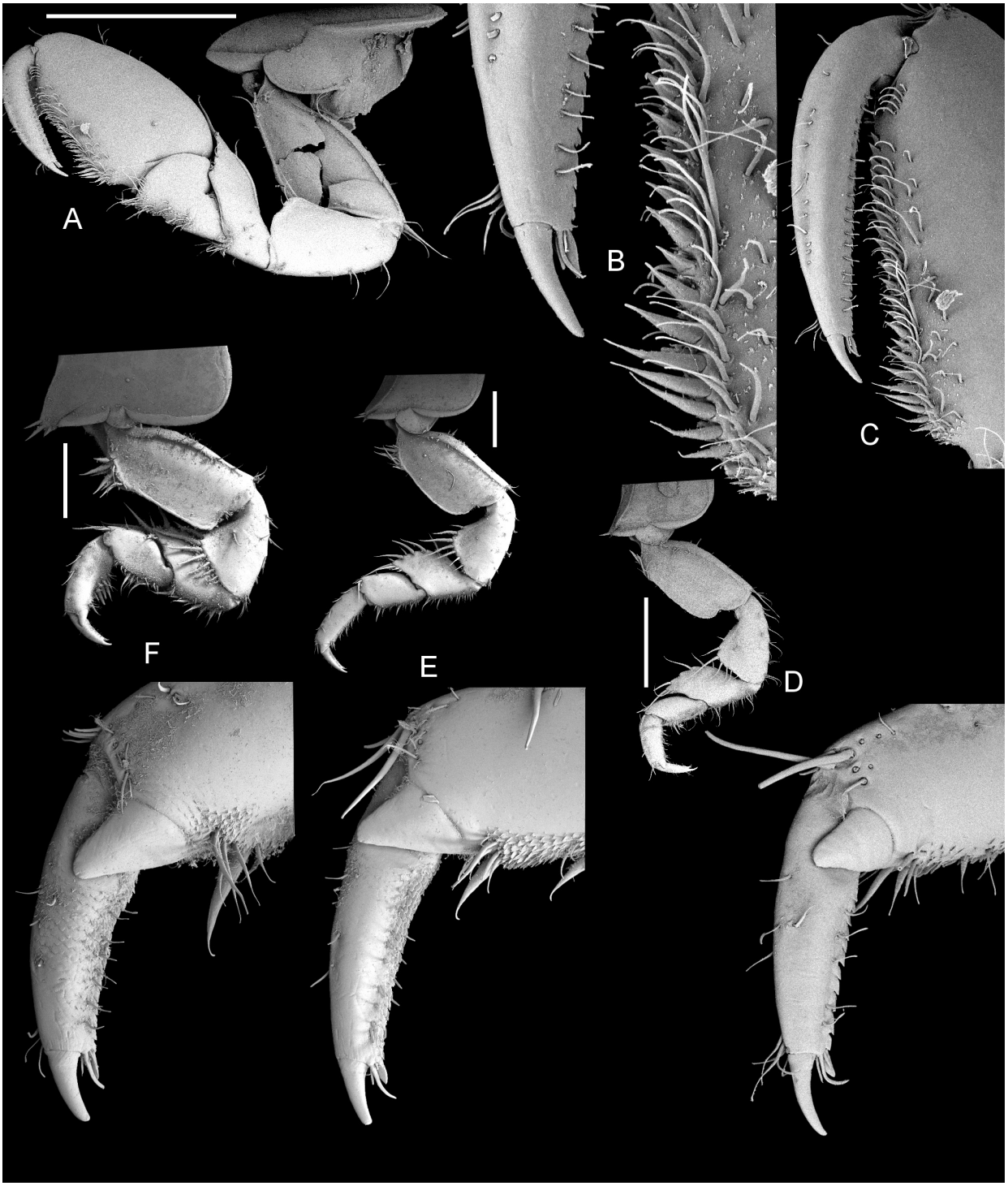

FIGURE 41. *Eophreatoicus kudjamarndi* sp. nov., anterior pereopods. Paratype female, AM P.98675: A–C, pereopod I lateral, enlargement of dactylus tip and palm, and entire palm region; D, pereopod II with enlargement of dactylus and articular plate. Paratype male, AM P.98674: E–F, pereopod II and IV, with enlargements of dactylus and articular plate. Scales 1 mm.

Pereopods II–III ratios. Pereopod II. Length:body length 0.29 male, 0.31 female. Basis length:pereopod length 0.31 male, 0.31 female; length:width 2.14 male, 2.08 female. Carpus length:pereopod length 0.13 male, 0.13 female; length:width 1.59 male, 1.85 female. Propodus length:pereopod length 0.14 male, 0.14 female; length:width 2.23 male, 1.95 female. Dactylus length:propodus length 0.67 male, 0.45 female; primary claw length:dactylar length 0.20 male, 0.33 female. *Pereopod III.* Length:body length 0.32 female. Basis 0.28 female; 2.33 female. Carpus length:pereopod length 0.11 female; 1.49 female. Propodus length:pereopod length 0.17 female; 3.40 female. Dactylus length:propodus length 0.53 female; 0.22 female. *Pereopods II–III.* Penicillate setae on distodorsal margin

of propodus; basis dorsal ridge with 6 tiny setae in indentations. Ischium II–IV of male dorsal margin with 6 simple setae, none robust. Carpus II of male with 6–7 robust based setae. Carpus II of female with 6 robust based setae, III of female with 4 robust based setae. Propodus of male robust-based setae respectively with 7–8, female respectively 4, female 5 altogether. Dactylus with scales on ventral margin.

Pereopod II. Basis lateral face with 3 tiny setae proximally in male and 5 simple setae proximally in female. Basis of male dorsal ridge epaulet without submarginal setal row, main setal row with 7 minor setae, without major setae distal to epaulet. Basis of female dorsal ridge epaulet without setal row below dorsal margin, main setal row with 5 minor setae, without major setae distally.

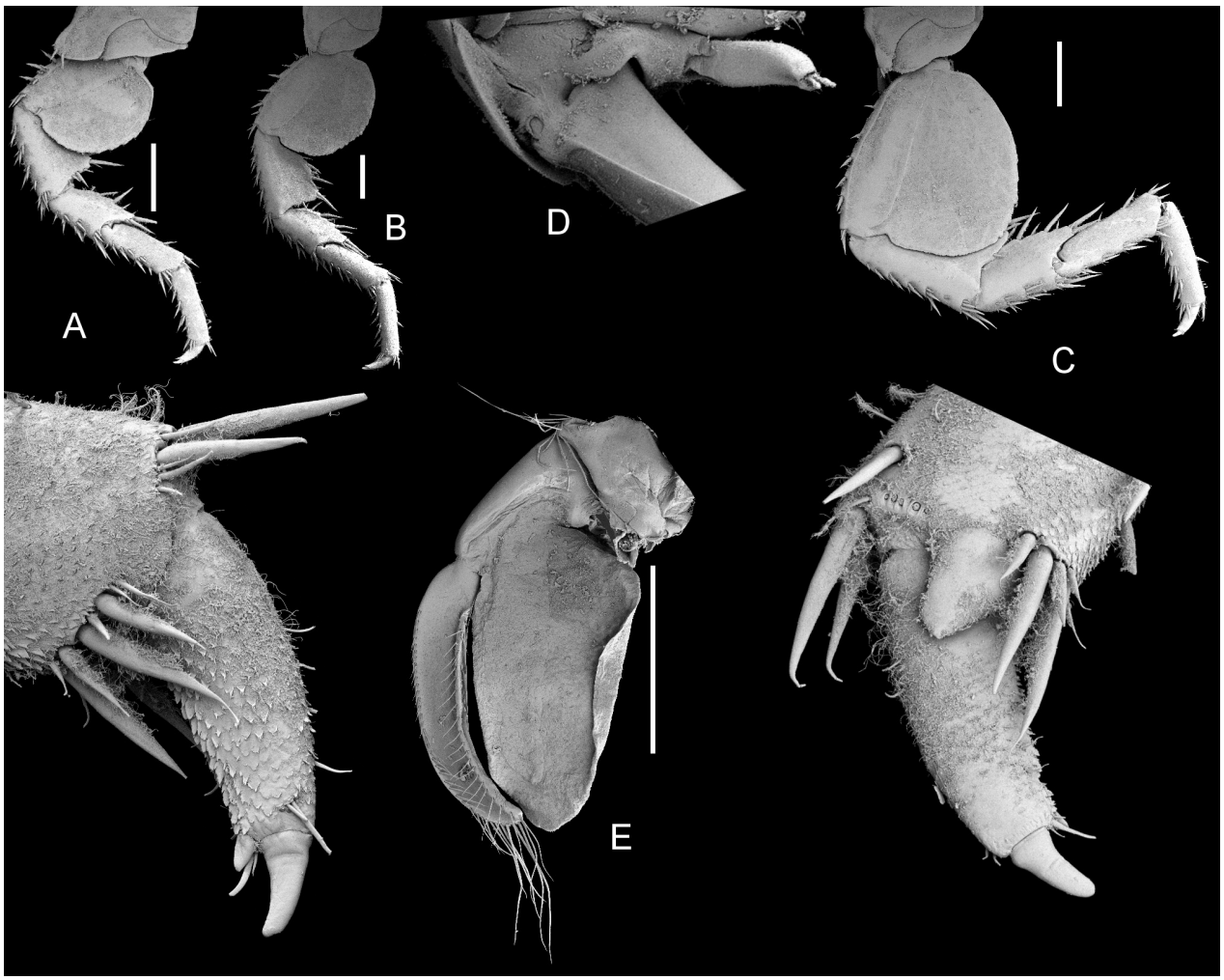

FIGURE 42. *Eophreatoicus kudjamarndi* sp. nov., posterior pereopods and appendix masculina. Paratype male, AM P.98674. A, pereopod V, lateral, with enlargement of dactylus. B, pereopod VI, lateral. C, pereopod VII, lateral, with enlargement of dactylus and articular plate, medial. D, penes on coxa of pereopod VII, two sperm protruding from distal orifice. E, pleopod II, endopod and appendix masculina. Scales 1 mm.

Pereopod IV. Penicillate setae in both sexes, of male occurring on anterodorsal margin of propodus, of female occurring on anterodorsal margins of propodus. Basis dorsal ridge of male without setae, of female dorsal ridge with 5 setae, of female dorsal ridge setae positioned along ridge. Ischium of male dorsal margin with 8 setae, female dorsal margin with 6 setae. Carpus of male ventral margin with robust-based setae in addition to simple, with 8 robust-based setae, 4 distinctly larger than others. Carpus of female ventral margin with robust-based setae, with 3 robust-based setae. Propodus of male distal width 0.62 maximum width, setae on ventral margin robust-based, 4 distinctly larger than remainder, longer than dactylar claw. Propodus of female with 3 robust setal types on ventral margin, posterior side of limb articular plate subequal in length to dactylar claw. Dactylus of male distal accessory claw approximately 0.5 primary claw length, female distal accessory claw approximately 0.5 length of primary claw. *Pereopod IV ratios.* Length:body length 0.28 male, 0.30 female. Basis length:width 2.42 male, 2.58 female.

Carpus length:pereopod length 0.13 male, 0.13 female. Propodus length:pereopod length 0.15 male, 0.15 female. Propodus length:width 2.05 male, 2.80 female.

Pereopods V–VII ratios. *Pereopod V.* Length:body length 0.28 male, 0.26 female. Basis length:width 1.37 male, 1.22 female. Carpus length:pereopod length 0.17 male, 0.16 female. Propodus length:pereopod length 0.17 male, 0.17 female. Dactylus claw length:dactylar length 0.28 male, 0.20 female. *Pereopod VI.* Length:body length 0.40 male, 0.33 female. Basis length:width 1.25 male, 1.22 female. Carpus length:pereopod length 0.17 male, 0.17 female. Propodus length:pereopod length 0.17 male, 0.18 female. Dactylus claw length:dactylar length 0.19 male, 0.17 female. *Pereopod VII.* Length:body length 0.41 male, 0.38 female. Basis length:width 1.12 male, 1.07 female. Carpus length:pereopod length 0.18 male, 0.18 female. Propodus length:pereopod length 0.16 male, 0.16 female. Dactylus claw length:dactylar length 0.41 male, 0.29 female.

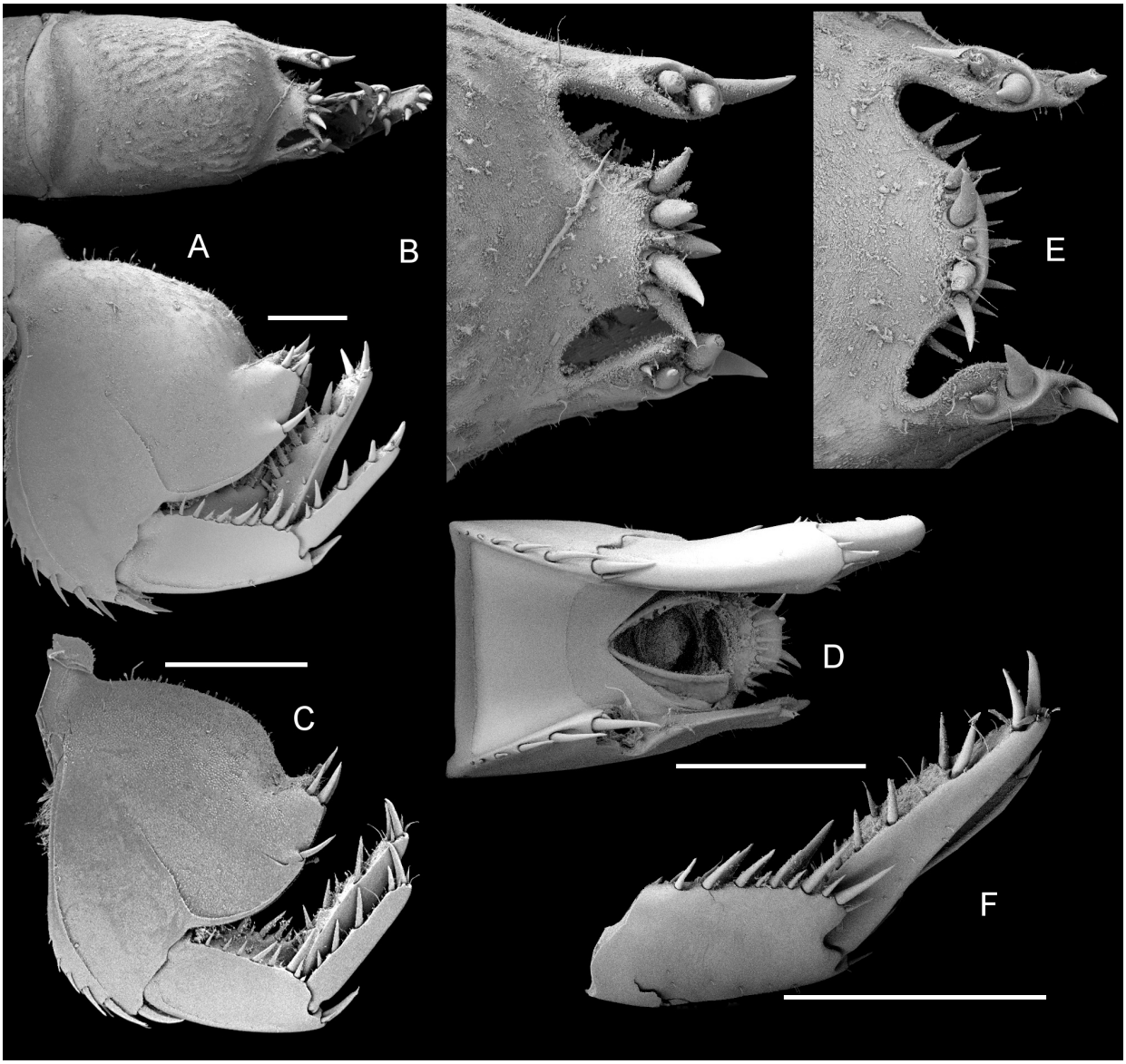

FIGURE 43. *Eophreatoicus kudjamarndi* sp. nov., pleotelson and uropods. A–B, Paratype male, AM P.98674, pleotelson dorsal and laterals, with enlargement of apex. Paratype female, AM P.98675: C–D, pleotelson, lateral and ventrals; E, apex, posterior; F, uropod, medial. Scales, 1 mm.

Pereopods V–VII. V–VII penicillate setae not on dorsal ridge of basis, penicillate setae not on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis (76°). V–VII ischium of male dorsal margin with 8–10 setae, including 3 robust setae. Propodus distal margins with 6 elongate robust or robust-based setae. Flattened stout triangular. Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, dorsal margin with 8 setae.

Penes. Extending near midline; distally tapering; distal tip truncate.

Pleopods. Length:body length male pleopod I 0.12, II 0.13, III 0.12, IV 0.12, V 0.10. Exopod length:width male pleopod I 2.40, II 2.01, III 1.56, IV 1.59, V 1.37. Exopod length of distal article:exopod length male pleopod II 0.25, III 0.25, IV 0.26, V 0.27. Endopod length:width male pleopod I 2.56, II 2.42, III 1.83, IV 1.65, V 1.62. Endopod length:exopod length male pleopod I 0.98, II 0.96, III 0.86, IV 0.81, V 0.82. Exopods without medial proximal lobes of pleopod I. Protopods medial margins II–V with large projections, of male medial margins with minutely serrate setae, of female medial margins with simple setae only; protopod II lateral epipod lobe-like, epipod III length 2.02 width.

Pleopod I exopod of male broadest proximally, distal margin rounded, medial margin straight, divergent from lateral margin proximally, dorsal surface lacking setae. Pleopod II endopod of male appendix masculina length 0.42 pleopod length, basal musculature pronounced, distal length 1.70 endopod proximal margin length; distally with 8 setae; 58 setae altogether.

Uropod. Of male total length 1.10 pleotelson length; protopod of male length:width 1.70, length 0.59 uropod total length. Uropod of female total length 1.10 pleotelson length. Protopod dorsomedial ridge length:endopod length 0.54 male. Protopod of male dorsolateral margin subequal to dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, without spinose setae, 3 robust simple setae. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 13 altogether. Exopod length:endopod length 0.79 male, 0.82 female. Exopod length:protopod length 0.85 male, 0.99 female. Exopod of male dorsal margin with 6 robust setae.

Distribution. Australia, Northern Territory, Arnhem Land, Myra Radiogenic Springs, which flows into Tin Camp Creek, East Alligator River catchment.

Habitat. Collected from riffle in spring or seep on rock and sand substrate.

Remarks. *Eophreatoicus kudjamarndi* sp. nov. was found in the same radiogenic spring group of Myra Springs as *E. bodmemurrngkudji* sp. nov. and appears to be phylogenetically closely related (Fig. 12). Nevertheless, *E. kudjamarndi* sp. nov. is easily distinguished by a speckled color on a light background, pereopod II epaulet with 3 major setae in the female, and the pleotelson posterolateral margin with two dorsal robust setae. Of the two species, *E. kudjamarndi* sp. nov. has longer and less robust limbs, longer setae and a small central robust seta between two pairs of robust setae on the pleotelson apex.

Eophreatoicus bodmemurrngkudji sp. nov.

(Figs 44–51)

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Type material. Holotype male, bl 29.7 mm, AM P.98676, dissected, SEM stubs MI1716 - MI1724, DNA GW108 Genbank COI MK967234 16S MK961109. Paratypes collected with holotype: female, AM P.98677, bl 17.4 mm, partially dissected, SEM stub MI1725, DNA GW109 Genbank COI MK967235 16S MK961110; paratype female, AM P.103504, bl 13.9 mm; 7 juveniles, AM P.103505, bl 8.7–5.0 mm.

Remarks on the Type material. The collection contained only a single adult male (the holotype) thus necessitating its dissection.

Type locality. Australia, West Arnhem Land, Myra Radiogenic Springs, ERISS site 7, small shallow stream flowing off escarpment, collected from riffle, substrate rocky/sandy, 12°30.0618’S, 133°21.3174’E., coll. J. Hanley, A. George and M. Ellis, 28.viii.2014.

Etymology. Because the Myra Falls name is already used, we use a morphological descriptor: pleotelson posterolateral margin dorsal setal position with one robust seta, or “bodmemurrngkudji”, which is an elision of “bodmemurrng-kudji” (language group Kunwinjku), meaning “spine one” or more precisely “back bone one”. This is pronounced “bot-mair-rr” (a tap of the tongue against the roof of the mouth) “koo-jee”. It might be pronounced by quickly saying “moodoong” followed by “kudji”.

Diagnosis. *Head.* Eyes bulging dorsolaterally, height medium, in lateral view subequal to width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region without obvious setae. *Pereon.* Dorsal cuticular surface smooth (without roughness

or tubercles); pereonites 1–4 transverse dorsal ridges not expressed; pereonites 5–7 transverse dorsal ridges low without transverse trough. *Pleonites.* 1–4 transverse dorsal ridges low without transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection concave. Dorsal surface rugose, with oblong tubercles, lacking posteromedial ridges or median groups of tubercles. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae, without fine setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length subequal to quarter basis length, main setal row with 3 major setae (H proximal seta missing). Basis of female dorsal ridge epaulet length subequal to quarter basis length, main setal row with 5–6 major setae. *Pereopod IV.* Propodus of male ventral margin without projection, with 4 robust setae on ventral margin. Dactylus of male length more than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge distinctly projecting dorsally with posterior margin exposed above shaft, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 robust setae distinctly larger than others, separated by shorter seta.



FIGURE 44. *Eophreatoicus bodmemurrngkudji* sp. nov., habitus. A, Holotype male, AM P.98676. B, paratype female, AM P.98677. Scale 10 mm.

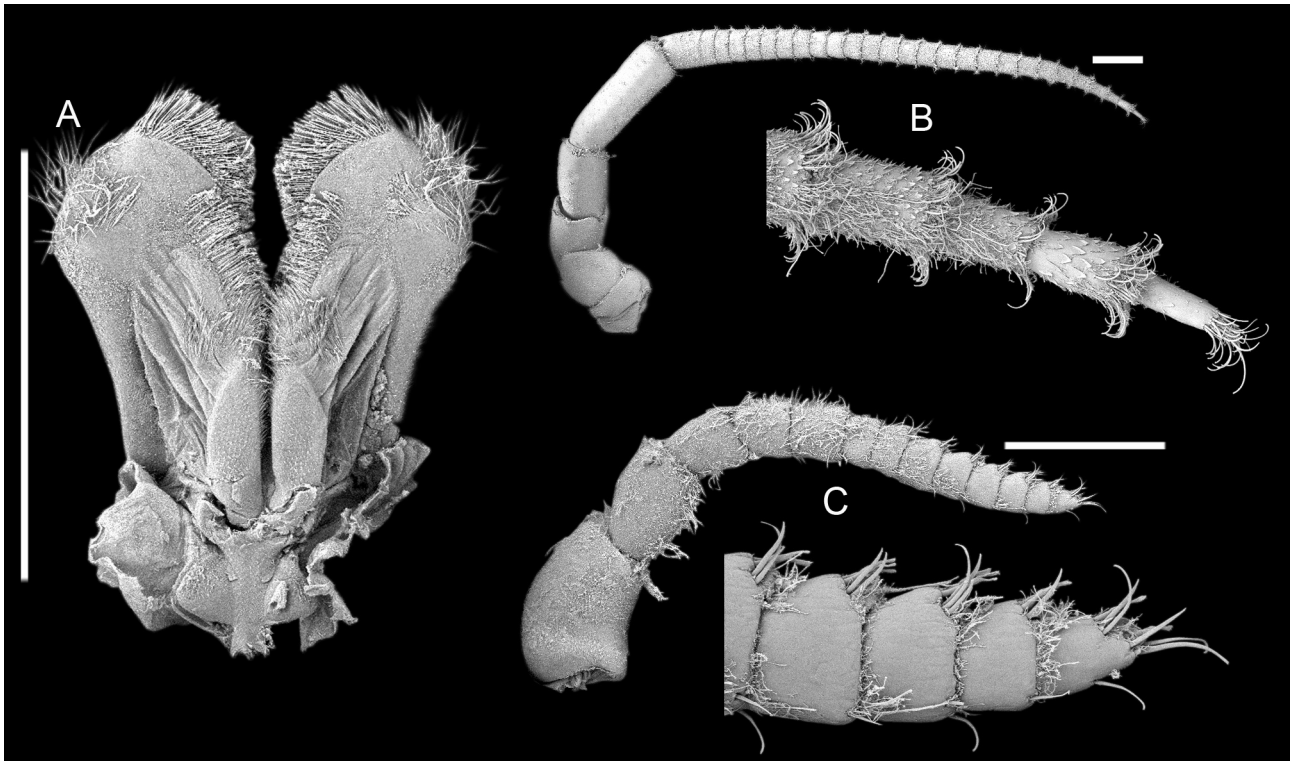

FIGURE 45. *Eophreatoicus bodmemurrngkudji* sp. nov., anterior limbs, holotype male, AM P.98676. A, paragnaths, ventral. B, antenna with enlargement of distal tip. C, antennula with enlargement of distal tip. Scales 1 mm.

Description. Body pigmentation dorsal surface dark brown with diffuse chromatophores, muscle insertions show as light cream color showing as scattered patches with following pattern: head with rows of patches separated by dark vertical bar originating ventrally from genal groove, pereonites 1–4 with convoluted patches, pereonites 5–7 with dendritic "T" shape, pleonites with two convoluted patches, pleotelson with multiple oval patches grouped in curved rows; length of largest male 17.5 mm, length of largest preparatory female 17.1 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Dorsal surface pitted; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin straight, orientation of longest axis between horizontal and vertical, maximum diameter 0.27–0.28 head depth (H, F), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view sigmoidal (weakly). Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region without obvious setae.

Pereon. Width near head width. Setae on dorsal surface not visible. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–4 in dorsal view respective lengths less than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.30 pleonite 1, 1.70 pleonite 2, 2.00 pleonite 3, 1.90 pleonite 4, 1.70 pleonite 5.

Pleotelson. Dorsal surface sparsely covered with setae. Depth 1.20 pereonite 7 depth. Lateral length less than depth, in male 0.85 depth (M2), in female 0.83 depth (F3). Lateral length 0.15 body length. Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.30 width of uropodal insertion, with one row of distally denticulate robust setae, including 4 robust setae altogether, posterior seta longer than anterior adjacent setae. Posterior apex length less than width, short. Posterior apex 0.12 pleotelson total length, width 0.44 pleotelson width.

Antennula. Length 0.15 body length in male, with 13 articles in male. Article 5 length 1.00 width. Article 6 length 0.55 width. Aesthetascs small (~4) mostly on distomedial margins. Terminal article length 1.20 width, 0.06 antennula total length. Distal articles oval in cross-section.

Antenna. Length 55.00 body length in male, 0.42 body length in female. Article 6 subequal to articles 4 and 5 combined. Flagellum length 0.66 total antenna length in male, with 27 articles in male, with 25 articles in female, proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.



FIGURE 46. *Eophreatoicus bodmemurrngkudji* sp. nov., mandibles. Holotype male, AM P.98676. Right mandible: A, dorsal; B, distal palp setation; C, gnathal tip, medial; D, molar process, dorsal. Left mandible: E, entire dorsal; F, palp, medial; G, palp, distal tip setation; H, palp, lateral, I, mandibular body, ventral; J, gnathal tip, dorsal; K, molar process, dorsal. Scales 0.1 mm.

Mandible. Palp article 3 setae on margin finely setulate, medial surface without additional setae, medial surface covered in cuticular combs, surface covered with cuticular hairs, with surface cuticular combs. Palp article 2 with distal group of setae. Palp article setae dense and robust. Left spine row with 16 spines, 2 of which bifurcate. Right spine row with 12 spines, 2 of which bifurcate. Left molar process triturating surface posterodorsal ridge projecting. Right molar process length subequal to width, with row of complex spines adjacent to triturating ridges, dorsal surface with ciliated spine row, 6 members altogether.

Maxillula. Medial lobe length 0.75 lateral lobe length; width less than lateral lobe, width 0.64 lateral lobe width; with 7 pappose setae; with simple accessory setae, one on distolateral margin and one between central pappose

setae, without short weakly setulate seta on distal tip. Lateral lobe distal margin distal setal row with 12 robust setae, with 5 denticulate robust setae, with 7 smooth robust setae. Lateral lobe ventral face setae closely spaced, without additional plumose seta.

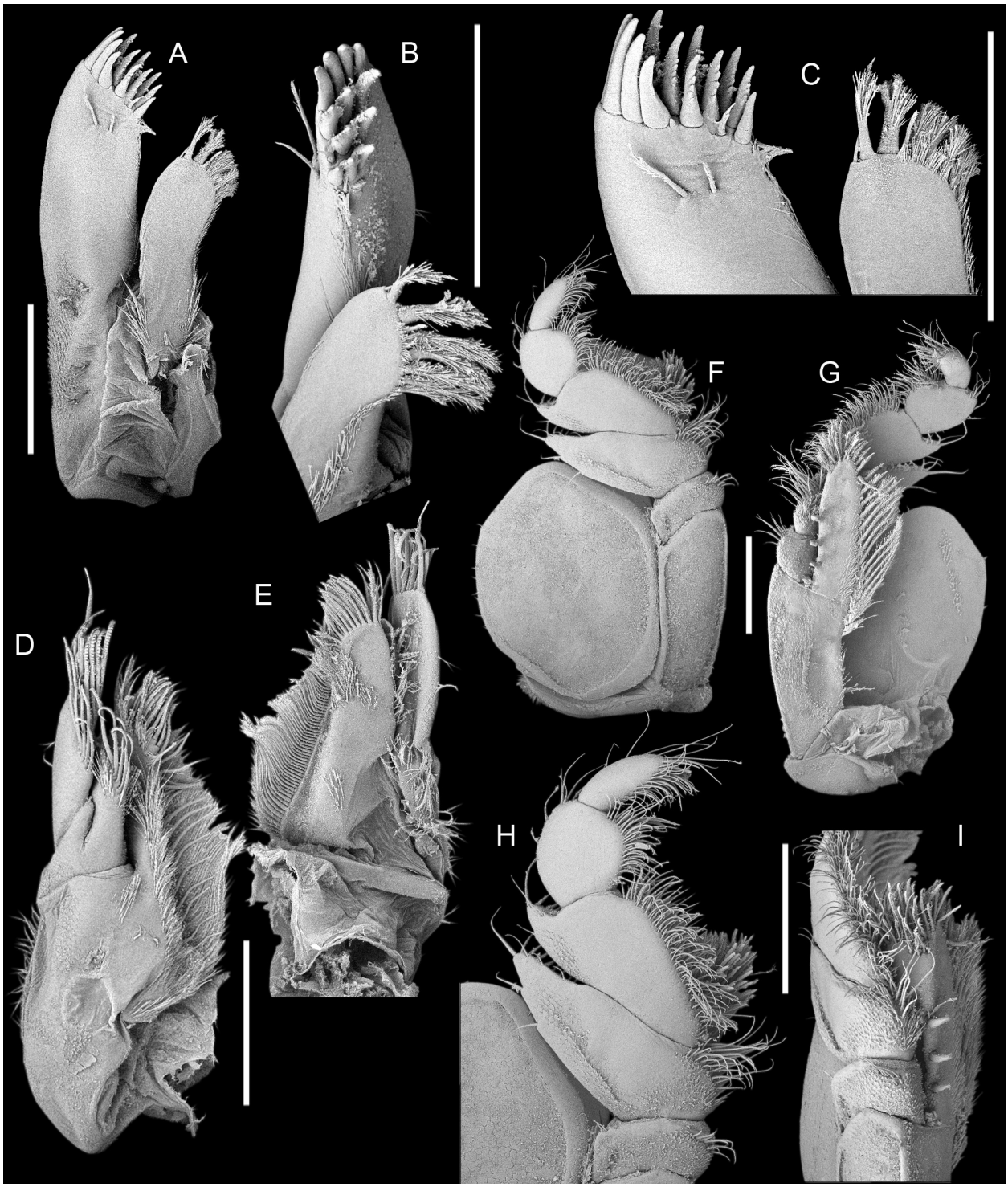

FIGURE 47. *Eophreatoicus bodmemurrngkudji* sp. nov., mouthparts. Holotype male, AM P.98676. A, maxillula, ventral. B–C, maxillula distal lobes, distomedial and ventral. D–E, maxilla, distomedial and dorsal. F–G, maxilliped, ventral and medial. H, maxillipedal palp, ventral. I, maxillipedal palp and endite with receptaculi, medial. Scales 0.5 mm.

Maxilla. Medial lobe proximal portion distinctly angled to distal portion. Outer lateral lobe longer than inner lateral lobe. Outer lateral lobe distal margin setal row with two angles, transverse to lateral margin and oblique on medial margin, both lateral lobes with bidenticulate setae on distal tips and on medial margin.

Maxilliped. Epipod distal tip broadly pointed, length 1.30 width. Endite length 0.47 total basis length; medial

margin with 3 coupling hooks on left side. Endite distal margin setulate setae, in fringe, without fine cuticular combs, 24 subdistal biserrate setae on ventral surface (approximately). Endite dorsal ridge with 16 large distally denticulate plumose setae. Palp insertion on basis without lateral margin plumose setae, without medial margin plumose setae. Palp insertion on basis ventral surface without subdistal smooth setae, without ventral surface subdistal biserrate setae. Palp article 4 length 1.10 width. Palp article 5 length 2.20 width, 0.95 article 4 length.

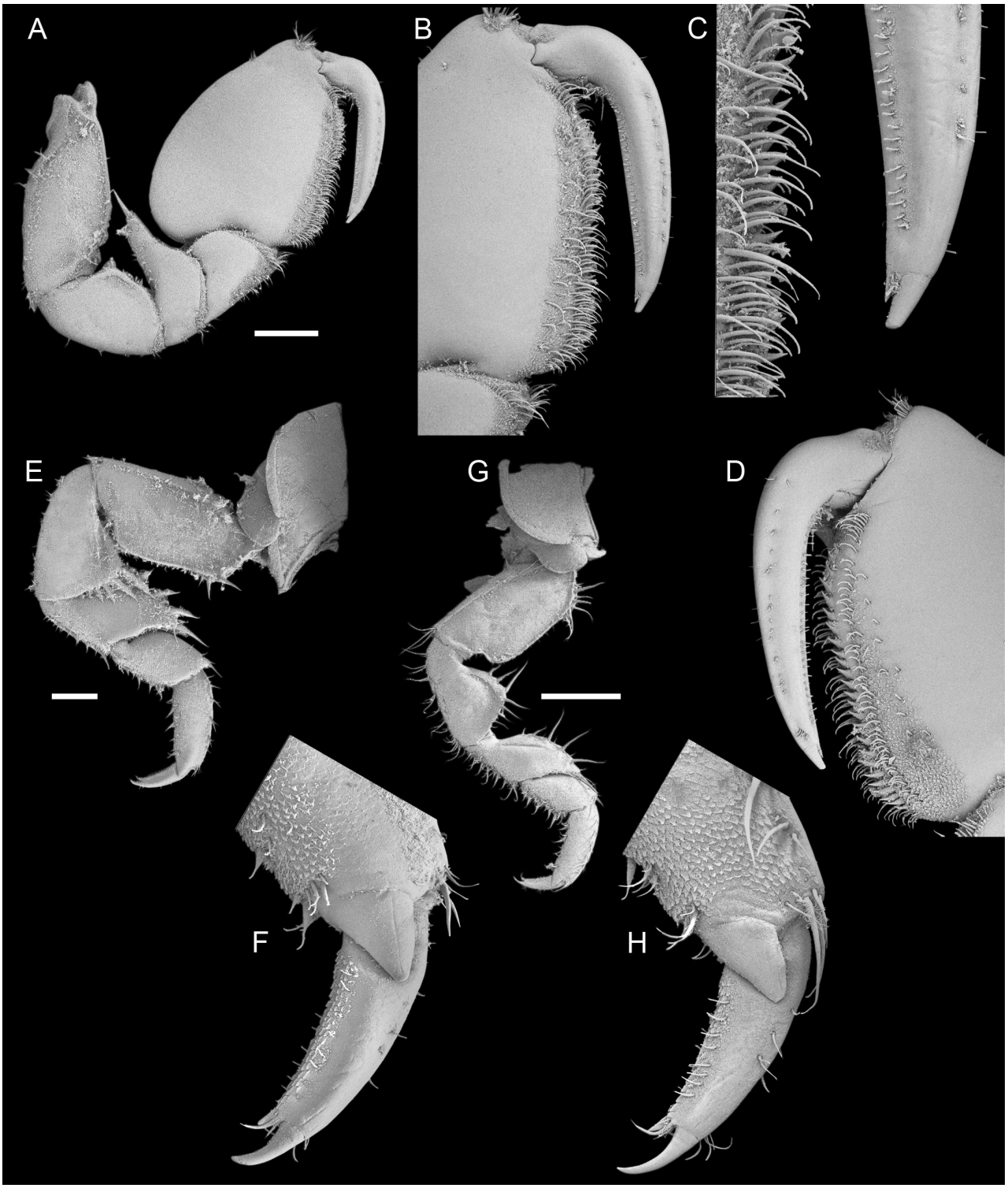

FIGURE 48. *Eophreatoicus bodmemurrngkudji* sp. nov., anterior pereopods. A–F, holotype male, AM P.98676. G–H, paratype female, AM P.98677. A–C, pereopod I, lateral, with enlargements of palm and and palm setation. D, pereopod I palm, medial. E–F, male pereopod II with enlargement of articular plate and dactylus. G–H, female pereopod II with enlargement of articular plate and dactylus. Scales 1 mm.

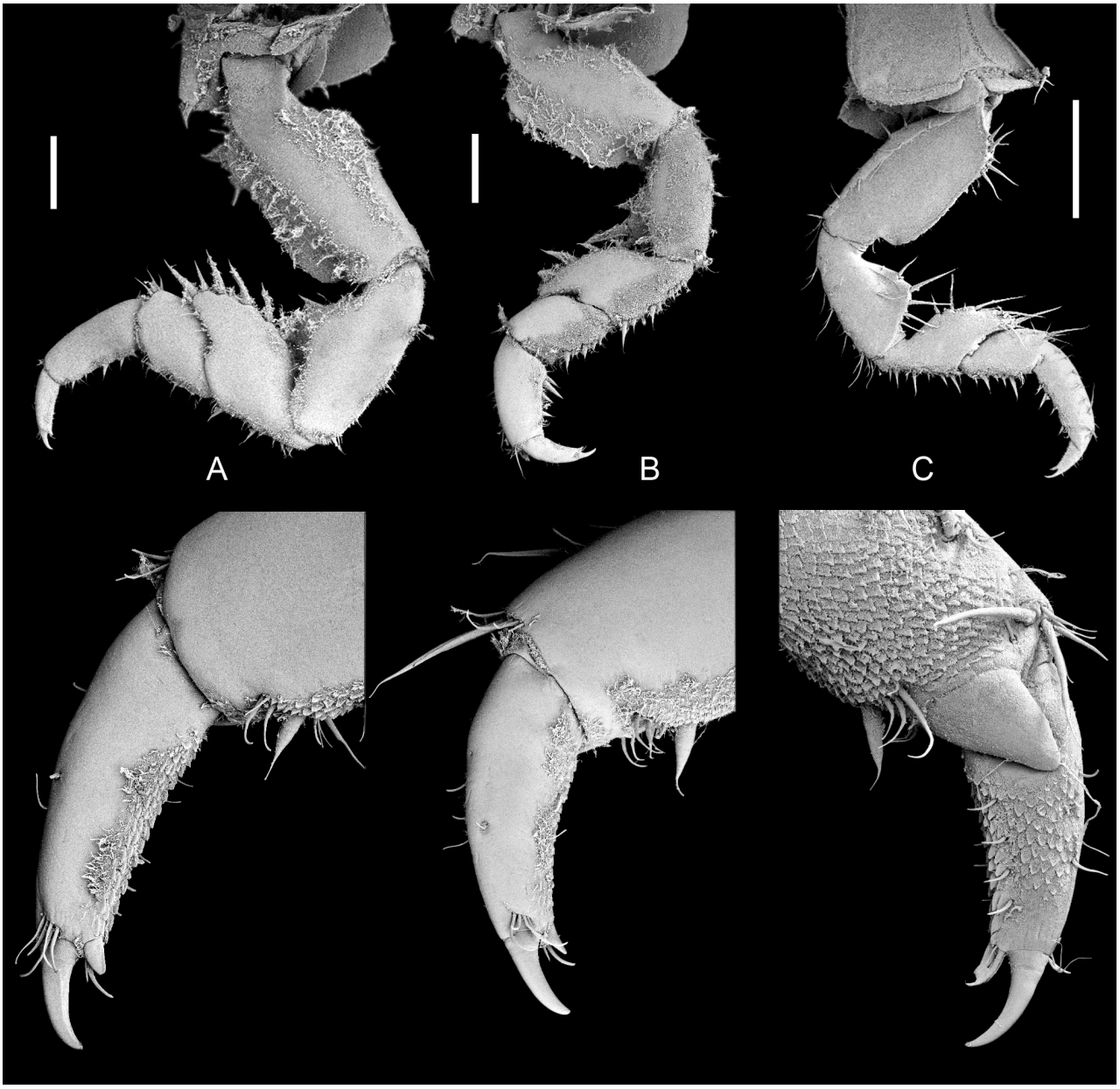

FIGURE 49. *Eophreatoicus bodmemurrngkudji* sp. nov., pereopods III–IV. A–B, pereopod III–IV, medial, with enlargement of articular plate and dactylus, holotype male, AM P.98676. C, pereopod IV with enlargement of articular plate and dactylus, lateral, paratype female, AM P.98677. Scales 1 mm.

Pereopod I. Length:body length 0.22 male, 0.28 female. Basis of male length 2.30 width; absent; lacking dorsal setae; ventrodistal margin lacking elongate setae, female ventrodistal margin lacking elongate setae. Ischium of male dorsal margin without simple setae. Ischium of female dorsal margin without simple setae. Merus of male distodorsal margin in cross section spine-like and pointed, with 1 or 2 robust simple setae, dorsal surface with setae only on distal margin; female distodorsal margin with few elongate simple setae, female dorsal surface with setae along dorsal axis (2 robust). Propodus length:pereopod length 0.25 male. Propodus length:width 1.20 male. Propodus of male dorsal margin setae confined to single group at distal margin, proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin convex, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae proximally on margin articulated, grading distally to articulation not expressed, 26 altogether. Propodal palm of female margin convex, stout denticulate setae serrate, without stout robust setae. Dactylus of male shorter than palm, length:palm length 0.87, female shorter than palm. Dactylus claw length: dactylus length 0.09 male.

Pereopods II–III ratios. Pereopod II. Length:body length 0.37 male, 0.37 female. Basis length:pereopod length 0.31 male, 0.30 female; length:width 2.10 male, 1.97 female. Carpus length:pereopod length 0.13 male, 0.12 female; length:width 1.45 male, 1.39 female. Propodus length:pereopod length 0.16 male, 0.15 female; length:width 2.37 male, 2.38 female. Dactylus length:propodus length 0.68 male, 0.64 female; primary claw length:dactylar length 0.22 male, 0.28 female. *Pereopods II–III.* Basis dorsal ridge with 6 tiny setae. Ischium II–IV of male dorsal margin none robust. Propodus of male robust-based setae respectively with 4–5. Dactylus with scales on ventral margin.

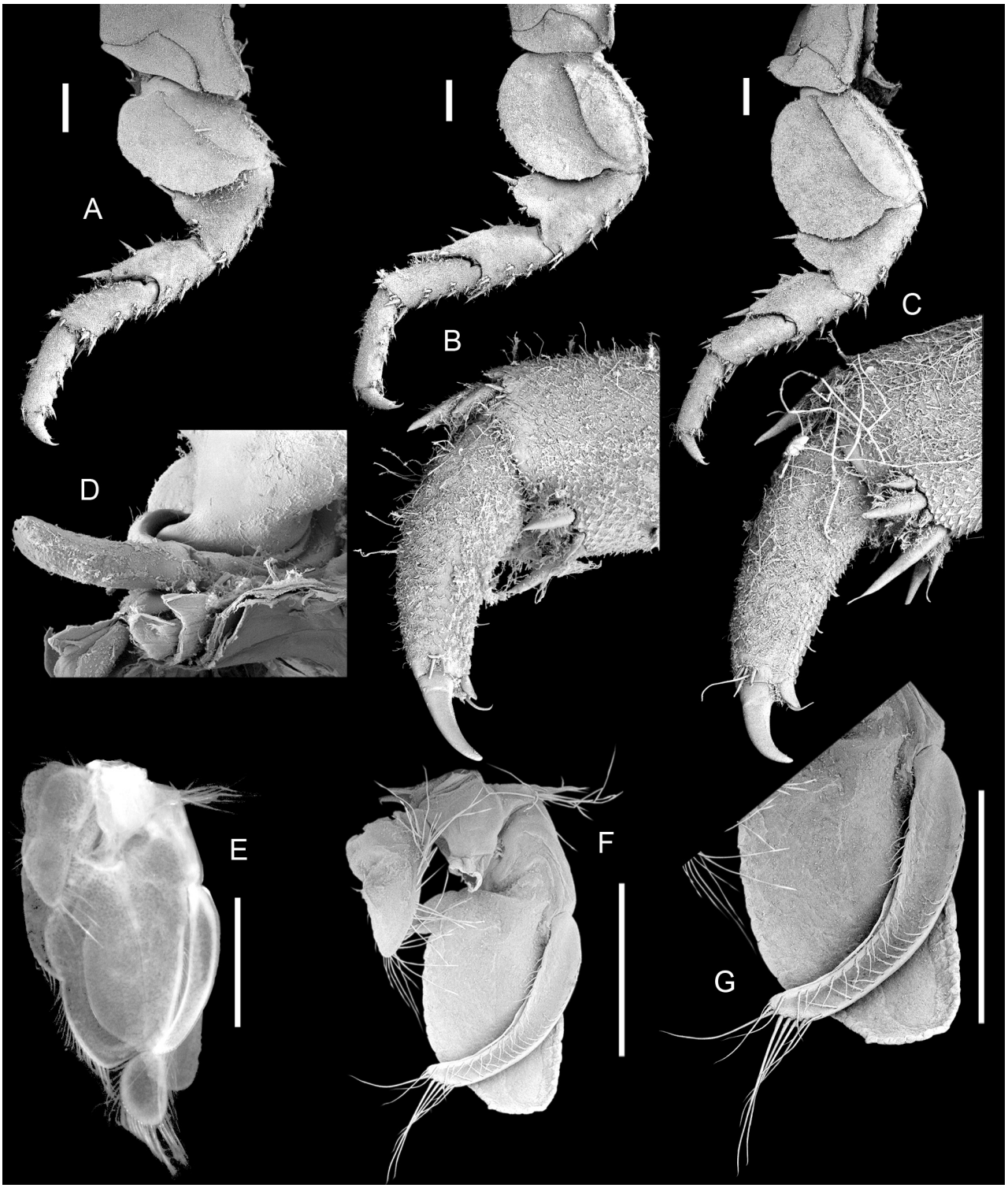

FIGURE 50. *Eophreatoicus bodmemurrngkudji* sp. nov., posterior pereopods and pleopod II. Holotype male, AM P.98676. A, pereopod V. B, pereopod VI with enlargement of dactylus. C, pereopod VII with enlargement of dactylus. D, pereopod VII penes, anteromedial. E, pleopod II, dorsal (light micrograph). F–G, pleopod II endopod and appendix masculina. Scales 1 mm.

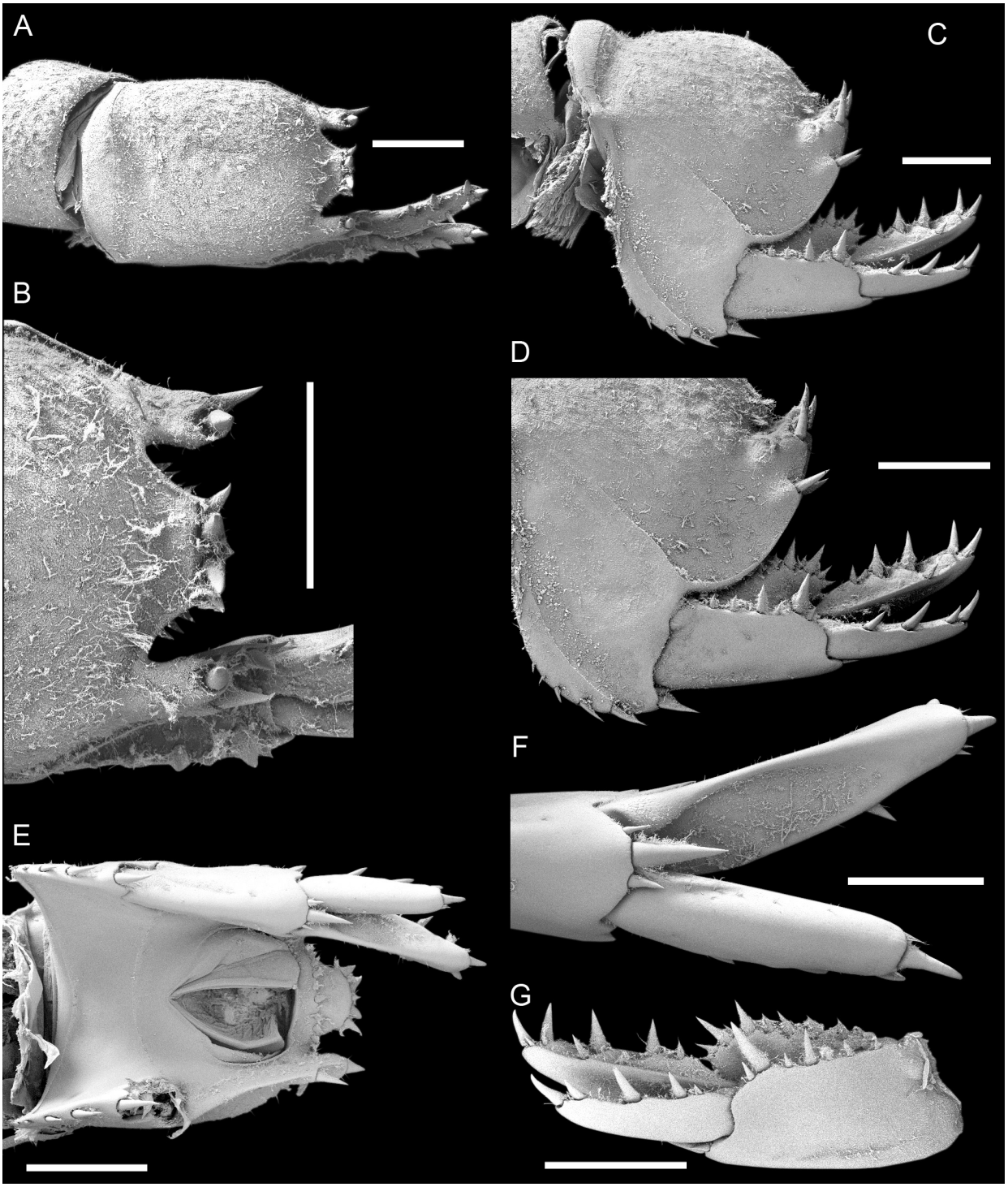

FIGURE 51. *Eophreatoicus bodmemurrngkudji* sp. nov., pleotelson and uropods. Holotype male, AM P.98676. A–B, pleotelson with enlargement of apex. C–D, pleotelson lateral with enlargement of posterolateral margin. E, pleotelson ventral. F–G, uropod ventral and lateral. Scales A–E G, 1 mm; F, 0.5 mm.

Pereopod II. Basis lateral face with 3 simple setae proximally in male and with 6 longer setae proximally in female. Basis of male dorsal ridge epaulet without submarginal setal row, main setal row with 2 minor setae, without major setae distal to epaulet. Basis of female dorsal ridge epaulet without setal row below dorsal margin, main setal row with 3 minor setae, without major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on anterodorsal margin of propodus or anterodorsal margin of carpus, of female occurring on anterodorsal margins of propodus or anterodorsal margins of carpus. Basis dorsal ridge of male without setae, of female dorsal ridge without setae. Ischium of male dorsal margin with

5 setae, female dorsal margin with 5 setae. Carpus of male ventral margin with robust setae in addition to simple setae. Carpus of female ventral margin with robust setae. Propodus of male distal width 0.68 maximum width, setae on ventral margin robust, 1 distinctly larger than remainder, shorter than dactylar claw. Propodus of female not in female, posterior side of limb articular plate shorter than dactylar claw. Dactylus of male distal accessory claw approximately 0.33 primary claw length, female distal accessory claw approximately 0.33 length of primary claw. *Pereopod IV ratios.* Length:body length 0.33 male, 0.32 female. Basis length:width 1.86 male, 1.87 female. Carpus length:pereopod length 0.13 male, 0.12 female. Propodus length:pereopod length 0.13 male, 0.14 female. Propodus length:width 1.74 male, 2.54 female.

Pereopods V–VII ratios. Pereopod V. Length:body length 0.37 male, 0.36 female. Basis length:width 1.29 male. Carpus length:pereopod length 0.19 male. Propodus length:pereopod length 0.17 male. Dactylus claw length: dactylar length 0.38 male. *Pereopod VI.* Length:body length 0.45 male, 0.41 female. Carpus length:pereopod length 0.17 male. Propodus length:pereopod length 0.17 male. Dactylus claw length:dactylar length 0.31 male. *Pereopod VII.* Length:body length 0.47 male, 0.41 female. Basis length:width 1.04 male. Carpus length:pereopod length 0.17 male. Propodus length:pereopod length 0.16 male. Dactylus claw length:dactylar length 0.33 male.

Pereopods V–VII. V–VII penicillate setae not on dorsal ridge of basis, penicillate setae not on carpus; penicillate setae not on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin including 3 robust setae. Propodus distal margins with 5 elongate robust or robust-based setae. Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with 1 seta, dorsal margin with 2 setae.

Penes. Extending near midline; distally tubular; distal tip rounded.

Pleopods. Exopods with medial proximal lobes of pleopod I. Protopods medial margins II–V with large projections, of male medial margins with minutely serrate setae, of female medial margins with simple setae only; protopod II lateral epipod lobe-like.

Pleopod I exopod of male broadest proximally, distal margin rounded, medial margin convex, divergent from lateral margin proximally, dorsal surface lacking setae. Pleopod II endopod of male appendix masculina length 0.49 pleopod length, basal musculature pronounced, distal length 1.80 endopod proximal margin length; distally with 6 setae; 54 setae altogether.

Uropod. Of male total length 1.00 pleotelson length; protopod of male length:width 2.00, length 0.56 uropod total length. Uropod of female total length 0.91 pleotelson length, protopod length 0.60 uropod total length. Protopod dorsomedial ridge length:endopod length 0.83 male, 0.81 female. Protopod of male dorsolateral margin longer than dorsomedial margin setae (stubby); of female dorsolateral margin longer than dorsomedial margin setae (not stubby). Protopod distoventral margin with 3 robust setae, without spinose setae, 3 robust simple setae. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 6 altogether; female dorsal margin with 7 robust setae. Exopod length:endopod length 0.79 male. Exopod length:protopod length 0.86 male, 0.83 female. Exopod of male dorsal margin with 4 robust setae, female 5 robust setae.

Distribution. Australia, Northern Territory, Arnhem Land, Myra Radiogenic Springs, which flows into Tin Camp Creek of the East Alligator River catchment.

Habitat. Small, shallow stream flowing off escarpment, collected from riffle, substrate mixed rock and sand.

Remarks. *Eophreatoicus bodmemurrngkudji* sp. nov. was found in the same radiogenic spring group, Myra Springs, as *E. kudjamarndi* sp. nov. and is phylogenetically close to this species as well (Fig. 12). They are, however, easy to distinguish. Of the two species, *E. bodmemurrngkudji* sp. nov. has shorter and more robust limbs, overall shorter setae, spread chromatophores in the dorsal cuticle, the pereopod II epaulet in the female has 5–6 major setae (vs. 3–4), only two pairs of robust setae on the pleotelson apex (vs. 1) and pleotelson posterolateral margin dorsal margin with only one robust seta. If these two species are indeed closely related, their geographic proximity suggests that they might be an example of reproductive character displacement (Brown & Wilson 1956), where reproductive effort is not wasted on potential but ineffective breeding with another related species.

Eophreatoicus kurdabeyhmay **sp. nov.**

(Figs 52–58)

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Eophreatoicus sp.”10”.—Wilson *et al.*, 2009: 361.

Type material. Holotype male, bl 22.5 mm, AM P.76305. Paratypes collected with holotype: male (M2), bl 25.9 mm, AM P.76306, dissected, DNA E82 Genbank COI EU263153 16S EU263223, SEM stubs AW711–715; preparatory female (F3), bl 14.2 mm, AM P.76307, dissected, DNA E83 (unsuccessful), SEM stubs AW716–719; 3 females, AM P.76308; 34 inds, AM P.76304.

Type locality. Australia, Northern Territory, Arnhem Land, escarpment stream south of Gunbalanya, 12°23.92'S, 133°05.00'E. Coll. C. Humphrey, 24.x.1998.



FIGURE 52. *Eophreatoicus kurdabeyhmay* sp. nov., habitus of types. Holotype male, AM P.76305: A, lateral habitus; B, head and pereopods I–II; C, pleonite 5 and pleotelson. D, paratype female, AM P.76307, lateral habitus. Scales A, C–D, 5 mm; B, 3 mm.

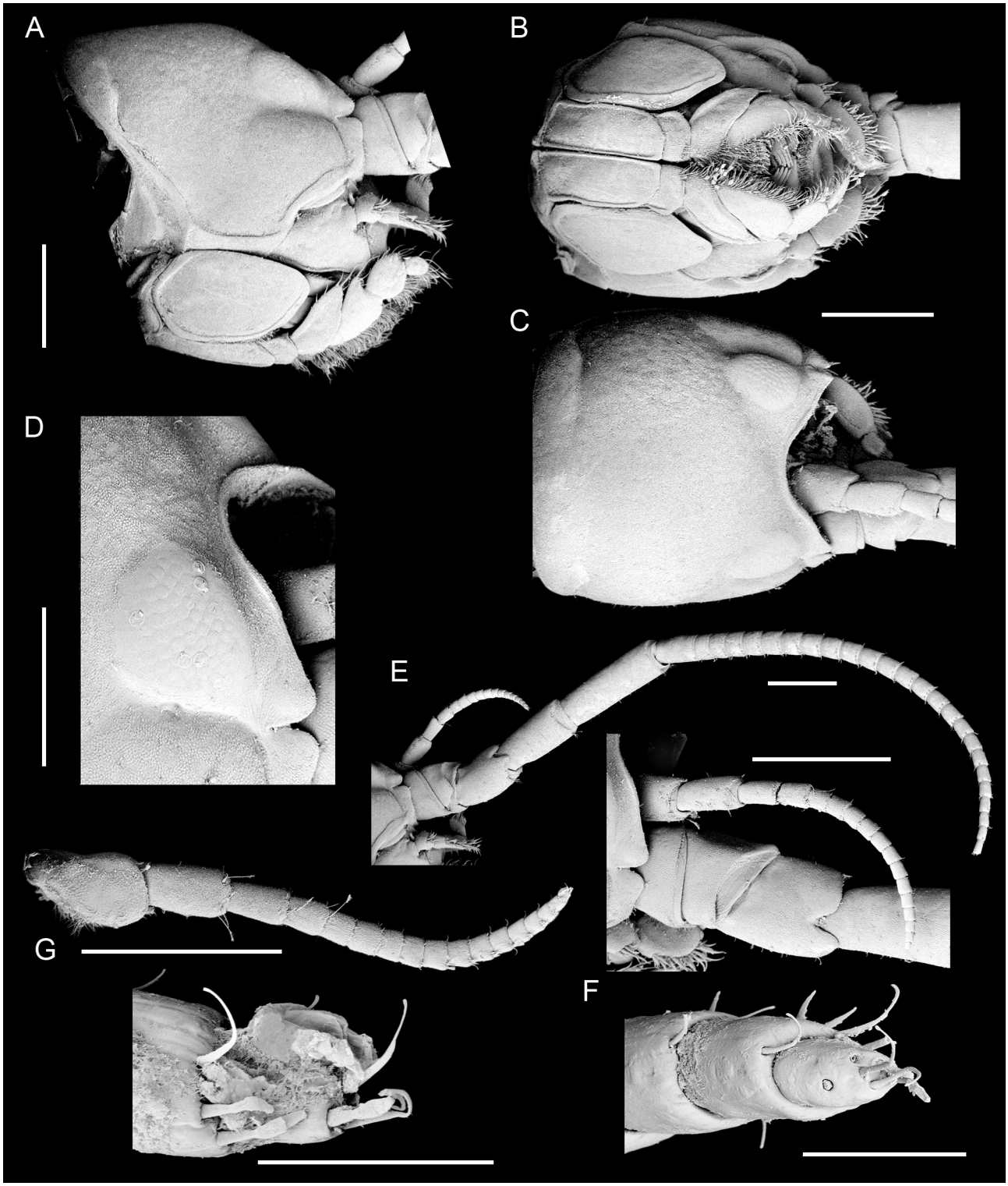

FIGURE 53. *Eophreatoicus kurdabeyhmay* sp. nov., head and antennae, paratype male, AM P.76306. A–C, head, lateral, ventral and dorsal, respectively. D, left lateral oblique enlargement of eye and frontal margin. E, antenna. F, right antennula and antennal basal articles, with enlargement of antennular distal tip. G, left antennula with enlargement of distal tip (with some debris). Scales 1 mm, enlargements F–G, 0.1 mm.

Etymology. The region around Oenpelli has escarpments and streams from which this species came in an area called "Kurda-beyh-may" (pronounced "goorda-bey-mai") in the Kundjeyhmi language. We have elided this to give the species name *kurdabeyhmay*.

Diagnosis. *Head.* Eyes bulging dorsolaterally, height small, in lateral view less than width of basal antennal

articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region without obvious setae. *Pereon.* Dorsal cuticular surface smooth (without roughness or tubercles); pereonites 1–4 transverse dorsal ridges rounded, expressed as transverse trough only; pereonites 5–7 transverse dorsal ridges carinate with transverse trough. *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection linear. Dorsal surface rugose, with small irregular rugose regions, lacking posteromedial ridges or median groups of tubercles. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae and one median robust seta (central seta significantly smaller than neighboring setae in male, only slightly smaller in female), with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length less than quarter length of basis, main setal row with 2 major setae (robust). Basis of female dorsal ridge epaulet length less than quarter length of basis, main setal row with 2 major setae (thin). *Pereopod IV.* Propodus of male ventral margin with projection, with 5 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 robust setae distinctly larger than others, separated by shorter seta.

Description. Body pigmentation broad dorsal light bar, chromatophores abundant light and diffuse; length of largest male 25.9 mm, length of largest preparatory female 14.2 mm, length of largest brooding female 15.7 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface angularly curved. Dorsal surface smooth; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin straight, orientation of longest axis vertical, maximum diameter 0.25–0.26 head depth (H, M2), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view smoothly curved. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region without obvious setae.

Pereon. Width near head width. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2 in dorsal view length less than 0.5 pleonite 5 length, 3–4 respective lengths more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth: pereonite 7 depth 1.40–1.50 pleonite 1 (M2, H), 1.80–1.90 pleonite 2 (M2, H), 2.00–2.40 pleonite 3 (M2, H), 2.00–2.10 pleonite 4 (M2, H), 1.80–1.90 pleonite 5 (M2, H).

Pleotelson. Dorsal surface length 1.00–1.30 width in dorsal view (M2, F3). Dorsal surface sparsely covered with setae. Depth 1.00–1.10–1.20 pereonite 7 depth (M2, H, F3). Lateral length less than depth, in male 0.76 depth (M2), in female 0.79 depth (F3). Lateral length 0.13 body length (M2, F3). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.30–1.40 width of uropodal insertion (F3, M2), with one row of distally denticulate robust setae, including 6–7 robust setae altogether (F3, M2, plus 2 anterior fine setae for both), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.17–0.18 pleotelson total length (M2, F3). Posterior apex length less than width, long. Posterior apex 0.12–0.17 pleotelson total length (F3, M2), width 0.45–0.48 pleotelson width (F3, M2). Posterior apex in lateral view forming an angle of 77–85–93° with immediately anterior dorsal surface (F3, M2, H), angled 146–152–153° from horizontal (H, M2, F).

Antennula. Length 0.12 body length in male (M2), 0.11 body length in female (F3), with 17 articles in male (M2), with 12 articles in female (F3). Article 5 length 0.95–1.40 width (M2, F3). Article 6 length 0.84–0.93 width (F3, M2). Aesthetascs small aesthetascs (1–3) mostly on distomedial margins. Terminal article length 1.00–1.30 width (F3, M2), 0.02–0.03 antennula total length (M2, F3). Distal articles oval in cross-section.

Antenna. Length 0.43 body length in male (M2), 0.34 body length in female (F3). Flagellum length 0.61 total antenna length in male (M2), 0.57 total antenna length in female (F3), with 25 articles in male (M2), with 20 articles in female (F3), proximal articles surface smooth (appearing rough but not scaled in SEM), proximal articles distal margin with rosette of short setae.

Maxilla. Outer lateral lobe wider than inner lateral lobe (1.2, F3).

Maxilliped. Epipod distal tip rounded, length 1.80 width (M2). Palp article 4 length 1.10 width (M2). Palp article 5 length 1.20 width (M2), 0.57 article 4 length (M2).

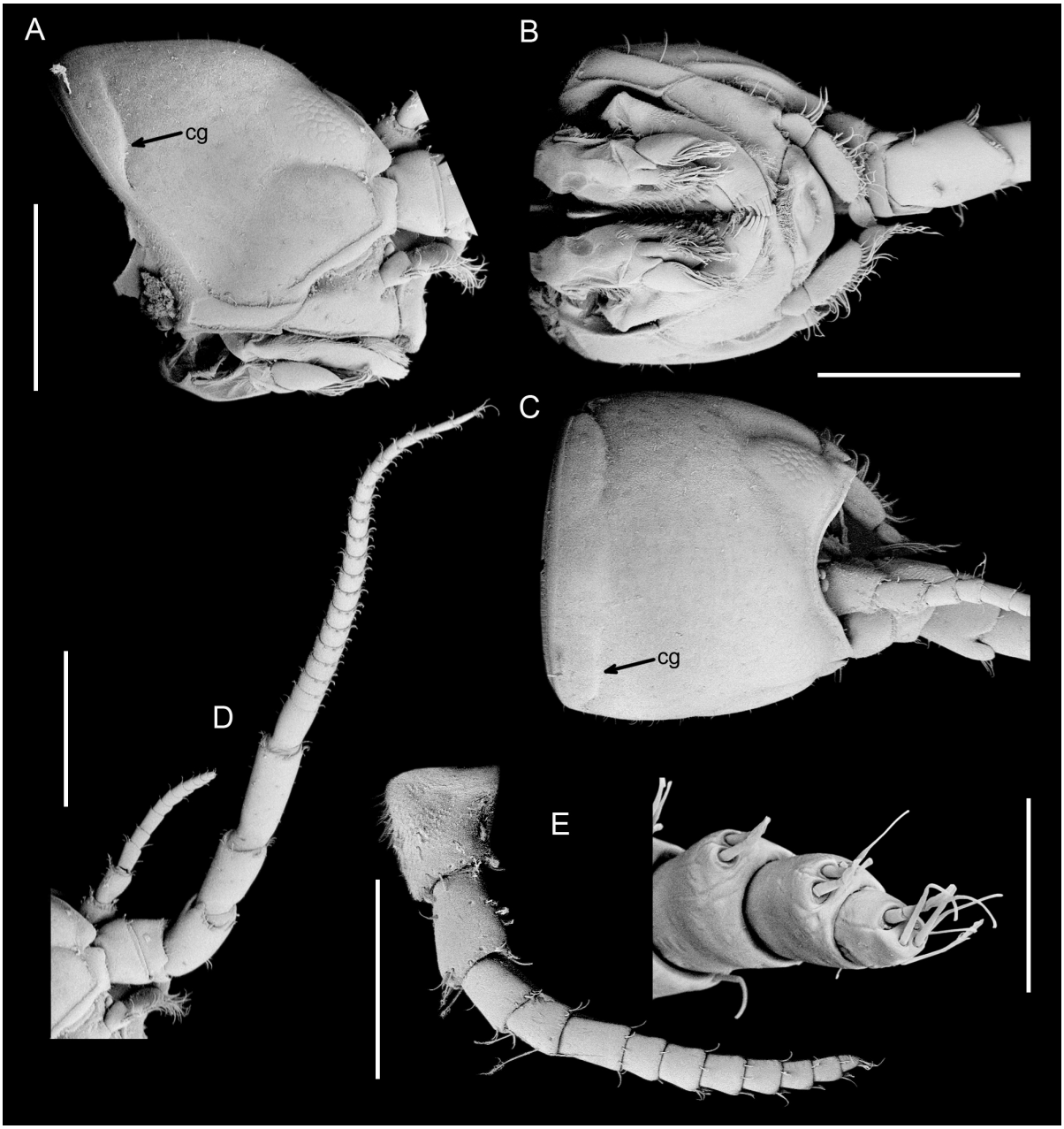

FIGURE 54. *Eophreatoicus kurdabeyhmay* sp. nov., head and antennae, paratype female, AM P.76307. A–C, head, lateral, ventral (maxilliped removed) and dorsal, respectively. D, right antennula and antenna. E, antennula with enlargement of distal tip. Scales A–D, 1 mm. E, 0.5 mm, enlargement 0.1 mm. A & C, **cg** cervical groove.

Pereopod I. Length:body length 0.31 male (M2), 0.30 female (F3). Basis of male length 2.50 width (M2), female length 2.20 width (F3); dorsal setae positioned proximally, 1 dorsal seta altogether (M2, robust, on proximal projection); female dorsal setae positioned proximally, female 5 dorsal setae altogether (1 elongate seta, rest fine and short); ventrodistal margin with 1 elongate seta, female with 4 elongate setae (F3), elongate setae subequal to ischium. Ischium of male dorsal margin without simple setae. Ischium of female dorsal margin with 3 simple setae (F3), setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with few elongate simple setae, dorsal surface with setae along dorsal axis (2 robust); female distodorsal margin with numerous elongate simple setae, female dorsal surface with setae along dorsal axis (2 robust 1 short proximal). Propodus length:pereopod length 0.23 male (M2), 0.19 female (F3). Propodus length: width 1.00 male (M2), 1.40 female (F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin (minimal and fine besides distal group), with 5 setae altogether (excluding distal group) (M2), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region

recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae proximally on margin articulated, grading distally to articulation not expressed, 33 altogether (M2). Propodal palm of female margin convex, with cuticular fringe weakly developed, stout denticulate setae serrate, 16 altogether (F3), with stout robust conical setae, 5 altogether (F3). Dactylus of male shorter than palm, length:palm length 0.92 (M2), female shorter than palm, female length:palm length 0.87 (F3). Dactylus of female ventrodistal margin distal cuticular fringe length 0.80 total length (F3, approx, dactylus not fully pried away from propodal palm). Dactylus claw length:dactylus length 0.05 male (M2), 0.16 female (F3). Dactylus of male positioned ventrally, 0.29 (F3) length of primary claw (claws appear broken in M2).

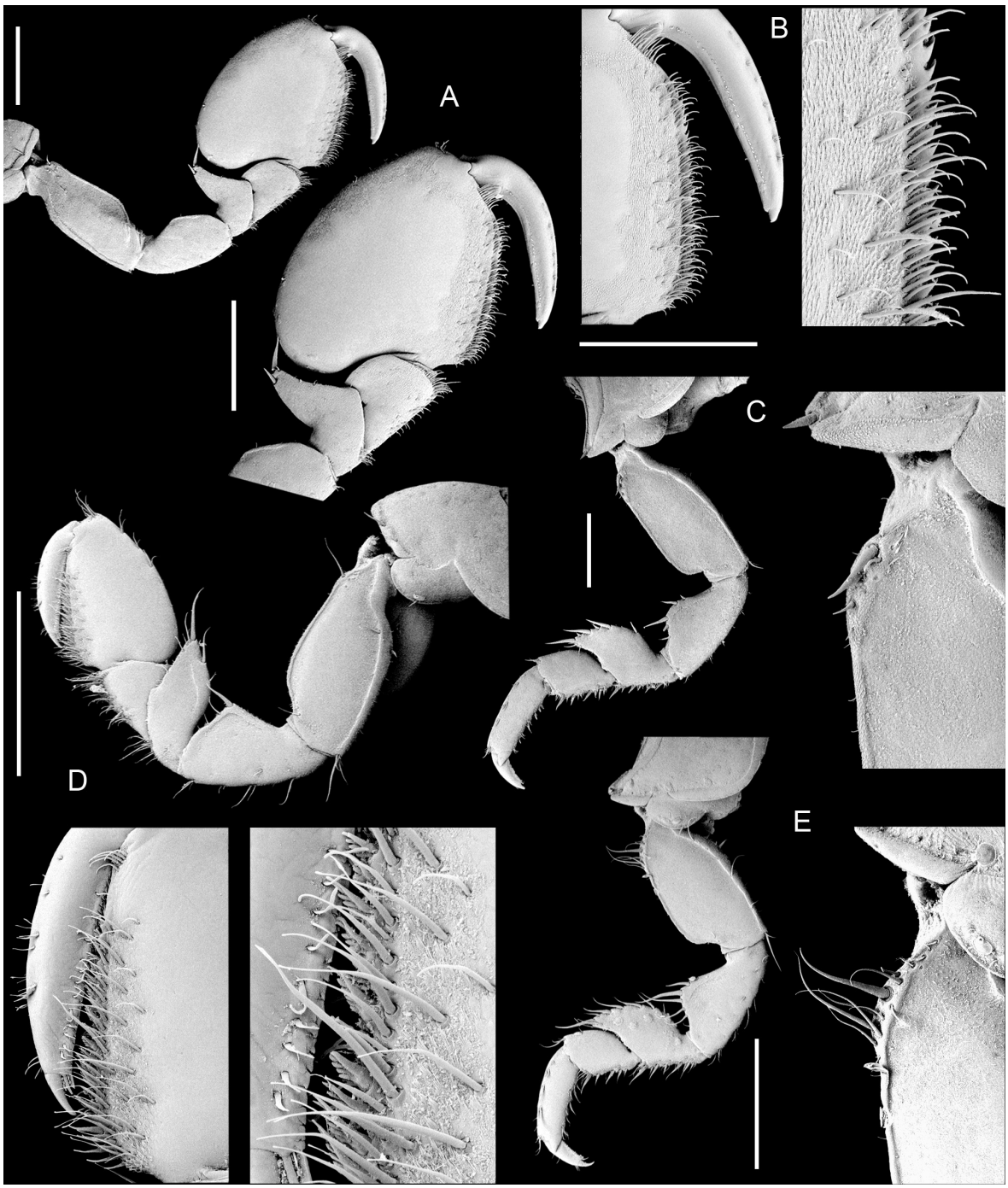

FIGURE 55. *Eophreatoicus kurdabeyhmay* sp. nov., anterior pereopods. Paratype male, AM P.76306: A, pereopod I with enlargement of distal segments; B, pereopod I palm with enlargement of palm setae; C, pereopod II with enlargement of basis epaulet. Paratype female, AM P.76307: D, pereopod I with enlargements of palm and palm setae; E, pereopod II with enlargement of basis epaulet. Scales 1 mm.

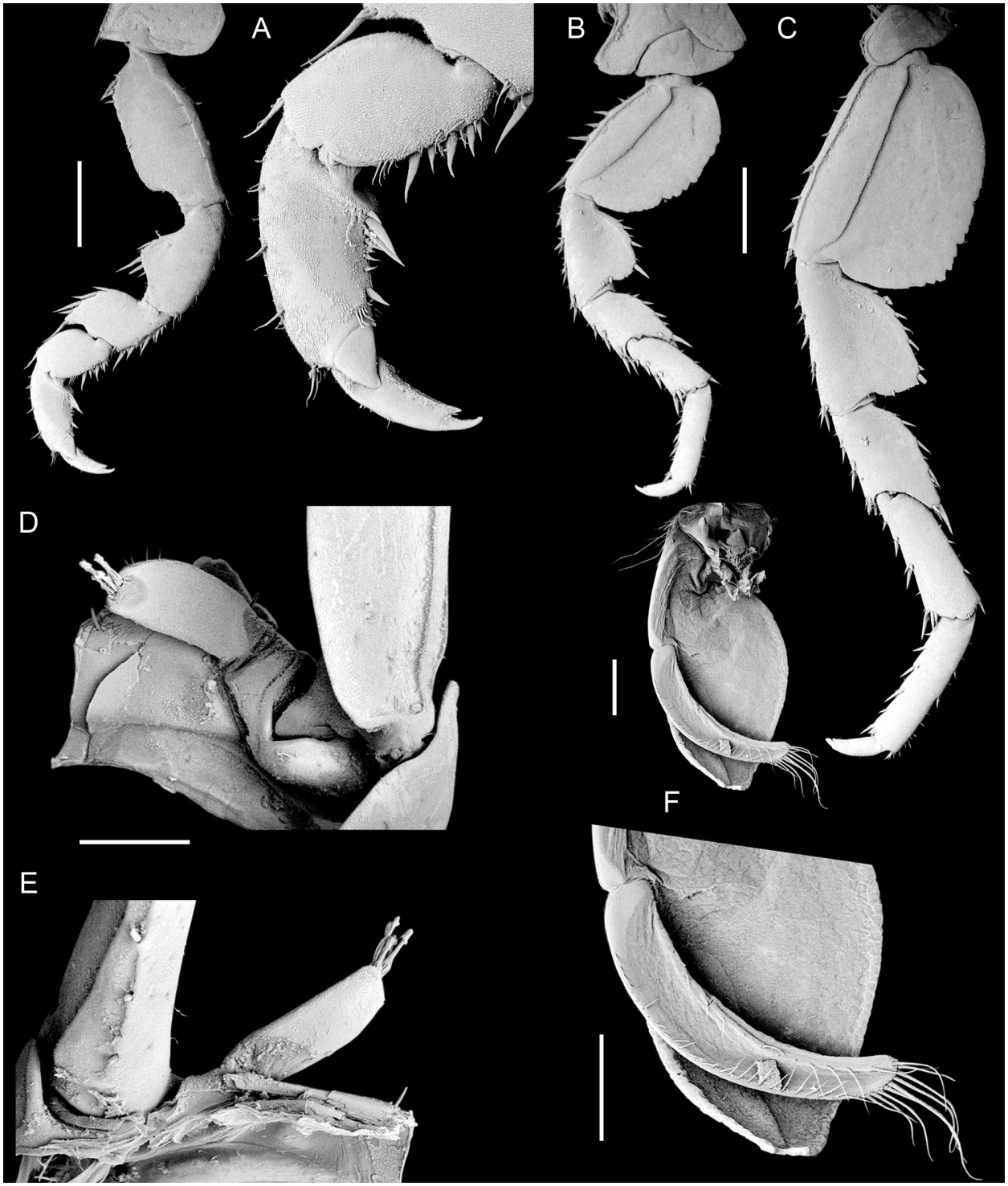

FIGURE 56. *Eophreatoicus kurdabeyhmay* sp. nov., paratype male, AM P.76306, posterior pereopods and pleopod II appendix masculina. A, pereopod IV with enlargement of palm. B–C, pereopods V and VII. D–E, pereopod VII penes, posterior and anterior respectively, note sperm bundles projecting from terminal pore. F, pleopod II endopod with enlargement of appendix masculina. Scales A–C, 1 mm, D–F, 0.5 mm.

Pereopods II–III ratios. Pereopod II. Length:body length 0.29–0.35 male (M2, H), 0.29 female (F3). Basis length:pereopod length 0.28–0.32 male (H, M2), 0.31 female (F3); length:width 2.40–2.70 male (H, M2), 2.20 female (F3). Carpus length:pereopod length 0.11–0.12 male (H, M2), 0.12 female (F3); length:width 1.40–1.50 male (H, M), 1.40 female (F3). Propodus length:pereopod length 0.16–0.18 male (H, M2), 0.17 female (F3); length: width 2.70–3.00 male (H, M2), 2.90 female (F3). Dactylus length:propodus length 0.45–0.55 male (M2, H), 0.52

female (F3); primary claw length:dactylar length 0.12 male (M), 0.30 female (F3). *Pereopod III.* Length:body length 0.31–0.35 male (M2, H), 0.27 female (F3). Basis length:pereopod length 0.29–0.30 male (M2, H), 0.29 female (F3); length:width 2.30–2.70 male (M2, H), 2.10 female (F3). Carpus length:pereopod length 0.11 male (H), 0.11 female (F3); length:width 1.40 male (H), 1.50 female (F3). Propodus length:pereopod length 0.14–0.16 male (H, M2), 0.17 female (F3); length:width 2.60 male (M2, H), 2.70 female (F3). Dactylus length:propodus length 0.50–0.53 male (M2, H), 0.45 female (F3). *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, propodus, dactylus; basis dorsal ridge with elongate setae forming 2 rows on proximal projection. Ischium II–IV of male dorsal margin with 5 simple setae (M2 pereopod II, pereopod IV), none robust. Dactylus ventral to primary claw, small in both sexes (less than 1/5 size of primary claw), with scales on ventral margin; 5–6 altogether (M2 pereopod II, approx).

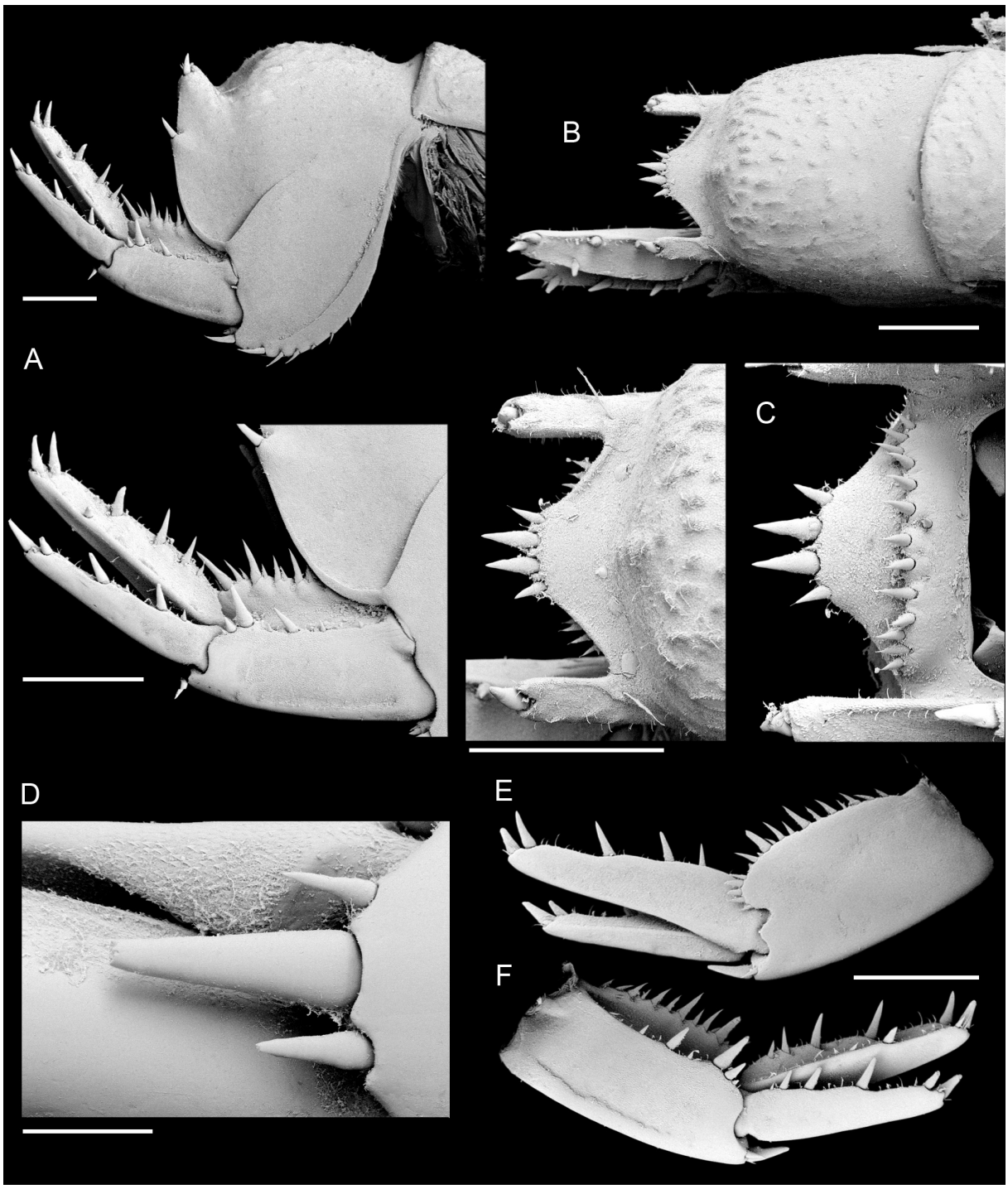

FIGURE 57. *Eophreatoicus kurdabeyhmay* sp. nov., paratype male, AM P.76306, pleotelson and uropods. A–B, pleotelson, lateral, with enlargement of uropod, and dorsal. C, apex, dorsal and ventral. D, uropod distal ventral margin robust setae. E–F, left uropod, medial and lateral. Scales 1.0 mm.

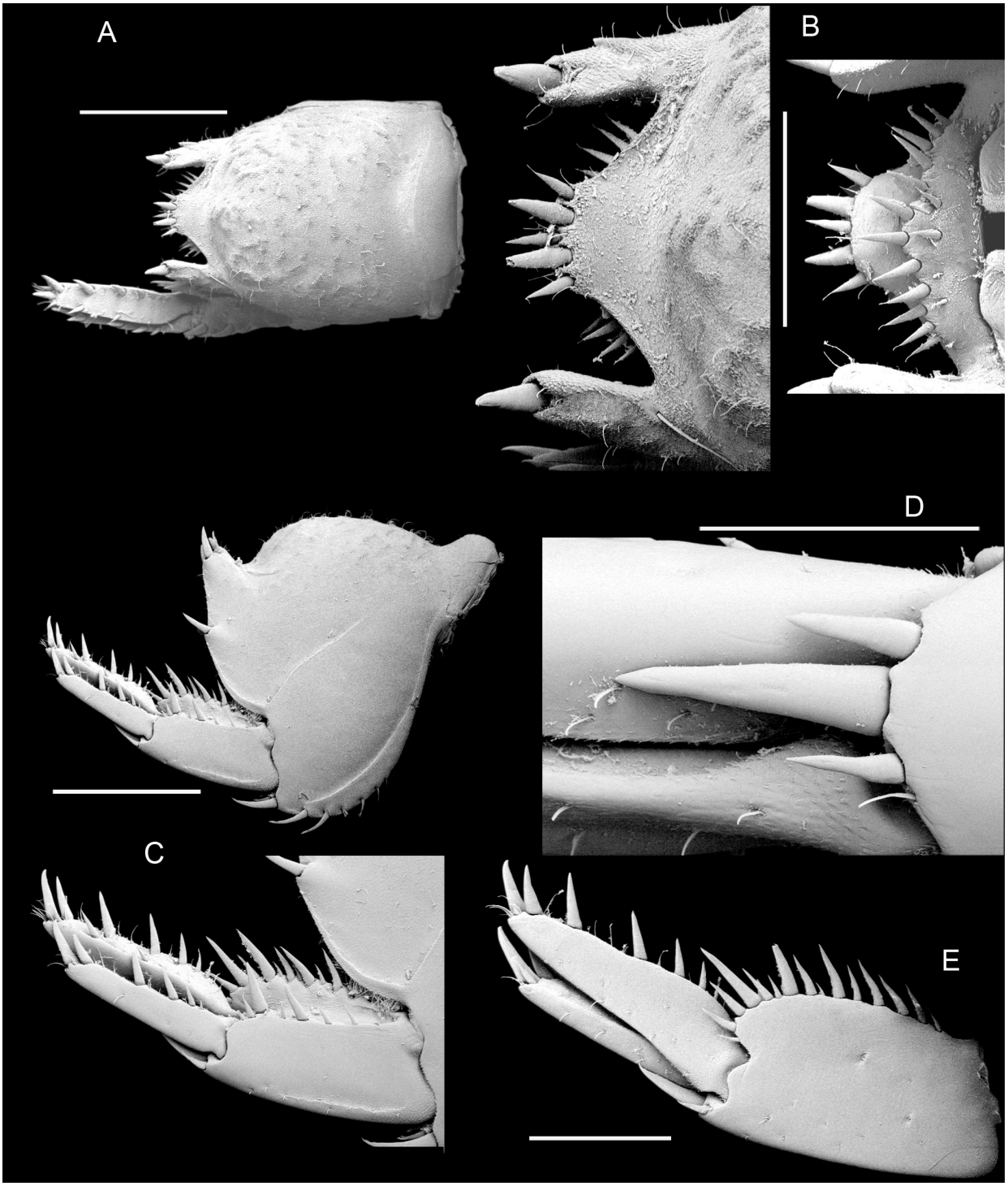

FIGURE 58. *Eophreatoicus kurdabeyhmay* sp. nov., paratype female, AM P.76307, pleotelson and uropods. A, pleotelson, dorsal. B, apex, dorsal and ventral. C, pleotelson lateral, with enlargement of uropod. D, uropod distal ventral margin robust setae. E, left uropod, medial. Scales A, C, 1 mm; B, D–E, 0.5 mm.

Pereopod II. Basis lateral face with 1 tiny simple seta proximally in male and 5 elongate simple setae along margin in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 1–3–4 minor setae, submarginal setal row with 2–2–4 setae, without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 2–3–4 minor setae, submarginal setal row with 2–4–4 setae, without major setae distally.

Pereopod IV. Basis of male dorsal ridge with 6 setae (M2), dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 5 setae (M2). Carpus of male ventral margin with simple setae only. Propodus of male

distal width 0.64 maximum width (M2), setae on ventral margin robust, 2 distinctly larger than remainder, longer than dactylar claw. Dactylus of male distal accessory claw approximately 0.33 primary claw length. *Pereopod IV ratios.* Length:body length 0.26 male (M2). Basis length:width 2.30 male (M2). Carpus length:pereopod length 0.12 male (M2). Propodus length:pereopod length 0.16 male (M2). Propodus length:width 2.10 male (M2).

Pereopods V–VII ratios. *Pereopod V.* Length:body length 0.27–0.29 male (M2, H). Basis length:width 1.30–1.50 male (H, M2). Carpus length:pereopod length 0.14 male (H, M2). Propodus length:pereopod length 0.16–0.17 male (M2, H). Dactylus claw length:dactylar length 0.29 male (M2). *Pereopod VI.* Length:body length 0.39–0.40 male (M2, H). Basis length:width 1.30 male (H). Carpus length:pereopod length 0.15–0.16 male (H, M2). Propodus length:pereopod length 0.17 male (H, M2). *Pereopod VII.* Length:body length 0.40–0.41 male (M2, H). Basis length:width 1.40 male (M2). Carpus length:pereopod length 0.16–0.17 male (H, M2). Propodus length:pereopod length 0.17–0.18 male (M2, H). Dactylus claw length:dactylar length 0.21 male (M2).

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae not on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 6–7 setae (M2 pereopod V, M2 pereopod VII). Propodus distal margins with 5–6 elongate robust or robust-based setae (M2 pereopod V, M2 pereopod VII). Dactylus accessory claw 0.34 primary claw length (M2 pereopod VII; not easily seen in M2 pereopod V). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with 1 seta, dorsal margin with 7 setae (M2).

Penes. Distally tapering; distal tip truncate.

Pleopods. Protopods of female medial margins with simple setae only.

Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 1.30 endopod proximal margin length; distally with 9 setae; 53 setae altogether (M2).

Uropod. Of male total length 1.10 pleotelson length (H, M2); protopod of male length 0.43–0.50 uropod total length (M2, H). Uropod of female total length 0.95 pleotelson length (F3), protopod length 0.47 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.63 male (M2), 0.70 female (F3). Protopod of male dorsolateral margin shorter than dorsomedial margin setae; of female dorsolateral margin shorter than dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, without spinose setae, 3 robust simple setae. Protopod lateral face with ventrolateral ridge (faint in male). Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 7 altogether (M2); female dorsal margin with 10 robust setae (F3). Exopod length:endopod length 0.79–0.85 male (H, M2), 0.79 female (F3). Exopod of male dorsal margin with 7 robust setae (M2), female 6 robust setae (F3).

Distribution. Australia, Northern Territory, Eastern Arnhem Land, escarpment stream south of Gunbalanya, flowing into the East Alligator River floodplain.

Habitat. Margin of stream in roots and litter.

Remarks. *Eophreatoicus kurdabeyhmay* sp. nov. is part of a group of three species found south of Gunbalanya (also known as Oenpelli) in Western Arnhem Land. The other two species are *E. gudjangah* sp. nov. and *E. indjangarlwurr* sp. nov. The three species appear to be closely related (Fig. 12). Notably, the three species found south of Gunbalanya have a small median seta on the pleotelson apex, which seems to be variable in size from specimen to specimen. Of the three species, *E. kurdabeyhmay* sp. nov. has an overall smooth cuticle, while the other two have more obvious cuticular roughness and tuberculation on the pleotelson. *Eophreatoicus kurdabeyhmay* sp. nov. can be identified by having only two major setae on the pereopod II epaulet, while the other two species have 4–6 major setae. *Eophreatoicus kurdabeyhmay* sp. nov. also has a uropodal protopod distoventral margin having only smooth robust setae (spinose in the other two species) The morphology data place this species in a clade with *E. korokoro* sp. nov. and *E. namarden* sp. nov. *E. kurdabeyhmay* sp. nov. differs from *E. namarden* sp. nov. in having a pleotelson posterolateral dorsal margin with lobe medial to the robust seta, and a convex uropod protopod dorsomedial ridge that distinctly curves ventrally in lateral view. *Eophreatoicus kurdabeyhmay* sp. nov. differs from *E. korokoro* sp. nov. in having a pleotelson posterior apex with two pairs of robust setae and one small median seta.

***Eophreatoicus gudjangah* sp. nov.**

(Figs 5A, 59–66)

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Eophreatoicus sp. "11".—Wilson *et al.*, 2009: 361.

Type material. Holotype male, bl 22.0 mm, AM P.76310. Paratypes collected with holotype: male (M3), bl 15.9 mm, AM P.76312, DNA E85 Genbank COI EU263155 16S EU263225, SEM stubs AW720–723; female preparatory (F2), bl 17.2 mm, AM P.76311, DNA E84 Genbank COI EU263154 16S EU263224, SEM stubs AW724–727; 25 inds, AM P.76309.

Type locality. Australia, Northern Territory, Arnhem Land, escarpment stream south of Gunbalanya, 12°23.00'S, 133°05.20'E. Coll. C. Humphrey, 24.x.1998.

Etymology. This species is named for the place at which it was found, called "Gudjangah" (pronounced "good-jung-are") in the Kunwinjku language by the local people. This species name "gudjangah" was also used for the shrimp *Leptopalaemon gudjangah* Short, Humphrey & Page, 2013.

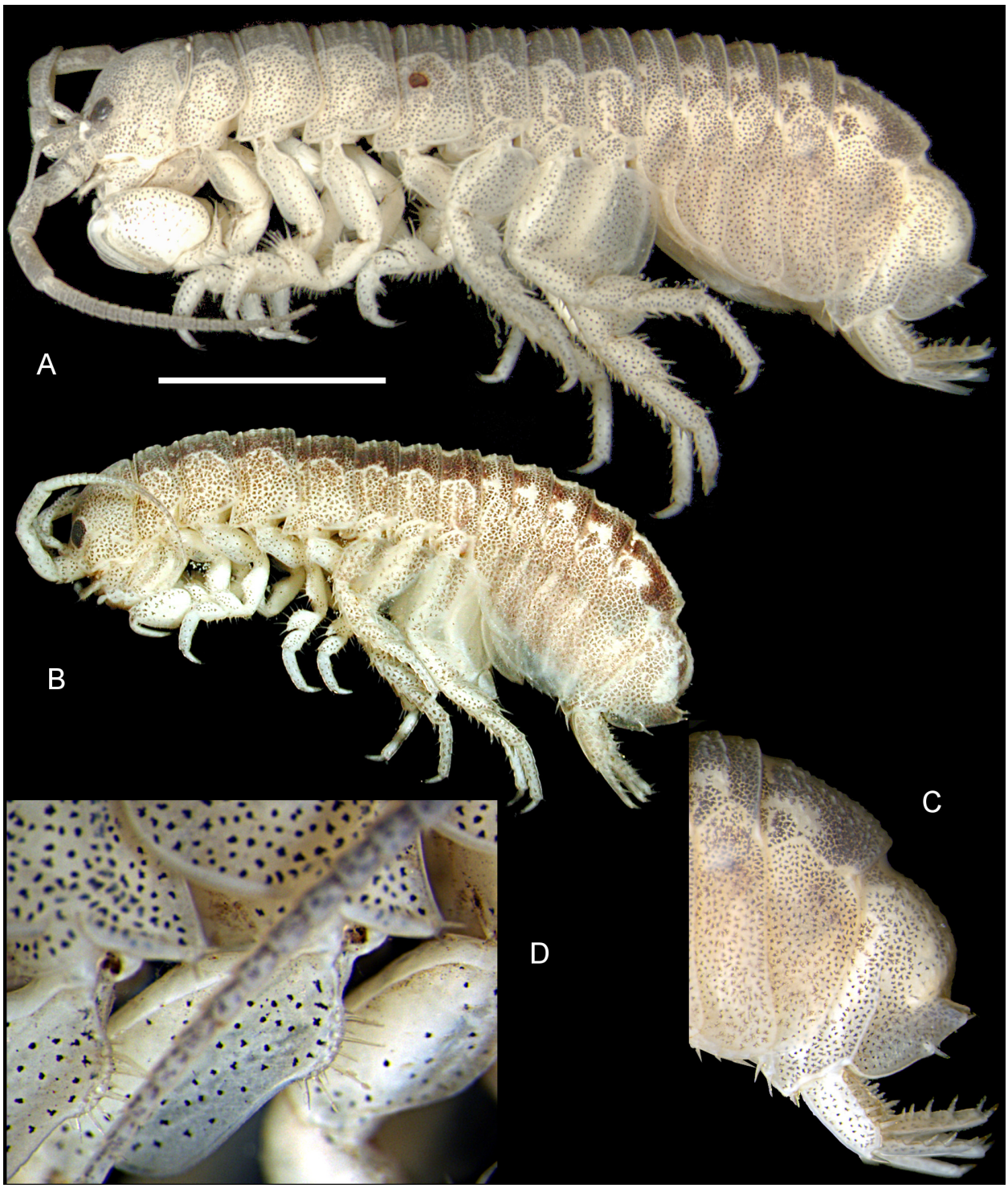

FIGURE 59. *Eophreatoicus gudjangah* sp. nov., habitus of types. Holotype male, AM P.76310: A, lateral; C, pleotelson, lateral; D, bases of pereopods II, III. B, paratype female, AM P.76311, lateral. Scale 5 mm.

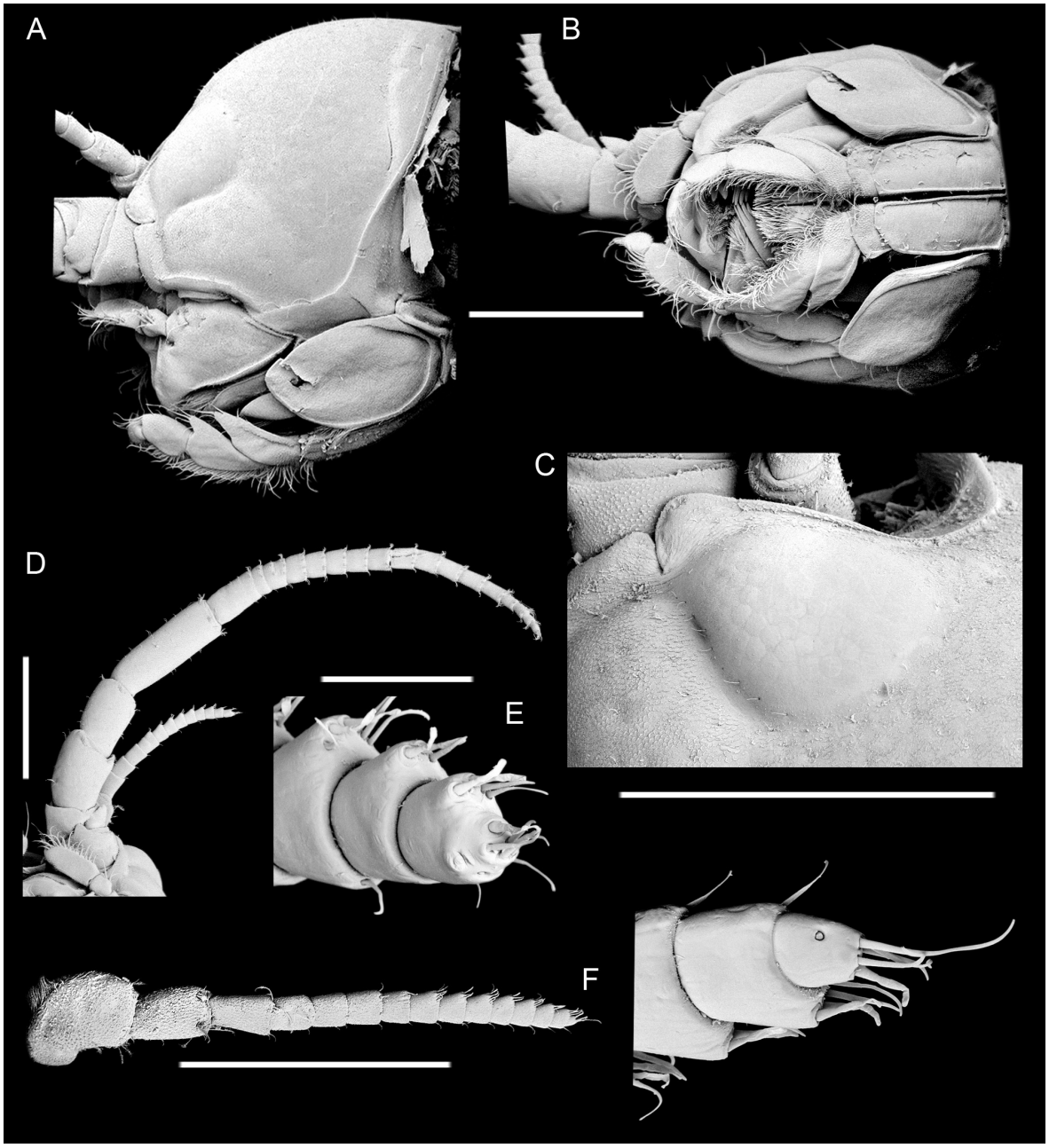

FIGURE 60. *Eophreatoicus gudjangah* sp. nov., paratype male, AM P.76312, head and antennae. A–B, head, lateral and ventral. C, eye and antennal notch. D, antenna and antennula in situ. E, antennula, distal tip. F, antennula ventral, with enlargement of distal tip. Scales, A–D, F 1 mm, E 0.1 mm.

Diagnosis. *Head.* Eyes bulging dorsolaterally, height small, in lateral view less than width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface with tubercles and small scales, increasing posteriorly, less so in younger stages; pereonites 1–4 transverse dorsal ridges rounded, expressed as transverse trough only; pereonites 5–7 transverse dorsal ridges carinate with transverse trough. *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection linear. Dorsal surface rugose, with oblong tubercles, lacking posteromedial ridges or median groups of tubercles. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view distinctly narrowing distally, proximal depth greater than distal depth, with two pairs of robust setae and one median robust seta (median setae smallest, male missing left seta, probably damage), with interdigitating fine setae in same

row as robust setae. *Antenna.* Article 5 shorter than article 4. *Pereopod I.* Dactylus of male ventrodistal margin with multiple rows of thin scale-like spines (scales smaller than in female); female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length less than quarter length of basis, main setal row with 5 major setae. Basis of female dorsal ridge epaulet length less than quarter length of basis, main setal row with 6 major setae. *Pereopod IV.* Propodus of male ventral margin without projection, with 2 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 robust setae distinctly larger than others, separated by shorter seta.

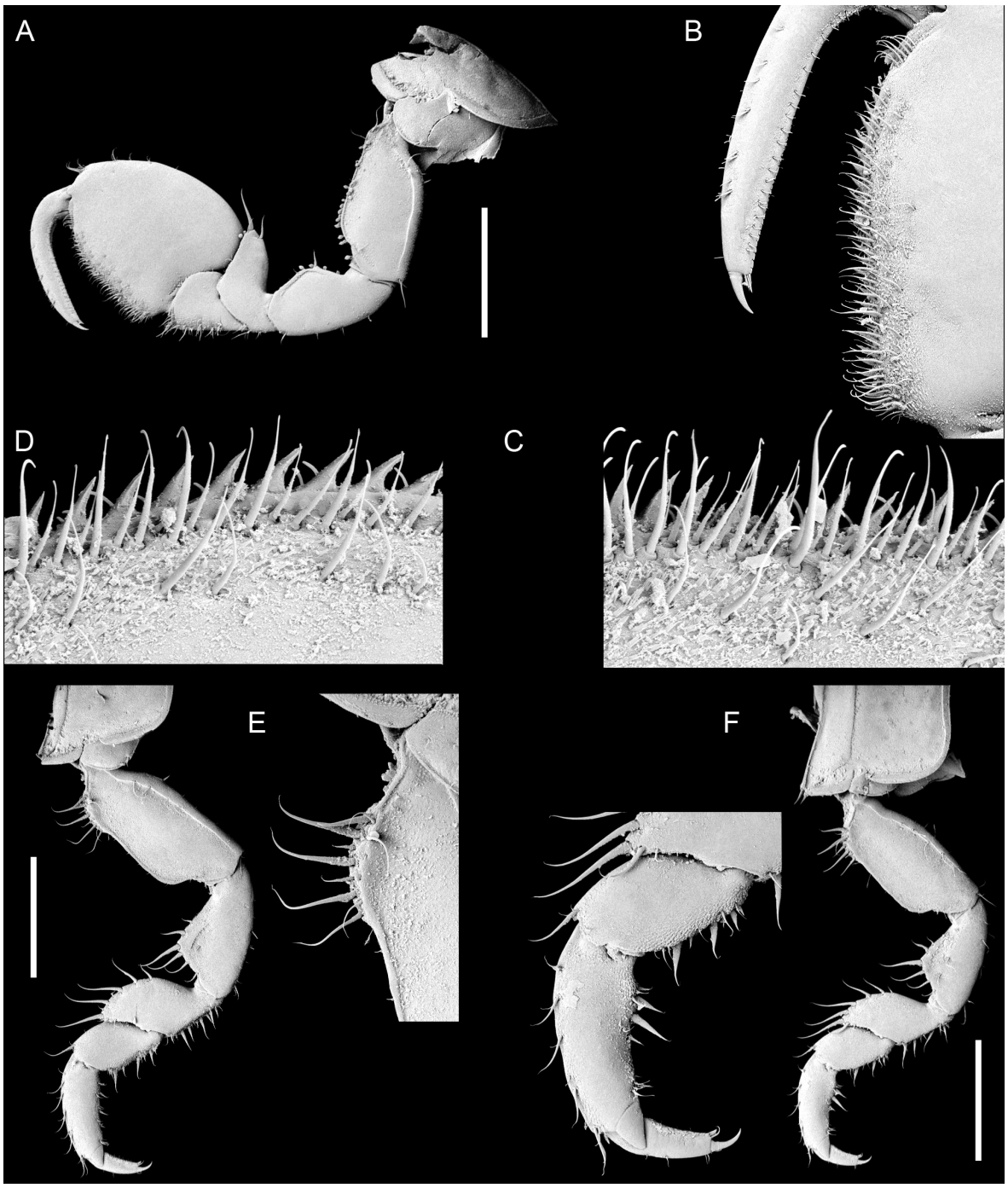

FIGURE 61. *Eophreatoicus gudjangah* sp. nov., paratype male, AM P.76312, anterior pereopods. A–B, pereopod I with enlargement of palm. C–D, pereopod I lateral and medial palm setation. E, pereopod II with enlargement of epaulet on basis. F, pereopod IV, distal segments and entire limb. Scales 1 mm.

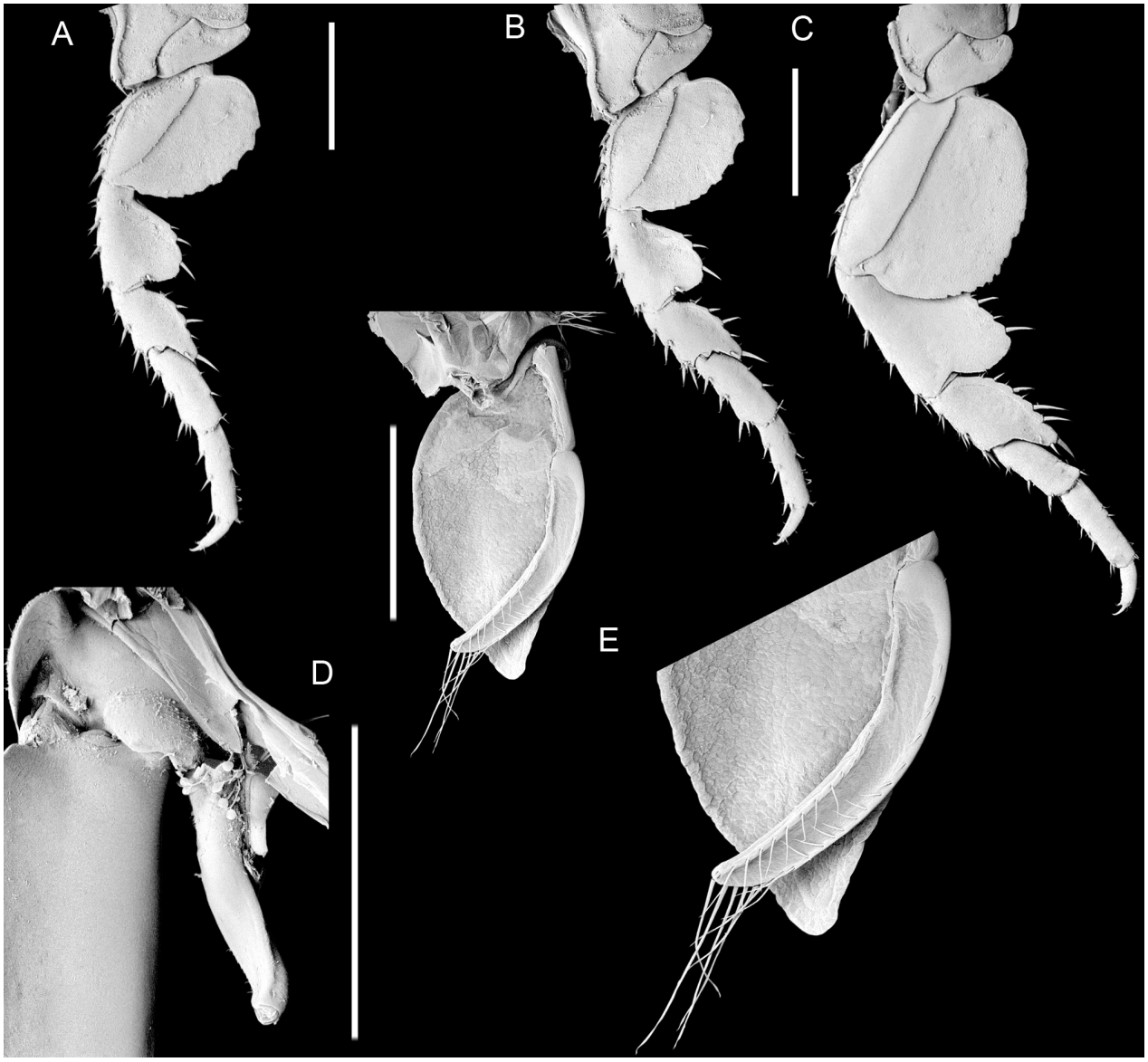

FIGURE 62. *Eophreatoicus gudjangah* sp. nov., paratype male, AM P.76312, posterior pereopods and pleopod II. A–C, pereopods V–VII. D, penes on coxa VII. E, pleopod II with enlargement of appendix masculina. Scales 1 mm.

Description. Body pigmentation light maculate body, with diffuse midline stripe and medium dark irregular bars dorsolaterally; chromatophores dense; length of largest male 22.0 mm, length of largest preparatory female 17.2 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface angularly curved. Dorsal surface pitted; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin straight, orientation of longest axis vertical, maximum diameter 0.21–0.24–0.28 head depth (H, M3, F2), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view smoothly curved. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

Pereon. Width near head width. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–3 in dorsal view respective lengths less than 0.5 pleonite 5 length, pleonite 4 length more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.30 pleonite 1 (H, M3, F2), 1.80–1.90–2.00 pleonite 2 (H, F2, M3), 1.90–2.10–2.20 pleonite 3 (H, F2, M3), 2.00–2.10–2.20 pleonite 4 (H, F2, M3), 1.80–2.00 pleonite 5 (H;M3, F2).

Pleotelson. Dorsal surface length 1.10 width in dorsal view (F2). Dorsal surface sparsely covered with setae; lacking cuticular combs on tubercles. Depth 1.50–1.60 pereonite 7 depth (H, F2;M3). Lateral length less than depth, in male 0.73 depth (M3), in female 0.74 depth. Lateral length 0.12 body length (M3, F2). Lateral surface anterior

to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.40–1.50 width of uropodal insertion (M3, F2), with one row of distally denticulate robust setae, including 5 robust setae altogether (M3, F2), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.13–0.15 pleotelson total length (M3, F). Posterior apex length less than width, long. Posterior apex 0.14 pleotelson total length (F2), width 0.49 pleotelson width (F2). Posterior apex in lateral view forming an angle of 62–97–100° with immediately anterior dorsal surface (F2, H, M3), angled 125–148–158° from horizontal (F2, H, M3).

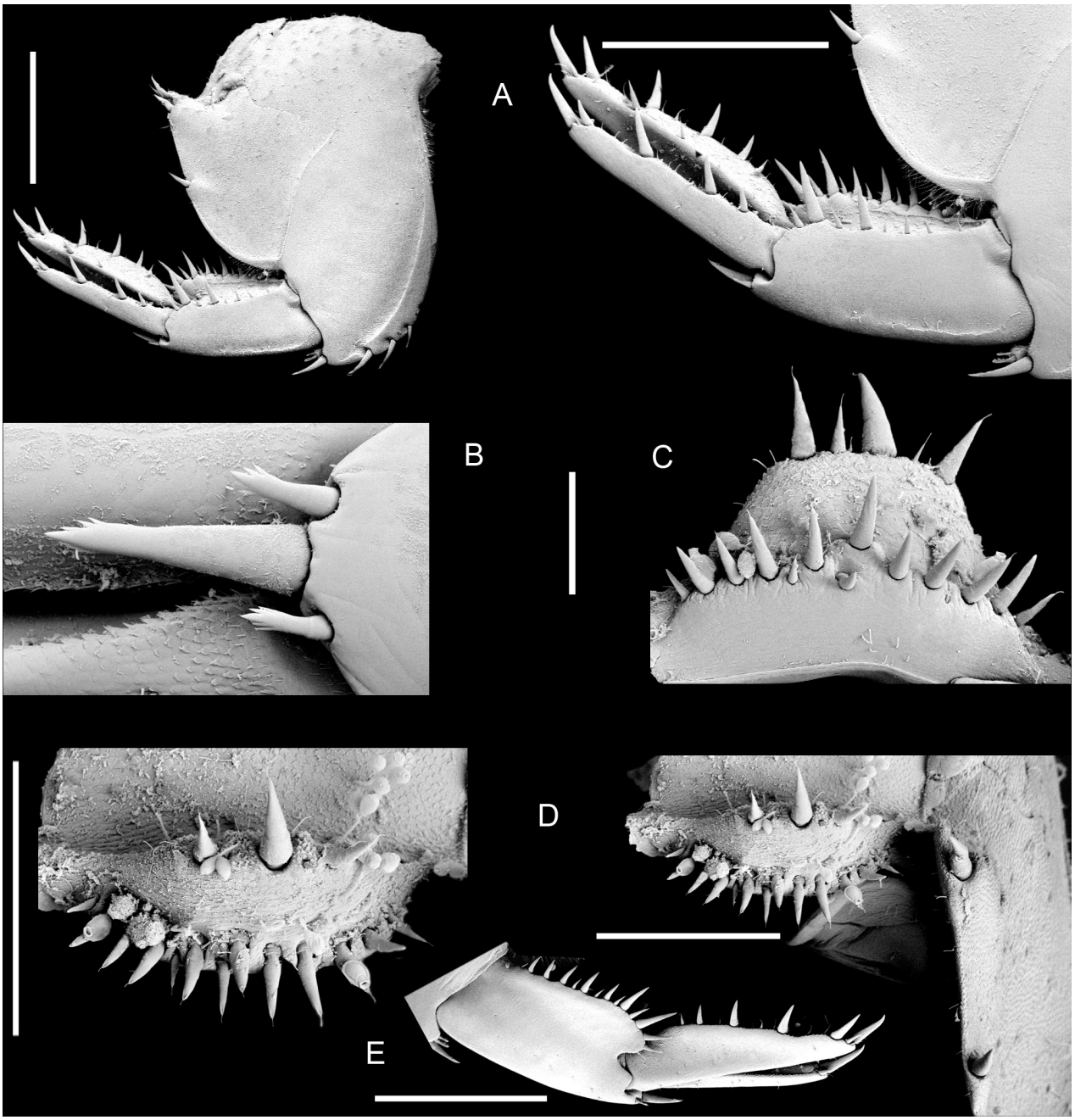

FIGURE 63. *Eophreatoicus gudjangah* sp. nov., paratype male, AM P.76312, pleotelson and uropods. A, lateral, with enlargement of uropod. B, uropod, enlargement of distoventral protopodal setae. C, pleotelson distal tip, ventral showing setal ridge. D, pleotelson distal tip, posterior. E, uropod medial. Scales A, E, 1 mm; B–C, 0.1 mm; D 0.5 mm.

Antennula. Length 0.13 body length in male (M3), 0.12 body length in female (F2), with 15 articles in male (M3), with 16 articles in female (F2). Article 5 length 0.97–1.10 width (M3, F2). Article 6 length 0.68–0.94 width (F2, M3). Aesthetascs small (1–4) mostly on distomedial margins. Terminal article length 0.62–0.99 width (F2, M3), 0.01–0.02 antennula total length (F2, M3). Distal articles in cross–section oval.

Antenna. Length 0.35 body length in male (M3), 0.39 body length in female (F2). Flagellum length 0.55 total antenna length in male (M3), 0.56 total antenna length in female (F2), with 17 articles in male (M3), with 21 articles in female (F2), proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Mouthfield. Clypeus width 0.40 head width (F2).

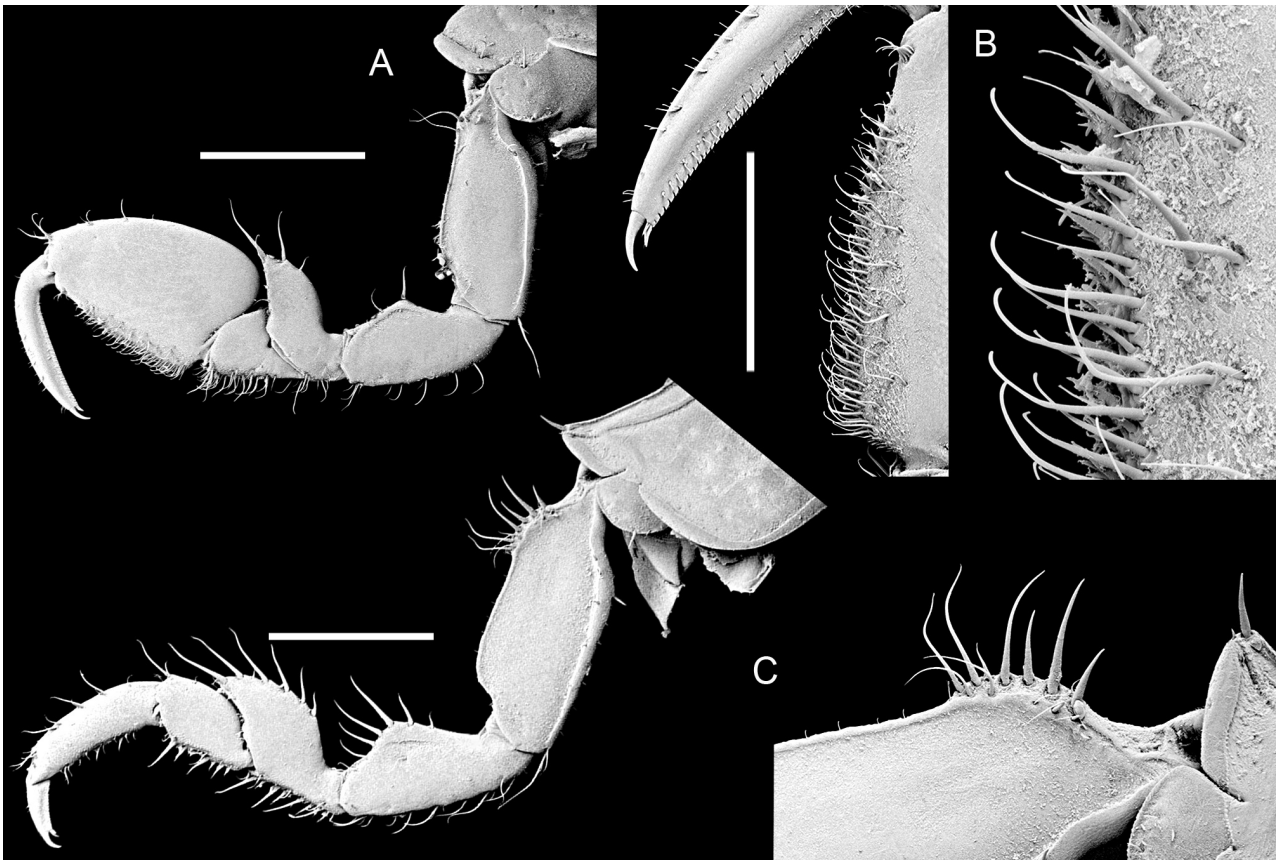

FIGURE 64. *Eophreatoicus gudjangah* sp. nov., paratype female, AM P.76311, anterior pereopods. A, pereopod I, entire, scale 1 mm. B, pereopod I palm and dactylus, scale 0.5 mm, with enlargement of palm setae. C, pereopod II, scale 1 mm, with enlargement of basis and epaulet. Scales A, C, 1 mm; B, 0.5 mm.

Maxilliped. Epipod distal tip rounded, length 1.80 width (F). Endite medial margin with 3 coupling hooks on right side (F2). Endite distal margin in fringe. Palp length 1.10–1.20 basis length (M3, F2). Palp article 4 shape elongate–oval. Palp article 5 length 0.95–1.00 article 4 length (M3, F2).

Pereopod I. Length:body length 0.35–0.38 male (M3, H), 0.32 female (F2). Basis of male length 2.30 width (M3), female length 2.60 width (F2); dorsal setae positioned proximally, 2 dorsal setae altogether (M2); female dorsal setae positioned proximally, female 3 dorsal setae altogether (F2); ventrodistal margin with 2 elongate setae (M3), female with 2 elongate setae (F2), elongate setae longer than ischium. Ischium of male dorsal margin with 1 simple seta, setae not robust. Ischium of female dorsal margin with 2 simple setae (F2), setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with few elongate simple setae, dorsal surface with setae along dorsal axis (2 heavy simple); female distodorsal margin with numerous elongate simple setae, female dorsal surface with setae along dorsal axis (3 simple). Propodus length:pereopod length 0.21 male (M3), 0.19 female (F2). Propodus length:width 1.10 male (M3), 1.30 female (F2). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 8 setae altogether (excluding distal group) (M3), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae articulated, 29 altogether (M3). Propodal palm of female margin convex, with cuticular fringe weakly developed, stout denticulate setae serrate, 23 altogether (F2), with stout robust conical setae, 4 altogether (F2). Dactylus of male length subequal to palm, length:palm length 0.98 (M3), female shorter than palm, female length:

palm length 0.94 (F3). Dactylus of female ventrodistal margin distal cuticular fringe length 0.71 total length (F2). Dactylus claw length:dactylus length 0.13 male (M3), 0.14 female (F2). Dactylus of male positioned ventrally, 0.41–0.50 (M3, F2) length of primary claw.

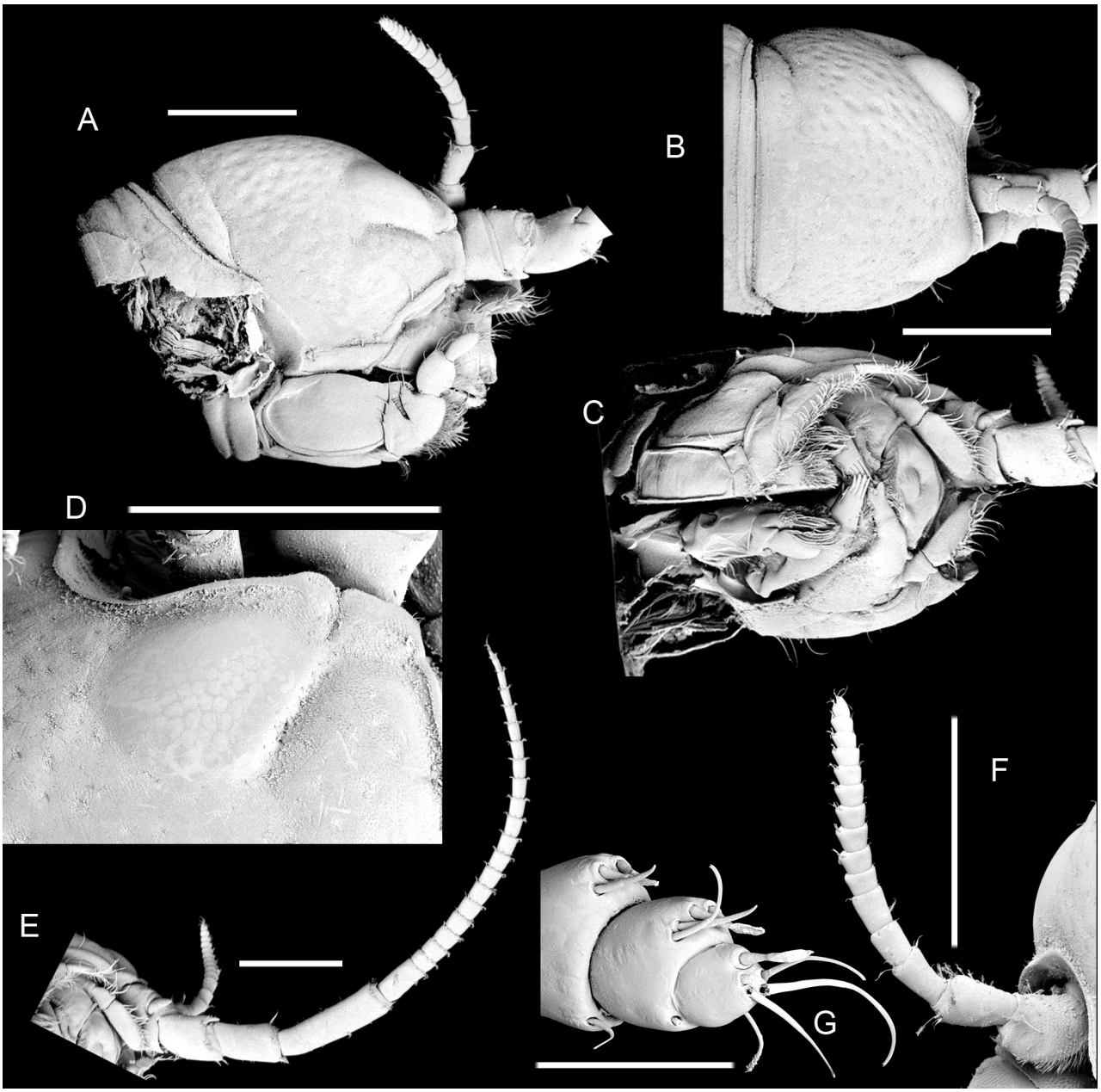

FIGURE 65. *Eophreatoicus gudjangah* sp. nov., paratype female, AM P.76311, head and antennae. A–C, head lateral, dorsal and ventral (one maxilliped removed). D, eye region. E, antenna. F, antennula. G, antennula distal tip. Scales all 1 mm except for G, 0.1 mm.

Pereopods II–III ratios. Pereopod II. Length:body length 0.33–0.34 male (M2, H), 0.32 female (F2). Basis length:pereopod length 0.30 male (M3), 0.30 female (F2); length:width 2.40–2.50 male (M3, H), 2.60 female (F2). Carpus length:pereopod length 0.13 male (M3), 0.12 female (F2); length:width 1.60 male (M3), 1.70 female (F2). Propodus length:pereopod length 0.16 male (M3), 0.16 female (F2); length:width 2.70 male (M3), 3.10 female (F2). Dactylus length:propodus length 0.60 male (M3), 0.56 female (F2); primary claw length:dactylar length 0.27 male (M3), 0.25 female (F2). *Pereopod III.* Length:body length 0.32–0.35 male (M3, H), 0.30 female (F2). Basis length:pereopod length 0.27–0.31 male (M3, H), 0.31 female (F2); length:width 1.90–2.60 male (M3, H), 2.70 female (F2). Carpus length:pereopod length 0.13 male (M3), 0.11 female (F2); length:width 1.70 male (M3), 1.40 female (F2). Propodus length:pereopod length 0.16–0.18 male (H, M3), 0.17 female (F2); length:width 2.80 male (H, M3), 3.20 female (F2). Dactylus length:propodus length 0.50 male (M3), 0.53 female (F2). *Pereopods II–III.*

Penicillate setae scattered on dorsal ridge of basis, carpus, propodus; basis dorsal ridge with setae forming 2 rows on proximal projection, anterior row with 5–6 larger setae and 2 simple (short) setae, posterior row with 5 simple setae. Ischium II–IV of male dorsal margin with 6 simple setae (M3 pereopod II, M3 pereopod IV), none robust. Dactylus ventral to primary claw, 0.28–0.29 length of primary claw, with scales on ventral margin; 14 altogether (F2 pereopod II,approx).

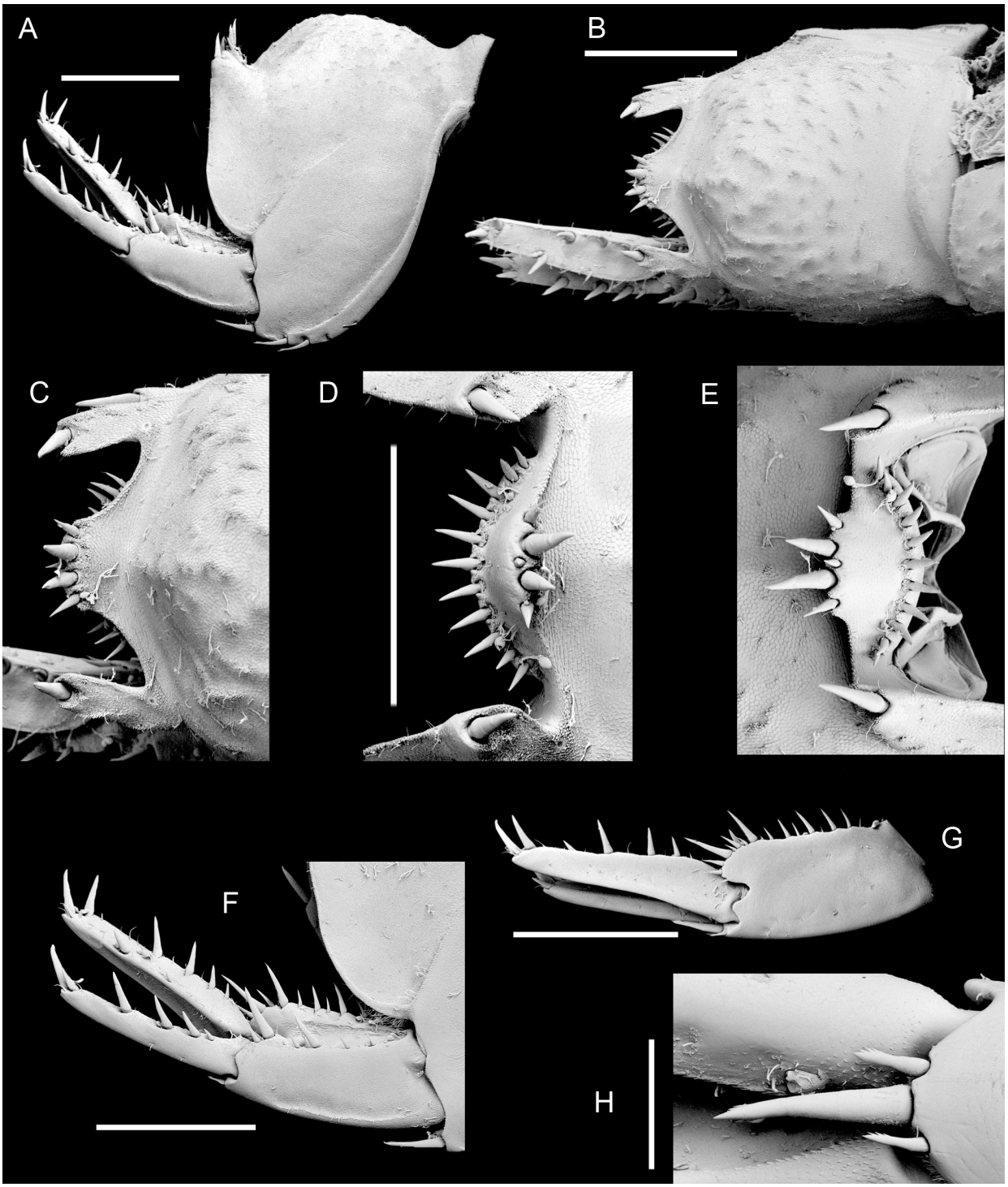

FIGURE 66. *Eophreatoicus gudjangah* sp. nov., paratype female, AM P.76311, pleotelson and uropods. A–B, pleotelson, lateral and dorsal. C–E, terminal apex, dorsal, posterior and ventral, showing postanal ridge setation. F, uropod, lateral. G, uropod, medial. H, protopod distoventral setae. Scales 1 mm, except for H, 0.2 mm.

Pereopod II. Basis lateral face with 3 simple setae proximally in male and 5 simple setae along margin in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 2–3–4 minor setae, submarginal

setal row with 3–3–4 setae, without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 2–2–3 minor setae, submarginal setal row with 3–4–5 setae, without major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 8 setae (M2), dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 6 setae (M3). Carpus of male ventral margin with simple setae only. Propodus of male distal width 0.68 maximum width (M3), setae on ventral margin robust-based, 1 distinctly larger than remainder, longer than dactylar claw (1.1, M3). Dactylus of male distal accessory claw approximately 0.25 primary claw length (M3,0.26). *Pereopod IV ratios.* Length:body length 0.30 male (H, M3). Basis length:width 2.40 male (M3). Carpus length:pereopod length 0.12 male (M3). Propodus length:pereopod length 0.16–0.17 male (M3, H). Propodus length:width 2.10–2.70 male (H, M3).

Pereopods V–VII ratios. Pereopod V. Length:body length 0.30–0.35 male (M3, H), 0.31 female (F2). Basis length:width 1.20–1.30 male (M3, H). Carpus length:pereopod length 0.17 male (M3), 0.14 female (F2). Propodus length:pereopod length 0.15 male (M3), 0.16 female (F2). Dactylus claw length:dactylar length 0.28 male (M3). *Pereopod VI.* Length:body length 0.43–0.47 male (M3, H), 0.41 female (F2). Basis length:width 1.20 male (H). Carpus length:pereopod length 0.17 male (H). Propodus length:pereopod length 0.18 male (M3, H), 0.17 female (F2). *Pereopod VII.* Length:body length 0.35–0.49 male (M3, H), 0.45 female (F2). Basis length:width 1.20 male (H, M3), 1.40 female (F2). Carpus length:pereopod length 0.11–0.16 male (M3, H), 0.15 female (F2). Propodus length:pereopod length 0.13–0.18 male (M3, H), 0.16 female (F2). Dactylus claw length:dactylar length 0.27 male (M3).

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 3–4 setae (M3 pereopod V, pereopod VII). Propodus distal margins with 3–4 elongate robust or robust-based setae (M3 pereopod V, pereopod VII). Dactylus accessory claw 0.30 primary claw length (M3 pereopod V). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with no setae, dorsal margin with 4 setae (M3, likely more, ridge partially covered).

Penes. With cuticular hairs on shaft (minimal, proximally); distally tapering; distal tip truncate.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 2.00 endopod proximal margin length; distally with 7 setae; 32 setae altogether (M3).

Uropod. Of male total length 1.10 pleotelson length (H, M3); protopod of male length 0.46–0.48 uropod total length (M3, H). Uropod of female total length 1.10 pleotelson length (F2), protopod length 0.47 uropod total length (F2). Protopod dorsomedial ridge length:endopod length 0.58 male (M3), 0.68 female (F2). Protopod of male dorsolateral margin subequal to dorsomedial margin setae; of female dorsolateral margin subequal to dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, with spinose setae, 3 robust spinose setae. Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 8 altogether (M3); female dorsal margin with 9 robust setae (F2). Exopod length: endopod length 0.86 male (M3), 0.82 female (F2). Exopod of male dorsal margin with 5 robust setae (M3), female 6 robust setae (F2).

Distribution. Australia, Northern Territory, Eastern Arnhem Land, south of Gunbalanya: a small, unnamed, seasonally-flowing stream arising from the escarpment. The stream is a tributary of another that feeds directly to the East Alligator River floodplain at Gunbalanya.

Habitat. Margin of stream in roots and litter.

Remarks. As mentioned in the remarks for *Eophreatoicus kurdabeyhmay* sp. nov., *E. gudjangah* sp. nov., with *E. indjangarlwurr* sp. nov., appear to be closely related genetically (Fig. 11), while many characters separate them morphologically (Fig. 10). Of the three, *E. gudjangah* sp. nov. lacks an angular projection on the palm of the male pereopod IV propodus, although its difference from that of *E. indjangarlwurr* sp. nov. is small. Externally, *E. gudjangah* sp. nov. has a lightly rugose cuticle and smaller eyes, but not as rugose as the larger eyed *E. indjangarlwurr* sp. nov., which also has a much more pitted head cuticle. They are sister species in the combined morphology-genetics phylogeny (Fig. 12), but *E. gudjangah* sp. nov. pairs with *E. boywek* sp. nov. using morphology alone. These two species can be distinguished by the pereopod II basis epaulet having 5–6 major setae (vs. 4–5) and the pleotelson postanal ridge has 12–13 robust setae (vs. 8–10).

***Eophreatoicus indjangarlwurr* sp. nov.**
(Figs 6C, 67–74)

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Eophreatoicus sp. "12".—Wilson *et al.*, 2009: 361.

Type material. Holotype male, bl 20.3 mm, AM P.76314. Paratypes collected with holotype: male (M2), bl 15.6 mm, AM P.76315, DNA E110 Genbank COI EU263157 16S EU263227, SEM stubs AW666–670; male, AM P.76317, DNA E63 Genbank COI EU263156 16S EU263226; female (F3), bl 11.0 mm, AM P.76316, SEM stubs AW671–674; 19 inds, AM 76313.

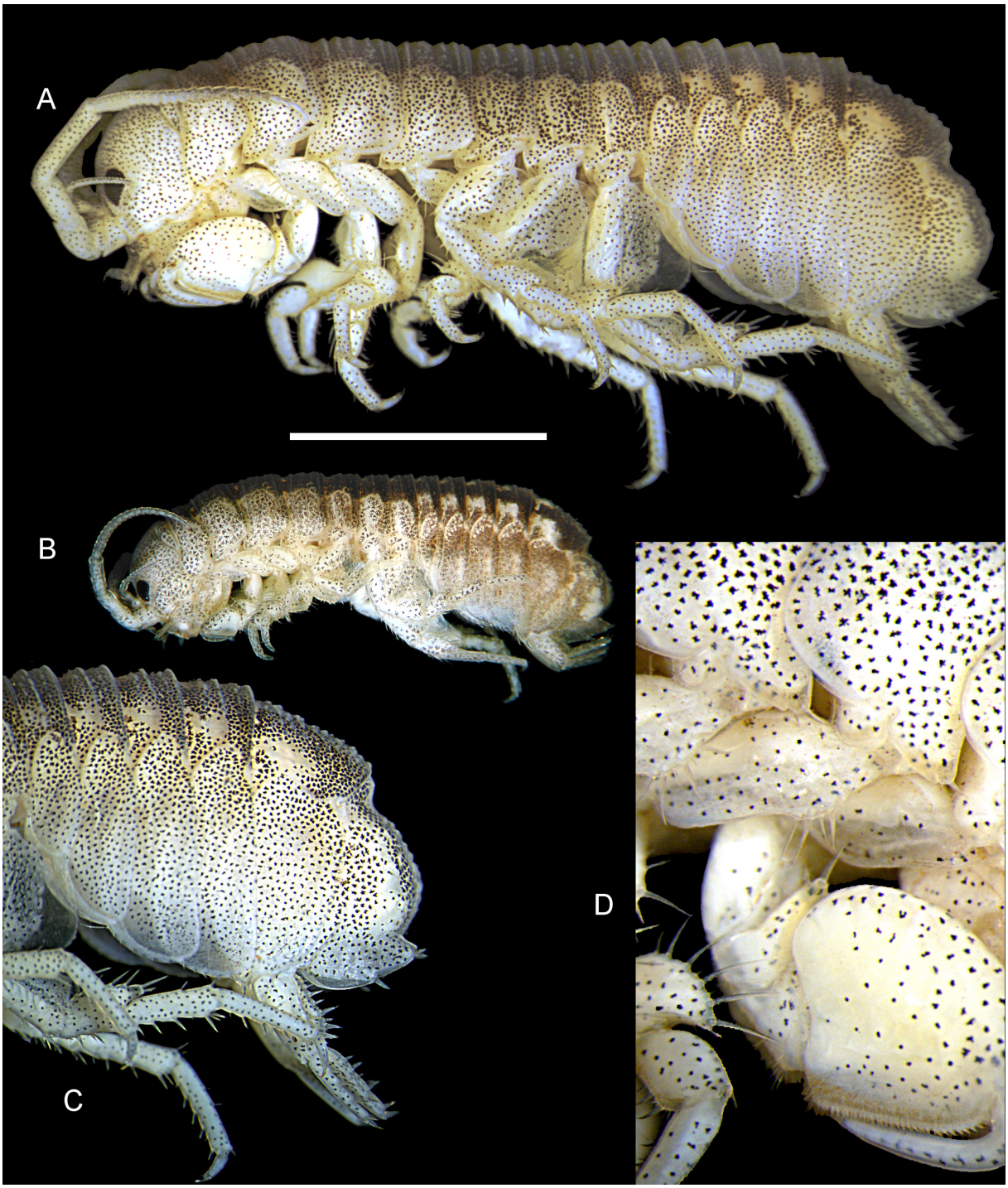

FIGURE 67. *Eophreatoicus indjangarlwurr* sp. nov., habitus of types. Holotype male, AM P.76314: A, lateral; C, posterior part of body; D, pereopod II basis epaulet. B, paratype female, AM P.76316, lateral. Scale 5 mm.

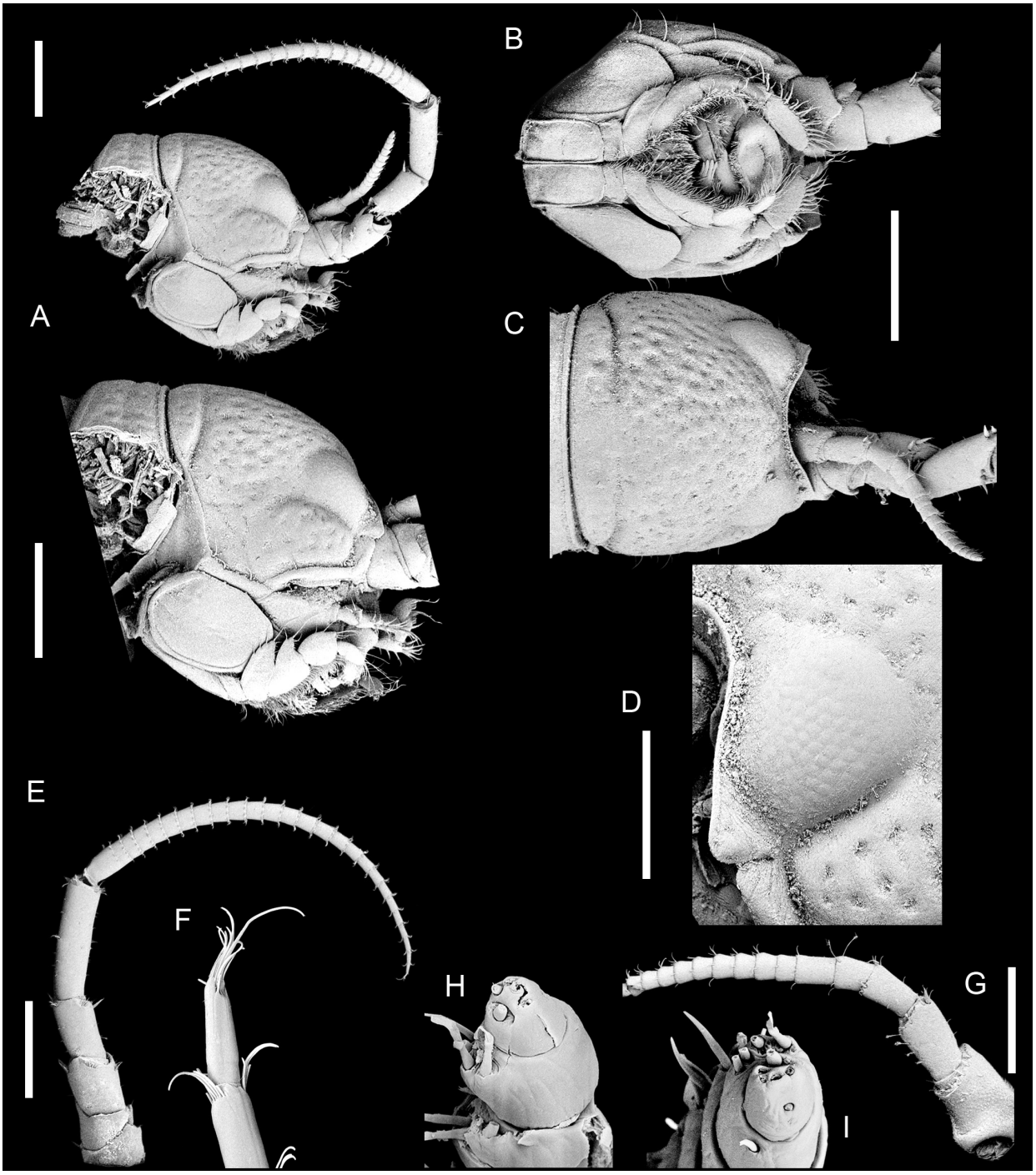

FIGURE 68. *Eophreatoicus indjangarlwurr* sp. nov., head and antennae, paratype male, AM P.76315. A, head and antennae lateral, with enlargement of head. B–C, head, ventral and dorsal. D, enlargement of eye. E–F, antenna with enlargement of distal tip. G–I, antennula, with enlargements of distal tip. Scales A–C, E, 1 mm; D, G, 0.5 mm.

Type locality. Australia, Northern Territory, Arnhem Land, gorge running east-west from Gunbalanya Road, ~1.5 km from road, pools at base of vertical rock wall, water dripping down rock face in gravel under rocks next to rock wall, 12°23.30'S, 133°02.20'E. Coll. G. Wilson & C. Humphrey, 7.vii. 1999.

Etymology. "Indjangarlwurr" (language group Kunwinjku) is name of the area where this species was found, as reported by the local Oenpelli clan. The word is pronounced in the Mengerrdji language as "in-ja-ngarl-woorr", where "ngarl" would rhyme with "Carl" ("rl" is a retroflex sound) and the final "rr" is a tapped sound.

Diagnosis. *Head.* Eyes bulging dorsolaterally, height medium, in lateral view subequal to width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head

in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface scaly or tuberculate, increasing posteriorly, apparent on all life stages; pereonites 1–4 transverse dorsal ridges rounded, expressed as transverse trough only; pereonites 5–7 transverse dorsal ridges carinate with transverse trough. *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection linear. Dorsal surface rugose, with elongate ridge-like tubercles, with several median tubercles, not merging into ridge. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae and one median robust seta (median setae smallest), with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 length subequal to article 4. *Pereopod I.* Dactylus of male ventrodistal margin with row of thin scale-like spines (scales smaller than in female); female ventrodistal margin with single row of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length subequal to quarter basis length, main setal row with 4 major setae. Basis of female dorsal ridge epaulet length subequal to quarter basis length, main setal row with 4 major setae. *Pereopod IV.* Propodus of male ventral margin with projection (slight), with 4 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 robust setae distinctly larger than others, separated by shorter seta.

Description. Body pigmentation dorsally irregularly 3 lined with center line being patches of pigment, mostly on posterior pereonites and pleonites; length of largest male 20.3 mm, length of largest preparatory female 11.0 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Dorsal surface pitted; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin concave, orientation of longest axis vertical, maximum diameter 0.31–0.32–0.33 head depth (M2, F3, H), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view smoothly curved. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

Pereon. Width near head width. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–3 in dorsal view respective lengths less than 0.5 pleonite 5 length, pleonite 4 length more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.40–1.50 pleonite 1 (F3, H), 1.70–2.00 pleonite 2 (F3;H, M2), 2.10–2.30 pleonite 3 (F3;H, M2), 2.10–2.40 pleonite 4 (F3;H, M2), 1.90–2.20 pleonite 5 (F3;H, M2).

Pleotelson. Dorsal surface length 0.94–1.10 width in dorsal view (M2, F3). Dorsal surface sparsely covered with setae; with cuticular combs on tubercles. Depth 1.20 pereonite 7 depth (M2). Lateral length less than depth, in male 0.76 depth (M2), in female 0.77 depth (F3). Lateral length 0.14 body length (H, M2, F3). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.40 width of uropodal insertion (M2, F3), with one row of distally denticulate robust setae, including 8 robust setae altogether (M2, F3), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.15 pleotelson total length (M2, F3). Posterior apex length less than width, long. Posterior apex 0.16–0.23 pleotelson total length (F3, M2), width 0.47–0.48 pleotelson width (F3, M2). Posterior apex in lateral view forming an angle of 71–79–88° with immediately anterior dorsal surface (M2, F3, H), angled 141–144–149° from horizontal (M2, H, F3).

Antennula. Length 0.14 body length in male (M2), 0.14 body length in female (F3), with 16 articles in male (M2), with 14 articles in female (F3). Article 5 length 1.40–1.50 width (M2, F3). Article 6 length 0.76–0.78 width (M2, F3). Aesthetascs small (1–4) mostly on distomedial margins. Terminal article length 1.00 width (F3), 0.01–0.03 antennula total length (M2, F3). Distal articles oval in cross-section.

Antenna. Length 0.48 body length in male (M2). Flagellum length 0.59 total antenna length in male (M2), with 25 articles in male (M2), proximal articles surface smooth, proximal articles distal margin with rosette of short setae.

Mouthfield. Clypeus width 0.40 head width (F3).

Maxilliped. Epipod distal tip rounded, length 1.40 width (M2). Palp article 4 shape elongate-oblong, length 2.30 width (M2). Palp article 5 length 2.80 width (M2), 0.76–0.78 article 4 length (F3, M2).

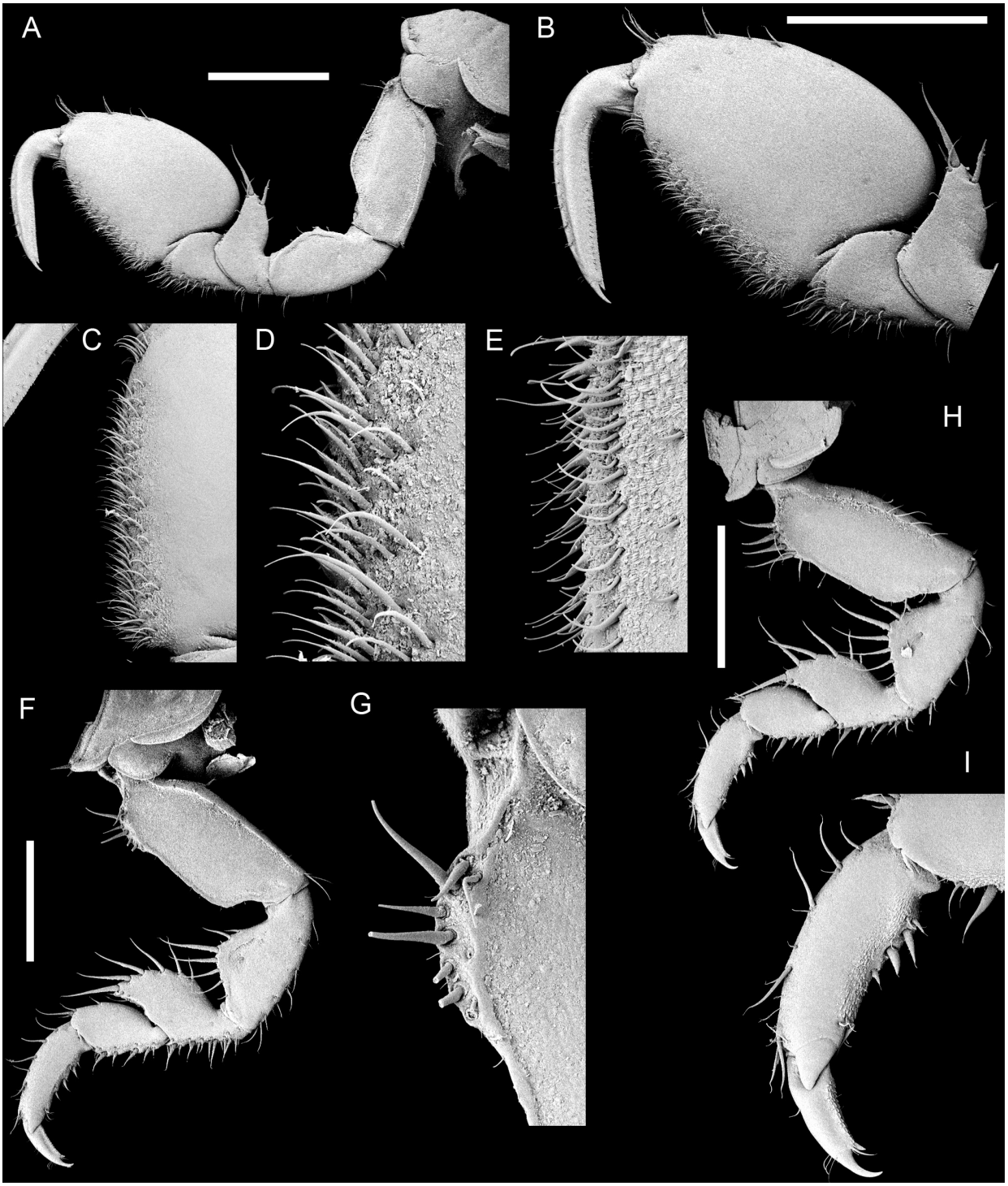

FIGURE 69. *Eophreatoicus indjangarlwurr* sp. nov., anterior pereopods, paratype male, AM P.76315. A–E, pereopod I: A, entire, lateral; B, distal segments; C, enlargement of palm, D–E, lateral and medial of palm setation. F–G, pereopod II with enlargement of epaulet. H–I, pereopod IV with enlargement of propodus and dactylus. Scales 1 mm.

Pereopod I. Length:body length 0.35–0.38 male (H, M2), 0.36 female (F3). Basis of male length 2.00 width (M2), female length 2.50 width (F3); dorsal setae positioned proximally, 3 dorsal setae altogether (M2); female dorsal setae positioned proximally, female 2 dorsal setae altogether (F3); ventrodistal margin lacking elongate setae (short setae only), female with 2 elongate setae (F3), elongate setae shorter than ischium or subequal to ischium (M2, F3). Ischium of male dorsal margin without simple setae. Ischium of female dorsal margin with 2 simple setae (F3), setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (2

heavy simple 1 tiny); female distodorsal margin with few elongate simple setae, female dorsal surface with setae along dorsal axis (2 heavy simple 1 tiny). Propodus length:pereopod length 0.22–0.28 male (M2, H), 0.18 female (F3). Propodus length:width 1.20–1.30 male (M2, H), 1.30 female (F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 5 setae altogether (excluding distal group) (M2), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae proximally on margin articulated, grading distally to articulation not expressed, 31 altogether (M2). Propodal palm of female margin straight, stout denticulate setae serrate, 18 altogether (F3), with stout robust conical setae, 3 altogether (F3). Dactylus of male shorter than palm, length:palm length 0.89 (M2), female length subequal to palm, female length:palm length 0.95 (F3). Dactylus of male ventrodistal margin ventrodistal margin distal cuticular fringe length 0.64 total length (M2); female ventrodistal margin distal cuticular fringe length 0.71 total length (F3). Dactylus claw length:dactylus length 0.10 male (M2), 0.15 female (F3). Dactylus of male positioned ventrally, 0.32–0.33 (F3, M2) length of primary claw.

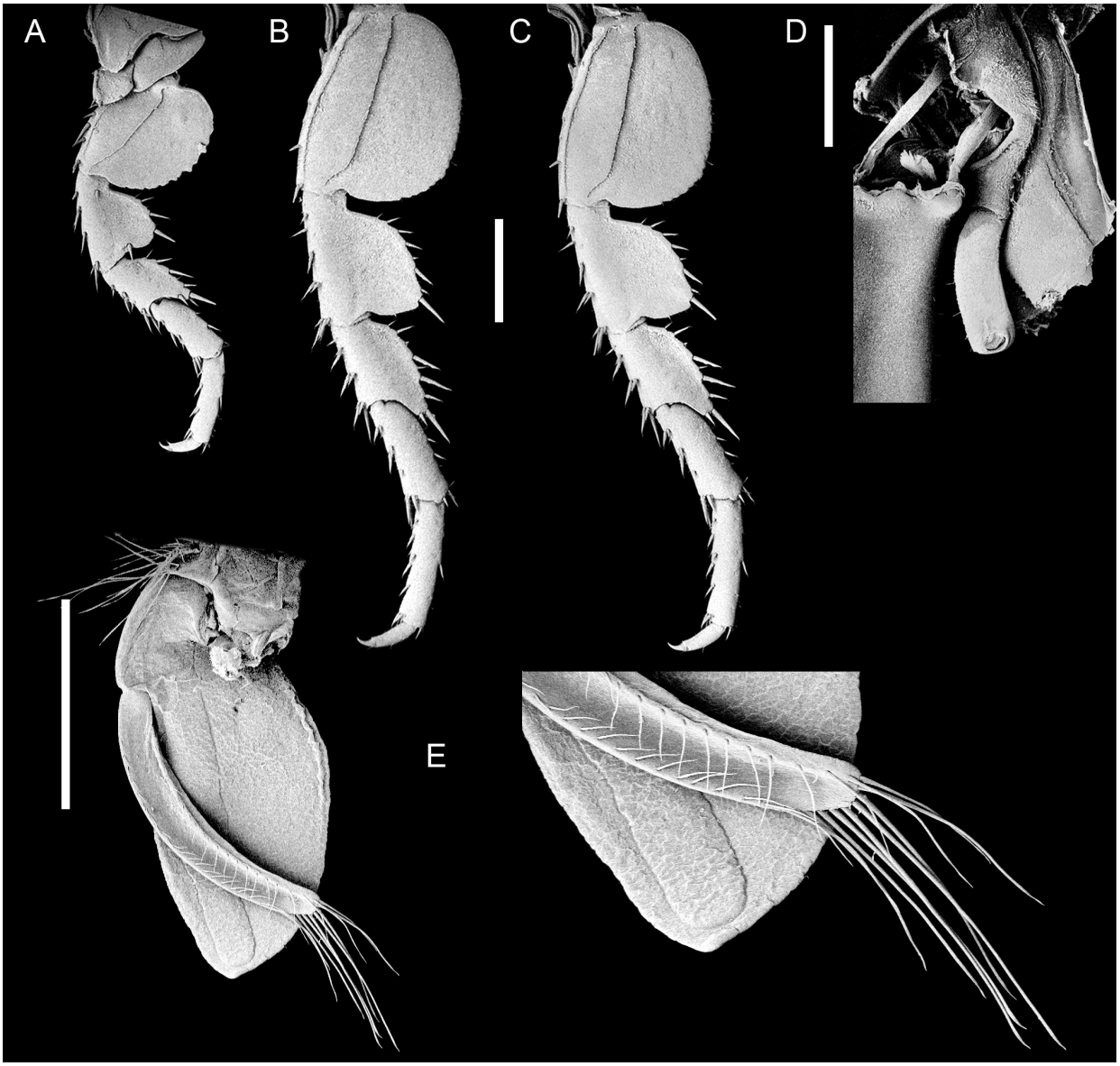

FIGURE 70. *Eophreatoicus indjangarlwurr* sp. nov., posterior pereopods and appendix masculina, paratype male, AM P.76315. A–C, pereopods V–VII, scale 1 mm. D, pereopod VII penes, scale 0.5 mm. E, pleopod II appendix masculina with enlargement of distal setation. Scale A–C, E, 1 mm; D, 0.5 mm.

Pereopods II–III ratios. Pereopod II. Length:body length 0.34–0.38 male (H, M2), 0.36 female (F3). Basis length:pereopod length 0.30–0.31 male (H, M2), 0.29 female (F3); length:width 2.50–2.60 male (H, M2), 2.30

female (F3). Carpus length:pereopod length 0.13 male (M2), 0.13 female (F3); length:width 1.70 male (M2), 1.80 female (F3). Propodus length:pereopod length 0.15–0.16 male (M2, H), 0.16 female (F3); length:width 2.80 male (H, M2), 3.00 female (F3). Dactylus length:propodus length 0.54–0.59 male (H, M2), 0.64 female (F3); primary claw length:dactylar length 0.27 male (M2), 0.29 female (F3). *Pereopod III*. Length:body length 0.31–0.40 male (H, M2). Basis length:pereopod length 0.30–0.31 male (M2, H); length:width 2.60–2.70 male (M2, H). Carpus length:pereopod length 0.08–0.10 male (M2, H); length:width 0.96–1.10 male (M2, H). Propodus length:pereopod length 0.19 male (H, M2); length:width 3.40–3.60 male (H, M2). Dactylus length:propodus length 0.44–0.45 male (H, M2). *Pereopods II–III*. Penicillate setae scattered on dorsal ridge of basis, propodus, dactylus; basis dorsal ridge with setae forming 2 rows on proximal projection, anterior row with 6–7 larger setae and 0–1 simple setae, posterior row with 2–5 setae. Ischium II–IV of male dorsal margin with 7 simple setae (M2 pereopod IV, M2 pereopod II), none robust. Dactylus ventral to primary claw, 0.34–0.36 length of primary claw, with scales on ventral margin; 10–12 altogether (M2 pereopod II, F3 pereopod II).

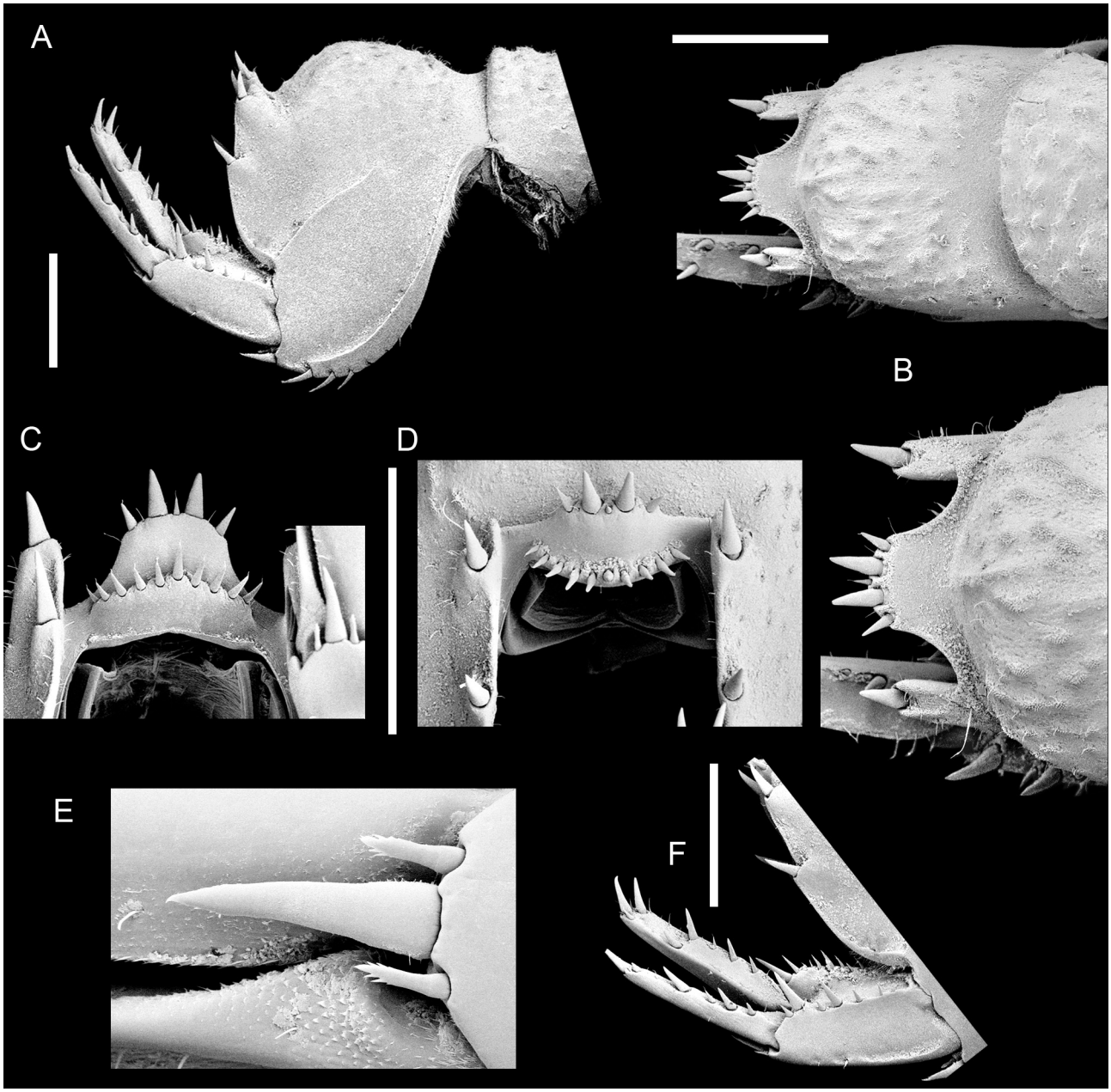

FIGURE 71. *Eophreatoicus indjangarlwurr* sp. nov., pleotelson and uropods, paratype male, AM P.76315. A–D, pleotelson: A, lateral; B, dorsal with enlargement of posterior apex; C–D, apex, ventral and posterior, showing postanal ridge setation. E, uropod protopod distoventral setae. F, uropod in situ, lateral. Scales 1 mm.

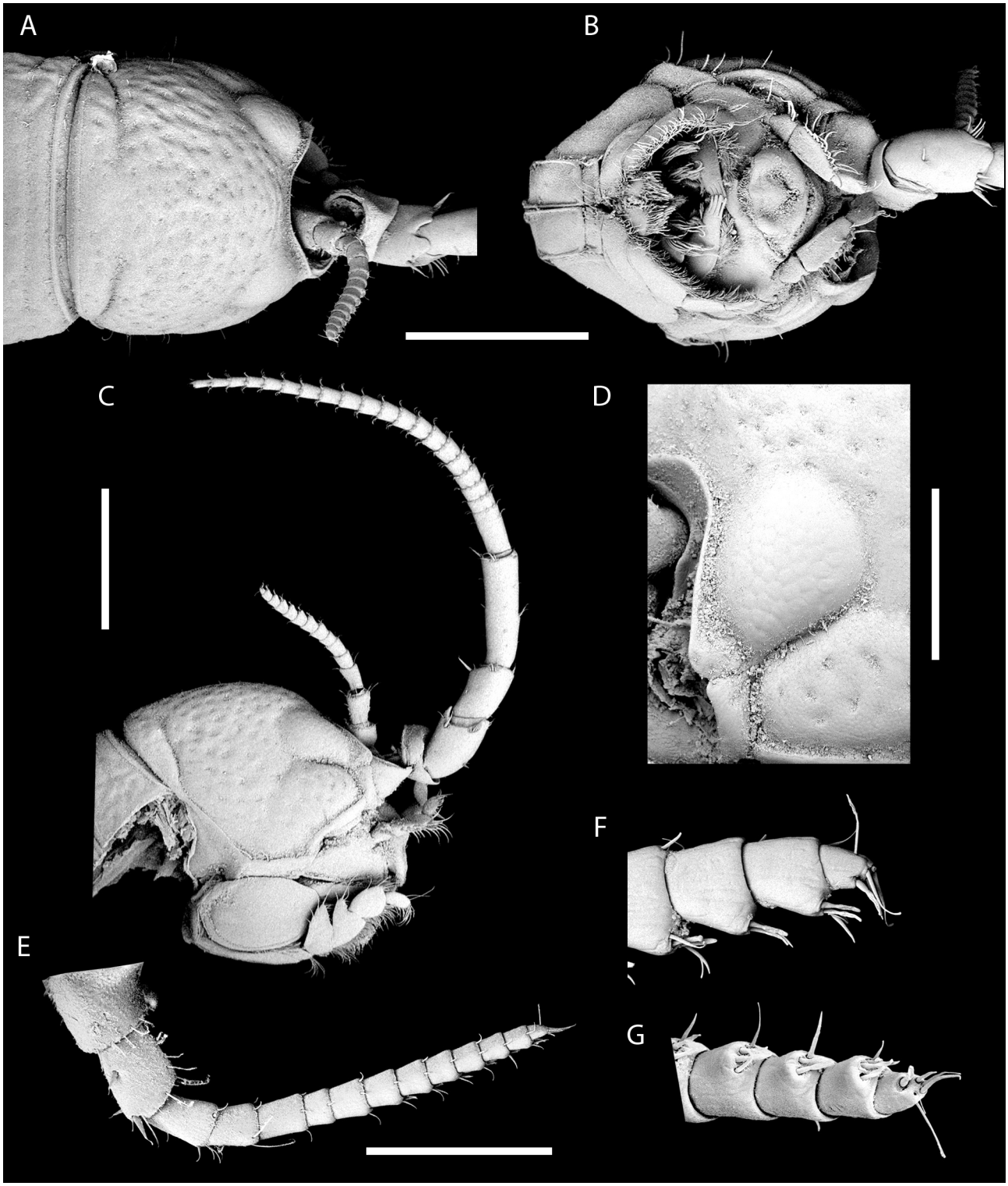

FIGURE 72. *Eophreatoicus indjangarlwurr* sp. nov., head and antennae, paratype female, AM P. 76316. A–C, dorsal, ventral and lateral with antennae, scales 1 mm. D, eye enlargement. E–G, antennula, with enlargements of distal tip, scale 0.5 mm. Scales A–C, 1 mm; D–E, 0.5 mm.

Pereopod II. Basis lateral face with 7 simple setae proximally in male and female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 2–2–4 minor setae (some almost robust), submarginal setal row with 3–3–5 setae, without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 2 minor setae (some almost robust), submarginal setal row with 2–3–3 setae, without major setae distally.

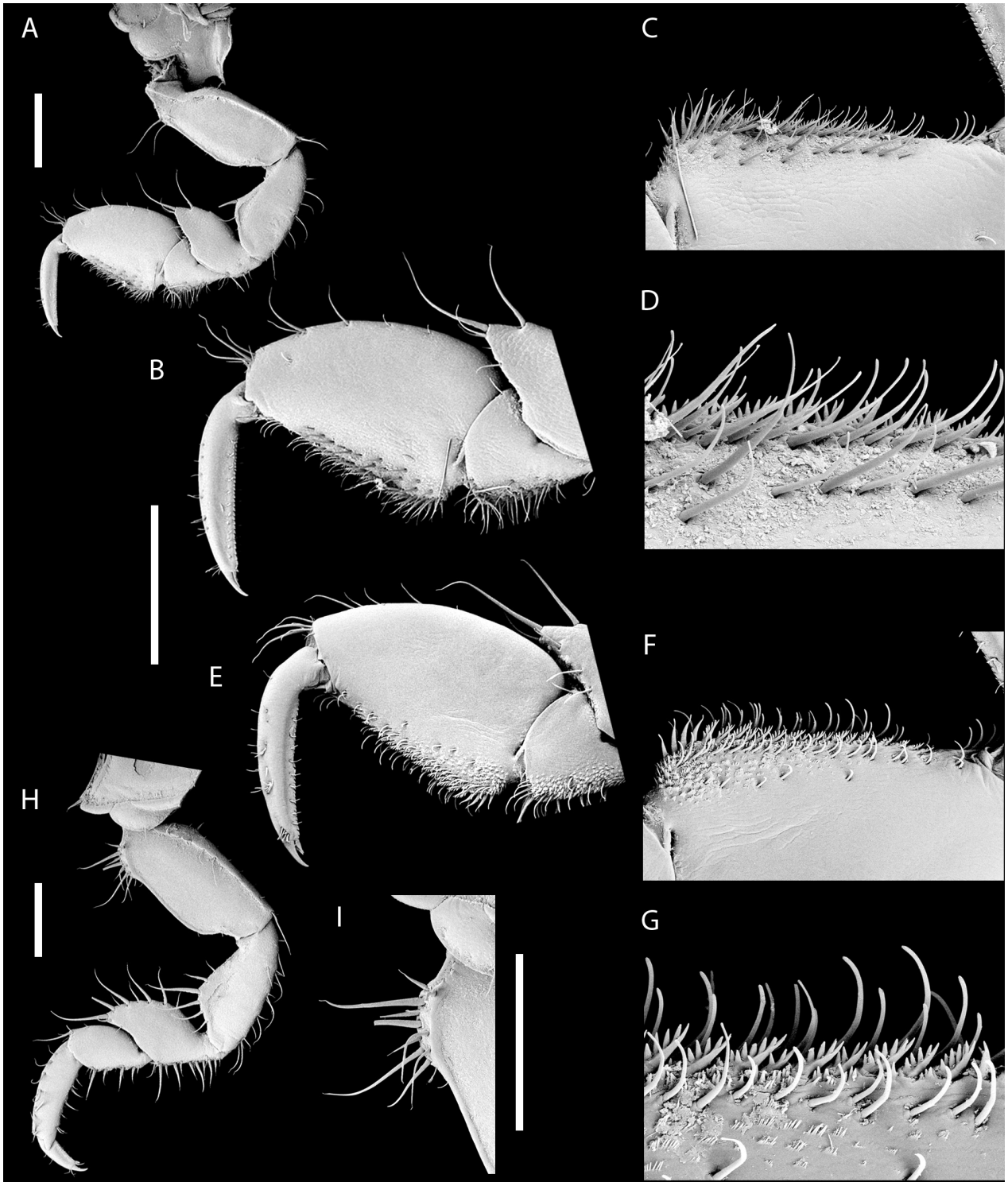

FIGURE 73. *Eophreatoicus indjangarlwurr* sp. nov., pereopods I–II, paratype female, AM P. 76316. A–D, left pereopod I, lateral, with enlargements of distal segments, palm and palm setation. E–G, left pereopod I distal segments, medial, with enlargements of palm and palm setation. H–I, pereopod II with enlargement of basis epaulet setae. Scales 0.5 mm.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 8 setae (M2), dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 7 setae (M2). Carpus of male ventral margin with simple setae only. Propodus of male distal width 0.67 maximum width (M2), setae on ventral margin robust, 2 distinctly larger than remainder, longer than dactylar claw. Dactylus of male distal accessory claw approximately 0.33 primary claw length (0.37, M2). *Pereopod IV ratios.* Length:body length 0.34 male (M2). Basis length:width 2.40 male

(M2). Carpus length:pereopod length 0.12 male (M2). Propodus length:pereopod length 0.16 male (M2). Propodus length:width 2.70 male (M2).

Pereopods V–VII ratios. *Pereopod V*. Length:body length 0.30–0.35 male (M2, H), 0.34 female (F3). Basis length:width 0.96–1.20 male (M2, H). Carpus length:pereopod length 0.16–0.18 male (H, M2). Propodus length: pereopod length 0.18 male (H, M2). Dactylus claw length:dactylar length 0.34 male (M2). *Pereopod VI*. Length: body length 0.42–0.45 male (M2, H), 0.42 female (F3). Basis length:width 1.30 male (M2). Carpus length:pereopod length 0.16–0.17 male (M2, H), 0.13 female (F3). Propodus length:pereopod length 0.17–0.18 male (M2, H), 0.17 female (F3). *Pereopod VII*. Length:body length 0.48–0.49 male (M2, H). Basis length:width 1.30 male (M2). Carpus length:pereopod length 0.15–0.17 male (M2, H). Propodus length:pereopod length 0.16–0.18 male (M2, H). Dactylus claw length:dactylar length 0.30 male (M2).

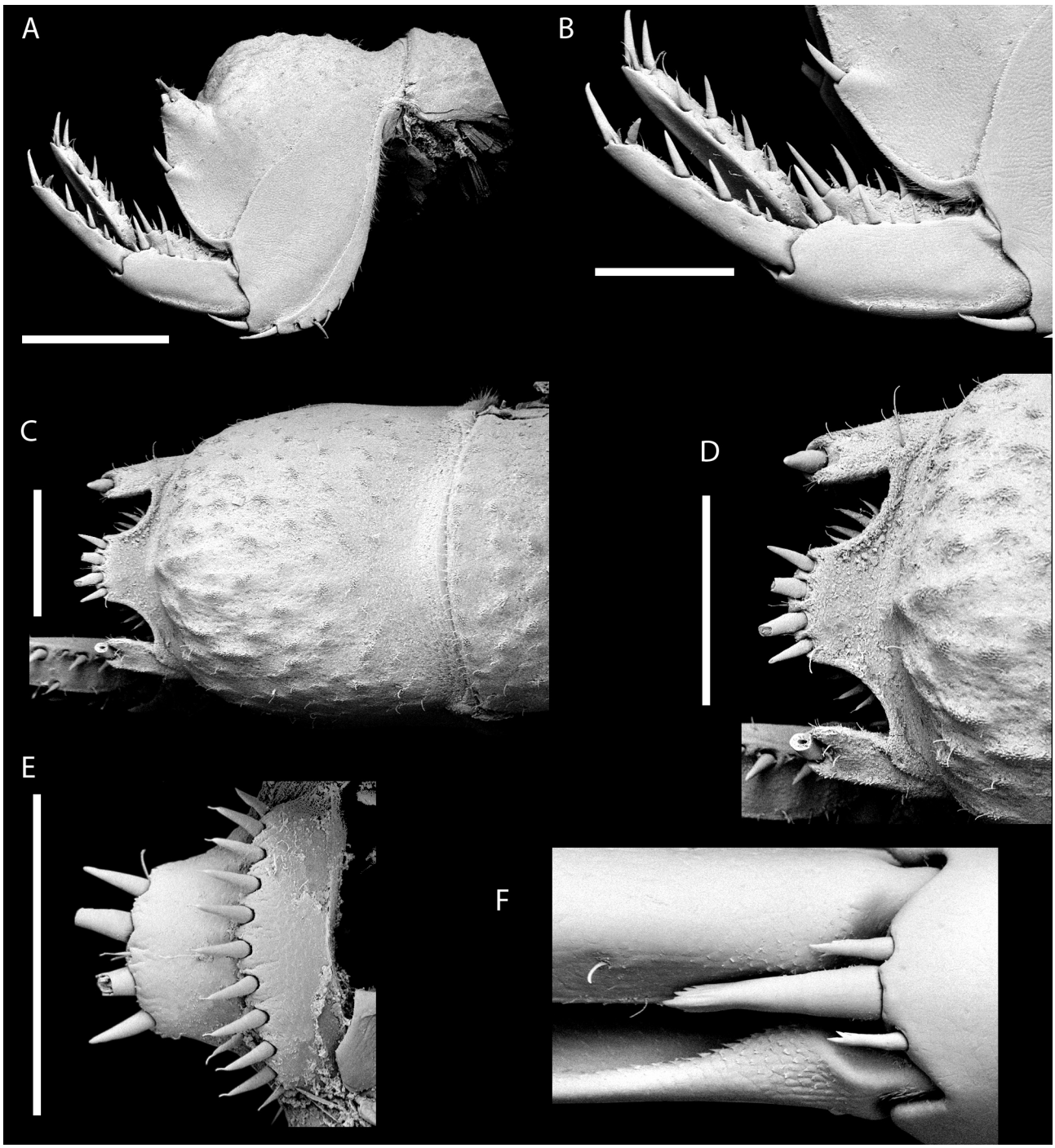

FIGURE 74. *Eophreatoicus indjangarlwurr* sp. nov., pleotelson and uropods, paratype female, AM P. 76316. A–B, lateral with enlargement of uropod. C–D, dorsal with enlargement of posterior vertex. E, postanal ridge setation and posterior vertex, ventral. F, uropod protopod distoventral setae. Scales A, 1 mm; B–E, 0.5 mm.

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 4–8 setae (M2 pereopod V, pereopod VII). Propodus distal margins with 4–5 elongate robust or robust-based setae (M2 pereopod V, pereopod VII). Dactylus accessory claw 0.29 primary claw length (M2 pereopod V). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with 1 seta, dorsal margin with 8 setae (M2).

Penes. Distally tapering; distal tip truncate.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 2.20 endopod proximal margin length; distally with 9 setae; 53 setae altogether (M2).

Uropod. Of male total length 1.00 pleotelson length (H, M2); protopod of male length 0.43–0.50 uropod total length (M2, H). Uropod of female total length 1.00 pleotelson length (F3), protopod length 0.46 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.61 male (M2), 0.58 female (F3). Protopod of male dorsolateral margin subequal to dorsomedial margin setae; of female dorsolateral margin subequal to dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, with spinose setae, 3 robust spinose setae. Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 8 altogether (M2); female dorsal margin with 10 robust setae (F3). Exopod length: endopod length 0.83 male (M2), 0.85 female (F3). Exopod of male dorsal margin with 6 robust setae (M2), female 6 robust setae (F3).

Distribution. Australia, Northern Territory, Eastern Arnhem Land, gorge running east-west from Gunbalanya Road, East Alligator River catchment.

Habitat. In gravel under rocks in pool at base of vertical rock wall and in water dripping down rock face.

Remarks. As mentioned in the remarks for *Eophreatoicus kurdabeyhmay* sp. nov., *E. indjangarlwurr* sp. nov., and *E. gudjangah* sp. nov., appear to be closely related genetically (Fig.11), while multiple characters separate them morphologically (Fig.10). Of the three, *E. indjangarlwurr* sp. nov. has the most rugose cuticle and largest eyes. In the morphological analysis, this species is in a weakly supported clade with both populations of *E. nawurlandja* sp. nov. These two species are distinguished by the pereopod II basis epaulet with four major setae in *E. indjangarlwurr* sp. nov. while the larger epaulet of *E. nawurlandja* sp. nov. has 5–6 major setae.

Eophreatoicus karrkkanj sp. nov.

(Figs 75–81)

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Eophreatoicus sp. "14".—Wilson *et al.*, 2009: 362. — Kilpert & Podsiadlowski, 2010: 36–44.

Type material. Holotype male, bl 19.9 mm, AM P.76319, ERISS A00844, coll. 24.xii.2004. Paratypes collected with holotype: male (M2) 22.8 mm, AM P.76320, DNA E111 Genbank 16S EU263231, SEM stubs AW675–680; female (F3), bl 16.0 mm, AM P.76321, DNA E112 Genbank 16S EU263232, SEM stubs AW681–683; brooding female with embryos, P.76318, complete mitochondrial genome FJ790313 (including COI and 16S); 12 ind, AM P.76318. Additional paratypes: Stockyard Ck 15.xii.1974: 1 ind, DNA E64 (unsuccessful), ex NTMus Cr010943, 8 inds, NTMus Cr010943.

Type locality. Australia, Northern Territory, Kakadu National Park: ERISS A00844, Cannon Hill/Hawk Dreaming, 12°22.50'S, 132°56.20'E. Sites adjacent to type locality with additional paratypes: Hawk Dreaming, 12°22.57'S, 132°56.40'E, coll. 24.xii.2004, A. Cameron, S.-A. Atkins & J. Hanley; Stockyard Creek, coll. 15.xii.1974, Ross Pengilley.

Etymology. The local name for the Hawk Dreaming site is "Karrkkanj" (language group Kundjeyhmi). The name of this species is pronounced "karrk-kanj", where the rr is a tap of the tongue up behind the top teeth and the "kanj" syllable finishes with a "ny" sound as in the "ny" sound in the middle of the word "onion".

Diagnosis. *Head.* Eyes bulging dorsolaterally, height medium, in lateral view subequal to width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface with tubercles and small scales, increasing posteriorly, less so in younger stages; pereonites 1–4 transverse dorsal ridges

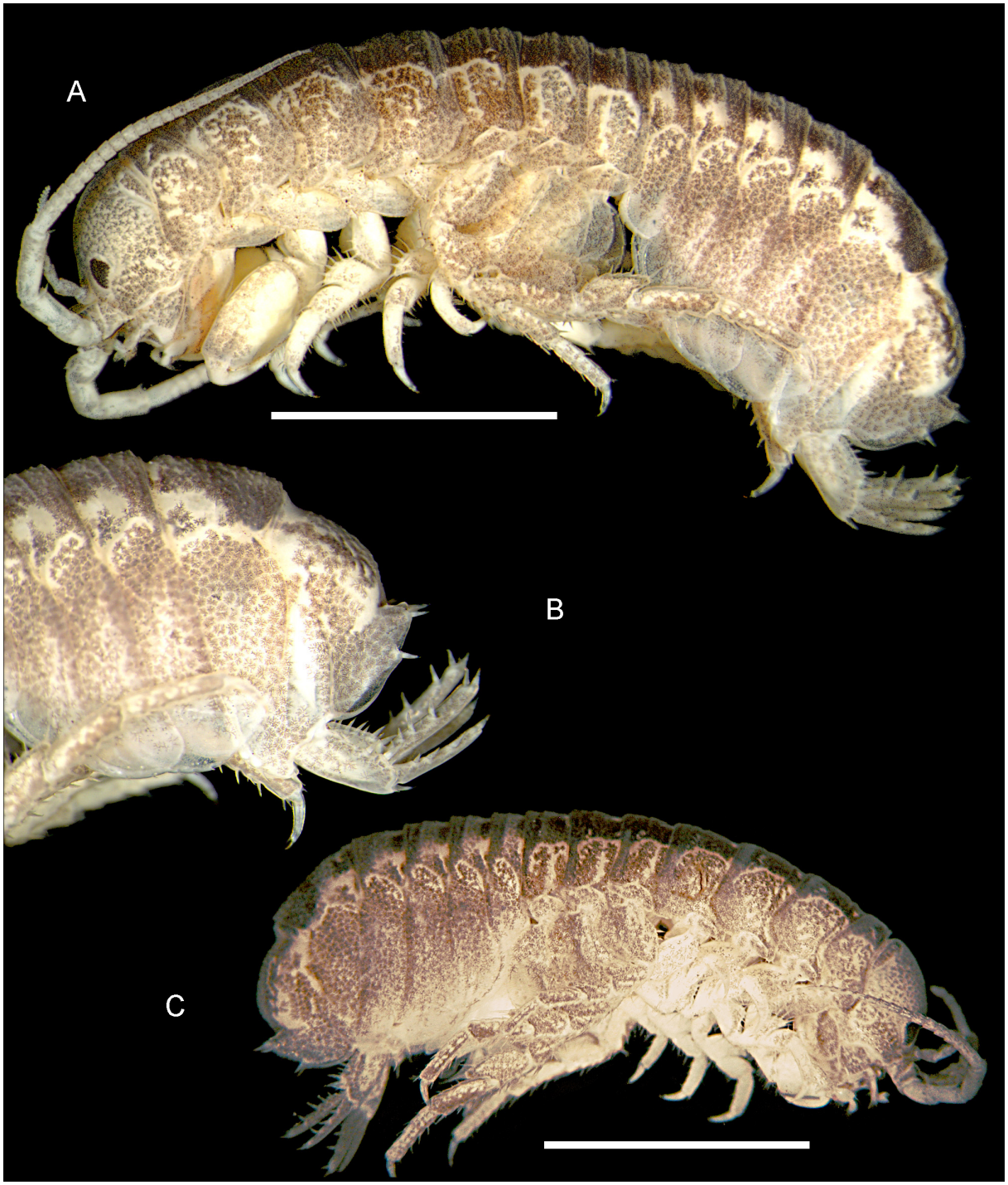


FIGURE 75. *Eophreatoicus karrkkanj* sp. nov., habitus of types. Holotype male, AM P.76319: A, lateral; B, pleotelson enlargement. C, paratype female, AM P.76321, lateral. Scales 5 mm.

not expressed; pereonites 5–7 transverse dorsal ridges low without transverse trough (per 7 only). *Pleonites.* 1–4 transverse dorsal ridges low without transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection linear. Dorsal surface rugose, with oblong tubercles, lacking posteromedial ridges or median groups of tubercles. Posterior apex in lateral view visible. Posterior apex in lateral view distinctly narrowing distally, proximal depth greater than distal depth, with two pairs of robust setae and one median robust seta (middle setae smaller), with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 shorter than article 4 (F3, M2). *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length greater than quarter basis length, main

setal row with 6 major setae. Basis of female dorsal ridge epaulet length greater than quarter basis length, main setal row with 6–7 major setae. *Pereopod IV.* Propodus of male ventral margin with projection, with 6 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 robust setae distinctly larger than others, separated by shorter seta.

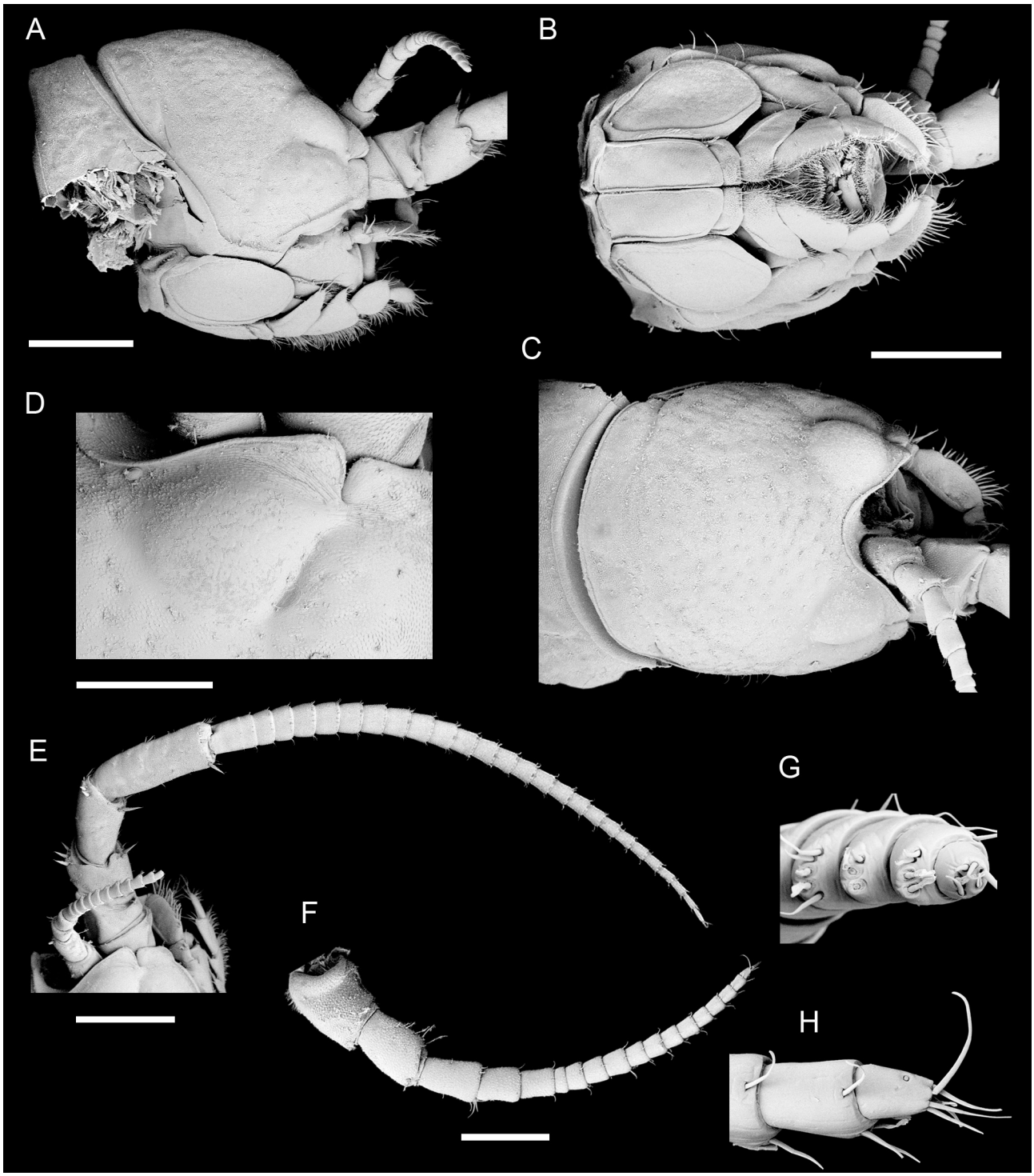


FIGURE 76. *Eophreatoicus karrkkanj* sp. nov., paratype male, AM P.76320, head and antennae. A–C, head, lateral ventral and dorsal. D, eye and antennal notch. E, antenna and antennula, in situ. F–H, antennula, lateral with enlargements of antennular tip. Scale A–C, E, 1 mm; D, F, 0.5 mm.

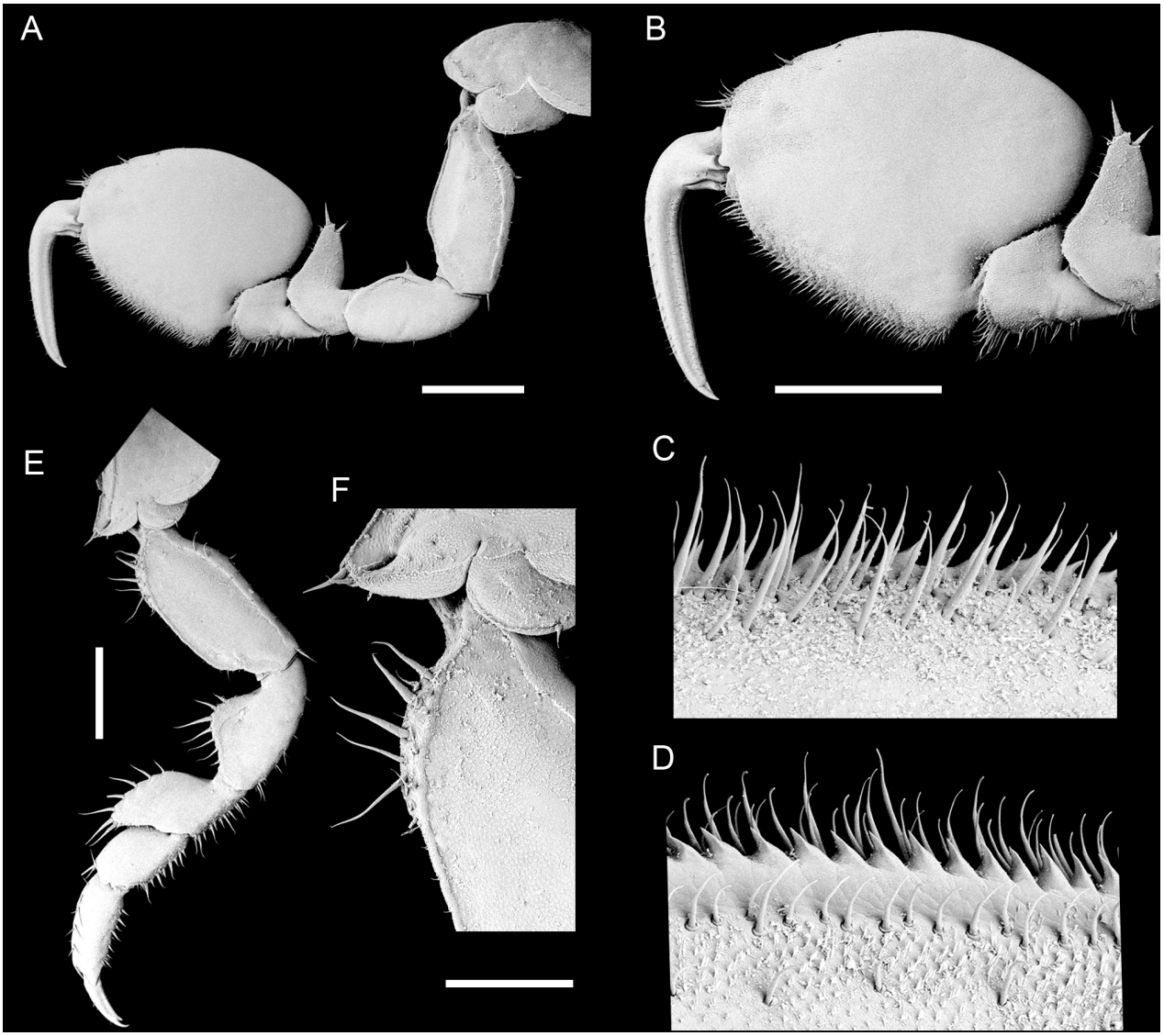


FIGURE 77. *Eophreatoicus karrkkanj* sp. nov., paratype male, AM P.76320, pereopods I–II. A–D, pereopod I entire, distal segments and palm, spine row lateral and medial. E–F, pereopod II entire and enlargement of epaulet. Scales A–B, E, 1 mm; F, 0.5 mm.

Description. Body length of largest male 22.8 mm, preparatory female 16.0 mm.

Head. Length subequal to width in dorsal view; lateral profile of dorsal surface indented behind eye region. Dorsal surface pitted; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin concave, orientation of longest axis vertical, maximum diameter 0.23–0.24 head depth (M2, H), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view straight. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

Pereon. Width near head width. Setae on dorsal surface scattered, fine, length tiny. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2 in dorsal view length less than 0.5 pleonite 5 length, 3–4 respective lengths more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth: pereonite 7 depth 1.50 pleonite 1 (H, F3), 2.00–2.20 pleonite 2 (H, F3), 2.40–2.50 pleonite 3 (H, F3), 2.50 pleonite 4 (H, F3), 2.20–2.50 pleonite 5 (F3, H).

Pleotelson. Dorsal surface length 1.00–1.20 width in dorsal view (M2, F3). Dorsal surface sparsely covered with setae; lacking cuticular combs on tubercles. Depth 1.70 pereonite 7 depth (H). Lateral length less than depth, in male 0.70 depth (M2), in female 0.72 depth (F3). Lateral length 0.13 body length. Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater

than width of uropodal insertion, length 1.80–1.90 width of uropodal insertion (F3, M2), with single row of simple robust setae grading anteriorly to fine setae, including 4 robust setae altogether (M2, F3), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.15 pleotelson total length (M2, F3). Posterior apex length less than width, long. Posterior apex 0.11–0.20 pleotelson total length (F3, M2), width 0.48–0.49 pleotelson width (F3, M2). Posterior apex in lateral view forming an angle of 77–101° with immediately anterior dorsal surface (F3, M2), angled 140–145° from horizontal (F3, M2).



FIGURE 78. *Eophreatoicus karrkkanj* sp. nov., paratype male, AM P.76320, posterior pereopods and male pleopod. A–B, pereopod IV entire with enlargement of distal segments. C, pereopod V. D–E, pereopod VII and penes. F–G, pleopod II endopod with enlargement of appendix masculina. Scales A, C–D, 1 mm; E–F, 0.5 mm.

Antennula. Length 0.16 body length in male (M2), 0.12 body length in female (F3), with 18 articles in male (M2), with 14 articles in female (F3). Article 5 length 1.20–1.50 width (F3, M2). Article 6 length 0.67–0.81 width (M2, F3). Aesthetascs small (1–3) on distomedial margins. Terminal article length 1.40–1.50 width (M2, F3), 0.02–0.04 antennula total length (M2, F3). Distal articles oval in cross-section.

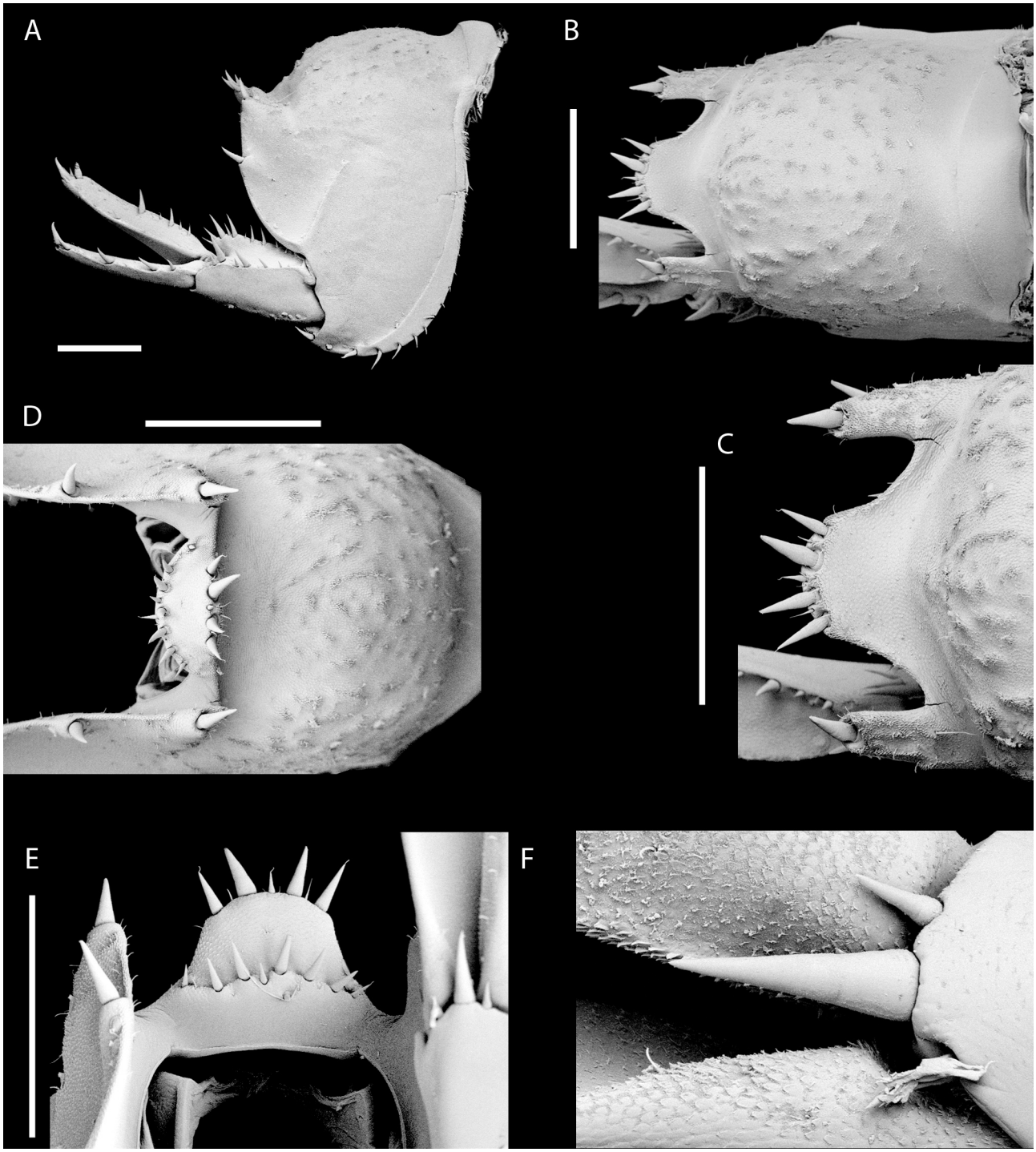


FIGURE 79. *Eophreatoicus karrkkanj* sp. nov., paratype male, AM P.76320, pleotelson and uropods. A, lateral. B–C, dorsal with enlargement of posterior apex. D, posterior. E, posterior apex ventral. F, uropod protopod distoventral setae. Scales 1 mm.

Antenna. Length 0.32 body length in male (M2), 0.38 body length in female (F3). Flagellum length 0.71 total antenna length in male (M2), 0.62 total antenna length in female (F3), with 26 articles in male (M2), with 19 articles in female (F3), proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Maxilliped. Epipod distal tip rounded, length 1.70 width (F3). Endite length 0.51 total basis length (M2). Endite distal margin in fringe. Palp length 1.00 basis length (M2, F3). Palp article 4 shape elongate-oval, length 1.30–1.40 width (M2, F3). Palp article 5 length 1.60 width (M2), 0.66–1.00 article 4 length (M2, F3).

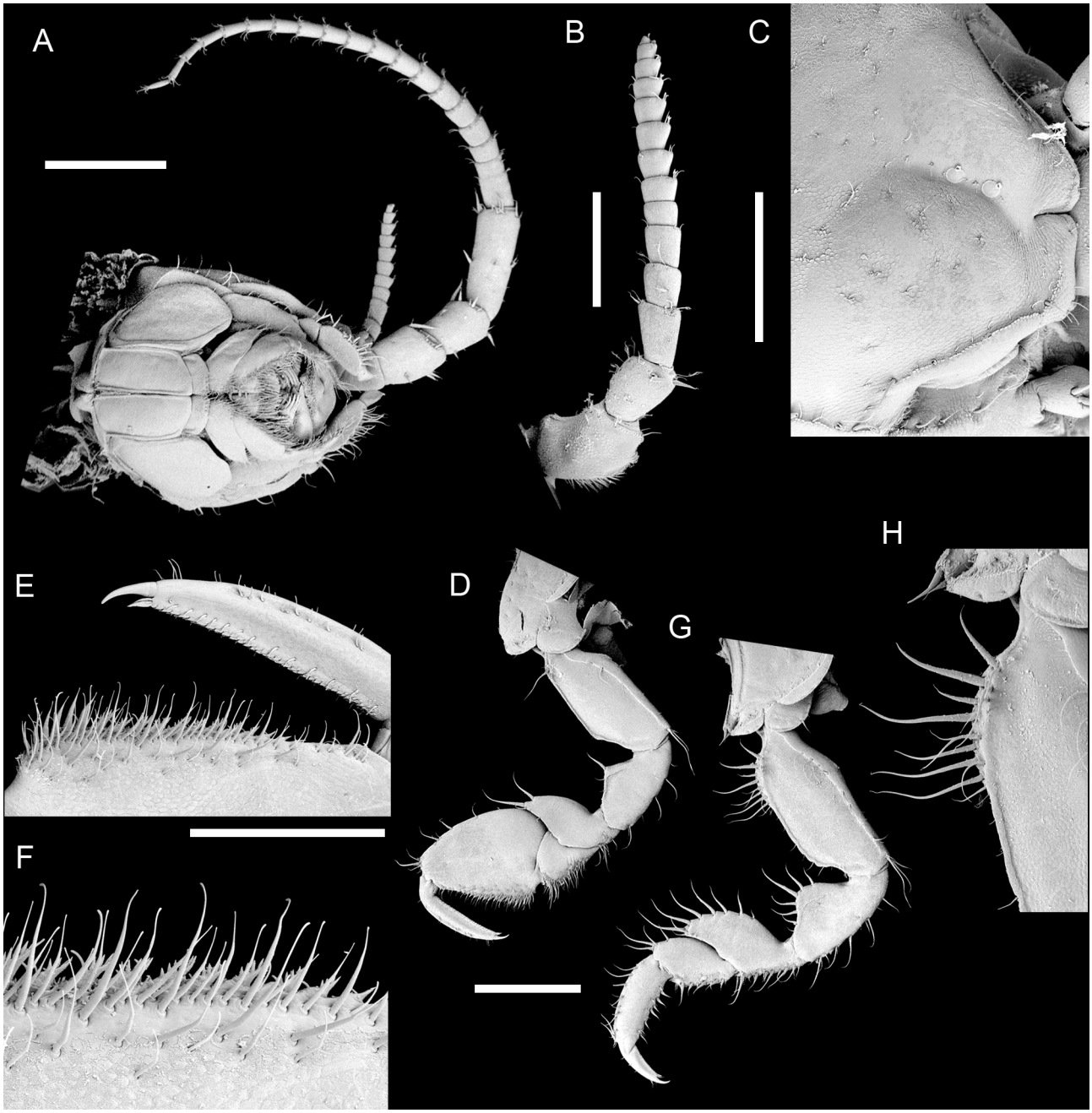


FIGURE 80. *Eophreatoicus karrkkanj* sp. nov., paratype female, AM P.76321. A, head and antennae, ventral. B, antennula. C, eye and cheek, lateral. D–F, pereopod I lateral, palm and enlargement of spine row. G–H, pereopod II with enlargement of epaulet. Scales A, D, G, 1 mm; B–C, E, 0.5 mm.

Pereopod I. Length:body length 0.34 male (M2), 0.33 female (F3). Basis of male length 2.10 width (M2), female length 2.00 width (F3); dorsal setae positioned proximally, 4 dorsal setae altogether (M2); female dorsal setae positioned proximally, female 4 dorsal setae altogether (F3); ventrodistal margin with 1 elongate seta, female with 3 elongate setae (F3), elongate setae subequal to ischium or longer than ischium (M2, F3). Ischium of male dorsal margin with 1 simple seta, setae not robust. Ischium of female dorsal margin with 2 simple setae (F3), setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (2 robust); female distodorsal margin with few elongate simple setae, female dorsal surface with setae along dorsal axis (2 heavy simple). Propodus length:pereopod length 0.22 male (M2), 0.19 female (F3). Propodus length:width 0.97 male (M2), 1.20 female (F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 4 setae altogether (excluding distal group) (M2), proximal region recurved and protruding to distodorsal margin of

carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae articulation not expressed, 30 altogether (M2,approx). Propodal palm of female margin straight, stout denticulate setae serrate, 10 altogether (F3), with stout robust conical setae, 8 altogether (F3, 2 distally and 6 proximally). Dactylus of male shorter than palm, length:palm length 0.91 (M2), female length subequal to palm, female length:palm length 1.00 (F3). Dactylus of female ventrodistal margin distal cuticular fringe length 0.70 total length (F3). Dactylus claw length:dactylus length 0.10 male (M2), 0.17 female (F3). Dactylus of male positioned ventrally, 0.43–0.51 (F3, M2) length of primary claw.

Pereopods II–III ratios. *Pereopod II*. Length:body length 0.31 male (M2), 0.33 female (F3). Basis length: pereopod length 0.31 male (M2), 0.34 female (F3); length:width 2.30 male (M2), 2.50 female (F3). Carpus length: pereopod length 0.12 male (M2), 0.15 female (F3); length:width 1.30–1.50 male (H, M2), 1.50 female (F3). Propodus length:pereopod length 0.16 male (M2), 0.15 female (F3); length:width 2.30–2.50 male (M2, H), 2.50 female (F3). Dactylus length:propodus length 0.58–0.63 male (M2, H), 0.59 female (F3); primary claw length: dactylar length 0.24 male (M2), 0.28 female (F3). *Pereopod III*. Length:body length 0.33 male (M2). Basis length: pereopod length 0.33 male (M2); length:width 2.60 male (M2). Carpus length:pereopod length 0.10 male (M2); length:width 1.20 male (H, M2). Propodus length:pereopod length 0.16 male (M2); length:width 2.80–3.00 male (M2, H). Dactylus length:propodus length 0.50–0.52 male (M2, H). *Pereopods II–III*. Penicillate setae scattered on dorsal ridge of basis, propodus., dactylus. Ischium II–IV of male dorsal margin with 6–7 simple setae (M2 pereopod IV, M2 pereopod II), none robust. Dactylus ventral to primary claw, 0.33–0.43 length of primary claw, with scales on ventral margin (F3, M2); 11 altogether (F3 pereopod II, approx).

Pereopod II. Basis lateral face with 8 short simple setae along margin in male and with 3 simple setae proximally in male and 9 simple setae in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 2–3–4 minor setae, submarginal setal row with 2–4–5 setae, with major setae distal to epaulet, 0–1 major setae (3 out of 5 sample has 1 seta). Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 1–3–6 minor setae, submarginal setal row with 1–3–4 setae, without major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 17 setae (M2), of male dorsal ridge setae positioned along ridge. Ischium of male dorsal margin with 6 setae (M2). Carpus of male ventral margin with simple setae only. Propodus of male distal width 0.77 maximum width (M2), setae on ventral margin robust-based, 2 distinctly larger than remainder (strongly curving distally), longer than dactylar claw. Dactylus of male distal accessory claw approximately 0.33 primary claw length. *Pereopod IV ratios*. Length:body length 0.27 male (M2). Basis length:width 2.30 male (M2). Carpus length:pereopod length 0.14 male (M2). Propodus length:pereopod length 0.16 male (M2). Propodus length:width 2.30 male (M2).

Pereopods V–VII ratios. *Pereopod V*. Length:body length 0.29–0.35 male (M2, H), 0.38 female (F3). Basis length:width 1.00–1.10 male (M2, H), 1.30 female (F3). Carpus length:pereopod length 0.16–0.18 male (H, M2), 0.16 female (F3). Propodus length:pereopod length 0.18–0.19 male (M2, H), 0.17 female (F3). Dactylus claw length:dactylar length 0.28 male (M2). *Pereopod VI*. Carpus length:pereopod length 0.18 female (F3). Propodus length:pereopod length 0.19 male (M2), 0.18 female (F3). *Pereopod VII*. Length:body length 0.42 male (M2). Basis length:width 1.20 male (M2). Carpus length:pereopod length 0.18 male (M2), 0.17 female (F3). Propodus length: pereopod length 0.19 male (M2), 0.17 female (F3). Dactylus claw length:dactylar length 0.21 male (M2).

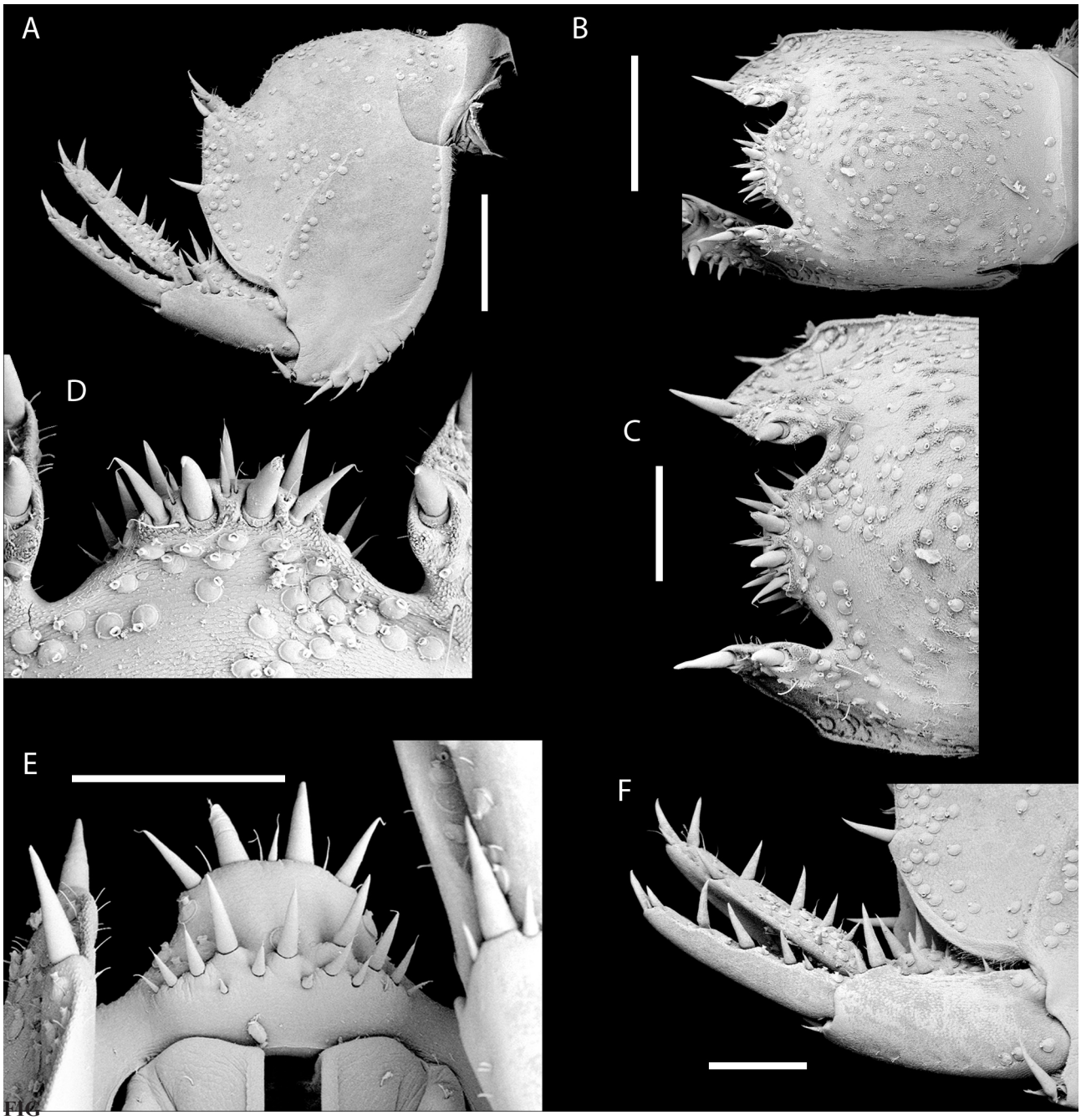
Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae not on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 5 setae (M2 pereopod VII). Propodus distal margins with 5 elongate robust or robust-based setae (M2 pereopod V, pereopod VII). Dactylus accessory claw 0.30–0.34 primary claw length (M2 pereopod VII, pereopod V). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with 1 seta, dorsal margin with 5 setae (M2).

Penes. Length need pereonite 7 pic; distally tapering; distal tip truncate.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 2.00 endopod proximal margin length; distally with 6 setae; 53 setae altogether (M2); distal margin endopod removed.

Uropod. Of male total length 1.20 pleotelson length (H, M2); protopod of male length 0.50–0.59 uropod total length (H, M2). Uropod of female total length 0.93 pleotelson length (F3), protopod length 0.40 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.59 male (M2), 0.51 female (F3). Protopod of male

dorsolateral margin subequal to dorsomedial margin setae; of female dorsolateral margin subequal to dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, with spinose setae, 3 robust spinose setae. Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 8 altogether (M2); female dorsal margin with 9 robust setae (F3). Exopod length: endopod length 0.89 male (M2), 0.89 female (F3). Exopod of male dorsal margin with 5 robust setae (M2), female 6 robust setae (F3).



FIG

URE 81. *Eophreatoicus karrkkanj* sp. nov., paratype female, AM P.76321, pleotelson and uropod. A, lateral. B–D, dorsal with enlargements of distal margin and posterior apex, apex not in plan. E, posterior apex and postanal ridge setation, ventral in plan. F, uropod in situ. Scales A–B, 1 mm; C, E–F, 0.5 mm.

Distribution. Australia, Northern Territory, Kakadu National Park, wetlands around Cannon Hill and Stockyard Creek (Fig. 1G), East Alligator River catchment.

Habitat. At the time of collection, the water pH was 4.7, with low turbidity.

Remarks. Cannon Hill, Hawk Dreaming and Stockyard Creek, where *Eophreatoicus karrkkanj* sp. nov. was collected, are all part of a sandstone outlier group east of the East Alligator River and northeast of the main Arnhem

Plateau on the eastern bank of the river. Cannon Hill is near two other outliers to the east, all of which are surrounded by floodplain. Consequently, this species appears to be geographically isolated from the other species from Kakadu National Park. *Eophreatoicus karrkkanj* sp. nov. is the sister group to *E. djirrinjbal* sp. nov. in the morphological analysis (Fig. 10), even though they are geographically separated by over 14 kilometers. *E. karrkkanj* sp. nov. has medium height eyes (near width of basal articles of the antenna), while *E. djirrinjbal* sp. nov. has smaller eyes. In the combined analysis (Fig. 12), *E. karrkkanj* sp. nov. is the sister group to *E. mok* sp. nov. which has a pereopod II basis epaulet with five major setae, while *E. karrkkanj* sp. nov. has 6–7 setae.

A brooding female of *E. karrkkanj* sp. nov. was sent to a laboratory in Germany where the entire mitochondrial genome was sequenced (Kilpert & Podsiadlowski 2010). Although not relevant to this project, their results showed that this species shares a unique inversion of the mitochondrial control region with other isopods, which appears to be a synapomorphy of the order.

Eophreatoicus ngarradj sp. nov.

(Figs 82–86)

urn:lsid:zoobank.org:act: 8D30F5E5-C16B-4E9C-9FAF-729456C6DB38
Eophreatoicus sp. "N2".— Wilson *et al.*, 2009: 362.

Type material. Holotype male, bl 15.9 mm, AM P.76380, ERISS A00846. Paratypes collected with holotype: male (M7), bl 15.2 mm, AM P.76381, DNA E89 Genbank COI EU263194 16S EU263266, SEM stubs AW752–756; female brooding (F8), bl 12.2 mm, AM P.76382, DNA E90 Genbank COI EU263195 16S EU263267, SEM stubs AW757–760; 23 inds, AM P.76379 female (F4) sequenced by Ronald Jenner, Genbank 16S MN015024, female (F5) sent to L. Podsiadlowski. Additional paratypes, ERISS A00845: 25 inds, AM P.76378.

Type locality. Australia, Northern Territory, Kakadu National Park, coll. A. Cameron S-A. Atkins & J. Hanley: ERISS A00846, Ngarradj site 2, 12°28.20'S, 132°55.67'E, 24.xii.2004. Sites adjacent to type locality with additional paratypes: ERISS A00845, Ngarradj site 1, 12°28.13'S, 132°55.41'E, 23.xii.2004.

Etymology. The name of this species "Ngarradj" (language Kundjeyhmi) is shortened from the term "Ngarradj Bawarddedjobkeng", meaning "Cockatoo split the rock". This is the local clan's name for the stream system previously referred to as "Swift Creek". The word is a single morpheme of two syllables, "nga-rradj". The tapped rr sound resembles a "d" said quickly, so it is pronounced "nga-duj", where "duj" rhymes with "judge". Ngarradj is one of several dreaming ("Djang") sites near the Jabiluka mine lease.

Diagnosis. *Head.* Eyes bulging dorsolaterally, height large, in lateral view greater than width of basal antennal articles, height greater than length in lateral view, bulging in dorsal view, projecting from head in distinct arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface smooth (without roughness or tubercles); pereonites 1–4 transverse dorsal ridges not expressed; pereonites 5–7 transverse dorsal ridges low without transverse trough. *Pleonites.* 1–4 transverse dorsal ridges low without transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection concave. Dorsal surface rugose, with oblong tubercles, with several median tubercles, not merging into ridge. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae (M7 has 5 robust setae: 2 large middle ones and 2 smaller ones as usual, but with an even smaller extra seta on one side), with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 length subequal to article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with single row of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length subequal to quarter basis length (M7, 0.26), main setal row with 6 major setae. Basis of female dorsal ridge epaulet length greater than quarter basis length (F8, 0.32), main setal row with 6 major setae (7–8). *Pereopod IV.* Propodus of male ventral margin with projection, with 4 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 adjacent robust setae distinctly larger than others.

Description. Body length of largest male 15.9 mm, brooding female 12.2 mm.



FIGURE 82. *Eophreatoicus ngarradj* sp. nov., types, lateral. A, holotype male, AM P.76380; B, paratype brooding female, bl 12.2 mm, AM P.76382. Scales 5 mm

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Dorsal surface pitted (shallow but depression with seta); setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin concave (ventral margin slightly concave), orientation of longest axis vertical, maximum diameter 0.29–0.34 head depth (H; M7, F8), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view sigmoidal (sigmoidal in dorsal view). Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

Pereon. Width near head width. Setae on dorsal surface not visible. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–4 in dorsal view respective lengths equal to or more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior (length of pleonite 2 and 3 subequal in H and F8 (not in M7)). Pleonites depth:pereonite 7 depth 1.40 pleonite 1 (H, F8), 1.90 pleonite 2 (H, F8), 1.90–2.10 pleonite 3 (F8, H), 1.90–2.10 pleonite 4 (F8, H), 1.70–2.00 pleonite 5 (F8, H).

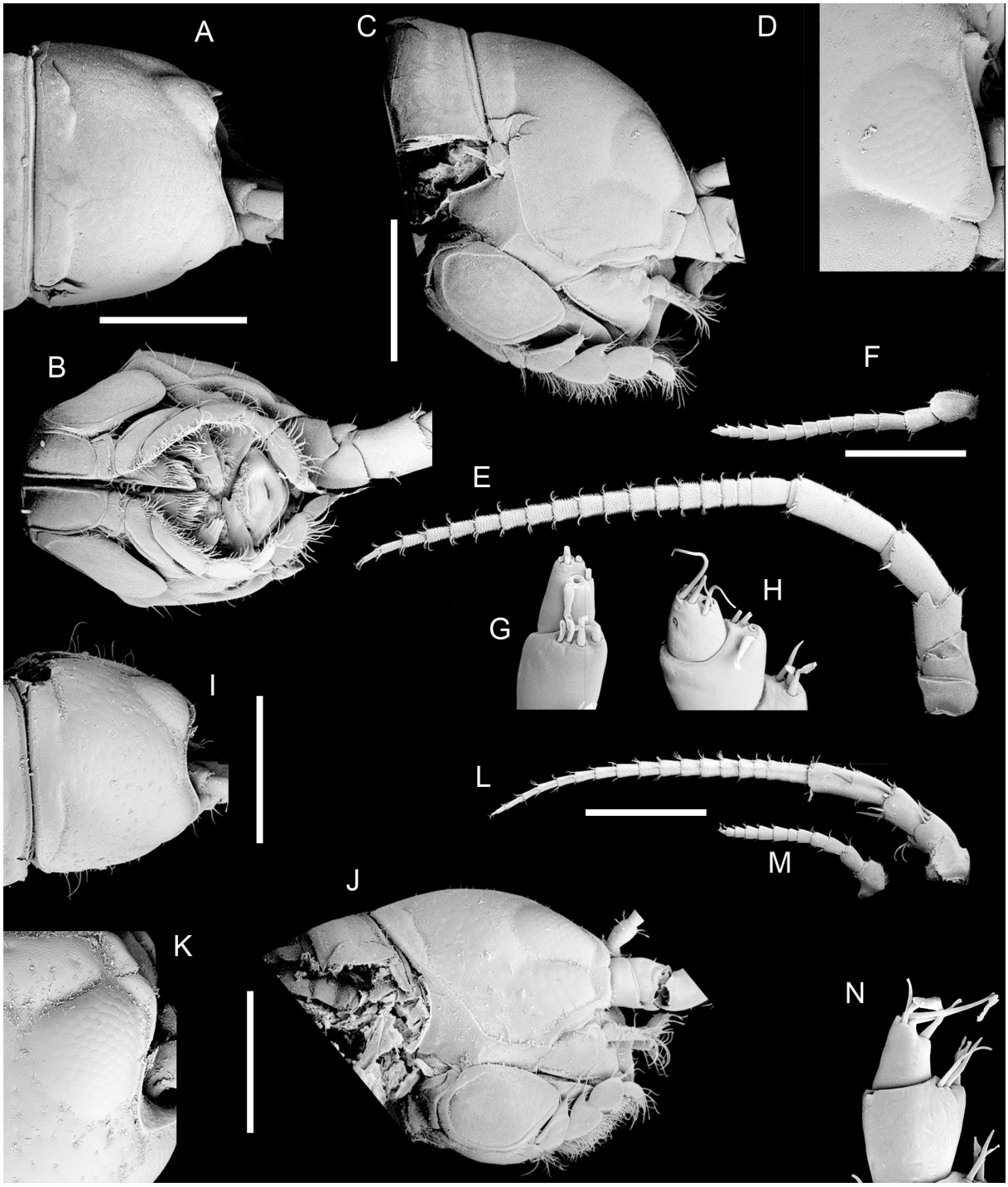


FIGURE 83. *Eophreatoicus ngarradj* sp. nov., head and antennae. Paratype male, AM P.76381: A–C, head dorsal, ventral and lateral; D, eye and antennal notch; E, antenna; F–H, antennula with enlargements of distal tip. Paratype female, AM P.76382: I–J, head dorsal and lateral; K, eye and antennal notch; L, antenna; M–N, antennula with enlargement of distal tip. Scales 1 mm.

Pleotelson. Dorsal surface length 0.87–1.00 width in dorsal view (F8, M7). Dorsal surface sparsely covered with setae; lacking cuticular combs on tubercles. Depth 1.40–1.70 pereonite 7 depth (F, H). Lateral length less than depth, in male 0.67–0.68 depth (M7, H), in female 0.69 depth (F8). Lateral length 0.13 body length (H, M7, F8). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.20–1.40 width of uropodal insertion (M7, F8), with one row of distally denticulate robust setae, including 5–7 robust setae altogether (M7, F8), posterior seta longer than anterior adjacent setae. Posterolateral margin dorsal setal position marginal seta larger

than submarginal seta. Posterior apex length less than width, long. Posterior apex 0.18–0.19 pleotelson total length (M7, F8), width 0.41–0.44 pleotelson width (M7, F8). Posterior apex in lateral view forming an angle of 95–107–108° with immediately anterior dorsal surface (M7, F8, H), angled 144–157–159° from horizontal (H, M7, F8).

Antennula. Length 0.14 body length in male (M7), 0.13 body length in female (F8), with 14 articles in male (M7), with 12 articles in female (F8). Article 5 length 1.00–1.50 width (F8, M7). Article 6 length 0.75–0.89 width (F8, M7). Aesthetascs small (1–3) mostly on distomedial margins. Terminal article length 1.20 width (M7, F8), 0.03–0.03 antennula total length (M7). Distal articles oval in cross-section.

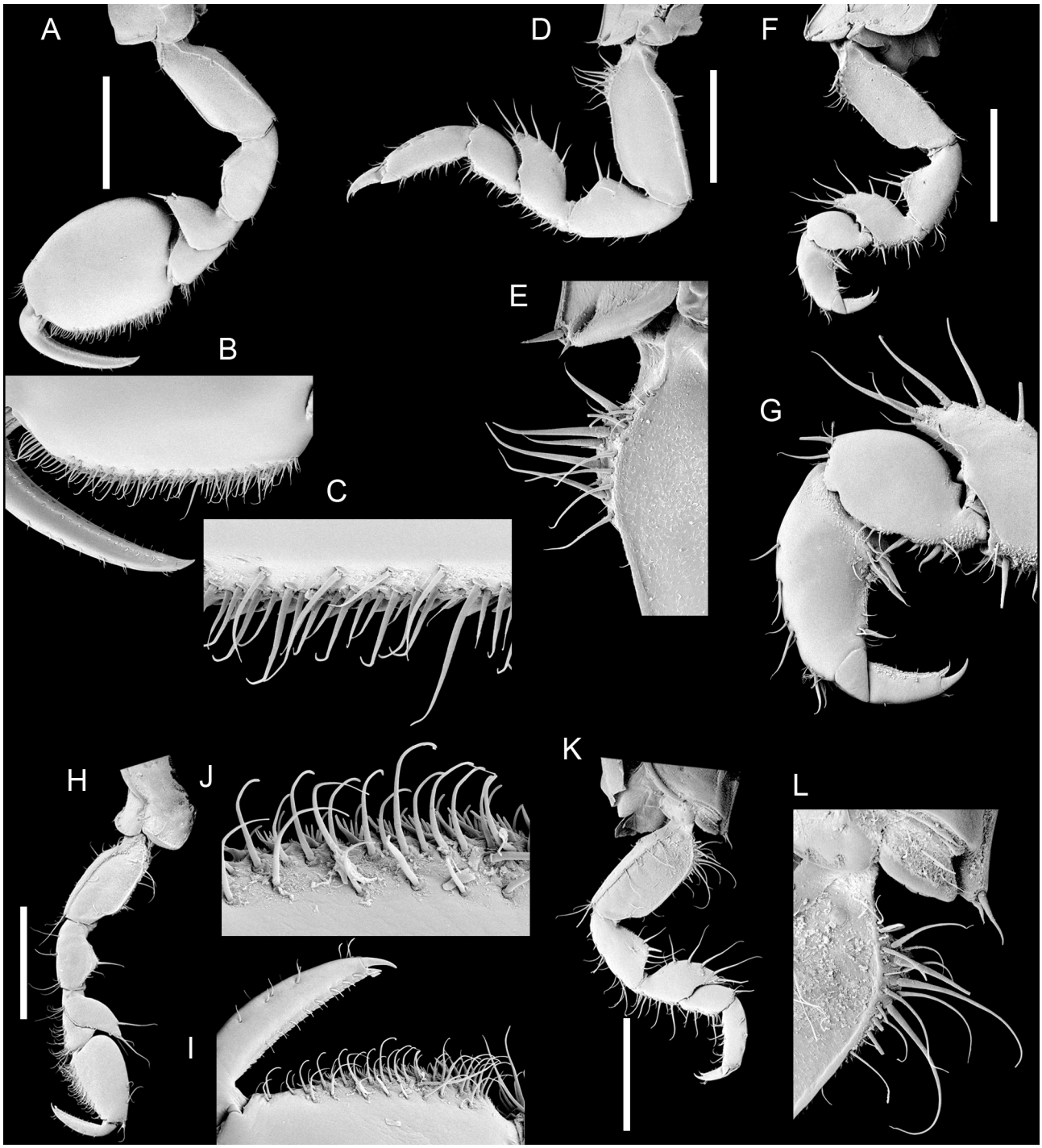


FIGURE 84. *Eophreatoicus ngarradj* sp. nov., anterior pereopods. Paratype male, AM P.76381: A–C, pereopod I with enlargement of palm and spine row setation; D–E, pereopod II with enlargement of epaulet; F–G, pereopod IV with enlargement of distal segments. Paratype female, AM P.76382: H–J, pereopod I with enlargement of palm and spine row setation; K–L, pereopod II with enlargement of epaulet. Scales 1 mm.

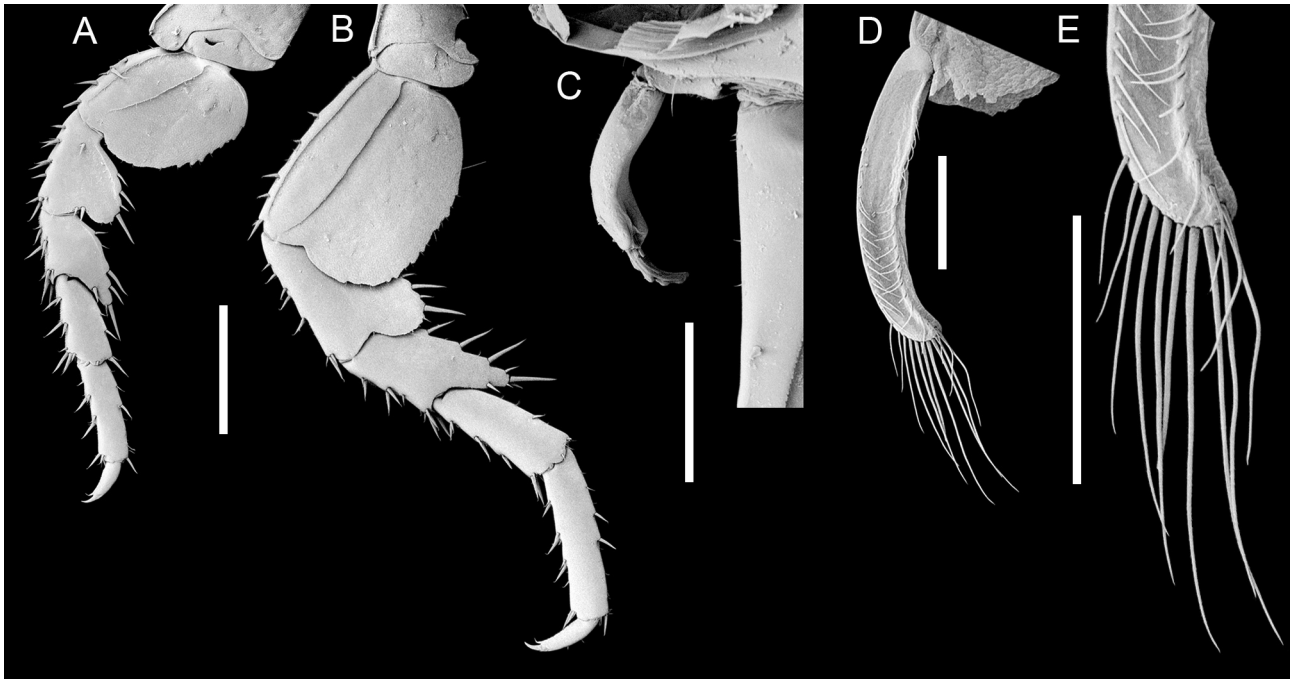


FIGURE 85. *Eophreatoicus ngarradj* sp. nov., posterior pereopods, penes, pleopod II appendix masculina, paratype male, AM P.76381. A, pereopod V. B–C, pereopod VII with enlargement of penes (sperm bundles projecting from distal orifice). D–E, appendix masculina with enlargement of distal tip. Scales: A–B, 1 mm; C–E, 0.5 mm.

Antenna. Length 0.42 body length in male (M7), 0.36 body length in female (F8). Flagellum length 0.58 total antenna length in male (M7), 0.61 total antenna length in female (F8), with 17 articles in male (M7), with 16 articles in female (F8), proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Mouthfield. Clypeus width 0.38–0.40 head width (M7, F8).

Maxilliped. Epipod distal tip rounded, length 1.40–1.70 width (F8, M7). Endite distal margin in fringe. Palp length 1.20–1.30 basis length (F8, M7); width across articles 2–3 1.30 endite width (M7). Palp article 4 shape elongate-oval, length 1.30–1.40 width (F8, M7). Palp article 5 length 1.60–1.70 width (M7, F8), 0.58–0.61 article 4 length (M7, F8).

Pereopod I. Length:body length 0.37 male (M7), 0.29 female (F8). Basis of male length 2.60 width (M7), female length 2.30 width (F8); dorsal setae positioned proximally, 3 dorsal setae altogether (M7); female dorsal setae positioned along ridge, female 8 dorsal setae altogether (F8); ventrodistal margin lacking elongate setae, female with 3 elongate setae (F8), elongate setae longer than ischium (F8). Ischium of male dorsal margin with 1 simple seta, setae not robust. Ischium of female dorsal margin with 3 simple setae (F8), setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (2 robust); female distodorsal margin with few elongate simple setae, female dorsal surface with setae along dorsal axis (2 heavy simple). Propodus length:pereopod length 0.24 male (M7), 0.19 female (F8). Propodus length:width 1.20 male (M7), 1.50 female (F8). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 3 setae altogether (excluding distal group) (M7), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae articulated, 28 altogether (M7). Propodal palm of female margin convex, stout denticulate setae serrate, 13 altogether (F8), with stout robust conical setae, 5 altogether (F8, 1 distally and 4 proximally). Dactylus of male length subequal to palm, length:palm length 0.99 (M7), female longer than palm, female length:palm length 1.20 (F3). Dactylus of female ventrodistal margin distal cuticular fringe length 0.67 total length (F8). Dactylus claw length:dactylus length 0.08 male (M7), 0.16 female (F8). Dactylus of male positioned ventrally, 0.41–0.43 (F8, M7) length of primary claw.

Pereopods II–III ratios. Pereopod II. Length:body length 0.30–0.33 male (H, M7), 0.29 female (F8). Basis length:pereopod length 0.32 male (M7), 0.31 female (F8); length:width 2.70 male (M7), 2.10 female (F8). Carpus length:pereopod length 0.10–0.13 male (H, M7), 0.11 female (F8); length:width 1.10–1.50 male (H, M7), 1.50 female (F8). Propodus length:pereopod length 0.18 male (H, M7), 0.17 female (F8); length:width 2.70–2.90 male (M7, H), 2.80 female (F8). Dactylus length:propodus length 0.50–0.54 male (M7, H), 0.51 female (F8); primary claw length:dactylar length 0.25 male (M7), 0.32 female (F8). *Pereopod III.* Length:body length 0.30–0.32 male (H, M7), 0.30 female (F8). Basis length:pereopod length 0.30 male (H, M7), 0.33 female (F8); length:width 2.10–2.20 male (M7, H), 2.60 female (F8). Carpus length:pereopod length 0.11 male (M7), 0.10 female (F8); length:width 1.30 male (M7), 1.30 female (F8). Propodus length:pereopod length 0.18 male (M7), 0.15 female (F8); length:width 2.80 male (M7), 3.50 female (F8). Dactylus length:propodus length 0.54 male (M7), 0.51 female (F8). *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, carpus, propodus.; basis dorsal ridge with setae forming 2 rows on proximal projection. Ischium II–IV of male dorsal margin with 4 simple setae (M7 pereopod II), none robust. Carpus II of male with 5 robust based setae. Carpus II of female with 4 robust based setae. Dactylus ventral to primary claw, 0.32–0.37 length of primary claw, with scales on ventral margin; 11 altogether (F8 pereopod II, approx).

Pereopod II. Basis lateral face with 8 tiny simple setae along margin in male and 8 elongate setae along margin in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 2–5 minor setae (3.5), submarginal setal row with 1–6 setae (4.5), without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 2–3–4 minor setae, submarginal setal row with 4–4–5 setae, without major setae distally (3 specimens has multiple setae, out of 10 specimens).

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 9 setae (M7), dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 5 setae (M7). Carpus of male ventral margin with simple setae only. Propodus of male distal width 0.56 maximum width (M7), setae on ventral margin robust-based, 2 distinctly larger than remainder, longer than dactylar claw (M7,1.1). Dactylus of male distal accessory claw approximately 0.33 primary claw length (M7,0.36). *Pereopod IV ratios.* Length:body length 0.29 male (M7), 0.29 female (F8). Basis length:width 2.80 male (M7). Carpus length:pereopod length 0.13 male (M7), 0.10 female (F8). Propodus length:pereopod length 0.16 male (M7), 0.13 female (F8). Propodus length:width 1.90 male (M7), 2.80 female (F8).

Pereopods V–VII ratios. Pereopod V. Length:body length 0.30–0.33 male (M2, H), 0.31 female (F8). Basis length:width 1.20–1.30 male (M7, H), 1.20 female (F8). Carpus length:pereopod length 0.15–0.17 male (H, M7), 0.14 female (F8). Propodus length:pereopod length 0.17–0.18 male (H, M7), 0.16 female (F8). Dactylus claw length:dactylar length 0.29 male (M7). *Pereopod VI.* Length:body length 0.41–0.44 male (M7, H), 0.39 female (F8). Carpus length:pereopod length 0.15–0.16 male (H, M7), 0.15 female (F8). Propodus length:pereopod length 0.18–0.20 male (H, M7), 0.17 female (F8). *Pereopod VII.* Length:body length 0.41–0.48 male (M7, H), 0.44 female (F8). Basis length:width 1.30 male (M7). Carpus length:pereopod length 0.14–0.17 male (H, M7), 0.16 female (F8). Propodus length:pereopod length 0.19–0.20 male (H, M7), 0.18 female (F8). Dactylus claw length:dactylar length 0.25 male (M7).

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 4 setae (M7 pereopod V, pereopod VII). Propodus distal margins with 3 elongate robust or robust-based setae (M7 pereopod V, pereopod VII). Dactylus accessory claw 0.26–0.34 primary claw length (M7 pereopod VII, pereopod V). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with 1 seta, dorsal margin with 4 setae (M7, likely more as margin partially obscured).

Penes. Distally tapering; distal tip truncate.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced; distally with 8 setae; 49 setae altogether (M7).

Uropod. Of male total length 1.30 pleotelson length (H, M7); protopod of male length 0.42–0.46 uropod total length (M7, H). Uropod of female total length 1.20 pleotelson length (F8), protopod length 0.49 uropod total length (F8). Protopod dorsomedial ridge length:endopod length 0.42–0.45 male (H, M7), 0.45 female (F8). Protopod of male dorsolateral margin subequal to dorsomedial margin setae; of female dorsolateral margin longer than dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, with spinose setae, 3 robust spinose setae (M7,

F8). Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 8 altogether (M7); female dorsal margin with 8 robust setae (F8). Exopod length:endopod length 0.74–0.89 male (H, M7), 0.81 female (F8). Exopod of male dorsal margin with 7 robust setae (M7), female 6 robust setae (F8).

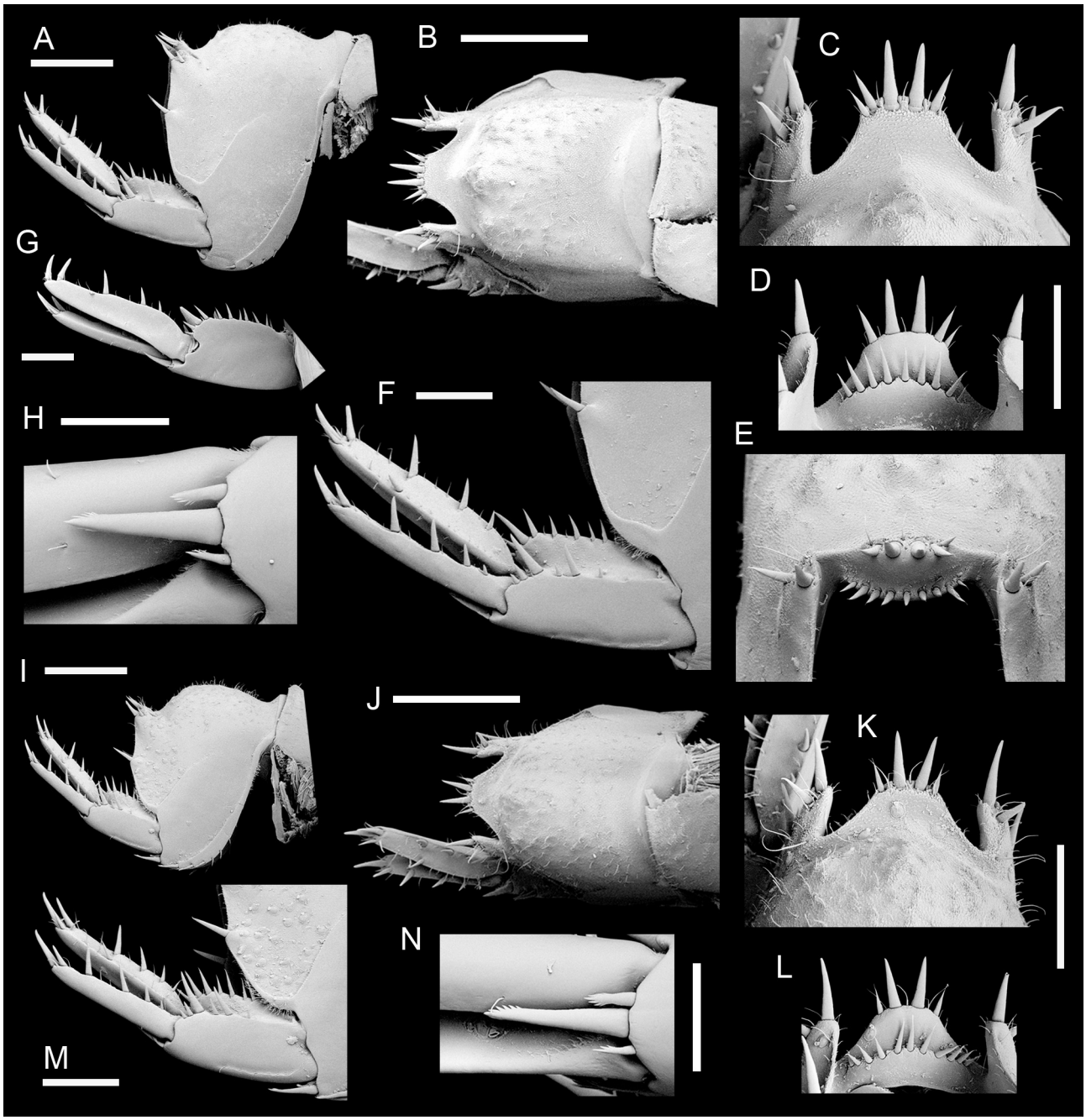


FIGURE 86. *Eophreatoicus ngarradj* sp. nov., pleotelson and uropods. Paratype male, AM P.76381: A–C, pleotelson lateral and dorsal; C–E, terminal apex dorsal, ventral with postanal ridge and posterior; F–H, uropod medial with enlargement of distoventral marginal setae. Paratype female, AM P.76382: I–J, pleotelson lateral and dorsal; K–L terminal apex dorsal and ventral with postanal ridge; M–N, uropod lateral in situ and enlargement of distoventral marginal setae. Scales: A–B, I–J, 1 mm; C–G, K–M, 0.5 mm; H N, 0.2 mm.

Distribution. Australia, Northern Territory, Kakadu National Park, Ngarradj Creek. This is a major right-bank tributary of the Ramsar-listed Magela Creek wetlands, East Alligator River catchment.

Habitat. *Eophreatoicus nagarradj* sp. nov. occurs in low pH (3.8–4.0), low turbidity waters at moderate environmental temperatures (29°C at the time of sampling). This species apparently tolerates a range of dissolved oxygen levels (34–91%).

Remarks. *Eophreatoicus ngarradj* sp. nov. is in a clade with *E. mawoenewoene* sp. nov. and *E. namarrkon* sp. nov. (Fig.12). *Eophreatoicus ngarradj* sp. nov. differs in having a pleotelson dorsal surface with oblong tubercles, while the other two species have only small irregular rugose regions. The pleotelson postanal ridge of *E. ngarradj* sp. nov. has 9–11 robust setae, while the other two species have 12 or more.

Eophreatoicus mawoenewoene sp. nov.
(Figs 87–91)

urn:lsid:zoobank.org:act: 3E960EA4-B534-4E3C-A8A3-1D7C7CD5971D
Eophreatoicus sp. "C1".—Wilson *et al.*, 2009: 362.

Type material. Holotype male, bl 13.7 mm, AM P.76368. Paratypes collected with holotype: male (M2), bl 14.4 mm, AM P.76369, DNA E113 Genbank COI EU263169 16S EU263240, SEM stubs AW684–688; preparatory female (F3), bl 9.8 mm, AM P.76370, SEM stubs AW689–692; male (M4), bl 16.7 mm, AM P.76371; juvenile, AM P.76372, DNA E36 Genbank COI EU263168 16S EU263239; 13 inds, AM P.76366; 37 inds, AM P.76367.

Type locality. Australia, Northern Territory, Kakadu National Park, Catfish Creek, 12°29.20'S, 132°58.14'E, coll. C. Humphrey, 12.v.1999.

Etymology. "Mawoenewoene" is the Gaagudju language name "ma-woene-woene" for the Catfish Creek region. The "oe" sound resembles the "ur" sound in word "fur". This place name was recorded and transcribed by the linguist Mark Harvey, who worked on Gaagudju in the 1980s and 1990s.

Diagnosis. *Head.* Eyes bulging dorsolaterally, height large, in lateral view greater than width of basal antennal articles, height greater than length in lateral view, bulging in dorsal view, projecting from head in distinct arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally (females more setose). *Pereon.* Dorsal cuticular surface smooth (without roughness or tubercles); pereonites 1–4 transverse dorsal ridges not expressed; pereonites 5–7 transverse dorsal ridges low without transverse trough (per 7 only). *Pleonites.* 1–4 transverse dorsal ridges low without transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection concave. Dorsal surface rugose, with oblong tubercles, lacking posteromedial ridges or median groups of tubercles (median ridge not prominent). Posterior apex in lateral view visible (F, M: partially). Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae, with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length subequal to quarter basis length, main setal row with 6 major setae. Basis of female dorsal ridge epaulet length subequal to quarter basis length, main setal row with 5–6 major setae. *Pereopod IV.* Propodus of male ventral margin with projection, with 6 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 adjacent robust setae distinctly larger than others.

Description. Body pigmentation dark speckled bar on pereopods and pleonite 5, lighter on PL.1–4, chromatophores dense anteriorly, more expanded posteriorly, lower parts of body lighter; length of largest male 16.7 mm, length of largest preparatory female 9.8 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Width 1.10 pereonite 1 width (F3). Dorsal surface pitted; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin concave, orientation of longest axis vertical, maximum diameter 0.32–0.33 head depth (H, F3), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view sigmoidal. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally (females more setose).

Pereon. Width near head width. Pereonite 1 0.36 in female (F3). Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–3 in dorsal view respective lengths less than 0.5 pleonite 5 length, pleonite 4 length more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites

depth:pereonite 7 depth 1.30–1.40 pleonite 1 (M2, F3; H), 1.70–1.80–1.90 pleonite 2 (M2, F3, H), 1.90–2.00 pleonite 3 (M2; H, F3), 1.90–2.00–2.10 pleonite 4 (M2, F3, H), 1.80–2.00 pleonite 5 (M2, F3; H).

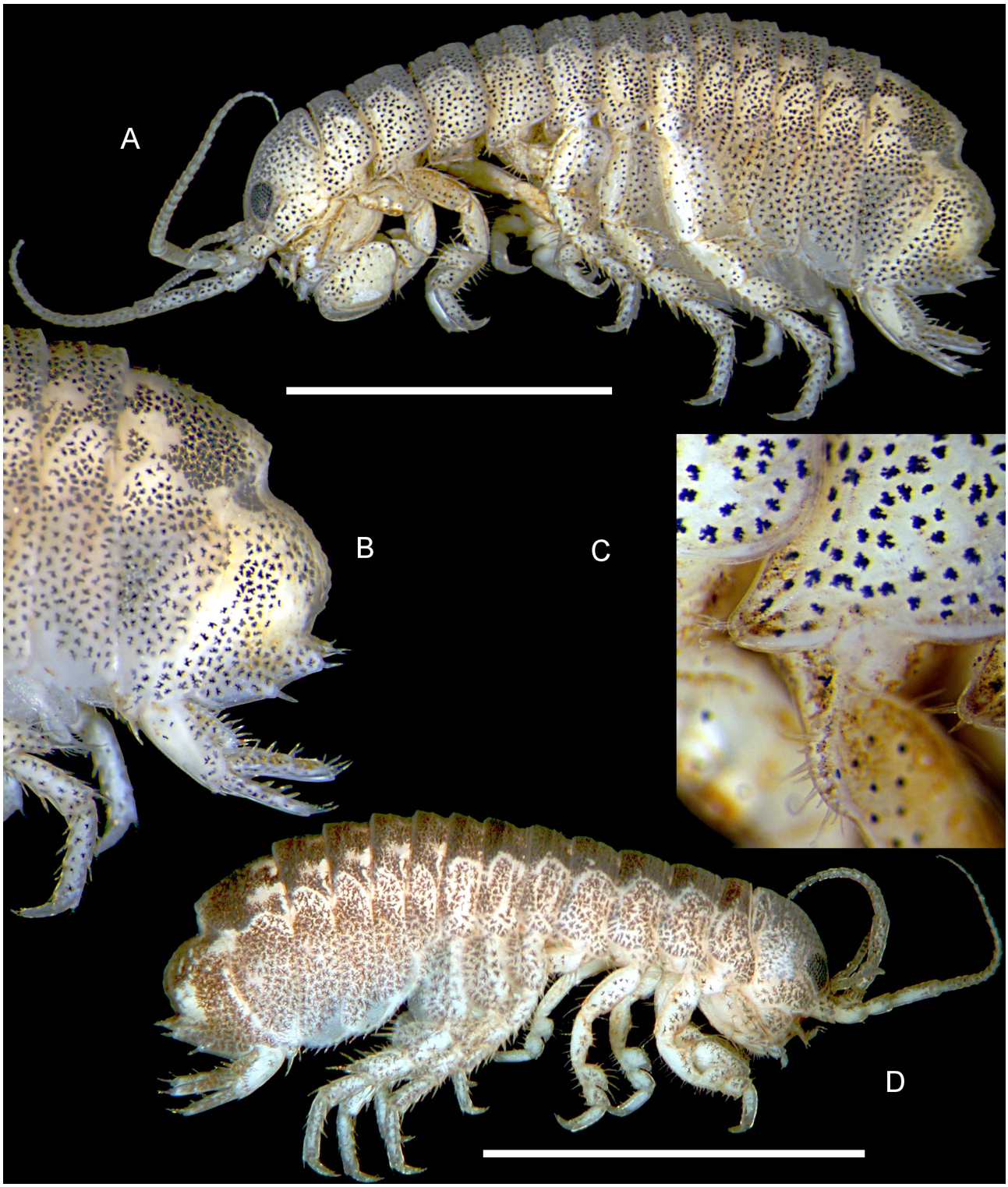


FIGURE 87. *Eophreatoicus mawoenewoene* sp. nov., types, habitus. Holotype male, AM P.76368: A, lateral; B, pleon and uropod; C, pereopod II basis epaulet. D, female paratype, AM P.76370, lateral. Scales 5 mm

Pleotelson. Dorsal surface length 1.00–1.10 width in dorsal view (F3, M2). Dorsal surface sparsely covered with setae. Depth 1.40–1.50 pereonite 7 depth (H, M2; F3). Lateral length less than depth, in male 0.74 depth (M2, H), in female 0.71 depth (F3). Lateral length 0.14 body length (M2, F3). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater

than width of uropodal insertion, length 1.10–1.30 width of uropodal insertion (F3, M2), with one row of distally denticulate robust setae, including 5–6 robust setae altogether (M2, F3), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.16–0.17–0.18 pleotelson total length (M2, H, F3), dorsal setal position marginal seta larger than submarginal seta. Posterior apex length less than width, long. Posterior apex 0.17–0.20 pleotelson total length (F3, M2), width 0.48–0.52 pleotelson width (M2, F3). Posterior apex in lateral view forming an angle of 85–109° with immediately anterior dorsal surface (F3, M2), angled 156–158° from horizontal (F3, M2).

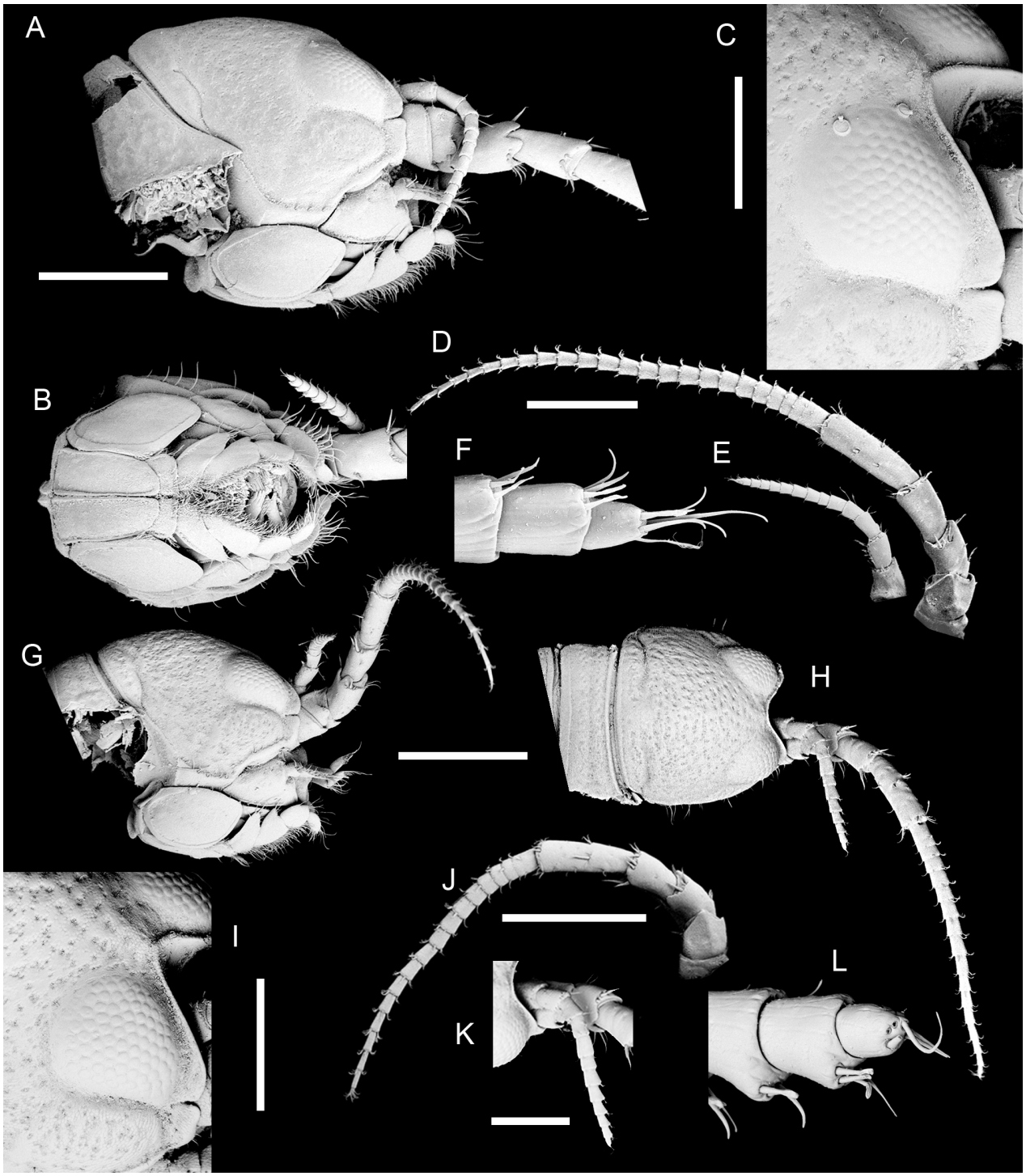


FIGURE 88. *Eophreatoicus* mawoenewoene sp. nov., head and antennae. Paratype male, AM P.76369: A–C, head lateral, ventral, enlargement of eye and antennal notch; D, antenna; E–F, antennula with enlargement of distal articles. Paratype female, AM P.76370: G–I, head lateral, dorsal, enlargement of eye and antennal notch; J, antenna; K–L, antennula with enlargement of distal articles. Scales: A–B, D–E, G–H, J, 1 mm; C, I, K, 0.5 mm.

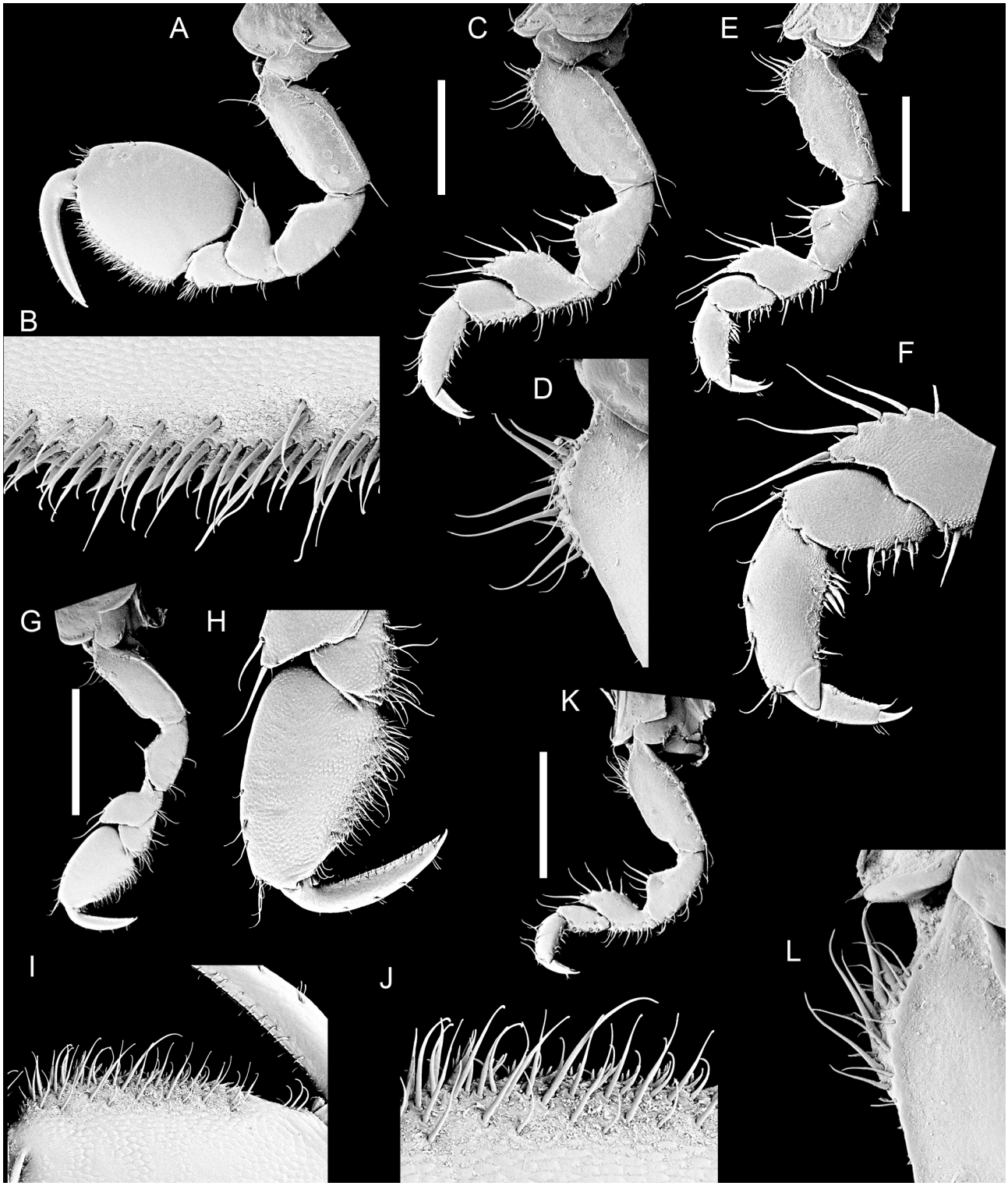


FIGURE 89. *Eophreatoicus mawoenewoene* sp. nov., anterior pereopods. Paratype male, AM P.76369: A–B, pereopod I with enlargement of palm setation; C–D, pereopod II with enlargement of epaulet; E–F, pereopod IV with enlargement of distal articles. Paratype female, AM P.76370: G–J, pereopod I with enlargement of palm and palm setation; K–L, pereopod II with enlargement of epaulet. Scales A, C, E, G, K, 1 mm.

Antennula. Length 0.14 body length in male (M2), 0.13 body length in female (F3), with 14 articles in male (M2), with 12 articles in female (F3). Article 5 length 1.20–1.30 width (M2, F3). Article 6 length 0.80–0.84 width (F3, M2). Aesthetascs small (1–3) mostly on distomedial margins. Terminal article length 1.10–1.30 width (M2, F3), 0.03–0.04 antennula total length (M2, F3). Distal articles oval in cross-section.

Antenna. Length 0.39 body length in male (H), 0.39 body length in female (F3). Article 6 shorter than articles 4 and 5 combined, or subequal to articles 4 and 5 combined (M2, F3). Flagellum length 0.54 total antenna length in female (F3), with 16 articles in female (F3), proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Maxilliped. Epipod distal tip rounded, length 1.60–1.80 width (F3, M2). Endite distal margin in fringe. Palp article 4 shape elongate-oval, length 1.20–1.50 width (F3, M2). Palp article 5 length 1.40–1.60 width (M2, F3), 0.54–0.70 article 4 length (M2, F3).

Pereopod I. Length:body length 0.39 male (M2), 0.35 female (F3). Basis of male length 2.50 width (M2), female length 2.70 width (F3); dorsal setae positioned proximally, 7 dorsal setae altogether (M2, approx); female dorsal setae positioned proximally, female 6 dorsal setae altogether (F3); ventrodistal margin with 1 elongate seta, female ventrodistal margin lacking elongate setae. Ischium of male dorsal margin with 2 simple setae (M2), setae not robust. Ischium of female dorsal margin with 1 simple seta, setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (2 heavy simple); female distodorsal margin with numerous elongate simple setae, female dorsal surface with setae along dorsal axis (2 heavy simple 1 tiny). Propodus length: pereopod length 0.22 male (M2), 0.19 female (F3). Propodus length:width 1.10–1.20 male (M2, H), 1.50 female (F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 5 setae altogether (excluding distal group) (M2), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae articulated, 30 altogether (M2). Propodal palm of female margin convex, stout denticulate setae serrate, 12 altogether (F3), with stout robust conical setae, 7 altogether (F3, 5 distally and 2 proximally). Dactylus of male length subequal to palm, length:palm length 0.96 (M2), female shorter than palm, female length:palm length 0.93 (F3). Dactylus of female ventrodistal margin distal cuticular fringe length 0.63 total length (F3). Dactylus claw length:dactylus length 0.09 male (M2), 0.15 female (F3). Dactylus of male positioned ventrally, 0.47–0.48(F3, M2) length of primary claw.

Pereopods II–III ratios. Pereopod II. Length:body length 0.28–0.34 male (H, M2), 0.33 female (F3). Basis length:pereopod length 0.29–0.30 male (M2, H), 0.33 female (F3); length:width 2.30–2.60 male (M2, H), 2.60 female (F3). Carpus length:pereopod length 0.10–0.13 male (H, M2), 0.11 female (F3); length:width 1.10–1.40 male (H, M2), 1.70 female (F3). Propodus length:pereopod length 0.17–0.18 male (M2, H), 0.13 female (F3); length:width 2.60–3.10 male (M2, H), 2.00 female (F3). Dactylus length:propodus length 0.56–0.58 male (H, M2), 0.75 female (F3); primary claw length:dactylar length 0.23 male (M2), 0.30 female (F3). *Pereopod III.* Length: body length 0.34 male (M4), 0.32 female (F3). Basis length:pereopod length 0.30 male (M4), 0.31 female (F3); length:width 2.60 male (M4), 2.50 female (F3). Carpus length:pereopod length 0.12 male (M4), 0.10 female (F3); length:width 1.70 male (M4), 1.20 female (F3). Propodus length:pereopod length 0.17 male (M4), 0.16 female (F3); length:width 3.30 male (M4), 2.80 female (F3). Dactylus length:propodus length 0.54 male (M4), 0.56 female (F3). *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, carpus, propodus. Ischium II–IV of male dorsal margin with 6 simple setae (M2 pereopod II), none robust. Dactylus ventral to primary claw, 0.37–0.43 length of primary claw, with scales on ventral margin (F, M); 15 altogether (F3, approx).

Pereopod II. Basis lateral face with 8 short simple setae along margin in male and with 8 long simple setae along margin and 2 short setae distally in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 2–3–3 minor setae, submarginal setal row with 3–5–6 setae, without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 2–3–4 minor setae, submarginal setal row with 4–4–5 setae, without major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 16 setae (M2), of male dorsal ridge setae positioned along ridge, of female dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 6 setae (M2). Carpus of male ventral margin with robust-based setae in addition to simple, with 1 robust-based seta. Propodus of male distal width 0.64 maximum width (M2), setae on ventral margin robust-based, 2 distinctly larger than remainder, longer than dactylar claw. Dactylus of male distal accessory claw approximately 0.33 primary claw length (M2, 0,34). *Pereopod IV ratios.* Length:body length 0.32 male (M2). Basis length:width 2.40 male (M2). Carpus length:pereopod length 0.12 male (M2). Propodus length:pereopod length 0.16 male (M2). Propodus length: width 2.10 male (M2).

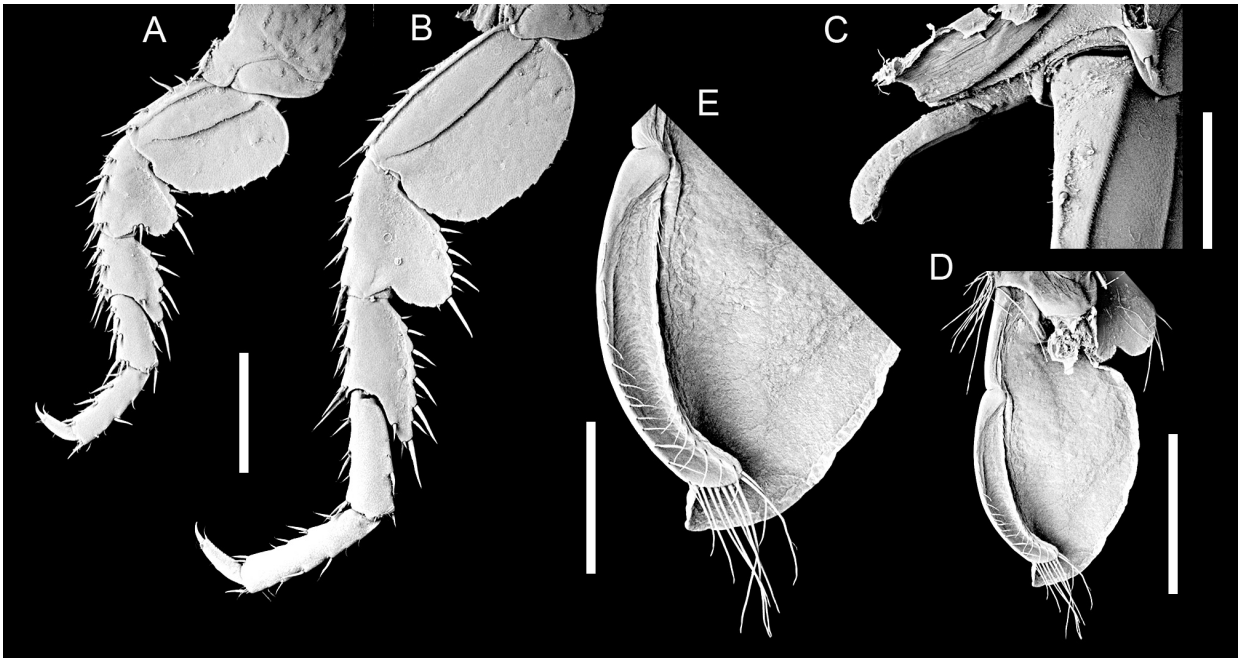


FIGURE 90. *Eophreatoicus mawoenewoene* sp. nov., posterior pereopods and appendix masculina, paratype male, AM P.76369. A–B, pereopod V, VII; C, pene; D–E, pleopod II endopod with enlargement of appendix masculina. Scales: A–B, D, 1 mm; C, E, 0.5 mm.

Pereopods V–VII ratios. Pereopod V. Length:body length 0.31 male (H, M2), 0.33 female (F3). Basis length: width 1.30 male (H, M2), 1.40 female (F3). Carpus length:pereopod length 0.14–0.15 male (M2, H), 0.14 female (F3). Propodus length:pereopod length 0.17 male (H, M2), 0.16 female (F3). Dactylus claw length:dactylar length 0.34 male (M2). *Pereopod VI.* Length:body length 0.40–0.42 male (H, M2), 0.44 female (F3). Basis length:width 1.40 male (H, M2). Carpus length:pereopod length 0.15–0.16 male (M2, H), 0.16 female (F3). Propodus length: pereopod length 0.17–0.18 male (H, M2), 0.20 female (F3). *Pereopod VII.* Length:body length 0.45–0.48 male (H, M2), 0.48 female (F3). Basis length:width 1.50 male (M2). Carpus length:pereopod length 0.15–0.16 male (H, M2), 0.14 female (F3). Propodus length:pereopod length 0.16–0.17 male (H, M2), 0.18 female (F3). Dactylus claw length:dactylar length 0.32 male (M2).

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 4–7 setae (M2 pereopod V, pereopod VII). Propodus distal margins with 3 elongate robust or robust-based setae (M2 pereopod V, pereopod VII). Dactylus accessory claw 0.31–0.42 primary claw length (M2 per V, VII). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with 1 seta, dorsal margin with 7 setae (M2).

Penes. Cuticle smooth; distally tapering; distal tip truncate.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 1.70 endopod proximal margin length; distally with 9 setae (lateral members stiff but small); 44 setae altogether (M2).

Uropod. Of male total length 0.95–1.10 pleotelson length (H, M2); protopod of male length 0.47–0.48 uropod total length (H, M2). Uropod of female total length 1.10 pleotelson length (F3), protopod length 0.51 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.46–0.58 male (M2, H), 0.50 female (F3). Protopod of male dorsolateral margin subequal to dorsomedial margin setae; of female dorsolateral margin subequal to dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, with spinose setae, 3 robust spinose setae (M2, F3). Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 8 altogether (M2); female dorsal margin with 9 robust setae (F3). Exopod length:endopod length 0.84–0.89 male (M2, H), 0.85 female (F3). Exopod of male dorsal margin with 7 robust setae (M2), female 5 robust setae (F3).

Distribution. Australia, Northern Territory, Kakadu National Park, Catfish Creek, a tributary of the East Alligator River.

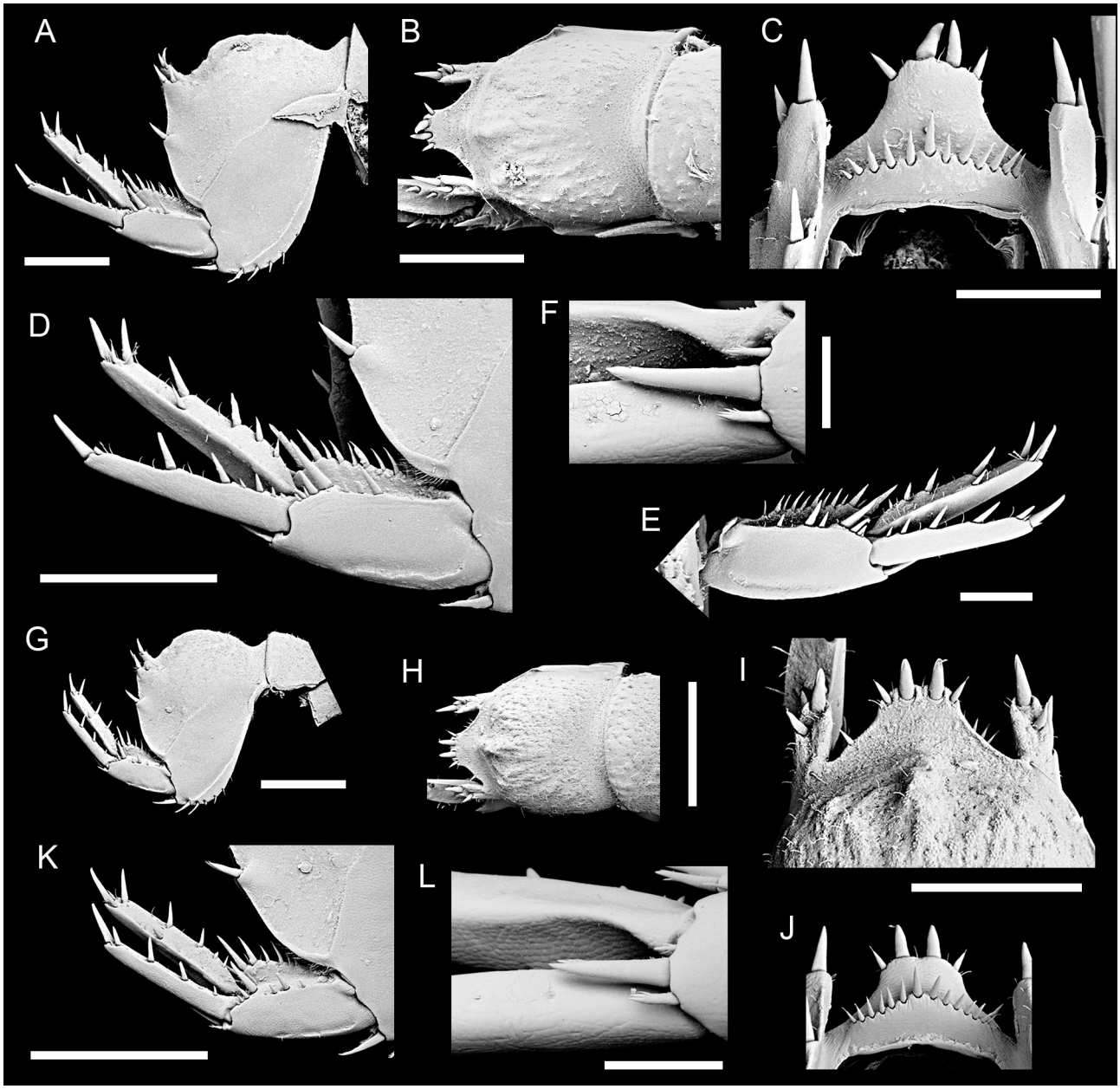


FIGURE 91. *Eophreatoicus mawoenewoene* sp. nov., pleotelson and uropods. Paratype male, AM P.76369: A–B, pleotelson lateral and dorsal; C, ventral apex with postanal ridge setation; D, uropod in situ. E–F, uropod detached, with enlargement of protopod distal margin setation. Paratype female, AM P.76370: G–H, pleotelson lateral and dorsal; I–J, apex dorsal and ventral with postanal ridge setation. Scales A–B, D, G–H, K, 1 mm; C, E, I–J, 0.5 mm; F, L, 0.2 mm.

Habitat. On the margin of stream in roots and leaf litter.

Remarks. *Eophreatoicus mawoenewoene* sp. nov. is in a clade with *E. ngarradj* sp. nov. and *E. namarrkon* sp. nov. (Fig.12). *Eophreatoicus mawoenewoene* sp. nov. is most similar to *E. ngarradj* sp. nov. and differs from that species in the following: 12–14 robust setae on the pleotelson postanal ventral ridge (9–11 setae), and the pleotelson dorsum is much less rugose and lacks a median ridge on the posterior inflection. *Eophreatoicus mawoenewoene* sp. nov. has multiple differences from *E. namarrkon* sp. nov. that are mentioned in the remarks for that species. *Eophreatoicus mawoenewoene* sp. nov. co-occurs with *E. binjdjarrang* sp. nov.; this species pair assisted finding the many key characters that distinguish species.

***Eophreatoicus binjdjarrang* sp. nov.**
(Figs 5B, 92–96)

urn:lsid:zoobank.org:act: ED01C26C-B2C4-4874-92D3-6C8B0BC58589
Eophreatoicus sp. "C2".—Wilson *et al.*, 2009: 362.

Type material. Holotype male, bl 13.1 mm, AM P.76375. Paratypes collected with holotype: male (M2), bl 15.4 mm, AM P.76376, DNA E78 COI EU263170 16S EU263242, SEM stubs AW693–697; male, AM P.76374, DNA E38 Genbank 16S EU263241; female preparatory (F3), bl 13.4 mm, AM P.76377, DNA E79 Genbank COI EU263171 16S EU263243, SEM stubs AW698–701; 7 inds, AM P.76373.

Type locality. Australia, Northern Territory, Kakadu National Park, Catfish Creek, 12°29.20'S, 132°58.14'E, coll. C. Humphrey, 12.v.1999.

Etymology. "Binjdjarrang" is the Kundjeyhmi (and Kunwinjku) name for a species of "catfish" from which the Creek gets its English name. The language of this place is Erre, but Kundjeyhmi use their name for the place. It is pronounced "beeny-jahdung", where "dung" rhymes with "hung".

Diagnosis. *Head.* Eyes bulging dorsolaterally, height large, in lateral view greater than width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region without obvious setae. *Pereon.* Dorsal cuticular surface with tubercles and small scales, increasing posteriorly, less so in younger stages; pereonites 1–4 transverse dorsal ridges rounded, expressed as transverse trough only; pereonites 5–7 transverse dorsal ridges carinate with transverse trough. *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection concave (concave in F3, almost straight in M2). Dorsal surface rugose, with oblong tubercles, with several median tubercles, not merging into ridge. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae, with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 shorter than article 4. *Pereopod I.* Dactylus of male ventrodistal margin low scales; with row of thin scale-like spines; female ventrodistal margin with multiple rows of thin scale-like spines (1 row distally, 2 rows proximally). *Pereopod II.* Basis of male dorsal ridge epaulet length less than quarter length of basis, main setal row with 3 major setae. Basis of female dorsal ridge epaulet length less than quarter length of basis, main setal row with 3 major setae. *Pereopod IV.* Propodus of male ventral margin without projection, with 3 robust setae on ventral margin (distal seta smaller). Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate subequal to shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge distinctly projecting dorsally with posterior margin exposed above shaft, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 adjacent robust setae distinctly larger than others.

Description. Body pigmentation medium dark, large maculate, dorsally with dark irregular but continuously colored bar (no stripes or patches); chromatophores dendritic, more spread posteriorly but not touching; length of largest male 15.4 mm, length of largest preparatory female 13.4 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Dorsal surface pitted; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin straight, orientation of longest axis vertical, maximum diameter 0.28–0.29 head depth (H, M2; F3), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view smoothly curved. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region without obvious setae.

Pereon. Width near head width. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–4 in dorsal view respective lengths less than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.30–1.40 pleonite 1 (H; M2, F3), 1.60–1.70–1.80 pleonite 2 (H, F3, M2), 1.80–2.00 pleonite 3 (H; F3, M2), 1.80–2.00 pleonite 4 (H; F3, M2), 1.70–1.80–1.90 pleonite 5 (H, F3, M2).

Pleotelson. Dorsal surface length 1.10 width in dorsal view (M2, F3). Dorsal surface sparsely covered with setae; with cuticular combs on tubercles. Depth 1.40–1.50–1.60 pereonite 7 depth (H, F3, M2). Lateral length less than depth, in male 0.76–0.77 depth (M2, H), in female 0.78 depth. Lateral length 0.13–0.14–0.16 body length (F3, M2, H). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.40–1.60–1.70

width of uropodal insertion (H, M2, F3), with one row of distally denticulate robust setae, including 8–10 robust setae altogether (F3, M2), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.16–0.19–0.20 pleotelson total length (M2, F3, H), dorsal setal position marginal seta larger than submarginal seta. Posterior apex length less than width, long. Posterior apex 0.19–0.20 pleotelson total length (F3, M2), width 0.42 pleotelson width (M2, F3). Posterior apex in lateral view forming an angle of 95–97° with immediately anterior dorsal surface (F3, M2), angled 157–166° from horizontal (M2, F3).

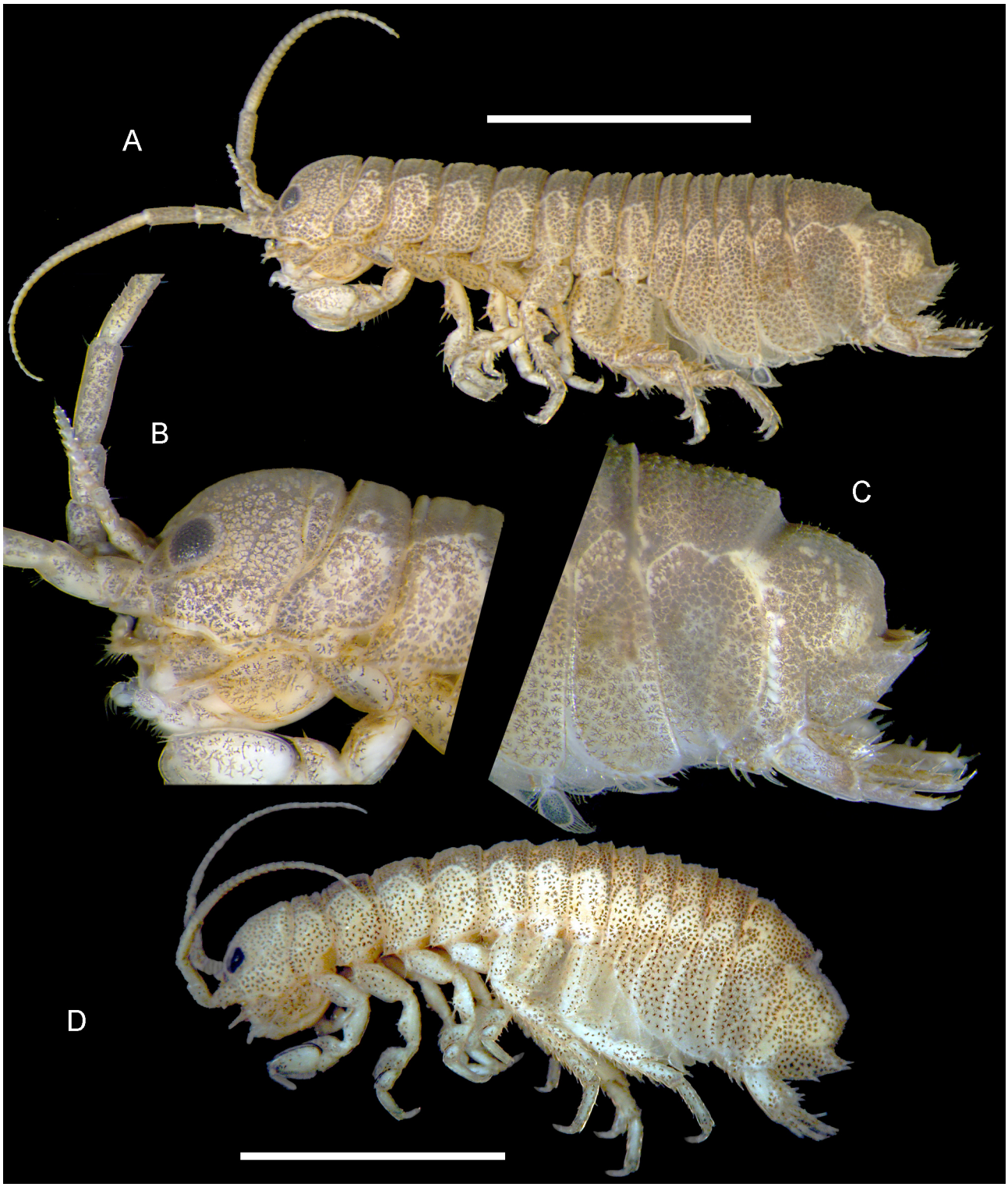


FIGURE 92. *Eophreatoicus binjdjarrang* sp. nov., types. Holotype male, AM P.76375: A, lateral; B, head; C, posterior pleonites and pleotelson. D, paratype female, AM P.76377, lateral. Scales 5 mm

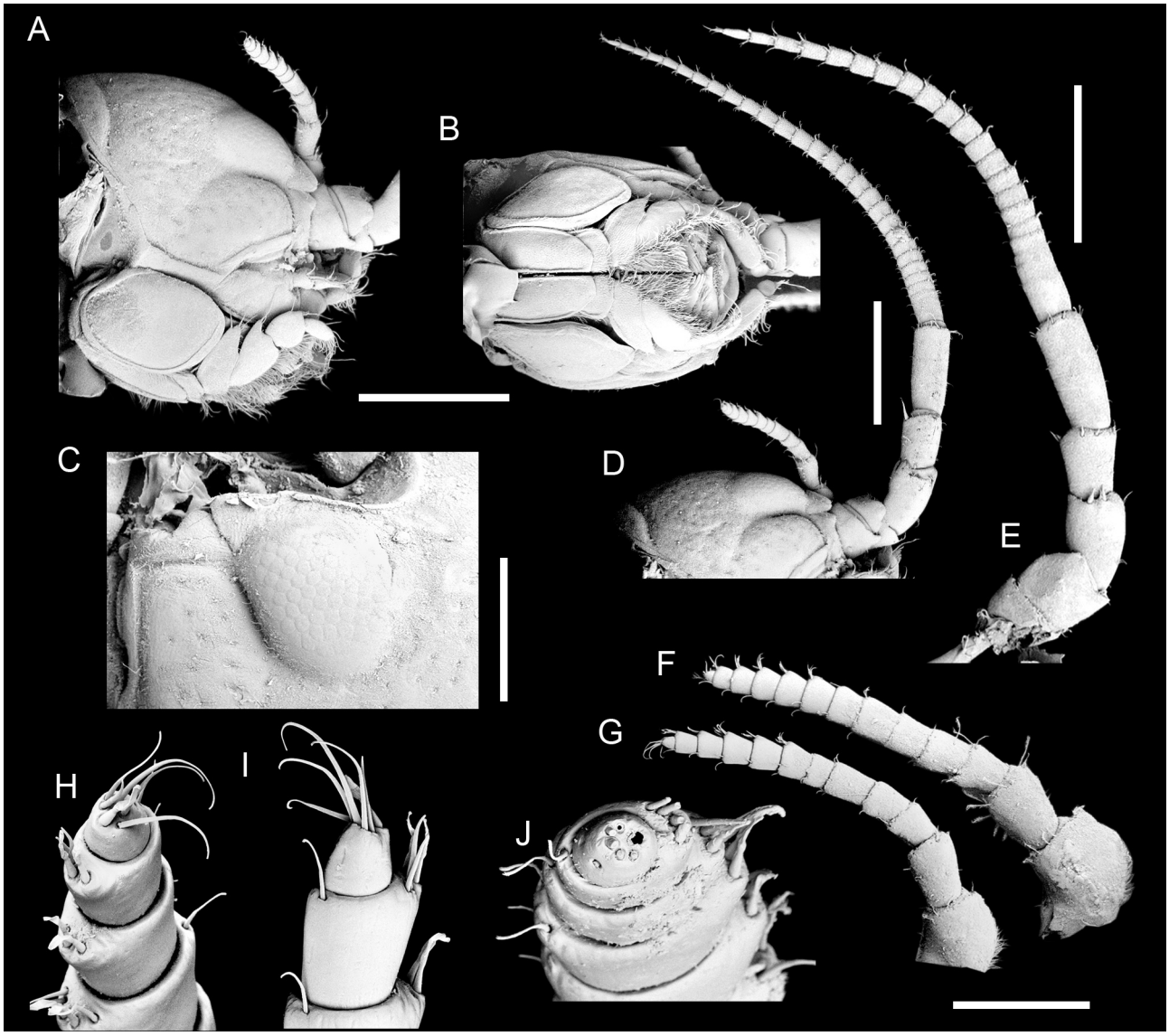


FIGURE 93. *Eophreatoicus binjdjarrang* sp. nov., head and antennae. Paratype female, AM P.76377: A–C, head, lateral ventral and enlargement of eye region; D, head with antenna and antennula; G–I, antennula with lateral and distal of distal tip. Paratype male, AM P.76376: E, antenna; F J, antennula with enlargement of distal tip. Scales A–B, D–E, 1 mm; C, F–G, 0.5 mm.

Antennula. Length 0.12 body length in male (M2), 0.12 body length in female (F3), with 13 articles in male (M2), with 12 articles in female (F3). Article 5 length 0.97–1.30 width (M2, F3). Article 6 length 0.70–1.00 width (F3, M2). Aesthetascs small (1–3) mostly on distomedial margins. Terminal article length 0.85 width, 0.02–0.03 antennula total length (M2, F3). Distal articles oval in cross-section.

Antenna. Length 0.35 body length in male (M2), 0.42 body length in female (F3). Flagellum length 0.57 total antenna length in male (M2), 0.59 total antenna length in female (F3), with 18 articles in male (M2), with 23 articles in female (F3), proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Mouthfield. Clypeus width 0.36–0.40 head width (F3, M2).

Maxilliped. Epipod distal tip rounded, length 1.50–1.70 width (F3, M2). Endite distal margin in fringe. Palp length 0.90 basis length (F3). Palp article 4 length 1.10 width (M2, F3). Palp article 5 length 1.80–1.90 width (F3, M2), 0.76–0.84 article 4 length (M2, F3).

Pereopod I. Length:body length 0.35 male (M2), 0.33 female (F3). Basis of male length 2.20 width (M2), female length 2.50 width (F3); dorsal setae positioned proximally, 2 dorsal setae altogether (M2); female dorsal setae

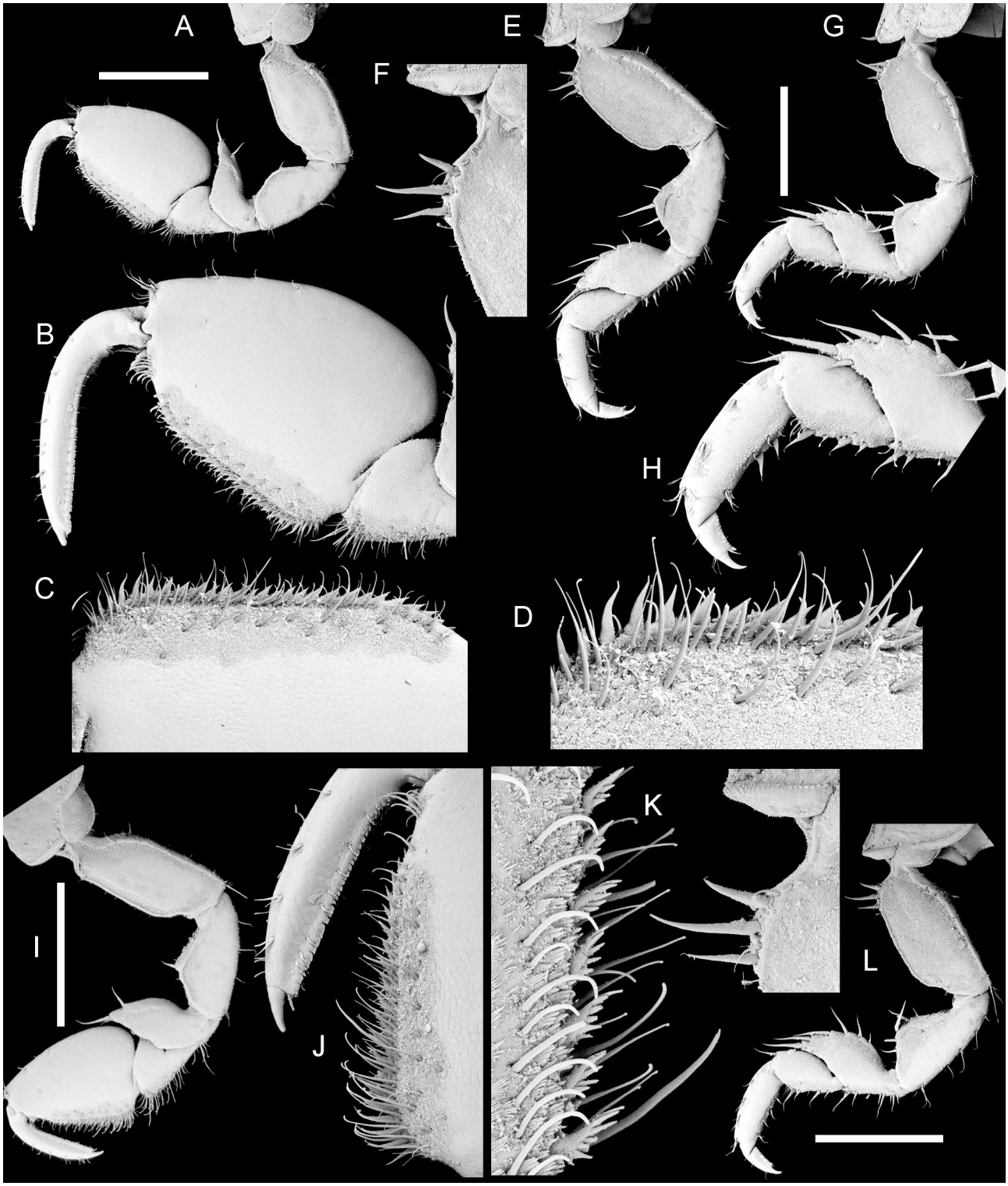


FIGURE 94. *Eophreatoicus binjdjarrang* sp. nov., anterior pereopods. Paratype male, AM P.76376: A–D, pereopod I entire, distal segments, palm lateral and palm setae medial; E–F, pereopod II with enlargement of epaulet setae; G–H, pereopod IV with enlargement of distal segments. Paratype female, AM P.76377: I–K, pereopod I entire, palm and dactylus and palm setae medial. L, pereopod II with enlargement of epaulet. Scales 1 mm.

positioned proximally, female 2 dorsal setae altogether (F3); ventrodistal margin lacking elongate setae, female with 1 elongate seta, elongate setae longer than ischium (F3). Ischium of male dorsal margin with 1 simple seta, setae not robust. Ischium of female dorsal margin with 1 simple seta, setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple

setae, dorsal surface with setae along dorsal axis (2 heavy simple); female distodorsal margin with few elongate simple setae, female dorsal surface with setae along dorsal axis (2 heavy simple). Propodus length:pereopod length 0.22 male (M2), 0.19 female (F3). Propodus length:width 1.30 male (M2), 1.40 female (F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 4 setae altogether (excluding distal group) (M2), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae proximally on margin articulated, grading distally to articulation not expressed, 27 altogether (M2). Propodal palm of female margin convex, stout denticulate setae serrate, 10 altogether (F3), with stout robust conical setae, 10 altogether (F3,5 distally and 5 proximally). Dactylus of male longer than palm, length:palm length 1.10 (M2), female length subequal to palm, female length:palm length 1.00 (F3). Dactylus of male ventrodistal margin ventrodistal margin distal cuticular fringe length 0.47 total length (M2); female ventrodistal margin distal cuticular fringe length 0.67 total length (F3). Dactylus claw length:dactylus length 0.14 female (F3). Dactylus of male positioned ventrally, 0.34(F3) length of primary claw.

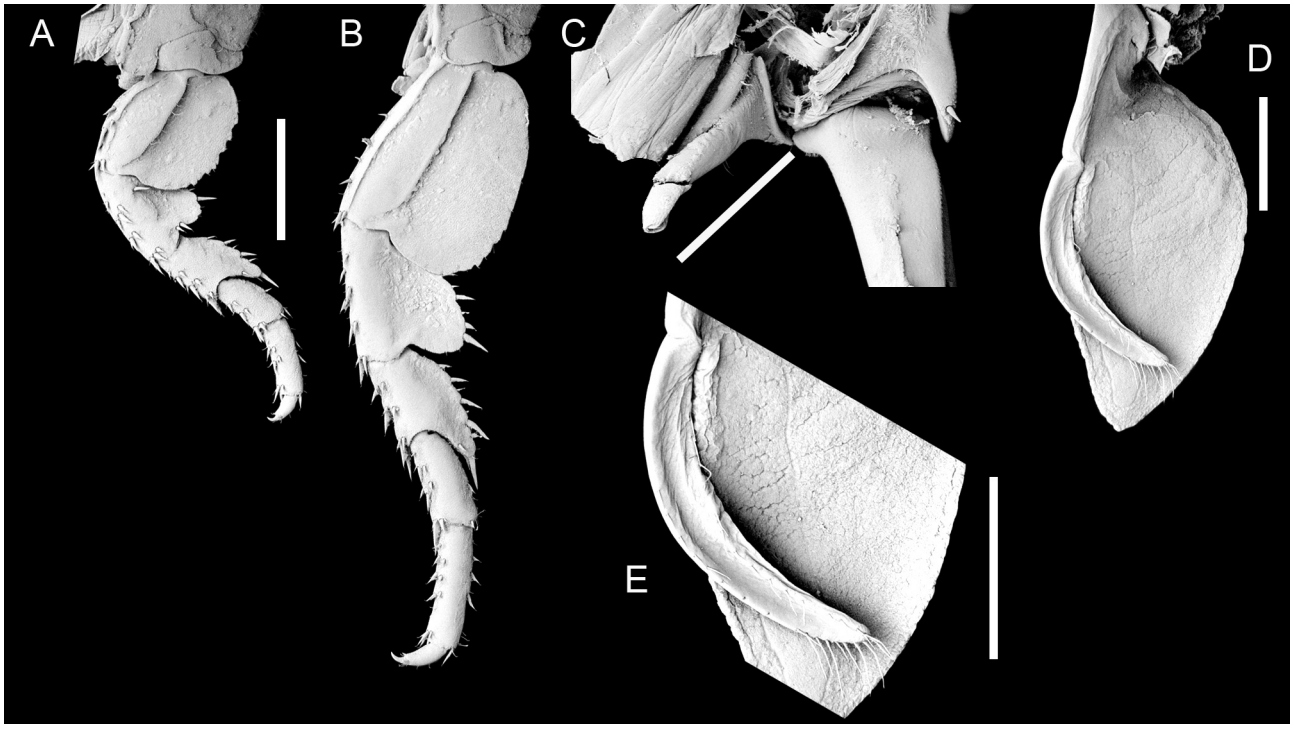


FIGURE 95. *Eophreatoicus binjdjarrang* sp. nov., posterior pereopods, pleopod II, paratype male, AM P.76376. A, pereopod V. B–C, pereopod VII, penes. D–E, pleopod II endopod and appendix masculina. Scales: A–B, 1 mm; C–E, 0.5 mm.

Pereopods II–III ratios. *Pereopod II*. Length:body length 0.33 male (M2), 0.32 female (F3). Basis length: pereopod length 0.29 male (M2), 0.29 female (F3); length:width 2.10 male (M2), 2.30 female (F3). Carpus length: pereopod length 0.12 male (M2), 0.12 female (F3); length:width 1.60 male (M2), 1.60 female (F3). Propodus length:pereopod length 0.16 male (M2), 0.16 female (F3); length:width 2.90 male (M2), 2.80 female (F3). Dactylus length:propodus length 0.54 male (M2), 0.55 female (F3); primary claw length:dactylar length 0.27 male (M2), 0.27 female (F3). *Pereopod III*. Length:body length 0.30 male (M2), 0.28 female (F3). Basis length:pereopod length 0.27 male (M2), 0.29 female (F3); length:width 2.10 male (M2), 2.30 female (F3). Carpus length:pereopod length 0.11 male (M2), 0.10 female (F3); length:width 1.50 male (M2), 1.10 female (F3). Propodus length:pereopod length 0.17 male (M2); length:width 3.20 male (M2). Dactylus length:propodus length 0.48 male (M2). *Pereopods II–III*. Penicillate setae scattered on dorsal ridge of basis, carpus, propodus., also seen on ventral ridge of merus(F3). Ischium II–IV of male dorsal margin with 5 simple setae (M2 pereopod II), none robust. Dactylus ventral to primary claw, 0.23–0.27 length of primary claw, with scales on ventral margin; 12 altogether (F3, approx).

Pereopod II. Basis lateral face with 6 long simple setae along margin in male and in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row without minor setae, submarginal setal row with 1–2–3 setae,

without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 2 minor setae, submarginal setal row with 2 setae (2), without major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 3 setae (M2), dorsal ridge setae positioned proximally, of female dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 4 setae (M2). Carpus of male ventral margin with simple setae only. Propodus of male distal width 0.79 maximum width (M2), setae on ventral margin robust, 2 distinctly larger than remainder, longer than dactylar claw. Dactylus of male distal accessory claw approximately 0.25 primary claw length (M2,0.25). *Pereopod IV ratios.* Length: body length 0.29 male (M2). Basis length:width 2.30 male (M2). Carpus length:pereopod length 0.11 male (M2). Propodus length:pereopod length 0.16 male (M2). Propodus length:width 2.80 male (M2).

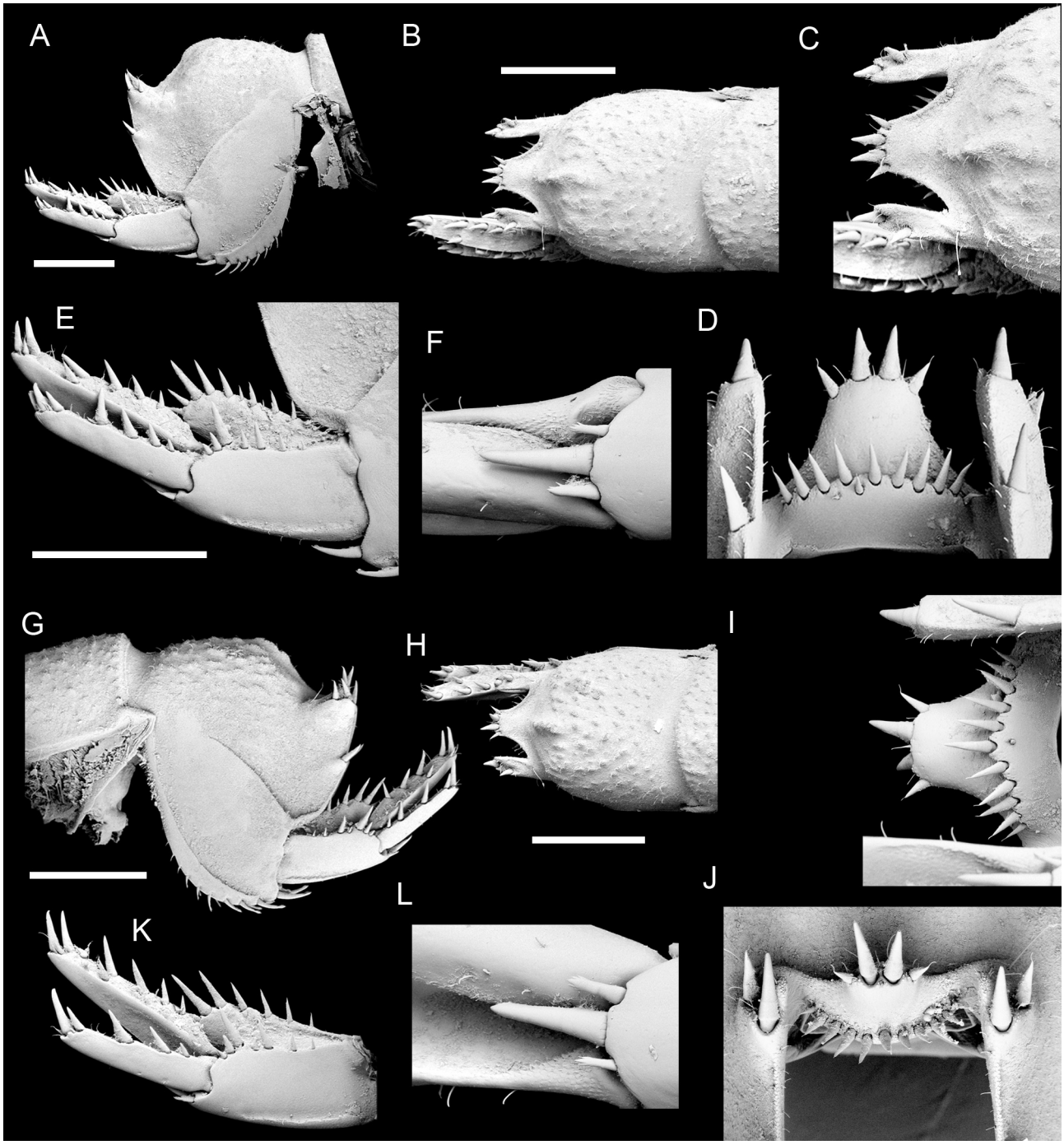


FIGURE 96. *Eophreatoicus binjdjarrang* sp. nov., pleotelson and uropods. Paratype male, AM P.76376: A–D, pleotelson lateral, dorsal, terminal apex dorsal and ventral; E–F, uropod lateral and protopod distoventral setae. Paratype female, AM P.76377: G–J, pleotelson lateral, dorsal, terminal apex ventral and posterior; K–L, uropod lateral and protopod distoventral setae. Scales 1 mm.

Pereopods V–VII ratios. *Pereopod V.* Length:body length 0.26–0.30 male (M2, H), 0.30 female (F3). Basis length:width 1.10–1.30 male (M2, H), 1.30 female (F3). Carpus length:pereopod length 0.13–0.15 male (M2, H), 0.14 female (F3). Propodus length:pereopod length 0.15–0.16 male (H, M2), 0.16 female (F3). Dactylus claw length: dactylar length 0.34 male (M2). *Pereopod VI.* Length:body length 0.36–0.37 male (M2, H), 0.38 female (F3). Basis length:width 1.20 male (H). Carpus length:pereopod length 0.13–0.17 male (H, M2), 0.13 female (F3). Propodus length:pereopod length 0.19 male (H, M2), 0.18 female (F3). *Pereopod VII.* Length:body length 0.38–0.40 male (M2, H), 0.43 female (F3). Basis length:width 1.20 male (M2). Carpus length:pereopod length 0.14–0.15 male (M2, H), 0.15 female (F3). Propodus length:pereopod length 0.17–0.18 male (M2, H), 0.17 female (F3). Dactylus claw length:dactylar length 0.12 male (M2).

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 6 setae (M2 pereopod VII). Propodus distal margins with 4–5 elongate robust or robust-based setae (M2 pereopod V, pereopod VII). Dactylus accessory claw 0.25–0.30 primary claw length (M2 pereopod V, pereopod VII). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with no setae, dorsal margin with 6 setae (M2).

Penes. Distally tapering; distal tip truncate.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 1.30 endopod proximal margin length; distally with 9 setae (all not much longer than more proximal setae); 32 setae altogether (M2).

Uropod. Of male total length 0.98–1.00 pleotelson length (H, M2); protopod of male length 0.47–0.49 uropod total length (M2, H). Uropod of female total length 0.98 pleotelson length (F3), protopod length 0.48 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.57–0.67 male (H, M2), 0.71 female (F3). Protopod of male dorsolateral margin shorter than dorsomedial margin setae; of female dorsolateral margin shorter than dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, with spinose setae, 3 robust spinose setae. Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 8 altogether (M2); female dorsal margin with 8 robust setae (F3). Exopod length:endopod length 0.79–0.83 male (M2, H), 0.84 female (F3). Exopod of male dorsal margin with 6–7 robust setae (H, M2), female 5 robust setae (F3).

Distribution. Australia, Northern Territory, Kakadu National Park, Catfish Creek, a tributary of the East Alligator River.

Habitat. On the margin of stream in roots and leaf litter.

Remarks. *Eophreatoicus binjdjarrang* sp. nov. forms a clade with *E. warnbi* sp. nov. in both the morphological and genetic analyses (Figs. 10–12). These species are easy to separate because *E. binjdjarrang* sp. nov. has large, low profile eyes, whereas *E. warnbi* sp. nov. has small but bulging eyes. Other features that differ from *E. warnbi* sp. nov. include: pleotelson dorsal surface with elongate ridge-like tubercles (rounded tubercles); pleotelson postanal ventral ridge with 11–12 robust setae on ridge (13–17); male pereopod IV propodus ventral margin with only three robust setae and without an angular projection (with 7 robust setae and projection); and uropod protopod dorsomedial ridge in lateral view convex with the distal part distinctly curving ventrally (approximately straight). *Eophreatoicus binjdjarrang* sp. nov. co-occurs with *E. mawoenewoene* sp. nov.

Eophreatoicus djirrinjbal **sp. nov.**

(Figs 9C, 97–101)

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Eophreatoicus sp. "S1".—Wilson *et al.*, 2009: 362.

Type material. Holotype male, AM P.76358, DNA E26. Paratype: male (M2), bl 20.4 mm, AM P.76355, DNA E93 Genbank COI EU263196 16S EU263268, SEM stubs AW761–762; female (F3), bl 16.8 mm, AM P.76356, DNA E94 Genbank COI EU263197 16S EU263269, SEM stubs AW767–770; preparatory female, AM P.76357, DNA E25 (unsuccessful); 8 inds, AM P.76354.

Type locality. Australia, Northern Territory, Kakadu National Park, Ngarradj Creek Spring, 12°30.797'S, 132°56.914'E, coll. C. Humphrey & party, 8.iv.2003.

Etymology. "Djirrinjbal" (language Kundjeyhmi) is the closest known named site to Ngarradj Creek Spring. It is pronounced "jee-diny-bull", where "diny" is one syllable and the final "nj" is like the ny sound in "onion".



FIGURE 97. *Eophreatoicus djirrinjbal* sp. nov. types. A, holotype male, AM P.76358. B, paratype female, AM P.76356. Scales 5 mm.

Diagnosis. *Head.* Eyes bulging dorsolaterally, height small, in lateral view less than width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface with tubercles and small scales, increasing posteriorly, less so in younger stages (shallow pits); pereonites 1–4 transverse dorsal ridges not expressed; pereonites 5–7 transverse dorsal ridges low without transverse trough. *Pleonites.* 1–4 transverse dorsal ridges low without transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection linear. Dorsal surface rugose, with elongate ridge-like tubercles, lacking posteromedial ridges or median groups of tubercles. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view distinctly narrowing distally, proximal depth greater than distal depth, with two pairs of robust setae and one median robust seta (robust seta in center smaller), with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length greater than quarter basis length (M2, 0.30), main setal row with 6–7 major setae. Basis of female dorsal ridge epaulet length greater than quarter basis length (F3, 0.42), main setal row with 7 major setae. *Pereopod IV.* Propodus of male ventral margin with projection, with 6 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 robust setae distinctly larger than others, separated by shorter seta.

Description. Body length of largest male 20.4 mm, preparatory female 16.8 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Dorsal surface pitted; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin concave, orientation of longest axis vertical, maximum diameter 0.23–0.24 head depth (M2, F3), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view sigmoidal. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

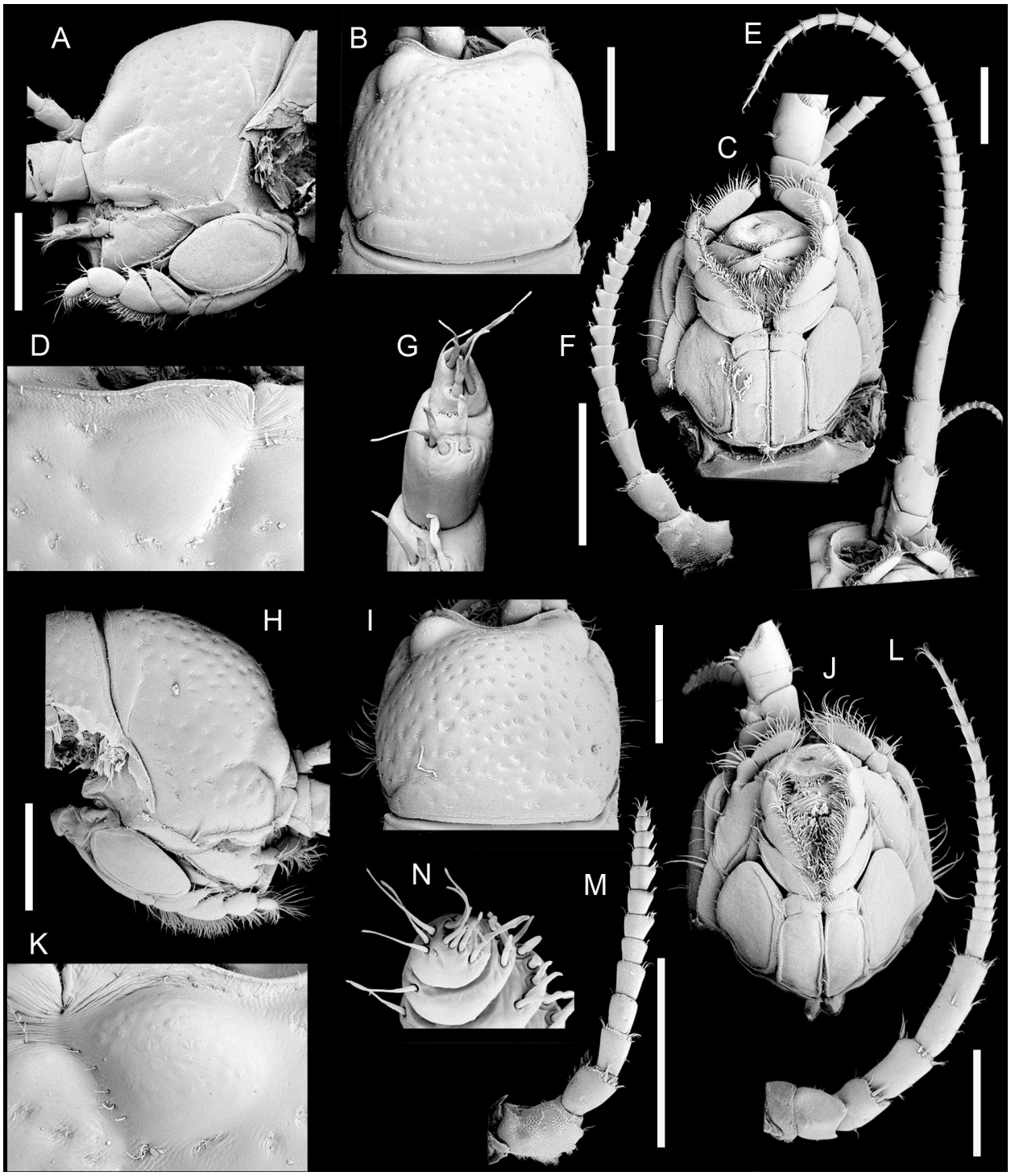

FIGURE 98. *Eophreatoicus djirrinjbal* sp. nov., head and antennae. Paratype male, AM P.76355: A–D, head, lateral dorsal and ventral with enlargement of head region; E, antenna; F–G, antennula with enlargement of distal tip. Paratype female, AM P.76356: H–K, head, lateral dorsal and ventral with enlargement of head region; L, antenna; M–N, antennula, with enlargement of distal tip. Scales 1 mm.

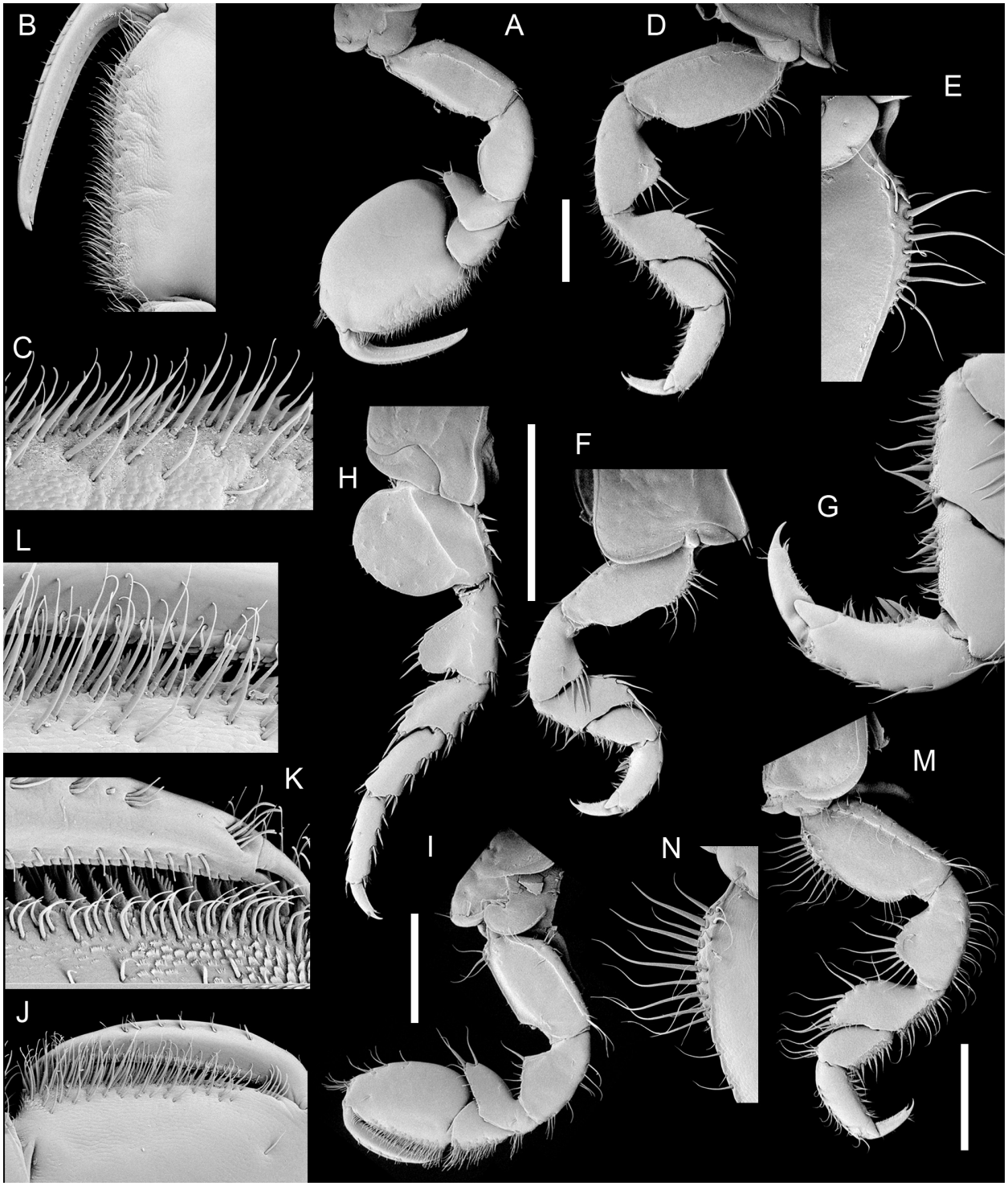

FIGURE 99. *Eophreatoicus djirrinjbal* sp. nov., anterior pereopods. Paratype male, AM P.76355: A–C, pereopod I with enlargement of palm and dactylus, and of palm setation; D–E, pereopod II with enlargement of epaulet on basis; F–G, pereopod IV with enlargement of palm region; H, pereopod V. Paratype female, AM P.76356: I–L, pereopod I with enlargement of palm and dactylus, and of palm setation, medial and lateral; M–N, pereopod II with enlargement of epaulet on basis. Scales 1 mm.

Pereon. Width near head width. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–3 in dorsal view respective lengths less than 0.5 pleonite 5 length, pleonite 4 length more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.40–1.50 pleonite 1 (M2, F3), 1.80 pleonite 2 (M2, F3), 2.00–2.10 pleonite 3 (M2, F3), 2.10 pleonite 4 (M2, F3), 1.90 pleonite 5 (M2, F3).

Pleotelson. Dorsal surface length 0.85–0.91 width in dorsal view (M2, F3). Dorsal surface sparsely covered with setae; with cuticular combs on tubercles. Depth 1.50 pereonite 7 depth (M2, F3). Lateral length less than depth, in male 0.73 depth (M2), in female 0.76 depth (F3). Lateral length 0.12–0.13 body length (M2, F3). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.60–1.70 width of uropodal insertion (M2, F3), with single row of simple robust setae grading anteriorly to fine setae, including 6–7 robust setae altogether (M2, F3), posterior seta longer than anterior adjacent setae. Posterior apex length less than width, long. Posterior apex 0.22 pleotelson total length (M2), width 0.54 pleotelson width (M2). Posterior apex in lateral view forming an angle of 72–82° with immediately anterior dorsal surface (F3, M2), angled 138–146° from horizontal (M2, F3).

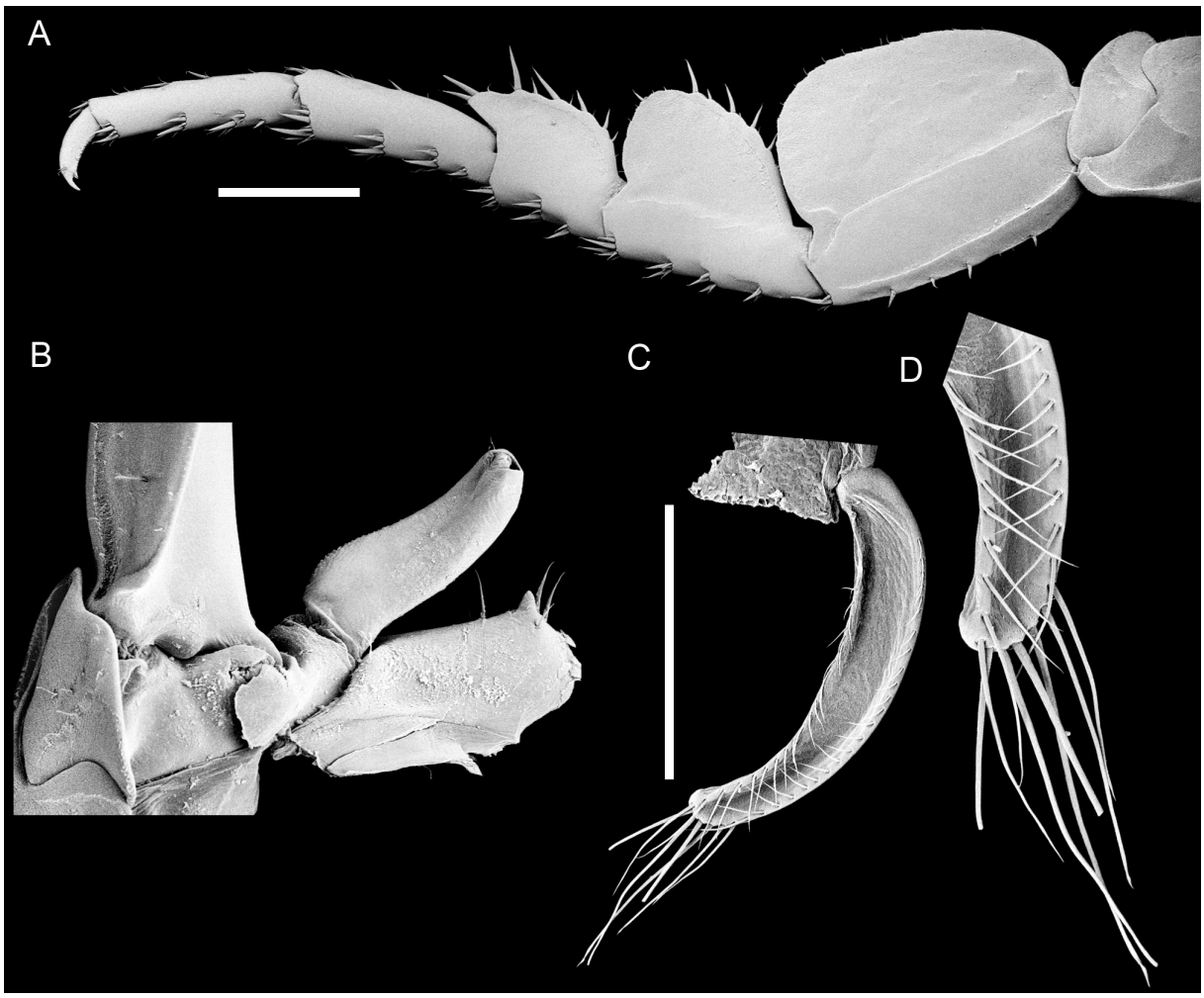

FIGURE 100. *Eophreatoicus djirrinjbal* sp. nov., paratype male, AM P.76355, pereopod VII and appendix masculina. A–B, pereopod VII with enlargement of pene, posterior. C–D, pleopod II appendix masculina. Scales 1 mm.

Antennula. Length 0.13 body length in male (M2), 0.13 body length in female (F3), with 17 articles in male (M2), with 13 articles in female (F3). Article 5 length 0.82–1.10 width (M2, F3). Article 6 length 0.85–0.91 width (M2, F3). Aesthetascs small (1–3) mostly on distomedial margins. Terminal article length 0.87–1.00 width (F3, M2), 0.01–0.02 antennula total length (M2, F3). Distal articles oval in cross-section.

Antenna. Length 0.47 body length in male (M2), 0.34 body length in female (F3). Flagellum length 0.63 total antenna length in male (M2), 0.52 total antenna length in female (F3), with 26 articles in male (M2), with 17 articles in female (F3), proximal articles surface smooth, proximal articles distal margin with rosette of short setae (sparse).

Mouthfield. Clypeus width 0.39 head width (M2).

Maxilliped. Epipod distal tip rounded, length 1.60–2.00 width (M2, F3). Endite distal margin in fringe. Palp length 1.00 basis length (M2). Palp article 4 shape elongate-oval, length 1.20–1.50 width (M2, F3). Palp article 5 length 1.70–1.90 width (F3, M2), 0.63–0.79 article 4 length (F3, M2).

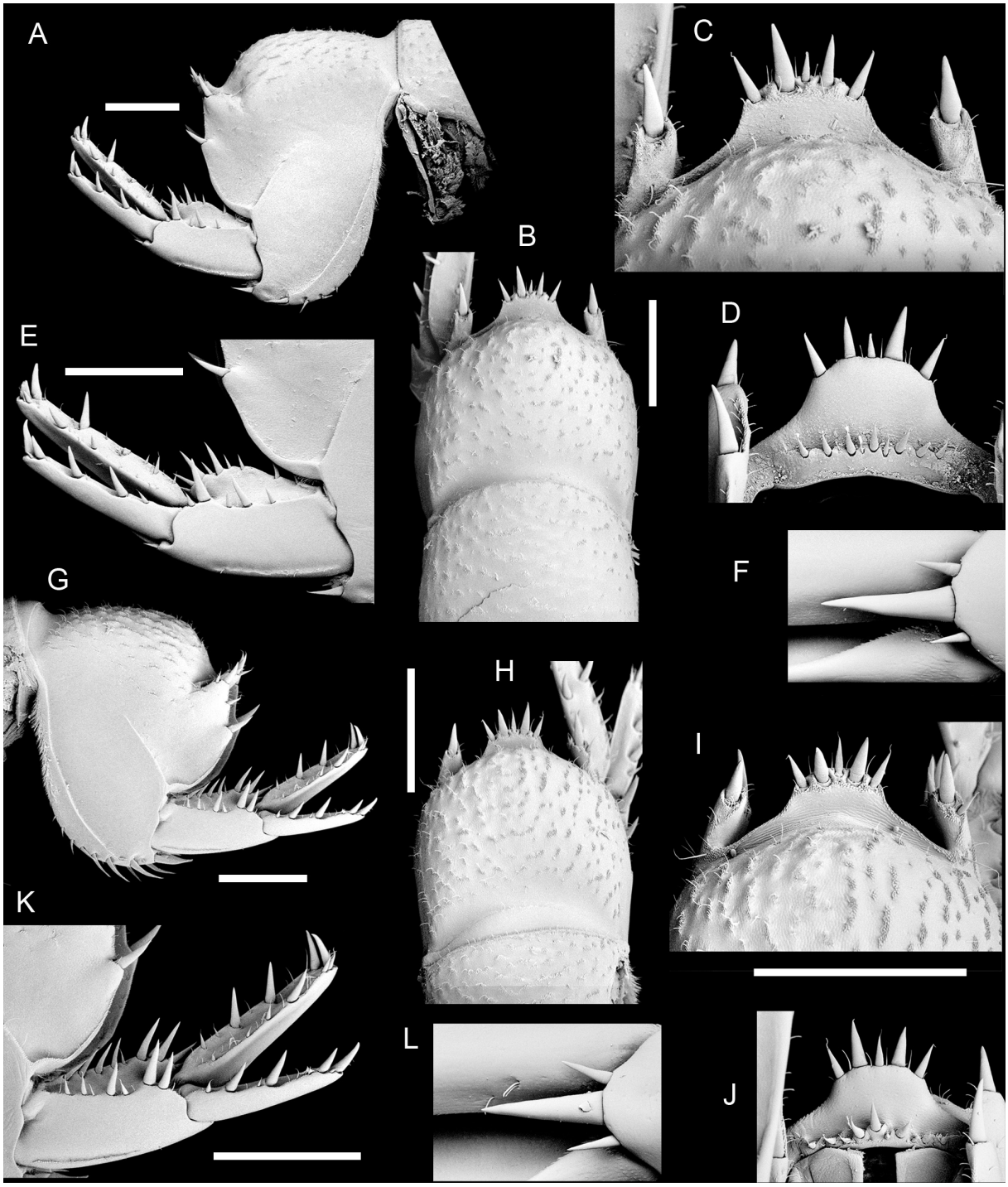

FIGURE 101. *Eophreatoicus djirrinjbal* sp. nov., pleotelson and uropods. Paratype male, AM P.76355: A, pleotelson lateral; B–D, pleotelson dorsal with enlargements of vertex, dorsal and ventral showing postanal ridge setation; E–F, uropod with enlargement of protopod distoventral margin setation. Paratype female, AM P.76356: G–J, pleotelson, lateral, dorsal with enlargements of vertex, dorsal and ventral showing postanal ridge setation; K–L, uropod with enlargement of protopod distoventral margin setation. Scales 1 mm.

Pereopod I. Length:body length 0.36 male (M2), 0.32 female (F3). Basis of male length 2.40 width (M2), female length 2.10 width (F3); absent; female dorsal setae positioned proximally, female 4 dorsal setae altogether (F3); ventrodistal margin with 1 elongate seta, female with 3 elongate setae (F3), elongate setae longer than ischium. Ischium of male dorsal margin without simple setae. Ischium of female dorsal margin with 7 simple setae (F3), setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal

margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (1 heavy simple 1 small); female distodorsal margin with few elongate simple setae, female dorsal surface with setae along dorsal axis (2 heavy simple). Propodus length:pereopod length 0.23 male (M2), 0.19 female (F3). Propodus length:width 1.10 male (M2), 1.40 female (F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 5 setae altogether (excluding distal group) (M2), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae articulated, 18 altogether (M2). Propodal palm of female margin convex, stout denticulate setae serrate, 12 altogether (F3), with stout robust conical setae, 5 altogether (F3,proximal to denticulate setae). Dactylus of male length subequal to palm, length:palm length 1.00 (M2), female longer than palm, female length:palm length 1.20 (F3). Dactylus of female ventrodistal margin distal cuticular fringe length 0.65 total length (F3, estimate, likely higher - unable to measure as margin partially obscured by propodal palm setae). Dactylus claw length:dactylus length 0.08 male (M2). Dactylus of male positioned ventrally, 0.57(M2) length of primary claw.

Pereopods II–III ratios. *Pereopod II*. Length:body length 0.35 male (M2), 0.31 female (F3). Basis length: pereopod length 0.29 male (M2), 0.30 female (F3); length:width 2.30 male (M2), 2.10 female (F3). Carpus length: pereopod length 0.12 male (M2), 0.11 female (F3); length:width 1.60 male (M2), 1.40 female (F3). Propodus length:pereopod length 0.16 male (M2), 0.16 female (F3); length:width 2.70 male (M2), 2.60 female (F3). Dactylus length:propodus length 0.58 male (M2), 0.66 female (F3); primary claw length:dactylar length 0.21 male (M2), 0.28 female (F3). *Pereopod III*. Length:body length 0.33 male (M2), 0.31 female (F3). Basis length:pereopod length 0.30 male (M2), 0.31 female (F3); length:width 2.30 male (M2), 2.50 female (F3). Carpus length:pereopod length 0.12 male (M2), 0.11 female (F3); length:width 1.60 male (M2), 1.40 female (F3). Propodus length:pereopod length 0.15 male (M2), 0.15 female (F3); length:width 2.50 male (M2), 2.60 female (F3). Dactylus length:propodus length 0.57 male (M2), 0.63 female (F3). *Pereopods II–III*. Penicillate setae scattered on dorsal ridge of basis, carpus, propodus.; basis dorsal ridge with setae forming 2 rows on proximal projection, simple elongate setae along rest of ridge in female(F3). Ischium II–IV of male dorsal margin with 7 simple setae (M2 pereopod II), none robust. Dactylus ventral to primary claw, 0.24–0.27 length of primary claw, with scales on ventral margin; 16 altogether (F3 pereopod II, approx).

Pereopod II. Basis lateral face with 4 simple setae along margin in male and 8 elongate setae along margin in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 5 minor setae (M3), submarginal setal row with 4 setae (M2), without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 3 minor setae (F3), submarginal setal row with 8 setae (F3), with major setae distally, with 6 major setae distal to epaulet (F3).

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 14 setae (M2), dorsal ridge setae positioned proximally, of female dorsal ridge setae positioned along ridge. Ischium of male dorsal margin with 7 setae (M2). Carpus of male ventral margin with simple setae only. Propodus of male distal width 0.71 maximum width (M2), setae on ventral margin robust-based, 2 distinctly larger than remainder, longer than dactylar claw (M2, 1.6). Dactylus of male distal accessory claw approximately 0.25 primary claw length (M2,0.23). *Pereopod IV ratios*. Length:body length 0.26 male (M2), 0.28 female (F3). Basis length:width 2.30 male (M2), 2.70 female (F3). Carpus length:pereopod length 0.13 male (M2), 0.09 female (F3). Propodus length:pereopod length 0.17 male (M2), 0.17 female (F3). Propodus length:width 2.30 male (M2), 3.00 female (F3).

Pereopods V–VII ratios. *Pereopod V*. Length:body length 0.31 male (M2), 0.31 female (F3). Basis length:width 1.00 male (M2), 1.20 female (F3). Carpus length:pereopod length 0.18 male (M2), 0.16 female (F3). Propodus length:pereopod length 0.16 male (M2), 0.16 female (F3). Dactylus claw length:dactylar length 0.28 male (M2). *Pereopod VI*. Length:body length 0.41 male (M2). Propodus length:pereopod length 0.17 male (M2). *Pereopod VII*. Length:body length 0.42 male (M2). Basis length:width 1.40 male (M2). Carpus length:pereopod length 0.17 male (M2). Propodus length:pereopod length 0.17 male (M2). Dactylus claw length:dactylar length 0.29 male (M2).

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 4–5 setae (M2 pereopod V, pereopod VII). Propodus distal margins with 5–6 elongate robust or robust-based setae (M2 pereopod VII, pereopod V). Dactylus accessory claw 0.28–0.29 primary claw length (M2 pereopod VII, pereopod V). Pereopod VII basis dorsal ridge distal margin

rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with 1 seta, dorsal margin with 5 setae (M2).

Penes. Distally tapering; distal tip truncate.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 1.80 endopod proximal margin length; distally with 7 setae; 51 setae altogether (M2).

Uropod. Of male total length 1.20 pleotelson length (M2); protopod of male length 0.49 uropod total length (M2). Uropod of female total length 1.10 pleotelson length (F3), protopod length 0.49 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.47 male (M2), 0.53 female (F3). Protopod of male dorsolateral margin longer than dorsomedial margin setae; of female dorsolateral margin subequal to dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, without spinose setae, 3 robust simple setae (M2, F3). Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 9 altogether (M2); female dorsal margin with 12 robust setae (F3). Exopod length: endopod length 0.83 male (M2), 0.79 female (F3). Exopod of male dorsal margin with 6 robust setae (M2), female 7 robust setae (F3).

Distribution. Australia, Northern Territory, Kakadu National Park, Ngarradj Creek Spring, in a tributary of Magela Creek, East Alligator River catchment.

Habitat. On the margin of stream in roots and leaf litter.

Remarks. *Eophreatoicus djirrinjbal* sp. nov. is in a clade (Fig. 12) with *E. mok* sp. nov. and *E. karrkkanj* sp. nov. Unlike the other two species, *E. djirrinjbal* sp. nov. has distinctly smaller eyes. Of the two species, *E. karrkkanj* sp. nov. is most similar to *E. djirrinjbal* sp. nov. The pleotelson dorsal surface in *E. karrkkanj* sp. nov. has oblong tubercles, whereas *E. djirrinjbal* sp. nov. has elongate ridge-like tubercles.

Eophreatoicus boywek sp. nov.

(Figs 102–106)

urn:lsid:zoobank.org:act: 27E36A41-17EE-46D6-8EA8-F552B352F281
Eophreatoicus sp. "Zr".—Wilson *et al.*, 2009: 362.

Type material. Holotype male, bl 14.6 mm, AM P.76297. Paratypes collected with holotype: male (M2), bl 15.9 mm, AM P.76298, DNA E86 Genbank COI EU263198 16S EU263270, SEM stubs AW728–731; female preparatory (F3), bl 12.7 mm, AM P.76299, DNA E87 Genbank COI EU263199 16S EU263271, SEM stubs AW733–736; 1 ind, AM P.76296, DNA E42 (unsuccessful); 26 inds, AM P.76294; 4 inds, AM P.76295.

Type locality. Australia, Northern Territory, Kakadu National Park, Zac's Retreat, 12°30.998'S, 132°54.124'E, coll. C. Humphrey, 3.iii.2003.

Other material examined. 21 inds, NTMus Cr010942, coll. 14.xi.1974, R. Pengilley, 12°31.52'S, 132°54.24'W.

Etymology. "Boywek Bakoluy", meaning "knob-tailed gecko descended" (language Kundjeyhmi) and pronounced "boy-wek bah-gol-ooee", is the closest named site to the locality of this species. The name can be shortened to "boywek", as used here.

Diagnosis. *Head.* Eyes bulging dorsolaterally, height small, in lateral view less than width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface with tubercles and small scales, increasing posteriorly, less so in younger stages; pereonites 1–4 transverse dorsal ridges rounded, expressed as transverse trough only; pereonites 5–7 transverse dorsal ridges carinate with transverse trough. *Pleonites*. 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection convex. Dorsal surface rugose, with oblong tubercles, lacking posteromedial ridges or median groups of tubercles. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae and one median robust seta, with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 shorter than article 4. *Pereopod I.* Dactylus of male ventrodistal margin low scales; with row of thin scale-like spines; female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal

ridge epaulet length less than quarter length of basis, main setal row with 4 major setae. Basis of female dorsal ridge epaulet length subequal to quarter basis length (F3,0.26), main setal row with 4–5 major setae. *Pereopod IV.* Propodus of male ventral margin without projection, with 3 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate subequal to shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 adjacent robust setae distinctly larger than others.

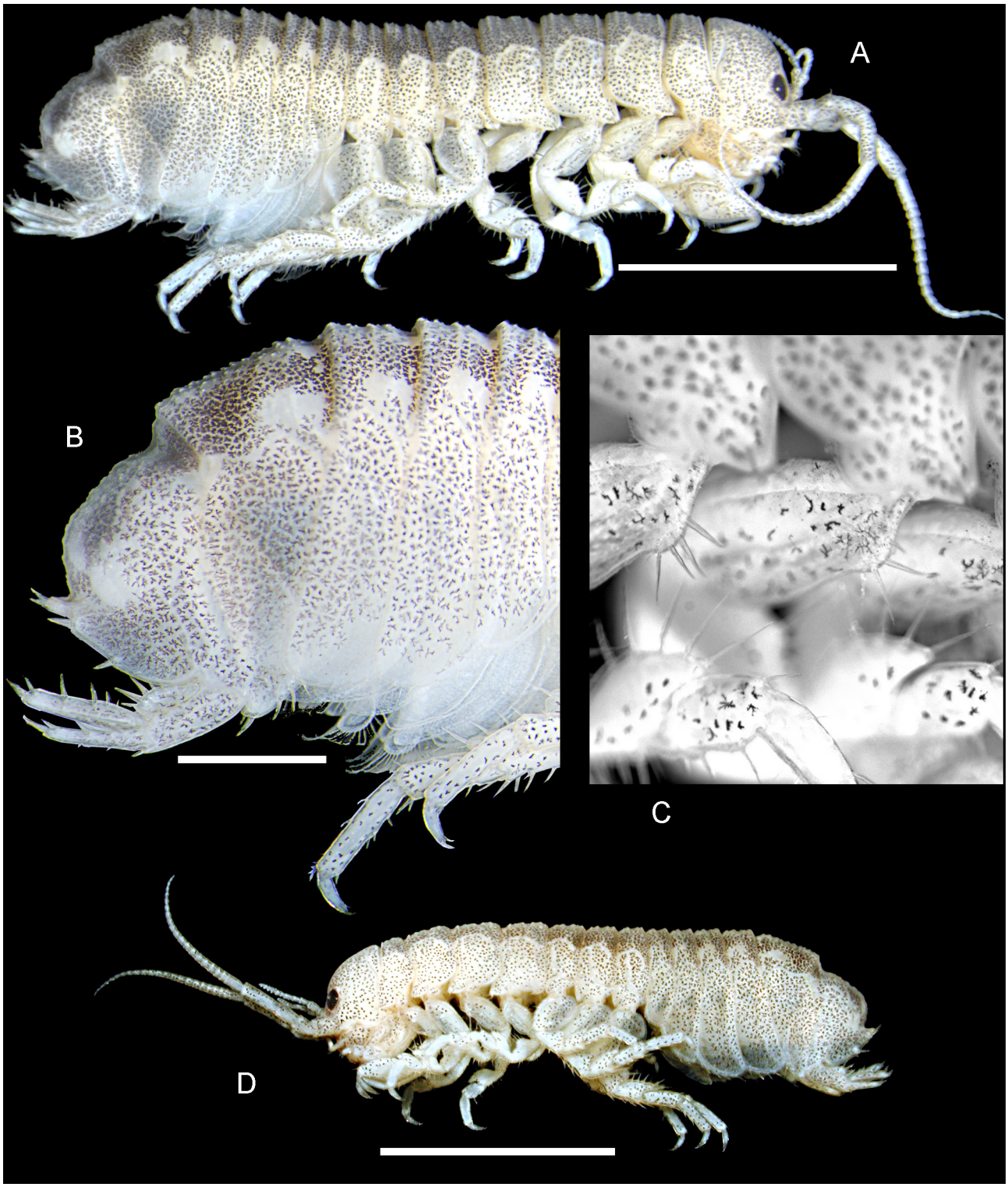

FIGURE 102. *Eophreatoicus boywek* sp. nov. habitus. A–C, holotype male, AM P.76297: A, lateral; B, posterior pleon, lateral, scale 1 mm; C, bases II–III epaulets. D, paratype female, AM P.76299, lateral. Scales 5 mm.

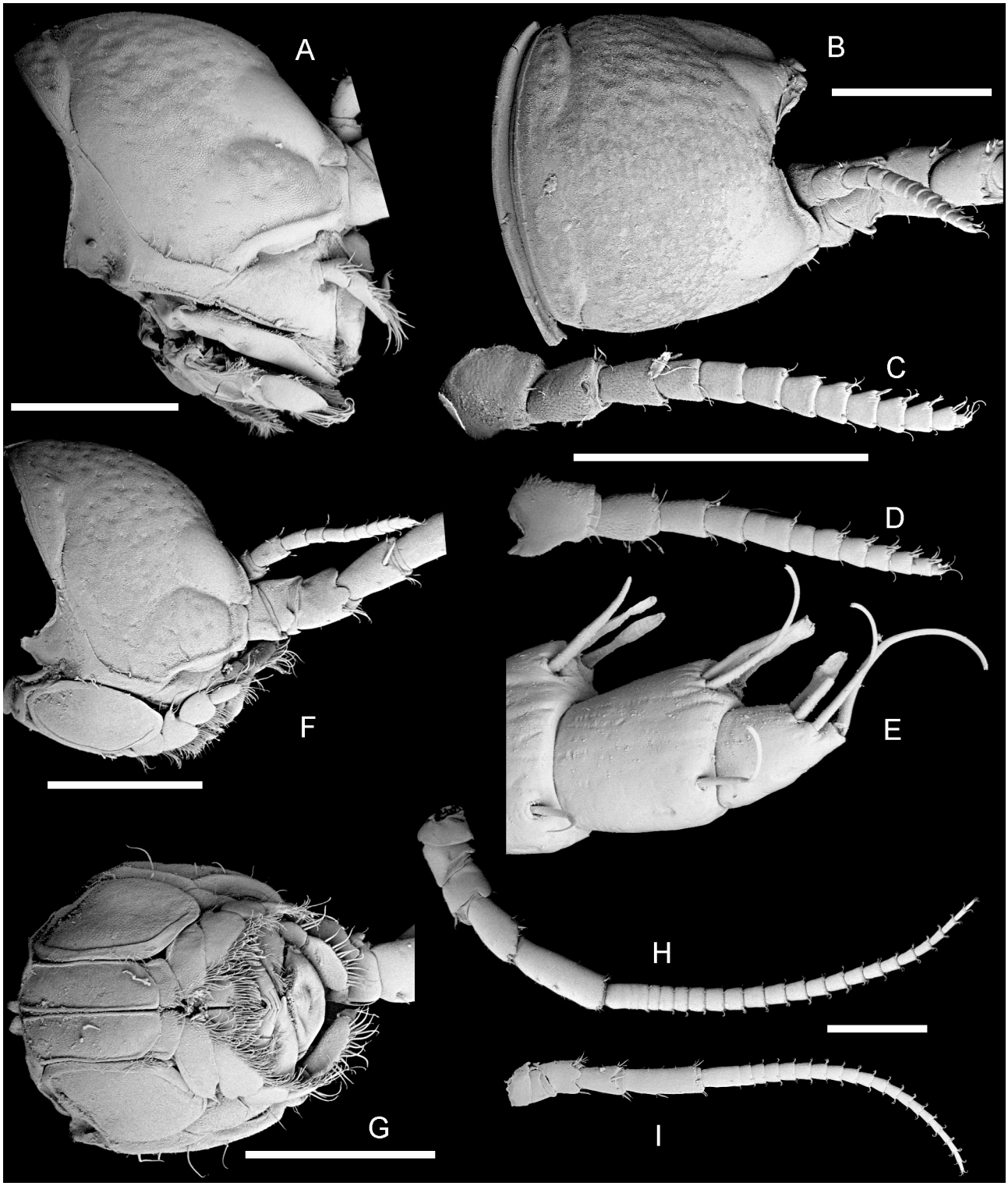

FIGURE 103. *Eophreatoicus boywek* sp. nov. head and antennae: paratype male, AM P.76298, paratype female, AM P.76299. A–B, male head, lateral and dorsal. C–D, antennula, male and female. E, antennula tip, male. F–G, female head, lateral and ventral. H–I, antenna, male and female. Scales 1 mm.

Description. Body pigmentation maculate and light colored, dorsal median line thin, broad dorsolateral bars, chromatophores small dense irregular; length of largest male 15.9 mm, length of largest preparatory female 12.7 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Dorsal surface pitted; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin straight, orientation of

longest axis vertical, maximum diameter 0.24–0.27 head depth (M2; H, F3), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view sigmoidal. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

Pereon. Width near head width. Coxal articulation to pereonites 2–4 nearly fused.

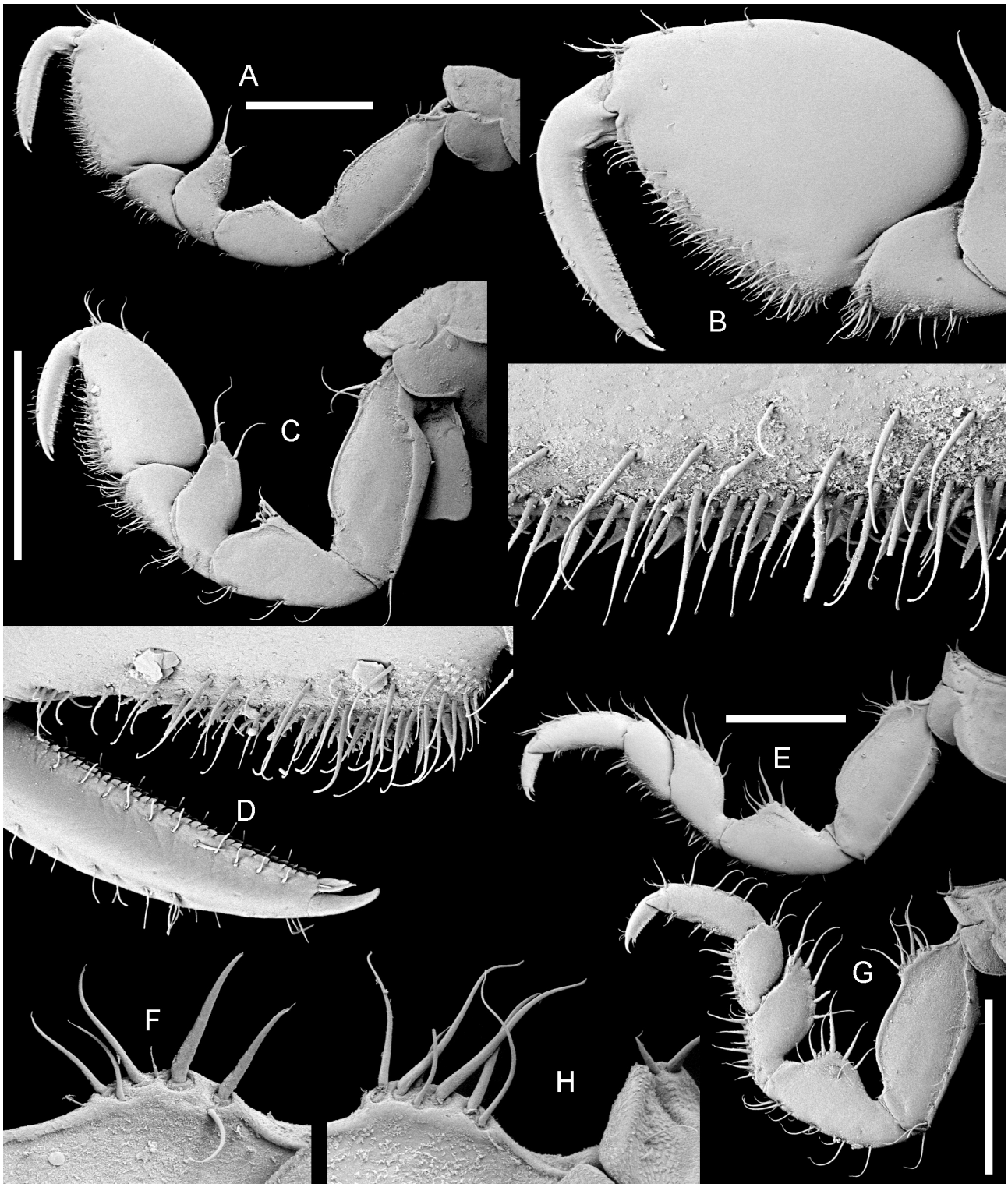

FIGURE 104. *Eophreatoicus boywek* sp. nov., pereopods I–II: paratype male, AM P.76298, paratype female, AM P.76299. A–B, male pereopod I, lateral, with enlargement of distal segments and palm setae. C–D, female pereopod I with enlargement of palm and dactylus. E–F, male pereopod II with enlargement of epaulet. G–H, female pereopod II with enlargement of epaulet. Scales 1 mm.

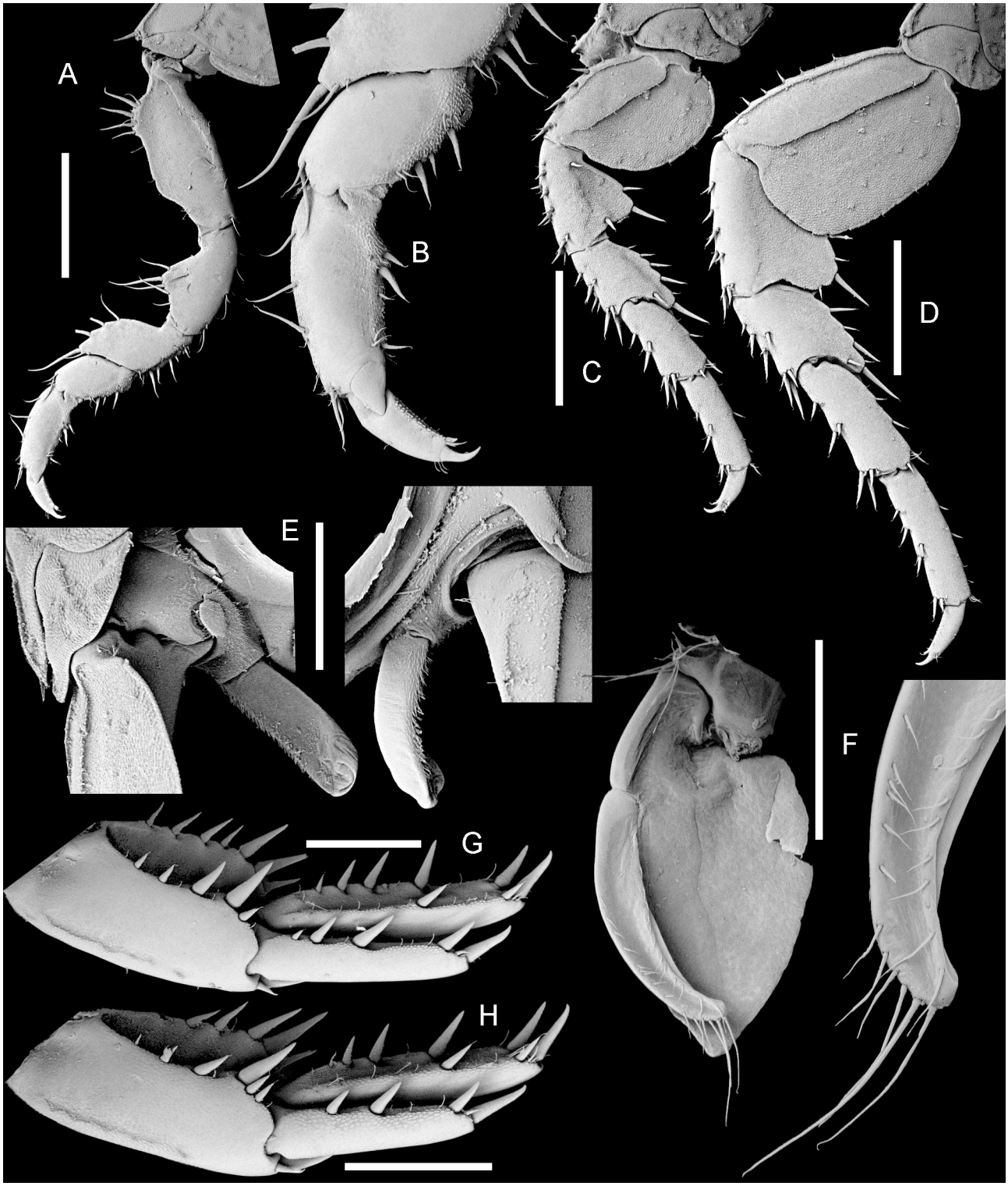

FIGURE 105. *Eophreatoicus boywek* sp. nov. pereopods, pleopod II, uropods. Paratype male, AM P.76298: A–B, pereopod IV with enlargement of distal articles; C, pereopod V; D, pereopod VII; E, pene posteroventral and anterior; F, pleopod II endopod and appendix masculina with enlargement of distal tip; G, uropod lateral. H, uropod lateral, paratype female, AM P.76299. Scales 1 mm, except for G–H, 0.5 mm.

Pleonites. Pleonites 2–4 in dorsal view respective lengths less than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.20–1.40 pleonite 1 (H, M2; F3), 1.60–1.70–1.80 pleonite 2 (H, M2, F3), 1.90–2.00–2.10 pleonite 3 (H, M2, F3), 1.80–2.00 pleonite 4 (H; M2, F3), 1.70–1.90 pleonite 5 (H; M2, F3).

Pleotelson. Dorsal surface length 0.87–0.89 width in dorsal view (F3, M2). Dorsal surface sparsely covered with setae; with cuticular combs on tubercles. Depth 1.10–1.50–1.60 pereonite 7 depth (H, F3, M2). Lateral length less than depth, in male 0.75–0.77 depth (H, M2), in female 0.78 depth (F3). Lateral length 0.13 body length (M2, F3). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.40 width of uropodal insertion (M2, F3), with one row of distally denticulate robust setae, including 6–7 robust setae altogether (M2, F3), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.12–0.13 pleotelson total length (F3, M2). Posterior apex length less than width, long. Posterior apex 0.20–0.22 pleotelson total length (M2, F3), width 0.47–0.49 pleotelson width (F3, M2). Posterior apex in lateral view forming an angle of 75–78–85° with immediately anterior dorsal surface (F3, H, M2), angled 132–136–144° from horizontal (H, F3, M2).

Antennula. Length 0.12 body length in male (M2), 0.12 body length in female (F3), with 14 articles in male (M2), with 12 articles in female (F3). Article 5 length 1.20–1.50 width (M2, F3). Article 6 length 0.63–0.78 width (M2, F3). Aesthetascs small (1–3) mostly on distomedial margins. Terminal article length 0.89–1.10 width (F3, M2), 0.02–0.02 antennula total length (M2, F3). Distal articles oval in cross-section.

Antenna. Length 0.41 body length in male (M2), 0.37 body length in female (F3). Article 6 subequal to articles 4 and 5 combined. Flagellum length 0.60 total antenna length in male (M2), 0.63 total antenna length in female (F3), with 21 articles in male (M2), with 23 articles in female (F3), proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Mouthfield. Clypeus width 0.32–0.34 head width (M2, F3).

Maxilliped. Epipod distal tip rounded, length 2.10 width (F3). Endite distal margin in fringe. Palp length 0.84 basis length (F3). Palp article 4 shape elongate-oval, length 1.10 width (F3). Palp article 5 length 2.30 width (F3), 1.10 article 4 length (F3).

Pereopod I. Length:body length 0.34 male (M2), 0.30 female (F3). Basis of male length 2.40 width (M2), female length 2.20 width (F3); dorsal setae positioned along ridge, 4 dorsal setae altogether (M2); female dorsal setae positioned proximally, female 3 dorsal setae altogether (F3); ventrodistal margin with 2 elongate setae (M2), female with 2 elongate setae (F3), elongate setae longer than ischium. Ischium of male dorsal margin with 1 simple seta, setae not robust. Ischium of female dorsal margin with 3 simple setae (F3), setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (2 heavy simple); female distodorsal margin with few elongate simple setae, female dorsal surface with setae along dorsal axis (2 heavy simple). Propodus length:pereopod length 0.21 male (M2), 0.18 female (F3). Propodus length:width 1.10 male (M2), 1.40 female (F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 4 setae altogether (excluding distal group) (M2), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae articulated, 17 altogether (M2). Propodal palm of female margin convex, stout denticulate setae serrate, 12 altogether (F3), with stout robust conical setae, 4 altogether (F3,proximal to denticulate setae). Dactylus of male longer than palm, length: palm length 1.10 (M2), female longer than palm, female length:palm length 1.20 (F3). Dactylus of male ventrodistal margin ventrodistal margin distal cuticular fringe length 0.40 total length (M2); female ventrodistal margin distal cuticular fringe length 0.67 total length (F3). Dactylus claw length:dactylus length 0.15 male (M2), 0.15 female (F3). Dactylus of male positioned ventrally, 0.36–0.46 (M2, F3) length of primary claw.

Pereopods II–III ratios. Pereopod II. Length:body length 0.30–0.35 male (M2, H), 0.30 female (F3). Basis length:pereopod length 0.29–0.31 male (M2, H), 0.31 female (F3); length:width 2.40 male (H, M2), 2.40 female (F3). Carpus length:pereopod length 0.10–0.11 male (H, M2), 0.12 female (F3); length:width 1.20–1.30 male (H, M2), 1.50 female (F3). Propodus length:pereopod length 0.15–0.16 male (H, M2), 0.16 female (F3); length:width 2.40–2.50 male (H, M2), 2.50 female (F3). Dactylus length:propodus length 0.63–0.64 male (M2, H), 0.61 female (F3); primary claw length:dactylar length 0.28 male (M2), 0.27 female (F3). *Pereopod III.* Length:body length 0.35 male (H). Basis length:pereopod length 0.31 male (H); length:width 2.70 male (H), 2.40 female (F3). Carpus length: pereopod length 0.10 male (H); length:width 1.30 male (H). Propodus length:pereopod length 0.16 male (H); length: width 2.80 male (H). Dactylus length:propodus length 0.52 male (H). *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, carpus, propodus., dactylus; basis dorsal ridge with setae forming 2 rows on proximal projection. Ischium II–IV of male dorsal margin with 5 simple setae (M2), none robust. Dactylus ventral to primary claw, 0.29–0.31 length of primary claw, with scales on ventral margin; 13 altogether (F3 pereopod II).

Pereopod II. Basis lateral face with 2 tiny setae proximally and one seta midlength in male and 6 simple setae along margin proximally in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row without minor setae, submarginal setal row with 2–2–3 setae, without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row 2 specimens has no fine setae, out of 5 specimens, main setal row with 0–1–2 minor setae, submarginal setal row with 3–3–4 setae, without major setae distally (1 specimen has 3 setae, out of 5 specimens).

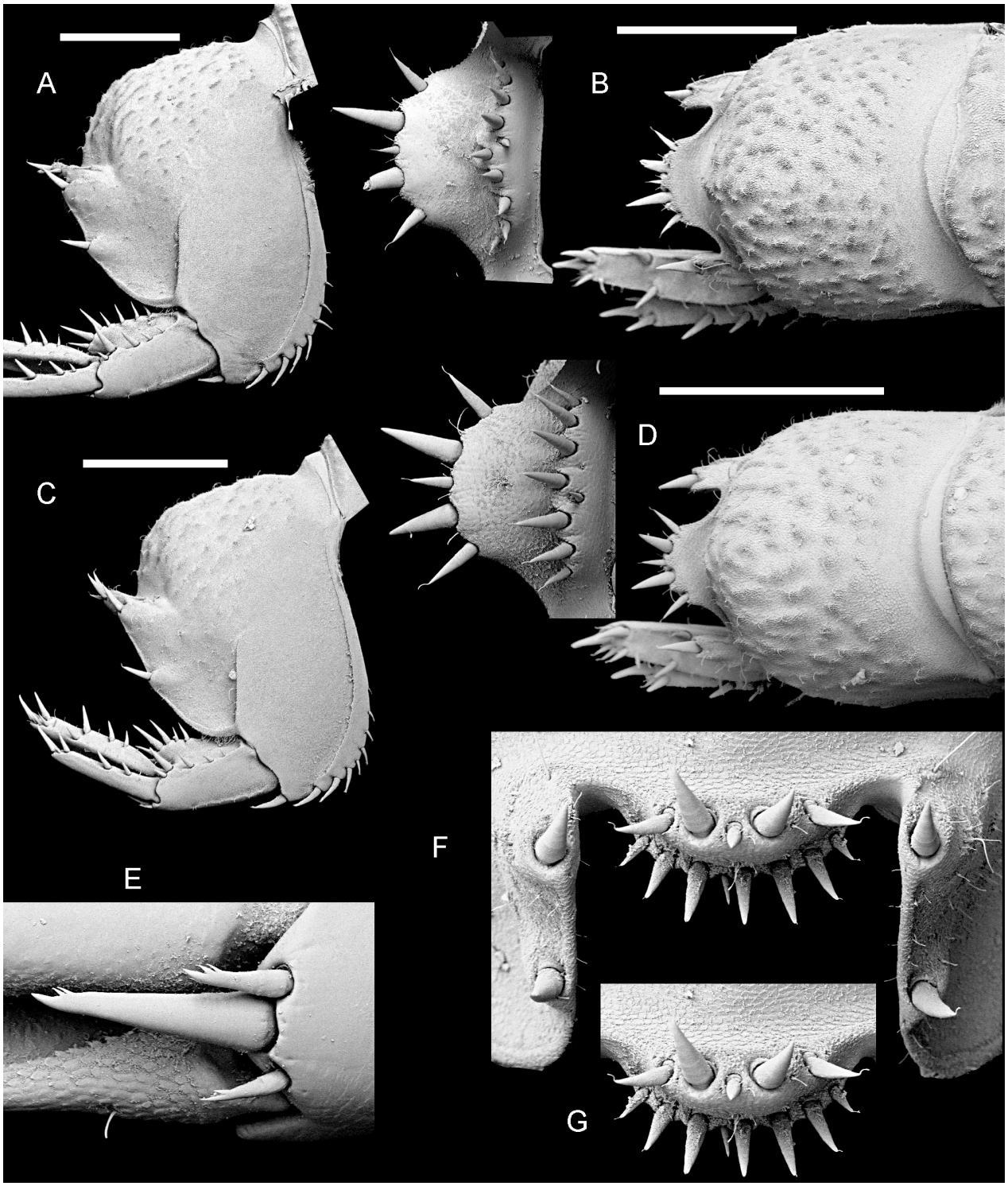

FIGURE 106. *Eophreatoicus boywek* sp. nov., pleotelson and uropods. A–B, F, paratype male, AM P.76298. C–E, G, paratype female, AM P.76299. A–B, lateral and ventral with enlargement of ventral apex. C–D, lateral and dorsal with enlargement of ventral apex. E, uropod protopod distoventral setae. F–G, pleotelson apex, posterior. Scales 1 mm.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 7 setae (M2), dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 7 setae (M2). Carpus of male ventral margin with simple setae only. Propodus of male distal width 0.75 maximum width (M2), setae on ventral margin robust-based, 1 distinctly larger than remainder, subequal in length to dactylar claw. Dactylus of male distal accessory claw approximately 0.33 primary claw length (M2,0.30). *Pereopod IV ratios.* Length:body length 0.33 male (M2). Basis length:width 2.40 male (M2). Carpus length:pereopod length 0.12 male (M2). Propodus length:pereopod length 0.16 male (M2). Propodus length:width 2.50 male (M2).

Pereopods V–VII ratios. Pereopod V. Length:body length 0.29–0.33 male (M2, H). Basis length:width 1.20–1.30 male (H, M2), 1.20 female (F3). Carpus length:pereopod length 0.15–0.16 male (H, M2). Propodus length:pereopod length 0.17–0.18 male (M2, H). Dactylus claw length:dactylar length 0.33 male (M2). *Pereopod VI.* Length:body length 0.39–0.41 male (H, M2), 0.36 female (F3). Basis length:width 1.30–1.40 male (H, M2). Carpus length: pereopod length 0.17 male (H, M2), 0.17 female (F3). Propodus length:pereopod length 0.17–0.18 male (M2, H), 0.18 female (F3). *Pereopod VII.* Length:body length 0.44 male (M2), 0.38 female (F3). Basis length:width 1.40 male (M2). Carpus length:pereopod length 0.16–0.17 male (H, M2), 0.16 female (F3). Propodus length:pereopod length 0.18–0.19 male (M2, H), 0.17 female (F3). Dactylus claw length:dactylar length 0.26 male (M2).

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 2–3 setae (M2 pereopod V, pereopod VII). Propodus distal margins with 3 elongate robust or robust-based setae (M2 pereopod V, pereopod VII). Dactylus accessory claw 0.29–0.33 primary claw length (M2 pereopod VII, pereopod V). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with 1 seta, dorsal margin with 3 setae (M2).

Penes. With cuticular hairs on shaft; distally tapering; distal tip truncate.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 1.80 endopod proximal margin length; distally with 5 setae (2 setae missing in SEM); 28 setae altogether (M2).

Uropod. Of male total length 1.00 pleotelson length (H, M2); protopod of male length 0.47 uropod total length (H, M2). Uropod of female total length 0.96 pleotelson length (F3), protopod length 0.48 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.55 male (M2), 0.61 female (F3). Protopod of male dorsolateral margin subequal to dorsomedial margin setae; of female dorsolateral margin subequal to dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, with spinose setae, 3 robust spinose setae. Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 8 altogether (M2); female dorsal margin with 9 robust setae (F3). Exopod length:endopod length 0.80–0.81 male (H, M2), 0.76 female (F3). Exopod of male dorsal margin with 6 robust setae (M2), female 5 robust setae (F3).

Distribution. Australia, Northern Territory, Kakadu National Park, Zac's Retreat located in a small tributary feeding into Magela Creek floodplain, East Alligator River catchment.

Habitat. In seep and small stream flowing from Jabiluka outlier.

Remarks. *Eophreatoicus boywek* sp. nov. is part of a large clade (Fig.12), including spp. nov. *E. nawurlandja, E. kurrih, E. djurrukunja*, and two other unnamed species Zi and J1. Unlike the named species, *E. boywek* sp. nov. has a pleotelson dorsal surface with more oblong tubercles rather than elongate ridge-like tubercles, and the pereopod II basis epaulet has only 4–5 major setae.

Eophreatoicus sp. Zi

Eophreatoicus sp. "Zi".—Wilson *et al.*, 2009: 362.

Material examined. Australia, Northern Territory, Kakadu National Park. West flowing tributary of Jabiluka Outlier, ISP site 20, 12°32.704'S, 132°54.844'E, coll. C. Humphrey & party, 3.iv.2003. Male, AM P.76292, DNA E16 Genbank 16S EU263272; female preparatory, AM P.76291, DNA E15 (unsuccessful); 10 males, bl ~20 mm (largest), AM P.76289; 7 females, largest bl ~18 mm, AM P.76290. ISP site 20, 12°32.71'S, 132°54.7'E, coll. C.

Humphrey, 3.iii.2003: brooding female, AM P.76301, embryos DNA E21–23 Genbank COI EU263201; 22 inds, AM P.76300. ISP site 20, 12°32.704'S, 132°54.844'E, coll. C. Humphrey & party, 3.iv.2003, male, AM P.76293, DNA E17 Genbank COI EU263200 16S EU263273.

Distribution. Australia, Northern Territory, Kakadu National Park, south of Zac's Retreat and flowing similarly into the Magela Creek floodplain, East Alligator River catchment.

Remarks. *Eophreatoicus* sp. Zi co-occurs with another poorly characterized species *E*. sp. Zu (see Wilson *et al*. 2009); they are difficult to distinguish from each other. *Eophreatoicus* sp. Zi, however, appears to be a sister group of *E. djurrukunja* sp. nov. with strong support in the combined analysis (Fig. 12). *Eophreatoicus* sp. Zi has a pereopod II basis epaulet with 5–8 major setae, while *E. djurrukunja* sp. nov. has only 5 setae in either sex.

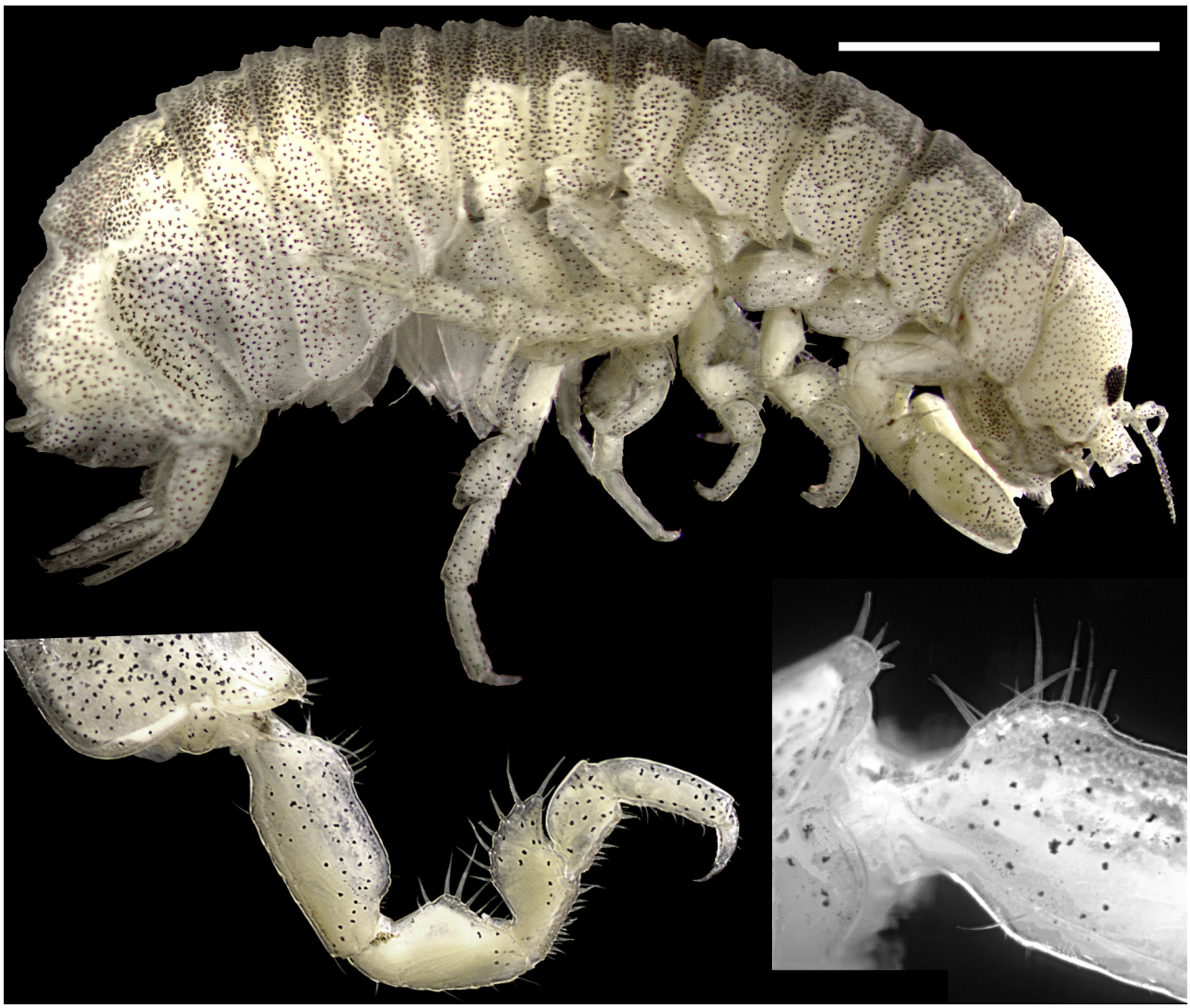

FIGURE 107. *Eophreatoicus* sp. Zu, male, AM P.103570. A, lateral. B–C, pereopod II with enlargement of epaulet. Scale 5 mm

Eophreatoicus sp. Zu

(Fig. 107)

Eophreatoicus sp. "Zu".—Wilson *et al.*, 2009: 363.

Material examined. Australia, Northern Territory, Kakadu National Park. West flowing tributary from Jabiluka Outlier, 12°32.239'S 132°55.67'E, coll. C. Humphrey, 3.iii.2003: Male, AM P.76303, DNA E59 GenBank COI EU263202 16S EU263274; juvenile female, AM P.76302, DNA E24 (unsuccessful); 22 inds, AM P.76300 (some

could be sp. Zi). W02A, 12°32.231'S 132°55.673'E, rocky waterfall, coll. L. Chandler, A. Sullivan, R. Gamarrawu, 18.iv.2007: 10 ind. AM P.97283; adult male (M5), AM P.103564, DNA E205 (unsuccessful); female with brood pouch (F6), AM P.103565, DNA E206 Genbank 16S MK961113 COI MK967238; juvenile male (M7), AM P.103566, DNA E207 Genbank 16S MK961114 COI MK967239; juvenile female (F8), AM P.103567, DNA E208 Genbank 16S MK961115 COI MK967240. W02B, rocky waterfall, 12°32.225'S, 132°55.676'E, 18.iv.2007, coll. L. Chandler, A. Sullivan, R. Gamarrawu: 13 ind. AM P.97284; embryos from female (F1) brood pouch, AM P.103568, DNA E201 (unsuccessful); embryos from female (F2) brood pouch, AM P.103569, DNA E202 Genbank 16S MK961111 COI MK967236; adult male (M3), limbs dissected, AM P.103570, DNA E203 (unsuccessful); juvenile male (M4), AM P.103571, DNA E204 Genbank 16S MK961112 COI MK967237.

Distribution. Australia, Northern Territory, Kakadu National Park, East of Zac's Retreat, flowing into Ngarradj Creek, a tributary flowing into Magela Creek floodplain, East Alligator River catchment.

Habitat. Collected from rocky waterfalls in two nearby places.

Remarks. This distinct species, *Eophreatoicus* sp. Zu, is not formally described owing to insufficient morphological data. The distinctness of this species is supported by genetic analyses (Wilson *et al.* 2009). *Eophreatoicus* sp. Zu is found abundantly on the southern side of the Jabiluka Outlier. This species remains undescribed at this time. Genetically, this species appears to be related to the same clade as *E. boywek* sp. nov. (Fig. 11) and has geographic proximity to this species. Males of *E*. sp. Zu have a pereopod II basis epaulet with five major setae, while *E. boywek* sp. nov. has four setae.

Eophreatoicus kudjaldordo sp. nov.

(Figs 108–113)

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Eophreatoicus sp. "J2".—Wilson *et al.*, 2009:362.

Type material. Holotype male, bl 22.6 mm, AM P.76361. Paratypes collected with holotype: male (M2), bl 26.4 mm, AM P.76362, DNA E91 COI EU263182 16S EU263254, SEM stubs, AW791–796; male, AM P.76365, DNA E28 Genbank COI EU263181 16S EU263253; female (F3), bl 15.4 mm, AM P.76363, DNA E92 Genbank COI EU263183 16S EU263255, SEM stubs AW797–800; preparatory female; AM P.76364, DNA E27 (unsuccessful); 7 males, AM P.76359; 7 females, AM P.76360.

Type locality. Australia, Northern Territory, Kakadu National Park, north of Wirnmuyurr Creek near Jabiluka, "7-J Scree site 3", 12°34.69'S 132°58.01'E, coll. C. Humphrey & party, 11.iv.2003.

Other material examined. Kakadu National Park, North of Wirnmuyurr Creek. W03B (7J), 12° 34.625' S, 132° 57.786' E, 18.iv.2007, coll. L. Chandler, A. Sullivan, R. Gamarrawu: AM P.97286, 26 individuals. Adult male, AM P.103497, DNA E209 Genbank 16S MK961116; juvenile female, DNA E210 (unsuccessful), AM P.103498. W03C (7J), 12° 34.663', 132° 57.923', 18.iv.2007, coll. L. Chandler, A. Sullivan, R. Gamarrawu: AM P.97287, 10 individuals; adult female with developing oostegites, AM P.103499, DNA E211 (unsuccessful); adult female with empty brood pouch, AM P.103500, DNA E212 (unsuccessful).

Etymology. "Kudjaldordo" in the Kundjeyhmi language was found in a document by Robert Layton (1981) regarding a statement on the Alligator Rivers Land Claim as a traditional foraging and camping area. This area roughly corresponds to the location where this species was collected. The name is pronounced "goo-jull-dord-oh", where the "rd" resembles end of "ford" (sound the "r").

Diagnosis. *Head.* Eyes bulging dorsolaterally, height small, in lateral view less than width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region without obvious setae. *Pereon.* Dorsal cuticular surface with scattered small scales or roughness; pereonites 1–4 transverse dorsal ridges not expressed; pereonites 5–7 transverse dorsal ridges carinate with transverse trough. *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection concave. Dorsal surface rugose, with elongate ridge-like tubercles, with several median tubercles, not merging into ridge. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae, with interdigitating fine setae in same row as robust setae.

Antenna. Article 5 length subequal to article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length less than quarter length of basis, main setal row with 3 major setae (M2 appears to have only 2 has lost the distal smaller seta). Basis of female dorsal ridge epaulet length less than quarter length of basis, main setal row with 3 major setae (2 robust and 1 distal smaller seta). *Pereopod IV.* Propodus of male ventral margin without projection, with 6 robust setae on ventral margin (proximal group curved distally). Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge distinctly projecting dorsally with posterior margin exposed above shaft, convex, in lateral view distal part distinctly curving ventrally (F3, M2); distal margin with 2 robust setae distinctly larger than others, separated by shorter seta, or with only 1 robust seta distinctly larger than others (M2, F3).

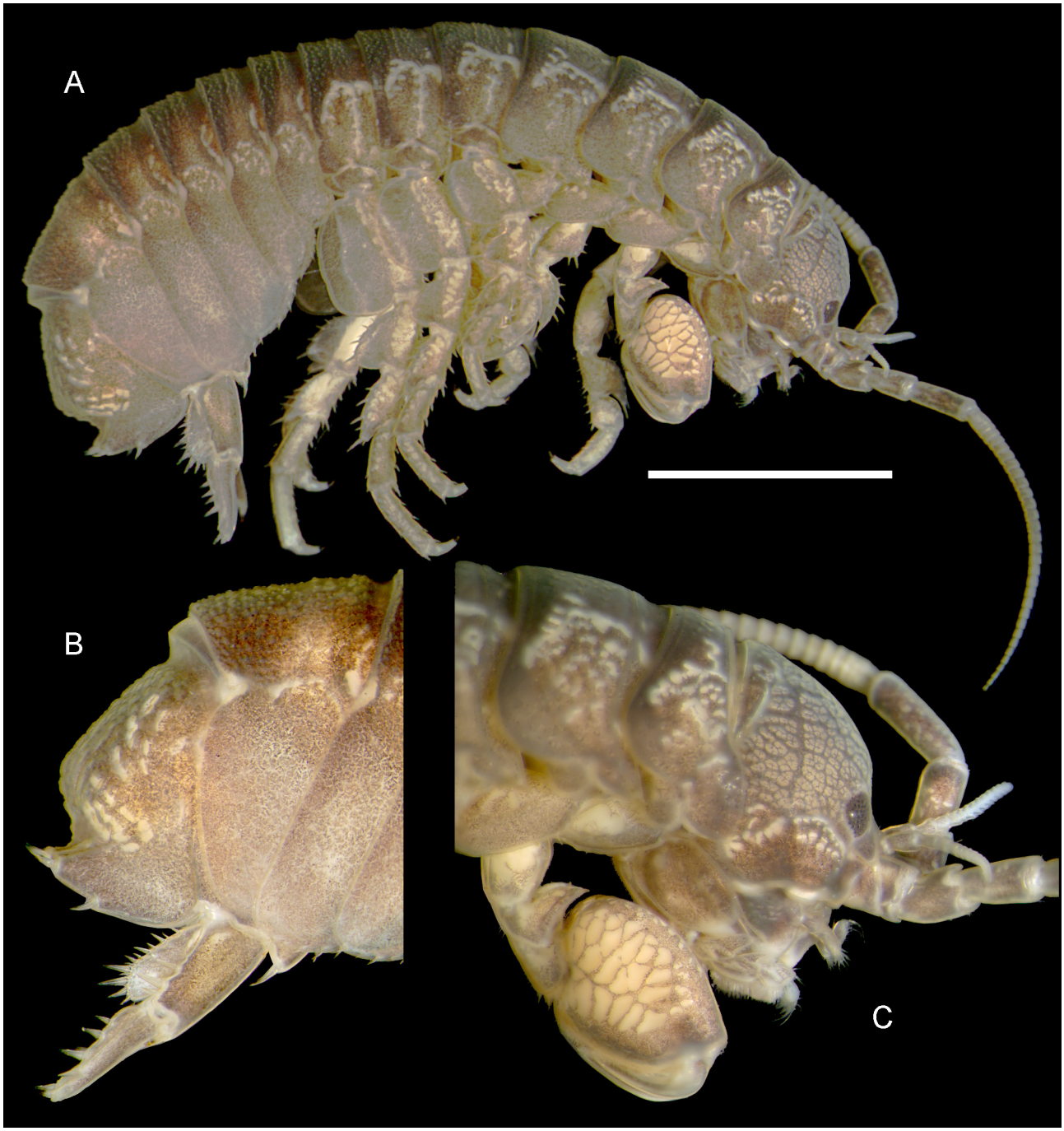

FIGURE 108. *Eophreatoicus kudjaldordo* sp. nov., holotype male, lateral, AM P.76361. A, habitus; B, posterior body; C, head. Scale 5 mm.

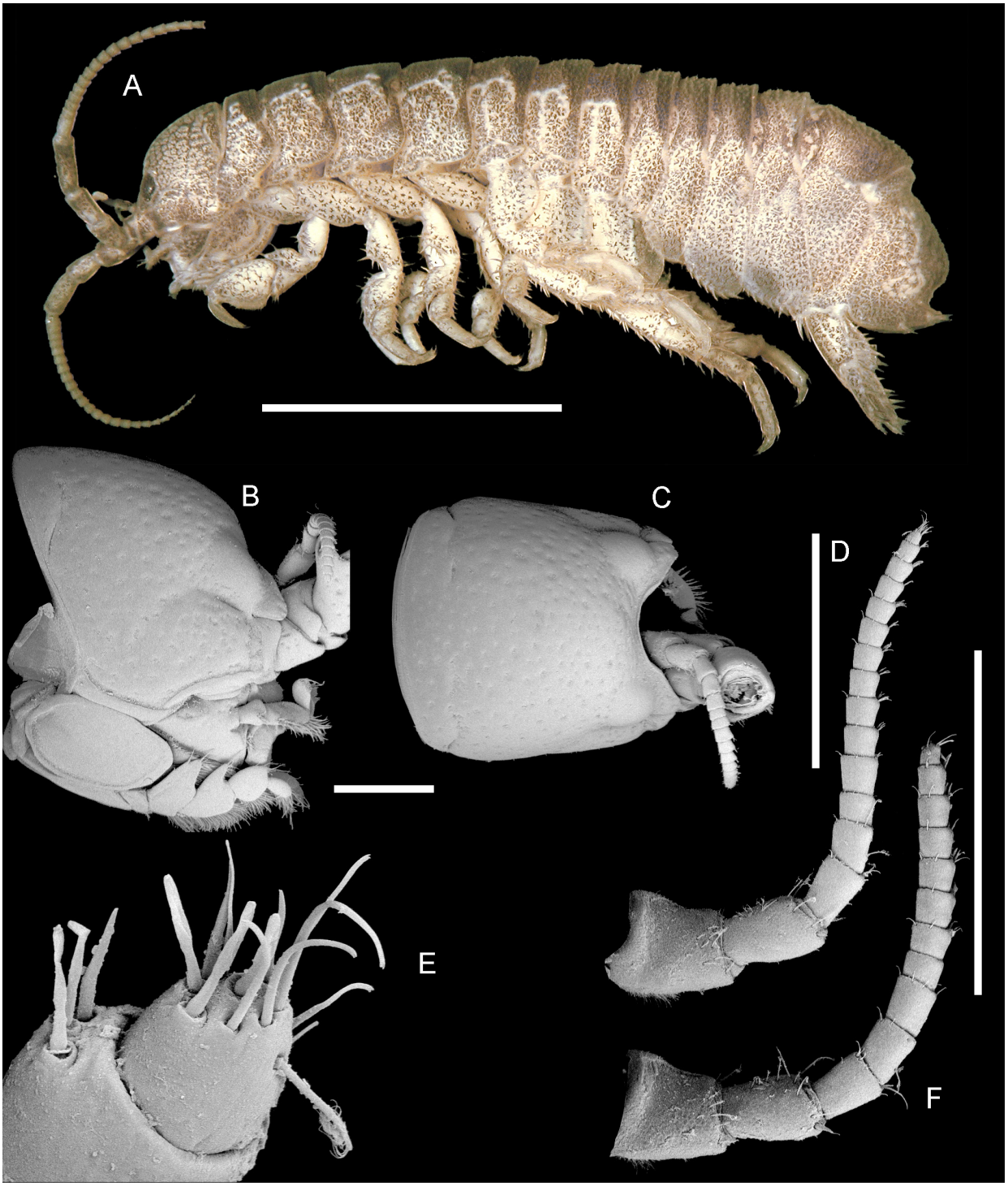

FIGURE 109. *Eophreatoicus kudjaldordo* sp. nov.. Female paratype, AM P.76363: A, habitus; B–C, head, lateral and dorsal; F, antennula. Paratype male, AM P.76362: D–E, antennula dorsal and distal tip. Scales: A, 5 mm; B–D, F, 1 mm.

Description. Body length of largest male 26.4 mm, preparatory female 15.4 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Width 1.00 pereonite 1 width (F3). Dorsal surface pitted; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin concave, orientation of longest axis vertical, maximum diameter 0.20–0.22 head depth (H, M2;F3), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view smoothly curved. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region without obvious setae.

Pereon. Width near head width. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–3 in dorsal view respective lengths less than 0.5 pleonite 5 length, pleonite 4 length more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.30 pleonite 1 (H, M2, F3), 1.60–1.70 pleonite 2 (H, F3;M2), 1.80–1.90–2.00 pleonite 3 (F3, H, M2), 1.90–2.00 pleonite 4 (F3;H, M2), 1.70–1.80 pleonite 5 (H, F3;M2).

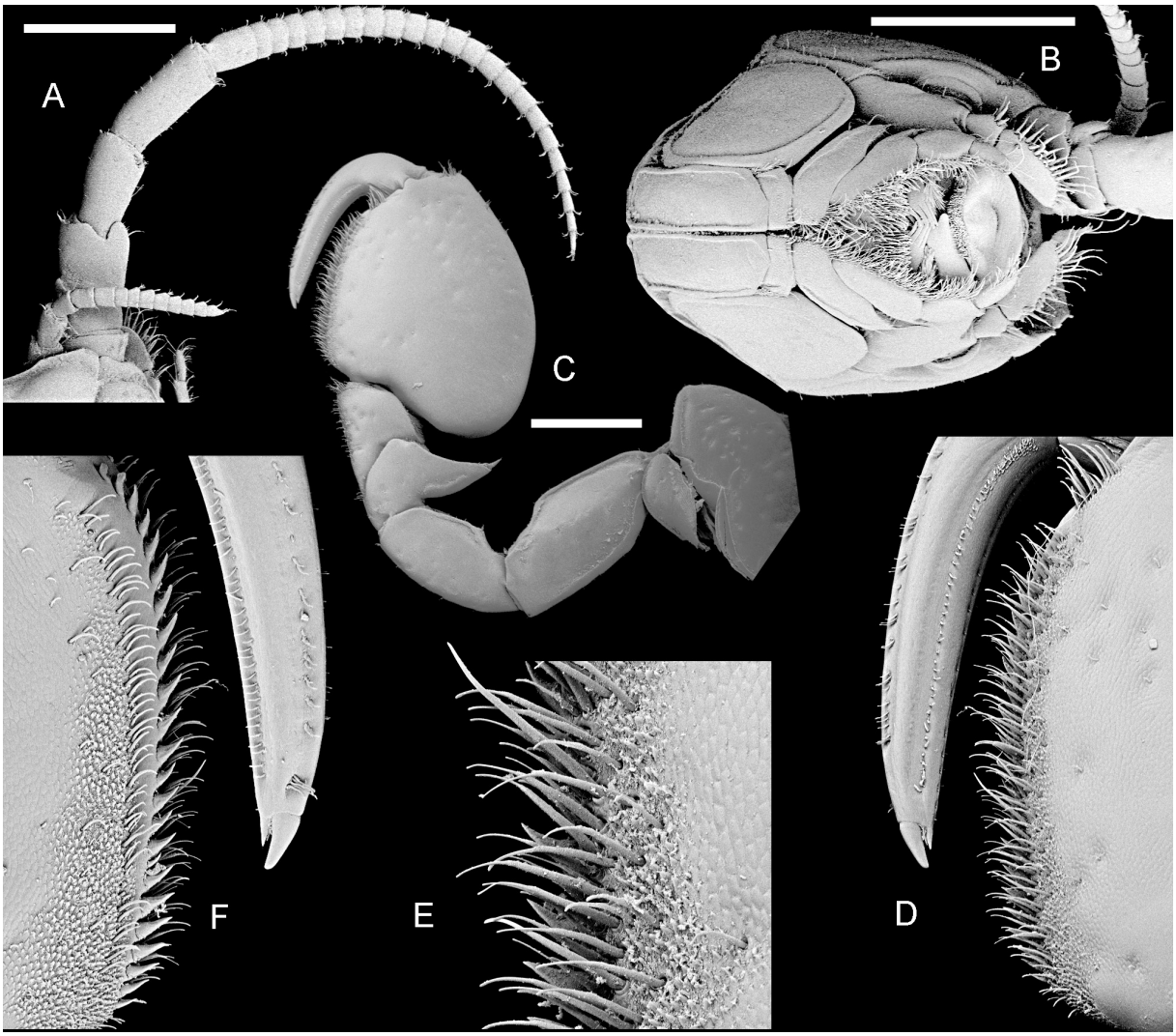

FIGURE 110. *Eophreatoicus kudjaldordo* sp. nov. Paratype female, AM P.76363: A, antenna and antennula; B, head, ventral. Paratype male, AM P.76362 pereopod I: C, lateral; D–E, palm and dactylus, lateral, with enlargement of palm setae; F, palm and dactylus, medial. Scales 1 mm.

Pleotelson. Dorsal surface length 1.20–1.30 width in dorsal view (M2, F3). Dorsal surface sparsely covered with setae; with cuticular combs on tubercles. Depth 1.50 pereonite 7 depth (H, M2, F3). Lateral length less than depth, in male 0.78 depth (M2, H), in female 0.84 depth (F3). Lateral length 0.13–0.14 body length (M2;H, F3). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.30–1.40 width of uropodal insertion (F3, M2), with one row of distally denticulate robust setae, including 5 robust setae altogether (M2, F3), posterior seta longer than anterior adjacent setae. Posterior apex length less than width, long. Posterior apex 0.16 pleotelson total length (F3), width 0.45 pleotelson width (F3). Posterior apex in lateral view forming an angle of 79° with immediately anterior dorsal surface (F3), angled 139° from horizontal (F3).

Antennula. Length 0.10 body length in male (M2), 0.11 body length in female (F3), with 16 articles in male (M2), with 13 articles in female (M2). Article 5 length 0.84–1.20 width (M2;F3). Article 6 length 0.71–0.98 width (F3, M2). Aesthetascs small (1–3) mostly on distomedial margins. Terminal article length 0.99–1.00 width (F3, M2), 0.02–0.03 antennula total length (M2, F3). Distal articles oval in cross-section.

Antenna. Length 0.40 body length in male (M2). Flagellum length 0.38 total antenna length in male (M2), with

30 articles in male (M2), proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Mouthfield. Clypeus width 0.30–0.32 head width (M2, F3).

Maxilliped. Epipod distal tip rounded, length 1.50–1.90 width (F3, M2). Endite distal margin in fringe. Palp article 4 length 1.10 width (M2, F3). Palp article 5 length 1.70–2.00 width (M2, F3), 0.71–0.90 article 4 length (M2, F3).

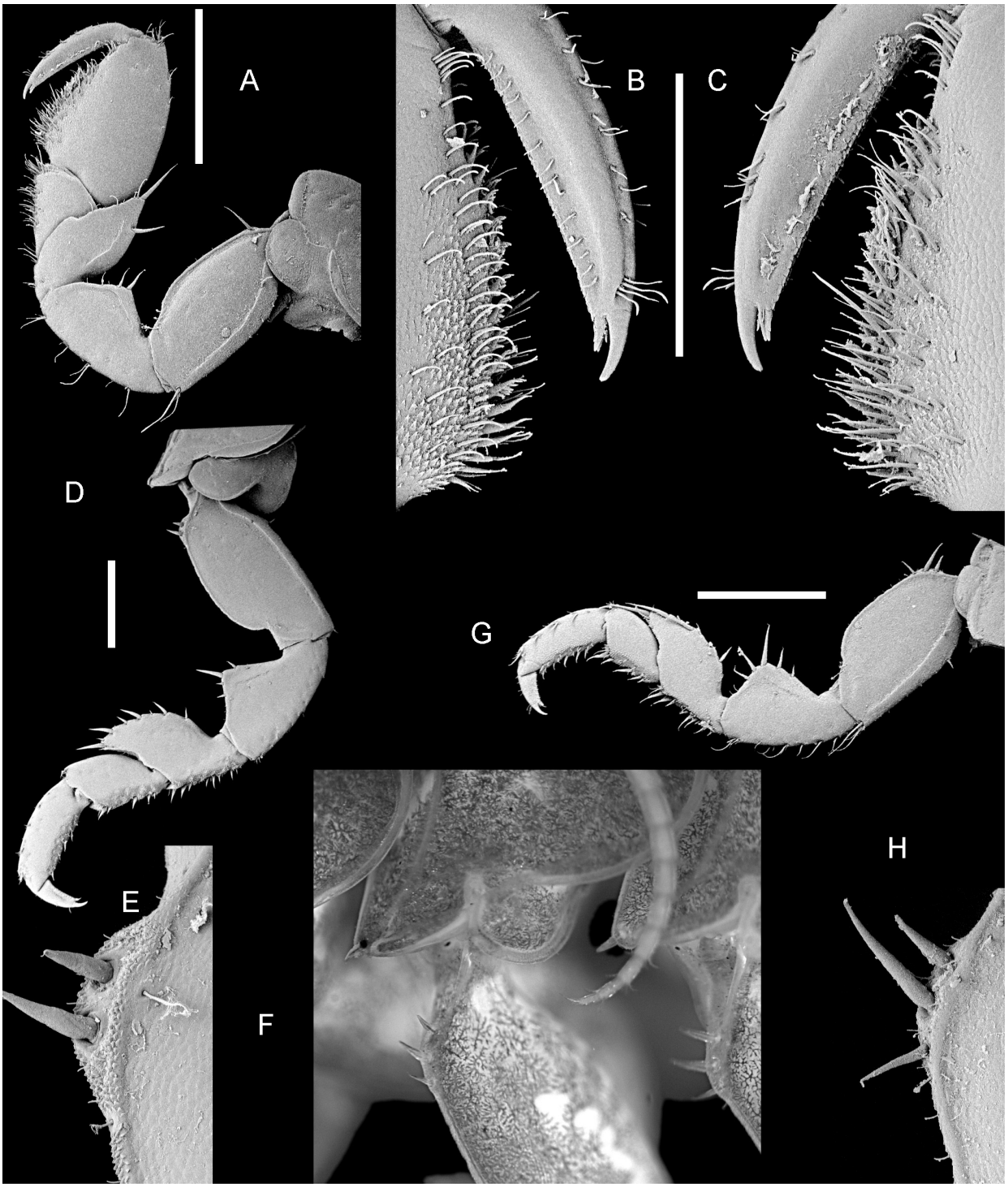

FIGURE 111. *Eophreatoicus kudjaldordo* sp. nov., pereopod I–II. Paratype female, AM P.76363: A–C, pereopod I; B–C, palm and dactylus, medial and lateral; G–H, with enlargement of epaulet on basis. D–E, pereopod II, paratype male, AM P.76362, with enlargement of epaulet on basis. F, pereopods II–III, epaulet on basis, holotype male, AM P.76361. Scales 1 mm, except for B, 0.5 mm.



FIGURE 112. *Eophreatoicus kudjaldordo* sp. nov.. Paratype male, AM P.76362: A–B, pereopod IV with enlargement of distal articles; C, pereopod V; D–E, pereopod VII with enlargement of pene; F–G, pleopod II endopod and appendix masculina distal tip. Scales 1 mm.

Pereopod I. Length:body length 0.31 male (M2), 0.31 female (F3). Basis of male length 2.20 width (M2), female length 2.10 width (F3); dorsal setae positioned proximally, 1 dorsal seta altogether (M2); female dorsal setae positioned proximally, female 1 dorsal seta altogether (F3); ventrodistal margin lacking elongate setae, female with 2 elongate setae (F3), elongate setae longer than ischium (F). Ischium of male dorsal margin with 1 simple seta, setae not robust. Ischium of female dorsal margin with 3 simple setae (F3), setae not robust. Merus of male distodorsal margin in cross section spine-like and pointed, with 1 or 2 robust simple setae, dorsal surface with setae only on distal margin (1 robust); female distodorsal margin with few elongate simple setae, female dorsal surface

with setae along dorsal axis (2 heavy simple). Propodus length:pereopod length 0.22 male (M2), 0.20 female (F3). Propodus length:width 0.96 male (M2), 1.30 female (F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 7 setae altogether (excluding distal group) (M2), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae proximally on margin articulated, grading distally to articulation not expressed, 24 altogether (M2). Propodal palm of female margin convex, stout denticulate setae serrate, 12 altogether (F3), with stout robust conical setae, 6 altogether (F3, proximal to denticulate setae). Dactylus of male length subequal to palm, length:palm length 1.00 (M2), female longer than palm, female length:palm length 1.10 (F3). Dactylus of female ventrodistal margin distal cuticular fringe length 0.71 total length (F3). Dactylus claw length:dactylus length 0.10 male (M2), 0.15 female (F3). Dactylus of male positioned ventrally, 0.44–0.51(F3, M2) length of primary claw.

Pereopods II–III ratios. Pereopod II. Length:body length 0.30–0.33 male (M2, H), 0.31 female (F3). Basis length:pereopod length 0.28–0.30 male (M2, H), 0.28 female (F3); length:width 2.10–2.40 male (M2, H), 1.80 female (F3). Carpus length:pereopod length 0.11–0.13 male (H, M2), 0.12 female (F3); length:width 1.20–1.60 male (H, M2), 1.40 female (F3). Propodus length:pereopod length 0.15–0.16 male (H, M2), 0.17 female (F3); length:width 2.40–2.50 male (H, M2), 2.60 female (F3). Dactylus length:propodus length 0.55–0.67 male (M2, H), 0.57 female (F3); primary claw length:dactylar length 0.25 male (M2), 0.31 female (F3). *Pereopod III.* Length:body length 0.30–0.32 male (M2, H), 0.28 female (F3). Basis length:pereopod length 0.29 male (H), 0.31 female (F3); length:width 2.20 male (H), 2.10 female (F3). Carpus length:pereopod length 0.10–0.10 male (M2, H), 0.10 female (F3); length:width 1.10 male (H, M2), 1.10 female (F3). Propodus length:pereopod length 0.15–0.17 male (H, M2), 0.16 female (F3); length:width 2.60–2.70 male (H, M2), 2.80 female (F3). Dactylus length:propodus length 0.56 male (H), 0.52 female (F3). *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, carpus, propodus., dactylus, also seen on ventral ridge of carpus(F3). Ischium II–IV of male dorsal margin with 4 simple setae (M2 pereopod II), none robust. Carpus II of male with 5 robust based setae, III of male with 5 robust based setae. Dactylus ventral to primary claw, 0.27–0.33 length of primary claw, with scales on ventral margin; 14 altogether (M2 pereopod II,approx).

Pereopod II. Basis lateral face with 1 short simple seta proximally in male and in female. Basis of male dorsal ridge epaulet without submarginal setal row, main setal row without minor setae (rare, 1 specimen out of 5), without major setae distal to epaulet. Basis of female dorsal ridge epaulet without setal row below dorsal margin, main setal row without minor setae, without major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 2 setae (M2), dorsal ridge setae positioned proximally, of female dorsal ridge with 3 setae, dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 4 setae (M2). Carpus of male ventral margin with robust setae in addition to simple setae. Propodus of male distal width 0.78 maximum width (M2), setae on ventral margin robust-based, 2 distinctly larger than remainder, longer than dactylar claw. Dactylus of male distal accessory claw approximately 0.5 primary claw length (M2,0.53). *Pereopod IV ratios.* Length:body length 0.25 male (M2), 0.27 female (F3). Basis length:width 2.00 male (M2). Carpus length:pereopod length 0.13 male (M2), 0.09 female (F3). Propodus length:pereopod length 0.15 male (M2), 0.17 female (F3). Propodus length:width 1.70 male (M2), 3.10 female (F3).

Pereopods V–VII ratios. Pereopod V. Length:body length 0.26–0.30 male (M2, H), 0.28 female (F3). Basis length:width 1.10–1.20 male (H, M2), 1.20 female (F3). Carpus length:pereopod length 0.13–0.16 male (H, M2), 0.12 female (F3). Propodus length:pereopod length 0.16–0.17 male (H, M2), 0.15 female (F3). Dactylus claw length:dactylar length 0.32 male (M2). *Pereopod VI.* Length:body length 0.38–0.39 male (M2, H), 0.35 female (F3). Basis length:width 1.20 male (H, M2). Carpus length:pereopod length 0.15 male (H, M2), 0.15 female (F3). Propodus length:pereopod length 0.16–0.18 male (M2, H), 0.17 female (F3). *Pereopod VII.* Length:body length 0.41–0.42 male (M2, H), 0.41 female (F3). Basis length:width 1.20 male (M2). Carpus length:pereopod length 0.15–0.16 male (H, M2), 0.12 female (F3). Propodus length:pereopod length 0.16–0.17 male (H, M2), 0.17 female (F3). Dactylus claw length:dactylar length 0.31 male (M2).

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 3–5 setae (M2 pereopod V, pereopod VII). Propodus distal

margins with 5 elongate robust or robust-based setae (M2 pereopod V, pereopod VII). Dactylus accessory claw 0.28–0.33 primary claw length (M2 pereopod VII, pereopod V). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with no setae, dorsal margin with 5 setae (M2).

Penes. Distally tapering; distal tip truncate.

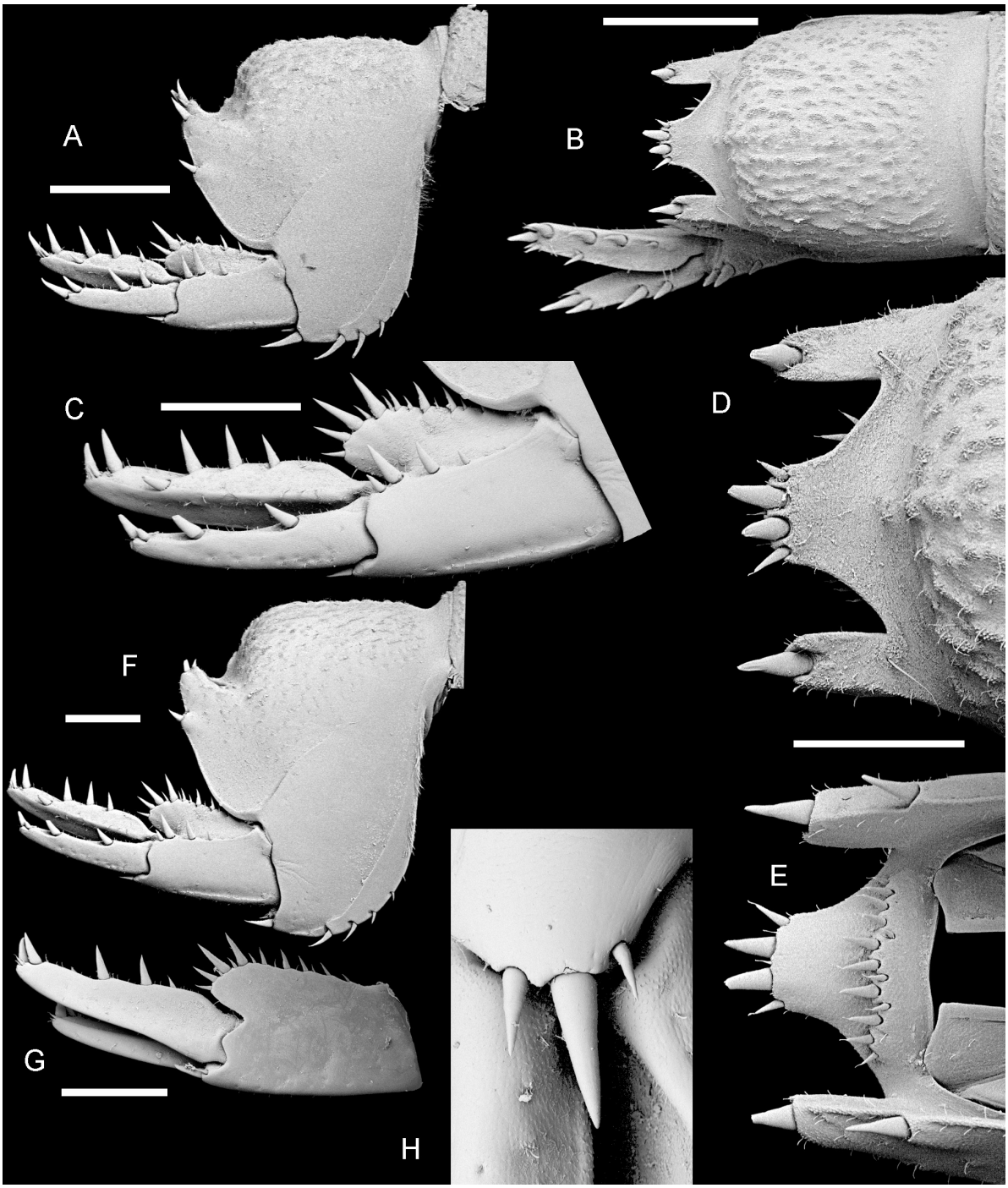

FIGURE 113. *Eophreatoicus kudjaldordo* sp. nov., pleotelson and uropods. Paratype female, AM P.76363: A–B, pleotelson, lateral and dorsal; C, uropod, lateral in situ; D–E, pleotelson apex, dorsal and ventral. Paratype male, AM P.76362, pleotelson apex damaged (not shown): F, pleotelson lateral; G, uropod medial; H, uropod protopod distoventral margin setae. Scales 1 mm, except for D–E, 0.5 mm.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 1.70 endopod proximal margin length; distally with 8 setae; 71 setae altogether (M2).

Uropod. Of male total length 1.00–1.10 pleotelson length (H, M2); protopod of male length 0.45 uropod total

length (H, M2). Uropod of female total length 1.00 pleotelson length (F3), protopod length 0.48 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.58–0.60 male (M2, H), 0.67 female (F3). Protopod of male dorsolateral margin shorter than dorsomedial margin setae; of female dorsolateral margin shorter than dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, without spinose setae, 3 robust simple setae. Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 7 altogether (M2); female dorsal margin with 8 robust setae (F3). Exopod length:endopod length 0.81–0.85 male (H, M2), 0.76 female (F3). Exopod of male dorsal margin with 4 robust setae (M2), female 4 robust setae (F3).

Distribution. Australia, Northern Territory, Kakadu National Park, Wirnmuyurr Creek, a tributary of Magela Creek, East Alligator River catchment.

Habitat. On the margin of small stream, among roots and leaf litter.

Remarks. *Eophreatoicus kudjaldordo* sp. nov. was found at a site called "7-J Creek", north of Wirnmuyurr Creek, in a pocket of rain forest with two other species (*E*. spp. J1 and J3), both of which had too few specimens to describe although we were successful in obtaining genetic data. *E. kudjaldordo* sp. nov. is the most abundant species, as a return visit to this locality in April 2007 recovered only this species, but not the others. The surprising discovery was that each of these species is genetically distant from each other (Fig. 11) despite occupying the same habitat. Of the described species, *E. kudjaldordo* sp. nov. is basally in clade containing the new species *E. djirrinjbal, E. mok* and *E. karrkkanj*, based the combined analysis results. Unlike these species, *E. kudjaldordo* sp. nov. has a short pereopod II basis epaulet with three robust major setae, a character found in the much larger new species, *E. barrkmarlam* and *E. balbun*. In the morphological analysis (Fig. 10), *E. kudjaldordo* sp. nov. is basal to a clade containing *E. warnbi* sp. nov. and *E. binjdjarrang* sp. nov. *Eophreatoicus kudjaldordo* sp. nov. shares with the other species a pereopod II basis epaulet with three robust major seta and overlapping numbers of setae on the pleotelson postanal ridge (13–17 vs. 13 setae). *Eophreatoicus kudjaldordo* sp. nov., however, has elongate ridge-like tubercles on the pleotelson, while *E. warnbi* sp. nov. has rounded tubercles, and *E. binjdjarrang* sp. nov. has oblong tubercles.

Eophreatoicus sp. J1

Eophreatoicus sp. "J1".—Wilson *et al.*, 2009: 362.

Material examined. Australia, Northern Territory, Kakadu National Park, north of Wirnmuyurr Creek, near Jabiluka: "7-J site 1", 12°34.65'S, 132°57.88'E; "7-J site 2 + 500m", 12°34.67'S, 132°58.00'E, coll. C. Humphrey & party, 11.iv.2003: male, 2 females and 4 juveniles, AM P.76324, "7-J site 2 + 500m", preparatory female, AM P.76325, DNA E12 Genbank COI EU263180 16S EU263252; "7-J site 1", 1 juvenile, ex AM P.76323, DNA E29 (unsuccessful); 1 juvenile, ex AM P.76323, DNA E30 (unsuccessful); 25 inds, AM P.76323.

Distribution. Australia, Northern Territory, Kakadu National Park, Wirnmuyurr Creek, a tributary of Magela Creek, East Alligator River catchment.

Habitat. On the margin of small stream among roots and leaf litter.

Remarks. The undescribed species, *Eophreatoicus* sp. J1, was found with two other species, *E. kudjaldordo* sp. nov. and *E*. sp. J3 (also undescribed), at the same locality, "7-J Creek". *Eophreatoicus* sp. J1 is distinct from these other two species in having a pereopod II basis epaulet with seven major setae (vs. three robust or four normal setae) and a uropod protopod dorsomedial ridge posterior margin that is hardly exposed (well exposed). In the genetic analyses (Fig. 11), *E*. sp. J1 emerges among the clade containing *E. nawurlandja* sp. nov. and other species. This species is rare compared to *E. kudjaldordo* sp. nov.; a return visit to the site in 2007 did not recover any specimens of this species. See remarks for *E. kudjaldordo* sp. nov. for more discussion. This species is not formally described owing to insufficient material but it is a morphologically distinct species. This observation is supported by genetic analyses (Wilson *et al.* 2009 and herein).

Eophreatoicus sp. J3

(Fig. 114)

Eophreatoicus sp. "J3".—Wilson *et al.*, 2009: 362.

Material examined. Australia, Northern Territory, Kakadu National Park, north of Wirnmuyurr Creek, near Jabiluka, "7-J Scree site 3", 12°34.69'S, 132°58.01'E, coll. C. Humphrey & party, 11.iv.2003: male, AM P.74593, DNA E114 Genbank COI EU263184 16S EU263256; 5 inds, AM P.74594.

Distribution. Australia, Northern Territory, Kakadu National Park, Wirnmuyurr Creek, a tributary of Magela Creek, East Alligator River catchment.

Habitat. On the margin of small stream among roots and leaf litter.



FIGURE 114. *Eophreatoicus* sp. J3, male, AM P.74593. A, lateral. B, posterior body. C, pleotelson and uropod, lateral. D, head with enlargement of pereopod II basis. Scale 5 mm.

Remarks. The undescribed species, *Eophreatoicus* sp. J3, was found with two other species, *E. kudjaldordo* sp. nov. and *E*. sp. J1 (also undescribed), at the same locality, "7-J Creek". *Eophreatoicus* sp. J3 is distinct from these other two species in having a pereopod II basis epaulet with four normal major setae (vs three robust or seven normal setae) and medium-sized eyes (vs. small eyes in *E. kudjaldordo* sp. nov.). *Eophreatoicus* sp. J3 emerges basally in a clade containing the newly described species *E. korokoro*, *E. binjdjarrang* and *E. warnbi*. This species is rare compared to *E. kudjaldordo* sp. nov.; a return visit to the site in 2007 did not recover any specimens of this species. See remarks for *E. kudjaldordo* sp. nov. for more discussion. This species is not formally described owing to insufficient material but it is a morphologically distinct species. This observation is supported by genetic analyses (Wilson *et al.* 2009 and herein).

Eophreatoicus djurrukunja sp. nov.

(Figs 115–119)

urn:lsid:zoobank.org:act: 15188AA2-D2F2-4E79-AECE-373D188F2FDA
Eophreatoicus sp. "M1".—Wilson *et al.*, 2009: 362.

Type material. Holotype male, bl 23.2 mm, AM P.76387. Paratypes collected with holotype: male (M2), bl 21.2 mm, AM P.76388, DNA E97, GenBank COI EU263187 16S EU263258, SEM stubs AW771–776; male, AM P.76384, DNA E18 GenBank COI EU263186; female (F3), bl 17.2 mm, AM P.76389, DNA E98 GenBank COI EU263188 16S EU263259, SEM stubs AW777–780; preparatory female, AM P.76385, DNA E19 (unsuccessful); preparatory female, AM P.76386, DNA E20 (unsuccessful); 18 inds, AM P.76383.

Type locality. Australia, Northern Territory, Kakadu National Park, North Magela Tributary site 1, base of gorge,12°36.54'S, 132°59.22'E, coll. C. Humphrey & party, 16.iv.2003.

Etymology. "Djurrukunja" is the nearest known place name to the locality of this species. The name marks a place around 3 km to the east of the collection site on the western side of the outlier. Historical site surveys and contemporary knowledge did not indicate names more specific to this site. The name is pronounced "joo-doo-goon-ya".**Diagnosis.** *Head.* Eyes bulging dorsolaterally, height medium, in lateral view subequal to width of basal antennal articles (H, F3, 0.93), height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head (M2, F3). Maxillipedal ridge with distinct dorsal edge, region without obvious setae. *Pereon.* Dorsal cuticular surface scaly or tuberculate, increasing posteriorly, apparent on all life stages (dimpled anteriorly); pereonites 1–4 transverse dorsal ridges rounded, expressed as transverse trough only; pereonites 5–7 transverse dorsal ridges carinate with transverse trough. *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection linear. Dorsal surface rugose, with elongate ridge-like tubercles, lacking posteromedial ridges or median groups of tubercles. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae and one median robust seta, with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length less than quarter length of basis, main setal row with 5 major setae. Basis of female dorsal ridge epaulet length subequal to quarter basis length, main setal row with 5 major setae (5). *Pereopod IV.* Propodus of male ventral margin without projection, with 6 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, in lateral view approximately straight; distal margin with 2 adjacent robust setae distinctly larger than others.

Description. Body length of largest male 23.2 mm, preparatory female 17.2 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Dorsal surface pitted; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin concave, orientation of longest axis vertical, maximum diameter 0.22–0.23–0.26 head depth (F3, H, M2), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view smoothly curved. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region without obvious setae.



FIGURE 115. *Eophreatoicus djurrukunja* sp. nov., habitus. Top, holotype male, AM P.76387, lateral. Bottom, paratype female, AM P.76389. Scales 5 mm.

Pereon. Width near head width. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–4 in dorsal view respective lengths less than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.30–1.40 pleonite 1 (F3, H), 1.70–1.80–2.00 pleonite 2 (F3, H, M2), 2.00–2.30 pleonite 3 (H, F3;M2), 2.00–2.10–2.30 pleonite 4 (F3, H, M2), 1.70–1.90–2.00 pleonite 5 (F3, H, M2).

Pleotelson. Dorsal surface length 0.84–1.10 width in dorsal view (F3, M2). Dorsal surface sparsely covered with setae; with cuticular combs on tubercles. Depth 1.50–1.60–1.70 pereonite 7 depth (F3, H, M2). Lateral length less than depth, in male 0.77–0.78 depth (H, M2), in female 0.78 depth (F3). Lateral length 0.14–0.15 body length (H, F3;M2). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods less than width of uropodal insertion, length 1.50–1.60 width of uropodal insertion (M2, F3), with one row of distally denticulate robust setae, including 5–6 robust setae altogether (F3, M2), posterior seta longer than anterior adjacent setae (except for last 2 setae in M2, which are shorter than its anterior seta). Posterior apex length less than width, long. Posterior apex 0.15–0.19 pleotelson total length (M2, F3), width 0.49–0.50 pleotelson width (F3, M2). Posterior apex in lateral view forming an angle of 60–90° with immediately anterior dorsal surface (F3;H, M2), angled 132–134–158° from horizontal (F3, M2, H).

Antennula. Length 0.13 body length in male (M2), 0.12 body length in female (F3), with 19 articles in male (M2), with 15 articles in female (F3). Article 5 length 0.88–0.98 width (M2, F3). Article 6 length 1.10 width (M2, F3). Aesthetascs small (1–3) mostly on distomedial margins. Terminal article length 1.00–1.10 width (F3, M2), 0.02–0.02 antennula total length (F3, M2). Distal articles oval in cross-section.

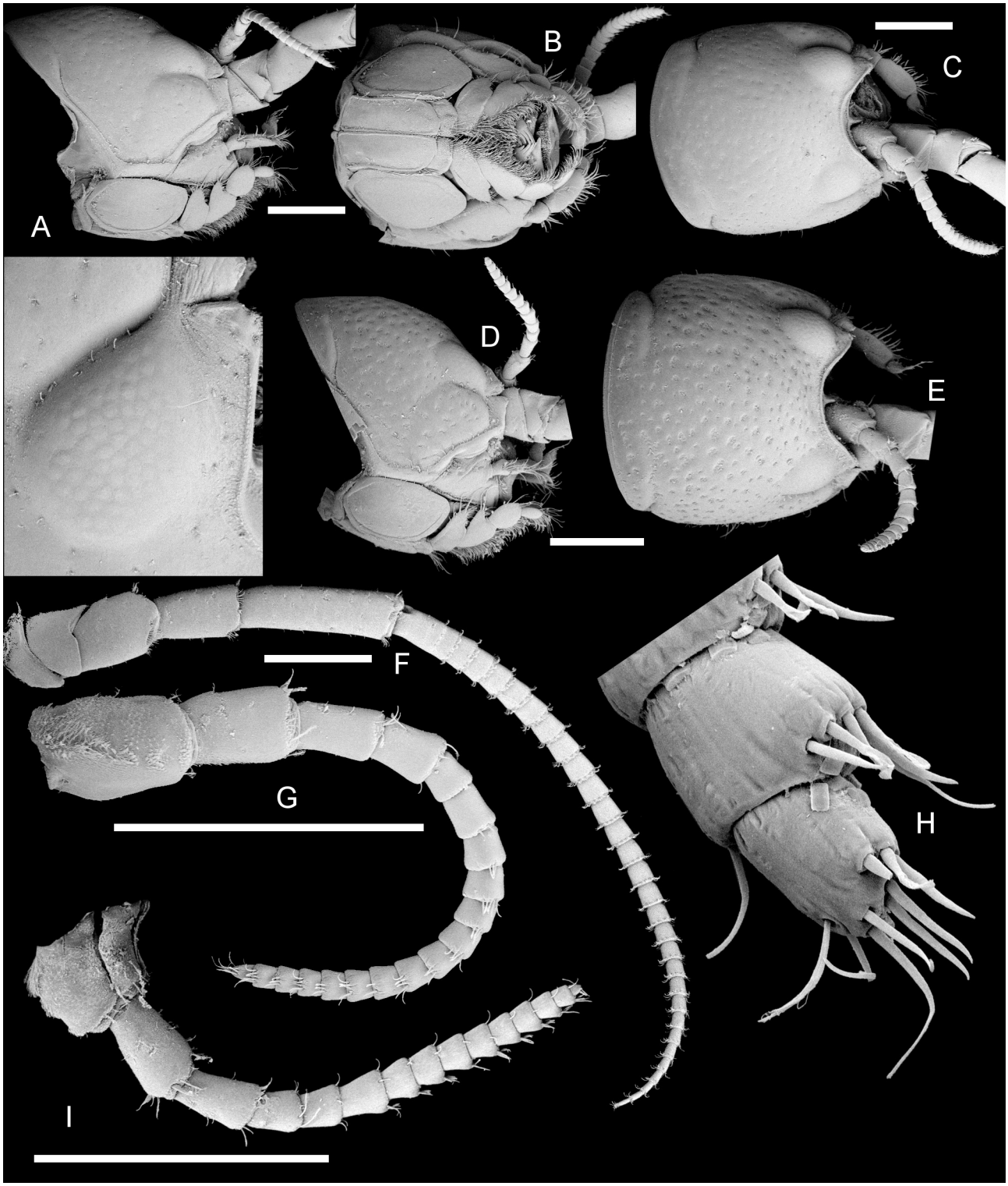

FIGURE 116. *Eophreatoicus djurrukunja* sp. nov. head and antennae. Paratype male, AM P.76388: A–C, head, lateral with enlargement of eye, ventral and dorsal; F, antenna; G–H, antennula with enlargement of distal tip. Paratype female, AM P.76389: D–E, head lateral and dorsal; I, antennula. Scales 1 mm.

Antenna. Length 0.44 body length in male (M2), 0.38 body length in female (F3). Article 6 shorter than articles 4 and 5 combined, or subequal to articles 4 and 5 combined (F3,0.91;M2,0.97). Flagellum length 0.61 total antenna length in male (M2), 0.55 total antenna length in female (F3), with 29 articles in male (M2), with 19 articles in female (F3), proximal articles surface smooth, proximal articles distal margin with rosette of short setae.

Mouthfield. Clypeus broad bar concave laterally at mandibular fossae.

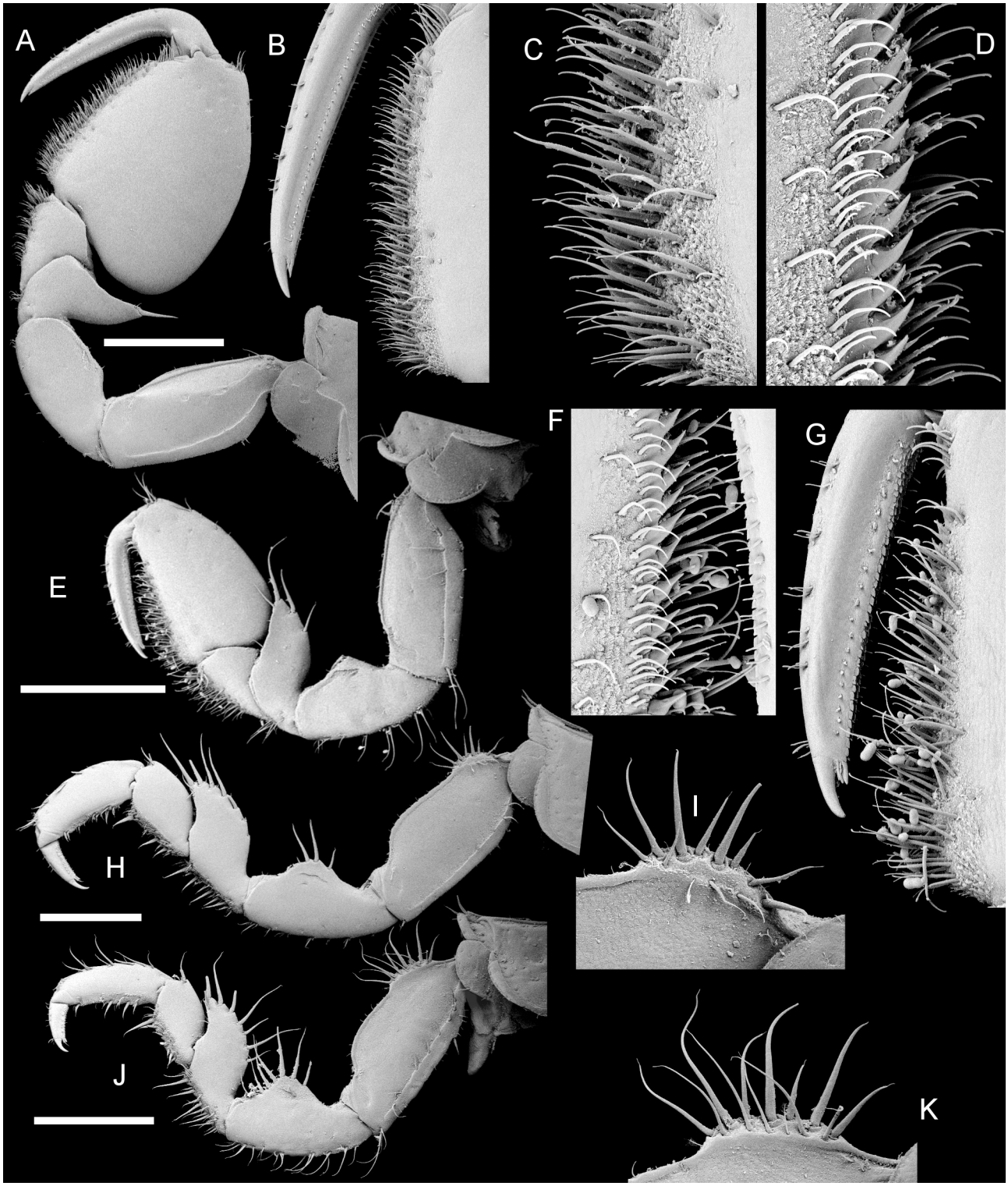

FIGURE 117. *Eophreatoicus djurrukunja* sp. nov., anterior pereopods. Paratype male, AM P.76388: A–D, pereopod I entire, palm and dactylus, palm setation lateral and medial; H–I, pereopod II, entire and enlargement of epaulet. Paratype female, AM P.76389: E–G, pereopod I, entire, palm setation medial and palm and dactylus lateral; J–K, pereopod II, entire and enlargement of epaulet. Scales 1 mm.

Maxilliped. Epipod distal tip rounded, length 1.70–1.90 width (F3, M2). Endite distal margin in fringe. Palp article 4 shape elongate-oval, length 1.30–1.40 width (M2, F3). Palp article 5 length 1.70–2.00 width (M2, F3), 0.60–0.66 article 4 length (M2, F3).

Pereopod I. Length:body length 0.35 male (M2), 0.31 female (F3). Basis of male length 2.40 width (M2),

female length 2.40 width (F3); dorsal setae positioned proximally, 3 dorsal setae altogether (M2); female dorsal setae positioned proximally, female 3 dorsal setae altogether (F3); ventrodistal margin lacking elongate setae, female with 2 elongate setae (F3), elongate setae subequal to ischium (F). Ischium of male dorsal margin without simple setae. Ischium of female dorsal margin with 1 simple seta, setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus (almost spine-like but concave), with 1 or 2 robust simple setae, dorsal surface with setae only on distal margin (1 robust); female distodorsal margin with numerous elongate simple setae, female dorsal surface with setae along dorsal axis (3 simple decreasing in size proximally). Propodus length:pereopod length 0.23 male (M2), 0.20 female (F3). Propodus length:width 1.10 male (M2), 1.40 female (F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 4 setae altogether (excluding distal group) (M2), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae articulated (each socket only partially expressed), 22 altogether (M2,approx). Propodal palm of female margin convex, with stout robust conical setae, 20 altogether (F3, approx), without elongate robust based setae. Dactylus of male longer than palm, length:palm length 1.10 (M2), female longer than palm, female length:palm length 1.10 (F3). Dactylus of female ventrodistal margin distal cuticular fringe length 0.72 total length (F3). Dactylus claw length:dactylus length 0.12 male (M2), 0.14 female (F3). Dactylus of male positioned ventrally, 0.37–0.49(F3, M2) length of primary claw.

Pereopods II–III ratios. Pereopod II. Length:body length 0.33–0.35 male (M2, H), 0.32 female (F3). Basis length:pereopod length 0.28–0.33 male (M2, F3), 0.29 female (F3); length:width 2.30–2.40 male (M2, H), 2.30 female (F3). Carpus length:pereopod length 0.09–0.12 male (H, M2), 0.12 female (F3); length:width 1.50 male (M2), 1.60 female (F3). Propodus length:pereopod length 0.16–0.17 male (H, M2), 0.17 female (F3); length:width 2.40–2.50 male (H, M2), 2.60 female (F3). Dactylus length:propodus length 0.64–0.65 male (H, M2), 0.56 female (F3); primary claw length:dactylar length 0.26 male (M2), 0.27 female (F3). *Pereopod III.* Length:body length 0.30–0.32 male (M2, H), 0.29 female (F3). Basis length:pereopod length 0.30–0.32 male (M2, H), 0.29 female (F3); length:width 2.80–3.00 male (H, M3), 2.50 female (F3). Carpus length:pereopod length 0.08–0.11 male (H, M2), 0.10 female (F3); length:width 1.20–1.40 male (H, M2), 1.10 female (F3). Propodus length:pereopod length 0.16–0.17 male (H, M2), 0.17 female (F3); length:width 2.20–2.70 male (H, M2), 3.00 female (F3). Dactylus length:propodus length 0.77 male (H), 0.53 female (F3). *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, carpus, propodus., dactylus. Ischium II–IV of male dorsal margin with 4 simple setae (M2 pereopod II), none robust. Carpus II of male with 7–8 robust based setae. Carpus II of female with 5 robust based setae. Dactylus ventral to primary claw, 0.30 length of primary claw, with scales on ventral margin; 18–30 altogether (M2 pereopod II approx, F3 pereopod II approx).

Pereopod II. Basis lateral face with 5 curved simple setae along margin in male and 10 setae in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 2–2–3 minor setae, submarginal setal row with 4–6–6 setae, without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 3 minor setae (3), submarginal setal row with 6 setae (6), without major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 8 setae (M2), dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 7 setae (M2). Carpus of male ventral margin with simple setae only. Propodus of male distal width 0.66 maximum width (M2), setae on ventral margin robust-based, 2 distinctly larger than remainder, longer than dactylar claw (M2, 1.1). Dactylus of male distal accessory claw approximately 0.25 primary claw length (M2,0.26). *Pereopod IV ratios.* Length:body length 0.28–0.30 male (M2, H). Basis length:width 2.40 male (M2). Carpus length:pereopod length 0.12 male (M2). Propodus length:pereopod length 0.16 male (M2). Propodus length:width 2.00 male (M2), 3.10 female (F3).

Pereopods V–VII ratios. Pereopod V. Length:body length 0.29–0.33 male (M2, H), 0.29 female (F3). Basis length:width 1.20 male (H, M2), 1.20 female (F3). Carpus length:pereopod length 0.15–0.18 male (H, M2), 0.15 female (F3). Propodus length:pereopod length 0.18 male (H, M2), 0.15 female (F3). Dactylus claw length:dactylar length 0.32 male (M2). *Pereopod VI.* Length:body length 0.44–0.45 male (M2, H). Basis length:width 1.20–1.40 male (M2, H). Carpus length:pereopod length 0.14–0.16 male (H, M2). Propodus length:pereopod length 0.18–0.19 male (M2, H). *Pereopod VII.* Length:body length 0.43–0.49 male (M2, H), 0.41 female (F3). Basis length:width 1.40 male (M2), 1.20 female (F3). Carpus length:pereopod length 0.16 male (M2), 0.14 female (F3). Propodus length: pereopod length 0.18 male (H, M2), 0.17 female (F3). Dactylus claw length:dactylar length 0.29 male (M2).

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 8–11 setae (M2 pereopod V, pereopod VII). Propodus distal margins with 5 elongate robust or robust-based setae (M2 pereopod V, pereopod VII). Dactylus accessory claw 0.26–0.35 primary claw length (M2 pereopod VII, pereopod V). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with 1 seta, dorsal margin with 11 setae (M2).

Penes. Distally tapering; distal tip truncate.



FIGURE 118. *Eophreatoicus djurrukunja* sp. nov., posterior pereopods and appendix masculina, paratype male, AM P.76388. A–B, pereopod IV with enlargement of distal segments. C, pereopod V. D–E, pereopod VII with enlargement of penes. F–G, pleopod II endopod and appendix masculina with enlargement of distal tip. Scales 1 mm.

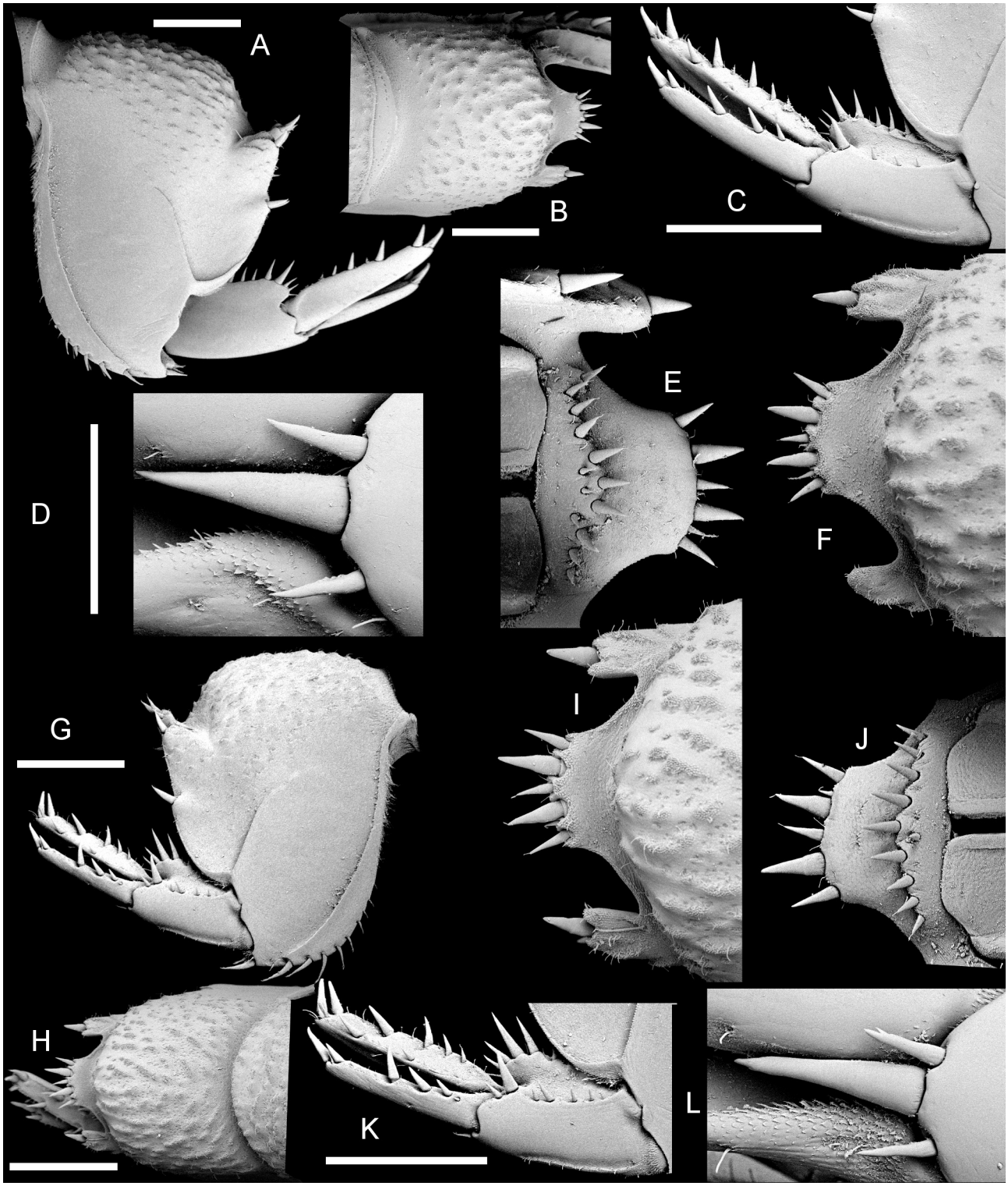

FIGURE 119. *Eophreatoicus djurrukunja* sp. nov., pleotelson and uropods. Paratype male, AM P.76388: A–B, pleotelson lateral and dorsal; C–D, uropod with enlargement of protopod distoventral setae; E–F, pleotelson apex ventral showing preanal ridge setation and dorsal. Paratype female, AM P.76389: G–H, pleotelson lateral and dorsal; I–J, pleotelson apex dorsal and ventral showing preanal ridge setation; K–L, uropod with enlargement of protopod distoventral setae.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 1.96 endopod proximal margin length; distally with 11 setae; 68 setae altogether (M2).

Uropod. Of male total length 0.98–1.10 pleotelson length (H, M2); protopod of male length 0.45–0.46 uropod total length (M2, H). Uropod of female total length 1.00 pleotelson length (F3), protopod length 0.51 uropod total

length (F3). Protopod dorsomedial ridge length:endopod length 0.51 male (M2), 0.56 female (F3). Protopod of male dorsolateral margin subequal to dorsomedial margin setae; of female dorsolateral margin longer than dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, with spinose setae (F3, M2), 3 robust spinose setae (F3), 3 robust simple setae (M2). Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 10 altogether (M2, 2 significantly smaller in size but robust in shape); female dorsal margin with 9 robust setae (F3). Exopod length:endopod length 0.81–0.86 male (M2, H), 0.82 female (F3). Exopod length:protopod length 1.02 male, 0.97 female. Exopod of male dorsal margin with 5 robust setae (M2), female 6 robust setae (F3).

Distribution. Australia, Northern Territory, Kakadu National Park, tributary of North Magela Creek, Magela Creek, East Alligator River catchment.

Habitat. On the margin of a small stream in roots and leaf litter.

Remarks. *Eophreatoicus djurrukunja* sp. nov. was found to be in the large clade bounded by the new species *E. nawurlandja*, *E. kurrih* and *E. boywek*, based primarily on the genetic results because the morphological analysis was inconclusive. Unlike these species, *E. djurrukunja* sp. nov. has no setae on the maxillipedal ridge of the head (present in the others) and the uropod protopod dorsomedial ridge margin is straight rather than convex. *Eophreatoicus djurrukunja* sp. nov. was collected near the locality where *E. warnbi* sp. nov. was found, a tributary of North Magela Creek. *Eophreatoicus djurrukunja* sp. nov. differs from *E. warnbi* sp. nov. in 15 diagnostic differences, such as having larger eyes, more major setae (five vs three) on the pereopod II epaulet, a more rugose pleotelson with ridge-like tubercles and a posterior apex with five robust setae vs. four.

***Eophreatoicus warnbi* sp. nov.**

(Figs 7B, 120–124)

urn:lsid:zoobank.org:act: 45D7D374-D90B-4996-A6AD-0522884C9D21
Eophreatoicus sp. "M2".—Wilson *et al.*, 2009: 362.

Type material. Holotype male, bl 26.7 mm, AM P.76395, North Magela Tributary site 2. Paratypes collected with holotype: male (M2), bl 27.6 mm, AM P.76396, DNA E95 GenBank COI EU263192 16S EU263264, SEM stubs AW801–806; male, AM P.76392, DNA E10 and E11 GenBank COI EU263190 16S EU263265; male, AM P.76393, DNA E13 COI GenBank EU263191 16S EU263263; female, AM P.76397, DNA E96 GenBank COI EU263193 16S EU263262, SEM stubs AW807–810; female, bl 15.9 mm, AM P.76391, DNA E08 and E09 GenBank COI EU263189 16S EU263260; brooding female, AM P.76394, DNA E14 GenBank 16S EU263261; 28 inds, AM P.76398. Additional paratypes collected near type locality: North Magela Tributary site 1, 4 juveniles, AM P.76390.

Type locality. Australia, Northern Territory, Kakadu National Park: North Magela Tributary site 2, higher up gorge, 12°36.36'S, 132°59.28'E. Site adjacent to type locality with additional paratypes: North Magela Tributary site 1, base of gorge, 12°36.54'S, 132°59.22'E, coll. C. Humphrey & party, 16.iv.2003.

Etymology. "Warnbi" is the regional name of the Mirarr clan estate, which indicates the region of the Magela Creek east of Madjinbardi. The name is pronounced "warn-bee", where the "warn" syllable rhymes with the North American English pronunciation of "barn".

Diagnosis. *Head.* Eyes bulging dorsolaterally, height small, in lateral view less than width of basal antennal articles (H,0.85; M2,0.82), height greater than length in lateral view, bulging in dorsal view, projecting from head in distinct arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region without obvious setae. *Pereon.* Dorsal cuticular surface with tubercles and small scales, increasing posteriorly, less so in younger stages; pereonites 1–4 transverse dorsal ridges rounded, expressed as transverse trough only; pereonites 5–7 transverse dorsal ridges carinate with transverse trough. *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection linear. Dorsal surface rugose, with rounded tubercles, with several median tubercles, not merging into ridge. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view distinctly narrowing distally, proximal depth greater than distal depth, with two pairs of robust setae, with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 length subequal to article 4, or longer than article 4 (F3, M2). *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length less than quarter length of basis, main setal

row with 3 major setae (3). Basis of female dorsal ridge epaulet length less than quarter length of basis, main setal row with 3–4–4 major setae. *Pereopod IV.* Propodus of male ventral margin with projection, with 7 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge distinctly projecting dorsally with posterior margin exposed above shaft, in lateral view approximately straight; distal margin with 2 adjacent robust setae distinctly larger than others.

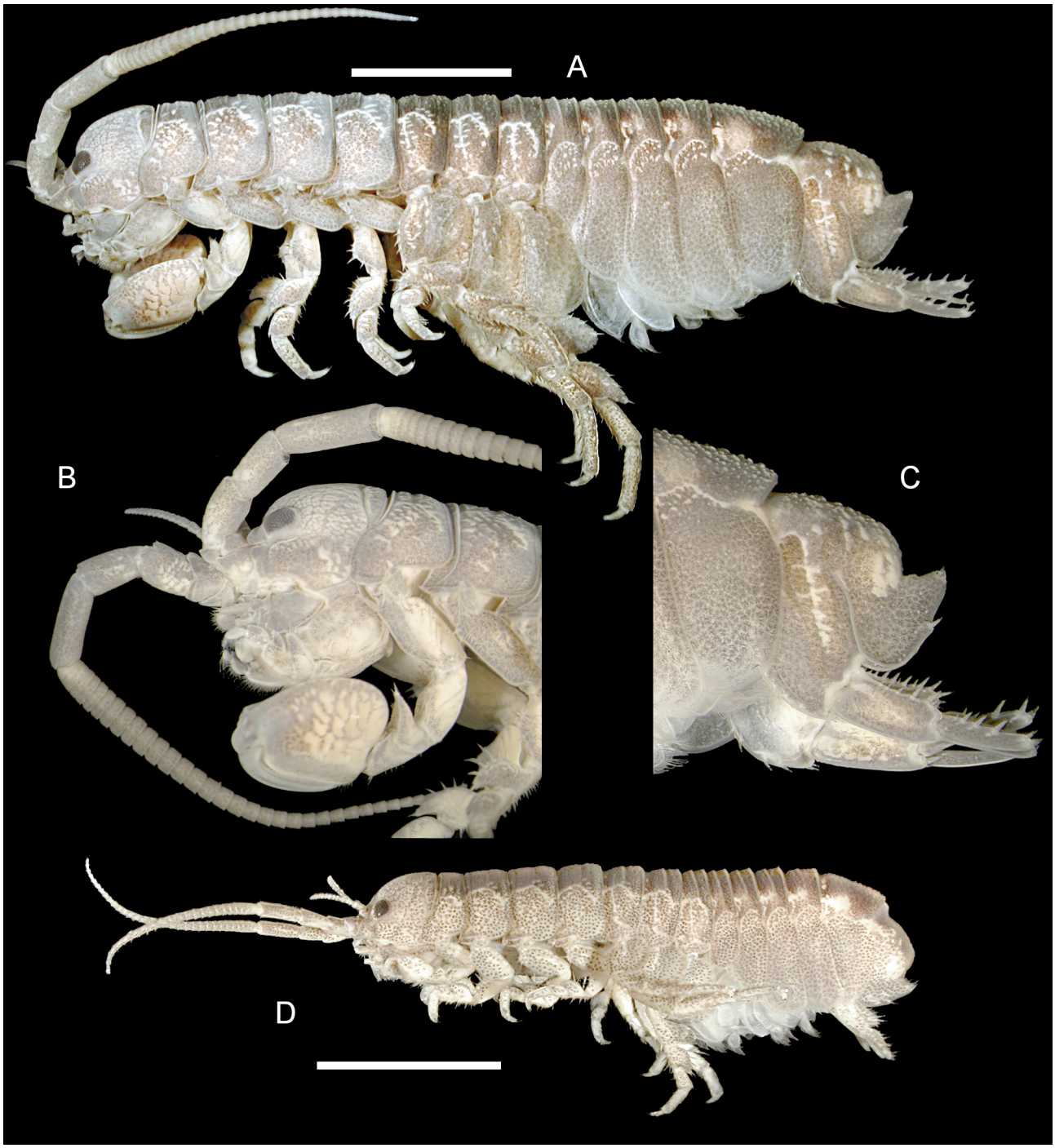

FIGURE 120. *Eophreatoicus warnbi* sp. nov., habitus. Holotype male, AM P.76395: A, lateral; B, head; C, pleotelson. Paratype female, AM P.76391: D, lateral. Scales 5 mm.

Description. Body length of largest male 27.6 mm, greater than body length of largest female (assumed).

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Width 0.94 pereonite 1 width (M2). Dorsal surface pitted (shallow pits); setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin concave, orientation of longest axis vertical, maximum diameter 0.23–0.24 head depth

(M2, H), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view sigmoidal. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region without obvious setae.

Pereon. Width near head width. Setae on dorsal surface scattered, fine (minimally). Coxal articulation to pereonites 2–4 nearly fused.

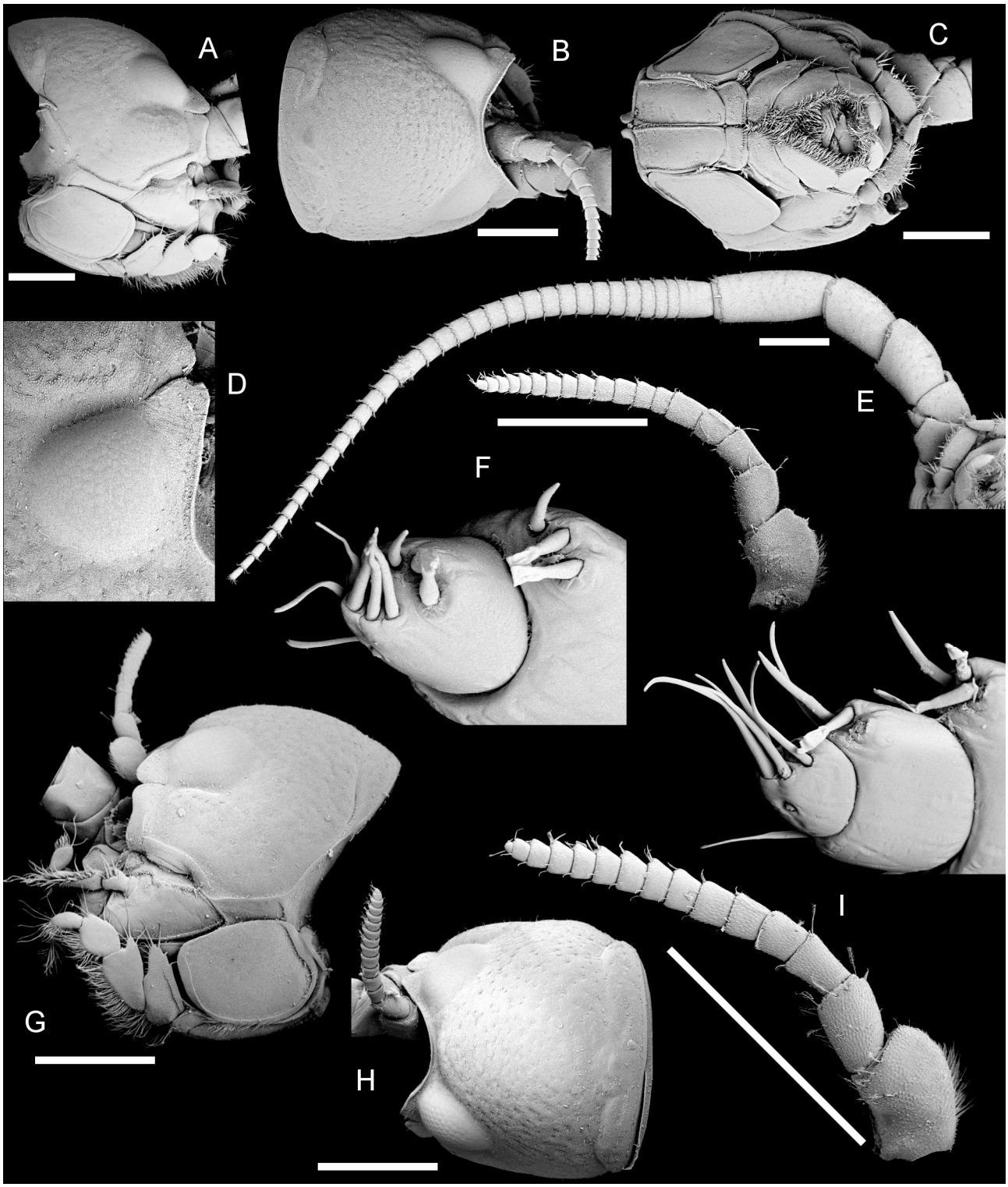

FIGURE 121. *Eophreatoicus warnbi* sp. nov., head and antennae. Paratype male, AM P.76392: A–D, head lateral, dorsal and ventral, with enlargement of eye; E, antenna; F, antennula with enlargement of distal tip. Paratype female, AM P.76397: G–H, head lateral and dorsal; I, antennula with enlargement of distal tip. Scales 1 mm.

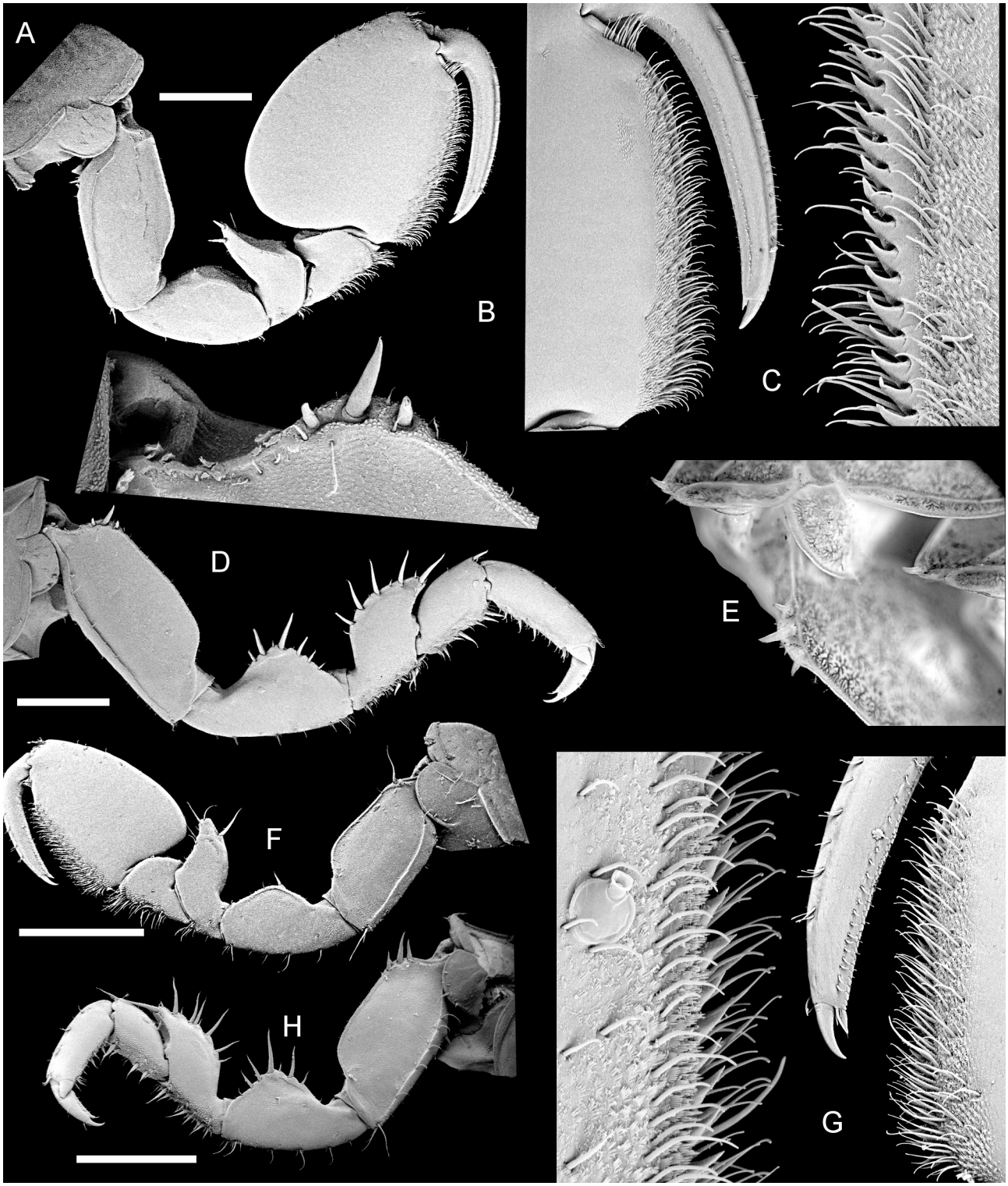

FIGURE 122. *Eophreatoicus warnbi* sp. nov., anterior pereopods. Paratype male, AM P.76392: A–C, pereopod I lateral, palm and palm setae medial; D, pereopod II with enlargement of epaulet. E, enlargement of epaulet, holotype male, AM P.76395. Paratype female, AM P.76397: F–G, pereopod I lateral, palm with enlargement of medial setae; H, pereopod II lateral. Scales 1 mm.

Pleonites. Pleonites 2–3 in dorsal view respective lengths less than 0.5 pleonite 5 length, pleonite 4 length more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.40 pleonite 1 (H, M2), 1.80–2.10 pleonite 2 (M2, H), 2.10–2.40 pleonite 3 (M2, H), 2.10–2.50 pleonite 4 (M2, H), 1.90–2.30 pleonite 5 (M2, H).

Pleotelson. Dorsal surface length 1.00–1.40 width in dorsal view (F3, M2). Dorsal surface sparsely covered with setae. Depth 1.70–1.80 pereonite 7 depth (M2, H). Lateral length less than depth, in male 0.81 depth (M2), in female 0.80 depth. Lateral length 0.13–0.15 body length (M2, H). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.60–1.70 width of uropodal insertion (F3, M2), with one row of distally denticulate robust setae, including 6–7 robust setae altogether (M2, F3), posterior seta longer than anterior adjacent setae. Posterolateral margin dorsal setal position more ventral setae subequal to dorsally-placed setae. Posterior apex length less than width, long. Posterior apex 0.16–0.20 pleotelson total length (M2, F3), width 0.42–0.44 pleotelson width (M2, F3). Posterior apex in lateral view forming an angle of 79–82–86° with immediately anterior dorsal surface (F3, M2, H), angled 138–143–151° from horizontal (H, F3, M2).

Antennula. Length 0.11 body length in male (M2), with 18 articles in male (M2), with 15 articles in female (F3). Article 5 length 0.78–1.10 width (F3, M2). Article 6 length 0.69–0.90 width (M2, F3). Aesthetascs small (1–3) mostly on distomedial margins. Terminal article length subequal to penultimate article length (M2), length 0.64–1.10 width (F3, M2), length 0.03 antennula total length (M2). Distal articles oval in cross-section.

Antenna. Flagellum length 0.61 total antenna length in female (F3), with 27 articles in female (F3), proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Mandible. Palp article 3 medial surface without additional setae. Palp article 2 with distal group of setae.

Maxilliped. Epipod distal tip rounded, length 1.30–1.60 width (F3, M2). Endite distal margin in fringe. Palp article 4 shape elongate-oval, length 1.20 width (M2, F3). Palp article 5 length 1.80–2.30 width (F3, M2), 0.73–0.98 article 4 length (F3, M2).

Pereopod I. Length:body length 0.34 male (M2). Basis of male length 2.20 width (M2), female length 2.00 width (F3); dorsal setae positioned proximally, 2 dorsal setae altogether (M2); female dorsal setae positioned proximally, female 4 dorsal setae altogether (F3); ventrodistal margin with 1 elongate seta, female with 2 elongate setae (F3), elongate setae longer than ischium. Ischium of male dorsal margin with 1 simple seta, setae not robust. Ischium of female dorsal margin with 1 simple seta, setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus (almost spine-like but concave), with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (2 robust); female distodorsal margin with few elongate simple setae, female dorsal surface with setae along dorsal axis (2 heavy simple). Propodus length:pereopod length 0.24 male (M2), 0.21 female (F3). Propodus length:width 1.10 male (M2), 1.30 female (F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 3 setae altogether (excluding distal group) (M2), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae articulated, 33 altogether (M2). Propodal palm of female margin convex, stout denticulate setae serrate, 3 altogether (F3, near proximal end, 2 of which appear bifid), with stout robust conical setae, 24 altogether (5 proximal to denticulate setae and 19 distal to denticulate setae). Dactylus of male length subequal to palm, length:palm length 1.00 (M2), female longer than palm, female length:palm length 1.10 (F3). Dactylus of female ventrodistal margin distal cuticular fringe length 0.52 total length (F3). Dactylus claw length:dactylus length 0.09 male (M2), 0.14 female (F3). Dactylus of male positioned ventrally, 0.37–0.45(M2, F3) length of primary claw.

Pereopods II–III ratios. *Pereopod II.* Length:body length 0.31–0.33 male (M2, H). Basis length:pereopod length 0.28–0.30 male (M2, H), 0.28 female (F3); length:width 2.30 male (M2), 2.00 female (F3). Carpus length:pereopod length 0.12 male (H, M2), 0.12 female (F3); length:width 1.50–1.60 male (H, M2), 1.70 female (F3). Propodus length:pereopod length 0.17 male (H, M2), 0.15 female (F3); length:width 2.80 male (H, M2), 2.50 female (F3). Dactylus length:propodus length 0.51–0.52 male (H, M2), 0.62 female (F3); primary claw length:dactylar length 0.27 male (M2), 0.28 female (F3). *Pereopod III.* Length:body length 0.31–0.32 male (M2, H). Basis length:pereopod length 0.30–0.31 male (H, M2); length:width 2.60 male (M2). Carpus length:pereopod length 0.11–0.12 male (M2, H); length:width 1.40–1.60 male (M2, H). Propodus length:pereopod length 0.15–0.17 male (M2, H); length:width 2.70–3.00 male (M2, H). Dactylus length:propodus length 0.47–0.48 male (H, M2). *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, carpus, propodus., dactylus. Ischium II–IV of male dorsal margin with 5–7 simple setae (M2 pereopod IV, M2 pereopod II), none robust. Dactylus ventral to primary claw, 0.22–0.27 length of primary claw, with scales on ventral margin; 6 altogether (M2 pereopod II).

Pereopod II. Basis lateral face with 3 simple setae decreasing in length distally in male and 5 curved simple

setae along margin in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row without minor setae (1 specimen has 2 setae, out of 5 specimens), submarginal setal row with 0–1–4 setae, without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 0–2–3 minor setae, submarginal setal row with 1–3–3 setae, without major setae distally.

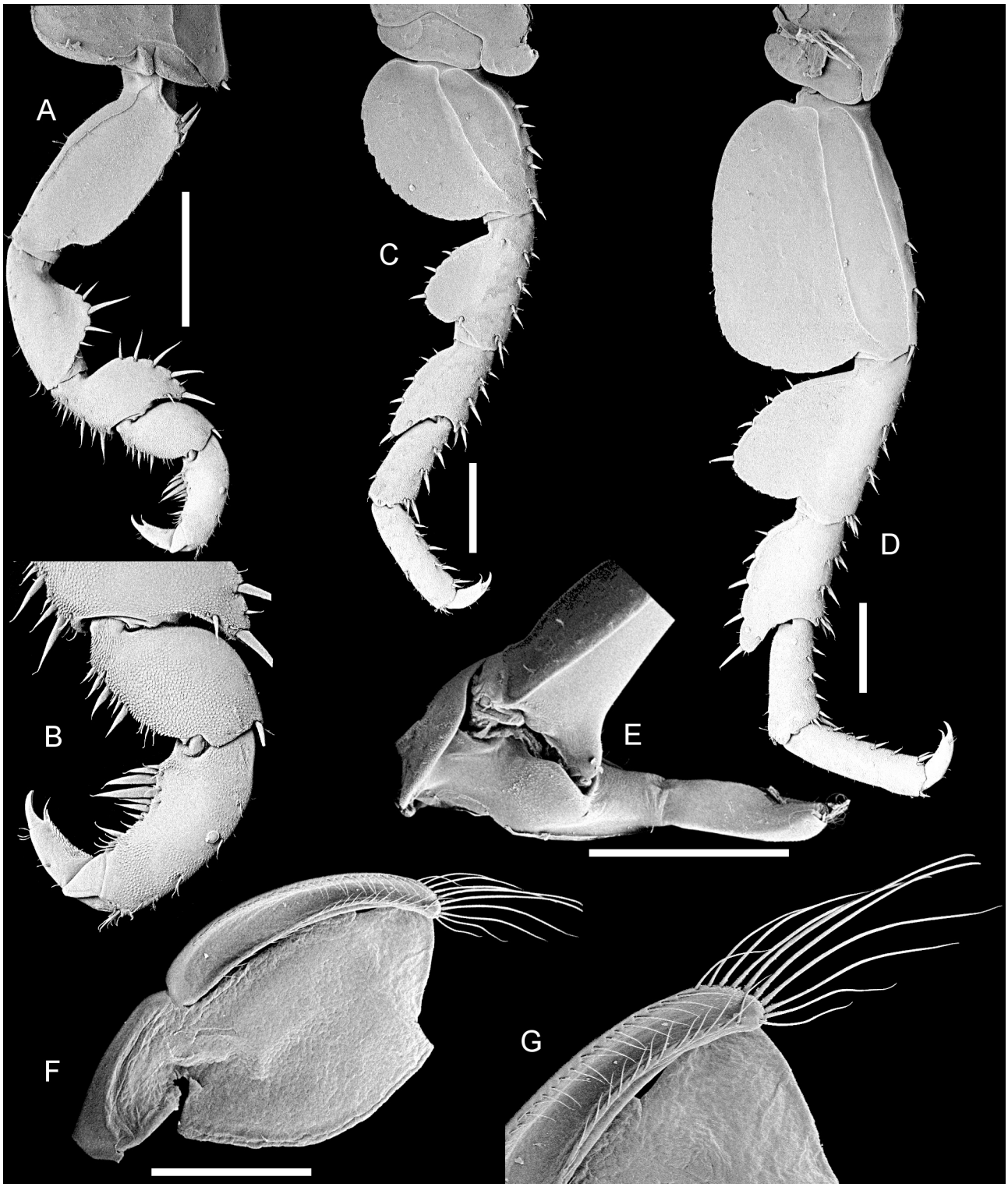

FIGURE 123. *Eophreatoicus warnbi* sp. nov., Paratype male, AM P.76392, posterior pereopods. A–B, pereopod IV with enlargement of distal segments. C–D, pereopod V, VII. E, pene. F–G, endopod pleopod II with enlargement of appendix masculina tip. Scales 1 mm.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 4 setae (M2), dorsal ridge setae

positioned proximally. Ischium of male dorsal margin with 5 setae (M2). Carpus of male ventral margin with simple setae only. Propodus of male distal width 0.70–0.72 maximum width (H, M2), setae on ventral margin robust, 2 distinctly larger than remainder, longer than dactylar claw (M2,1.3). Dactylus of male distal accessory claw approximately 0.25 primary claw length (M2, 0.27). *Pereopod IV ratios.* Length:body length 0.24 male (M2). Basis length:width 2.20 male (M2). Carpus length:pereopod length 0.13 male (M2). Propodus length:pereopod length 0.15 male (M2). Propodus length:width 2.20–2.40 male (M2, H).

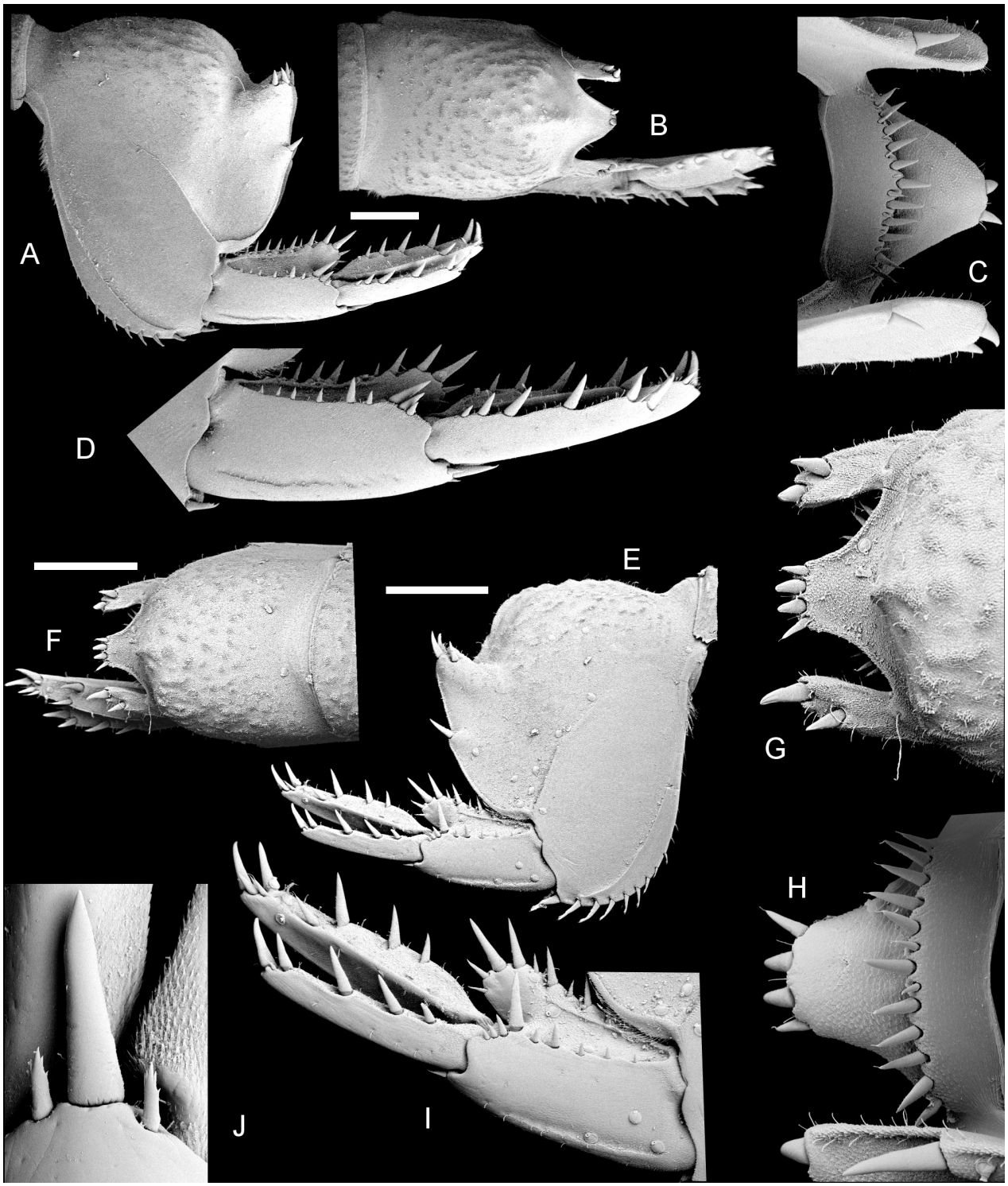

FIGURE 124. *Eophreatoicus warnbi* sp. nov., pleotelson and uropods. Paratype male, AM P.76392: A–C, pleotelson lateral, dorsal and enlargement of ventral apex and postanal ridge setation (apex damaged on this specimen); D, uropod. Paratype female, AM P.76397: E–H, pleotelson lateral, dorsal, enlargement of dorsal apex and ventral apex with postanal ridge setation. I–J, uropod with enlargement of protopod distolateral setae. Scales 1 mm.

Pereopods V–VII ratios. Pereopod V. Length:body length 0.28–0.36 male (M2, H). Basis length:width 1.10–1.20 male (M2, H). Carpus length:pereopod length 0.13–0.15 male (H, M2). Propodus length:pereopod length 0.16–0.17 male (H, M2). Dactylus claw length:dactylar length 0.34 male (M2). *Pereopod VI.* Length:body length 0.45 male (H). Basis length:width 1.40 male (M2). Carpus length:pereopod length 0.14 male (H). Propodus length: pereopod length 0.18 male (H). *Pereopod VII.* Length:body length 0.37–0.46 male (M2, H). Basis length:width 1.40 male (M2). Carpus length:pereopod length 0.13–0.14 male (M2, H). Propodus length:pereopod length 0.15–0.17 male (M2, H). Dactylus claw length:dactylar length 0.30 male (M2).

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 5–7 setae (M2 pereopod V, pereopod VII). Propodus distal margins with 3 elongate robust or robust-based setae (M2 pereopod V, pereopod VII). Dactylus accessory claw 0.26–0.27 primary claw length (M2 pereopod V, pereopod VII). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with no setae, dorsal margin with 7 setae (M2).

Penes. Distally tapering; distal tip truncate.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 1.60 endopod proximal margin length; distally with 9 setae; 67 setae altogether (M2).

Uropod. Of male total length 1.00 pleotelson length (H, M2); protopod of male length 0.49–0.52 uropod total length (M2, H). Uropod of female total length 1.00 pleotelson length (F3), protopod length 0.45 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.69 male (M2), 0.61 female (F3). Protopod of male dorsolateral margin shorter than dorsomedial margin setae; of female dorsolateral margin shorter than dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, with spinose setae, 3 robust spinose setae. Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 8 altogether (M2); female dorsal margin with 8 robust setae (F3). Exopod length: endopod length 0.81 male (M2), 0.80 female (F3). Exopod length:protopod length 0.94 male, 0.95 female. Exopod of male dorsal margin with 5 robust setae (M2), female 5 robust setae (F3).

Distribution. Australia, Northern Territory, Kakadu National Park, tributary of North Magela Creek, Magela Creek, East Alligator River catchment.

Habitat. On the margin of stream in roots and leaf litter.

Remarks. *Eophreatoicus warnbi* sp. nov., as mentioned in the remarks for *E. djurrukunja* sp. nov., is distinct from this latter species despite being found in the same tributary of North Magela Creek. *Eophreatoicus warnbi* sp. nov. was found to be the sister group of *E. binjdjarrang* sp. nov. in the combined analysis. *Eophreatoicus warnbi* sp. nov. is different from this species in having smaller, somewhat protruding eyes, a less rugose pleotelson with rounded tubercles, a pleotelson postanal ridge with 13–17 robust setae (11–12) and a well developed and setose protrusion on the palm of pereopod IV propodus (seven setae vs no protrusion and three robust setae).

Eophreatoicus kurrih sp. nov.

(Figs 125–130)

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Eophreatoicus sp. "05".—Wilson *et al.*, 2009: 361.

Type material. Holotype male, bl 22.9 mm, NTMus Cr018521. Paratypes collected with holotype: male (M2), bl 23.1 mm, AM P.74578, DNA E115 GenBank COI EU263185 16S EU263257, SEM stubs AW641–646; juvenile female, AM P.74577, DNA E60 GenBank 16S EU263217; brooding female (F3), bl 11.9 mm, AM P.74579, SEM stubs AW647–649; brooding female, bl 11.1 mm, photographed, NTMus Cr019003; male, partially dissected, NTMus Cr018522; 281 inds, NTMus Cr009641.

Type locality. Australia, Northern Territory, Kakadu National Park, Mt. Brockman, east side of Blue Tongue Dreaming, 12°45.00'S, 132 °56.00'E, coll. 4.viii.1976, possibly by R. Pengilley.

Etymology. "Kurrih" means "blue tongue". The collection site is called Kurrih Birrangdoy, "blue tongue hit his mouth", but it is contracted to just "kurrih". The spelling system for Kundjeyhmi and Kunwinjku has no letter "g" (except in the nasal digraph "ng"), so it is spelled Kurrih but the "g" as in gurrih is used. The final "h" is a glottal stop (a sudden cut off).

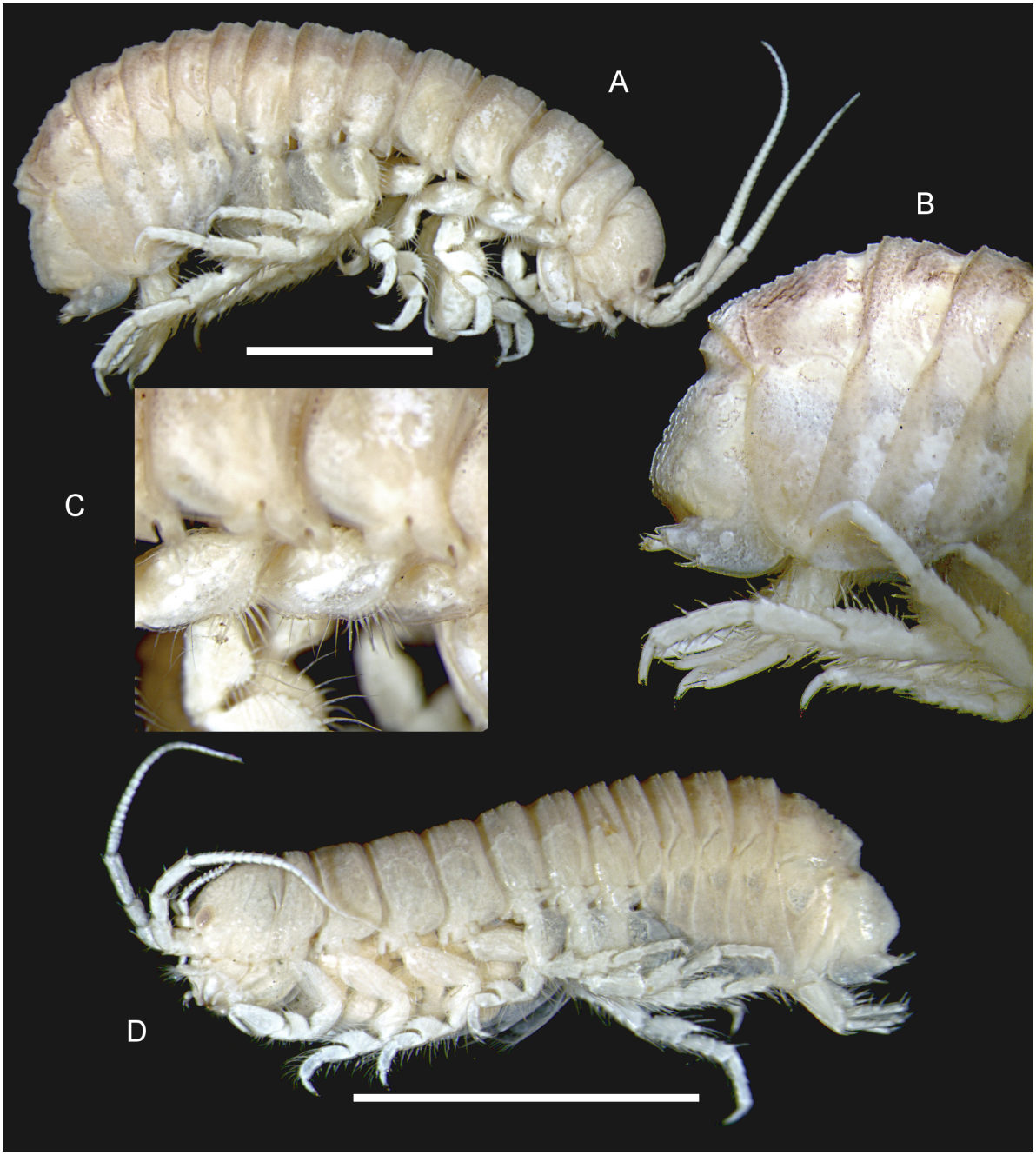

FIGURE 125. *Eophreatoicus kurrih* sp. nov., habitus. Holotype male, NTMus Cr018521: A, lateral; B, posterior pleonites and pleotelson; C, pereopod II–III basis epaulet setation. D, paratype female, NTMus Cr019003, lateral. Scales 5 mm.

Diagnosis. *Head.* Eyes bulging dorsolaterally, height small, in lateral view less than width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending just above anterolateral margin of pereonite 1. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface with tubercles and small scales, increasing posteriorly, less so in younger stages; pereonites 1–4 transverse dorsal ridges rounded, expressed as transverse trough only; pereonites 5–7 transverse dorsal ridges carinate with transverse trough. *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection concave. Dorsal surface rugose, with elongate ridge-like tubercles, with several median tubercles, not merging into ridge. Posterior apex in lateral view visible (F3, H). Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae and one median robust seta (only M2 missing median seta), with interdigitating fine setae in same row as robust

setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines (1 row distally, 2 rows proximally). *Pereopod II.* Basis of male dorsal ridge epaulet length greater than quarter basis length, main setal row with 6–7–8 major setae. Basis of female dorsal ridge epaulet length greater than quarter basis length, main setal row with 6–7–8 major setae. *Pereopod IV.* Propodus of male ventral margin without projection, with 5 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge distinctly projecting dorsally with posterior margin exposed above shaft, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 adjacent robust setae distinctly larger than others.

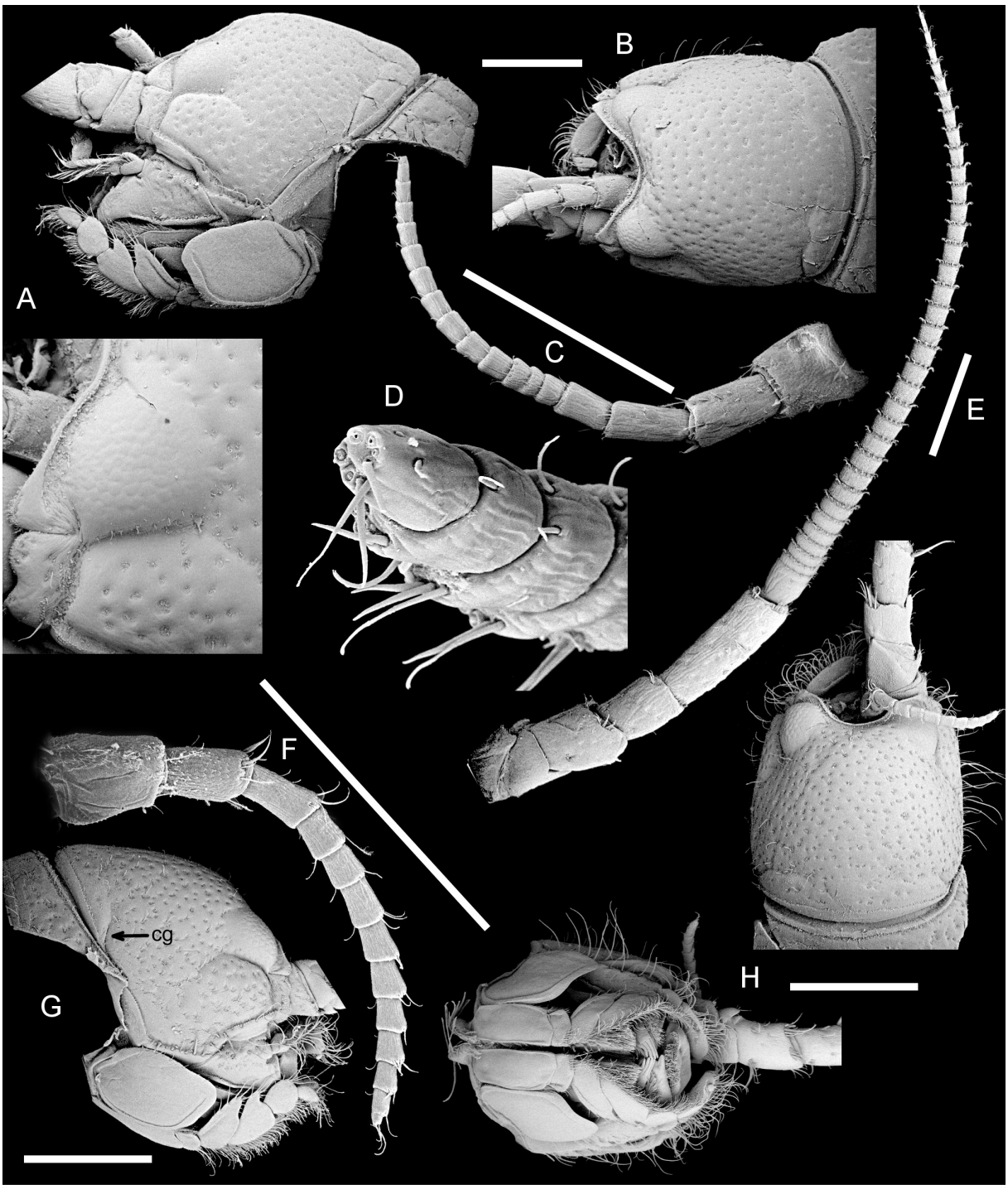

FIGURE 126. *Eophreatoicus kurrih* sp. nov., head and antennae. Paratype male, AM P.74578: A–B, lateral with enlargement of eye, and dorsal; C–D, antennula, with enlargement of distal tip; E, antenna. Paratype female, AM P.74579: F, antennula; G–H, lateral, ventral and dorsal; cg, cervical groove. All scales 1 mm.

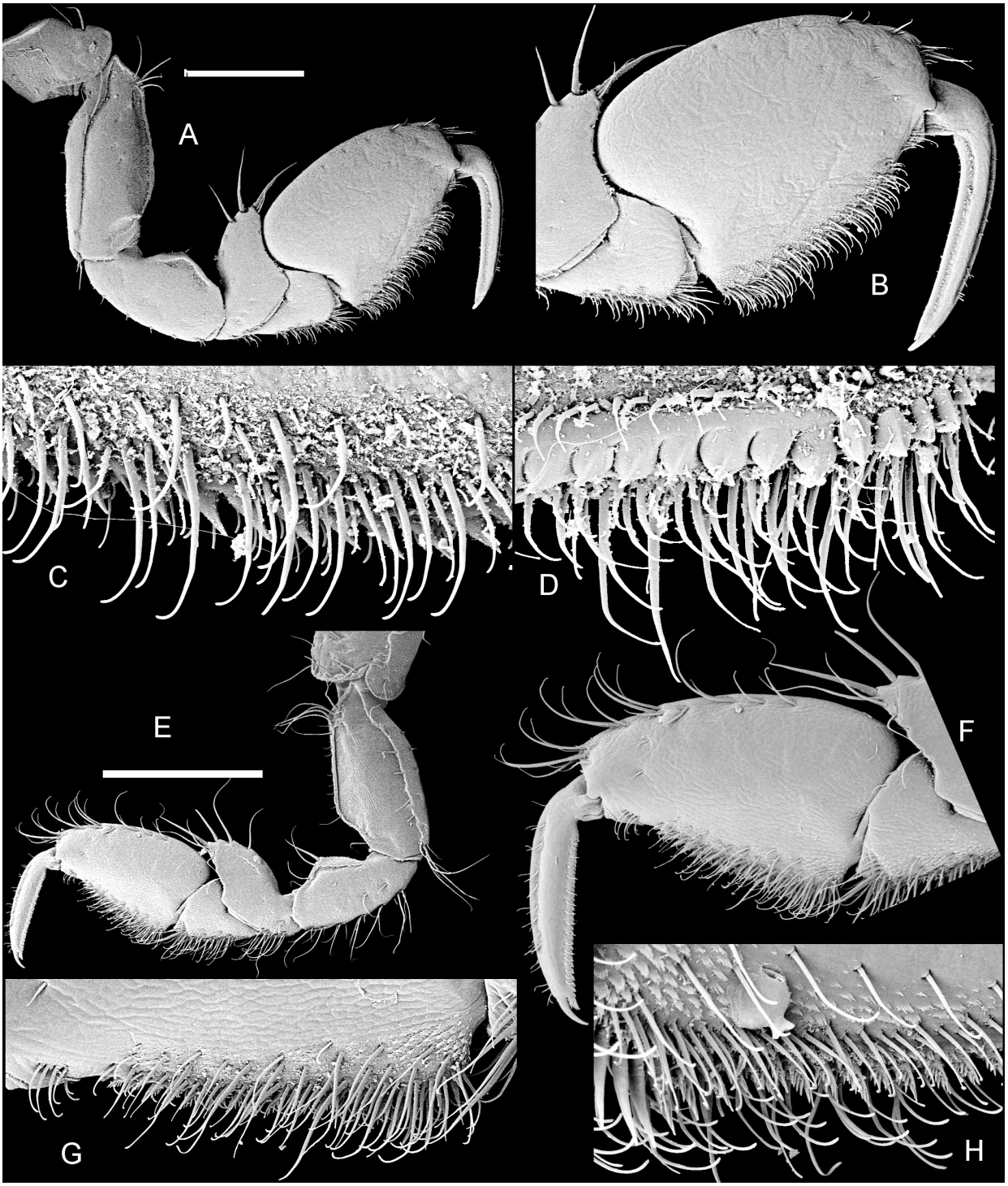

FIGURE 127. *Eophreatoicus kurrih* sp. nov., pereopod I. Paratype male, AM P.74578: A–B, lateral with enlargement distal segments. C–D, palm setation lateral and medial. Paratype female, AM P.74579: E–F, lateral; G–H, palm setation lateral and medial. Scales 1 mm.

Description. Body pigmentation light irregular broad dorsal bar having darker midline patches, chromatophores numerous small and dense; length of largest male 23.1 mm, length of largest brooding female 11.9 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Dorsal surface pitted; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin concave, orientation of longest axis vertical, maximum diameter 0.22–0.26 head depth (F3, H), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view smoothly curved. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

Pereon. Width near head width. Setae on dorsal surface scattered, fine. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–3 in dorsal view respective lengths less than 0.5 pleonite 5 length, pleonite 4 length more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.10 pleonite 1 (H), 1.40 pleonite 2 (H), 1.60 pleonite 3 (H), 1.60 pleonite 4 (H), 1.40 pleonite 5 (H).

Pleotelson. Dorsal surface length 1.10 width in dorsal view (H, F3). Dorsal surface sparsely covered with setae or sparsely covered with elongate simple setae (H, F3); with cuticular combs on tubercles. Depth 1.00–1.20 pereonite 7 depth (F3, H). Lateral length less than depth, in male 0.84–0.85 depth (M2, H), in female 0.83 depth. Lateral length 0.12–0.16 body length (H, F3). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.30–1.40 width of uropodal insertion (F3, H), with one row of distally denticulate robust setae (grading anteriorly to simple robust setae and then fine setae), including 8 robust setae altogether (H, F3), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.13–0.17 pleotelson total length (F3, H). Posterior apex length less than width, long. Posterior apex 0.27 pleotelson total length (H, F3), width 0.49–0.57 pleotelson width (F3, H). Posterior apex in lateral view forming an angle of 84–91° with immediately anterior dorsal surface (H, F3), angled 124–141° from horizontal (F3, H).

Antennula. Length 0.11 body length in male (H), 0.15 body length in female (F3), with 16 articles in male (H), with 13 articles in female (F3). Article 5 length 0.72–1.00 width (H, F3). Article 6 length 1.10–1.30 width (H, F3). Aesthetascs small (1–3) on distomedial margins. Terminal article length 1.80 width (F3, H), 0.02–0.04 antennula total length (F3, H). Distal articles oval in cross-section.

Antenna. Length 0.43 body length in male (H). Flagellum length 0.64 total antenna length in male (H), 0.51 total antenna length in female (F3), with 35 articles in male (H), with 25 articles in female (F3), proximal articles surface smooth, proximal articles distal margin with rosette of short setae.

Maxilliped. Epipod distal tip rounded. Endite distal margin in fringe. Palp article 4 shape subcircular or elongate-oval (F3, H), length 1.00–1.20 width (F3, H). Palp article 5 length 1.60 width (H, F3), 0.69–0.71 article 4 length (F3, H).

Pereopod I. Length:body length 0.30 male (H), 0.38 female (F3). Basis of male length 2.30 width (H), female length 2.20 width (F3); dorsal setae positioned proximally, 4 dorsal setae altogether (H); female dorsal setae positioned along ridge, female 20 dorsal setae altogether (F3); ventrodistal margin with 2 elongate setae (H), female with 6 elongate setae (F3), elongate setae longer than ischium. Ischium of male dorsal margin with 1 simple seta, setae not robust. Ischium of female dorsal margin with 4 simple setae (F3), setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (3 heavy simple); female distodorsal margin with numerous elongate simple setae, female dorsal surface with setae along dorsal axis (4 simple decreasing in size proximally). Propodus length:pereopod length 0.22 male (H), 0.39 female (F3). Propodus length:width 1.30 male (H), 1.50 female (F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 8 setae altogether (excluding distal group) (H), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally inflated setae, stout robust setae articulation not expressed, 20 altogether (H). Propodal palm of female margin convex, stout denticulate setae serrate, 16 altogether (F3), with stout robust conical setae, 6 altogether (F3). Dactylus of male shorter than palm, length:palm length 0.86 (H), female shorter than palm, female length:palm length 0.91 (F3). Dactylus of female ventrodistal margin distal cuticular fringe length 0.70 total length (F3). Dactylus claw length:dactylus length 0.10 male (H), 0.17 female (F3). Dactylus of male positioned ventrally, 0.37–0.43 (H, F3) length of primary claw.

Pereopods II–III ratios. Pereopod II. Length:body length 0.29 male (H), 0.39 female (F3). Basis length: pereopod length 0.28 male (H), 0.30 female (F3); length:width 2.10 male (H), 2.10 female (F3). Carpus length: pereopod length 0.11 male (H), 0.12 female (F3); length:width 1.40 male (H), 1.50 female (F3). Propodus length: pereopod length 0.16 male (H), 0.15 female (F3); length:width 2.50 male (H), 2.70 female (F3). Dactylus length: propodus length 0.59 male (H), 0.59 female (F3); primary claw length:dactylar length 0.20 male (H), 0.28 female (F3). *Pereopod III.* Length:body length 0.31 male (H), 0.31 female (F3). Basis length:pereopod length 0.29 male (H), 0.29 female (F3); length:width 2.30 male (H), 2.10 female (F3). Carpus length:pereopod length 0.11 male (H);

length:width 1.40 male (H), 1.60 female (F3). Propodus length:pereopod length 0.14 male (H), 0.13 female (F3); length:width 2.20 male (H), 2.20 female (F3). Dactylus length:propodus length 0.72 male (H), 0.69 female (F3); primary claw length:dactylar length 0.29 male (H). *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, ischium, merus, propodus; basis dorsal ridge with elongate setae (more than 10) forming 2 rows on proximal projection, rest of ridge with row of elongate simple setae (more than 10). Ischium II–IV of male dorsal margin with 6–7 simple setae (H pereopod IV, H pereopod II), none robust. Dactylus ventral to primary claw, 0.38–0.41 length of primary claw, with scales on ventral margin; 10 altogether (F3 pereopod II).

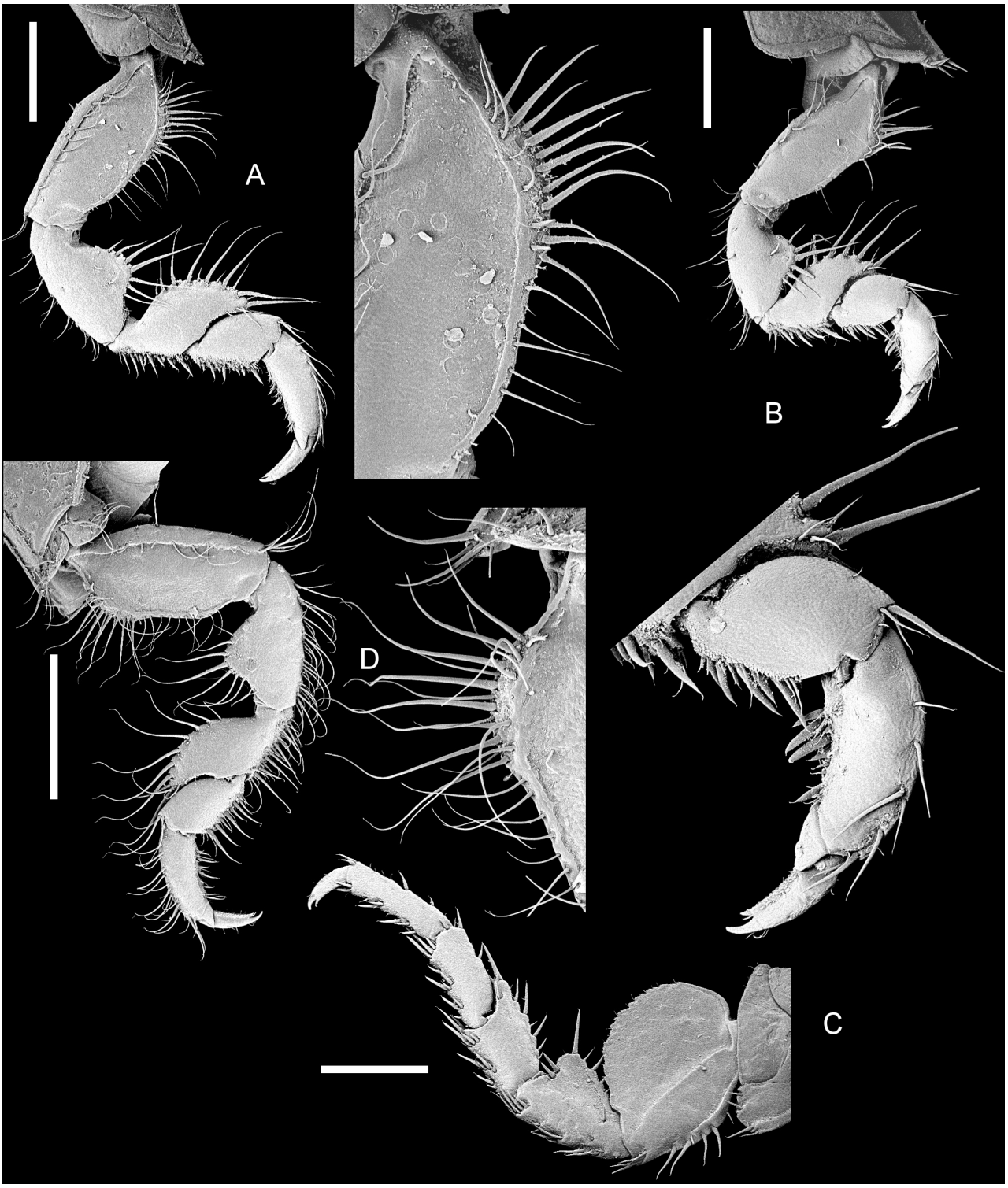

FIGURE 128. *Eophreatoicus kurrih* sp. nov., pereopods II–V. Paratype male, AM P.74578: A, pereopod II with enlargement of epaulet; B, pereopod IV with enlargement of distal articles; C, pereopod V. Paratype female, AM P.74579: D, pereopod II with enlargement of epaulet. All scales 1 mm.

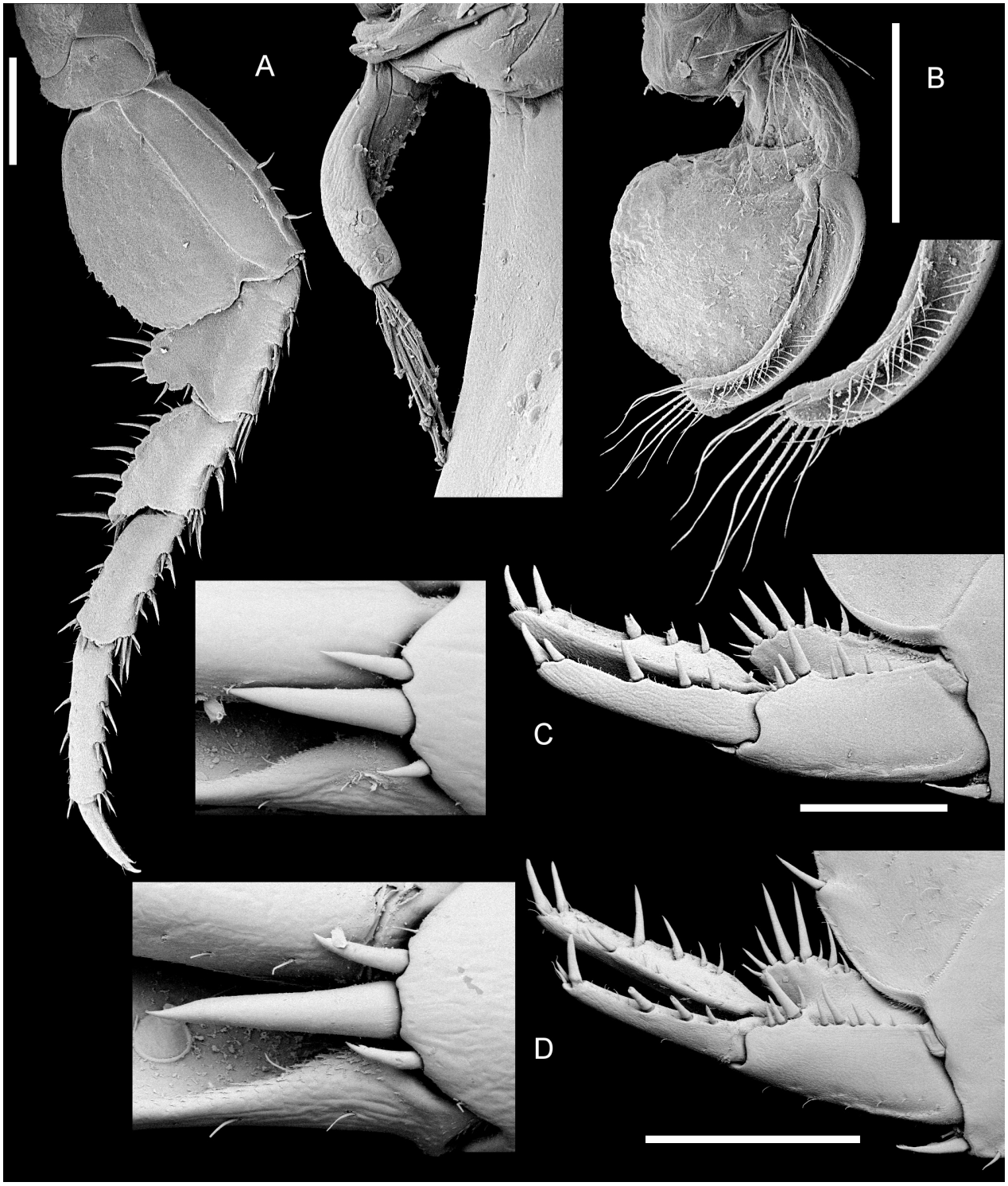

FIGURE 129. *Eophreatoicus kurrih* sp. nov., pereopod VII, pleopod II, uropod. Paratype male, AM P.74578: A, pereopod VII with enlargement of pene; B, pleopod II appendix masculina with enlargement of distal tip; C, uropod with enlargement of protopod distoventral setae. Paratype female, AM P.74579: D, uropod with enlargement of protopod distoventral setae. All scales 1 mm.

Pereopod II. Basis lateral face with 8 elongate simple setae in male and 9 in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 2–3–4 minor setae, submarginal setal row with 2–4–7 setae, with major setae distal to epaulet, 4–6–9 major setae. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 3–4–6 minor setae, submarginal setal row with 4–5–8 setae, with major setae distally, with 6–8–9 major setae distal to epaulet.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus. Basis of male dorsal ridge with 19 setae (H), of male dorsal ridge setae positioned along ridge. Ischium of male dorsal margin with 6 setae (H). Carpus of male ventral margin setae in several groups, with simple setae only. Propodus of male distal width 0.73 maximum width (H), setae on ventral margin robust-based, 2 distinctly larger than remainder, longer than dactylar claw. Dactylus of male distal accessory claw approximately 0.5 primary claw length (H, 0.46 length of primary claw). *Pereopod IV ratios.* Length:body length 0.26 male (H), 0.28 female (F3). Basis length:width 2.70 male (H). Carpus length:pereopod length 0.12 male (H). Propodus length:pereopod length 0.14 male (H). Propodus length:width 2.10 male (H).

Pereopods V–VII ratios. Pereopod V. Length:body length 0.26 male (H), 0.28 female (F3). Basis length:width 0.98 male (H), 1.20 female (F3). Carpus length:pereopod length 0.16 male (H), 0.15 female (F3). Propodus length: pereopod length 0.17 male (H), 0.17 female (F3). Dactylus claw length:dactylar length 0.22 male (H). *Pereopod VI.* Length:body length 0.39 male (H), 0.38 female (F3). Basis length:width 1.20 male (H), 1.40 female (F3). Carpus length:pereopod length 0.15 male (H), 0.15 female (F3). Propodus length:pereopod length 0.17 male (H), 0.15 female (F3). *Pereopod VII.* Length:body length 0.38 male (H). Basis length:width 1.20 male (H). Carpus length: pereopod length 0.16 male (H). Propodus length:pereopod length 0.17 male (H). Dactylus claw length:dactylar length 0.17 male (H).

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 5 setae (H pereopod V, H pereopod VII), including H pereopod V, H pereopod VII. Propodus distal margins with 4 elongate robust or robust-based setae (H pereopod V, H pereopod VII). Dactylus accessory claw 0.34–0.35 (H pereopod V, H pereopod VII) primary claw length. Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with 2 setae, dorsal margin with 5 setae (H, possibly more as ridge partially obscured).

Penes. Distally tapering; distal tip truncate.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 1.70 endopod proximal margin length; distally with 8 setae; 57 setae altogether (approx).

Uropod. Of male total length 1.10 pleotelson length (H); protopod of male length 0.41 uropod total length (H). Uropod of female total length 1.00 pleotelson length (F3), protopod length 0.45 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.57 male (H), 0.53 female (F3). Protopod of male dorsolateral margin subequal to dorsomedial margin setae; of female dorsolateral margin longer than dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, with spinose setae (F3, H), 1 robust spinose seta, 2–3 robust simple setae (F3, H). Protopod lateral face with ventrolateral ridge (faint, can be scored as absent?). Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 5 altogether (H); female dorsal margin with 8 robust setae (F3). Exopod length:endopod length 0.81 male (H), 0.79 female (F3). Exopod length:protopod length 0.96 male, 0.94 female. Exopod of male dorsal margin with 5 robust setae (H), female 6 robust setae (F3).

Distribution. Australia, Northern Territory, Kakadu National Park, Mt. Brockman, E. side Blue Tongue Dreaming of Gulunggul Creek, a tributary of Magela Creek, East Alligator River catchment.

Habitat. On the margin of stream in roots and leaf litter.

Remarks. *Eophreatoicus kurrih* sp. nov. is known to have introgressed with *E. nawurlandja* sp. nov. (Wilson *et al.* 2009); it is, however, distinctly different by nine diagnostic characters, a subset of 114 descriptive character differences. *Eophreatoicus kurrih* sp. nov. (vs. *E. nawurlandja* sp. nov.) has small, slightly protruding eyes (medium bulging in dorsal view), the male pereopod II basis epaulet with six–eight major setae (five), the male pereopod IV propodus ventral margin lacking an angular projection (with) and the uropod protopod dorsomedial ridge distinctly projecting dorsally (projecting dorsally with plate above shaft but posterior margin hardly exposed). In the morphological analysis, *E. kurrih* sp. nov. is placed in a clade with *E. galunggul* sp. nov., although with little character support, such that clade was collapsed in Fig. 11. *Eophreatoicus galunggul* sp. nov. species differs by 14 diagnostic characters and has even larger, more bulging eyes and an overall smooth cuticle rather than the small eyes and rugose cuticle of *E. kurrih* sp. nov. Interestingly, the two species are in geographic proximity, 2.25 km following the stream bed, in a rugged area just south of Ranger Mine facility in Kakadu National Park.

Specimens of *Eophreatoicus kurrih* sp. nov. were collected in August 1976, possibly by R. Pengilley (Gavin Dally, Museum and Art Gallery of the Northern Territory, pers. comm.), but were not sequenced until 2006. The

specimens apparently were preserved in ethanol of unknown concentration and yet the DNA survived 30 years under museum curation, which was remarkable. Contributing to the careful museum curation by the staff of MAGNT, *Eophreatoicus* specimens have large bodies that allow extracting of internal tissues, which are protected from the external preservative solution.

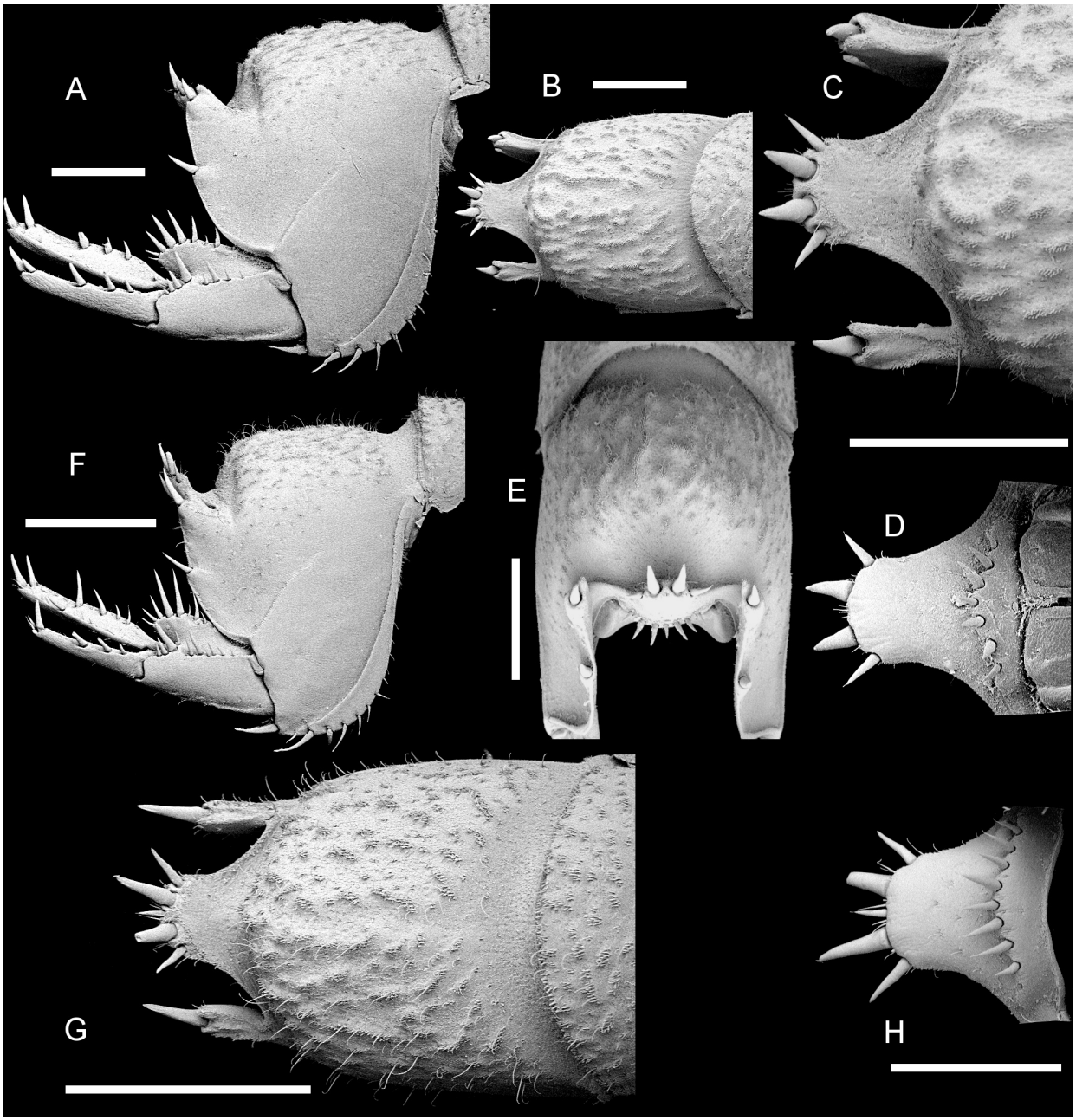

FIGURE 130. *Eophreatoicus kurrih* sp. nov., pleotelson. Paratype male, AM P.74578: A–B, dorsal and lateral, scale 1 mm; C–D, enlargement of terminal apex, dorsal and ventral, scale 1 mm; E, posterior. Paratype female, AM P.74579: F–G, lateral and dorsal, scales 1 mm; H, enlargement of terminal apex, ventral, scale 0.5 mm.

Eophreatoicus galunggul **sp. nov.**

(Figs 4B, 7A, 131–135)

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Eophreatoicus sp. "Gb".—Wilson *et al.*, 2009: 362.

Type material. Holotype male, bl 17.6 mm, AM P.74602, Gulunggul Ck site 3. Paratypes collected with holotype:

male (M2), bl 18.9 mm, AM P.74603, DNA E104 GenBank COI EU263178 16S EU263249, SEM stubs AW817–822; female (F3), bl 14.8 mm, AM P.74604, DNA E105 COI GenBank EU263179 16S EU263250, SEM stubs AW823–826; 6 inds, AM P.74605. Additional paratypes collected near type locality: Gulunggul Ck site 1, preparatory female, bl ~12 mm, AM P.74600, DNA E45 GenBank COI EU26317716S EU263251; 5 inds, AM P.74599; Gulunggul Ck site 4, juvenile female, P.74601.



FIGURE 131. *Eophreatoicus galunggul* sp. nov., types, lateral. Top, holotype male, AM P.74602. Bottom, paratype female, AM P.74604. Scale 5 mm.

Type locality. Australia, Northern Territory, Gulunggul Ck sites, coll. C. Humphrey, 13.xi.1998. Gulunggul Ck site 1, first south tributary in Radon Springs, 12°45.28'S, 132°54.50'E. Sites adjacent to type locality with additional paratypes: Gulunggul Ck site 3, pools in north tributary of Radon Springs, 12°44.72'S, 132°55.46'E; Gulunggul Ck site 4, small seep in north tributary of Radon Springs, 12°44.19'S, 132°55.30'E.

Etymology. "Galunggul" comes from the commonly known name for the creek in which this species was found. The name in the Kundjeyhmi dialect is pronounced "goo-loong-gool".

Diagnosis. *Head.* Eyes bulging dorsolaterally, height large, in lateral view greater than width of basal antennal articles, height greater than length in lateral view, bulging in dorsal view, projecting from head in distinct arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface smooth (without roughness or tubercles); pereonites 1–4 transverse dorsal ridges rounded, expressed as transverse trough only; pereonites 5–7 transverse dorsal ridges carinate with transverse trough. *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection linear. Dorsal surface without tubercles or short ridges, with smoothly rounded posteromedial ridge. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae, with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length subequal to quarter basis length, main setal row with 6–7 major setae. Basis of female dorsal ridge epaulet length greater than quarter basis length, main setal row with 6–7 major setae. *Pereopod IV.* Propodus of male ventral margin with projection, with 2 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge distinctly projecting dorsally with posterior margin exposed above shaft, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 adjacent robust setae distinctly larger than others.

Description. Body pigmentation dorsally with broad dark irregular bar (not three lined), abruptly darker on Pers 5–7 and pleonites than anteriorly, chromatophores dendritic; length of largest male 18.9 mm, length of largest preparatory female 14.8 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Dorsal surface smooth; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin concave, orientation of longest axis vertical, maximum diameter 0.27–0.29 head depth (F, H), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view smoothly curved. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

Pereon. Width near head width. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–3 in dorsal view respective lengths less than 0.5 pleonite 5 length, pleonite 4 length more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.40 pleonite 1 (H, M2), 2.00 pleonite 2 (H, M2), 2.10–2.20 pleonite 3 (H, M2), 2.10 pleonite 4 (H, M2), 1.90–2.10 pleonite 5 (M2, H).

Pleotelson. Dorsal surface length 1.10 width in dorsal view (M2, F3). Dorsal surface sparsely covered with setae. Depth 1.20–1.70 pereonite 7 depth (M2, H). Lateral length less than depth, in male 0.77 depth (M2, H), in female 0.76 depth (F3). Lateral length 0.13–0.14–0.15 body length (M2, F3, H). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.40–1.60 width of uropodal insertion (M2, F3), with one row of distally denticulate robust setae, including 5 robust setae altogether (M2, F3), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.11–0.13–0.16 pleotelson total length (F3, M2, H). Posterior apex length less than width, long. Posterior apex 0.17–0.20 pleotelson total length (M2, F3), width 0.40–0.49 pleotelson width (M2, F3). Posterior apex in lateral view forming an angle of 85–107–116° with immediately anterior dorsal surface (F3, M2, H), angled 150–157–164° from horizontal (H, F3, M2).

Antennula. Length 0.12 body length in male (M2), 0.12 body length in female (F3), with 13 articles in male (M2), with 11 articles in female (F3). Article 5 length 1.20 width (M2, F3). Article 6 length 1.10–1.20 width (M2, F3). Aesthetascs small (1–3) mostly on distomedial margins. Terminal article length 1.30 width (M2, F3), 0.03–0.04 antennula total length (M2, F3). Distal articles oval in cross-section.

Antenna. Length 0.41 body length in male (M2), 0.40 body length in female (F3). Flagellum length 0.62 total antenna length in male (M2), 0.60 total antenna length in female (F3), with 22 articles in male (M2), with 20 articles in female (F3), proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

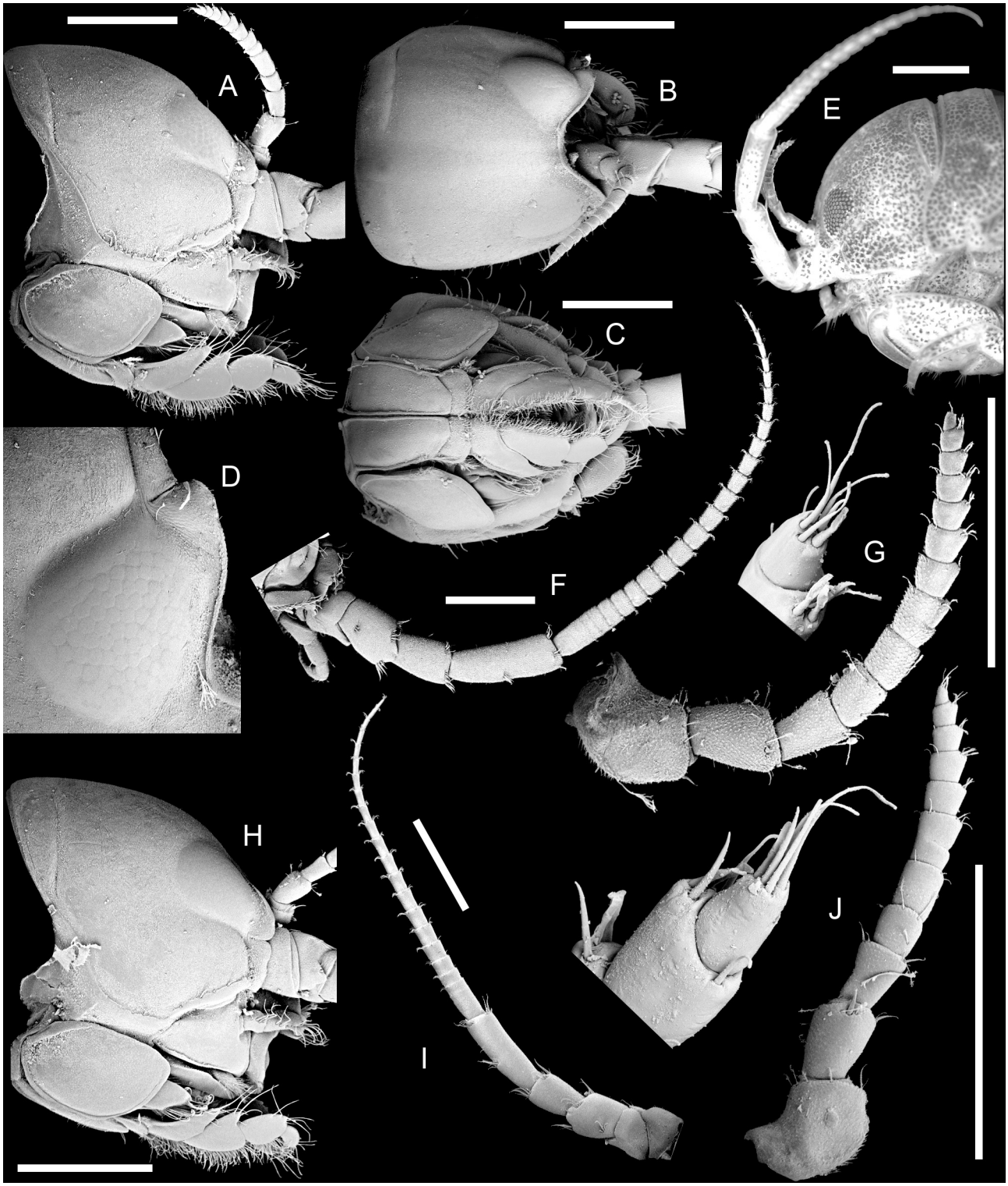

FIGURE 132. *Eophreatoicus galunggul* sp. nov., head and antennae. Paratype male, AM P.74603: A–D, head lateral, dorsal, ventral, enlargement of eye region; F, antenna; G, antennula with enlargement of tip. Holotype male, AM P.74602: E, head lateral. Paratype female, AM P.74604: H, head lateral. I, antenna; J, antennula with enlargement of tip. Scales 1 mm.

Maxilliped. Epipod distal tip rounded, length 1.50–1.60 width (M2, F3). Palp article 4 shape elongate-oval, length 1.20–1.50 width (M2, F3). Palp article 5 length 1.80–2.30 width (M2, F3), 0.71–0.87 article 4 length (M2, F3).

Pereopod I. Length:body length 0.37 male (M2), 0.32 female (F3). Basis of male length 2.50 width (M2), female length 2.50 width (F3); dorsal setae positioned proximally, 5 dorsal setae altogether (M2,approx); female

dorsal setae positioned proximally, female 6 dorsal setae altogether (F3); ventrodistal margin lacking elongate setae (has 1 simple seta but not elongate), female with 1 elongate seta (F3), elongate setae subequal to ischium or longer than ischium (M2, F3). Ischium of male dorsal margin with 2 simple setae (M2), setae robust, including 1 robust setae. Ischium of female dorsal margin with 1 simple seta, setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (2 short robust); female distodorsal margin with few elongate simple setae, female dorsal surface with setae along dorsal axis (2 elongate simple). Propodus length:pereopod length 0.23 male (M2), 0.19 female (F3). Propodus length:width 1.20–1.50 male (M2, H), 1.60 female (F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 4 setae altogether (excluding distal group) (M2), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae articulation not expressed, 31 altogether (M2). Propodal palm of female margin convex, stout denticulate setae serrate, 18 altogether (F3), with stout robust conical setae, 3 altogether (F3, proximally). Dactylus of male shorter than palm, length: palm length 0.91 (M2), female length subequal to palm, female length:palm length 0.95 (F3). Dactylus of female ventrodistal margin distal cuticular fringe length 0.77 total length (F3). Dactylus claw length:dactylus length 0.07 male (M2), 0.12 female (F3). Dactylus of male positioned ventrally, 0.36–0.52 (M2, F3) length of primary claw.

Pereopods II–III ratios. Pereopod II. Length:body length 0.34 male (M2), 0.33 female (F3). Basis length: pereopod length 0.31 male (M2), 0.32 female (F3); length:width 2.40 male (M2), 2.40 female (F3). Carpus length: pereopod length 0.12 male (M2), 0.11 female (F3); length:width 1.30–1.50 male (H, M2), 1.50 female (F3). Propodus length:pereopod length 0.16 male (M2), 0.15 female (F3); length:width 2.70–3.00 male (M2, H), 2.60 female (F3). Dactylus length:propodus length 0.55–0.59 male (H, M2), 0.60 female (F3); primary claw length: dactylar length 0.19 male (M2), 0.26 female (F3). *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, carpus, propodus., dactylus. Ischium II–IV of male dorsal margin with 6 simple setae (M2 pereopod II), none robust. Dactylus ventral to primary claw, 0.30–0.31 length of primary claw, with scales on ventral margin (F3, M2); 12 altogether (F3 pereopod II,approx).

Pereopod II. Basis lateral face with 8 simple setae along margin in male and with 8 long simple setae along margin in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 3–4 minor setae, submarginal setal row with 4–5 setae, without major setae distal to epaulet (a single specimen has 1 seta, out of 7 specimens). Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 3–4–5 minor setae, submarginal setal row with 5–6–7 setae, without major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 10 setae (M2, 4 of which forming posterior row), dorsal ridge setae positioned proximally, of female dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 6 setae (M2). Carpus of male ventral margin with simple setae only. Propodus of male distal width 0.71 maximum width (M2), setae on ventral margin robust-based, no setae distinctly larger than others, longer than dactylar claw (M2, 1.5 dactylar claw). Dactylus of male distal accessory claw approximately 0.33 primary claw length (M2, 0.36). *Pereopod IV ratios.* Length:body length 0.29 male (M2). Basis length:width 2.40 male (M2). Carpus length:pereopod length 0.11 male (M2). Propodus length:pereopod length 0.16 male (M2). Propodus length:width 2.30 male (M2).

Pereopods V–VII ratios. Pereopod V. Length:body length 0.30–0.31 male (H, M2), 0.30 female (F3). Basis length:width 1.20–1.30 male (H, M2), 1.30 female (F3). Carpus length:pereopod length 0.16–0.17 male (M2, H), 0.16 female (F3). Propodus length:pereopod length 0.18 male (H, M2), 0.17 female (F3). Dactylus claw length: dactylar length 0.25 male (M2). *Pereopod VII.* Length:body length 0.45 male (M2). Basis length:width 1.40 male (M2). Carpus length:pereopod length 0.17 male (M2). Propodus length:pereopod length 0.18 male (M2). Dactylus claw length:dactylar length 0.23 male (M2).

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 5–6 setae (M2 pereopod V, pereopod VII). Propodus distal margins with 3–5 elongate robust or robust-based setae (M2 pereopod V, pereopod VII). Dactylus accessory claw 0.26 primary claw length (M2 pereopod VII). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with no setae, dorsal margin with 6 setae (M2).

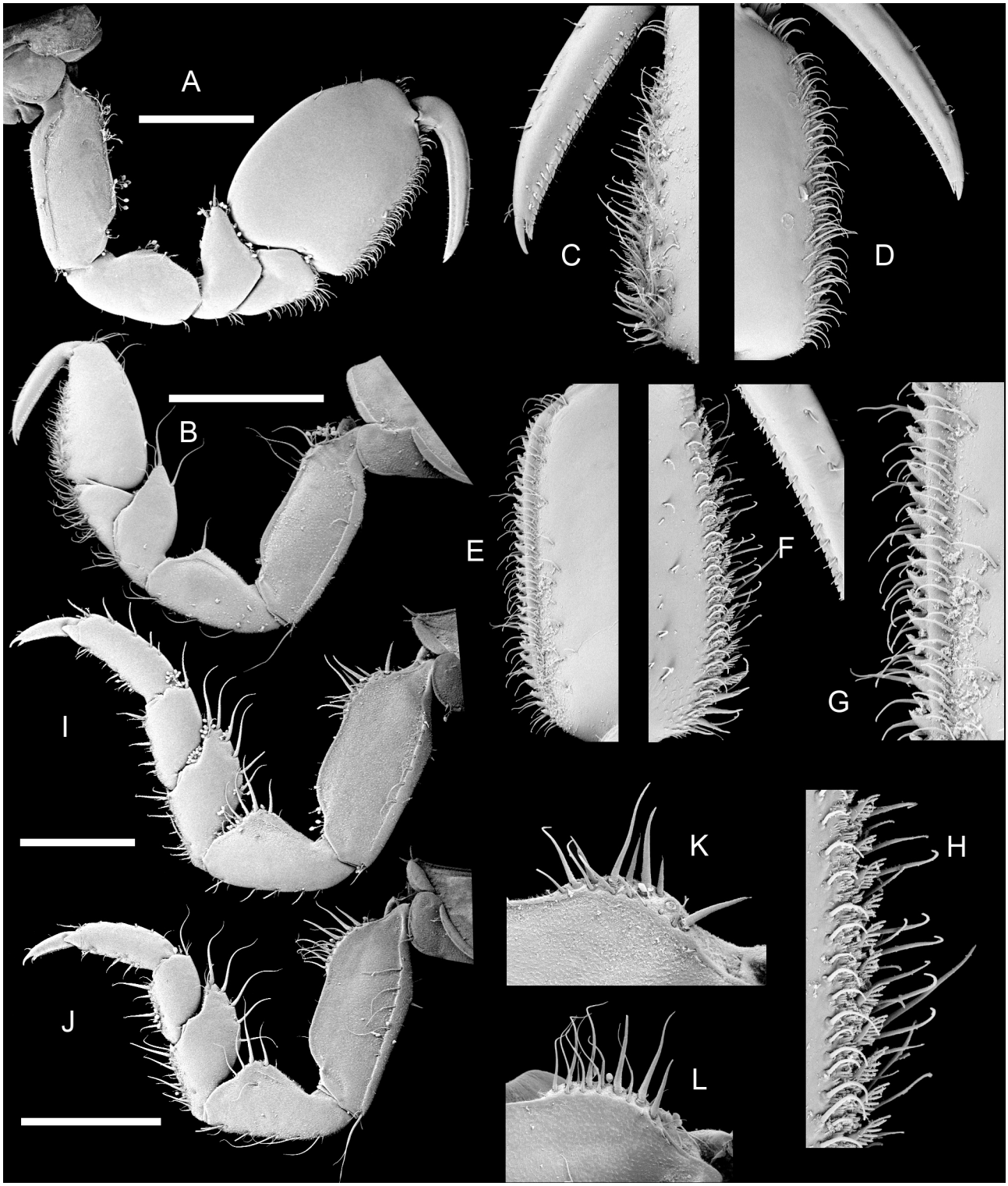

FIGURE 133. *Eophreatoicus galunggul* sp. nov., anterior pereopods. Paratype male, AM P.74603: A, C, E, G, pereopod I entire, palm and dactylus, palm medial side, enlargement of setation; I K, pereopod II, enlargement of epaulet. Paratype female, AM P.74604: B, C, F, H, pereopod I entire, palm and dactylus, palm medial side, enlargement of setation; J L, pereopod II, enlargement of epaulet. Scales 1 mm.

Penes. Distally tapering; distal tip truncate.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 1.80 endopod proximal margin length; distally with 5 setae; 40 setae altogether (M2).

Uropod. Of male total length 0.98–1.10 pleotelson length (H, M2); protopod of male length 0.46–0.49 uropod

total length (H, M2). Uropod of female total length 1.00 pleotelson length (F3), protopod length 0.49 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.42 male (M2, approximate, as dorsomedial ridge partially obscured), 0.54 female (F3). Protopod of male dorsolateral margin longer than dorsomedial margin setae; of female dorsolateral margin longer than dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, with spinose setae, 3 robust spinose setae (M2, F3). Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 8 altogether (M2); female dorsal margin with 8 robust setae (F3). Exopod length:endopod length 0.80–0.86 male (H, M2), 0.86 female (F3). Exopod of male dorsal margin with 6 robust setae (M2), female 8 robust setae (F3).

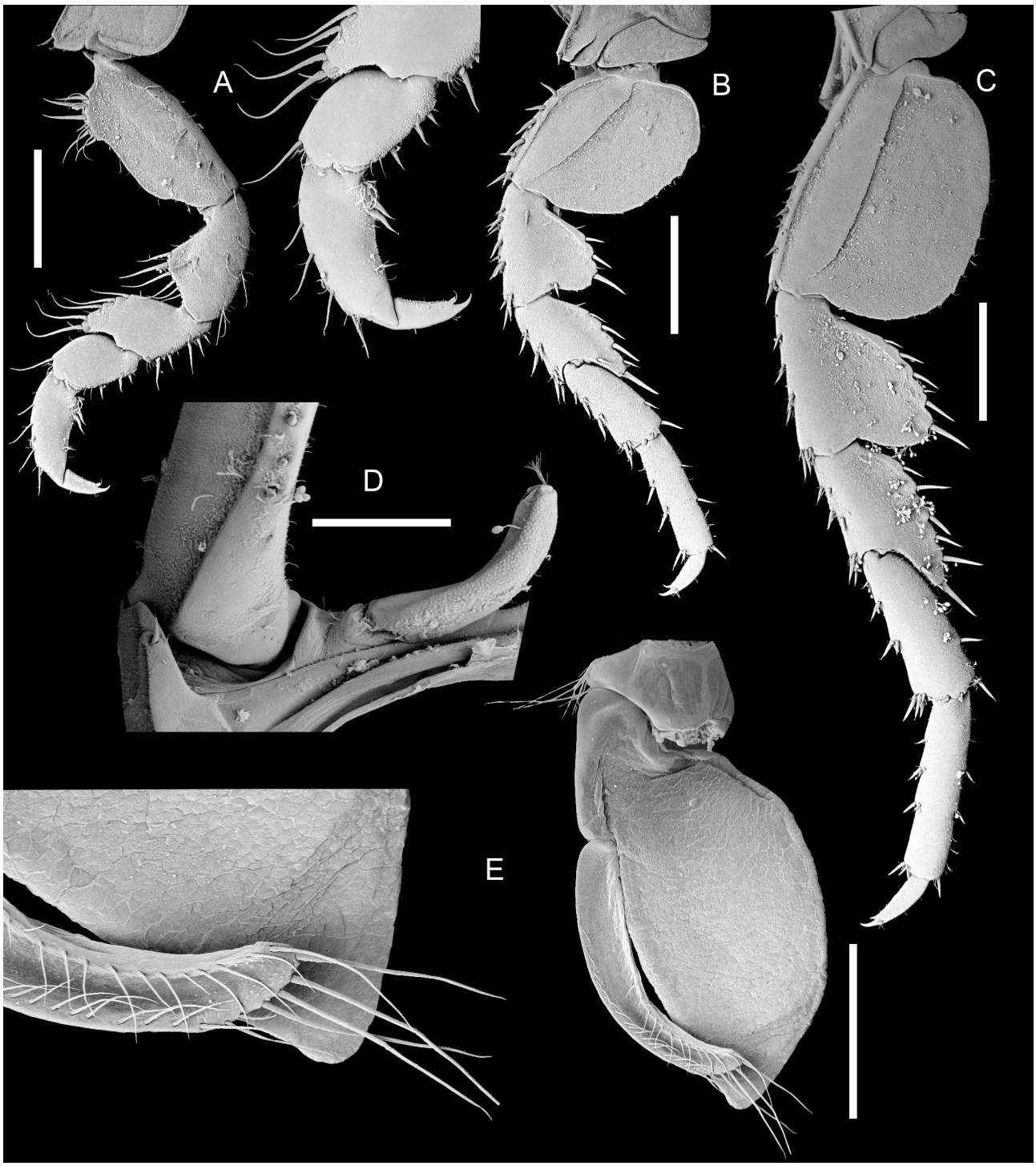

FIGURE 134. *Eophreatoicus galunggul* sp. nov., posterior pereopods, paratype male, AM P.74603. A, pereopod IV with enlargement of distal segments. B, pereopod V. C, pereopod VII. D, pene, anterior. E, pleopod II endopod with enlargement of appendix masculina distal tip. Scales 1 mm except for D, 0.5 mm.

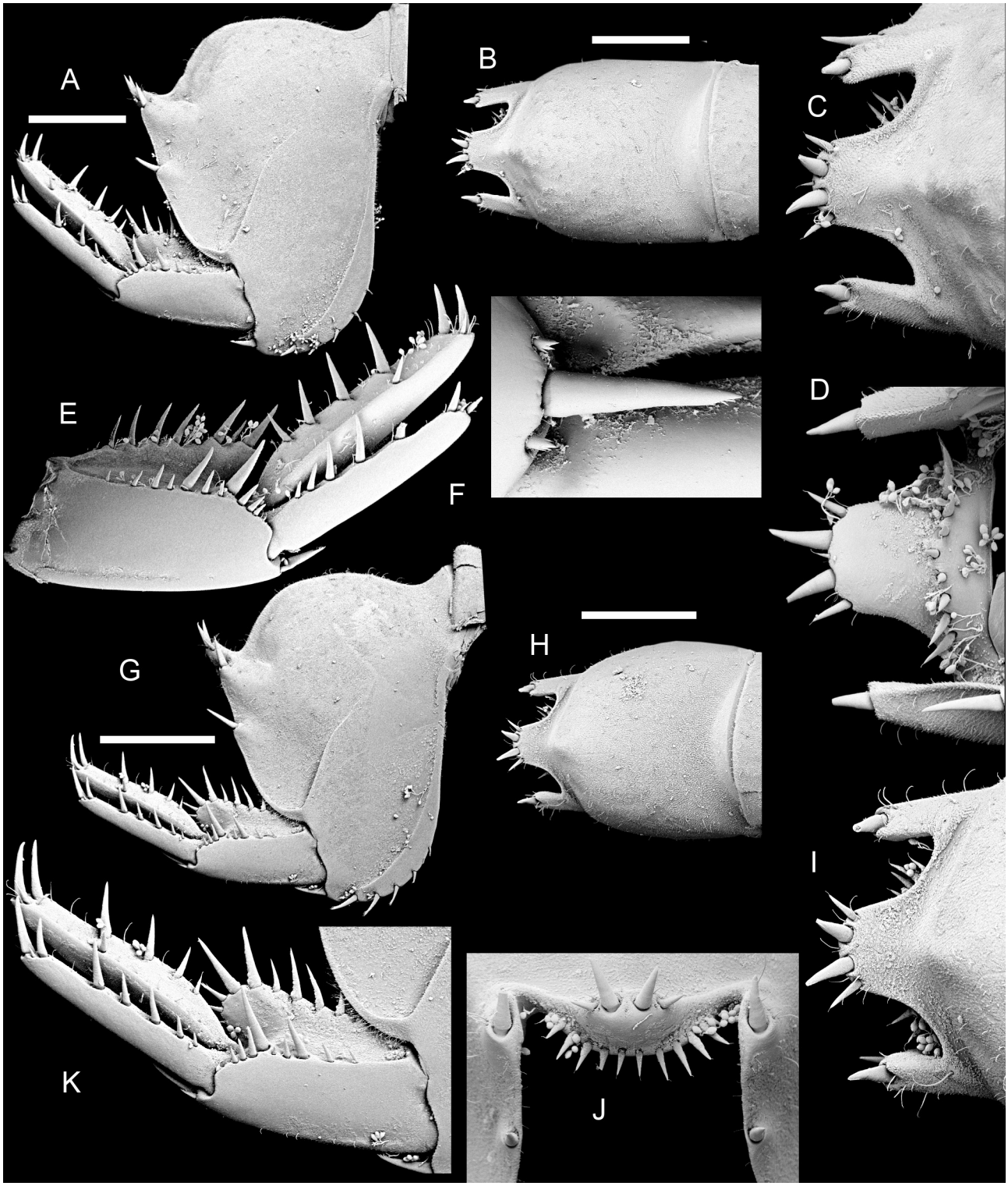

FIGURE 135. *Eophreatoicus galunggul* sp. nov., pleotelson and uropods. Paratype male, AM P.74603: A–D, pleotelson lateral, dorsal, dorsal and ventral terminal apex; E–F, uropod lateral with enlargement of distoventral protopod setae. Paratype female, AM P.74604: G–J, pleotelson lateral, dorsal, dorsal and posterior terminal apex; K, uropod lateral. Scales 1 mm.

Distribution. Australia, Northern Territory, Kakadu National Park, Radon Springs, upper Gulunggul Creek, a tributary of Magela Creek, East Alligator River catchment.

Habitat. On the margin of stream or in seep among roots and leaf litter.

Remarks. *Eophreatoicus galunggul* sp. nov., as mentioned in the remarks for *E. kurrih* sp. nov., is a large-eyed species with smooth cuticle that has a rounded ridge on the posterodorsal margin of the pleotelson, making it unlike

any other species of *Eophreatoicus*. It co-occurs with the population of *E. nawurlandja* sp. nov. in the tributary of Gulunggul Creek (from which it derives its name), as well as Radon Springs. *Eophreatoicus galunggul* sp. nov. is easily separated from *E. nawurlandja* sp. nov. because, in addition to the features mentioned above, its pleotelson apex has only two pairs of robust setae, lacking the medial fifth seta found in *E. nawurlandja* sp. nov.

Eophreatoicus nawurlandja sp. nov.

(Figs 2, 4A, 136–141)

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Eophreatoicus sp. "01".—Wilson *et al.*, 2009: 361.
Eophreatoicus sp. "23".—Wilson *et al.*, 2009: 361.
Eophreatoicus sp. "Ga".—Wilson *et al.*, 2009: 362.

Type material. Holotype male, bl 18.3 mm, AM P.76441, CH19990314. Paratypes collected with holotype at CH19990314: preparatory female, bl 11.7 mm, AM P.76440, DNA E41 GenBank COI EU263139; preparatory female (F2), bl 13.4 mm, AM P.76442, DNA E80 GenBank COI EU263140 16S EU263210, SEM stubs AW707–710; 12 inds, AM P.76439. Additional paratypes: CH19990405, juvenile?, AM P.76402, DNA E39 (unsuccessful), 16 inds, AM P.76401; CH19940122, 8 inds, AM P.76446. OSSIX: male (M3), bl 27.2 mm, AM P.76443, DNA E81 GenBank COI EU263141 16S EU263209, SEM stubs AW702–706; 5 inds, AM P.76444; 22 inds, AM P.76445. OSSI, 5.i.1991, 6 inds, AM P.76447; CH19981212, male, DNA E40 GenBank COI EU263167 16S EU263238, AM P.76449; 13 inds, AM P.76448.

Type locality. Australia, Northern Territory, Nanguluwar sites: CH19990314, Nanguluwar (west side of Nourlangie Rock), 12°50.54'S, 132°49.03'E, coll. 14.iii.1999, C. Humphrey. Sites adjacent to type locality with additional paratypes: CH19990405, south east of Nanguluwar, 12°50.70'S, 132°49.32'E, coll. 05.iv.1999, C. Humphrey; CH19940122, pool on temporary stream, Little Nourlangie Rock, 12°51'S, 132°48'E, coll. 22.i.1994, P. Dostine; OSSIX, Little Nourlangie Rock, drifting from cave stream, 12°51'S, 132°48' E, coll. 27.ii.1994, P. Dostine; OSSI, Nourlangie Rock, 12°51'S, 132°48'E, coll. 5.i.1991; CH19981212, Nourlangie Rock Cave, coll. C. Humphrey, 12.xii.1998.

Other material examined. See Gulunggul Creek population of this species.

Etymology. "Nawurlandja" is the name for Little Nourlangie Rock, near where one population of this species was collected. The official spelling uses "dj" for the palatal stop sound. This spelling is used by the Kakadu National Park in their signage. The name is pronounced "nah-woorl-un-juh".

Diagnosis. *Head.* Eyes bulging dorsolaterally, height medium, in lateral view subequal to width of basal antennal articles (M3, F2), height greater than length in lateral view, bulging in dorsal view, projecting from head in distinct arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface with tubercles and small scales, increasing posteriorly, less so in younger stages; pereonites 1–4 transverse dorsal ridges rounded, expressed as transverse trough only; pereonites 5–7 transverse dorsal ridges carinate with transverse trough. *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection linear. Dorsal surface rugose, with elongate ridge-like tubercles, with several median tubercles, not merging into ridge. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae and one median robust seta (central seta smallest, about half size of others), with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length greater than quarter basis length, main setal row with 5 major setae. Basis of female dorsal ridge epaulet length subequal to quarter basis length, main setal row with 5–5–6 major setae. *Pereopod IV.* Propodus of male ventral margin with projection, with 5 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 adjacent robust setae distinctly larger than others.

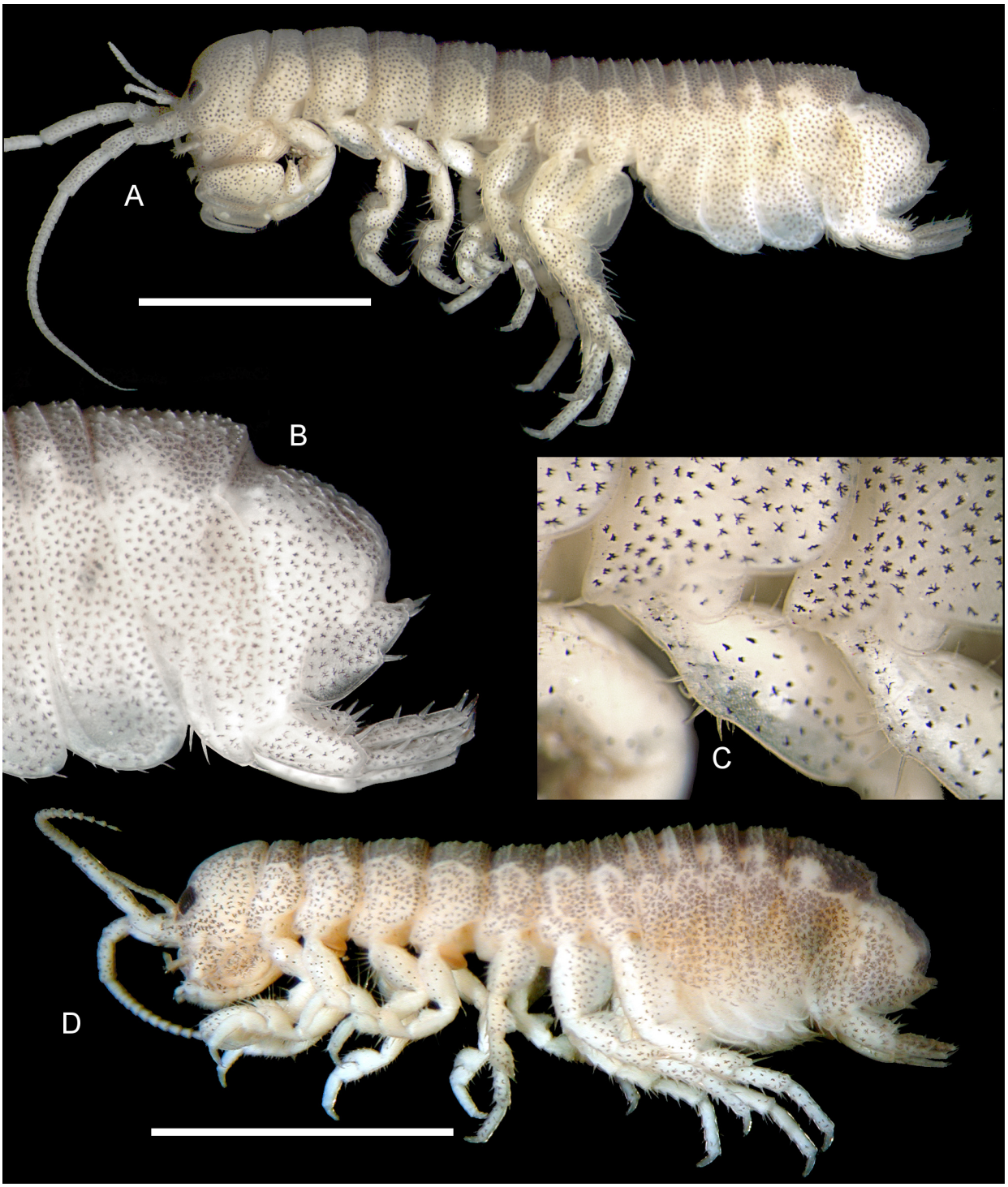

FIGURE 136. *Eophreatoicus nawurlandja* sp. nov., habitus. Holotype male, AM P.76441, A, lateral; B, pleotelson lateral; C, pereopod II–III bases showing epaulet setation. D, paratype female, AM P.76442, lateral. Scales 5 mm.

Description. Body pigmentation light colored dorsally, maculate, with faint thin median line and broad irregular dorsolateral bars, chromatophores small, dense; length of largest male 27.3 mm, length of largest preparatory female 16.7 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Dorsal surface pitted; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin straight, orientation of longest axis vertical, maximum diameter 0.24–0.27 head depth (M, F), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view sigmoidal. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

Pereon. Width near head width. Setae on dorsal surface not visible. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–3 in dorsal view respective lengths less than 0.5 pleonite 5 length, pleonite 4 length more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.30 pleonite 1 (H), 1.80 pleonite 2 (H), 2.10 pleonite 3 (H), 2.00 pleonite 4 (H), 1.90 pleonite 5 (H).

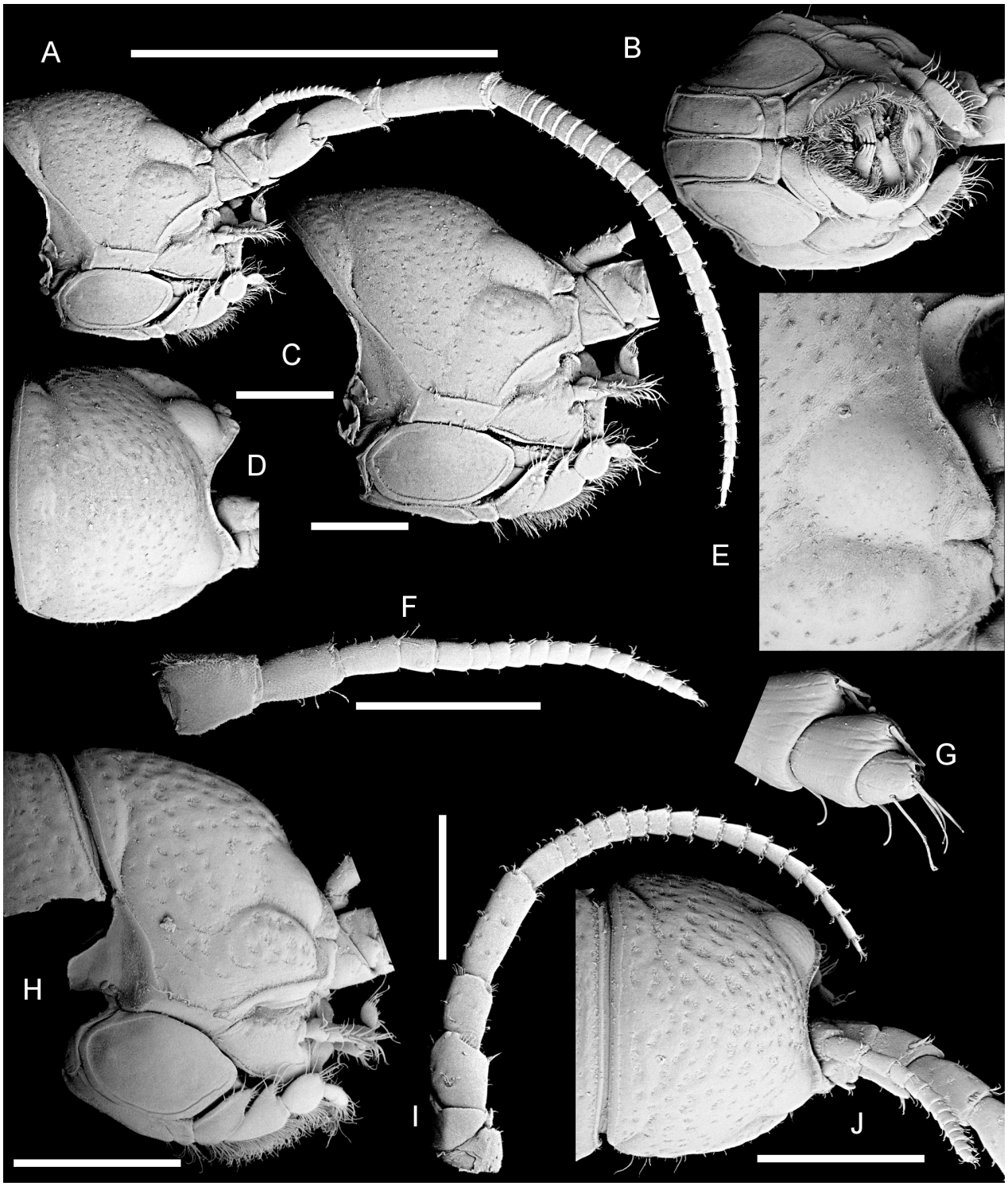

FIGURE 137. *Eophreatoicus nawurlandja* sp. nov., head and antennae. Paratype male, AM P.76443: A, head lateral with antenna; B, head ventral; C, head lateral enlarged; D, head dorsal; E, eye enlargement; F, antennula; G. antennula tip. Paratype female, AM P.76442: H, head lateral; I, antenna; J, head dorsal;. Scales 1 mm except for A, 5 mm.

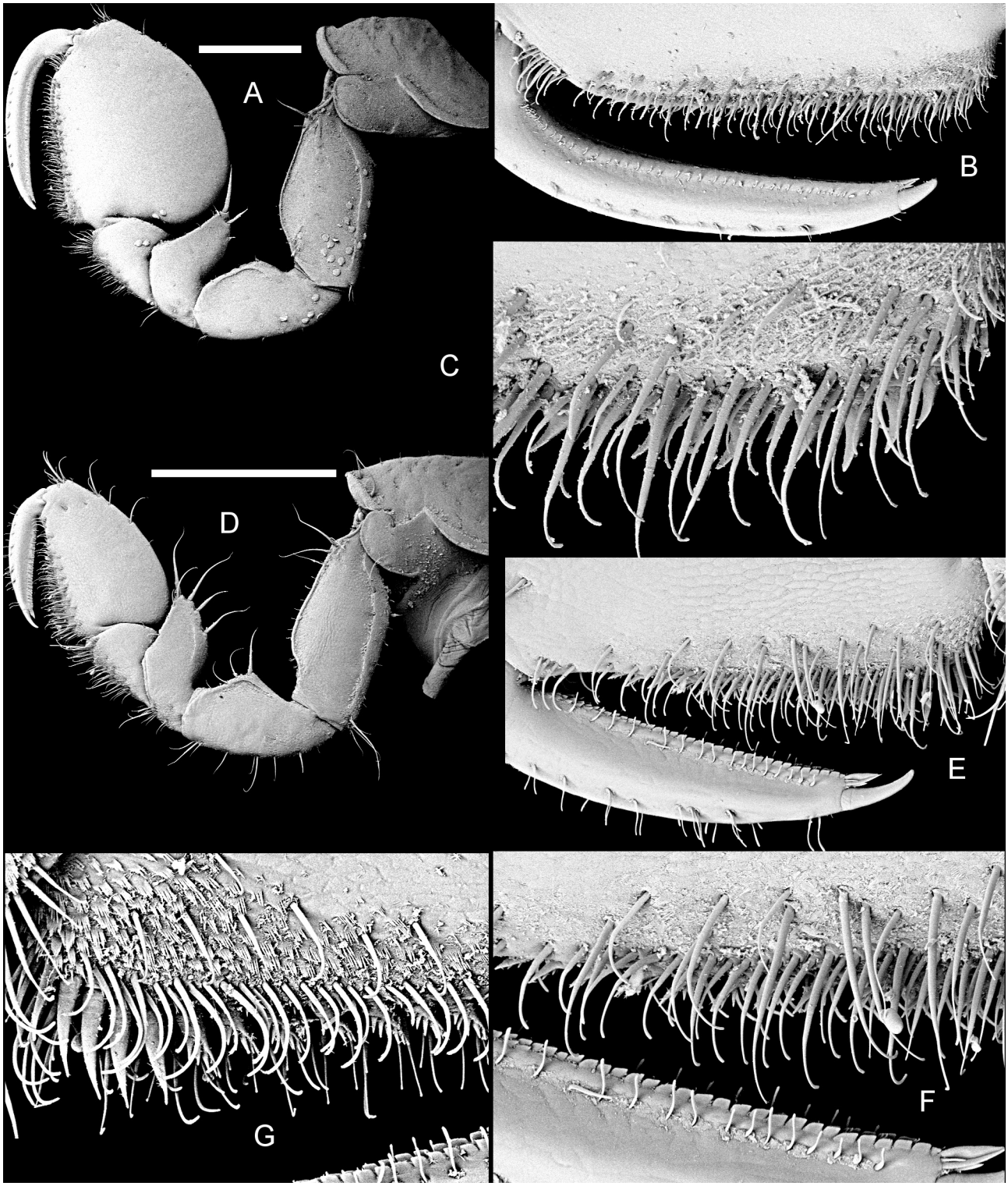

FIGURE 138. *Eophreatoicus nawurlandja* sp. nov., pereopod I. Paratype male, AM P.76443: A, entire, lateral; B, palm; C, palm setae. Paratype female, AM P.76442: D, entire, lateral; E, palm; F, palm setae and dactylar scales; G, palm setae and dactylar scales, medial. Scales 1 mm.

Pleotelson. Dorsal surface length 1.10 width in dorsal view (M3). Dorsal surface sparsely covered with setae; lacking cuticular combs on tubercles. Depth 1.50 pereonite 7 depth (H). Lateral length less than depth, in male 0.74 depth (M3), in female 0.75 depth. Lateral length 0.12–0.13 body length (M3, F2). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.30–1.50 width of uropodal insertion (F2, M3), with one

row of distally denticulate robust setae, including 10 robust setae altogether (M3, F2), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.13–0.16 pleotelson total length (M3, F2). Posterior apex length less than width, long. Posterior apex 0.12–0.18 pleotelson total length (F2, M3), width 0.44–0.52 pleotelson width (F2, M3). Posterior apex in lateral view forming an angle of 60–88° with immediately anterior dorsal surface (F2, M3), angled 123–153° from horizontal (F2, M3).

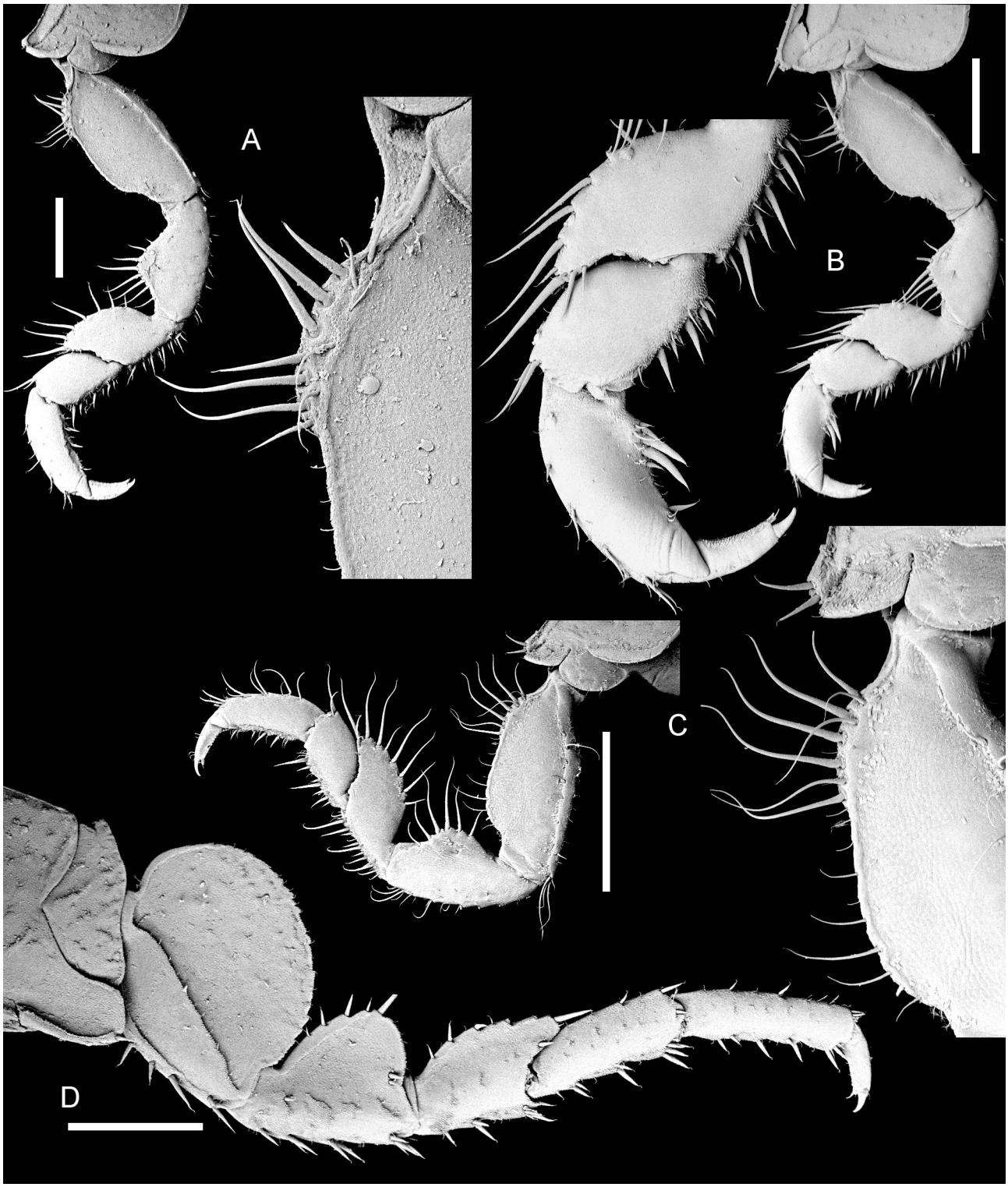

FIGURE 139. *Eophreatoicus nawurlandja* sp. nov., pereopods II–V. Paratype male, AM P.76443: A, pereopod II with enlargement of epaulet on basis; B, pereopod IV, with enlargement of distal segments; D, pereopod V. Paratype female, AM P.76442: C, pereopod II with enlargement of epaulet on basis. Scales 1 mm.

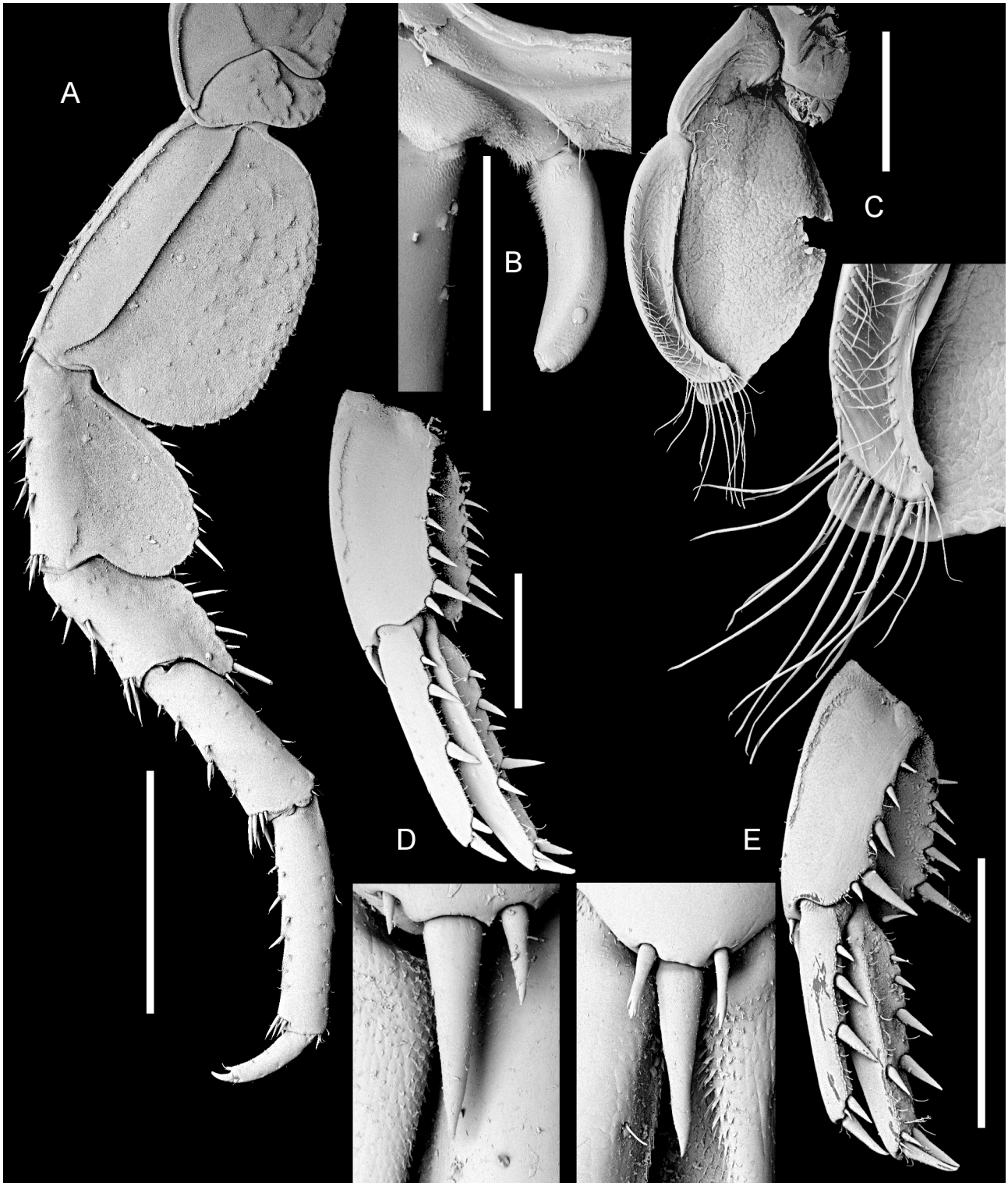

FIGURE 140. *Eophreatoicus nawurlandja* sp. nov., pereopod VII and uropods. Paratype male, AM P.76443: A, pereopod VII; B, pene; C, pleopod II appendix masculina with enlargement of distal tip; D, uropod with enlargement of protopod distoventral setae. Paratype female, AM P.76442: E, uropod with enlargement of protopod distoventral setae. Scales 1 mm except for A, 2 mm.

Antennula. Length 0.11 body length in male (M3), 0.10 body length in female (F2), with 17 articles in male (M3), with 12 articles in female (F2). Article 5 length 0.87–1.20 width (F2, M3). Article 6 length 0.65–0.92 width (M3, F2). Aesthetascs small (1–3) mostly on distomedial margins. Terminal article length 1.10–1.30 width (M3, F2), 0.02–0.06 antennula total length (M3, F2). Distal articles oval in cross-section.

Antenna. Length 0.41 body length in male (M3), 0.40 body length in female (F2). Flagellum length 0.64 total antenna length in male (M3), 0.57 total antenna length in female (F2), with 27 articles in male (M3), with 16 articles in female (F2), proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Mandible. Palp article 3 medial surface without additional setae, without setules, surface lacking cuticular hairs.

Maxilliped. Epipod distal tip rounded. Endite distal margin in fringe. Palp article 4 shape elongate-oval, length 2.10–2.20 width (F2, M3). Palp article 5 length 1.40 width (M3), 0.82–1.00 article 4 length (F2, M3).

Pereopod I. Length:body length 0.31 male (M3), 0.31 female (F2). Basis of male length 2.30 width (M3), female length 2.40 width (F2); dorsal setae positioned proximally, 4 dorsal setae altogether (M3); female dorsal setae positioned proximally, female 3 dorsal setae altogether (F2); ventrodistal margin with 2 elongate setae (M3), female with 4 elongate setae (F2), elongate setae longer than ischium. Ischium of male dorsal margin with 1 simple seta, setae not robust. Ischium of female dorsal margin with 4 simple setae (F2), setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with few elongate simple setae, dorsal surface with setae along dorsal axis (2 robust 1 tiny); female distodorsal margin with numerous elongate simple setae, female dorsal surface with setae along dorsal axis (4 simple). Propodus length: pereopod length 0.22 male (M3), 0.18 female (F2). Propodus length:width 1.10 male (M3), 1.30 female (F2). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 3 setae altogether (excluding distal group) (M3), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae proximally on margin articulated, grading distally to articulation not expressed, 24–30 altogether. Propodal palm of female margin straight, stout denticulate setae serrate, 12 altogether (F2), with stout robust conical setae, 5 altogether (F2). Dactylus of male length subequal to palm, length:palm length 1.04 (M3), female length subequal to palm, female length:palm length 0.98 (F2). Dactylus of female ventrodistal margin distal cuticular fringe length 0.70 total length (F2). Dactylus claw length:dactylus length 0.09 male (M3), 0.17 female (F2). Dactylus of male positioned ventrally, 0.41–0.45 (F2, M3) length of primary claw.

Pereopods II–III ratios. *Pereopod II.* Length:body length 0.29 male (M3), 0.31 female (F2). Basis length: pereopod length 0.29 male (M3), 0.31 female (F2); length:width 2.30 male (M3), 2.40 female (F2). Carpus length: pereopod length 0.12 male (M3), 0.13 female (F2); length:width 1.50 male (M3), 1.60 female (F2). Propodus length:pereopod length 0.17 male (M3), 0.16 female (F2); length:width 2.80 male (M3), 2.30 female (F2). Dactylus length:propodus length 0.56 male (M3), 0.63 female (F2); primary claw length:dactylar length 0.18 male (M3), 0.28 female (F2). *Pereopod III.* Length:body length 0.25 male (M3), 0.32 female (F2). Basis length:pereopod length 0.29 male (M3), 0.28 female (F2); length:width 2.50 male (M3), 2.20 female (F2). Carpus length:pereopod length 0.11 male (M3), 0.11 female (F2); length:width 1.40 male (M3), 1.40 female (F2). Propodus length:pereopod length 0.16 male (M3), 0.15 female (F2); length:width 2.40 male (M3), 2.80 female (F2). Dactylus length:propodus length 0.64 male (M3); primary claw length:dactylar length 0.23 male (M3). *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, propodus.; basis dorsal ridge with elongate setae forming 2 rows on proximal projection, rest of ridge with no setae or several elongate simple setae. Ischium II–IV of male dorsal margin with 7–8 simple setae (M2 pereopod IV, M2 pereopod II), none robust. Dactylus ventral to primary claw, 0.36–0.37 length of primary claw, with scales on ventral margin (F only); 8 altogether (F2 pereopod II).

Pereopod II. Basis lateral face with 4 simple setae along margin. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 1–2–3 minor setae, submarginal setal row with 1–3–5 setae, without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 1–3–5 minor setae, submarginal setal row with 1–3–5 setae, with major setae distally, with 0–0–3 major setae distal to epaulet.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 9 setae (M3), dorsal ridge setae positioned proximally, of female dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 7 setae (M3). Carpus of male ventral margin with simple setae only. Propodus of male distal width 0.71 maximum width (M3), setae on ventral margin robust-based, 2 distinctly larger than remainder, longer than dactylar claw. Dactylus of male distal accessory claw approximately 0.5 primary claw length. *Pereopod IV ratios.* Length:body length 0.25 male (M3), 0.29 female (F2). Basis length:width 2.50 male (M3), 2.40 female (F2). Carpus length:

pereopod length 0.11 male (M3), 0.12 female (F2). Propodus length:pereopod length 0.16 male (M3), 0.16 female (F2). Propodus length:width 2.20 male (M3), 2.50 female (F2).

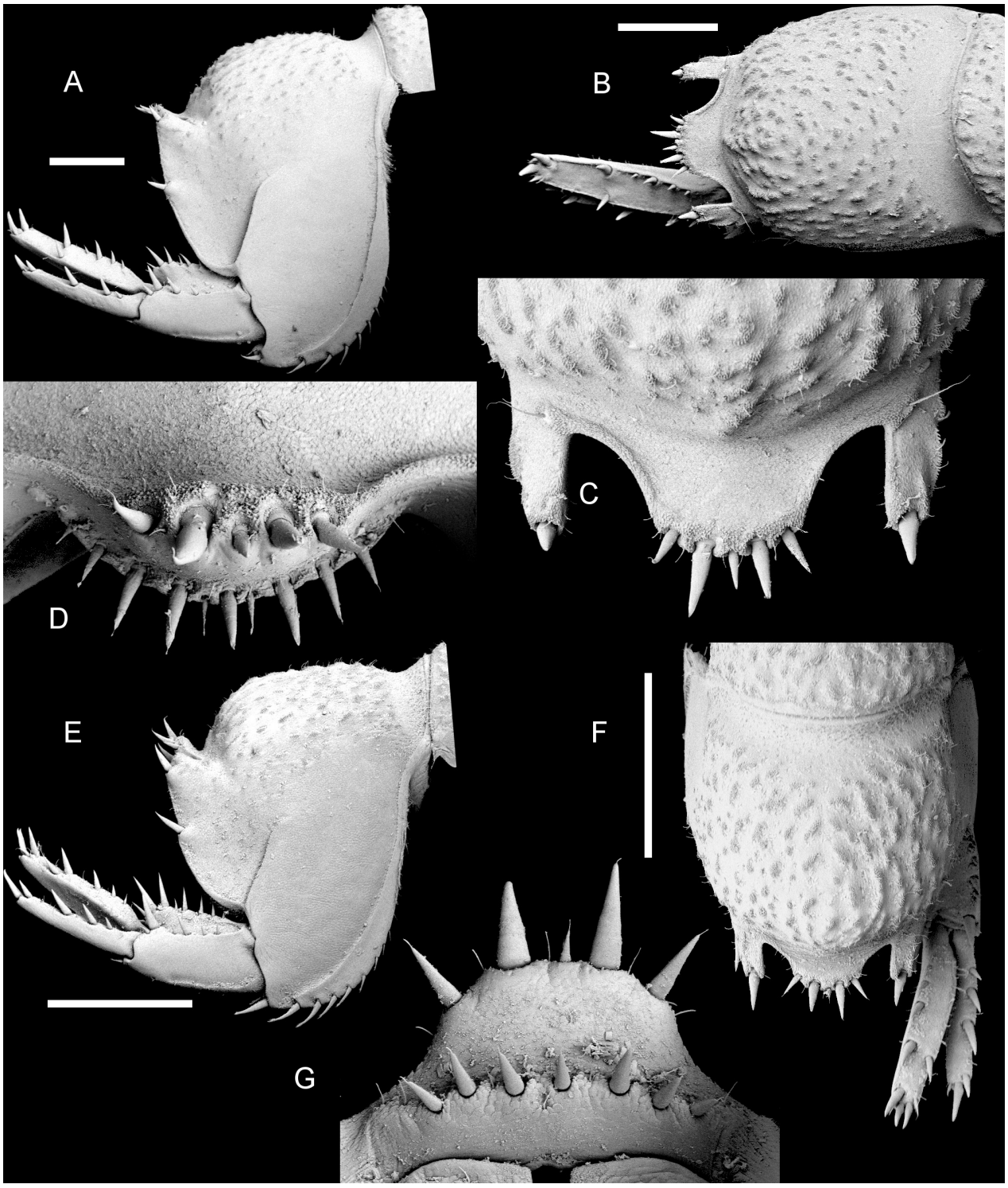

FIGURE 141. *Eophreatoicus nawurlandja* sp. nov., pleotelson. Paratype male, AM P.76443: A, lateral; B, dorsal; C, pleotelson apex, dorsal; D, pleotelson apex and posteroventral setal row, posterior. Paratype female, AM P.76442: E, lateral; F, dorsal; G, pleotelson apex and posteroventral setal row, ventral. Scales 1 mm.

Pereopods V–VII ratios. Pereopod V. Length:body length 0.27 male (M3), 0.31 female (F2). Basis length:width 0.98 male (M3), 1.30 female (F2). Carpus length:pereopod length 0.17 male (M3), 0.15 female (F2). Propodus length:pereopod length 0.18 male (M3), 0.16 female (F2). Dactylus claw length:dactylar length 0.27 male (M3). *Pereopod VI.* Length:body length 0.38 male (M3), 0.40 female (F2). Basis length:width 1.20 male (M3), 1.30

female (F2). Carpus length:pereopod length 0.16 female (F2). Propodus length:pereopod length 0.18 male (M3), 0.18 female (F2). *Pereopod VII.* Length:body length 0.37 male (M3), 0.41 female (F2). Basis length:width 1.40 male (M3), 1.50 female (F2). Carpus length:pereopod length 0.11 male (M3), 0.16 female (F2). Propodus length: pereopod length 0.18 male (M3), 0.18 female (F2). Dactylus claw length:dactylar length 0.22 male (M3).

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 5–7 setae (M3, pereopod V,VII). Propodus distal margins with 5–7 elongate robust or robust-based setae (M3). Dactylus accessory claw 0.29 dorsal claw length (M3 pereopod VII). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with 1 seta, dorsal margin with 7 setae (M3).

Penes. With cuticular hairs on shaft; distally tapering; distal tip truncate.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 1.70 endopod proximal margin length; distally with 11 setae; 66 setae altogether (M3).

Uropod. Of male total length 1.00 pleotelson length (M3); protopod of male length 0.36 uropod total length (M3). Uropod of female total length 1.00 pleotelson length (F2), protopod length 0.44 uropod total length (F2). Protopod dorsomedial ridge length:endopod length 0.55 male (M3), 0.80 female. Protopod of male dorsolateral margin longer than dorsomedial margin setae; of female dorsolateral margin subequal to dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, with spinose setae, 2 robust spinose setae (F2), 1–3 robust simple setae (F, M). Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 9 altogether (M3); female dorsal margin with 8 robust setae (F2). Exopod length:endopod length 0.77 male (M3), 0.83 female (F2). Exopod length:protopod length 0.96 male, 0.97 female. Exopod of male dorsal margin with 5 robust setae (M3), female 5 robust setae (F2).

Distribution. Australia, Northern Territory, Kakadu National Park: streams and caves around Nourlangie Rock, including Gubara Pools (=Burdulba Springs), a tributary of Nourlangie Creek, South Alligator River catchment, and extending to Radon Springs, upper Gulunggul Creek, a tributary of Magela Creek, East Alligator River catchment (see Gulunggul Creek population of this species below).

Habitat. Among roots and leaf litter.

Remarks. Large male *Eophreatoicus nawurlandj*a sp. nov. can be extremely tuberculate, but smaller individuals are much less so. Tubercles are scattered towards the anterior end and posterior end of body and form distinct ridges on pleon. "*Eophreatoicus* sp. 01" and "*E.* sp. Ga" of Wilson *et al.* (2009) are considered the same species, *E. nawurlandja* sp. nov., because the morphological differences between them are minor mostly with only slight differences in measurement or setal counts. Females of the two populations are virtually identical. These two populations are also genetically similar, within a few mtDNA bases (Wilson *et al.* 2009), where "*E.* sp. 01" seems to be a monophyletic subclade of "*E.* sp. Ga" that had more genetic variability. The latter observation is not surprising because "*E.* sp. Ga" was collected from multiple locations. These two populations have the smallest genetic (uncorrected p) distance (0.007; Appendix 3). The Nourlangie population of *E. nawurlandja* sp. nov. is genetically identical (p-distance=0) with *E. kurrih* sp. nov., owing to introgression, a hypothesis supported by their separation in the morphological cladogram. Further corroboration of this species identification could require multiple nuclear DNA sequences from these three sites, as well as finding the dry season concentrations of each population.

Eophreatoicus nawurlandja sp. nov. is also found at Gubara Pools (=Burdulba Springs), while *E. gubara* sp. nov. is found upstream in a forest tributary less than 0.5 km away. An additional site southeast of Koongarra Saddle (12°50.9'S 132°51.73'E, 4.iv.1999, coll. C. Humphrey) had specimens similar to *E. nawurlandja* sp. nov., but differed in a few minor ways, such as some specimens having one more major seta (6 instead of a maximum of 5) on the pereopod II epaulet. An attempt to obtain DNA sequence data from a specimen was unsuccessful. This collection (AM P.76399) has been recorded as a variant item in our DELTA database.

Gulunggul Creek population of *Eophreatoicus nawurlandja* sp. nov.

(Figs 142–147)

Material examined. Australia, Northern Territory, ERISS Gulunggul Ck sites, coll. C. Humphrey, 13.xi.1998. Gulunggul Ck site 1, first south tributary in Radon Springs, 12°45.28'S, 132°54.50'E; Gulunggul Ck site 2, seep

upstream in Radon Springs, 12°45.26'S, 132°55.00'E; Gulunggul Ck site 3, pools in north tributary of Radon Springs, 12°44.72'S, 132°55.46'E; Gulunggul Ck site 4, small seep in north tributary of Radon Springs, 12°44.19'S, 132°55.30'E; Gulunggul Ck site 5, eastern tributary of Gulunggul Ck, 12°44.77'S, 132°54.15'E. Male, bl 18.5 mm, AM P.76277 (exemplar specimen), Gulunggul Ck site 4. Gulunggul Ck site 1, male M (M1), bl ~16 mm, AM P.76266, DNA E44 GenBank COI EU263172 16S EU263244; 15 inds, AM P.76265; Gulunggul Ck site 2, preparatory female, bl ~15 mm, AM P.76268, DNA E46 GenBank COI EU263173 16S EU263245; 13 inds, AM P.76267; Gulunggul Ck site 3, juvenile male, bl ~14 mm, AM P.76270, DNA E47 GenBank COI EU263174 16S EU263246; 33 inds, AM P.76269; Gulunggul Ck site 4, male (M2), bl 19.4 mm, AM P.76278, SEM stubs AW827–831; juvenile male, bl ~14 mm, AM P.76276, DNA E48 GenBank COI EU263175 16S EU263247; preparatory female (F3), bl 16.2 mm, AM P.76279, SEM stubs AW832–835; 63 inds, AM P.76275; variant, AM P.76280; Gulunggul Ck site 5, male, bl ~16 mm, AM P.76272, DNA E49 GenBank COI EU263176 16S EU263248; juvenile male, bl ~14 mm, AM P.76274, DNA E50 (unsuccessful); 12 inds, AM P.76271; 7 inds, AM P.76273. Gubara Pools (= Burdulba Springs), 12°49.6'S, 132°52.733'E, coll. C. Humphrey, 24.x.2008: 2 inds, AM P.97199; 14 inds, AM P.97200; 1 male, AM P.97200, DNA GW101 GenBank 18S MK961119, COI MK995022; 13 inds, AM P.99360.

Differences from type population. *Body* pigmentation medium dark, laterally mottled, dorsally with pair of wide dark irregular bars and thin median line, chromatophores dense; length of largest male 19.4 mm, length of largest preparatory female 16.2 mm. *Head*. Cervical groove in lateral view extending nearly to dorsal margin of head (almost connecting medially). Posterior apex with two pairs of robust setae and one median robust seta (similar size to lateral setae). *Pereopod II.* Basis of male dorsal ridge epaulet length subequal to quarter basis length, main setal row with 5–5–7 major setae. Basis of female dorsal ridge epaulet length subequal to quarter basis length, main setal row with 5–6–7 major setae.

Additional Description. *Head.* Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Dorsal surface pitted; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin straight, orientation of longest axis vertical, maximum diameter 0.24–0.25–0.26 head depth (M1, F3, M2), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view sigmoidal. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

Pereon. Width near head width. Setae on dorsal surface not visible. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–3 in dorsal view respective lengths less than 0.5 pleonite 5 length, pleonite 4 length more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.30–1.40 pleonite 1 (M1, F3), 1.80–1.90 pleonite 2 (M1, F3), 2.00–2.10 pleonite 3 (M1, F3), 2.00–2.10 pleonite 4 (M1, F3), 1.70–2.00 pleonite 5 (M1, F3).

Pleotelson. Dorsal surface length 0.90–1.10 width in dorsal view (M2, F3). Dorsal surface sparsely covered with setae; lacking cuticular combs on tubercles. Depth 1.40–1.50 pereonite 7 depth (M1, F3). Lateral length less than depth, in male 0.74–0.75 depth (M2, M1), in female 0.74 depth. Lateral length 0.13–0.14–0.15 body length (F3, M2, M1). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.50–1.70 width of uropodal insertion (M2, F3), with one row of distally denticulate robust setae, including 12 robust setae altogether (M2, F3), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.10–0.11 pleotelson total length (F3, M2). Posterior apex length less than width, long. Posterior apex 0.18–0.22 pleotelson total length (F3, M2), width 0.52 pleotelson width (M2, F3). Posterior apex in lateral view forming an angle of 63–81–87° with immediately anterior dorsal surface (M1, M2, F3), angled 121–142–143° from horizontal (M1, F3, M2).

Antennula. Length 0.12 body length in male (M2), 0.12 body length in female (F3), with 17 articles in male (M2), with 15 articles in female (F3). Article 5 length 0.60–0.69 width (M2, F3). Article 6 length 0.78–0.80 width (M2, F3). Aesthetascs small (1–3) mostly on distomedial margins. Terminal article length 0.81 width, 0.01–0.02 antennula total length (M2, F3). Distal articles oval in cross-section.

Antenna. Length 0.49 body length in male (M2), 0.41 body length in female (F3). Flagellum length 0.64 total antenna length in male (M2), 0.58 total antenna length in female (F3), with 33 articles in male (M2), with 24 articles in female (F3), proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Mouthfield. Clypeus width 0.35 head width (F3).

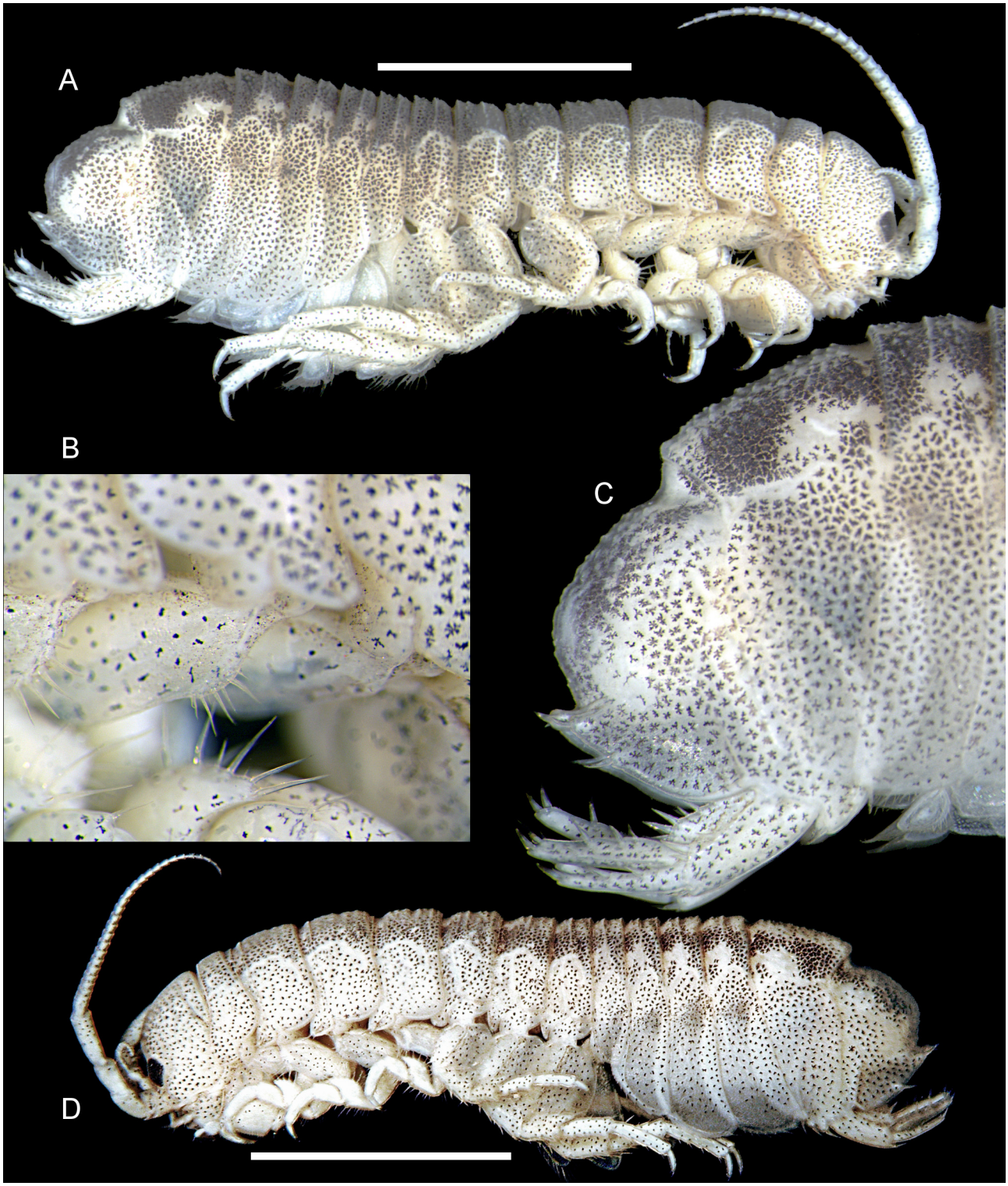

FIGURE 142. *Eophreatoicus nawurlandja* sp. nov. (Gulunggul Creek population), habitus. Male, AM P.76277: A, lateral; B, pereopod II basis epaulet setation; C, posterior pleonites and pleotelson. D, female, AM P.76269, lateral. Scales 5 mm

Mandible. Palp article 3 medial surface without additional setae, without setules, surface lacking cuticular hairs.

Maxilliped. Epipod distal tip rounded, length 1.90 width (F3). Endite distal margin in fringe. Palp length 1.30 basis length (F3). Palp article 4 shape elongate-oval, length 2.30 width (F3). Palp article 5 length 3.30 width (F3), 0.92 article 4 length (F3).

Pereopod I. Length:body length 0.35 male (M2), 0.30 female (F3). Basis of male length 2.20 width (M2),

female length 2.40 width (F3); dorsal setae positioned proximally, 5 dorsal setae altogether (M2); female dorsal setae positioned proximally, female 4 dorsal setae altogether (2 distally 4 proximally); ventrodistal margin with 1 elongate seta, female with 1 elongate seta, elongate setae longer than ischium. Ischium of male dorsal margin with 1 simple seta, setae not robust. Ischium of female dorsal margin with 3 simple setae (F3), setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (1 robust); female distodorsal margin with numerous elongate simple setae, female dorsal surface with setae along dorsal axis (3 simple decreasing in size proximally). Propodus length:pereopod length 0.22 male (M2), 0.20 female (F3). Propodus length:width 1.10 male (M2), 1.50 female (F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 3 setae altogether (excluding distal group) (M2), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae proximally on margin articulated, grading distally to articulation not expressed, 28 altogether (M2). Propodal palm of female margin straight, stout denticulate setae serrate, 13 altogether (F3), with stout robust conical setae, 6 altogether (F3, 2 distally 4 proximally). Dactylus of male length subequal to palm, length:palm length 0.99 (M2), female length subequal to palm, female length:palm length 0.98 (F3). Dactylus of female ventrodistal margin distal cuticular fringe length 0.74 total length (F3). Dactylus claw length:dactylus length 0.12 male (M2), 0.16 female (F3). Dactylus of male positioned ventrally, 0.39–0.43 (M2, F3) length of primary claw.

Pereopods II–III ratios. *Pereopod II*. Length:body length 0.32 male (M2), 0.31 female (F3). Basis length: pereopod length 0.29 male (M2), 0.30 female (F3); length:width 2.20 male (M2), 2.20 female (F3). Carpus length: pereopod length 0.12 male (M2), 0.13 female (F3); length:width 1.40 male (M2), 1.60 female (F3). Propodus length:pereopod length 0.16 male (M2), 0.16 female (F3); length:width 2.50 male (M2), 2.60 female (F3). Dactylus length:propodus length 0.61 male (M2), 0.60 female (F3); primary claw length:dactylar length 0.27 male (M2), 0.27 female (F3). *Pereopod III*. Length:body length 0.31 male (M1, M2), 0.29 female (F3). Basis length:pereopod length 0.28–0.31 male (M1, M2); length:width 2.20–2.30 male (M1, M2). Carpus length:pereopod length 0.11 male (M1, M2), 0.11 female (F3); length:width 1.40–1.50 male (M2, M1), 1.60 female (F3). Propodus length:pereopod length 0.15–0.16 male (M1, M2), 0.16 female (F3); length:width 2.60–2.70 male (M1, M2), 3.10 female (F3). Dactylus length:propodus length 0.51–0.62 male (M2, M1), 0.49 female (F3). *Pereopods II–III*. Penicillate setae scattered on dorsal ridge of basis, carpus, propodus. Ischium II–IV of male dorsal margin with 7 simple setae (M2 pereopod II), none robust. Dactylus ventral to primary claw, 0.30–0.37 length of primary claw, with scales on ventral margin (F3, M2); 11 altogether (F3 pereopod II, approx).

Pereopod II. Basis lateral face with 6 short simple setae along margin in male and with 7 long simple setae along margin in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 0–2–4 minor setae, submarginal setal row with 0–4–6 setae, without major setae distal to epaulet (a single specimen has 1 seta, out of 27 specimens). Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 0–3–5 minor setae, submarginal setal row with 3–6 setae (4.5), with major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 9 setae (M2), dorsal ridge setae positioned proximally, of female dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 7 setae (M2). Carpus of male ventral margin with simple setae only. Propodus of male distal width 0.70 maximum width (M2), setae on ventral margin robust-based, 2 distinctly larger than remainder, longer than dactylar claw (M2,1.1 dactylar claw). Dactylus of male distal accessory claw approximately 0.5 primary claw length. *Pereopod IV ratios*. Length:body length 0.27 male (M2), 0.26 female (F3). Basis length:width 2.40 male (M2). Carpus length: pereopod length 0.12 male (M2), 0.12 female (F3). Propodus length:pereopod length 0.15 male (M2), 0.16 female (F3). Propodus length:width 2.10 male (M2), 2.90 female (F3).

Pereopods V–VII ratios. *Pereopod V*. Length:body length 0.28–0.30 male (M2, M1), 0.25 female (F3). Basis length:width 1.20 male (M1, M2), 1.10 female (F3). Carpus length:pereopod length 0.16 male (M1, M2), 0.17 female (F3). Propodus length:pereopod length 0.16–0.17 male (M1, M2), 0.19 female (F3). Dactylus claw length: dactylar length 0.29 male (M2). *Pereopod VI*. Length:body length 0.41 male (M1, M2), 0.36 female (F3). Basis length:width 1.20 male (M1, M2). Carpus length:pereopod length 0.14–0.16 male (M2, M1), 0.16 female (F3). Propodus length:pereopod length 0.18–0.19 male (M1, M2), 0.20 female (F3). *Pereopod VII*. Length:body length

0.41–0.42 male (M2, M1), 0.38 female (F3). Basis length:width 1.40 male (M2). Carpus length:pereopod length 0.16–0.18 male (M1), 0.18 female (F3). Propodus length:pereopod length 0.18 male (M1, M2), 0.20 female (F3). Dactylus claw length:dactylar length 0.25 male (M2).

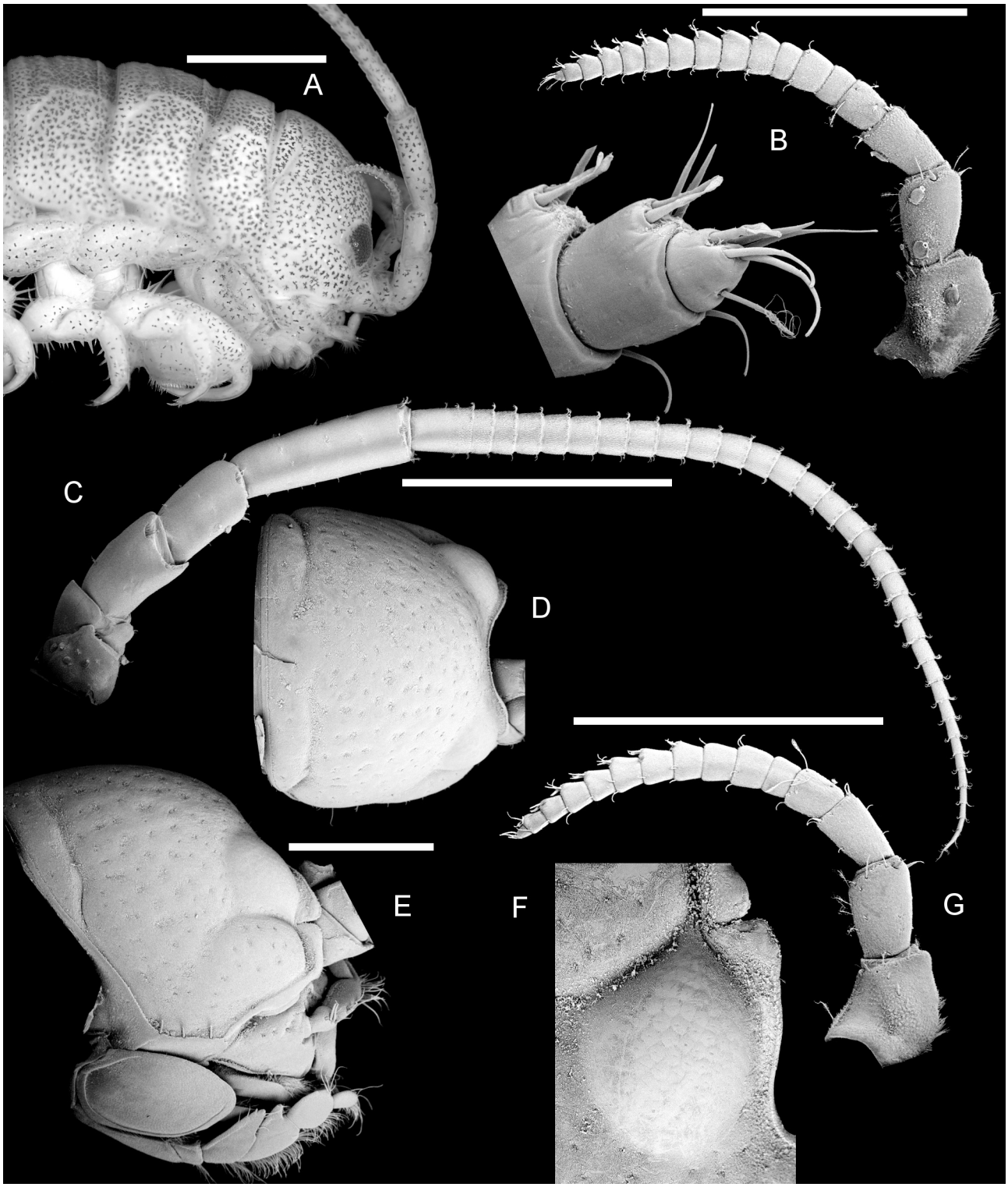

FIGURE 143. *Eophreatoicus nawurlandja* sp. nov. (Gulunggul Creek population), head and antennae. Male, AM P.76277: A, head, lateral. Male, AM P.76278: B, antennula with enlargement of distal tip, C, antenna. Female, AM P.76269: D–E, head dorsal and lateral; F, eye enlargement; G, antennula. Scales A, 2 mm; B–E, 1 mm.

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 5–8 setae (M2 pereopod V, pereopod VII). Propodus distal

margins with 4–5 elongate robust or robust-based setae (M2 pereopod VII, pereopod V). Dactylus accessory claw 0.24–0.30 primary claw length (M2 pereopod V, pereopod VII). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with 1 seta (M2), dorsal margin with 8 setae (M2).

Penes. With cuticular hairs on shaft; distally tapering; distal tip truncate.

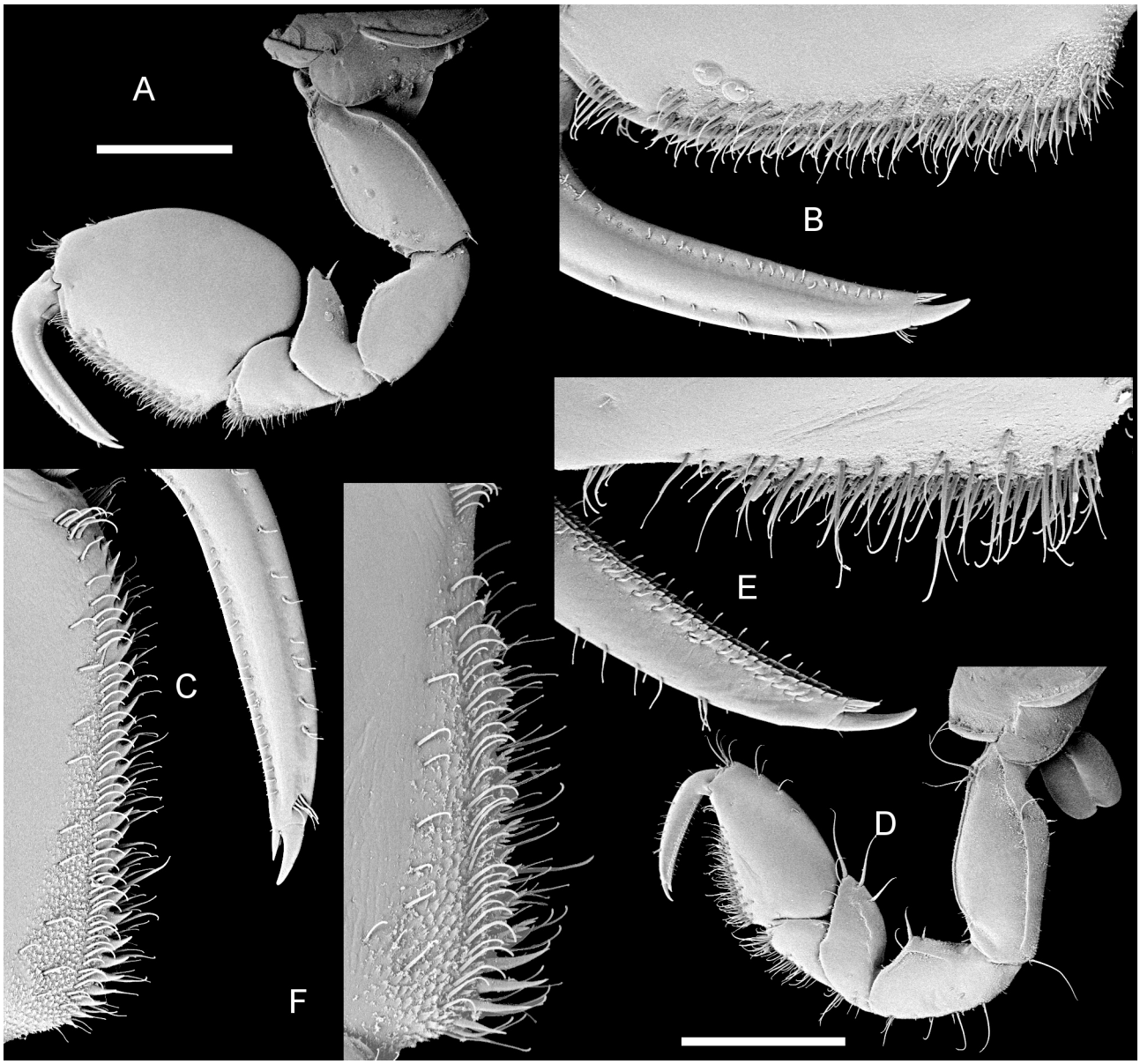

FIGURE 144. *Eophreatoicus nawurlandja* sp. nov. (Gulunggul Creek population), pereopod I. Male, AM P.76277: A, lateral; B, palm and dactylus, lateral; C, palm and dactylus, medial. Female, AM P.76279: D, pereopod I lateral; E, palm and dactylus, lateral; F, palm, medial. Scales A, D, 1 mm.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 1.80 endopod proximal margin length; distally with 12 setae (5 setae missing in SEM); 67 setae altogether (M2).

Uropod. Of male total length 0.99–1.10 pleotelson length (M1, M2); protopod of male length 0.46–0.48 uropod total length (M2, M1). Uropod of female total length 0.93 pleotelson length (F3), protopod length 0.47 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.43–0.54 male (M1, M2), 0.70 female (F3). Protopod of male dorsolateral margin shorter than dorsomedial margin setae; of female dorsolateral margin shorter than dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, with spinose setae, 2–3 robust spinose setae (M2, F3), 1 robust simple seta. Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 10 altogether (M2); female

dorsal margin with 8 robust setae (F3). Exopod length:endopod length 0.81–0.82 male (M2, M1), 0.81 female (F3). Exopod of male dorsal margin with 6 robust setae (M2), female 5 robust setae (F3).

Distribution. Australia, Northern Territory, Kakadu National Park, from Radon Springs (upper Gulunggul Creek), Magela Creek and East Alligator River catchments, to Gubara Pools (=Burdulba Springs), Nourlangie Creek and South Alligator River catchments.

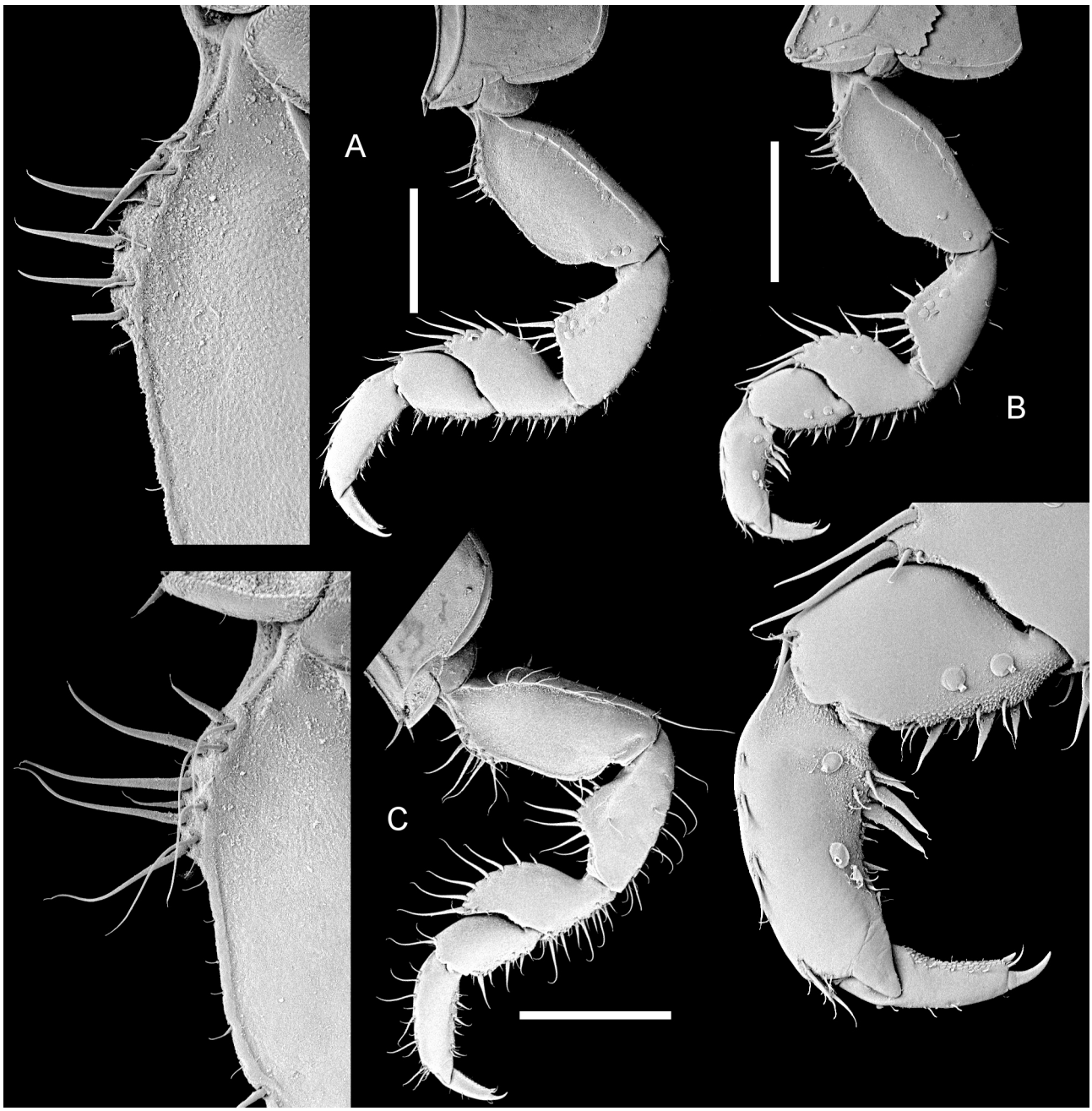

FIGURE 145. *Eophreatoicus nawurlandja* sp. nov. (Gulunggul Creek population), anterior pereopods. Male, AM P.76278: A, pereopod II with enlargement of epaulet; B, pereopod IV with enlargement of distal segments. C, pereopod II, female, AM P.76279, with enlargement of epaulet. Scales 1 mm.

Habitat. Among roots and leaf litter along margin of creek or pool. Water temperature range 22.1–29.3°C.

Remarks. This population of *Eophreatoicus nawurlandja* sp. nov. occurs with another species, *E. galunggul* sp. nov., but can be separated in samples by a distinctly striped dorsal surface and smaller eyes. This population was originally separated from the specimens at the type locality around Nourlangie Rock owing to a few differences in males, such as setation of the pereopod II basis epaulet and the size of the median seta on the pleotelson apex but most other characters are identical or are minor differences in measurements. Additionally, Wilson *et al.* (2009) found that the two species were not distinct genetically, so this population is considered to be conspecific with *E.*

nawurlandja sp. nov. The two localities are separated by a linear distance of 16 km and as much as 25 km if the streams are followed. The watershed from Gulunggul Creek to Nourlangie must have higher connectivity than among the other sites, at least for this species; most other species described here have restricted distributions (see remarks for *E. balbun* sp. nov.). *Eophreatoicus kurrih* sp. nov. at Blue Tongue Dreaming is found much closer to this population of *E. nawurlandja* sp. nov., but is genetically identical to the Nourlangie population in its mtDNA. *Eophreatoicus kurrih* sp. nov., however, is morphologically distinct and is treated here as a separate species (see remarks for the Nourlangie population and discussion of spp. 05 and 01 in Wilson *et al.* 2009).

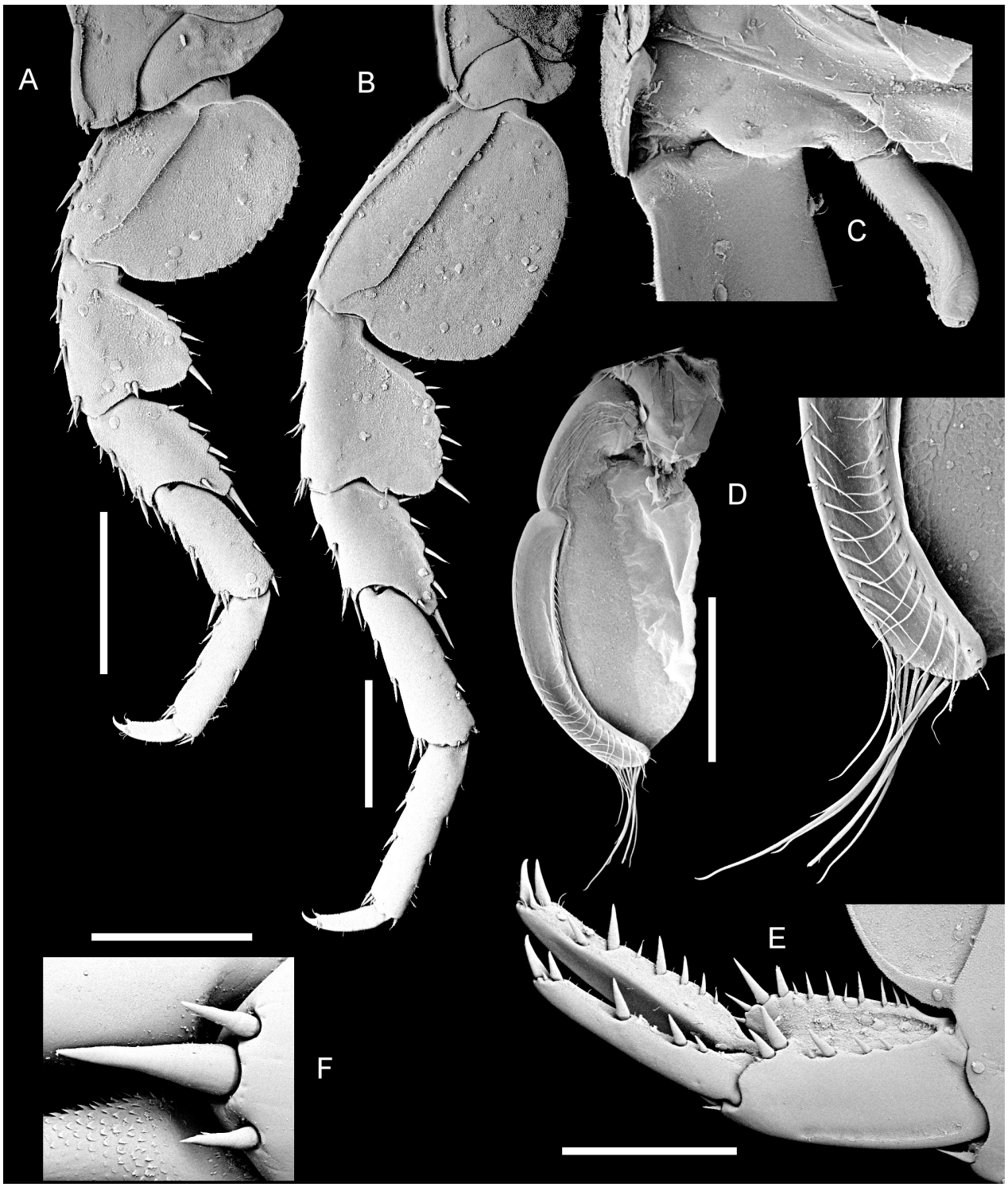

FIGURE 146. *Eophreatoicus nawurlandja* sp. nov. (Gulunggul Creek population), male, AM P.76278, posterior limbs. A, pereopod V. B–C, pereopod VII and pene. D, pleopod II appendix masculina with enlargement of distal tip. E–F, uropod lateral, in situ, with enlargement of protopod posterodistal setae. Scales 1 mm except for F, 0.2 mm.

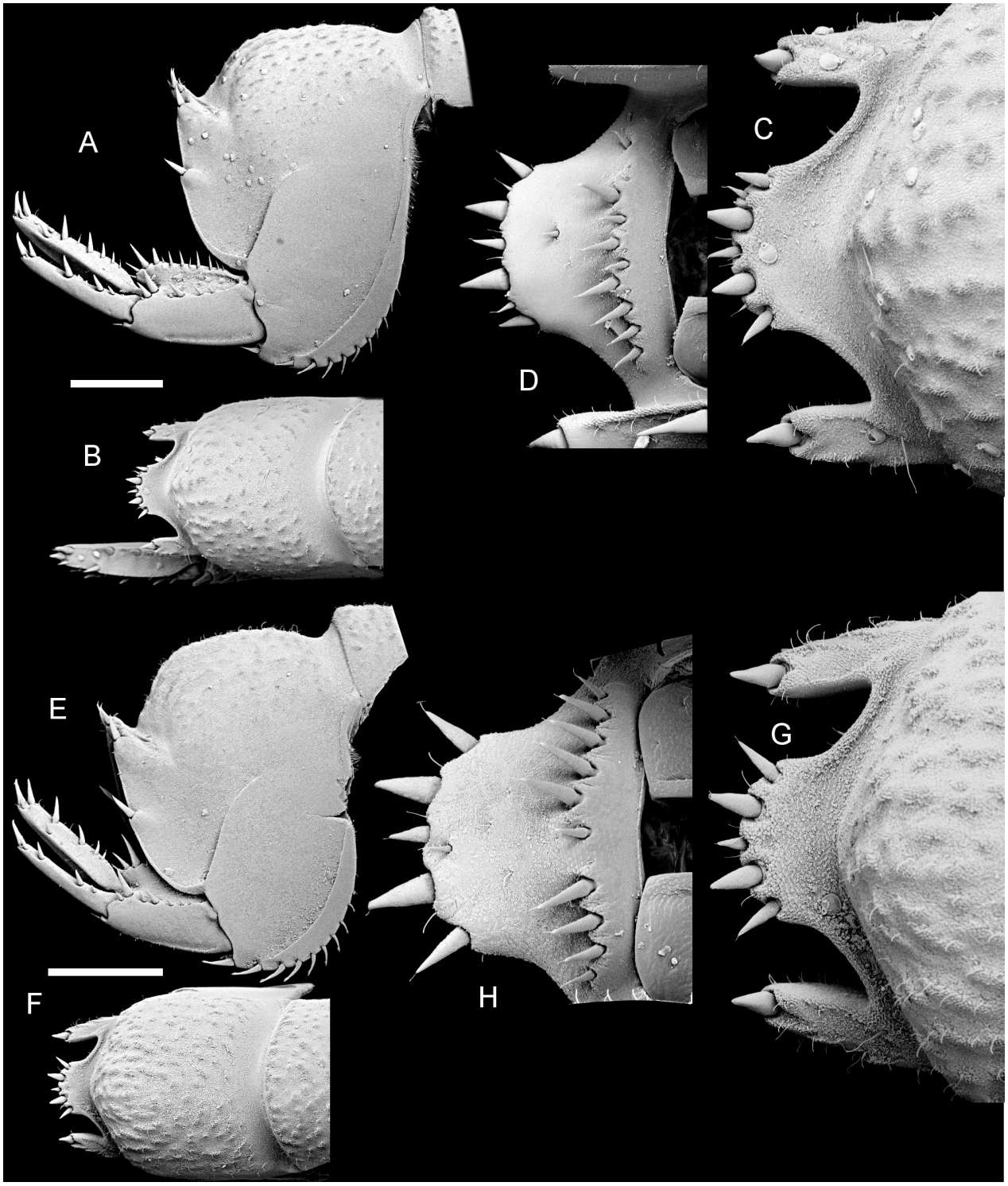

FIGURE 147. *Eophreatoicus nawurlandja* sp. nov. (Gulunggul Creek population), pleotelson. Male, AM P.76278: A–B, lateral and dorsal; C, apex dorsal; D, apex and postanal spine row, ventral. Female, AM P.76279: E–F, lateral and dorsal; G, apex dorsal; H, apex and postanal spine row, ventral. Scales A–B, E–F, 1 mm.

Eophreatoicus korokoro **sp. nov.**

(Figs 148–152)

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Eophreatoicus sp. "02".—Wilson *et al.*, 2009: 361.

Type material. Holotype male, bl 16.8 mm, AM P.74598, SEM stub AW737. Paratypes collected with holotype: female, AM P.74596, DNA E37 GenBank COI EU263142 16S EU263211; brooding female (F2), bl 13.5 mm, AM P.74597, DNA E88 GenBank COI EU263143 16S EU263212, SEM stubs AW738–741; 6 inds, AM P.74595.

Type locality. Australia, Northern Territory, Arnhem Land, upper Magela Creek, 12°46.20'S, 133°04.80'E, coll. K. McAlpine & L. Thurtell, 17.ix.1998.

Etymology. "Korokoro" is a name for the upper Magela Creek near where this species was collected. It is a long stretch of water that non-Aboriginal people call "Bowerbird", located upstream of a helicopter landing site. The "ko" sounds like Australian English "gore" (rhymes with poor) and "ro" sounds like English "raw".

Diagnosis. *Head.* Eyes bulging dorsolaterally, height medium, in lateral view subequal to width of basal antennal articles, height greater than length in lateral view, bulging in dorsal view, projecting from head in distinct arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface with undulating or dimpled surface; pereonites 1–4 transverse dorsal ridges rounded, expressed as transverse trough only; pereonites 5–7 transverse dorsal ridges carinate with transverse trough. *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection concave. Dorsal surface rugose, with rounded tubercles, lacking posteromedial ridges or median groups of tubercles. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with one pair of robust setae and one median robust seta or with two pairs of robust setae (mature females with only 3 setae), without fine setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length less than quarter length of basis, main setal row with 2 major setae (robust). Basis of female dorsal ridge epaulet length less than quarter length of basis, main setal row with 2 major setae (F2). *Pereopod IV.* Propodus of male ventral margin with projection, with 5 robust setae on ventral margin. Dactylus of male length more than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly beyond pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 adjacent robust setae distinctly larger than others.

Description. Body pigmentation medium brown, broad irregular dorsal bar, lighter on pers 1–4, chromatophores spread and diffusely reticulate, margins touching; length of largest male 16.8 mm, length of largest brooding female 13.5 mm.

Head. Length greater than width in dorsal view; lateral profile of dorsal surface smoothly curved. Dorsal surface pitted (shallow pits); setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin concave, orientation of longest axis vertical, maximum diameter 0.24–0.29 head depth (F2, H), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view smoothly curved. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

Pereon. Width near head width. Setae on dorsal surface not visible. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–3 in dorsal view respective lengths less than 0.5 pleonite 5 length, pleonite 4 length more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.10 pleonite 1 (H), 1.40 pleonite 2 (H), 1.60 pleonite 3 (H), 1.60 pleonite 4 (H), 1.40 pleonite 5 (H).

Pleotelson. Dorsal surface length 1.20 width in dorsal view (F2). Dorsal surface sparsely covered with setae. Depth 1.40–1.50 pereonite 7 depth (F2, H). Lateral length less than depth, in male 0.80 depth (H), in female 0.84 depth. Lateral length 0.14–0.15 body length (H, F2). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.30 width of uropodal insertion (F2), with one row of distally denticulate robust setae, including 6 robust setae altogether (F2), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.16 pleotelson total length (F2), dorsal setal position marginal seta larger than submarginal seta. Posterior apex length less than width, long. Posterior apex 0.15 pleotelson total length (F2), width 0.42 pleotelson width (F2). Posterior apex in lateral view forming an angle of 70–97° with immediately anterior dorsal surface (H, F2), angled 141–162° from horizontal (H, F2).

Antennula. Length 0.11 body length in female (F2), with 11 articles in female (F2). Article 5 length 1.30 width (F2). Article 6 length 0.71 width (F2). Aesthetascs small (1–3) mostly on distomedial margins. Terminal article length 0.94 width (F2), 0.03 antennula total length (F2). Distal articles oval in cross-section.

Antenna. Length 0.43 body length in female (F2). Flagellum length 0.60 total antenna length in female (F2), with 35 articles in male (H), with 22 articles in female (F2), proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Mouthfield. Clypeus width 0.38 head width (F2).



FIGURE 148. *Eophreatoicus korokoro* sp. nov., types, lateral. Top, holotype male, AM P.74598. Bottom, paratype female, AM P.74597. Scale 10 mm.

Maxilliped. Epipod distal tip rounded, length 1.40 width (F2). Endite distal margin in fringe. Palp article 4 shape elongate-oval, length 1.10 width (F2). Palp article 5 length 1.60 width (F2), 0.81 article 4 length (F2).

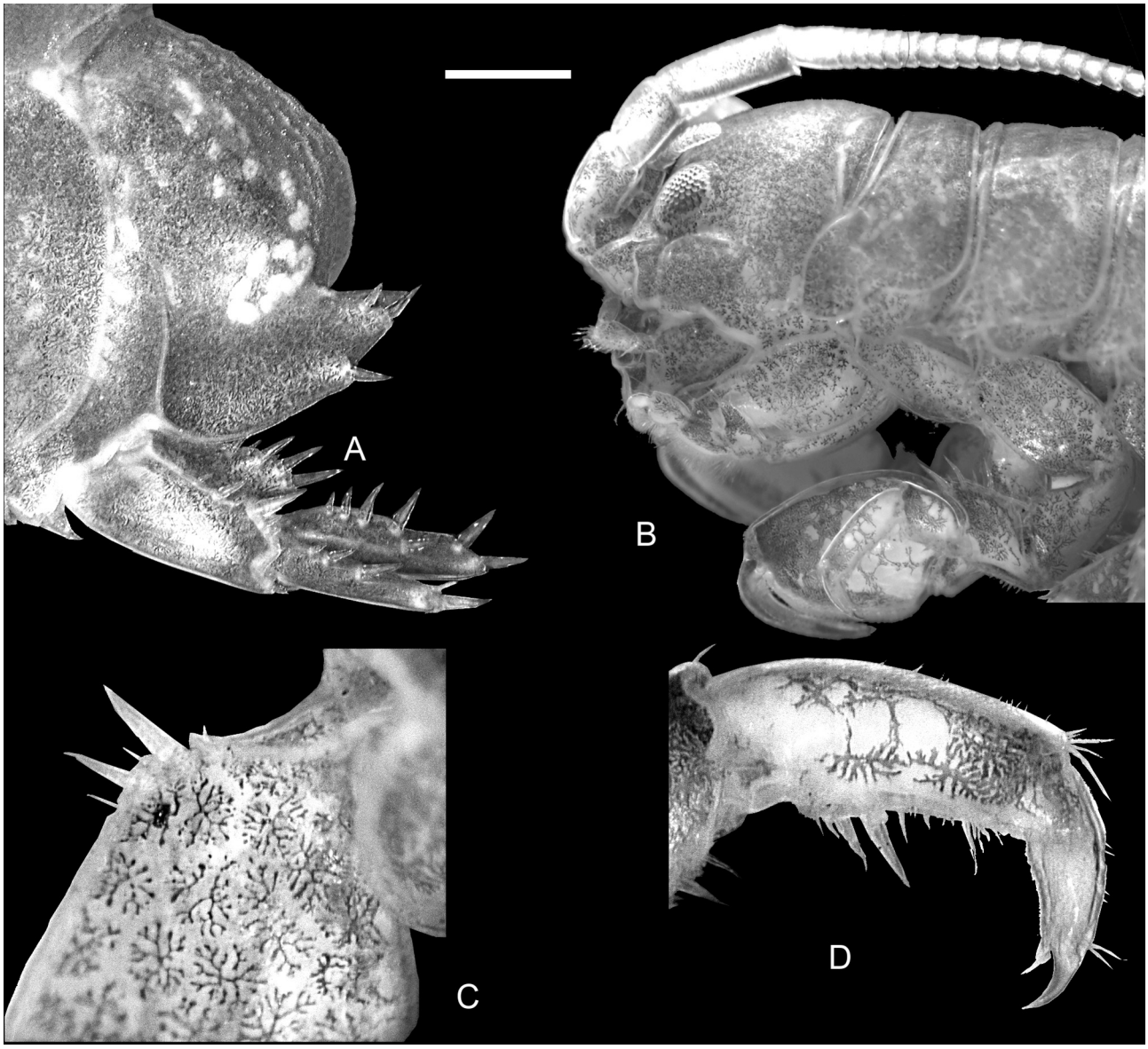

FIGURE 149. *Eophreatoicus korokoro* sp. nov. holotype male, AM P.74598. A, pleotelson. B, head. C, pereopod II basis epaulet. D, pereopod IV distal articles. Scale 1 mm.

Pereopod I. Length:body length 0.34 female (F2). Basis of female length 2.40 width (F2); dorsal setae positioned proximally, 1 dorsal seta altogether (F2); with 1 elongate seta, subequal to ischium. Ischium of female dorsal margin with 2 simple setae (F2), setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (2 heavy simple); female distodorsal margin with numerous elongate simple setae, female dorsal surface with setae along dorsal axis (2 heavy simple). Propodus length:pereopod length 0.20 female (F2). Propodus length:width 1.40 female (F2). Propodus of male dorsal margin setae in several groups between proximal and distal margin, proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin with marginal row of stout robust basally flattened distally curved spine-like setae. Propodal palm of female margin convex, stout denticulate setae serrate, 12 altogether (F2), with stout robust conical setae, 3 altogether (F2). Dactylus of male shorter than palm, length:palm length 0.88, female shorter than palm, female length:palm length 0.86. Dactylus of female ventrodistal margin distal cuticular fringe length 0.68 total length (F2). Dactylus claw length:dactylus length 0.16 female (F2). Dactylus of male large, positioned ventrally, 0.40 length of primary claw.

Pereopods II–III ratios. Pereopod II. Length:body length 0.30 male (H), 0.34 female (F2). Basis length:pereopod

length 0.32 male (H), 0.29 female (F2); length:width 2.10 male (H), 2.10 female (F2). Carpus length:pereopod length 0.11 male (H), 0.12 female (F2); length:width 1.20 male (H), 1.60 female (F2). Propodus length:pereopod length 0.16 male (H), 0.15 female (F2); length:width 2.80 male (H), 2.60 female (F2). Dactylus length:propodus length 0.57 male (H), 0.46 female (F2); 0.34 female (F2). *Pereopod III.* Length:body length 0.32 female. Propodus 2.30 female. Dactylus length:propodus length 0.67 female. *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, propodus.; basis dorsal ridge with Setae forming 2 rows on proximal projection. Dactylus ventral to primary claw, 0.40 length of primary claw, with scales on ventral margin; 8 altogether (F2 pereopod II,approx).

Pereopod II. Basis lateral face with 4 simple setae widely spaced along margin. Basis of male dorsal ridge epaulet without submarginal setal row, main setal row with 2 minor setae, without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 2 minor setae (F2), submarginal setal row with 1 setae, without major setae distally.

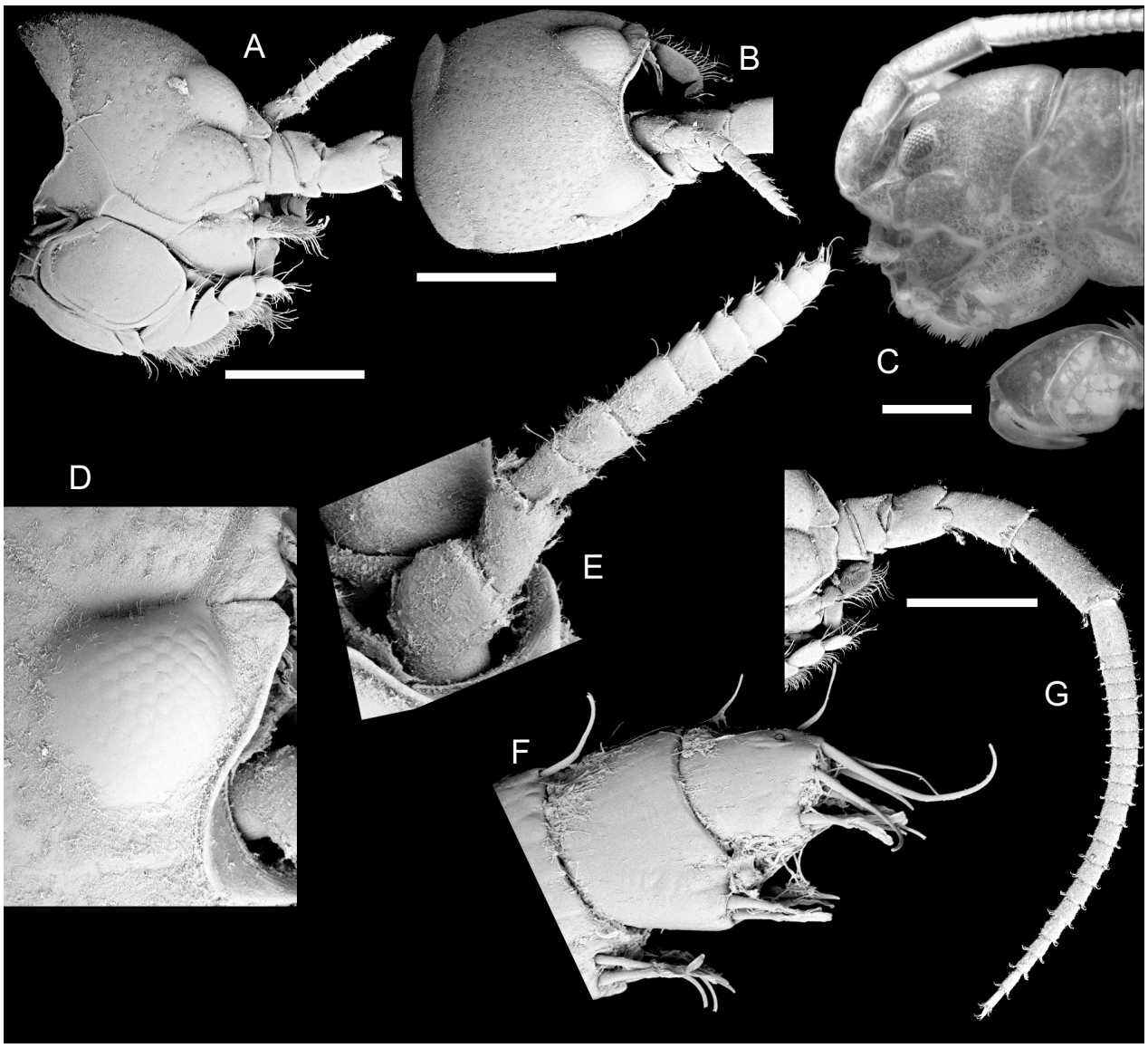

FIGURE 150. *Eophreatoicus korokoro* sp. nov., head and antennae. Paratype female, AM P.74597: A–B head, lateral and dorsal; D, enlargement of eye; E–F, antennula with enlargement of distal tip; G, antenna. Holotype male, AM P.74598: C head, lateral. Scales 1 mm.

Pereopod IV. Penicillate setae in both sexes. Basis of male dorsal ridge setae positioned proximally, of female dorsal ridge setae positioned proximally. Carpus of male ventral margin setae in several groups, with robust-based setae in addition to simple. Carpus of female ventral margin with simple setae. Propodus of male setae on ventral margin robust-based, 2 distinctly larger than remainder, longer than dactylar claw. Dactylus of male distal accessory claw approximately 0.5 primary claw length. *Pereopod IV ratios.* Length:body length 0.27 male (H).

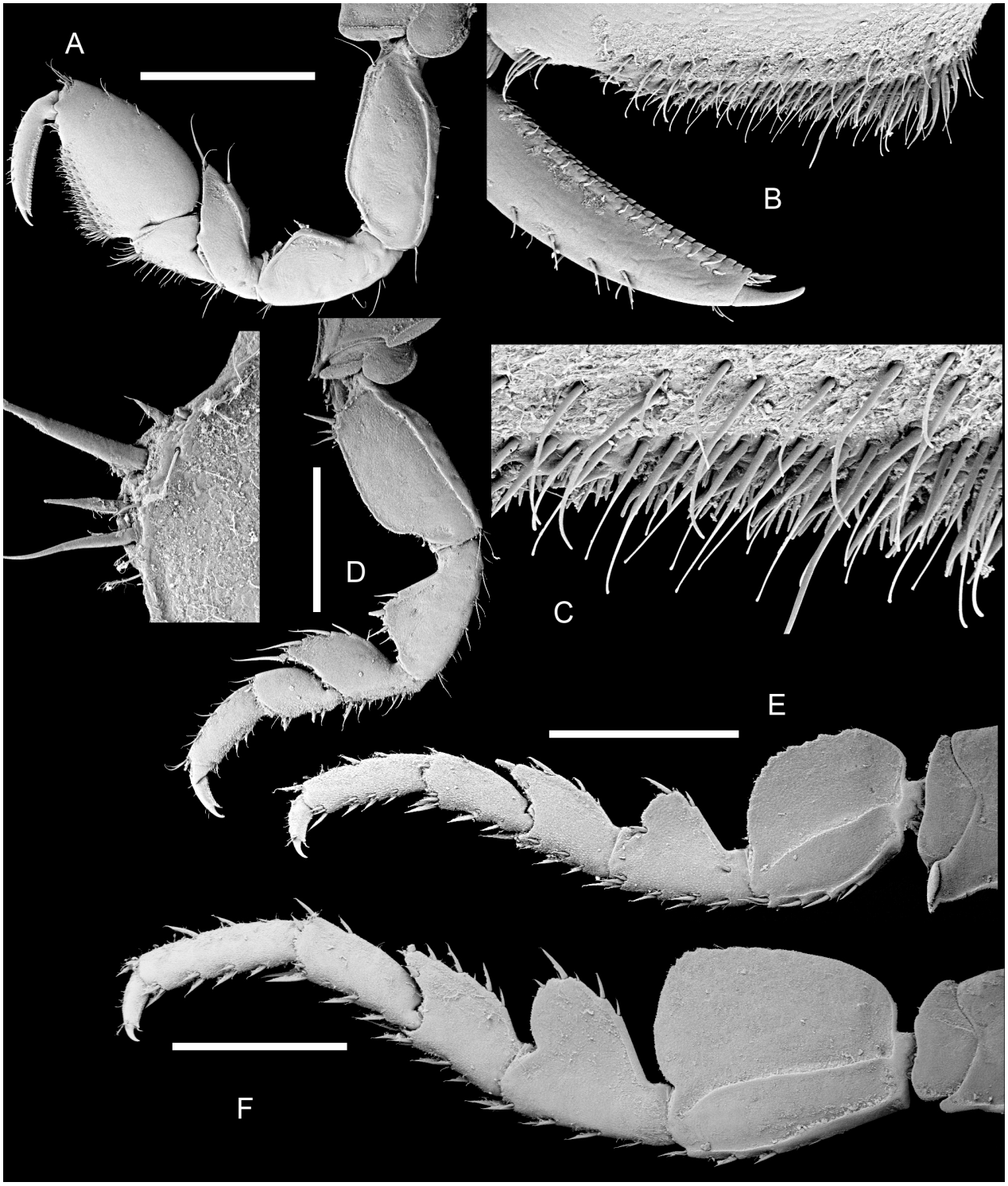

FIGURE 151. *Eophreatoicus korokoro* sp. nov., pereopods, paratype female, AM P.74597. A, pereopod I entire. B–C, palm and dactylus with enlargement of setation. D, pereopod II with enlargement of epaulet. E, pereopod V. F, pereopod VII. Scales 1 mm.

Pereopods V–VII ratios. Pereopod V. Length:body length 0.30 male (H), 0.30 female (F2). Basis length:width 1.30 female (F2). Carpus length:pereopod length 0.16 female (F2). Propodus length:pereopod length 0.16 female (F2). Dactylus claw length:dactylar length 0.39 female (F2). *Pereopod VI.* Length:body length 0.30 female (F2). *Pereopod VII.* Length:body length 0.41 female (F2). Basis length:width 1.20 female (F2). Carpus length:pereopod length 0.15 female (F2). Propodus length:pereopod length 0.17 female (F2). Dactylus claw length:dactylar length 0.29 female (F2).

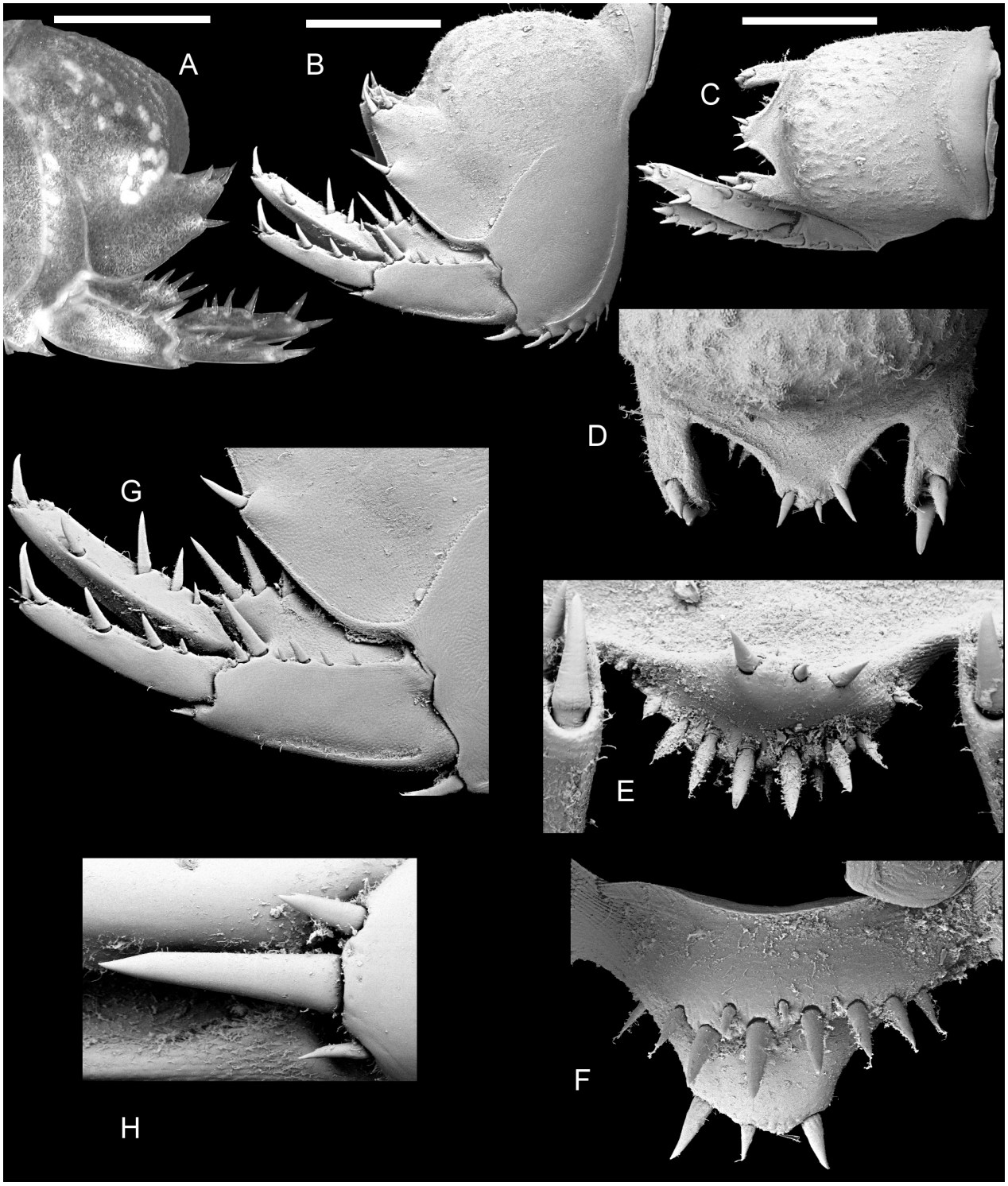

FIGURE 152. *Eophreatoicus korokoro* sp. nov., pleotelson and uropods. A, pleotelson lateral, holotype male, AM P.74598. Paratype female, AM P.74597: B–C, pleotelson lateral and dorsal; D–E, F, pleotelson apex dorsal, posterior and ventral showing postanal ridge setation; G–H, uropod lateral and protopod distoventral setae. Scales 1 mm.

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. Propodus distal margins with 2 elongate robust or robust-based setae (F2 Pereopod V). Dactylus accessory claw 0.28–0.34 dorsal claw length (F2 pereopod VII, F2 pereopod V). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with 1 seta (F2), dorsal margin with 4 setae (F2).

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced; distally with 7 setae (6 setae missing in SEM); 61 setae altogether (H).

Uropod. Of male total length 1.00 pleotelson length (H); protopod of male length 0.48 uropod total length (H). Uropod of female total length 1.00 pleotelson length (F2); protopod length 0.47 uropod total length (F2). Protopod dorsomedial ridge length:endopod length 0.63 male (H), 0.64 female (F2). Protopod of male dorsolateral margin subequal to dorsomedial margin setae; of female dorsolateral margin shorter than dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, with spinose setae (F2), 2 robust spinose setae, 1 robust simple setae. Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 6 altogether (H); female dorsal margin with 5 robust setae (F2). Exopod length:endopod length 0.95 male (H), 0.80 female (F2). Exopod of male dorsal margin with 5 robust setae (H), female 5 robust setae (F2).

Distribution. Australia, Northern Territory, Arnhem Land, upper Magela Creek, East Alligator River catchment.

Habitat. Among roots and leaf litter on the margin of Magela Creek.

Remarks. *Eophreatoicus korokoro* sp. nov. was collected in the upper reaches of Magela Creek, which flows west then northward out of the Arnhem Plateau. This species is part of a moderately supported clade in the morphological analysis that includes *E. kurdabeyhmay* sp. nov. and *E. namarden* sp. nov. The latter, an easily recognized species, will be discussed below but it is readily distinguished from *E. korokoro* sp. nov. by having rows of rounded tubercles on all dorsal surfaces including the head, whereas the other two species lack significant tubercles on the pereon and head. *Eophreatoicus korokoro* sp. nov. differs from the other two species in having the pleotelson postanal ventral surface with 10 setae and the posterolateral pleotelson posterolateral dorsal margin with two setae.

The pleotelson apex in most individuals in this small collection have two pairs of robust setae with the middle pair larger than the lateral pair. Two mature females have an apex with one central robust seta and a lateral pair (Fig. 134). The apex shown in the figure (AM P.74597) appears to be distorted, but S. Keable (pers. com.) reports that a large female (one of six in AM P.74595) has this condition but does not appear damaged as in the figure. Owing to the small collection, we report this species as having both conditions.

Eophreatoicus gubara sp. nov.

(Figs 7C, 8D, 153–160)

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Type material. Holotype male, bl 17.3 mm, AM P.76468. Paratypes collected with holotype: male (M2), bl 21.3 mm, AM P.54099, SEM stubs AW042–050, 079 082; male (M4), bl ~22 mm, AM P.76470; male (M6), bl 25.2 mm, AM P.76472, SEM stubs AW742, 747; 2 males, AM P.55044, SEM stubs AW079 and AW082; 2 females (F3), AM P.55044, SEM stubs AW041–042, AW051–052 and AW061; males and females, AM P.76469, dissected parts in vials; female (F5), bl ~16 mm, AM P.76471; female brooding (F7), bl 17.4 mm, AM P.76473, SEM stubs AW748–751; 746 inds, AM P.76467.

Type locality. Australia, Northern Territory, Kakadu National Park, ~1 km upstream of Gubara Pools near Nourlangie Rock, 12°49.65’ S 132°52.96’ E, coll. G. Wilson, W. Ponder, 15.viii.1994.

Etymology. “Gubara” is from the name of the pools that are near Nourlangie Rock. The name is pronounced “goo-ba-ra”.

Diagnosis. *Head.* Eyes bulging dorsolaterally, height small, in lateral view less than width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface with tubercles and small scales, increasing posteriorly, less so in younger stages; pereonites 1–4 transverse dorsal ridges rounded, expressed as transverse trough only; pereonites 5–7 transverse dorsal ridges carinate with transverse trough. *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection concave. Dorsal surface rugose, with oblong tubercles, lacking posteromedial ridges or median groups of tubercles. Posterior apex in lateral view obscured by posterolateral margin. Posterior

apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae, with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length less than quarter length of basis, main setal row with 3–4 major setae. Basis of female dorsal ridge epaulet length greater than quarter basis length, main setal row with 4 major setae. *Pereopod IV.* Propodus of male ventral margin without projection, with 8 robust setae on ventral margin. Dactylus of male length subequal to propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate subequal to shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge distinctly projecting dorsally with posterior margin exposed above shaft, in lateral view approximately straight; distal margin with 2 adjacent robust setae distinctly larger than others.

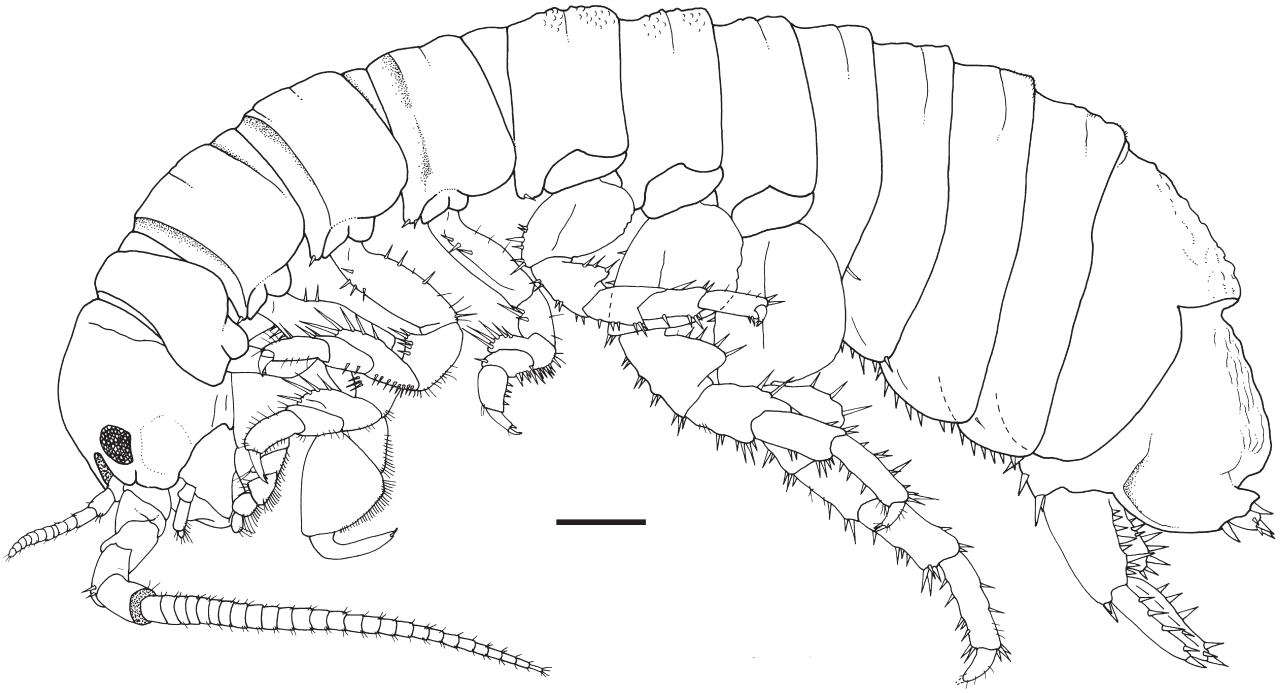

FIGURE 153. *Eophreatoicus gubara* sp. nov., holotype male, line illustration, AM P.76468, lateral, scale 1 mm.

Description. Body pigmentation dark brown dorsal surface with dark brown marbled effect on lateral margins of pereon, pleon and pereopods in ethanol. Dark brown body, dorsally with dark irregular bar, with paired light and central dark spots on anterior margins of pereonites 4–7 and pleonites 1–4; chromatophores large diffuse, touching; length of largest male 26.0 mm, length of largest brooding female 16.1 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved (anteriorly flattened). Width 0.98 pereonite 1 width (M6). Dorsal surface pitted; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin straight, orientation of longest axis vertical, maximum diameter 0.23–0.25–0.27 head depth (F7, H, M6), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view straight. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

Pereon. Width near head width. Setae on dorsal surface scattered, fine, length 0.01–0.03 body depth (tiny). Pereonite 1 length:width ratio in dorsal view 0.29 in male, 0.27 in female. Pereonites 2–7 length:width ratios in male 0.48, 0.56, 0.30, 0.32, 0.38, 0.36; female 0.38, female 0.55, female 0.42, female 0.42, female 0.32, female 0.29. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–4 in dorsal view respective lengths equal to or more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, pleonite 4 length greater than pleonites 1–3, 1–4 width 0.89 composite length in dorsal view. Pleonites 1–5 of male dorsal length:maximum pleonite width ratios: 0.28, 0.28, 0.22, 0.35, 0.60. Pleonites depth:pereonite 7 depth 1.50 pleonite 1, 1.93 pleonite 2, 2.29 pleonite 3, 2.29 pleonite 4, 2.07 pleonite 5.

Pleotelson. Dorsal surface length 0.93 width in dorsal view. Dorsal surface sparsely covered with setae; with cuticular combs on tubercles. Depth 1.86 pereonite 7 depth. Lateral length less than depth, in male 0.83 depth (H,

M2), in female 0.84 depth. Lateral length 0.16 body length. Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.70 width of uropodal insertion, with single row of simple robust setae grading anteriorly to fine setae, including 10 robust setae altogether, posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.17 pleotelson total length. Posterior apex length approximately subequal to width, long. Posterior apex 0.22 pleotelson total length, width 0.59 pleotelson width. Posterior apex in lateral view forming an angle of 55–64° with immediately anterior dorsal surface (M6, F7), angled 132° from horizontal (M6).

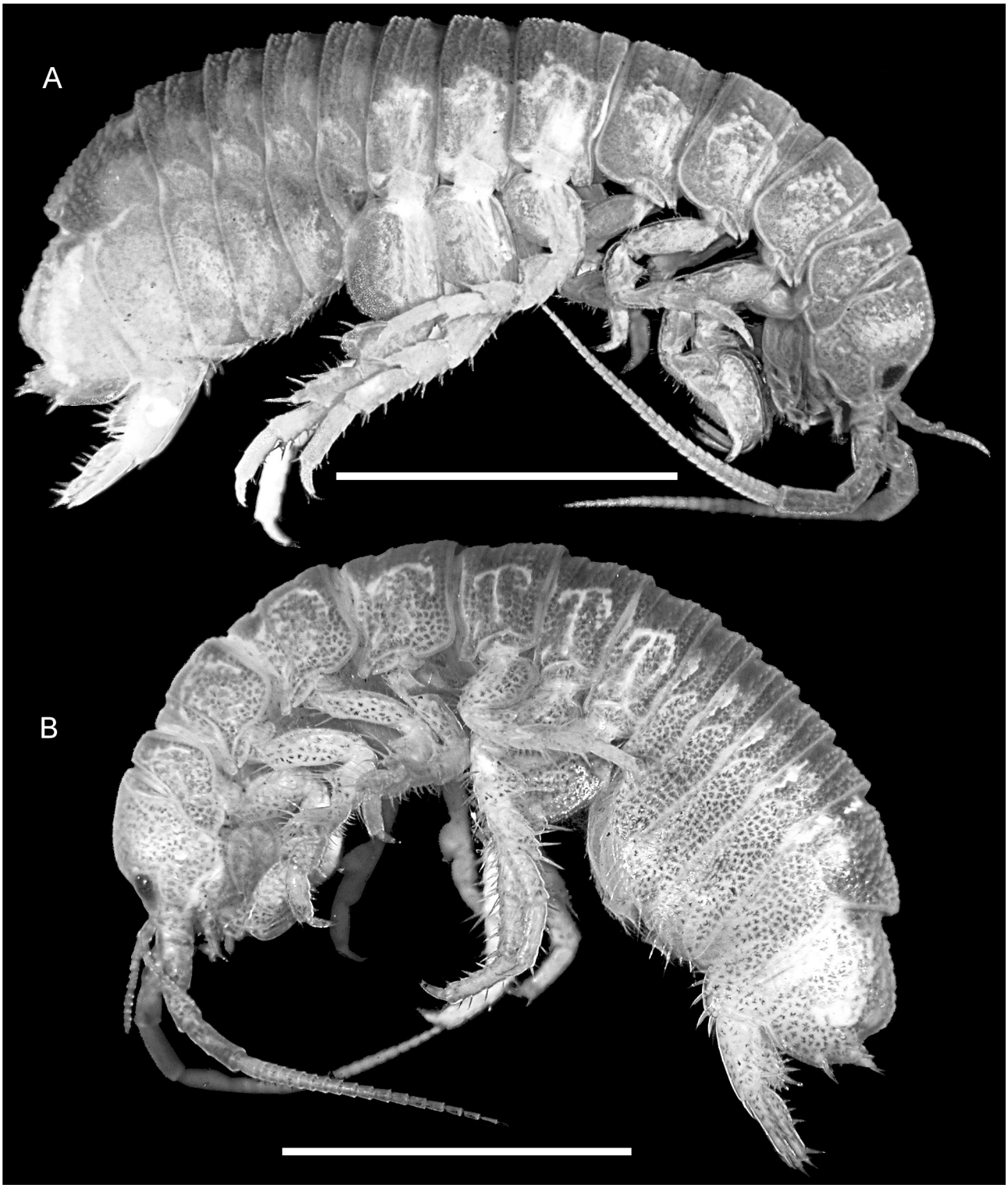

FIGURE 154. *Eophreatoicus gubara* sp. nov., lateral habitus of types. A, holotype male, AM P.76468. B, paratype female, AM P.76473. Scales 5 mm.

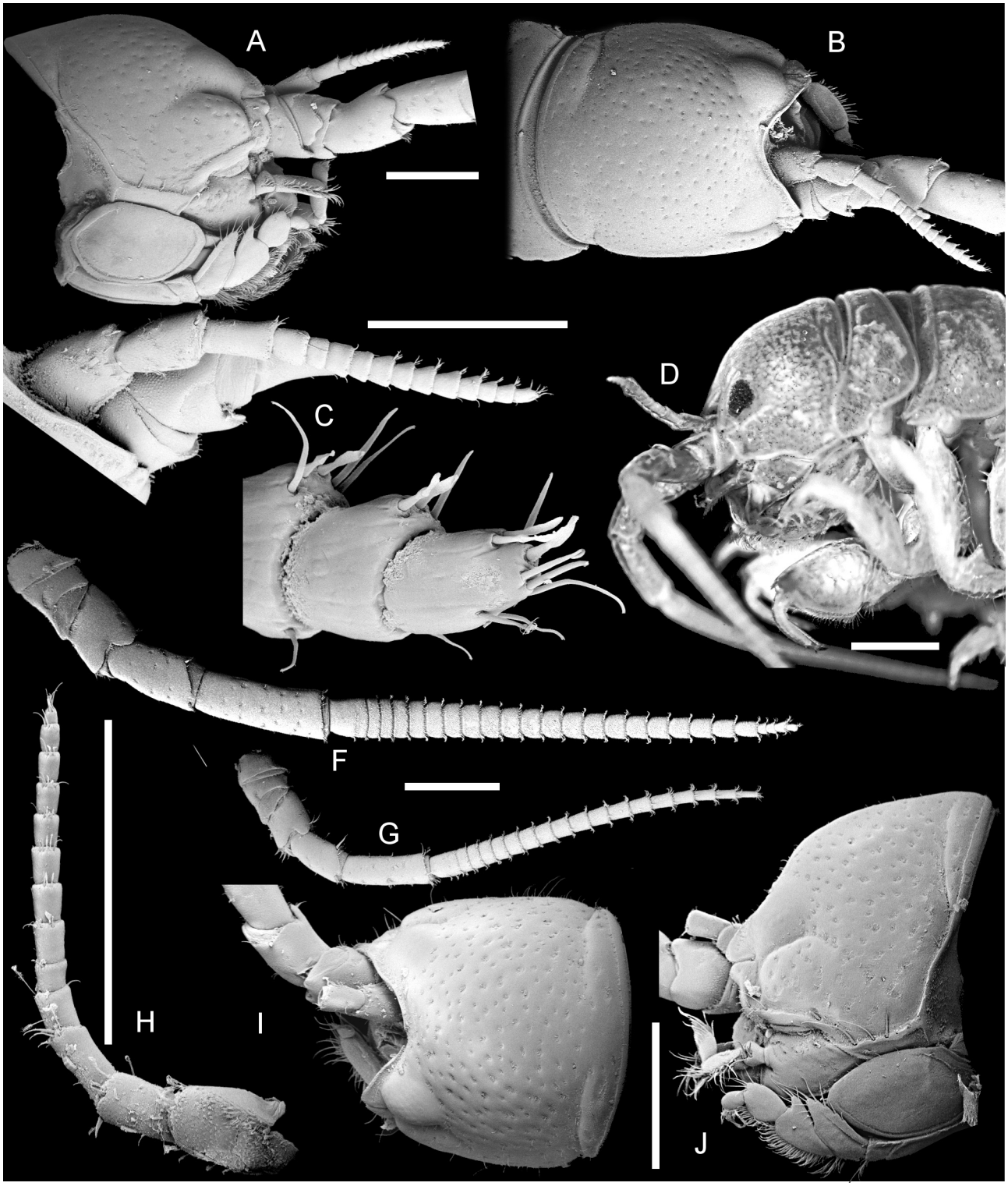

FIGURE 155. *Eophreatoicus gubara* sp. nov., head and antennae. Paratype male, AM P.76472: A–B, head lateral and dorsal; C, antennula with enlargement of distal tip; F, antenna. Holotype male, AM P.76468: D, head lateral. Paratype female, AM P.76473: G, antenna (same scale as F); H, antennula; I–J, head dorsal and lateral. Scales 1 mm.

Antennula. Length 0.10 body length in male, 0.13 body length in female, with 16 articles in male, with 11 articles in female. Article 5 length 0.92 width (male). Article 6 length 0.42 width (male). Aesthetascs small (2–3) mostly on distomedial margins. Terminal article longer than penultimate article, length 1.60 width, length 0.03 antennula total length. Distal articles oval in cross-section.

Antenna. Length 0.29 body length in male, 0.41 body length in female. Flagellum length 0.68 total antenna

length in male, 0.65 total antenna length in female, with 24–30 articles in male, with 17–21 articles in female, proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Mouthfield. Clypeus width 0.64 head width (male). Labrum semicircular end with a lateral ridge half way down. Paragnaths with distolaterally rounded lobes, having a medial setal row separated from a lateral setal row.

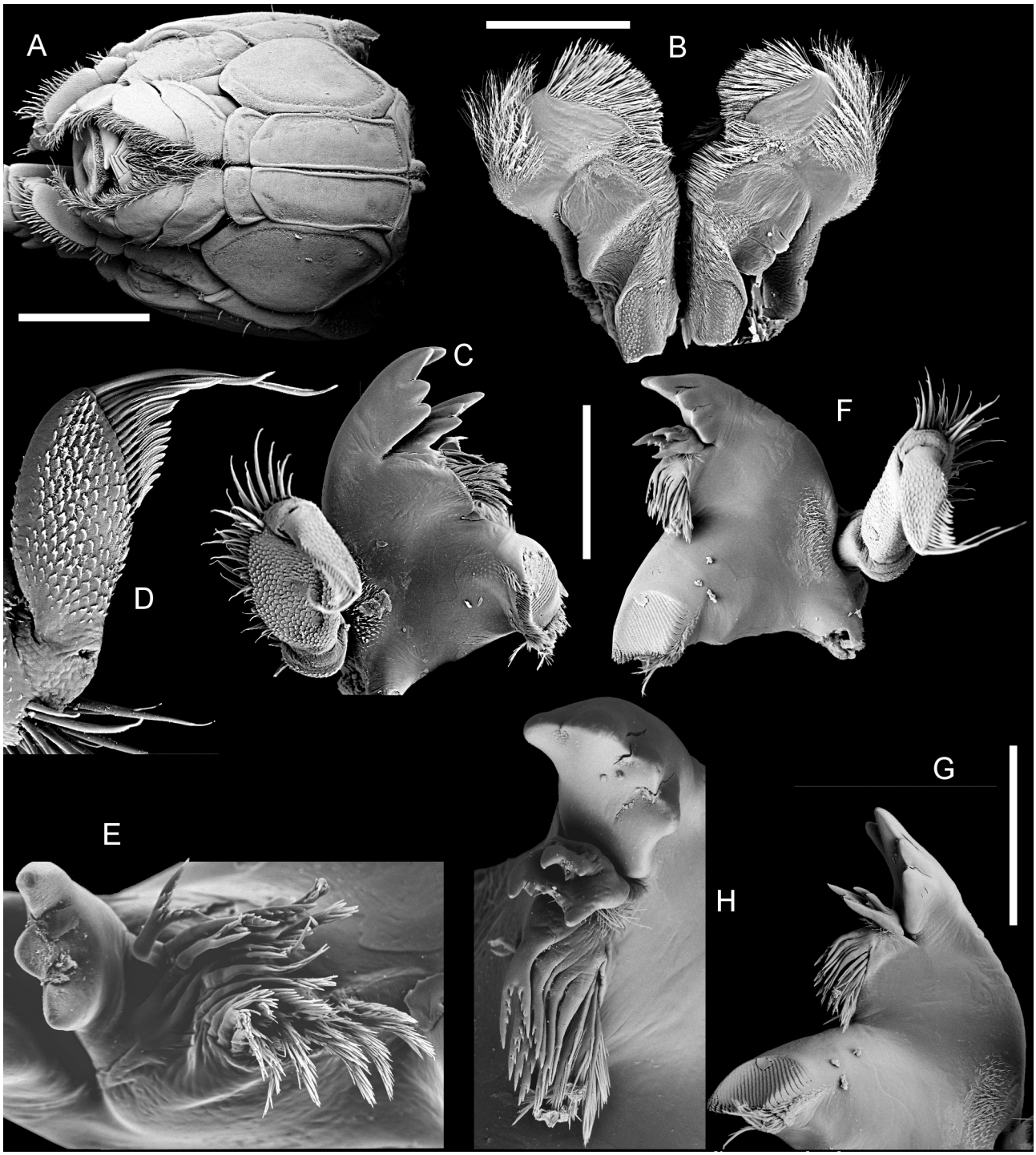

FIGURE 156. *Eophreatoicus gubara* sp. nov., mouthparts. Paratype male, AM P.76472: A, head, ventral. Paratype male, AM P.54099: B, paragnath, ventral. Paratype female, AM P.55044: C, left mandible dorsal; D, palp article 3; E, lacinia mobilis and spine row, medial. Paratype male, AM P.54099: F, right mandible, dorsal; G, gnathal edge, dorsal; H, spine row, lacinia mobilis and incisor process, medial. Scales: A, 1 mm; B, 0.2 mm; C, F, G, 0.5 mm.

Mandible. Palp length 1.00 mandible length. Palp article 3 with 16 setae (14 short and 2 long setae), setae on margin finely setulate, medial surface without additional setae, medial surface covered in cuticular combs, surface covered with cuticular hairs, with surface cuticular combs. Palp article 2 without distal group of setae. Palp article

setae with 1 seta on article 1, with group of setae (longer than half article length) on dorsolateral margins article 2. Left spine row with 9 spines (approx), 4 of which bifurcate. Right spine row with 9 spines (approx.), 4 of which bifurcate, first spine separated from remaining spines. Left molar process triturating surface posterodorsal ridge not projecting. Right molar process without row of complex spines adjacent to triturating ridges, dorsal surface with ciliated spine row, 5 members altogether.

Maxillula. Medial lobe length 0.48 lateral lobe length; width less than lateral lobe, width 0.64 lateral lobe width; with 7 pappose setae; with simple accessory setae, 1 altogether, on distolateral margin, with 4 short weakly setulate setae on distal tip. Lateral lobe distal margin distal setal row with 4 robust setae, with 6 denticulate robust setae, with 6 smooth robust setae. Lateral lobe ventral face with 3 plumose setae, setae closely spaced, additional plumose seta among proximal distal robust setae.

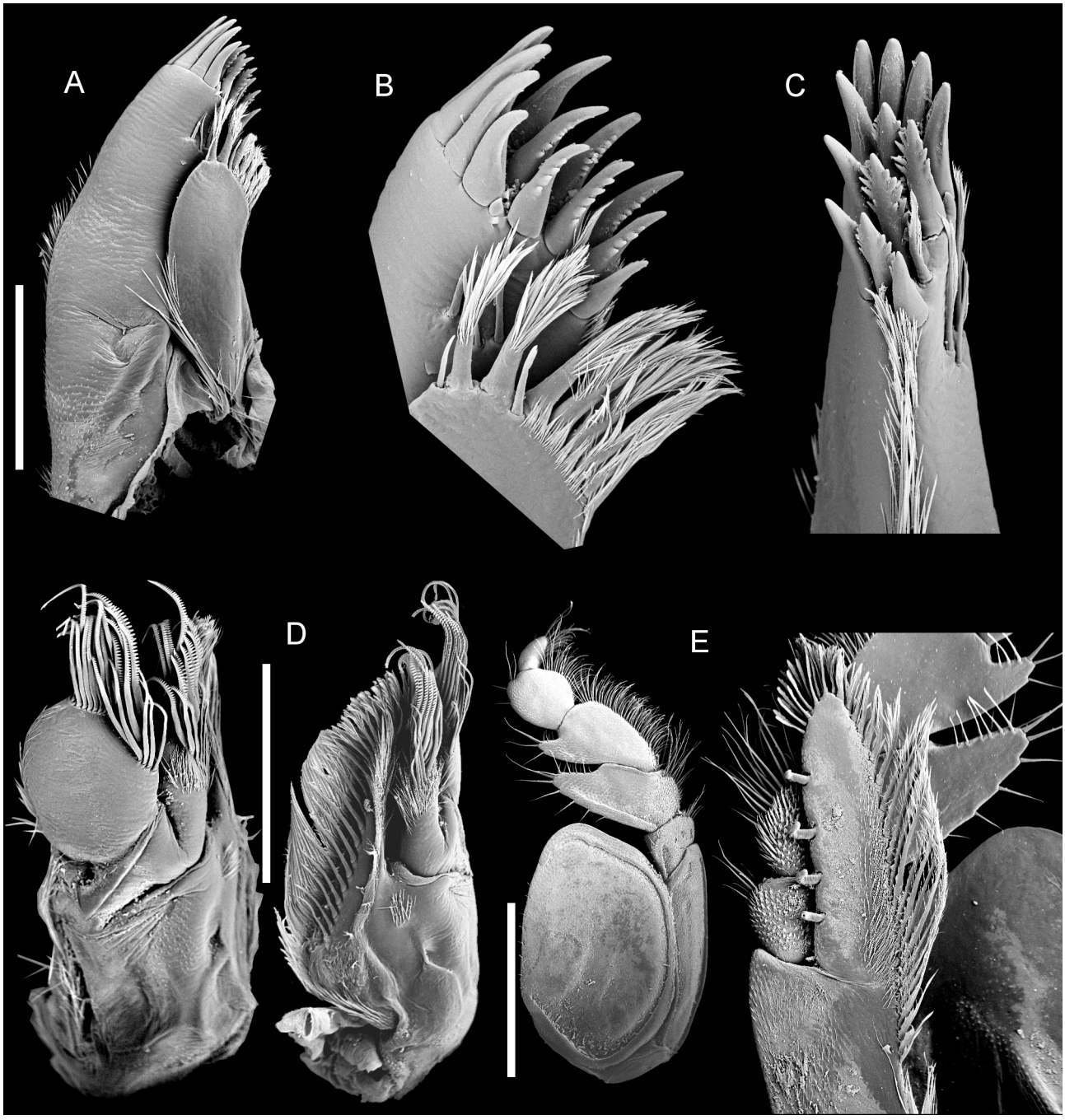

FIGURE 157. *Eophreatoicus gubara* sp. nov., mouthparts. A–C, maxillula with enlargement of distal margin and lateral lobe, medial, paratype male, AM P.54099, scale 0.5 mm. D, maxilla, right lateral and left medial, paratype female, AM P.55044, scale 0.5 mm. E, maxilliped entire and endite, medial, paratype male, AM P.54099, scale 1 mm.

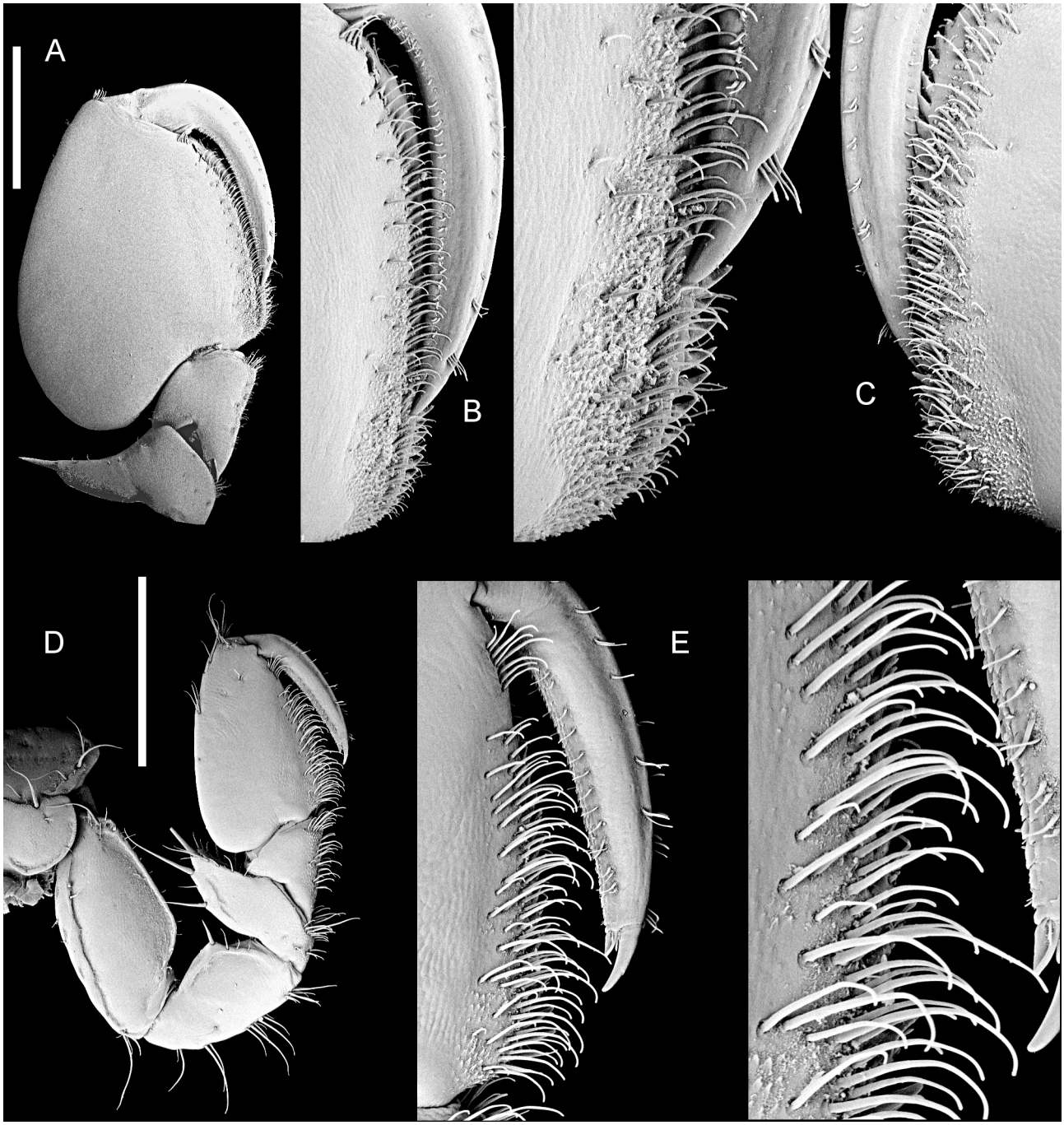

FIGURE 158. *Eophreatoicus gubara* sp. nov., pereopods I. Paratype male, AM P.76472: A, distal articles, medial; B, palm and dactylus, medial, with enlargement of setae; C, palm and dactylus, lateral. Paratype female, AM P.76473: D, pereopod I, lateral; E, palm and dactylus, with enlargement of setation. Scales A, D, 1 mm.

Maxilla. Medial lobe width 1.00 outer lateral lobe width; proximal portion without inflection with distal portion; setae in ventral basal rows forming single row of sparse medium length setae, setae in dorsal basal row forming single row of tightly bunched long fine setae, setae in distal row forming 2 rows of setae. Outer lateral lobe length subequal to inner lateral lobe, wider than inner lateral lobe. Outer lateral lobe distal margin setal row with two angles, transverse to lateral margin and oblique on medial margin, both lateral lobes with bidenticulate setae on distal tips and on medial margin, with 10 long bidenticulate setae, inner lateral lobe with 6 long bidenticulate setae.

Maxilliped. Epipod distal tip rounded, length 1.33 width. Endite length 0.51 total basis length, medial margin with 4 coupling hooks on right side; medial margin with 4 coupling hooks on left side. Endite distal margin fine setae, in fringe, with fine cuticular combs, in lateral group. Endite dorsal ridge with 16 large distally denticulate

plumose setae. Palp insertion on basis lateral margin with 1 plumose seta, without medial margin plumose setae. Palp insertion on basis ventral surface with 6 subdistal smooth setae, without ventral surface subdistal biserrate setae. Palp length 0.83 basis length; width across articles 2–3 2.40 endite width. Palp article 4 length 1.18 width. Palp article 5 length 1.75 width, 0.70 article 4 length.



FIGURE 159. *Eophreatoicus gubara* sp. nov., pereopods II–VII. Paratype male, AM P54099: A–B, pereopod II with enlargement of basis epaulet (dashed line indicates missing seta); C, pereopod IV. Paratype female, AM P.76473: D–E, pereopod II with enlargement of basis epaulet. Paratype male, AM P.76472: F, pereopod V; G–H, pereopod VII with posterior of pene. Scales 1 mm.

Pereopod I. Length:body length 0.28 male (H), 0.27 female (F7). Basis of male length 2.00 width, female length 2.52 width; dorsal setae positioned proximally, 1 dorsal seta altogether (M6); female dorsal setae positioned proximally, female 7 dorsal setae altogether (F7); ventrodistal margin with 2 elongate setae (M6), female with 3 elongate setae (F7), elongate setae longer than ischium. Ischium of male dorsal margin without simple setae. Ischium of female dorsal margin with 3 simple setae (F7), setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (2 robust 1 small); female distodorsal margin with numerous elongate simple setae, female dorsal surface with setae along dorsal axis (3 heavy simple 1 small). Propodus length:pereopod length 0.25 male, 0.15 female. Propodus length:width 1.10 male, 1.40 female. Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 6 setae altogether (excluding distal group) (M6), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae proximally on margin articulated, grading distally to articulation not expressed, 26 altogether (M6). Propodal palm of female margin convex, stout denticulate setae serrate, 10 altogether (F7), with stout robust conical setae, 6 altogether (F7, 3 distally 3 proximally). Dactylus of male shorter than palm, length:palm length 0.67, female shorter than palm, female length:palm length 0.88. Dactylus of female ventrodistal margin distal cuticular fringe length 0.72 total length. Dactylus claw length:dactylus length 0.12 male, 0.20 female. Dactylus of male positioned ventrally, 0.33–0.35 (F7, M6) length of primary claw. Dactylus of female occurring ventrally, half size of claw.

Pereopods II–III ratios. Pereopod II. Length:body length 0.26 male, 0.33 female. Basis length:pereopod length 0.32 male, 0.31 female; length:width 1.85 male, 2.13 female. Carpus length:pereopod length 0.13 male, 0.09 female; length:width 1.11 male, 1.11 female. Propodus length:pereopod length 0.15 male, 0.16 female; length:width 1.71 male, 1.80 female. Dactylus length:propodus length 0.75 male, 0.44 female; primary claw length:dactylar length 0.24 male, 0.33 female. *Pereopod III.* Length:body length 0.28 male, 0.32 female. Basis length:pereopod length 0.30 male, 0.29 female; length:width 1.96 male, 1.94 female. Carpus length:pereopod length 0.15 male, 0.13 female; length:width 1.39 male, 1.56 female. Propodus length:pereopod length 0.15 male, 0.13 female; length:width 2.08 male, 1.75 female. Dactylus length:propodus length 0.56 male, 0.71 female; primary claw length:dactylar length 0.29 male, 0.36 female. *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, carpus, propodus, dactylus; basis dorsal ridge with setae forming 2 rows on proximal projection, rest of ridge with row of fine setae in F7; setae only on proximal projection as one row in M6. Ischium II–IV of male dorsal margin with 5–7 simple setae (M6 per II and per IV), none robust. Dactylus ventral to primary claw, 0.34 length of primary claw, with scales on ventral margin; 20 altogether (M6 pereopod II, approx).

Pereopod II. Basis lateral face with 3 short simple setae proximally in male, 7 elongate simple setae in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 1–3 minor setae, submarginal setal row with 2–3–4 setae, without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 2–4–5 minor setae, submarginal setal row with 4–6–9 setae, with major setae distally, with 3–4–6 major setae distal to epaulet.

Pereopod IV. Penicillate setae in both sexes, of male occurring on anterodorsal margin of propodus, of female occurring on dorsal margin of basis. Basis of male dorsal ridge with 5 setae (M6), dorsal ridge setae positioned proximally, of female dorsal ridge with 8 setae, dorsal ridge setae positioned along ridge. Ischium of male dorsal margin with 7 setae (M6), female dorsal margin with 5 setae. Carpus of male ventral margin with simple setae only. Carpus of female ventral margin with simple setae. Propodus of male distal width 0.67–0.83 maximum width, setae on ventral margin robust, 2 distinctly larger than remainder, shorter than dactylar claw. Propodus of female not in female, posterior side of limb articular plate subequal in length to dactylar claw. Dactylus of male distal accessory claw approximately 0.5 primary claw length, female distal accessory claw approximately 0.33 length of primary claw. *Pereopod IV ratios.* Length:body length 0.26 male, 0.29 female. Basis length:width 2.08 male, 2.27 female. Carpus length:pereopod length 0.13 male, 0.11 female. Propodus length:pereopod length 0.13 male, 0.14 female. Propodus length:width 1.33 male, 2.33 female.

Pereopods V–VII ratios. Pereopod V. Length:body length 0.25 male, 0.23 female. Basis length:width 1.17 male, 1.29 female. Carpus length:pereopod length 0.16 male, 0.14 female. Propodus length:pereopod length 0.19 male, 0.16 female. Dactylus claw length:dactylar length 0.34 male, 0.33 female (F3). *Pereopod VI.* Length:body length 0.35 male, 0.32 female. Basis length:width 1.23 male, 1.17 female. Carpus length:pereopod length 0.16 male, 0.14

female. Propodus length:pereopod length 0.17 male, 0.18 female. Dactylus claw length:dactylar length 0.27 male, 0.29 female. *Pereopod VII.* Length:body length 0.33 male, 0.40 female. Basis length:width 1.10 male, 1.14 female. Carpus length:pereopod length 0.13 male, 0.14 female. Propodus length:pereopod length 0.14 male, 0.16 female. Dactylus claw length:dactylar length 0.20 male, 0.36 female.

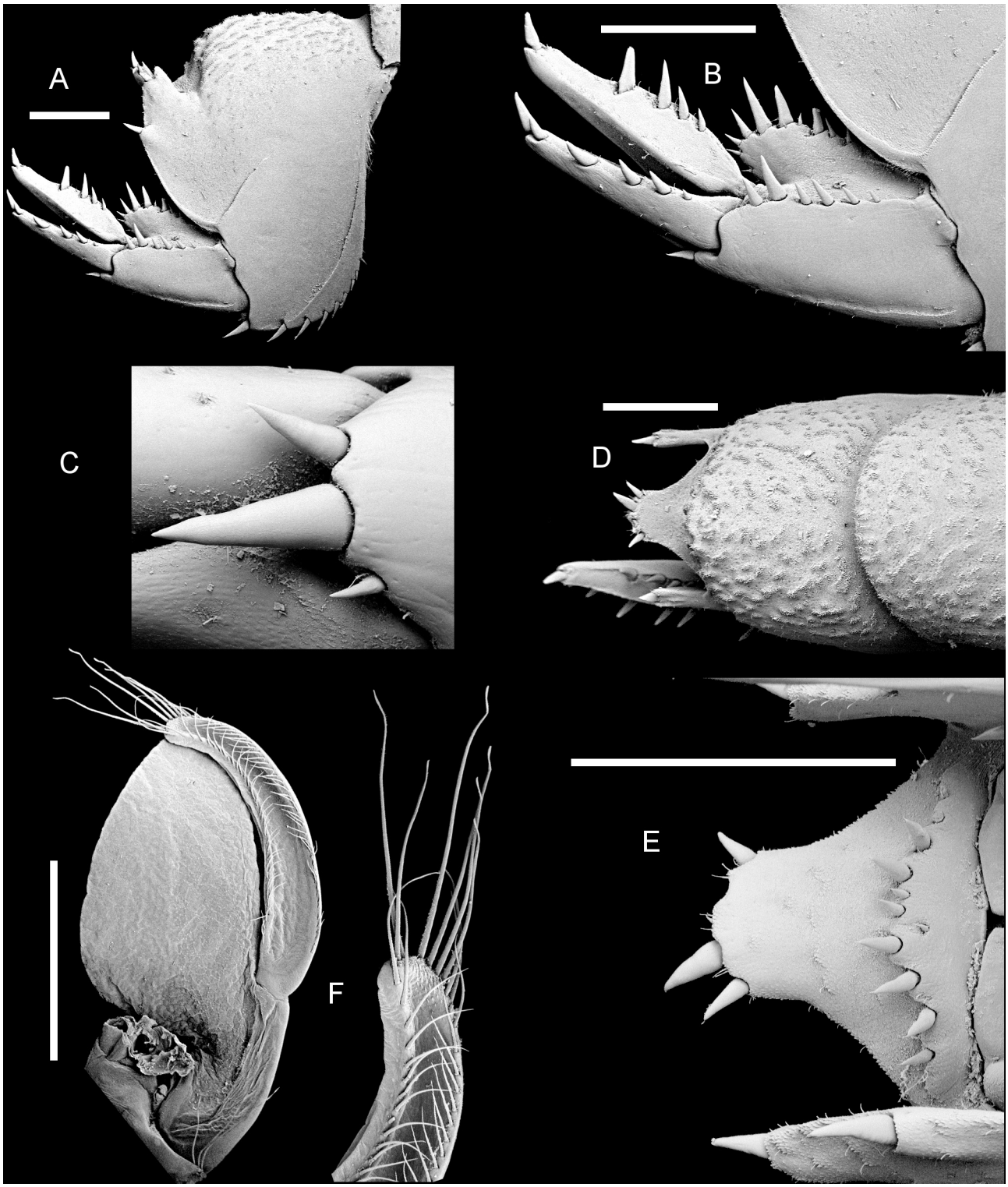

FIGURE 160. *Eophreatoicus gubara* sp. nov., pleotelson and uropods, paratype male, AM P.76472. A, pleotelson lateral. B, uropod lateral. C, distoventral protopodal setae. D, pleotelson dorsal. E, pleotelson distal margin ventral setation. F, pleopod II appendix masculina with enlargement of distal tip. Scales 1 mm.

Pereopods V–VII. V–VII penicillate setae not on dorsal ridge of basis, penicillate setae not on carpus; penicillate setae not on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium

of male dorsal margin with 4–5 setae (M6 pereopod V, pereopod VII). Propodus distal margins with 3–4 elongate robust or robust-based setae. Dactylus accessory claw 0.42 primary claw length (M6 pereopod V). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with 1 seta, dorsal margin with 5 setae (M6).

Penes. Length 0.45 body width at pereonite 7; distally tapering; distal tip truncate.

Pleopods. Length:body length male pleopod I 0.12, II 0.15, III 0.14, IV 0.15, V 0.13. Length:body length female pleopod I 0.13, II 0.15, III 0.13, IV 0.16, V 0.13. Exopod length:width male pleopod I 2.29, II 1.67, III 1.33, IV 1.22, V 1.18. Exopod length of distal article:exopod length male pleopod II 0.25, III 0.30, IV 0.38, V 0.41. Exopod length: width female pleopod I 1.95, II 1.80, III 1.25, IV 1.54, V 1.13. Exopod length of distal article:exopod length female pleopod III 0.28, 0.27, IV 0.20, V 0.39. Endopod length:width male pleopod I 2.19, II 1.83, III 1.60, IV 1.68, V 1.57. Endopod length:exopod length male pleopod I 1.09, II 1.10, III 1.14, IV 1.24, V 1.00. Endopod length:width female pleopod I 2.16, II 1.71, III 2.00, IV 2.59, V 1.75. Endopod length:exopod length female pleopod I 1.12, II 1.00, III 1.40, IV 1.10, V 1.30. Exopods I with lateral proximal lobe, with medial proximal lobes of pleopod I. Protopods medial margins II–V with large projections, of male medial margins with minutely serrate setae, of male medial margins pleopod I 19 minutely serrate setae (14 on margin, 3 on vertical ridge half way along medial lobe ventral surface, and 2 on small button-like medial lobe adjacent to exopod attachment); pleopods II–V with 18/13/22/22 minutely serrate setae respectively, of female medial margins with minutely serrate setae, medial margins pleopod I 17 minutely serrate setae (13 on margin, 4 on vertical ridge half way along medial lobe ventral surface); pleopod II 13 minutely serrate setae, pleopods III–V minutely serrate setae (in similar numbers to male); protopod II lateral epipod lobe-like, in male pleopod I has 24 minutely serrate setae on proximal half of lateral epipod; pleopods II–V have 68/57/62/59 simple & minutely serrate setae respectively (the positions & numbers respectively for the 4 pleopods are 48/35/42/35 minutely serrate setae on the epipod's medial margin, and 20/22/20/24 short simple & long minutely serrate setae on the epipod's lateral margin)., in female pleopod I has 18 minutely serrate setae on proximal half of lateral epipod; pleopods II has 44 simple & minutely serrate setae (27 minutely serrate setae on the epipod's medial margin, and 17 short simple & long minutely serrate setae on the epipod's lateral margin); pleopods III–V have many simple & minutely serrate setae (in similar numbers to the male).

Pleopod I exopod of male broadest proximally, distal margin rounded, dorsal surface lacking setae. Pleopod II endopod of male appendix masculina length 0.41 pleopod length, basal musculature pronounced, distal length 1.50 endopod proximal margin length; distally with 9 setae; 72 setae altogether (approximately).

Uropod. Of male total length 0.93 pleotelson length; protopod of male length:width 5.00, length 0.47 uropod total length. Uropod of female total length 1.07 pleotelson length; protopod length:width 3.92; protopod length 0.51 uropod total length. Protopod dorsomedial ridge length:endopod length 0.62 male (M6), 0.63 female (F7). Protopod of male dorsolateral margin shorter than dorsomedial margin setae; of female dorsolateral margin subequal to dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, without spinose setae, 3 robust simple setae. Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae placed midlength, 4 altogether; female dorsal margin with 3 robust setae. Exopod length:endopod length 0.83 male, 0.85 female. Exopod length:protopod length 0.87 male, 0.93 female. Exopod of male dorsal margin with 3 robust setae, female 3 robust setae.

Distribution. Australia, Northern Territory, Kakadu National Park, ~1 km upstream of Gubara Pools near Nourlangie Rock, Burdulba Creek, a tributary of Nourlangie Creek, South Alligator catchment.

Habitat. In rock pool under roots and leaf litter.

Remarks. *Eophreatoicus gubara* sp. nov. is darkly pigmented, not light and maculate like *E. nawurlandja* sp. nov. The two species are most easily separated using the tuberculation of the pleotelson, the shape of the uropod protopod dorsomedial ridge and the shape of the dorsal lobe on the pleotelson posterolateral plate. Remarkably, the sole locality for this species is less than 0.5 km from a population of the relatively widespread *E. nawurlandja* sp. nov. at Gubara pools (=Burdulba Springs). *Eophreatoicus gubara* sp. nov. is weakly associated with *E. kershawi* in the morphological analysis but has 17 diagnostic differences. *Eophreatoicus gubara* sp. nov. compared to *E. kershawi* is a much more rugose species with smaller eyes and has a much more prominent uropodal protopod dorsomedial ridge. We have no genetic data for *E. gubara* sp. nov., which contributed to this species having a highly unstable position in the combined analysis.

***Eophreatoicus namarrkon* sp. nov.**
(Figs 161–165)

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Eophreatoicus sp. "20".—Wilson *et al.*, 2009: 362.

Type material. Holotype male, bl 24.5 mm, AM P.72627, PAN19990528. Paratypes collected with holotype: male (M2), bl 21.7 mm, AM P.72628, DNA E109 GenBank COI EU263162, 16S EU263234, SEM stubs AW619–623; female (F3), bl 15.0 mm, AM P.72629, SEM stubs AW624–627; preparatory female, bl ~11 mm, AM P.74573, DNA E58 GenBank EU263161 16S EU263233; 53 inds, AM P.74574; 4 inds, AM P.74576. Additional paratypes: PAN19990524, 12 inds, AM P.74575.

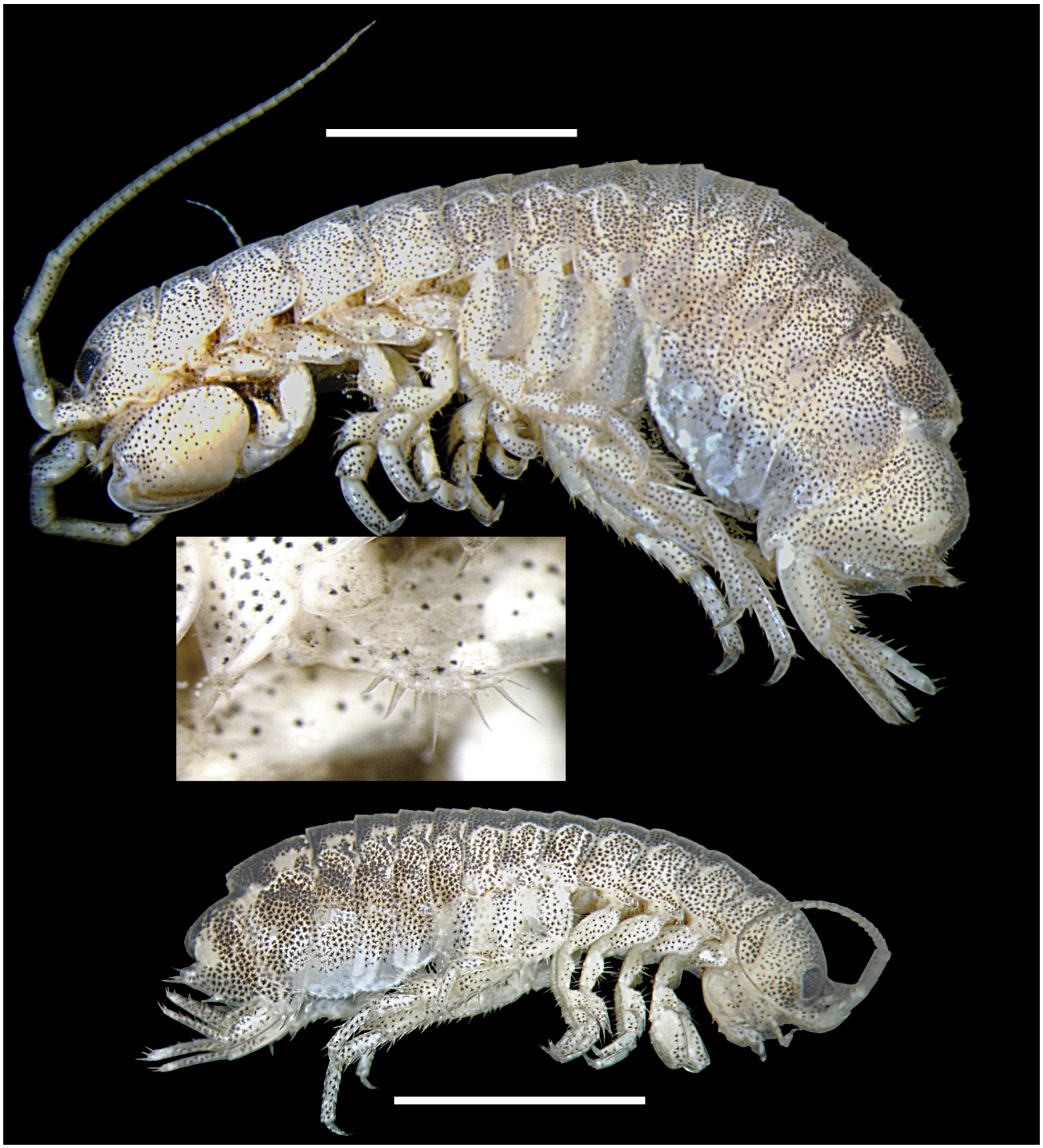

FIGURE 161. *Eophreatoicus namarrkon* sp. nov., types, lateral. Top, holotype male, AM P.72627 with enlargement of epaulet on pereopod II. Bottom, paratype female, AM P.74573. Scale 5 mm.

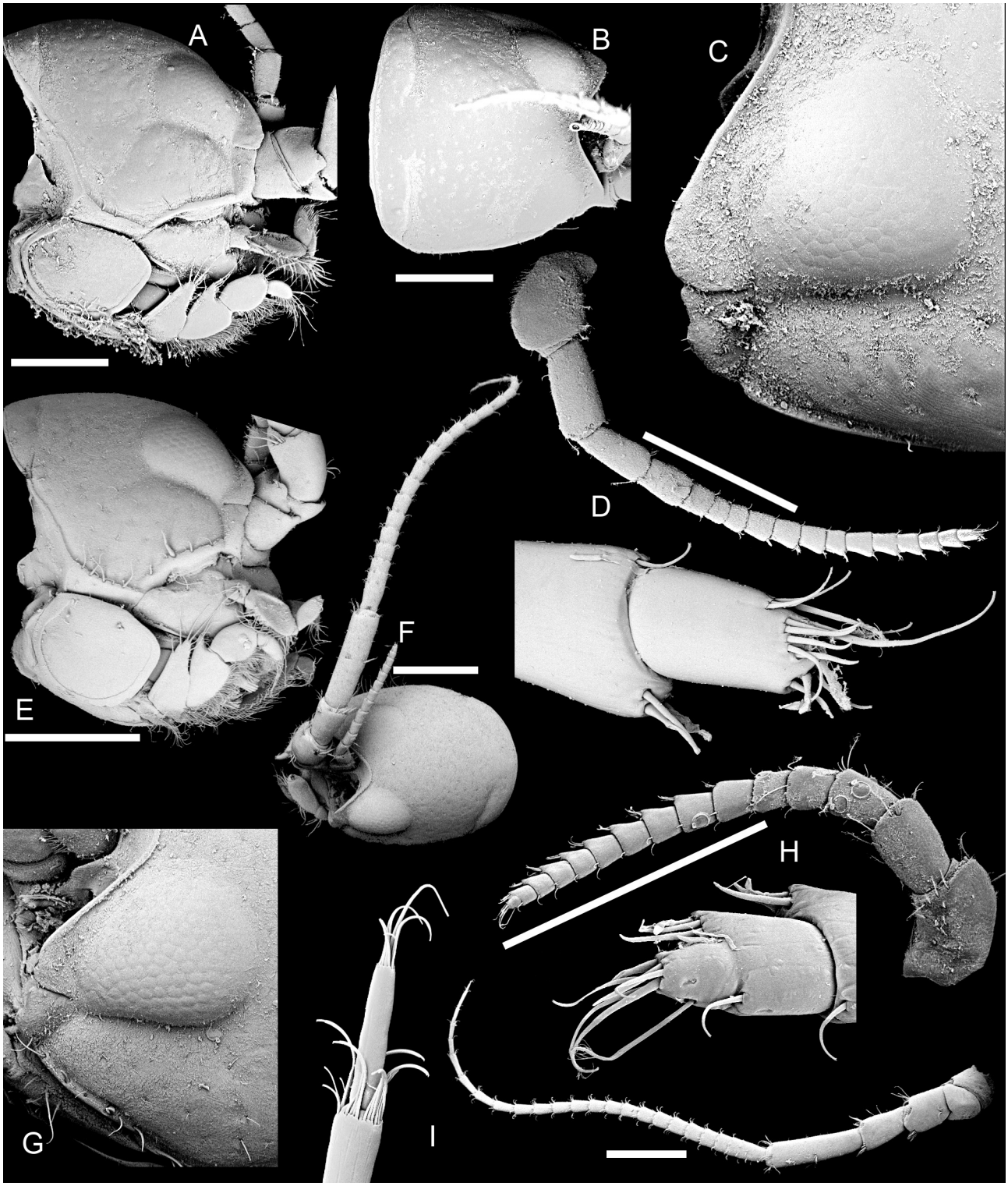

FIGURE 162. *Eophreatoicus namarrkon* sp. nov., head and antennae. Paratype male AM P.72628: A–C, head lateral, dorsal and enlargement of eye region; D, antennula with enlargement of distal tip. Paratype female, AM P.72629: E–G, head lateral, dorsal and enlargement of eye region; H, antennula with enlargement of distal tip; I, antenna with enlargement of distal tip. Scales 1 mm.

Type locality. Australia, Northern Territory, Kakadu National Park, PAN19990528, creek north of Namarrkon Gorge, 12°54.079'S, 132°57.45'E, coll. G. Spiers & P. Alderson, 28.v.1999. Sites adjacent to type locality with additional paratypes: PAN19990524, plateau creek north of Namarrkon Gorge, 12°54.17'S, 132°57.35'E, coll. 24.v.1999, G. Spiers.

Etymology. "Namarrkon" means 'lightning', referring to the creek north of Namarrkon Gorge. This name, in the Kundjeyhmi and Kunwinjku languages, is pronounced "na-marr-gon" where "rr" is a tapped sound. Say "na-muda-gon" (where "muda" rhymes with butter said quickly).

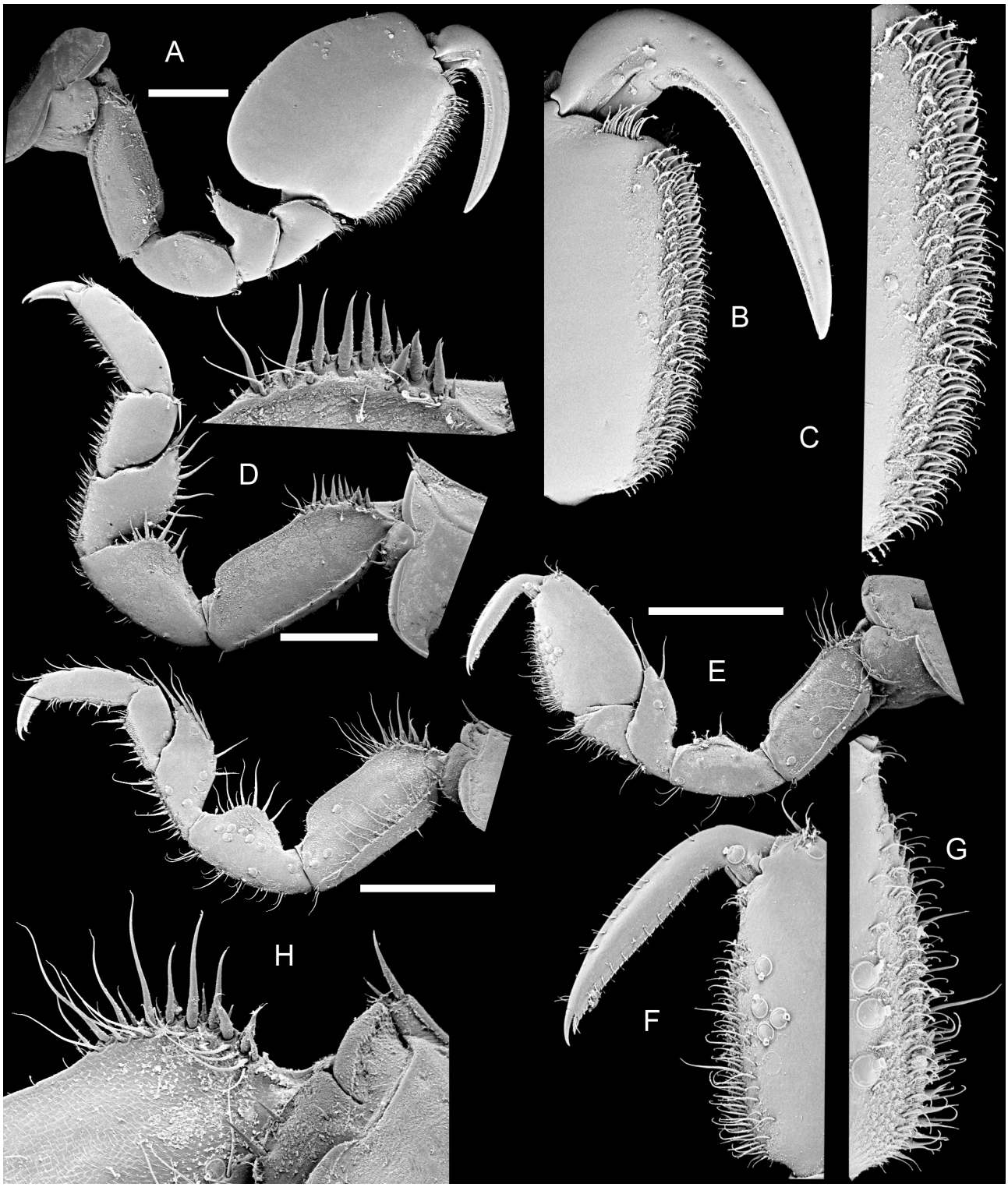

FIGURE 163. *Eophreatoicus namarrkon* sp. nov., anterior pereopods. Paratype male, AM P.72628: A–C, pereopod I lateral, palm and dactylus, enlargement of palm setae; D, pereopod II with enlargement of epaulet. Paratype female, AM P.72629: E–G, pereopod I lateral, palm and dactylus, medial enlargement of palm setae; H, pereopod II with enlargement of epaulet. Scales 1 mm.

Diagnosis. *Head.* Eyes bulging dorsolaterally, height large, in lateral view greater than width of basal antennal articles, height greater than length in lateral view, bulging in dorsal view, projecting from head in distinct arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal

edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface smooth (without roughness or tubercles); pereonites 1–4 transverse dorsal ridges not expressed; pereonites 5–7 transverse dorsal ridges not expressed. *Pleonites.* 1–4 transverse dorsal ridges not expressed. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection linear. Dorsal surface rugose, with oblong tubercles or with small irregular rugose regions, with several median tubercles, not merging into ridge. Posterior apex in lateral view obscured by posterolateral margin (obscured partially). Posterior apex in lateral view distinctly narrowing distally, proximal depth greater than distal depth, with two pairs of robust setae (central pair significantly larger than lateral pair), with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 length subequal to article 4, or longer than article 4 (F3, M2). *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines (1 row distally, 2 rows proximally). *Pereopod II.* Basis of male dorsal ridge epaulet length greater than quarter basis length, main setal row with 11 major setae (M2, more than 2 setae rows, short robust-based setae not counted). Basis of female dorsal ridge epaulet length greater than quarter basis length, main setal row with 9 major setae (F3). *Pereopod IV.* Propodus of male ventral margin with projection, with 8 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, convex, in lateral view distal part distinctly curving ventrally; distal margin with all robust setae approximately same size.

Description. Body pigmentation dorsally with broad irregular dark bar, indistinctly 3 lined, chromatophores dendritic to broad and diffuse; length of largest male 24.0 mm, length of largest brooding female 20.0 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Dorsal surface pitted (shallow pits); setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin concave, orientation of longest axis vertical, maximum diameter 0.34–0.37 head depth (F3, H), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view smoothly curved. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

Pereon. Width near head width. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–4 in dorsal view respective lengths equal to or more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from 1–3, pleonite 4 longer than 1–2 and shorter than 3. Pleonites depth:pereonite 7 depth 1.50–1.60 pleonite 1 (H, F3), 2.20–2.30 pleonite 2 (H, F3), 2.50–2.60 pleonite 3 (F3, H), 2.50–2.60 pleonite 4 (F3, H), 2.20–2.30 pleonite 5 (F3, H).

Pleotelson. Dorsal surface length 1.10 width in dorsal view (M2). Dorsal surface sparsely covered with setae. Depth 1.90–2.00 pereonite 7 depth (F3, H). Lateral length less than depth, in male 0.75 depth (M2), in female 0.74 depth. Lateral length 0.13–0.14–0.19 body length (H, F3, M2). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.30–1.50 width of uropodal insertion (F3, M2), with one row of distally denticulate robust setae, including 7 robust setae altogether (M2, F3), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.15–0.21 pleotelson total length (F3, M2), dorsal setal position posterior seta subequal to submarginal seta. Posterior apex length less than width, long. Posterior apex 0.23 pleotelson total length (M2), width 0.54 pleotelson width (M2). Posterior apex in lateral view forming an angle of 81–88–95° with immediately anterior dorsal surface (F3, M2, H), angled 150–156–160° from horizontal (H, F3, M2).

Antennula. Length 0.22 body length in male (M2), 0.14 body length in female (F3), with 17 articles in male (M2), with 15 articles in female (F3). Article 5 length 0.87–1.50 width (F3, M2). Article 6 length 0.91–1.00 width (M2, F3). Aesthetascs small (1–4) mostly on distomedial margins. Terminal article length subequal to penultimate article length, length 1.70 width (M2), length 0.02–0.04 antennula total length (F3, M2). Distal articles oval in cross-section.

Antenna. Length 0.75 body length in male (M2), 0.50 body length in female (F3). Flagellum length 0.62 total antenna length in male (M2), 0.64 total antenna length in female (F3), with 26 articles in male (M2), with 22 articles in female (F3), proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Mouthfield. Clypeus width 0.30 head width (M2).

Maxilliped. Epipod distal tip rounded, length 1.20–1.40 width (F3, M2). Endite distal margin in fringe. Palp length 1.30 basis length (M2). Palp article 4 shape elongate-oval, length 1.10–1.40 width (F3, M2). Palp article 5 length 1.60–2.00 width (M2, F3), 0.54–0.70 article 4 length (M2, F3).

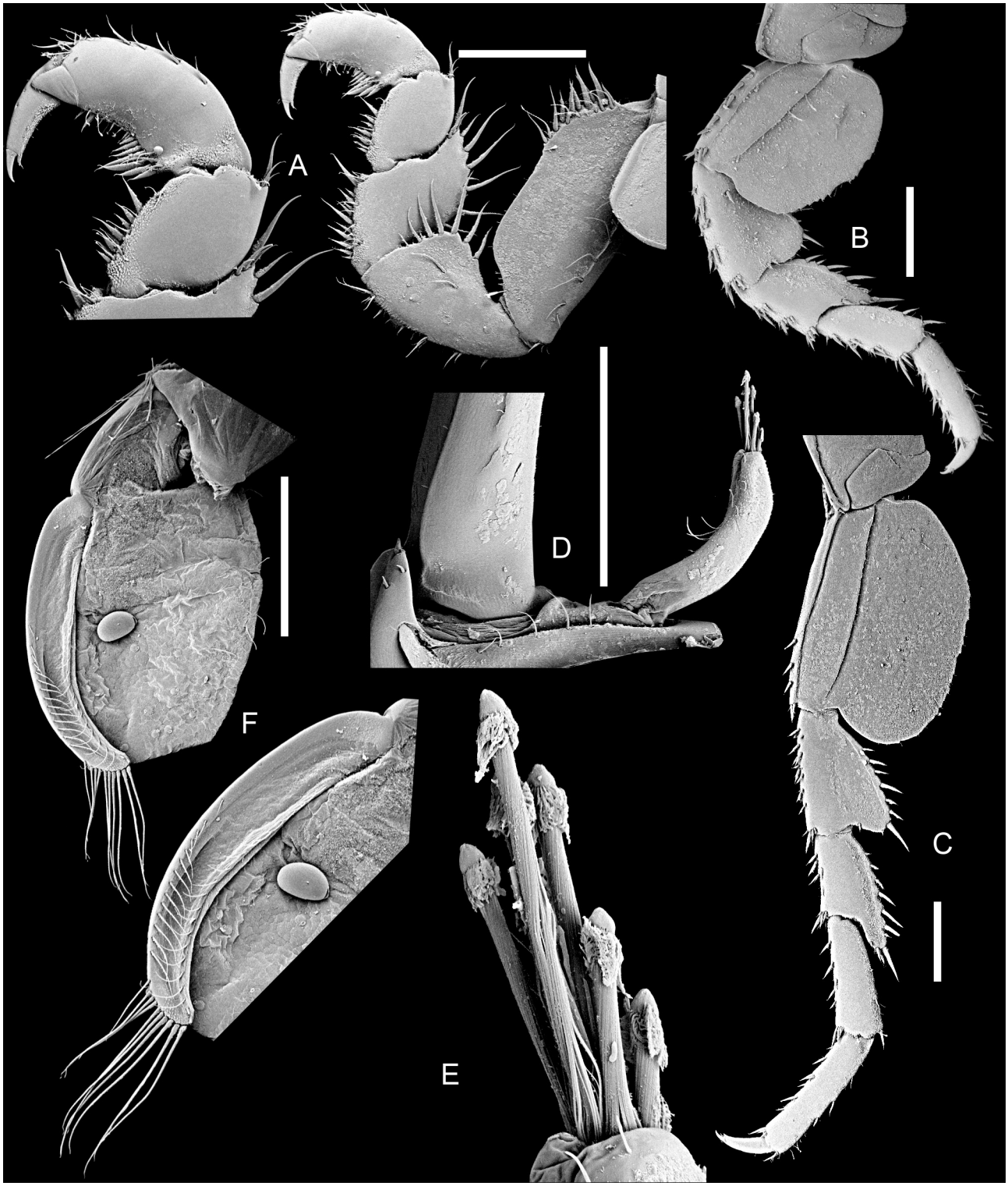

FIGURE 164. *Eophreatoicus namarrkon* sp. nov., posterior pereopods and pleopod II, paratype male, AM P.72628. A, pereopod IV with enlargement of palm. B, pereopod V. C, pereopod VII. D–E, pene, posterior and enlargement of extruded sperm bundles. F, pleopod II endopod with enlargement of appendix masculina. Scales 1 mm.

Pereopod I. Length:body length 0.41–0.42 male (H M2), 0.32 female (F3). Basis of male length 2.90 width (M2), female length 2.30 width (F3); dorsal setae positioned proximally, 4 dorsal setae altogether (M2); female dorsal setae positioned proximally, female 11 dorsal seta altogether (F3); ventrodistal margin lacking elongate setae, female ventrodistal margin lacking elongate setae. Ischium of male dorsal margin without simple setae. Ischium of female dorsal margin with 2 simple setae (F3), setae not robust. Merus of male distodorsal margin in

cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (2 robust 1 small); female distodorsal margin with few elongate simple setae, female dorsal surface with setae along dorsal axis (2 heavy simple). Propodus length:pereopod length 0.25 male (M2), 0.21 female (F3). Propodus length:width 1.10 male (M2), 1.40 female (F3). Propodus of male dorsal margin setae in 1 group between proximal and distal margin in addition to single group at distal margin, with 2 setae altogether (excluding distal group) (M2), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae articulation not expressed, 36 altogether (M2). Propodal palm of female margin convex, stout denticulate setae serrate, 4 altogether (F3), with stout robust conical setae, 18 altogether (F3). Dactylus of male shorter than palm, length:palm length 0.92 (M2), female shorter than palm, female length:palm length 0.93 (F3). Dactylus of female ventrodistal margin distal cuticular fringe length 0.63 total length (F3). Dactylus claw length:dactylus length 0.09 male (M2), 0.13 female (F3). Dactylus of male positioned ventrally, 0.59 (M2) length of primary claw.

Pereopods II–III ratios. *Pereopod II*. Length:body length 0.45 male (M2), 0.31 female (F3). Basis length: pereopod length 0.31 male (M2), 0.30 female (F3); length:width 2.50 male (M2), 2.20 female (F3). Carpus length: pereopod length 0.13 male (M2), 0.12 female (F3); length:width 1.50 male (M2), 1.50 female (F3). Propodus length:pereopod length 0.18 male (M2), 0.17 female (F3); length:width 2.60 male (M2), 3.00 female (F3). Dactylus length:propodus length 0.43 male (M2), 0.52 female (F3); primary claw length:dactylar length 0.18 male (M2), 0.28 female (F3). *Pereopod III*. Length:body length 0.29–0.32 male (H, M2). Basis length:pereopod length 0.30 male (H); length:width 2.50 male (H). Carpus length:pereopod length 0.12 male (H); length:width 1.30 male (H). Propodus length:pereopod length 0.15–0.17 male (M2, H); length:width 2.50 male (H). Dactylus length:propodus length 0.54–0.55 male (M2, H). *Pereopods II–III*. Penicillate setae scattered on dorsal ridge of basis, carpus, propodus. Ischium II–IV of male dorsal margin with 10 simple setae (M2 pereopod II), none robust. Dactylus ventral to primary claw, 0.34–0.39 length of primary claw, with scales on ventral margin (F3, M2); 12 altogether (F3 pereopod II, approx).

Pereopod II. Basis lateral face with 9 simple setae along margin in male and 14 elongate simple setae along margin in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 2 minor setae (M2), submarginal setal row with 7 setae (M2), without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 5 minor setae (F3), submarginal setal row with 9 setae (F3), without major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 18 setae (M2), dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 7 setae (M2), female dorsal margin with 5 setae (F3). Carpus of male ventral margin with simple setae only. Propodus of male distal width 0.64 maximum width (M2), setae on ventral margin robust-based, 2 distinctly larger than remainder, longer than dactylar claw (1.3 claw length). Dactylus of male distal accessory claw approximately 0.25 primary claw length (0.27, M2). *Pereopod IV ratios*. Length:body length 0.40 male (M2), 0.28 female (F3). Basis length:width 2.50 male (M2), 2.60 female (F3). Carpus length:pereopod length 0.12 male (M2), 0.09 female (F3). Propodus length:pereopod length 0.15 male (M2), 0.15 female (F3). Propodus length:width 1.90 male (M2), 3.60 female (F3).

Pereopods V–VII ratios. *Pereopod V*. Length:body length 0.32–0.44 male (H, M2), 0.32 female (F3). Basis length:width 1.10–1.30 male (M2, H), 1.30 female (F3). Carpus length:pereopod length 0.15–0.16 male (H, M2), 0.13 female (F3). Propodus length:pereopod length 0.17–0.18 male (M2, H), 0.16 female (F3). Dactylus claw length:dactylar length 0.24 male (M2). *Pereopod VI*. Length:body length 0.38–0.41 male (M2, H). Carpus length: pereopod length 0.16 male (H, M2). Propodus length:pereopod length 0.18 male (H, M2). *Pereopod VII*. Length: body length 0.47–0.60 male (H, M2). Basis length:width 1.40 male (M2). Carpus length:pereopod length 0.15 male (H, M2). Propodus length:pereopod length 0.18–0.19 male (M2, H). Dactylus claw length:dactylar length 0.22 male (M2).

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 5–7 setae (M2 pereopod V, pereopod VII). Propodus distal margins with 2–4 elongate robust or robust-based setae (M2 pereopod V, pereopod VII). Dactylus accessory claw 0.33–0.39 primary claw length (M2 pereopod VII, pereopod V). Pereopod VII basis dorsal ridge distal margin

rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with 1 seta, dorsal margin with 7 setae (M2).

Penes. Distally tapering; distal tip truncate.

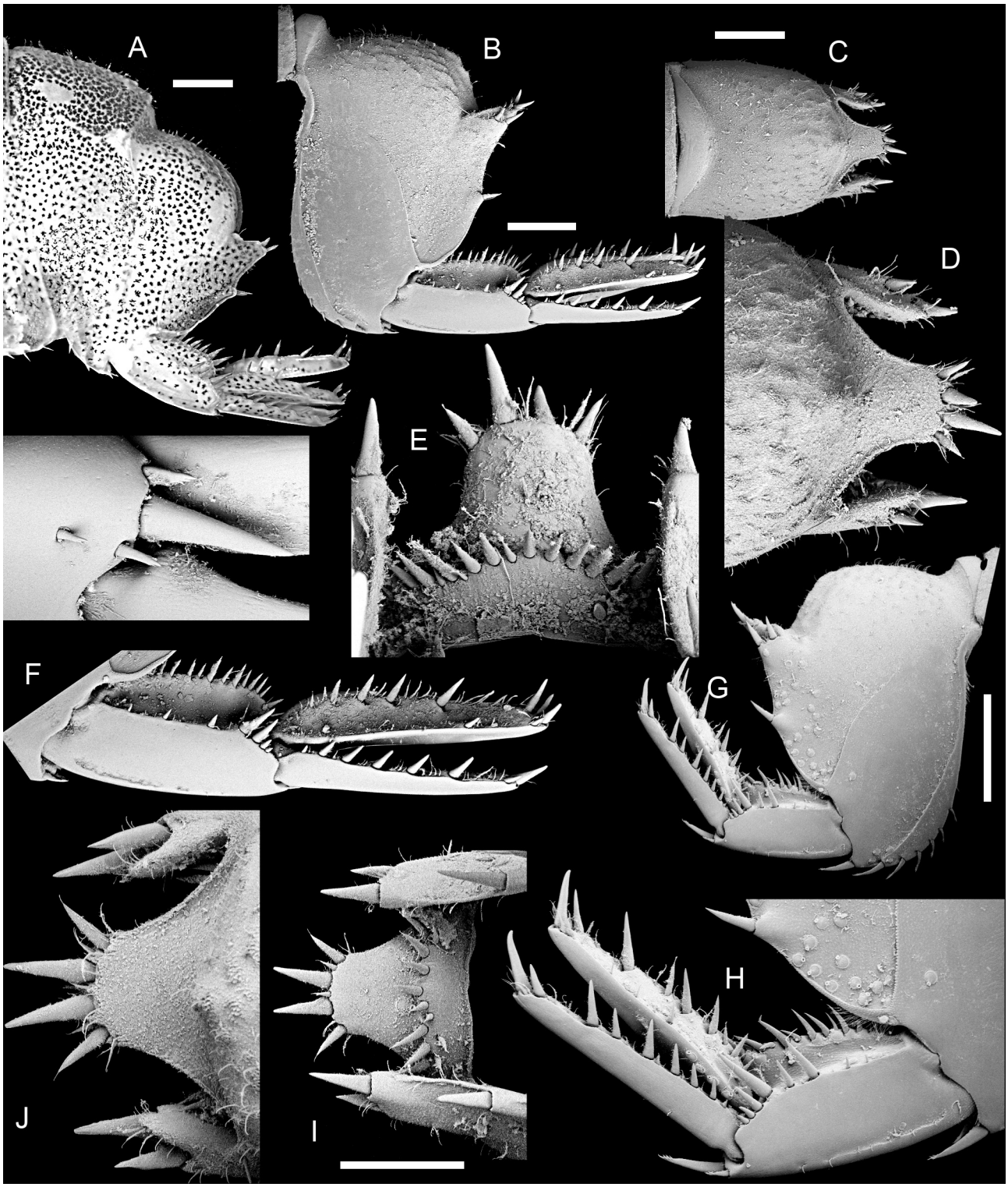

FIGURE 165. *Eophreatoicus namarrkon* sp. nov., pleotelson and uropods. Holotype male, AM P.72627: A, pleotelson lateral. Paratype male, AM P.72628: B–D, pleotelson lateral, dorsal, enlargement of apex; E, pleotelson ventral showing postanal ridge setation; F, uropod with enlargement of protopod posterodistal setae. Paratype female, AM P.72629: H, pleotelson lateral; I, pleotelson ventral showing postanal ridge setation; J, pleotelson vertex dorsal. Scale 1 mm.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 1.90 endopod proximal margin length; distally with 9 setae; 46 setae altogether (M2).

Uropod. Of male total length 1.30–1.40 pleotelson length (H, M2); protopod of male length 0.42–0.47 uropod total length (M2, H). Uropod of female total length 1.10 pleotelson length (F3); protopod length 0.42 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.43 male (M2), 0.53 female (F3). Protopod of male dorsolateral margin subequal to dorsomedial margin setae; of female dorsolateral margin subequal to dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, with spinose setae, 3 robust spinose setae. Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 10 altogether (M2); female dorsal margin with 10 robust setae (F3). Exopod length: endopod length 0.88 male (M2), 0.93 female (F3). Exopod of male dorsal margin with 8 robust setae (M2), female 9 robust setae (F3).

Distribution. Australia, Northern Territory, Kakadu National Park, creek north of Namarrkon Gorge, a tributary of Nourlangie Creek, South Alligator River catchment.

Habitat. Among roots, leaf litter and sand at edge of rocky creek bed. This is a fish-free habitat where the isopods were reported to be less cryptic.

Remarks. *Eophreatoicus namarrkon* sp. nov. was found to be in a clade with *E. ngarradj* sp. nov. and *E. mawoenewoene* sp. nov. in the combined analysis (Fig. 13). *Eophreatoicus namarrkon* sp. nov. is larger than the other species (male body length around 22–24 mm instead of around 16 mm) and is identified as follows: having a smooth cuticle on the pereon (the other two species have low transverse dorsal ridges) and a pereopod II basis epaulet with 9–11 major setae (4–6 major setae).

Eophreatoicus namimminya sp. nov.

(Figs 166–170)

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Eophreatoicus sp. "08".—Wilson *et al.*, 2009: 361.

Type material. Holotype male, bl 18.6 mm, AM P.72639, LDC3028. Paratypes collected with holotype: adult male (M4), bl 17.0 mm, AM P.72642, DNA E106 GenBank COI EU263149 16S EU263219, SEM stubs AW600–605; 4 inds, AM P.74581. Additional paratypes. LDC#1: 1 ind, AM P.74584, DNA E52 (unsuccessful); 3 inds, AM P.74583. LDC#3: subadult male (M2), bl 14.3 mm, AM P.72640, SEM stubs AW606–607; male, AM P.74580, DNA E51 GenBank COI EU263148 16S EU263218; female (F3), bl 14.4 mm, AM P.72641, DNA E107 GenBank COI EU263150 16S EU263220, SEM stubs AW608–610; preparatory female, AM P.74583, DNA E52 (unsuccessful); 36 inds, AM P.74582. LDC#4, 1 ind, AM P.74585.

Type locality. Australia, Northern Territory, Kakadu National Park, Lightning Dreaming Creek, 12°54.76'S, 132° 55.78'E, in main pool below waterfall, 5.ix.1998, LDC3028, coll. C. Humphrey. Sites adjacent to type locality with additional paratypes: LDC#3, 5.ix.1998. LDC#1, 25.x.1998, mid-level above waterfall. LDC#4, 25.x.1998, pools below main pool.

Etymology. "Namimminya" ("na-mim-minja"), where "mim" refers to the lightning spirit's eye, is the name of the main pool that is part of local place "Lightning Dreaming". This name is pronounced "na-mim-min-ya".

Diagnosis. *Head.* Eyes bulging dorsolaterally, height large, in lateral view greater than width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface smooth (without roughness or tubercles); pereonites 1–4 transverse dorsal ridges not expressed; pereonites 5–7 transverse dorsal ridges low without transverse trough. *Pleonites.* 1–4 transverse dorsal ridges low without transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection linear. Dorsal surface rugose, with small irregular rugose regions, with several median tubercles, not merging into ridge. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view distinctly narrowing distally, proximal depth greater than distal depth, with two pairs of robust setae and one median robust seta (middle pair largest, central seta smallest), with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 shorter than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with single row of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length subequal to quarter basis length, main setal row with 5–6 major setae (M2, M4). Basis of female dorsal ridge epaulet length subequal to quarter basis length, main setal row with 5 major

setae (F3). *Pereopod IV.* Propodus of male ventral margin with projection, with 5 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly beyond pleotelson apex. Protopod dorsomedial ridge distinctly projecting dorsally with posterior margin exposed above shaft, convex, in lateral view distal part distinctly curving ventrally; distal margin with 2 adjacent robust setae distinctly larger than others.



FIGURE 166. *Eophreatoicus namimminya* sp. nov., types, lateral. Top, holotype male, AM P.72639. Middle paratype male, AM P.72640. Bottom, paratype female, AM P.72641. Scales 5 mm.

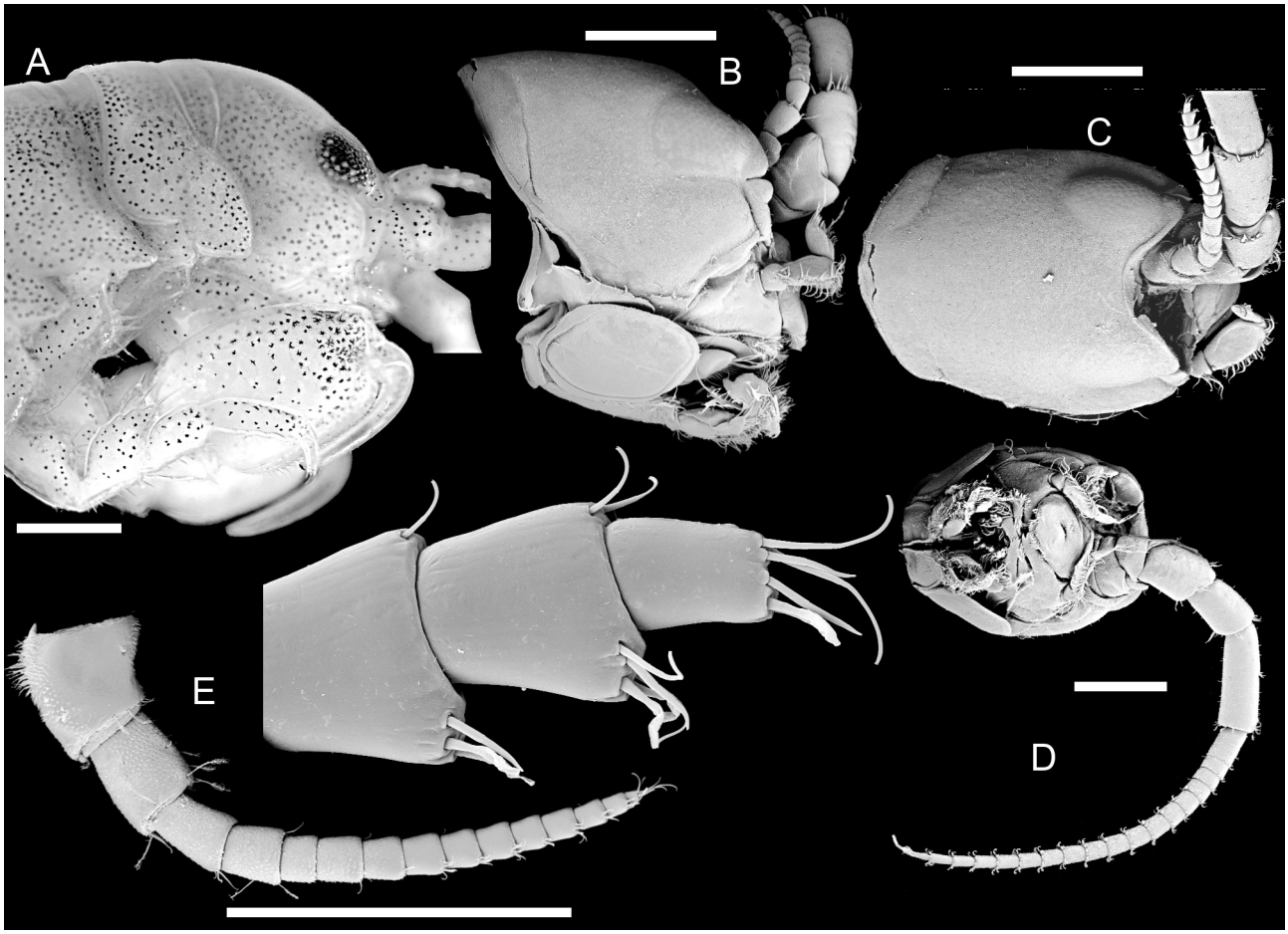

FIGURE 167. *Eophreatoicus namimminya* sp. nov., head and antennae. A, head and anterior pereopods, holotype male, AM P.72639. Paratype male, AM P.72642: B–C, head lateral and dorsal; D, head and antenna anteroventral. E, antennula with enlargement of distal tip. Scales 1 mm.

Description. Body pigmentation Medium dark posteriorly to maculate on limbs, dorsally with dark broad irregular bar. Chromatophores vary from dendritic or dense on males to broad and diffuse on females. Females appear darker than males; length of largest male 17.0 mm, length of largest preparatory female 14.4 mm, length of largest brooding female 15.0 mm.

Head. Length greater than width in dorsal view; lateral profile of dorsal surface smoothly curved. Dorsal surface pitted (shallow pits); setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin straight, orientation of longest axis vertical, maximum diameter 0.27–0.32–0.34 head depth (H, F3, M2), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view straight. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

Pereon. Width near head width. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–3 in dorsal view respective lengths less than 0.5 pleonite 5 length, pleonite 4 length more than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.30–1.60 pleonite 1 (H, F3), 1.80–1.90 pleonite 2 (H, F3), 1.90–2.10 pleonite 3 (H, F3), 1.80–2.20 pleonite 4 (H, F3), 1.70–1.90 pleonite 5 (H, F3).

Pleotelson. Dorsal surface length 1.10–1.30–1.40 width in dorsal view (M2, M4, F3). Dorsal surface sparsely covered with setae. Depth 0.94–1.10–1.20 pereonite 7 depth (H, M2, F3). Lateral length less than depth, in male 0.77–0.78 depth (H, M2), in female 0.84 depth. Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.30–1.40–1.70 width of uropodal insertion (M2, F3, M4), with one row of distally denticulate robust setae, including 6–7 robust setae altogether (M2, M4; F3), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.15–0.16 pleotelson total length (F3, M2;M4), dorsal setal position marginal

seta larger than submarginal seta. Posterior apex length less than width, long. Posterior apex 0.18–0.20 pleotelson total length (F3, M4; M2), width 0.43–0.48–0.52 pleotelson width (M2, M4, F3). Posterior apex in lateral view forming an angle of 98–107–109° with immediately anterior dorsal surface (F3, M4, M2), angled 158–164–171° from horizontal (M4, F3, M2).

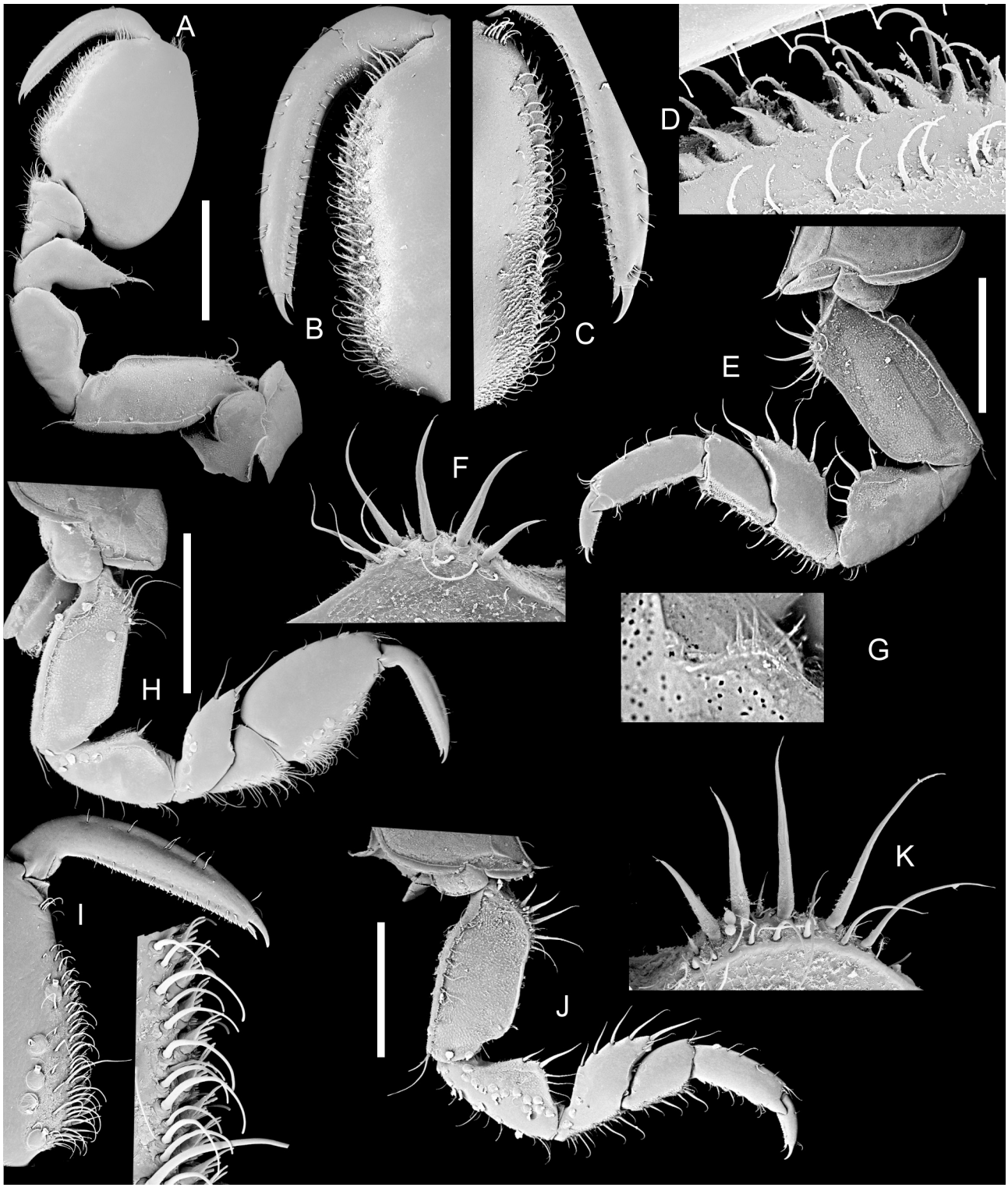

FIGURE 168. *Eophreatoicus namimminya sp. nov.*, anterior pereopods. Paratype male, AM P.72642: A–D, pereopod I lateral, palm and dactylus lateral and medial, enlargement of medial palm setae; E–F, pereopod II with enlargement of epaulet. G, holotype male, AM P.72639, pereopod II epaulet. Paratype female, AM P.72641: H–I, pereopod I lateral, palm and dactylus, lateral enlargement of palm setae; J–K, pereopod II and enlargement of epaulet. Scales 1 mm.



FIGURE 169. *Eophreatoicus namimminya sp. nov.*, posterior pereopods and pleopod II, paratype male, AM P.72642. A, pereopod IV with enlargement of distal segments. B, pereopod V. C–D, pereopod VII with medial enlargement of articular plate and dactylus. E, pene, posterior showing extruded sperm bundles. F–G, pleopod II endopod and enlargement of appendix masculina. Scales 1 mm.

Antennula. Length 0.13 body length in male (M4), with 15 articles in male (M4). Article 5 length 0.82 width (M4). Article 6 length 1.00 width (M4). Aesthetascs small (1–4) mostly on distomedial margins. Terminal article length 1.30 width, 0.02 antennula total length (M4). Distal articles oval in cross-section.

Antenna. Length 0.44 body length in male (M4). Flagellum length 0.59 total antenna length in male (M4), with 19 articles in male (M4), proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Mouthfield. Clypeus width 0.44 head width (M4).

Maxilliped. Epipod distal tip rounded.

Pereopod I. Length:body length 0.32–0.37 male (M2, M4), 0.31 female. Basis of male length 2.30–2.80 width (M4, M2), female length 2.30 width (F3); dorsal setae positioned along ridge, 8–13 dorsal setae altogether (M4, M2 approx); female dorsal setae positioned proximally, female 12 dorsal setae altogether (F3, approx); ventrodistal margin with 1–2 elongate setae (M4), female with 2 elongate setae (F3), elongate setae longer than ischium. Ischium of male dorsal margin with 1 simple seta, setae not robust. Ischium of female dorsal margin with 1 simple seta, setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (1 heavy simple 1 small); female distodorsal margin with numerous elongate simple setae, female dorsal surface with setae along dorsal axis (3 simple decreasing in size proximally). Propodus length:pereopod length 0.22–0.23 male (M2, M4), 0.20 female (F3). Propodus length:width 1.10–1.20 male (M4, M2), 1.50 female (F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 4–5 setae altogether (excluding distal group) (M4, M2), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust conical setae, stout robust setae proximally on margin articulated, grading distally to articulation not expressed, 25–30 altogether (M2, M4). Propodal palm of female margin convex, with cuticular fringe weakly developed, stout denticulate setae serrate, 14 altogether (F3), with stout robust conical setae, 9 altogether (F3, 4 distally 5 proximally). Dactylus of male shorter than palm, length:palm length 0.94–0.95 (M4, M2), female length subequal to palm, female length:palm length 1.00 (F3). Dactylus of female ventrodistal margin distal cuticular fringe length 0.72 total length (F3). Dactylus claw length:dactylus length 0.10–0.13 male (M4, M2), 0.14 female (F3). Dactylus of male positioned ventrally, 0.44–0.47 (M4, F3) length of primary claw.

Pereopods II–III ratios. Pereopod II. Length:body length 0.31–0.32 male (M2, M4), 0.32 female (F3). Basis length:pereopod length 0.29–0.30 male (M4, M2), 0.30 female (F3); length:width 2.20–2.40 male (M4, M2), 2.30 female (F3). Carpus length:pereopod length 0.11–0.12 male (M2, M4), 0.13 female (F3); length:width 1.40–1.50 male (M4, M2), 1.80 female (F3). Propodus length:pereopod length 0.16–0.17 male (M2, M4), 0.17 female (F3); length:width 2.60 male (M2, M4), 2.70 female (F3). Dactylus length:propodus length 0.54–0.57 male (M4, M2), 0.55 female (F3); primary claw length:dactylar length 0.23–0.28 male (M4, M2), 0.28 female (F3). *Pereopod III.* Length:body length 0.31 male (M2). *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, propodus, dactylus, also seen on ventral margin of propodus in female; basis dorsal ridge with elongate setae forming 2 rows on proximal projection, anterior row with 4–6 larger setae and 3–6 simple setae, posterior row with 7–10 simple setae. Ischium II–IV of male dorsal margin with 5–6 simple setae (M2 pereopod II, M4 pereopod IV; M4 pereopod II), none robust. Dactylus ventral to primary claw, 0.28–0.29 length of primary claw, with scales on ventral margin; 11–12 altogether (M2 pereopod II, F3 pereopod II).

Pereopod II. Basis lateral face with 8 fine simple setae along margin in male and 10 elongate setae in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 3 minor setae (M2, M4), submarginal setal row with 7 setae (M2, M4), without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 5 minor setae (F3), submarginal setal row with 8 setae (F3), without major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus, of female occurring on dorsal margin of basis or anterodorsal margins of propodus or anterodorsal margins of carpus. Basis of male dorsal ridge with 10 setae (M4), dorsal ridge setae positioned proximally, of female dorsal ridge with 15 setae (F3), dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 5 setae (M4), female dorsal margin with 6 setae (F3). Carpus of male ventral margin with simple setae only. Carpus of female ventral margin with simple setae. Propodus of male distal width 0.67 maximum width, setae on ventral margin robust, 2 distinctly larger than remainder (gap in between), longer than dactylar claw. Propodus of female not in female, posterior side of limb articular plate longer than dactylar claw. Dactylus of male distal accessory claw approximately 0.25 primary claw length (M4, 0.28), female distal accessory claw approximately 0.25 length of primary claw (F3, 0.35). *Pereopod IV ratios.* Length:body length 0.32 male (M4), 0.32 female (F3). Basis length:width 2.50 male (M4), 2.20 female (F3). Carpus length:pereopod length 0.12 male (M4), 0.09 female (F3). Propodus length:pereopod length 0.17 male (M4), 0.15 female (F3). Propodus length:width 2.30 male (M4), 2.80 female (F3).

Pereopods V–VII ratios. Pereopod V. Length:body length 0.31–0.32 male (M4, H), 0.33 female (F3). Basis

length:width 0.95 male (M4). Carpus length:pereopod length 0.15–0.16 male (H, M4), 0.13 female (F3). Propodus length:pereopod length 0.17–0.18 male (H, M4), 0.16 female (F3). Dactylus claw length:dactylar length 0.30 male (M4). *Pereopod VI.* Length:body length 0.44 male (H). Carpus length:pereopod length 0.15 male (H). Propodus length:pereopod length 0.17 male (H). *Pereopod VII.* Length:body length 0.46 male (M4). Basis length:width 1.40 male (M4). Carpus length:pereopod length 0.16 male (M4). Propodus length:pereopod length 0.18 male (M4). Dactylus claw length:dactylar length 0.29 male (M4).

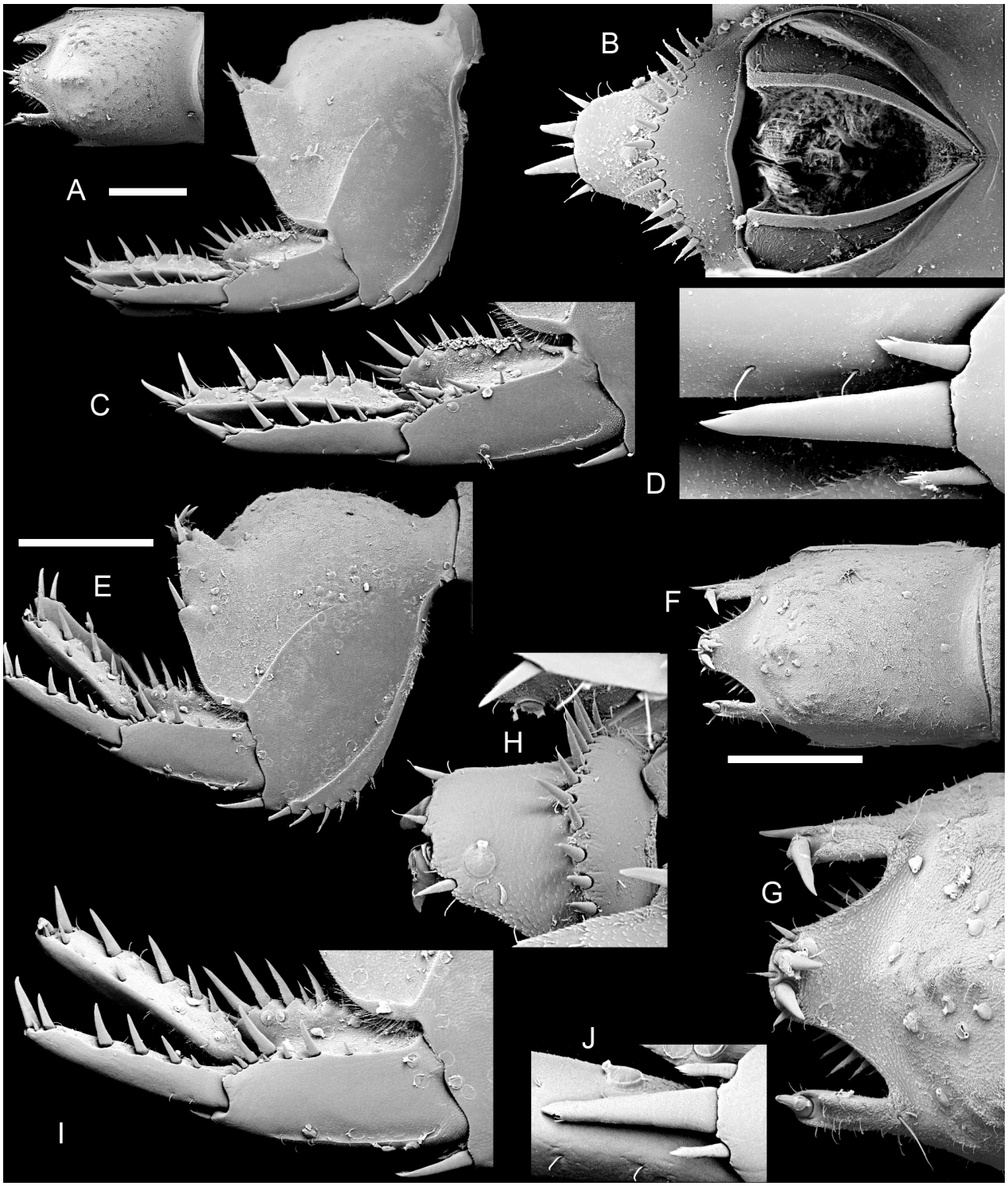

FIGURE 170. *Eophreatoicus namimminya sp. nov.*, pleotelson and uropods. Paratype male, AM P.72642: A, pleotelson dorsal and lateral; B, apex ventral showing postanal ridge setation; C–D, uropod, protopod posterodistal setae. Paratype female, AM P.72641: E–F, pleotelson lateral, dorsal; G, pleotelson apex dorsal. H, pleotelson apex ventral–oblique showing postanal ridge setation; I–J, uropod, enlargement of protopod posterodistal setae. Scales 1 mm.

Pereopods V–VII. V–VII penicillate setae not on dorsal ridge of basis, penicillate setae not on carpus; penicillate setae not on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 4–7 setae (M4 pereopod V, M4 pereopod VII). Propodus distal margins with 4–5 elongate robust or robust-based setae (M4 pereopod V, M4 pereopod VII). Dactylus accessory claw 0.25–0.30 primary claw length (M4 pereopod VII, M4 pereopod V). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with no setae, dorsal margin with 7 setae (M4).

Penes. Distally tapering; distal tip truncate.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 1.70 endopod proximal margin length; distally with 7 setae; 20–63 setae altogether (M2, M4).

Uropod. Of male total length 1.00–1.10 pleotelson length (M2, M4); protopod of male length:width 2.50 (M4), length 0.43–0.45 uropod total length (M2, M4). Uropod of female total length 1.00 pleotelson length (F3), protopod length 0.46 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.63–0.64 male (M2, M4), 0.63 female (F3). Protopod of male dorsolateral margin shorter than dorsomedial margin setae; of female dorsolateral margin shorter than dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, with spinose setae, 3 robust spinose setae. Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 7–11 altogether (M2, M4); female dorsal margin with 9 robust setae (F3). Exopod length:endopod length 0.76–0.78 male (M4, M2), 0.84 female (F3). Exopod of male dorsal margin with 6 robust setae (M2, M4), female 7 robust setae (F3).

Distribution. Australia, Northern Territory, Kakadu National Park, Lightning Dreaming, Namarrgon Creek, above and below waterfall, a tributary of Nourlangie Creek, South Alligator River catchment.

Habitat. Amongst roots and leaf litter at margin of pools around waterfall.

Remarks. *Eophreatoicus namimminya* sp. nov. is similar to *E. namarrkon* sp. nov. When first surveying the species, the two were placed together owing to their overall coloration and relatively smooth cuticle. The combined analysis shows that they are part of the same clade although separated by several nodes in the phylogenetic estimates. The two species differ substantially in the number of major setae on the epaulet (5–6 vs 9–11) and in the overall eye size. The eye of the holotype of *E. namimminya* sp. nov. is smaller than in other specimens of both sexes, showing an approximate variation of 21%. Another species, *E. gudjangah* sp. nov., shows a similarly large variation in eye but *Kakadubeh rangemyahwurd* gen. nov., sp. nov. and *Eremisopus beei* Wilson & Keable, 2002a have an even larger variation in eye size. The variation seems to be sex linked: smaller eyes in the former genus but larger eyes in the latter correspond to the size differences in the males and females. Larger specimens of the same species appear to have smaller eyes, which is also the case here where the holotype is the largest measured specimen.

Eophreatoicus namarden sp. nov.

(Figs 6D, 171–175)

urn:lsid:zoobank.org:act: D51DA949-3B3F-4F2B-BBAD-834C9122CA7F
Eophreatoicus sp. "09".—Wilson *et al.*, 2009: 361.

Type material. Holotype male, bl 17.4 mm, AM P.72624, LDC3028. Paratypes collected with holotype: male (M2), bl 19.5 mm, AM P.72625, DNA E108 GenBank COI EU263152 16S EU263222, SEM stubs AW611–615; female (F3), bl 10.1 mm, AM P.72626, SEM stubs AW616–618; 13 males, AM P.74589; 14 females, AM P.74588; 13 inds, AM P.74587. Additional paratypes: LDC#1, 1 ind, AM P.74590; LDC#2, 5 inds, AM P.74592; LDC#4, male, AM P.74586, DNA E53 GenBank COI EU263151 16S EU263221; LDC#4, 11 inds, AM P.74591.

Type locality. Australia, Northern Territory, Kakadu National Park, Lightning Dreaming Creek, 12°54.76'S, 132°55.78'E, LDC3028, in main pool below waterfall, 5.ix.1998, coll. C. Humphrey. Sites adjacent to type locality with additional paratypes: 25.x.1998: LDC#1, mid-level above waterfall; LDC#2, in waterfall; LDC#4, pools below main pool.

Etymology. "Namarden" is a synonym for "lightning", referring to the main pool that is part of local place "Lightning Dreaming". This name is pronounced "na-mard-en" where "mard" rhymes with the North American English pronunciation of "hard".

Diagnosis. *Head.* Eyes bulging dorsolaterally, height medium, in lateral view subequal to width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head

in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region without obvious setae. *Pereon.* Dorsal cuticular surface strongly tuberculate in all life stages with two or more transverse rows of rounded tubercles; pereonites 1–4 transverse dorsal ridges rounded, expressed as transverse trough only; pereonites 5–7 transverse dorsal ridges expressed only as transverse trough (tuberculate). *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough (tuberculate). *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection linear. Dorsal surface rugose, with oblong tubercles, lacking posteromedial ridges or median groups of tubercles. Posterior apex in lateral view visible. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae and one median robust seta, with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 shorter than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length less than quarter length of basis, main setal row with 2 major setae (M2). Basis of female dorsal ridge epaulet length less than quarter length of basis, main setal row with 2 major setae (F3). *Pereopod IV.* Propodus of male ventral margin without projection, with 5 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, concave, in lateral view distal part distinctly curving dorsally; distal margin with only 1 robust seta distinctly larger than others.

Description. Body pigmentation light brown sides, dorsally with dark and light patches resolving laterally and posteriorly into dark irregular bar; chromatophores broad diffuse touching; length of largest male 19.5 mm, length of largest brooding female 10.6 mm.

Head. Length shorter than width in dorsal view, or length subequal to width in dorsal view (F3, M2); lateral profile of dorsal surface smoothly curved. Width 1.10 pereonite 1 width (F3). Dorsal surface pitted (setae in depressions next to tubercles); with numerous tubercles; scattered evenly, setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin straight, orientation of longest axis vertical, maximum diameter 0.18–0.22 head depth (M2, F3), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view sigmoidal. Mandibular (genal or cheek) groove with acute indentation. Maxillipedal ridge with distinct dorsal edge, region without obvious setae.

Pereon. Width near head width. Setae on dorsal surface scattered, fine, length 0.02 body depth (approx). Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–4 in dorsal view respective lengths less than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.20–1.30–1.40 pleonite 1 (F3, H, M2), 1.50–1.70 pleonite 2 (F3; H, M2), 1.70–1.80–1.90 pleonite 3 (F3, M2, H), 1.70–1.90 pleonite 4 (F3; H, M2), 1.50–1.60 pleonite 5 (M2; H, F3).

Pleotelson. Dorsal surface length 1.30 width in dorsal view (M2, F3). Dorsal surface sparsely covered with setae. Depth 1.40–1.50 pereonite 7 depth (H, M2; F3). Lateral length less than depth, in male 0.82–0.84 depth (H, M2), in female 0.79 depth. Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.60–1.70 width of uropodal insertion (F3, M2), with one row of distally denticulate robust setae, including 6–7 robust setae altogether (M2, F3), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.12–0.15 pleotelson total length (M2, F3). Posterior apex length less than width, long. Posterior apex 0.15–0.17 pleotelson total length (F3, M2), width 0.47 pleotelson width (M2, F3). Posterior apex in lateral view forming an angle of 53–67–98° with immediately anterior dorsal surface (F3, H, M2), angled 129–133–140° from horizontal (H, F3, M2).

Antennula. Length 0.09 body length in male (M2), 0.08 body length in female (F3), with 12 articles in male (M2), with 9 articles in female (F3). Article 5 length 1.10 width (M2, F3). Article 6 length 0.65–0.66 width (F3, M2). Aesthetascs small (1–4) mostly on distomedial margins. Terminal article length 0.88–0.95 width (M2, F3), 0.03–0.06 antennula total length (M2, F3). Distal articles oval in cross-section.

Antenna. Length 0.25 body length in male (M2), 0.25 body length in female (F3). Flagellum length 0.52 total antenna length in male (M2), 0.50 total antenna length in female (F3), with 17 articles in male (M2), with 11 articles in female (F3), proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Mouthfield. Clypeus width 0.41 head width (F3).



FIGURE 171. *Eophreatoicus namarden* sp. nov., habitus. Top, holotype male, AM P.72624. Bottom, Paratype female, AM P. 72626. Scales 5 mm.

Mandible. Palp article 3 medial surface without additional setae, with surface cuticular combs.

Maxilliped. Endite medial margin with 3 coupling hooks on left side (F3). Palp length 1.40 basis length (F3). Palp article 4 shape elongate-oval, length 1.10–2.00 width (M2, F3). Palp article 5 length 1.70–1.80 width (M2, F3), 0.77–0.82 article 4 length (M2, F3).

Pereopod I. Length:body length 0.31 male (M2), 0.29 female (F3). Basis of male length 2.20 width (M2), female length 1.90 width (F3); dorsal setae positioned proximally, 1 dorsal seta altogether (M2); female dorsal setae positioned proximally, female 2 dorsal setae altogether (F3); ventrodistal margin lacking elongate setae, female with 2 elongate setae (F3), elongate setae subequal to ischium or longer than ischium (M2, F3). Ischium of male dorsal margin without simple setae. Ischium of female dorsal margin with 1 simple seta, setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (2 short robust); female distodorsal margin with numerous elongate simple setae, female dorsal surface with setae along dorsal axis (2 heavy simple). Propodus length:pereopod length 0.23 male (M2), 0.21 female (F3). Propodus length:width 1.00 male (M2), 1.30 female

(F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 10 setae altogether (excluding distal group) (M2), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust conical setae, stout robust setae proximally on margin articulated, grading distally to articulation not expressed, 25 altogether (M2). Propodal palm of female margin convex, with cuticular fringe weakly developed, stout denticulate setae serrate, 11 altogether (F3), with stout robust conical setae, 4 altogether (F3). Dactylus of male shorter than palm, length:palm length 0.91 (M2), female shorter than palm, female length:palm length 0.85 (F3). Dactylus of female ventrodistal margin distal cuticular fringe length 0.66 total length (F3). Dactylus claw length:dactylus length 0.13 male (M2), 0.20 female (F3). Dactylus of male positioned ventrally, 0.37–0.41 (M2, F3) length of primary claw.

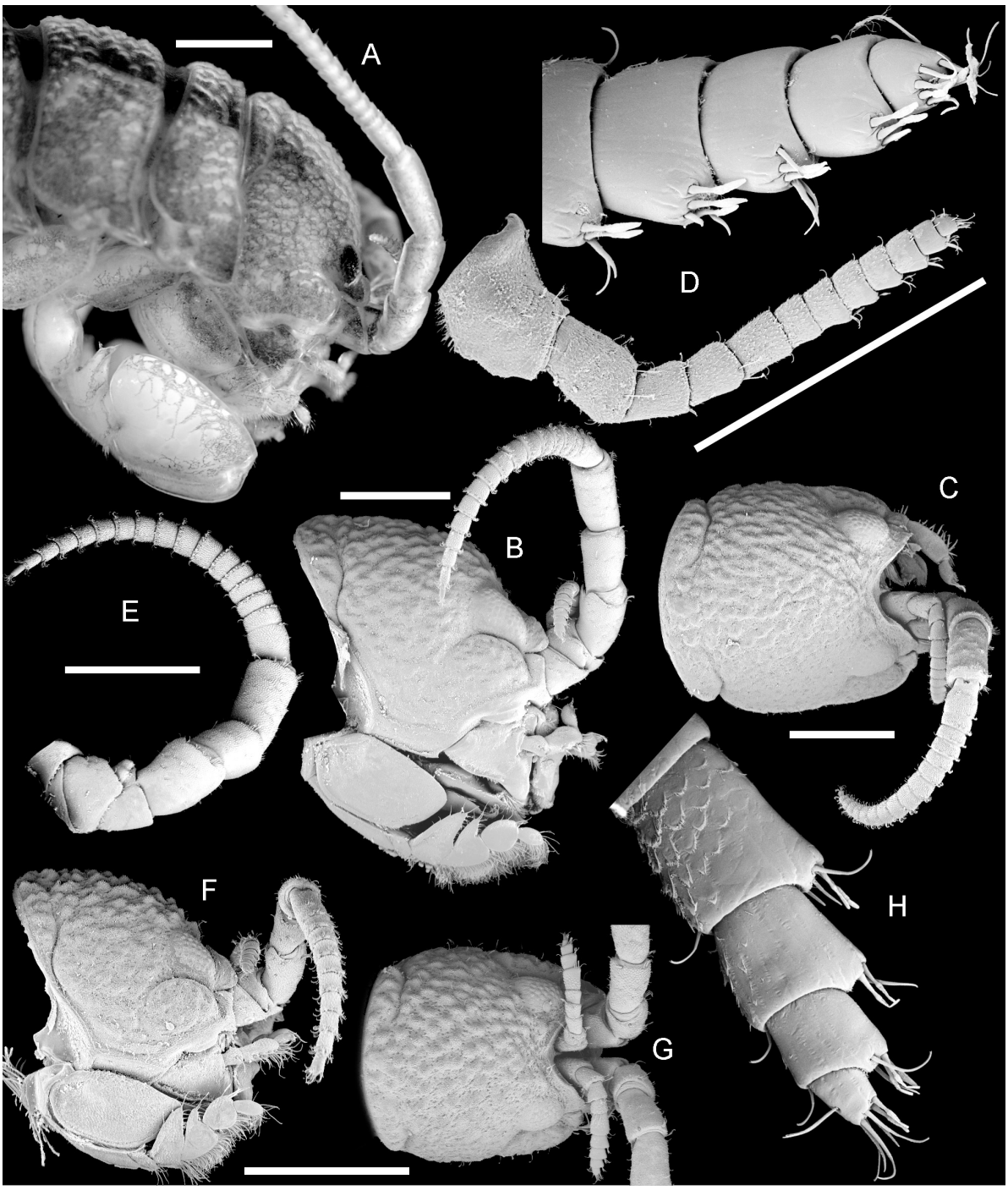

FIGURE 172. *Eophreatoicus namarden* sp. nov., head and antennae. Holotype male, AM P.72624, A, head lateral. Paratype male, AM P.72625: B–E, head lateral, head dorsal, antennula with enlargement of distal tip, antenna. Paratype female, AM P. 72626: F–H, head lateral, head dorsal, antennula distal tip enlargement. Scales 1 mm.



FIGURE 173. *Eophreatoicus namarden* sp. nov., anterior pereopods. Paratype male, AM P.72625: A–C, pereopod I, palm region and enlargement of spine row setae, pereopod II with enlargement of epaulet. Paratype female, AM P. 72626: D–E, pereopod I and palm region. F, pereopod II with enlargement of epaulet. Scales 1 mm.

Pereopods II–III ratios. Pereopod II. Length:body length 0.28–0.29 male (M2, H), 0.28 female (F3). Basis length:pereopod length 0.30–0.31 male (H, M2), 0.30 female (F3); length:width 2.00–2.10 male (H, M2), 2.00 female (F3). Carpus length:pereopod length 0.11–0.12 male (M2, H), 0.10 female (F3); length:width 1.20–1.30 male (M2, H), 1.10 female (F3). Propodus length:pereopod length 0.17–0.18 male (H, M2), 0.16 female (F3); length:width 2.50–2.70 male (M2, H), 1.90 female (F3). Dactylus length:propodus length 0.46–0.53 male (H, M2), 0.64 female (F3); primary claw length:dactylar length 0.25 male (M2), 0.32 female (F3). *Pereopod III.* Length:body length 0.28 male (M2), 0.30 female (F3). Basis length:pereopod length 0.32 male (M), 0.32 female (F3); length:

width 2.20 male (M2), 2.10 female (F3). Carpus length:pereopod length 0.09 male (M2), 0.09 female (F3); length: width 0.96 male (M2). Propodus length:pereopod length 0.15 female (F3); 2.50 female (F3). Dactylus length: propodus length 0.57 female (F3). *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, ischium, carpus, propodus, and also ventral margin of propodus; basis dorsal ridge with 2 setae on proximal knob in M2, 4 setae (longer than those in M2) on proximal knob in F3. Ischium II–IV of male dorsal margin with 2–3 simple setae (M2 pereopod II, pereopod IV), none robust. Dactylus ventral to primary claw, 0.19–0.35 length of primary claw, with scales on ventral margin; 7 altogether (F2 pereopod II; unclear in male).

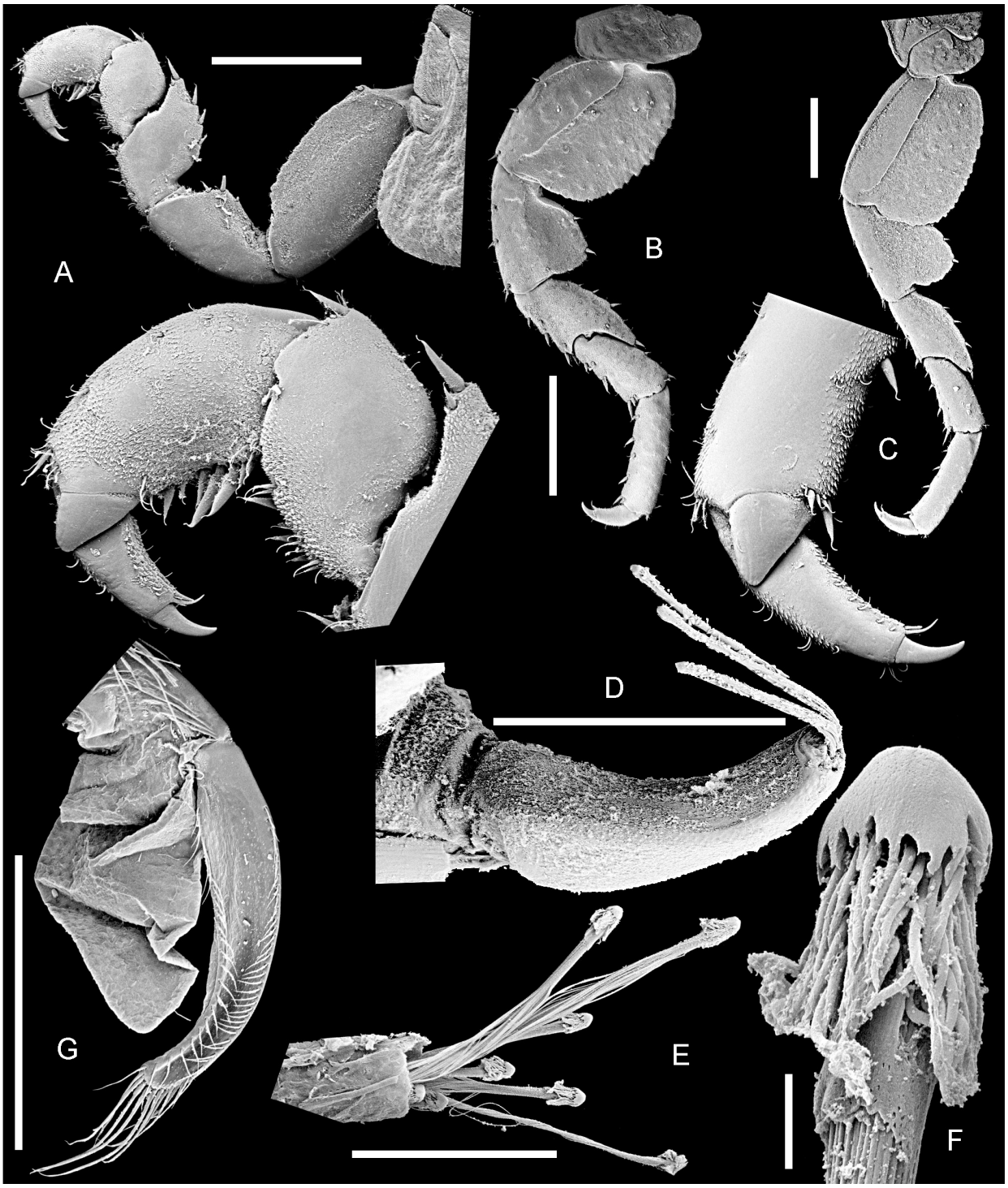

FIGURE 174. *Eophreatoicus namarden* sp. nov., posterior pereopods and pleopod II, paratype male, AM P.72625. A, pereopod IV with enlargement of palm region. B, pereopod V. C, pereopod VII with enlargement of medial articular plate. D–F, penes, projecting sperm bundles, enlargement of sperm bundle head showing sperm heads and protein cap. G, pleopod II endopod with appendix masculina. Scales: A–C, G, 1 mm; D, 0.5 mm; E, 0.2 mm; F, 10 micrometers.

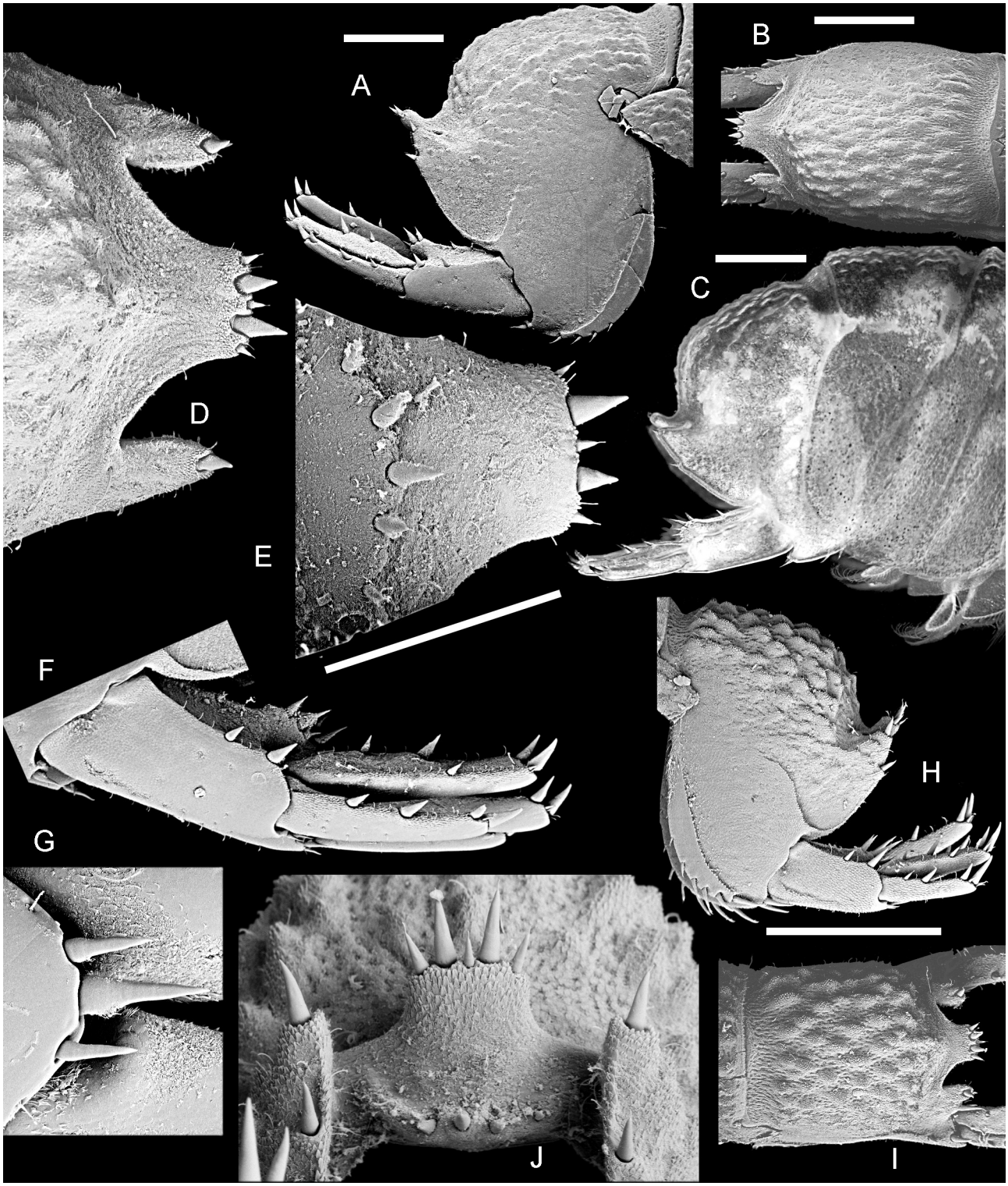

FIGURE 175. *Eophreatoicus namarden* sp. nov., pleotelson and uropods. Paratype male, AM P.72625: A–B, pleotelson, lateral and dorsal; D–E, pleotelson, dorsal posterior margin, ventral apex with preanal ridge setae; F–G, uropod, lateral and protopod posteroventral margin setae. Holotype male, AM P.72624: C, posterior pleon and uropod. Paratype female, AM P. 72626: H–I, pleotelson, lateral and dorsal; J, pleotelson apex, posterior with preanal ridge setae. Scales: A–C, H–I, 1 mm; E, 0.5 mm;

Pereopod II. Basis lateral face without setae in male and two elongate simple setae proximally in female. Basis of male dorsal ridge epaulet without submarginal setal row, main setal row with 3 minor setae (M2), without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 2 minor setae (F3), submarginal setal row with 1 setae, without major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 1 setae, dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 3 setae (M2). Carpus of male ventral margin with simple setae only. Propodus of male distal width 0.71 maximum width (M2), setae on ventral margin robust-based, 2 distinctly larger than remainder, shorter than dactylar claw. Dactylus of male distal accessory claw approximately 0.25 primary claw length. *Pereopod IV ratios.* Length:body length 0.22 male (M2). Basis length:width 2.10 male (M2). Carpus length: pereopod length 0.12 male (M2). Propodus length:pereopod length 0.15 male (M2). Propodus length:width 1.70 male (M2).

Pereopods V–VII ratios. Pereopod V. Length:body length 0.28–0.30 male (M2, H), 0.29 female (F3). Basis length:width 1.10–1.40 male (M2, H). Carpus length:pereopod length 0.13–0.14 male (H, M2), 0.14 female (F3). Propodus length:pereopod length 0.18 male (H, M2), 0.18 female (F3). Dactylus claw length:dactylar length 0.37 male (M2). *Pereopod VI.* Length:body length 0.39 male (M2), 0.36 female (F3). Basis length:width 1.40 male (H, M2). Carpus length:pereopod length 0.12 female (F3). Propodus length:pereopod length 0.20 male (M2), 0.18 female (F3). *Pereopod VII.* Length:body length 0.39 male (M2). Basis length:width 1.30 male (M2). Carpus length: pereopod length 0.13 male (M2). Propodus length:pereopod length 0.18 male (M2). Dactylus claw length:dactylar length 0.32 male (M2).

Pereopods V–VII. Penicillate setae dorsodistally on carpus; dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 2–3 setae (pereopod V, pereopod VII). Propodus distal margins with 1–3 elongate robust or robust-based setae (M2 pereopod VII, M2 pereopod V). Dactylus accessory claw 0.28–0.30 primary claw length (M2 pereopod V, M2 pereopod VII). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with no setae, dorsal margin with 3 setae (M2, likely more, ridge partially covered).

Penes. Distally tapering; distal tip truncate.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 2.00 endopod proximal margin length (approximately greater than); distally with 9 setae; 68 setae altogether (M2).

Uropod. Of male total length 0.92–0.97 pleotelson length (M2, H); protopod of male length 0.46–0.48 uropod total length (M2, H). Uropod of female total length 0.93 pleotelson length (F3), protopod length 0.41 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.62 male (M2), 0.62 female (F3). Protopod of male dorsolateral margin shorter than dorsomedial margin setae (stubby); of female dorsolateral margin shorter than dorsomedial margin setae (not stubby). Protopod distoventral margin with 3 robust setae, without spinose setae, 3 robust simple setae. Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 5 altogether (M2); female dorsal margin with 6 robust setae (F3). Exopod length:endopod length 0.78–0.81 male (M2, H), 0.80 female (F3). Exopod of male dorsal margin with 4 robust setae (M2), female 6 robust setae (F3).

Distribution. Australia, Northern Territory, Kakadu National Park, Lightning Dreaming, Namarrgon Creek, above and below waterfall, a tributary of Nourlangie Creek, South Alligator River catchment.

Habitat. Among roots and leaf litter at margin of pools around waterfall.

Remarks. *Eophreatoicus namarden* sp. nov. co-occurs with *E. namimminya* sp. nov. at the waterfall and plunge pool of Lightning Dreaming, which allowed identifying many diagnostic characters for species of *Eophreatoicus*. In the phylogenetic analyses, this species is not clearly associated with any other clade. This species is the most tuberculate species in Kakadu National Park and is easily recognized. It also has the smallest eyes (diameter only 0.18 head depth).

Eophreatoicus barrkmarlam sp. nov.

(Figs 7E, 176–183)

urn:lsid:zoobank.org:act: F57D69F1-E755-407F-BD67-76E23FE3E0A6
"*Eophreatoicus* sp. 04".—Wilson *et al.*, 2009: 361. — Lins *et al.*, 2012: table S1.

Type material. Holotype male, bl 22.6 mm, AM P.76460, NT3. Paratypes collected with holotype: male, bl 24.8 mm, AM P.61302; male (M2), bl 26.7 mm, AM P.76461, SEM stubs AW154–162; male (M4), bl 32.5 mm, AM P.76463, SEM stub AW182; female, bl 16.3 mm, AM P.61302; female (F3), bl 14.7 mm, AM P.76462, SEM stubs

AW163–170; 357 inds, AM P.76459. Additional paratypes. NT5: 7 inds, AM P.76465. NT6: 73 inds, AM P.76466. CLH samples, 14.xi.2008: Stream 1, small creek along Jim Jim Road, 16 inds, AM P.97197; Stream 2, small creek along Jim Jim Road: 16 inds, AM P.97198; rock face of main waterfall: brooding female, AM P.81109, DNA GW093 Genbank CO1 MK995023 16S MN015023 18S MK961117.

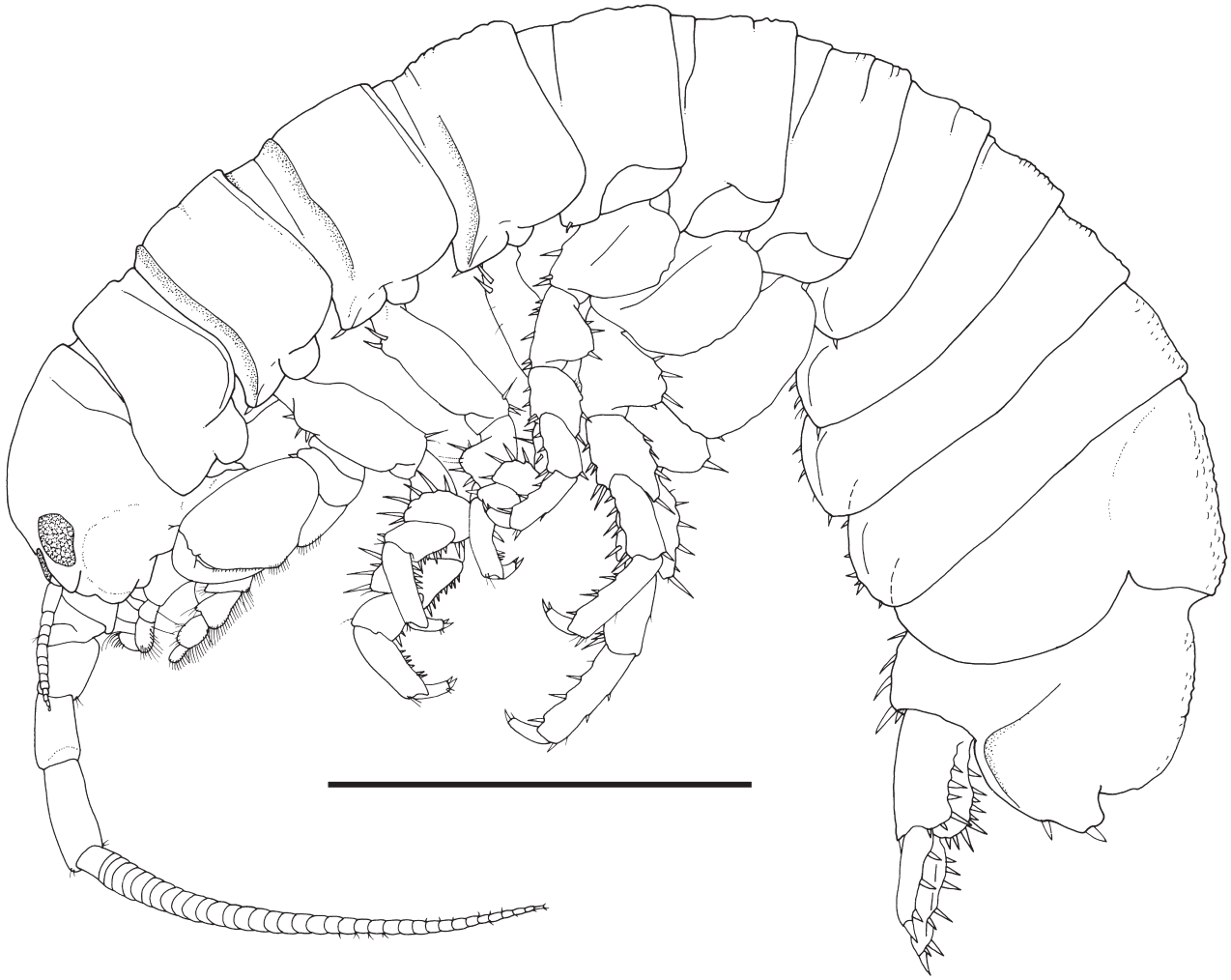

FIGURE 176. *Eophreatoicus barrkmarlam* sp. nov., holotype male line illustration, AM P.76460, left lateral, scale 5 mm.

Remarks on the Type material. Specimens in the initial collection were preserved with formaldehyde, so the pigment in the chromatophores was lost.

Type locality. Australia, Northern Territory, Kakadu National Park, Jim Jim Falls region. Coll. 16.viii.1994, G. Wilson W. Ponder & V. Kessner. NT3, spring flowing in Gorge adjacent to pool below Jim Jim Falls, 13°16.73'S, 132°49.84'E. Sites adjacent to type locality with additional paratypes: NT5, spring emerging near Jim Jim Road near base of escarpment, 13°15.26'S, 132°49.21'E; NT6, rapid flowing spring-fed stream crossing Jim Jim Road, ~4.1km from end of road, 13°15.28'S, 132°49.21'E. Sites collected by C. Humphrey close to the type locality with additional paratypes: 14.xi.2008: stream 1, small creek along Jim Jim Road, 13°15.170'S, 132°49.293'E; stream 2, small creek along Jim Jim Road, 13°15.263'S, 132°49.246'E; rock face of main waterfall, 13°16.366'S, 132°50.379'E (estimated).

Etymology. "Barrkmarlam" is the traditional owner name in the Kundjeyhmi Jawoyn dialect for Jim Jim Falls. "Barrk" means "black wallaroo". The name is pronounced "Barrk-marl-am", where the "rr" is a tapped sound and the "rl" is a retroflex sound ("marl" rhymes with North American English "Carl").

Diagnosis. *Head.* Eyes bulging dorsolaterally, height small, in lateral view less than width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface with scattered

small scales or roughness; pereonites 1–4 transverse dorsal ridges not expressed; pereonites 5–7 transverse dorsal ridges carinate with transverse trough. *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface rugose, with elongate ridge-like tubercles, with several median tubercles, not merging into ridge. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae, with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet length subequal to quarter basis length, main setal row with 3 major setae (M2). Basis of female dorsal ridge epaulet length subequal to quarter basis length, main setal row with 3 major setae (F3). *Pereopod IV.* Propodus of male ventral margin with projection, with 7 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge distinctly projecting dorsally with posterior margin exposed above shaft, in lateral view approximately straight; distal margin with 2 adjacent robust setae distinctly larger than others.

Description. Body length of largest male 32.5 mm, preparatory female 16.3 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface flattened curve. Width need pereonite dorsal view. Dorsal surface pitted; setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin concave, orientation of longest axis vertical, maximum diameter 0.27 head depth (H), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view smoothly curved. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

Pereon. Width near head width. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–4 in dorsal view respective lengths less than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites 1–5 of male dorsal length:maximum pleonite width ratios: need pic of pereonite - dorsal. Pleonites depth:pereonite 7 depth 1.20 pleonite 1 (H), 1.40 pleonite 2 (H), 1.60 pleonite 3 (H), 1.70 pleonite 4 (H), 1.60 pleonite 5 (H).

Pleotelson. Dorsal surface length 1.30 width in dorsal view (M2). Dorsal surface sparsely covered with setae; with cuticular combs on tubercles. Depth 1.50 pereonite 7 depth (H). Lateral length less than depth, in male 0.78–0.79 depth (H, M2), in female 0.79 depth. Lateral length 0.13–0.14 body length (M2, H). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.40 width of uropodal insertion (M2), with single row of simple robust setae grading anteriorly to fine setae, including 4 robust setae altogether (M2), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.19 pleotelson total length (M2). Posterior apex length less than width, long. Posterior apex 0.16 pleotelson total length (M2), width 0.30 pleotelson width (M2). Posterior apex in lateral view forming an angle of 51–76° with immediately anterior dorsal surface (M2, F3), angled 144–145° from horizontal (F3, M2).

Antennula. Length 0.09 body length in male (M2), 0.10 body length in female (F3), with 15 articles in male (M2), with 13 articles in female (F3). Article 5 length 1.20–1.30 width (F3, M2). Article 6 length 0.69–0.96 width (M2, F3). Aesthetascs small (2) mostly on distomedial margins. Terminal article length 1.20–1.30 width (M2, F3), 0.03–0.04 antennula total length (M2, F3). Distal articles oval in cross-section.

Antenna. Length 0.44 body length in female (F3). Flagellum length 0.68 total antenna length in female (F3), with 35 articles in female (F3), proximal articles surface scaled only on distal margin, proximal articles distal margin with rosette of short setae.

Mandible. Palp article 3 with 12–21 setae (F3,10 short and 2 long setae; M2,19 short and 2 long setae), setae on margin finely setulate, medial surface without additional setae, medial surface without setules (few cuticular hairs but not approaching the condition found in *E. gubara* sp. nov.), surface covered with cuticular hairs, with surface cuticular combs. Palp article setae with 1 seta on article 1, with a group of setae (longer than half article length) on dorsolateral margins article 2. Left molar process triturating surface posterodorsal ridge not projecting.

Maxillula. Medial lobe length 0.65 lateral lobe length (M2); width less than lateral lobe, width 0.51 lateral lobe width (M2); with 6–7 pappose setae (F3, M2); with simple accessory setae, 2 altogether, one on distolateral margin and one between central pappose setae, without short weakly setulate seta on distal tip. Lateral lobe distal margin narrow, distal setal row with 4 robust setae, with 7 denticulate robust setae, with 5 smooth robust setae. Lateral lobe

ventral face with 2 plumose setae (lightly plumose), setae closely spaced, additional plumose seta among proximal distal robust setae.

Maxilla. Medial lobe proximal portion without inflection with distal portion. Outer lateral lobe longer than inner lateral lobe. Outer lateral lobe distal margin setal row approximately linear and transverse to lobe axis, both lateral lobes with bidenticulate setae on distal tips and on medial margin.

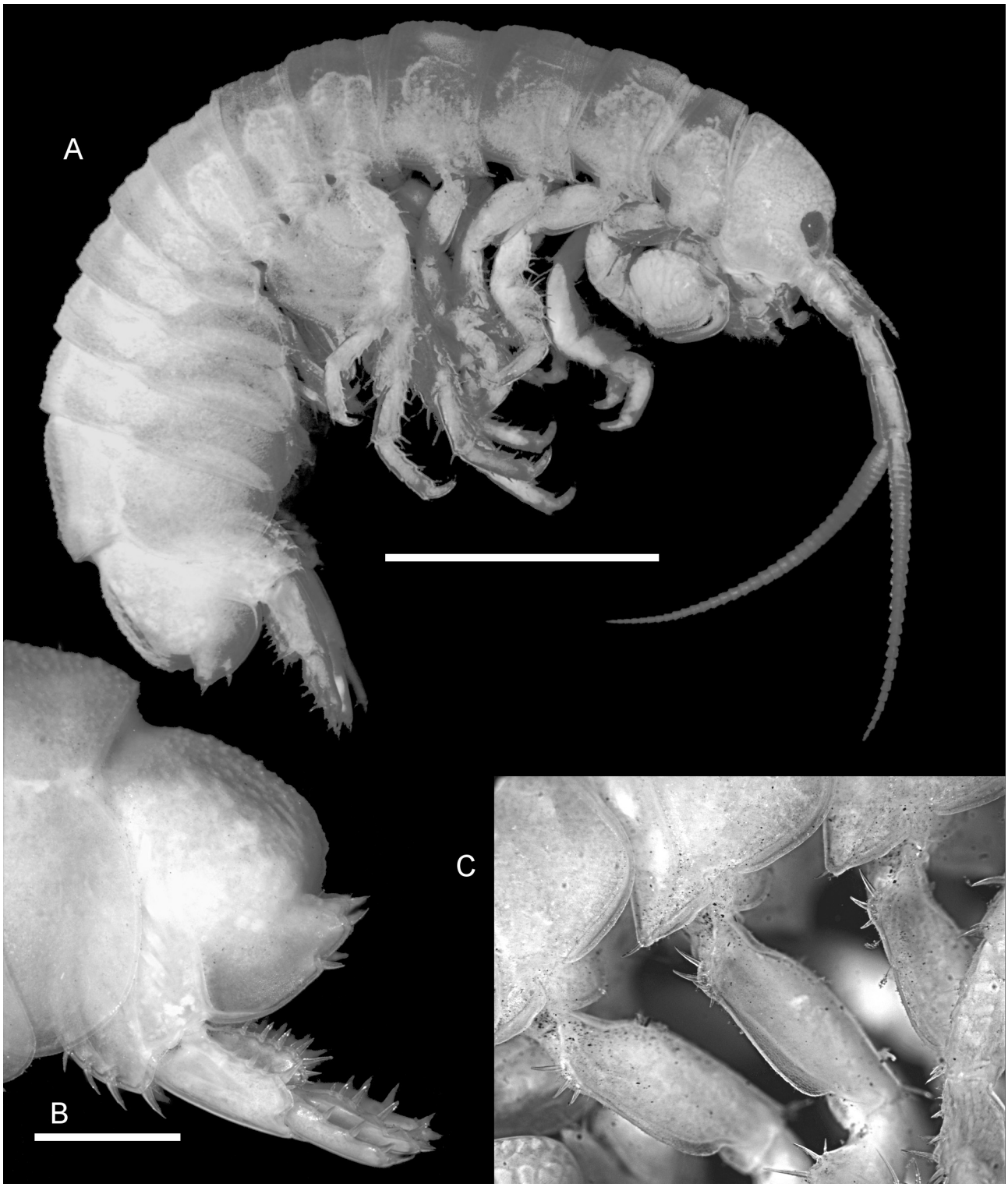

FIGURE 177. *Eophreatoicus barrkmarlam* sp. nov., holotype male, AM P.76460. A, lateral,; B, pleotelson, lateral; C, bases of pereopods II–IV. Scales A, 5 mm; B, 1 mm.

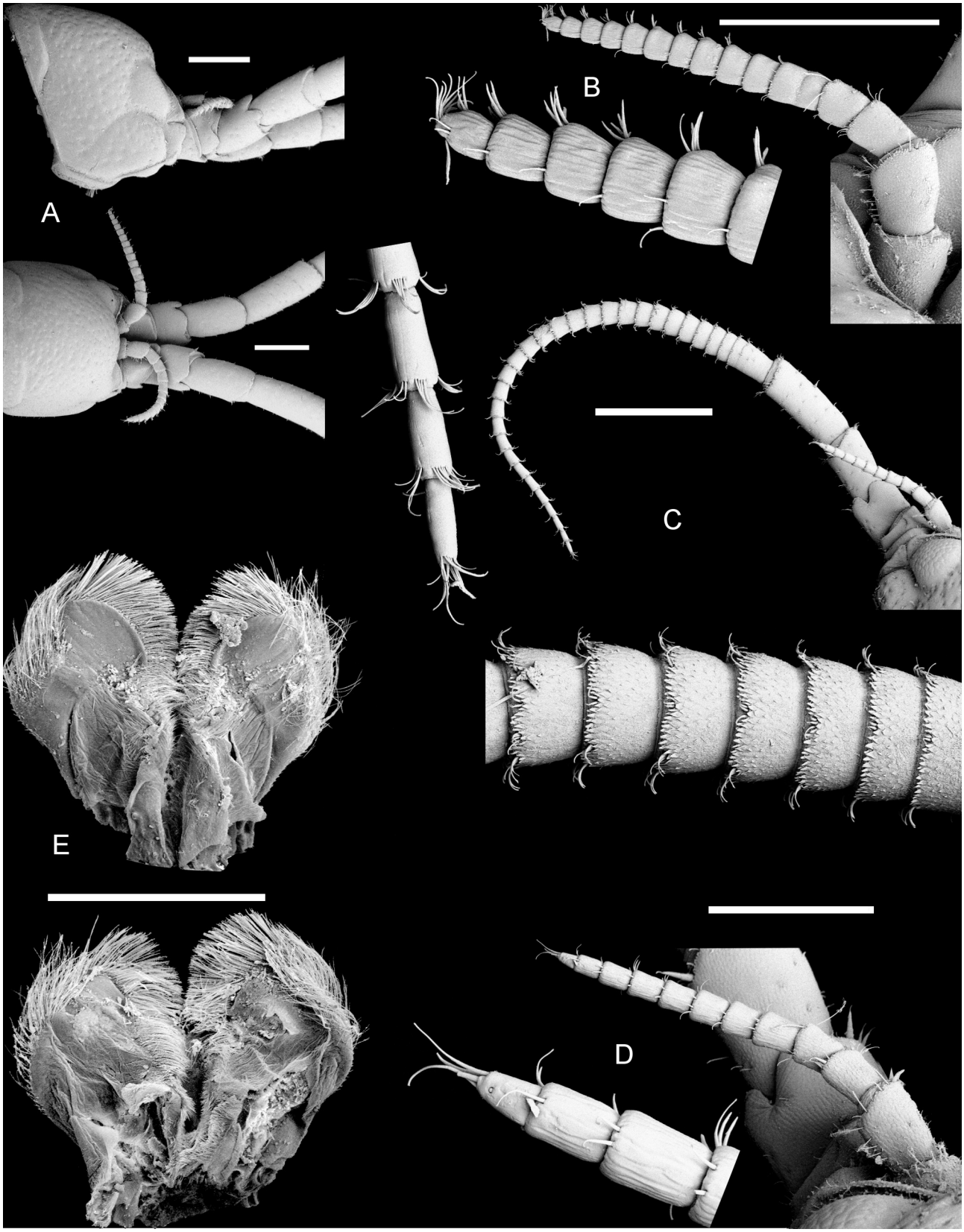

FIGURE 178. *Eophreatoicus barrkmarlam* sp. nov., head, antennae and paragnaths. Paratype male, AM P.76461: A, head, lateral and dorsal; B, antennula with enlargement of distal tip; E, paragnaths, ventral and dorsal. Paratype female, AM P.76462: C, antenna in situ, with enlargements of flagellar articles and distal tip; D, antennula with enlargement of distal tip. Scales A–C, E, 1 mm; D, 0.5 mm.

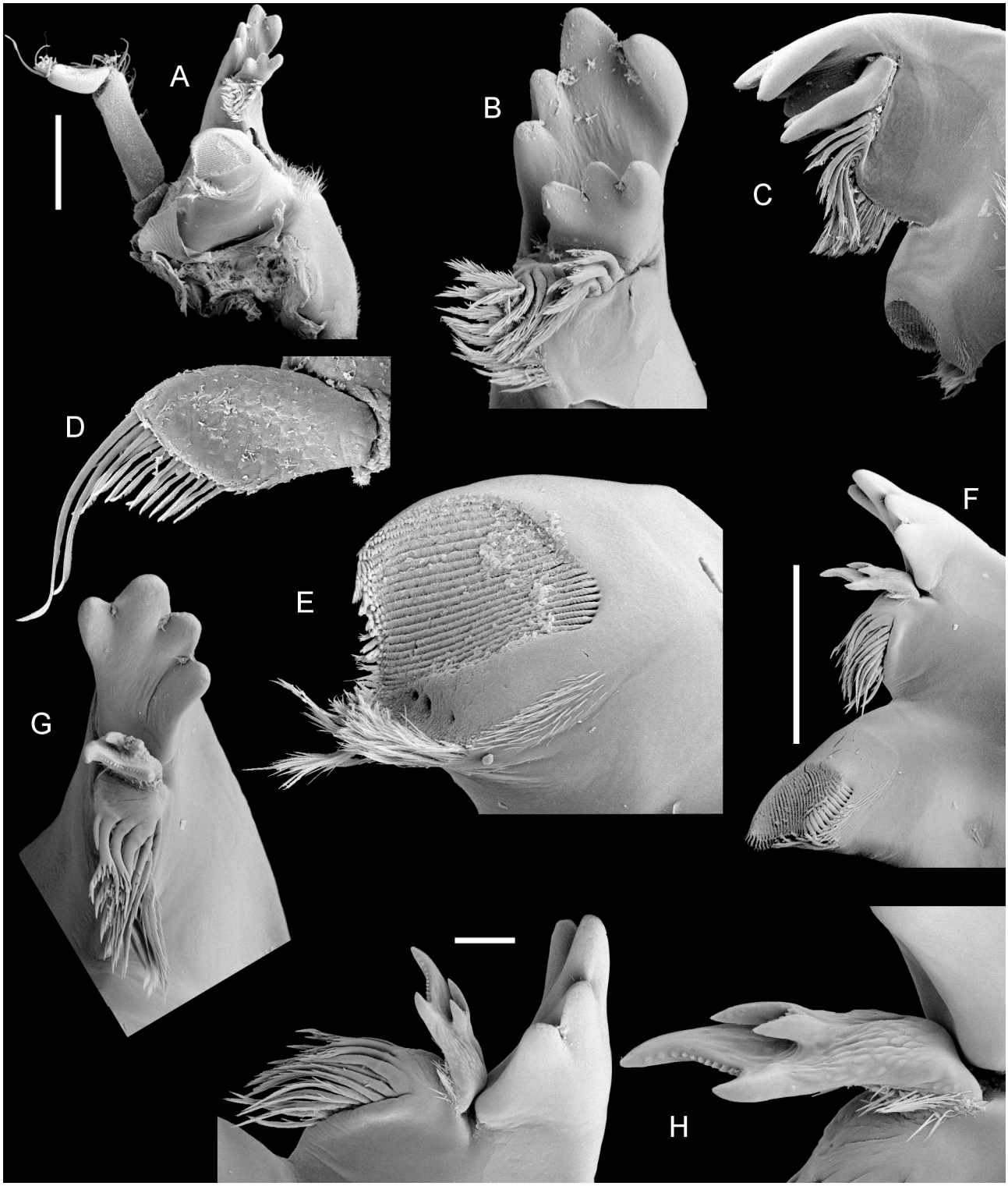

FIGURE 179. *Eophreatoicus barrkmarlam* sp. nov., paratype male, AM P.76461, mandibles. A, left mandible, medial. B, left gnathal tip, medial. C, left gnathal edge, ventral. D, left palp article 3 dorsal. E, left molar process, medial, showing three pores on posterior margin. F, right gnathal edge, dorsal. G–H, right gnathal tip, medial and dorsal, with enlargement of right lacinia mobilis. Scales: A, 1 mm; G–H, 0.1 mm.

Maxilliped. Epipod distal tip rounded, length 1.20 width (F). Endite medial margin with 5 coupling hooks on right side (M2, F3); 5–6 coupling hooks on left side (F3, M2). Endite distal margin fine setae, in fringe, with fine cuticular combs, in lateral group. Endite dorsal ridge with 25 large distally denticulate plumose setae. Palp insertion on basis lateral margin with 2 plumose setae, without medial margin plumose setae. Palp insertion on basis ventral

surface without subdistal smooth setae, without ventral surface subdistal biserrate setae. Palp width across articles 2–3 2.20 endite width (M2). Palp article 4 length 1.10 width (M2).

Pereopod I. Length:body length 0.32 male (M2), 0.31 female (F3). Basis of male length 2.10 width (M2), female length 2.30 width (F3); dorsal setae positioned proximally, 1 dorsal seta altogether (M2); female dorsal setae positioned proximally, female 2 dorsal setae altogether (F3); female with 2–3 elongate setae (F3, 2 long 1 short), elongate setae longer than ischium. Ischium of male dorsal margin without simple setae. Ischium of female dorsal margin with 2 simple setae (F3), setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (2 short robust); female distodorsal margin with numerous elongate simple setae, female dorsal surface with setae along dorsal axis (3 simple decreasing in size proximally). Propodus length:pereopod length 0.23 male (M2), 0.21 female (F3). Propodus length:width 1.10 male (M2), 1.40 female (F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 3 setae altogether (excluding distal group) (M2), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae articulation not expressed, 33 altogether. Propodal palm of female margin convex, stout denticulate setae serrate, 11 altogether (F3), with stout robust conical setae, 4 altogether (F3, two distally and two proximally). Dactylus of male shorter than palm, length:palm length 0.83 (M2), female shorter than palm, female length:palm length 0.91 (F3). Dactylus of female ventrodistal margin distal cuticular fringe length 0.73 total length (F3). Dactylus claw length:dactylus length 0.11 male (M2), 0.18 female (F3). Dactylus of male positioned ventrally, 0.47–0.49 (M2, F3) length of primary claw.

Pereopods II–III ratios. Pereopod II. Length:body length 0.30 male (M2), 0.29 female (F3). Basis length: pereopod length 0.30 male (M2), 0.28 female (F3); length:width 2.00 male (M2), 1.80 female (F3). Carpus length: pereopod length 0.14 male (M2), 0.12 female (F3); length:width 1.60 male (M2), 1.40 female (F3). Propodus length: pereopod length 0.15 male (M2), 0.17 female (F3); length:width 2.30 male (M2), 2.50 female (F3). Dactylus length: propodus length 0.54 male (M2), 0.49 female (F3); primary claw length:dactylar length 0.32 male (M2), 0.36 female (F3). *Pereopod III.* Length:body length 0.30 male (M2), 0.31 female (F3). Basis length:pereopod length 0.30 male (M2), 0.28 female (F3); length:width 2.00 male (M2), 1.90 female (F3). Carpus length:pereopod length 0.12 male (M2), 0.13 female (F3); length:width 1.50 male (M2), 1.60 female (F3). Propodus length:pereopod length 0.16 male (M2), 0.17 female (F3); length:width 2.60 male (M2), 2.30 female (F3). Dactylus length:propodus length 0.47 male (M2), 0.45 female (F3); primary claw length:dactylar length 0.35 male (M2), 0.38 female (F3). *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, ischium, carpus, propodus; basis dorsal ridge with elongate setae forming 2 rows on proximal projection. Ischium II–IV of male dorsal margin with 5–6 simple setae (M2 pereopod II, pereopod III), none robust. Dactylus ventral to primary claw, 0.28–0.29–0.34 length of primary claw, with scales on ventral margin; 20–39–90 altogether (F3 pereopod III, F3 pereopod II, M2 pereopod II).

Pereopod II. Basis lateral face 2–3 short robust setae proximally in male and 7 elongate simple setae along margin in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 3 minor setae (when present), submarginal setal row with 3 setae (M2), without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 1 minor setae (F3, or more, obscured), submarginal setal row with 2 setae (F3, or more, obscured), without major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus, of female occurring on dorsal margin of basis or anterodorsal margins of propodus or anterodorsal margins of carpus. Basis of male dorsal ridge with 4 setae (M2), dorsal ridge setae positioned proximally, of female dorsal ridge with 4 setae (F3), dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 5 setae (M2), female dorsal margin with 7 setae (F3). Carpus of male ventral margin with single setal row, with robust-based setae in addition to simple, with 6 robust-based setae. Carpus of female ventral margin with simple setae. Propodus of male distal width 0.77 maximum width (M2), setae on ventral margin robust, 2 distinctly larger than remainder, subequal in length to dactylar claw. Propodus of female not in female, posterior side of limb articular plate subequal in length to dactylar claw. Dactylus of male distal accessory claw approximately 0.5 primary claw length, female distal accessory claw approximately 0.5 length of primary claw (F3,0.42). *Pereopod IV ratios.* Length:body length 0.27 male (M2), 0.29 female (F3). Basis length:width 2.00 male (M2), 1.90 female (F3). Carpus length:pereopod length 0.11 male (M2), 0.13 female (F3). Propodus length:pereopod length 0.14 male (M2), 0.15 female (F3). Propodus length:width 2.00 male (M2), 2.50 female (F3).

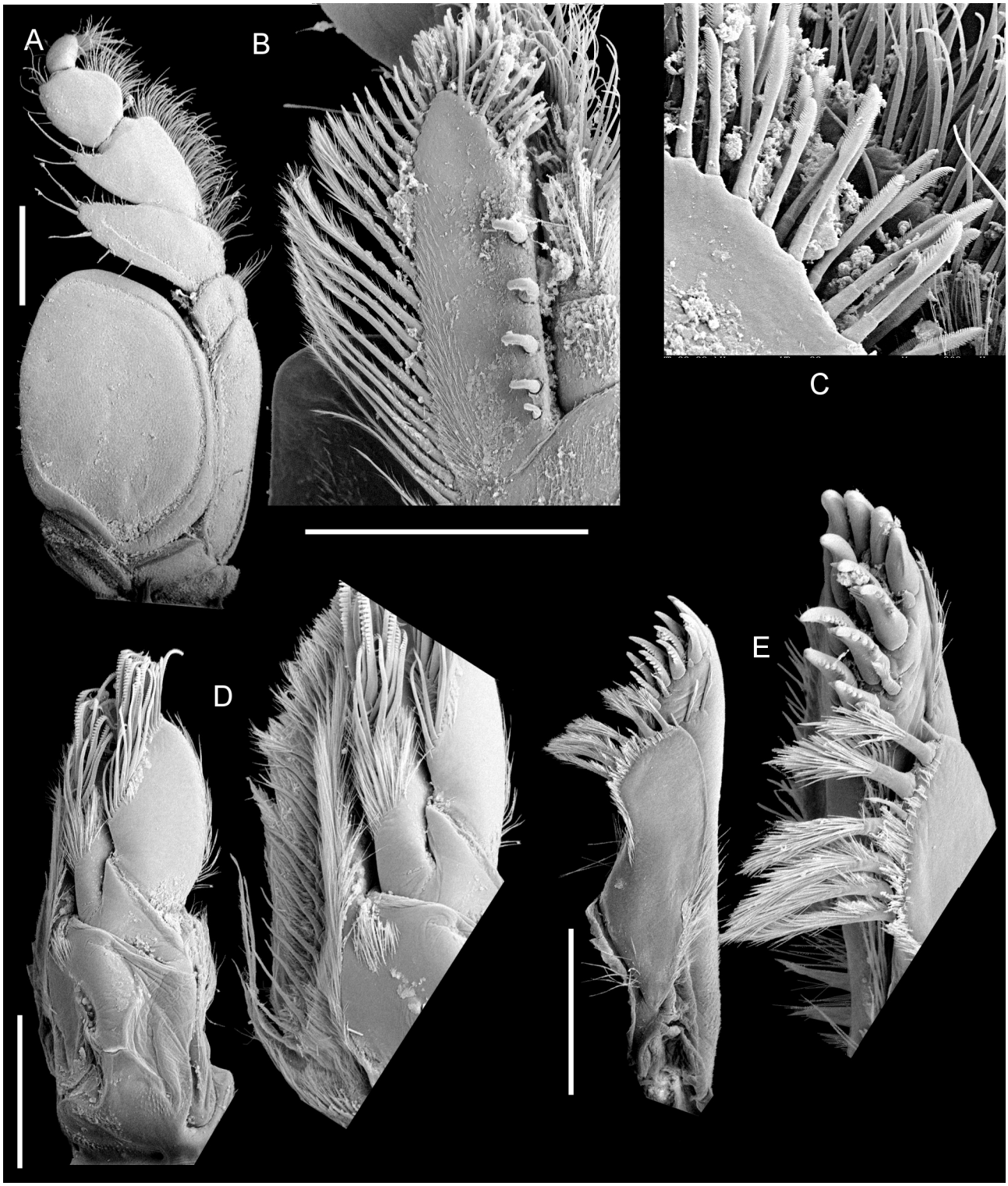

FIGURE 180. *Eophreatoicus barrkmarlam* sp. nov., paratype male, AM P.76461, mouthparts. A, maxilliped. B–C, maxillipedal endite, medial, with enlargement of distal setae. D, maxilla with enlargement of medial setation. E, maxillula with enlargement of distal setation in medial. Scales 0.5 mm.

Pereopods V–VII ratios. Pereopod V. Length:body length 0.26 male (M2), 0.28 female (F3). Basis length:width 0.93 male (M2), 0.97 female (F3). Carpus length:pereopod length 0.15 male (M2), 0.14 female (F3). Propodus length:pereopod length 0.16 male (M2), 0.17 female (F3). Dactylus claw length:dactylar length 0.32 male (M2), 0.34 female (F3). *Pereopod VI.* Length:body length 0.35 male (M2), 0.37 female (F3). Basis length:width 1.20 male (M2), 1.10 female (F3). Carpus length:pereopod length 0.15 male (M2), 0.15 female (F3). Propodus length:pereopod

length 0.17 male (M2), 0.16 female (F3). Dactylus claw length:dactylar length 0.38 male (M2), 0.39 female (F3). *Pereopod VII.* Length:body length 0.39 male (M2), 0.40 female (F3). Basis length:width 1.30 male (M2), 1.10 female (F3). Carpus length:pereopod length 0.17 male (M2), 0.15 female (F3). Propodus length:pereopod length 0.16 male (M2), 0.17 female (F3). Dactylus claw length:dactylar length 0.29 male (M2), 0.39 female (F3).

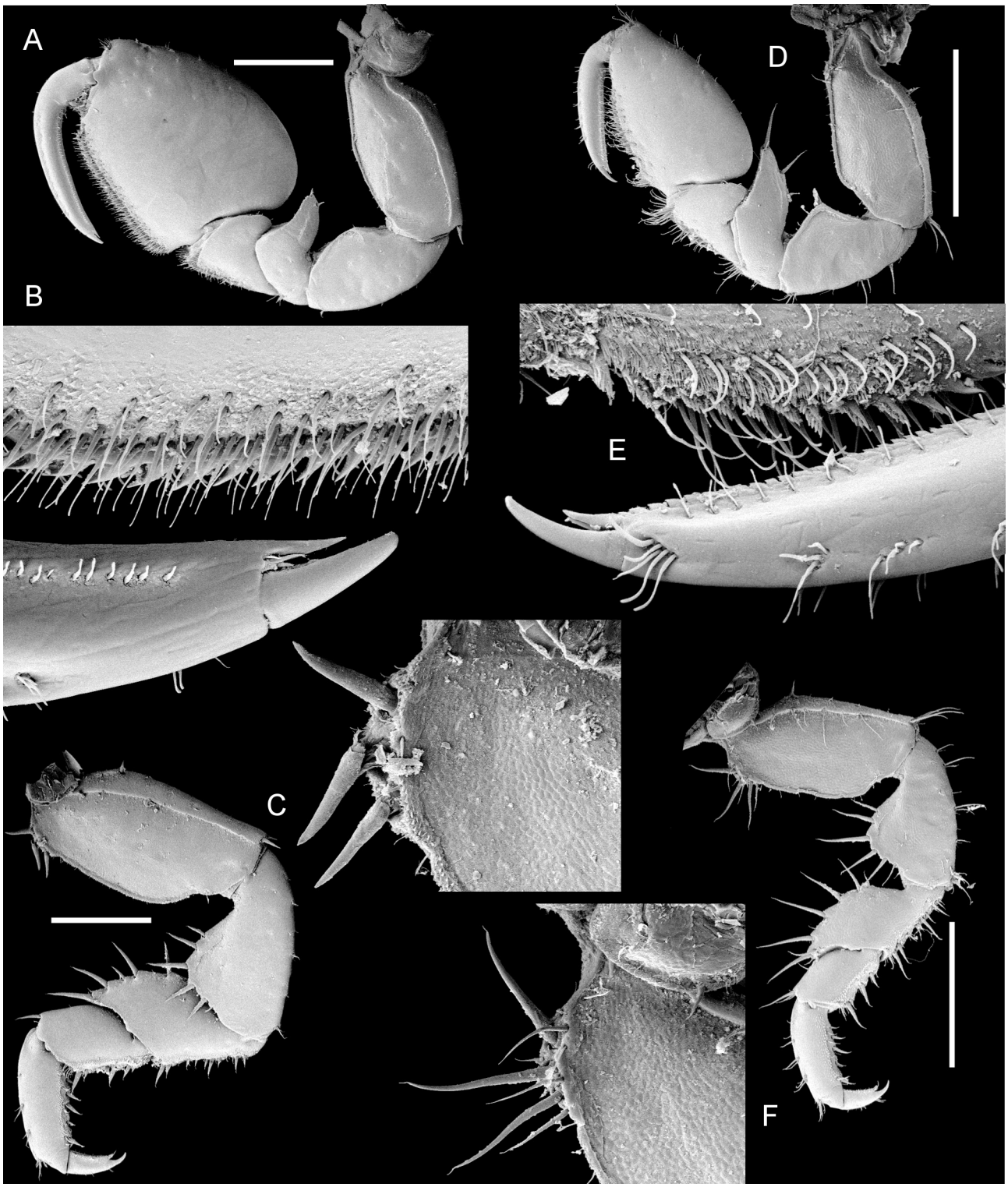

FIGURE 181. *Eophreatoicus barrkmarlam* sp. nov., pereopods I–II. Paratype male, AM P.76461: A–B, pereopod I and enlargement of palm setae and dactylus, lateral; C, pereopod II with enlargement of basis epaulet. Paratype female, AM P.76462: D–E, pereopod I and enlargement of palm setae and dactylus, medial; F, pereopod II with enlargement of basis epaulet. Scales 1 mm.

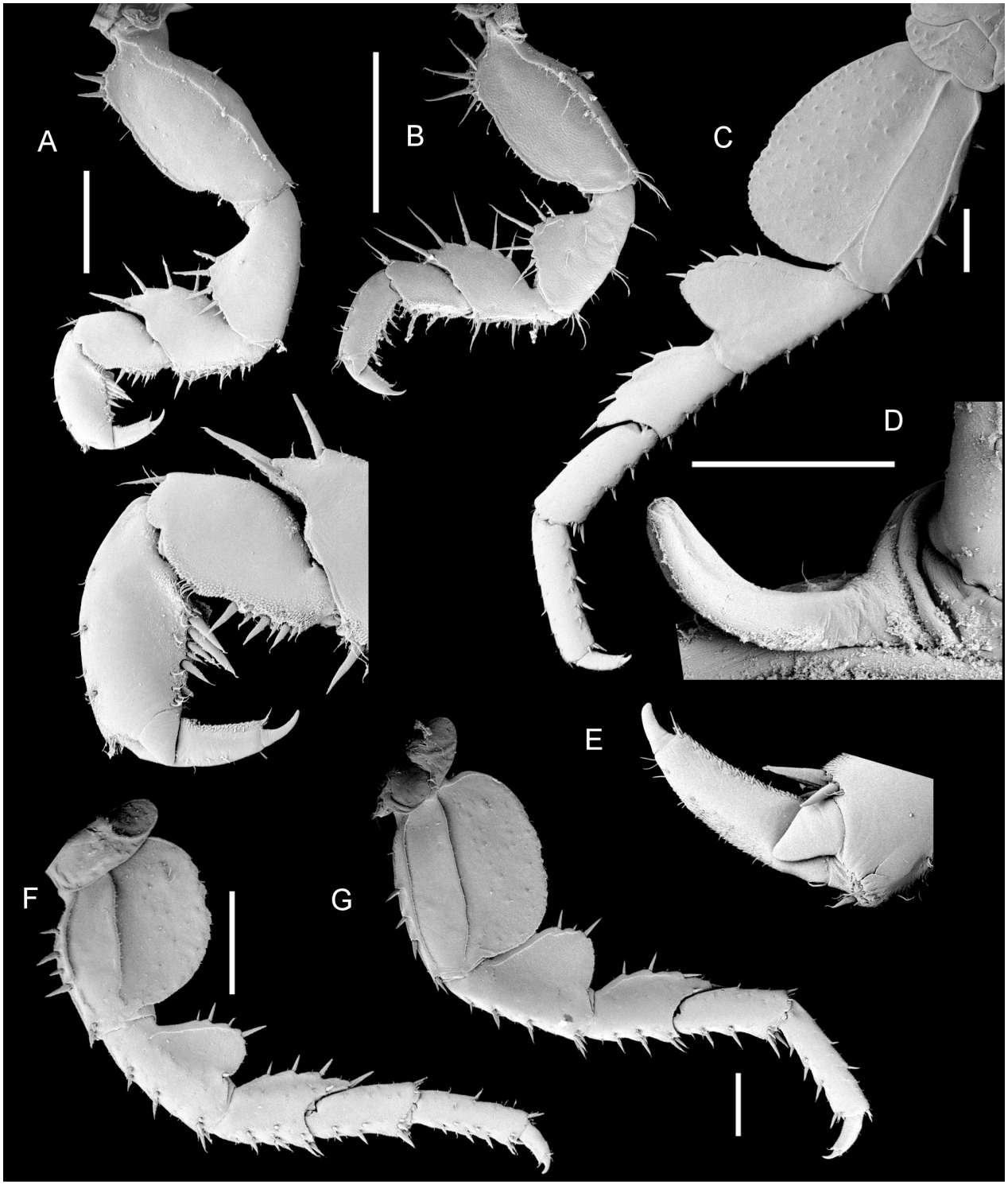

FIGURE 182. *Eophreatoicus barrkmarlam* sp. nov., pereopods IV–VII. Paratype male, AM P.76461: A, pereopod IV with enlargement of palm; F, pereopod V; G, pereopod VI. Paratype male, AM P.76463, C, pereopod VII; D, penes; E, dactylus VII showing articular plate. Paratype female, AM P.76462: B, female pereopod IV. Scales 1 mm.

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin including 4–5 robust setae (M2 pereopod V, M2 pereopod VII). Propodus distal margins with 4 elongate robust or robust-based setae (M2 pereopod V, F3 pereopod V,VII). Dactylus accessory claw 0.21–0.24 primary claw length (M2 pereopod VII, pereopod V). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with no setae, dorsal margin with 5 setae (M2).

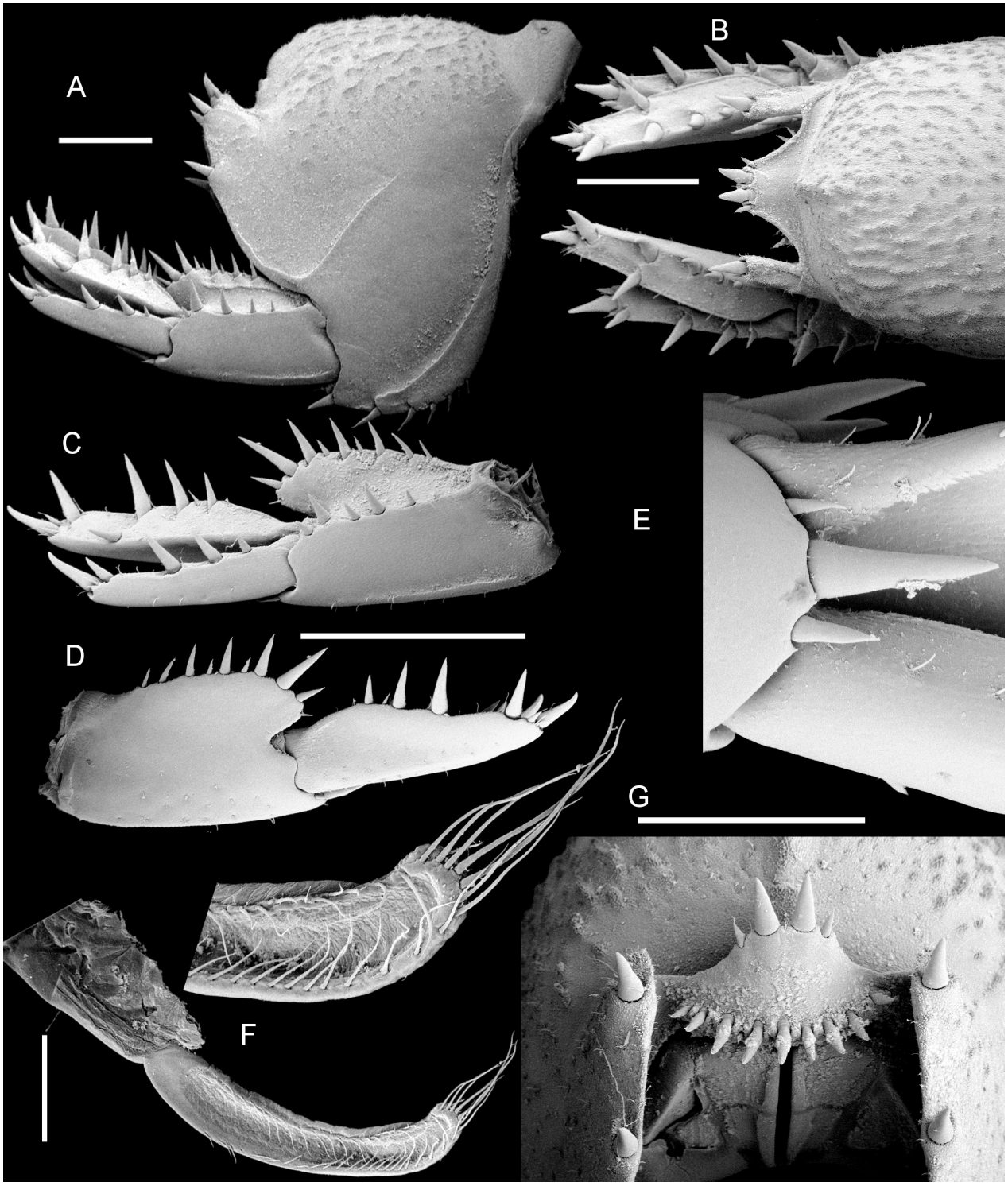

FIGURE 183. *Eophreatoicus barrkmarlam* sp. nov., pleotelson and uropods. Paratype male, AM P.76461, A–B, pleotelson, lateral and dorsal; F, pleopod II appendix masculina with enlargement of distal tip and stiff setae; G, pleotelson, posterior, showing postanal ridge with setae. Paratype female, AM P.76462: C–D, uropod, lateral and medial; E, protopod ventrodistal setae. Scales 1 mm.

Penes. Extending near midline; distally tapering; distal tip truncate.

Pleopods. Exopods I with lateral proximal lobe, with medial proximal lobes of pleopod I. Protopods medial margins II–V with large projections, of male medial margins with minutely serrate setae, of male medial margins pleopod I 11 simple setae on margin and 6 minutely serrate on vertical ridge half way along medial lobe ventral surface; pleopods II–V 5/16/8/16 minutely serrate setae respectively, of female medial margins with minutely serrate

setae, of female medial margins pleopod I 11 simple setae on margin and 6 minutely serrate on vertical ridge half way along medial lobe ventral surface; pleopod II 9 minutely serrate setae; pleopods III–V minutely serrate setae (in similar numbers to male); protopod II lateral epipod lobe-like, in male pleopod I has 22 minutely serrate setae on proximal half of lateral epipod; pleopods II–V have 53/56/56/68 simple & minutely serrate setae respectively (the positions & numbers respectively for the 4 pleopods are 33/40/38/40 minutely serrate setae on the epipod's medial margin, and 20/16/18/28 short simple & long minutely serrate setae on the epipod's lateral margin), in female pleopod I has 12 minutely serrate setae on proximal half of lateral epipod; pleopods II has 34 simple & minutely serrate setae (22 minutely serrate setae on the epipod's medial margin, and 12 short simple & long minutely serrate setae on the epipod's lateral margin); pleopods III–V have many simple & minutely serrate setae (in similar numbers to the male).

Pleopod I exopod of male distal margin rounded, dorsal surface lacking setae. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 1.80 endopod proximal margin length; distally with 7 setae; 51 setae altogether (M4).

Uropod. Of male total length 1.10 pleotelson length (M2); protopod of male length:width 2.80 (M2), length 0.52 uropod total length (M2). Uropod of female total length 1.00 pleotelson length (F3), protopod length:width 3.20 (F3), protopod length 0.54 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.77 male (M2), 0.79 female (F3). Protopod of male dorsolateral margin shorter than dorsomedial margin setae; of female dorsolateral margin shorter than dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, without spinose setae, 3 robust simple setae. Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae placed midlength, 4 altogether (M2); female dorsal margin with 4 robust setae (F3). Exopod length:endopod length 0.84 male (M2), 0.85 female (F3). Exopod length: protopod length 0.90 male, 0.86 female. Exopod of male dorsal margin with 4 robust setae (M2), female 4 robust setae (F3).

Distribution. Australia, Northern Territory, Kakadu National Park, streams crossing Jim Jim Road, spring emerging near Jim Jim Road, near base of escarpment, and spring flowing into pool adjacent to Jim Jim Falls Gorge, Jim Jim Creek, South Alligator River catchment.

Habitat. Among roots, gravel and under stones, spring fed streams flowing from escarpment or waterfall. Water temperature at the time of sampling 24–30°C (1994).

Remarks. *Eophreatoicus barrkmarlam* sp. nov. from the Jim Jim Falls differs from *E. kershawi* in not having a submarginal robust seta on pleotelson lateral plates (i.e. off the posterolateral margin). The largest males were found in this collection, some exceeding 3 cm (32.5 mm). Females are more setose and have somewhat larger eyes (see Remarks for *E. namimminya* sp. nov.). Small individuals may have a smoother cuticle and might lack the median ridge on the pleotelson. *Eophreatoicus barrkmarlam* sp. nov. is the sister species of *E. balbun* sp. nov.; they have only eight diagnostic character differences and have many overall similarities. The two species, however, differ by as many as 130 descriptive character differences. The eyes of *E. barrkmarlam* sp. nov. are smaller and protrude from head in a low arc (larger and protruding in a distinct arc); the transverse dorsal ridges of pereonites 5–7 are more carinate, associated with a transverse trough (trough not expressed); the female pereopod II basis epaulet has only 3 major setae (4 setae); and the male pereopod IV dactylus is longer than the propodal palm (shorter). The genetic divergence of this species pair is discussed further the remarks for *E. balbun* sp. nov. Specimens in the initial collection, NT4, were preserved with formaldehyde so the pigment in the chromatophores was lost.

Eophreatoicus balbun **sp. nov.**

(Figs 9B, 184–189)

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Eophreatoicus sp. "04".—Wilson *et al.*, 2009: 361.

Type material. Holotype male, 24.0 mm, P.76452, CH19981011. Paratypes collected with holotype: P.76450, 23 inds; P.76453, male 23.6 mm, DNA E99 GenBank EU263146 EU263215; P.76454, SEM stubs AW781–786; brooding female, 13 mm, DNA E100 GenBank CO1 EU263147 16S EU263216, SEM stubs AW787–790. Additional paratypes. KM19981024: male, AM P.76456, DNA E55 (unsuccessful); male, AM P.76458, DNA E56 (unsuccessful); preparatory female, AM P.76451, DNA E54 (unsuccessful); 10 inds, AM P.76455; 7 inds, AM P.76457. NT4: 172 inds, P.76464.

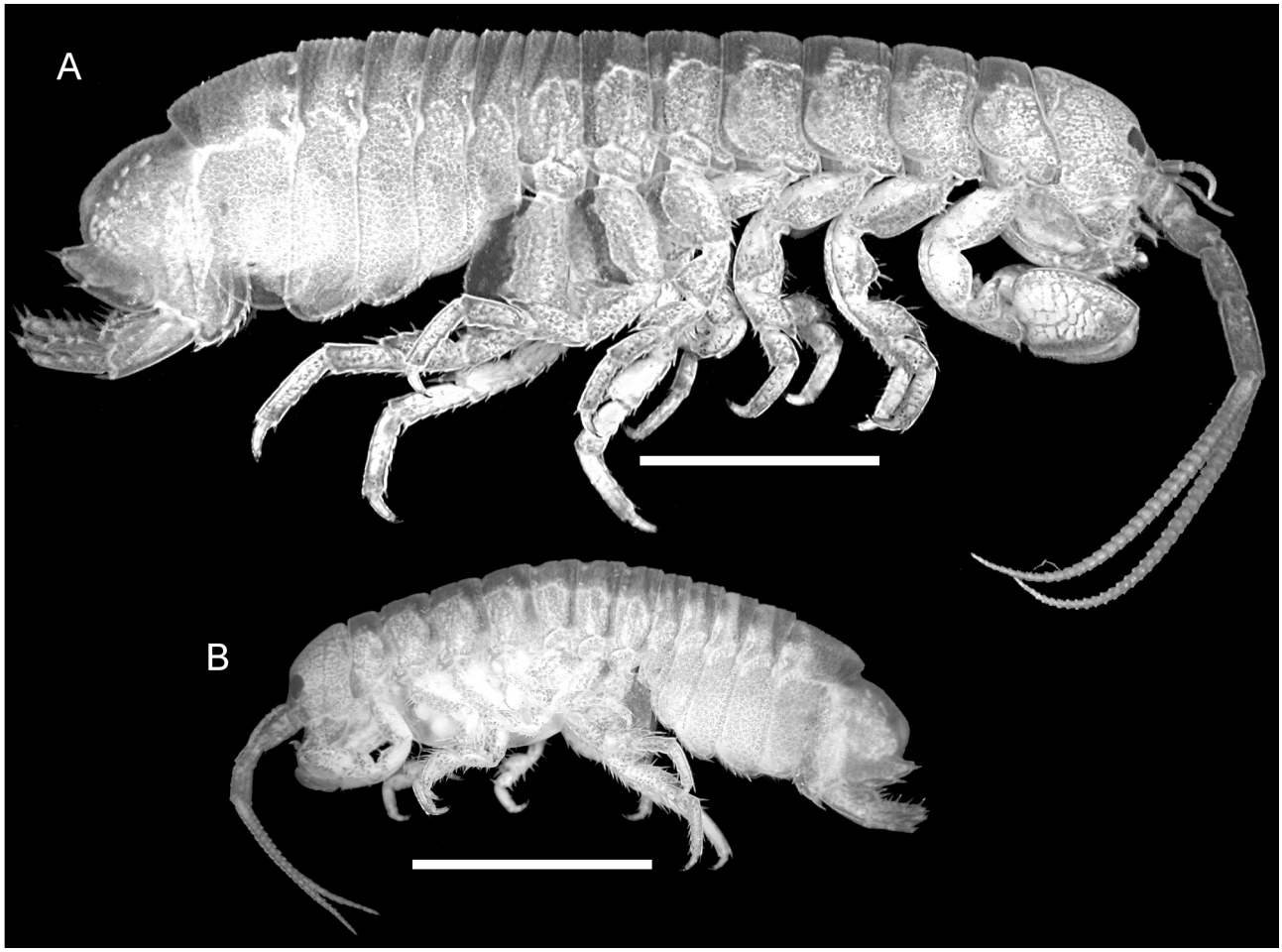

FIGURE 184. *Eophreatoicus balbun* sp. nov., habitus. A, holotype male, AM P.76452, lateral, scale 5 mm. B, paratype female, AM P.76454 lateral, scale 5 mm.

Type locality. Australia, Northern Territory, Kakadu National Park, Twin Falls region: CH19981011, seep to left of Twin Falls, 13°19.29'S, 132°46.85'E, coll. C. Humphrey, 11.x.1998. Sites adjacent to type locality with additional paratypes: CH19981024, stream west of Twin Falls, downstream of plunge pool, 13°19.00'S, 132°46.03'E, coll. C. Humphrey, 24.x.1998; KM19981024, stream west of Twin Falls, seep at base of waterfall, 13°19.05'S, 132°46.04'E, coll. 24.x.1998, K. McAlpine; NT4, Gorge to the west of Twin Falls, 13°18.99'S, 132°46.38'E, coll. W. Ponder, G. Wilson, 16.viii.1994.

Etymology. "Balbun" is recorded by George Chaloupka from Nipper Kapirikki as the Kundjeyhmi Jawoyn name for a site to the west of Twin Falls. Chaloupka also indicates that Twin Falls specifically are called Djudbirri but we have chosen the closer site name. The name is pronounced "bal-boon", where "bal" rhymes with English "hull".

Diagnosis. *Head.* Eyes bulging dorsolaterally, height medium, in lateral view subequal to width of basal antennal articles, height less than length in lateral view, bulging in dorsal view, projecting from head in distinct arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface with scattered small scales or roughness; pereonites 1–4 transverse dorsal ridges not expressed (increasingly defined posteriorly); pereonites 5–7 transverse dorsal ridges low without transverse trough. *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection concave. Dorsal surface rugose, with oblong tubercles, with several median tubercles, not merging into ridge. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view weakly narrowing distally, dorsal and ventral surfaces approximately parallel, with two pairs of robust setae (median setae larger than lateral setae), without fine setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth; female ventrodistal margin with multiple rows of thin scale-like spines. *Pereopod II.* Basis of male dorsal ridge epaulet

length less than quarter length of basis, main setal row with 3 major setae. Basis of female dorsal ridge epaulet length less than quarter length of basis, main setal row with 4 major setae. *Pereopod IV.* Propodus of male ventral margin with projection, with 6 robust setae on ventral margin. Dactylus of male length more than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge projecting dorsally with plate above shaft but posterior margin hardly exposed, in lateral view approximately straight; distal margin with 2 adjacent robust setae distinctly larger than others.

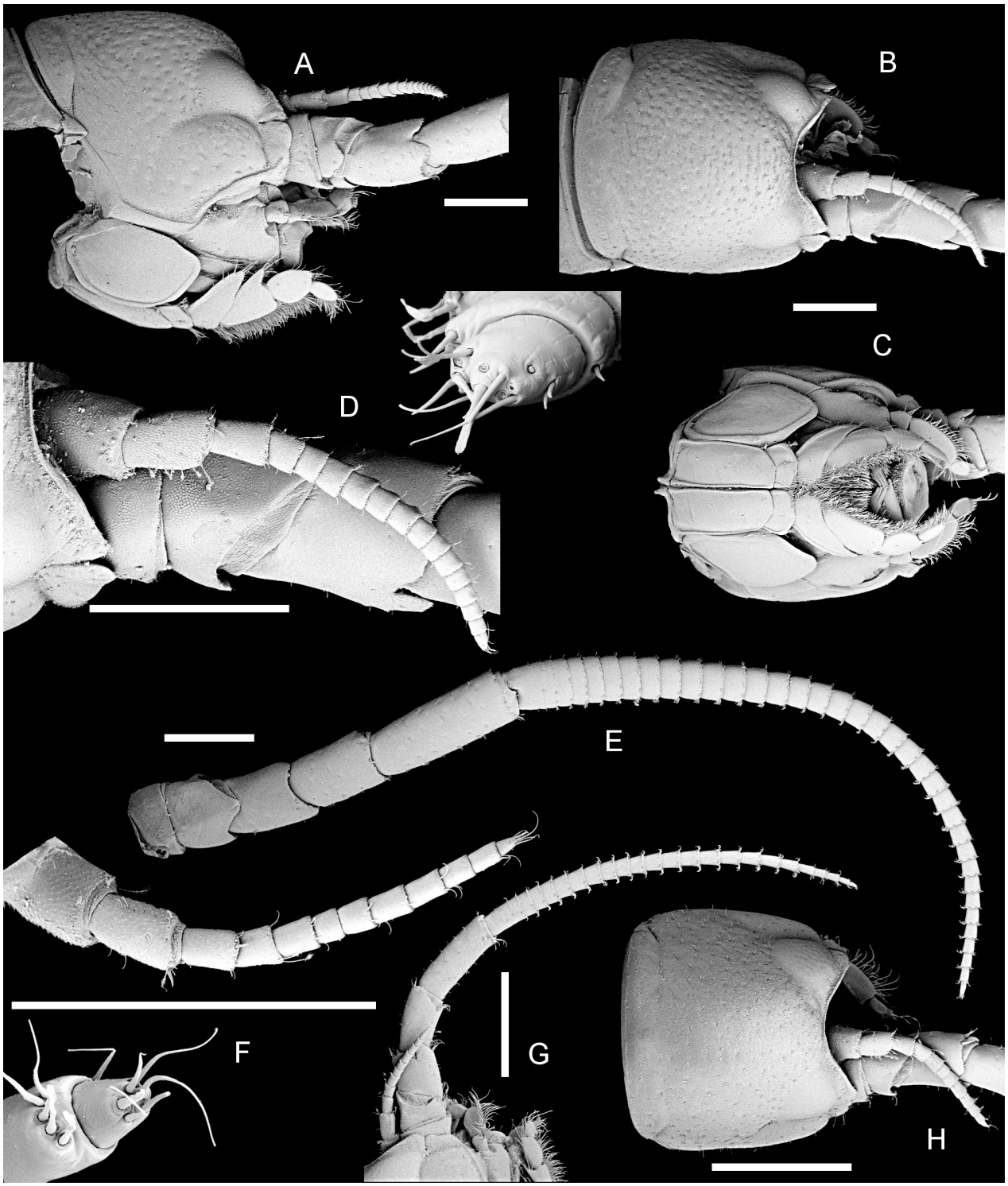

FIGURE 185. *Eophreatoicus balbun* sp. nov., head and antennae. Paratype male, AM P.76453: A–C, head lateral, dorsal and ventral; D, antennula with enlargement of distal tip; E, antenna. Paratype female, AM P.76454: F, antennula with enlargement of distal tip; G, antenna, antennula and anterior head; H, head, dorsal. Scales 1 mm.

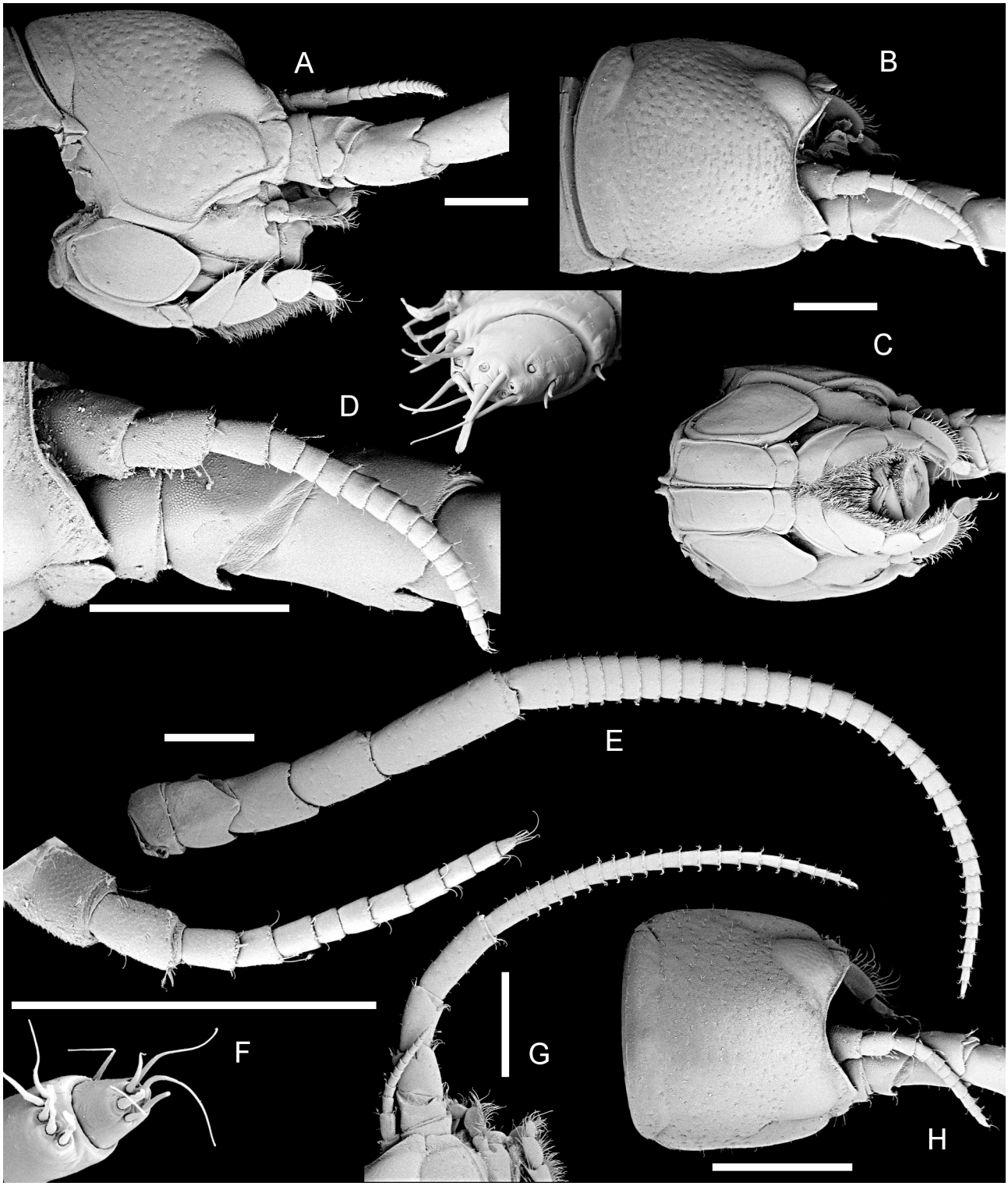

FIGURE 186. *Eophreatoicus balbun* sp. nov., pereopod I. Paratype male, AM P.76453: A–D, pereopod I entire, enlargement of distal articles, palm setae lateral and palm medial. Paratype female, AM P.76454: E–H, pereopod I entire, enlargement of palm and proximal dactylus, palm setae lateral and palm setae medial. Scales 1 mm.

Description. Body pigmentation even brown dorsal surface with light transition between dorsal and lateral surfaces, lateral surfaces light brown with expanded chromatophores, head mottled light brown, pleotelson even brown with light muscle attachment spots; length of largest male 24.0 mm, length of largest brooding female 13.0 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Width 1.00

pereonite 1 width. Dorsal surface pitted; setae tiny and sparse. Eyes oval, orientation of longest axis between horizontal and vertical, maximum diameter 0.34 head depth, ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view sigmoidal. Mandibular (genal or cheek) groove with acute indentation. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

Pereon. Width near head width. Setae on dorsal surface not visible. Coxal articulation to pereonites 2–4 nearly fused.



FIGURE 187. *Eophreatoicus balbun* sp. nov., pereopods. Paratype male, AM P.76453: A, pereopod II basis with enlargement of epaulet; B, pereopod IV with enlargement of distal articles; D, pereopod V. Paratype female, AM P.76454: C, pereopod II basis with enlargement of epaulet. Scales 1 mm.

Pleonites. Pleonites 2–4 in dorsal view respective lengths less than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.18 pleonite 1, 1.48 pleonite 2, 1.69 pleonite 3, 1.75 pleonite 4, 1.51 pleonite 5.

Pleotelson. Dorsal surface length 1.10 width in dorsal view. Dorsal surface lacking observable simple setae; with cuticular combs on tubercles. Depth 1.30 pereonite 7 depth. Lateral length less than depth, in male 0.82 depth (M2), in female 0.84–0.85 depth. Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.42 width of uropodal insertion, with single row of simple robust setae, including 6 robust setae altogether, posterior seta length subequal to anterior adjacent setae. Posterolateral margin medial length 0.66 pleotelson total length. Posterior apex length less than width, long. Posterior apex 0.23 pleotelson total length, width 0.40 pleotelson width.

Antennula. Length 0.12 body length in male, 0.11 body length in female, with 17 articles in male, with 11 articles in female. Article 5 length 0.77 width. Article 6 length 0.75 width. Aesthetascs single or paired on distal 7 articles, with multiple aesthetascs on terminal article. Terminal article length subequal to penultimate article length, length 1.36 width, length 0.03 antennula total length. Distal articles oval in cross-section.

Antenna. Length 0.54 body length in male, 0.43 body length in female. Flagellum length 0.62 total antenna length in male, 0.63 total antenna length in female, with 32 articles in male, with 23–24 articles in female, proximal articles surface scaled only on distal margin (tiny), proximal articles distal margin with rosette of short setae.

Pereopod I. Basis of male length 2.10 width, female length 2.10 width; dorsal setae positioned proximally, 1 dorsal seta altogether; female dorsal setae positioned proximally, female 2 dorsal setae altogether; ventrodistal margin lacking elongate setae (1 robust seta), female with 5 elongate setae, shorter than ischium. Ischium of male dorsal margin without simple setae. Ischium of female dorsal margin with 6 simple setae, setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (2 short robust); female distodorsal margin with numerous elongate simple setae, female dorsal surface with setae along dorsal axis (3 simple decreasing in size proximally). Propodus length:pereopod length 0.24 male, 0.24 female. Propodus length:width 1.30 male, 1.70 female. Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 14 setae altogether (excluding distal group), proximal region not protruding, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae articulation not expressed, 35 altogether. Propodal palm of female margin convex, stout denticulate setae serrate, 13 altogether, with stout robust conical setae, 8 altogether (5 proximal, 3 distal). Dactylus of male length:palm length 1.04, female longer than palm, female length:palm length 1.10. Dactylus of female ventrodistal margin distal cuticular fringe length 0.67 total length. Dactylus claw length:dactylus length 0.13 male, 0.14 female. Dactylus of male without articulation. Dactylus of female with articulation.

Pereopods II–III ratios. Pereopod II. Length:body length 0.35 male, 0.33 female. Basis length:pereopod length 0.29 male, 0.28 female; length:width 2.28 male, 2.28 female. Carpus length:pereopod length 0.13 male, 0.12 female; length:width 1.50 male, 1.50 female. Propodus length:pereopod length 0.15 male, 0.16 female; length:width 2.50 male, 2.80 female. Dactylus length:propodus length 0.67 male, 0.55 female; primary claw length:dactylar length 0.30 male, 0.17 female. *Pereopod III.* Length:body length 0.33 male, 0.33 female. Basis length:pereopod length 0.30 male, 0.31 female; length:width 2.40 male, 2.60 female. Carpus length:pereopod length 0.12 male, 0.12 female; length:width 1.60 male, 1.63 female. Propodus length:pereopod length 0.17 male, 0.14 female; length:width 3.10 male, 2.60 female. Dactylus length:propodus length 0.50 male, 0.65 female; primary claw length:dactylar length 0.33 male, 0.21 female. *Pereopods II–III.* Penicillate setae distally on basis dorsal (anterior) margin; basis dorsal ridge with several tiny setae on dorsal and ventral margins. Ischium II–IV of male dorsal margin with 1 simple seta (tiny), none robust. Carpus II of male with 4–5 robust based setae. Carpus II of female with 5 robust based setae. Propodus of male robust-based setae respectively with 5–6. Dactylus with scales on ventral margin; 10 altogether (at least).

Pereopod II. Basis lateral face 2–3 short robust setae proximally in male and 7 simple setae along margin in female. Basis of male dorsal ridge epaulet without submarginal setal row, main setal row with 1 minor setae, without major setae distal to epaulet. Basis of female dorsal ridge epaulet without setal row below dorsal margin, main setal row with 4 minor setae, without major setae distally.

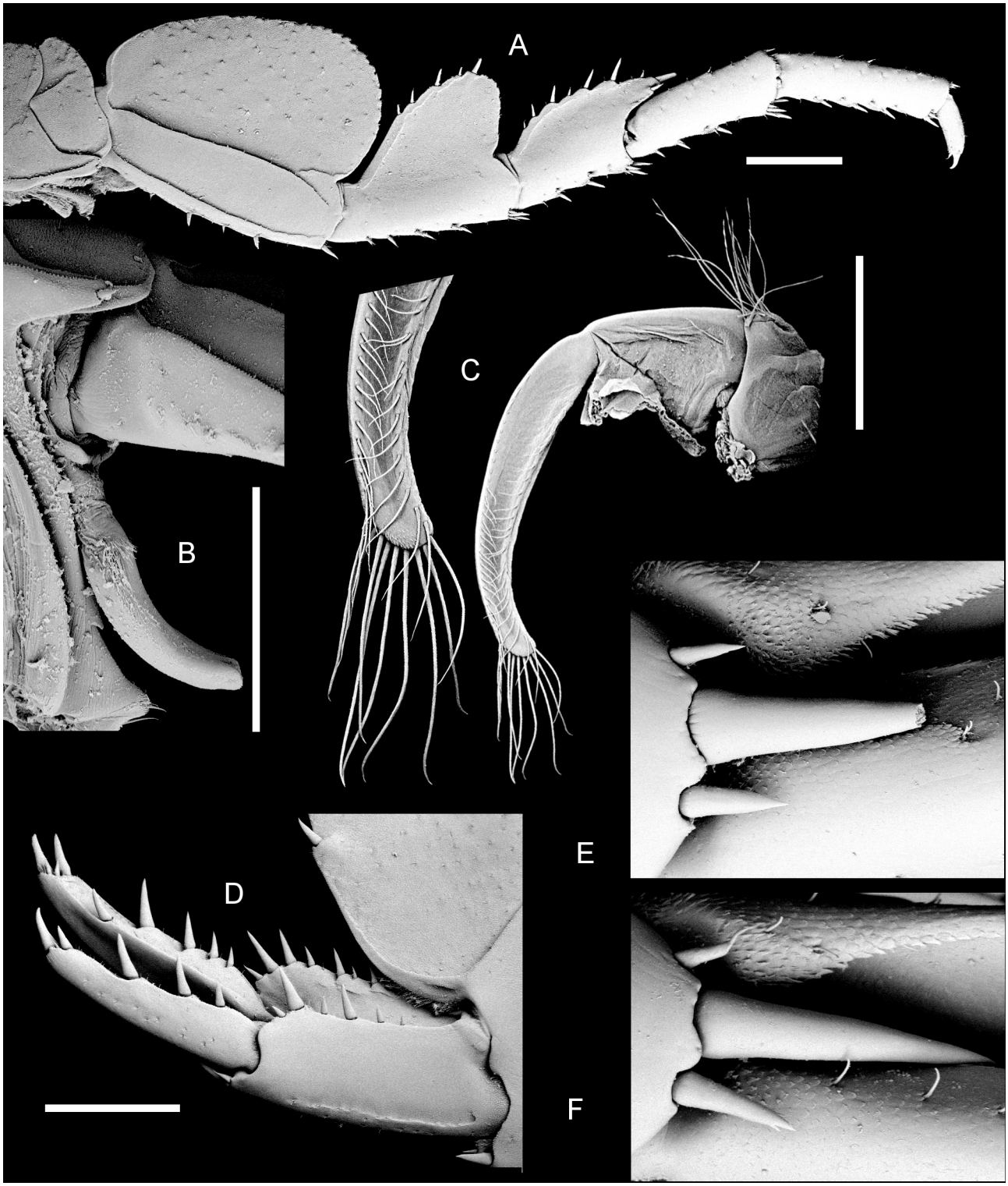

FIGURE 188. *Eophreatoicus balbun* sp. nov. Paratype male, AM P.76453: A, pereopod VII; B, penes; C, appendix masculina of pleopod II with enlargement of distal tip setae; D, uropod in situ on pleotelson; E, distoventral setae of uropodal protopod. Paratype female, AM P.76454: F, distoventral setae of uropodal protopod. Scales 1 mm.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis, of female occurring on dorsal margin of basis. Basis of male dorsal ridge with 1–2 setae, dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 5 setae. Carpus of male ventral margin setae in several groups, with robust-based setae in addition to simple, with 4 robust-based setae, none distinctly larger than others. Carpus of female ventral margin with robust-based setae, with 2 robust-based setae (at least). Propodus of male distal width 0.63 maximum width,

setae on ventral margin robust, 2 distinctly larger than remainder, subequal in length to dactylar claw. Propodus of female with 4 robust setal types on ventral margin, posterior side of limb articular plate subequal in length to dactylar claw. Dactylus of male distal accessory claw approximately 0.25 primary claw length. *Pereopod IV ratios*. Length:body length 0.28 male, 0.29 female. Basis length:width 2.40 male. Carpus length:pereopod length 0.14 male. Propodus length:pereopod length 0.13 male. Propodus length:width 1.40 male.

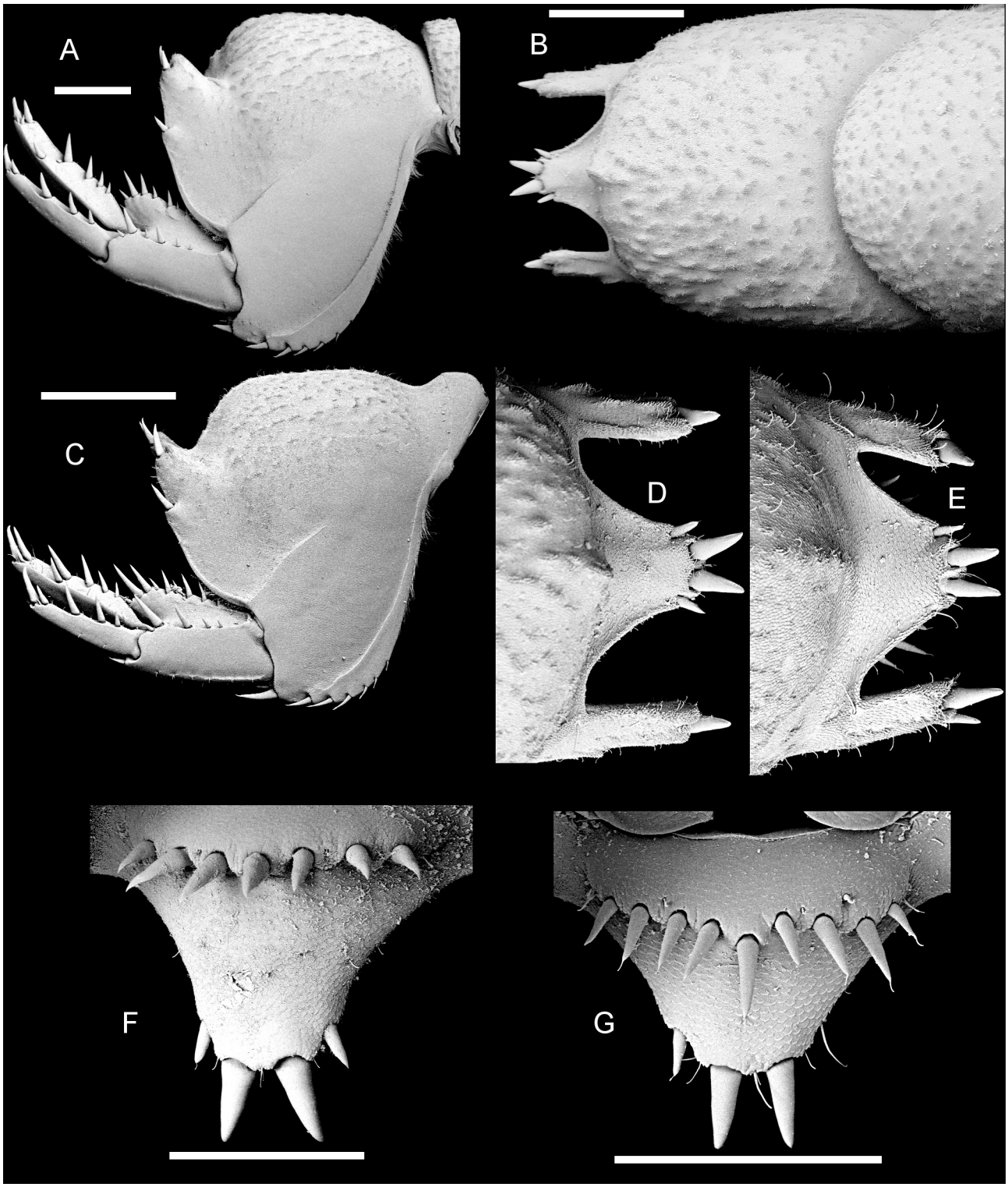

FIGURE 189. *Eophreatoicus balbun* sp. nov., pleotelsons. Paratype male, AM P.76453: A, lateral; B, dorsal; D, apex, dorsal; F, apex, ventral. Paratype female, AM P.76454: C, lateral; E, apex, dorsal; G, apex, ventral. F & G are at different angles to the horizontal (female apex tilted dorsally more), so shapes of apices are different. Scales: A–C, 1 mm; F–G, 0.5 mm.

Pereopods V–VII ratios. Pereopod V. Length:body length 0.39 male, 0.37 female. Basis length:width 1.15 male, 1.40 female. Carpus length:pereopod length 0.17 male, 0.15 female. Propodus length:pereopod length 0.15 male, 0.16 female. Dactylus claw length:dactylar length 0.31 male, 0.29 female. *Pereopod VI.* Length:body length 0.39 male, 0.43 female. Basis length:width 1.18 male, 1.08 female. Carpus length:pereopod length 0.17 male, 0.18 female. Propodus length:pereopod length 0.17 male, 0.17 female. Dactylus claw length:dactylar length 0.30 male, 0.28 female. *Pereopod VII.* Length:body length 0.43 male, 0.43 female. Basis length:width 1.30 male, 1.17 female. Carpus length:pereopod length 0.17 male, 0.15 female. Propodus length:pereopod length 0.17 male, 0.17 female. Dactylus claw length:dactylar length 0.25 male, 0.36 female.

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae not on carpus; penicillate setae not on propodus. V–VII ischium of male dorsal margin including 5 robust setae. Short, distally rounded. Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with no setae, dorsal margin with 5 setae.

Penes. Extending near midline; distally tapering; distal tip truncate.

Pleopods. Exopods I with lateral proximal lobe, with medial proximal lobes of pleopod I. Protopods medial margins II–V with large projections, of male medial margins with minutely serrate setae, of female medial margins with minutely serrate setae.

Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 2.10 endopod proximal margin length; distally with 9 setae; 63 setae altogether.

Uropod. Of male total length 0.95 pleotelson length. Uropod of female total length 0.87 pleotelson length. Protopod dorsomedial ridge length:endopod length 0.57 male, 0.78 female. Protopod of male dorsolateral margin subequal to dorsomedial margin setae; of female dorsolateral margin subequal to dorsomedial margin setae. Protopod distoventral margin with 3 robust setae, without spinose setae (tiny spinules present on lateral setae in female), 3 robust simple setae. Protopod lateral face with ventrolateral ridge. Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 9 altogether; female dorsal margin with 8 robust setae. Exopod length:endopod length 0.82 male, 0.78 female. Exopod of male dorsal margin with 5 robust setae, female 5 robust setae.

Distribution. Australia, Northern Territory, Kakadu National Park, below Twin Falls, stream in gorge west of Twin Falls, Twin Falls Creek, a tributary of Jim Jim Creek, South Alligator River catchment.

Habitat. Downstream of plunge pool, seep at base of waterfall, and seep among *Eucalyptus* and *Pandanus*. Water temperature at the time of sampling 19–22°C (1994).

Remarks. *Eophreatoicus balbun* sp. nov. is closely related to *E. barrkmarlam* sp. nov. See remarks for the latter species for morphological detail. These two species are closely related both genetically and morphologically. The average uncorrected mtDNA p-distance between species of *Eophreatoicus* and *Kakadubeh* (Appendix 3) was 0.173 (maximum 0.250) but between these two species, the distance was 0.060. The uncorrected p-distance between the two geographically overlapping populations of *E. nawurlandja* sp. nov. is even smaller (0.007). The geographic distance between the type localities of *E. balbun* sp. nov. (Twin Falls) and *E. barrkmarlam* sp. nov. (Jim Jim Falls) is only 7–8 km, suggesting that geographic speciation occurs at less than a 10 km scale. The maximum genetic p-distance (0.250) occurs between *E. balbun* sp. nov. and *E. indjangarlwurr* sp. nov. where the geographic distance is 110 km.

Eophreatoicus sp. 03DJ

(Fig.190)

Eophreatoicus sp. "03?".—Wilson *et al.*, 2009: 362.

Material examined. Australia, Northern Territory, Kakadu National Park, coll. M. Ziembicki, K. McAlpine & K. Brennan, 27.vi.1998: Jackpot Ck, OSS site 4, 13°23.483'S, 132°23.617'E: juvenile male, bl 15 mm, P.76288, DNA E73 Genbank CO1 EU263144 16S EU263213; 1 ind, P.53196; male, P.97894; brooding female, P.97895. Dogleg Ck, OSS site 5, 13°24.183'S, 132°24.433'E: 8 inds, AM P.53197; female, bl 17 mm, P.53197, DNA E74 Genbank CO1 EU263145 16S EU263214.

Distribution. Australia, Northern Territory, Kakadu National Park, Jackpot and Dogleg Creeks, small tributaries feeding direcly into the upper South Alligator River catchment.

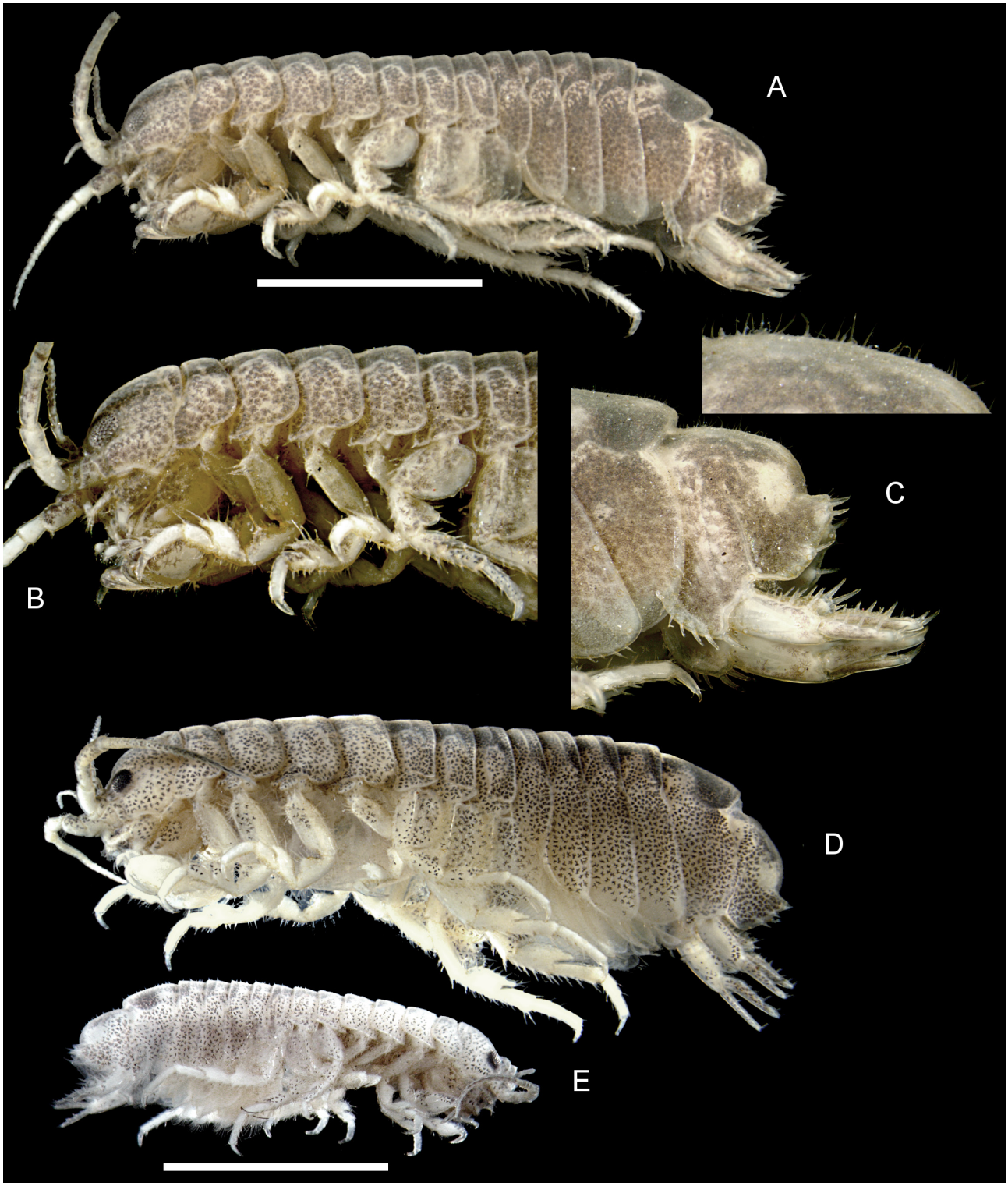

FIGURE 190. *Eophreatoicus* sp. 03DJ, habitus. Male, AM P.97894: A, lateral; B, anterior body; C, pleotelson with enlargement of dorsal surface. D, paratype female, AM P.97895, lateral. E, juvenile male, AM P.53197. Scales 5 mm.

Habitat. Among roots and gravel and under stones, spring fed streams flowing from escarpment.

Remarks. *Eophreatoicus* sp. 03DJ was originally thought to be similar or conspecific with *E. warddebarrarn* sp. nov. from the nearby Rockhole Mine Creek, because it appeared to be a collection of only subadults. Subsequently, this species was found to be distinct by multiple characters. These specimens were adults, being distinctly smaller than those from Rockhole Mine Creek. Other than their size, the most easily seen difference is the smoother dorsal surface of the pleotelson (no ridges or tubercles). The pereopod II basis epaulet has 5 major setae (4 setae), despite

their smaller size. At the time of this writing, a full characterization of *E*. sp. 03DJ was not available, other than photographs of small adult specimens (Fig. 190) and DNA data from two juveniles from both localities (Dogleg Creek and Jackpot Creek). *Eophreatoicus* sp. 03DJ is not formally described owing to insufficient material but is a morphologically distinct species. This observation is supported by genetic analyses (Wilson *et al*. 2009 and herein).

Eophreatoicus warddebarrarn sp. nov.

(Figs 191–195)

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Type material. Holotype male, bl 18.2 mm, AM P.76287, SEM stubs AW811–816, ERISS site 11B. Paratypes collected with holotype: 4 inds (male 19.1 mm), AM P.76286. Additional paratypes. RMC19920409: 11 inds (female bl 16.2 mm; juvenile male bl 15.8 mm), AM P.76567. RMC19920430: 8 inds, AM P.76568.

Type locality. Australia, Northern Territory, Kakadu National Park. ERISS site 11B, Rockhole Mine Ck, 13°31.70'S, 132°27.85'E, coll. 7.v.1992, A. Spiers. Sites near type locality with additional paratypes, 13°20.208'S, 132°27.859'E, coll. C. Humphrey & P. Dostine: RMC19920409, 9.iv.1992; RMC19920430, 30.iv.1992.

Etymology. "Wardde-barrarn" in the local Kundjeyhmi Kunwinjku language means "rocky gorge", which we have elided to "warddebarrarn".

Diagnosis. *Head.* Eyes bulging dorsolaterally, height medium, in lateral view subequal to width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending just above anterolateral margin of pereonite 1. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface smooth (without roughness or tubercles); pereonites 1–4 transverse dorsal ridges not expressed; pereonites 5–7 transverse dorsal ridges carinate with transverse trough. *Pleonites.* 1–4 transverse dorsal ridges well developed with transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection concave. Dorsal surface rugose, with small irregular rugose regions, with several median tubercles, not merging into ridge. Posterior apex in lateral view obscured by posterolateral margin (only slightly). Posterior apex in lateral view distinctly narrowing distally, proximal depth greater than distal depth, with two pairs of robust setae, with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 longer than article 4. *Pereopod I.* Dactylus of male ventrodistal margin smooth. *Pereopod II.* Basis of male dorsal ridge epaulet length less than quarter length of basis, main setal row with 4 major setae (H). Basis of female dorsal ridge epaulet length less than quarter length of basis, main setal row with 4 major setae. *Pereopod IV.* Propodus of male ventral margin with projection, with 4 robust setae on ventral margin. Dactylus of male length less than propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate greater than shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge distinctly projecting dorsally with posterior margin exposed above shaft, concave, in lateral view distal part distinctly curving dorsally; distal margin with 2 adjacent robust setae distinctly larger than others.

Description. Body pigmentation light maculate, dorsally with 2 broad irregular bars and thin faint median line, chromatophores variable dense to dendritic; length of largest male 19.1 mm, length of largest preparatory female 16.4 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface smoothly curved. Dorsal surface pitted (shallow pits); setae tiny and sparse. Eyes dorsal margin convex, ventral margin concave, orientation of longest axis vertical, maximum diameter 0.29–0.31 head depth (F2, H), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view smoothly curved (very faint). Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.

Pereon. Width near head width. Setae on dorsal surface not visible. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–3 in dorsal view respective lengths less than 0.5 pleonite 5 length, pleonite 4 length more than 0.5 pleonite 5 length (for F2, pleonite 3 and 0.5 pleonite 5 length subequal), 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.30 pleonite 1 (H), 1.70 pleonite 2 (H), 1.80 pleonite 3 (H), 1.70 pleonite 4 (H), 1.70 pleonite 5 (H).

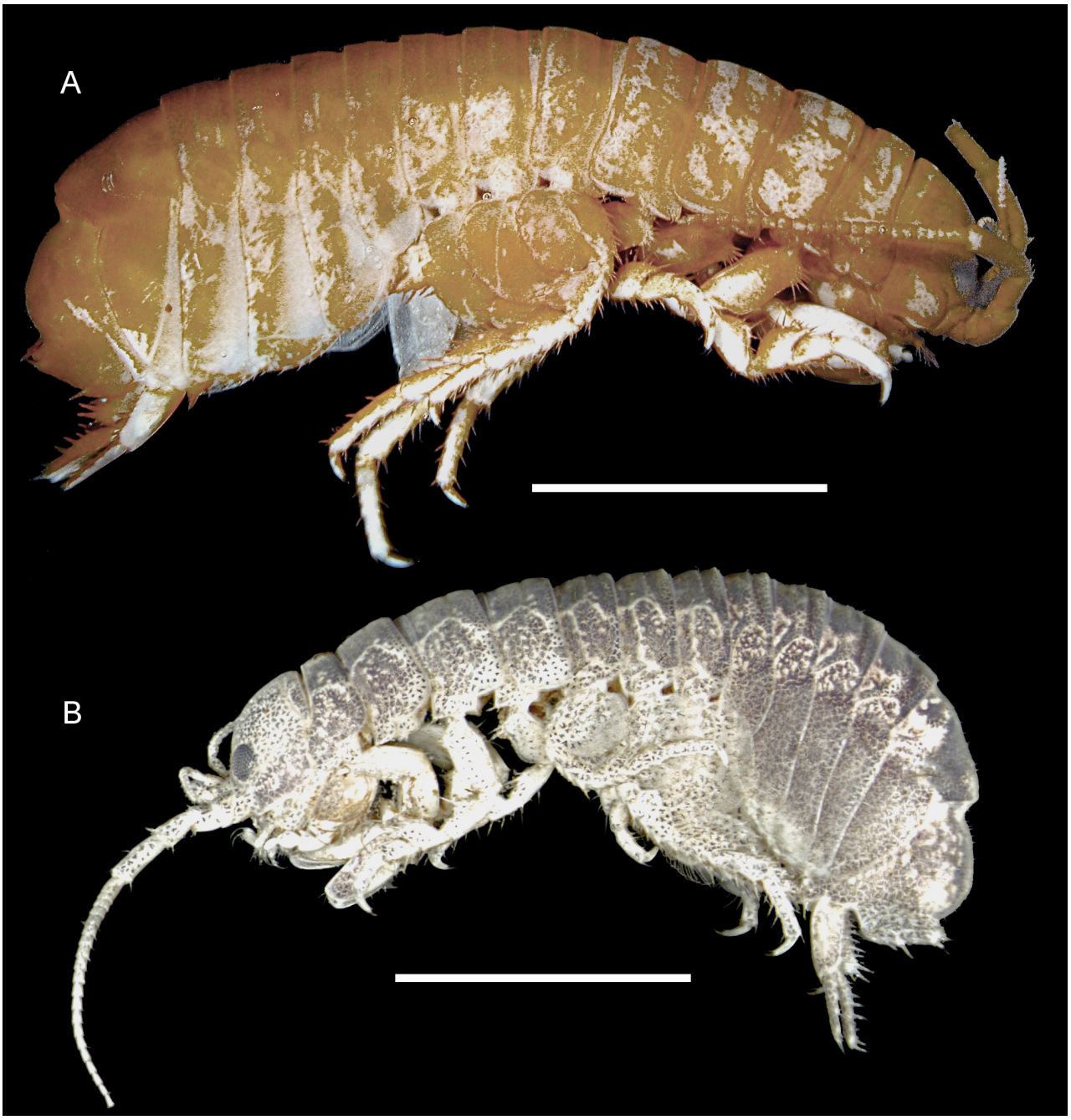

FIGURE 191. *Eophreatoicus warddebarrarn* sp. nov., habitus. A, holotype male, AM P.76287. B, paratype female, AM P.76567. Scales 5 mm.

Pleotelson. Dorsal surface length 0.84 width in dorsal view (H). Dorsal surface sparsely covered with setae. Depth 1.30 pereonite 7 depth (H). Lateral length less than depth, in male 0.73 depth (H), in female 0.78 depth. Lateral length 0.14–0.15 body length (F, H). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.40 width of uropodal insertion (H), with single row of simple robust setae grading anteriorly to fine setae, including 8 robust setae altogether (H), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.16 pleotelson total length (H). Posterior apex length less than width, long. Posterior apex 0.18 pleotelson total length (H), width 0.36 pleotelson width (H). Posterior apex in lateral view forming an angle of 83–105° with immediately anterior dorsal surface (F2, H), angled 171° from horizontal (H).

Antennula. Length 0.15 body length in male (H), with 16 articles in male (H). Article 5 length 0.66 width (H). Article 6 length 0.97 width (H). Aesthetascs small (1–3) on distomedial margins. Terminal article length 0.80 width (H), 0.02 antennula total length (H). Distal articles oval in cross-section.

Antenna. Length 0.17 body length in male (H). Flagellum length 0.68 total antenna length in male (H), with 25 articles in male (H), proximal articles surface finely scaled on sides, proximal articles distal margin with rosette of short setae.

Mouthfield. Clypeus width 0.27 head width (H).

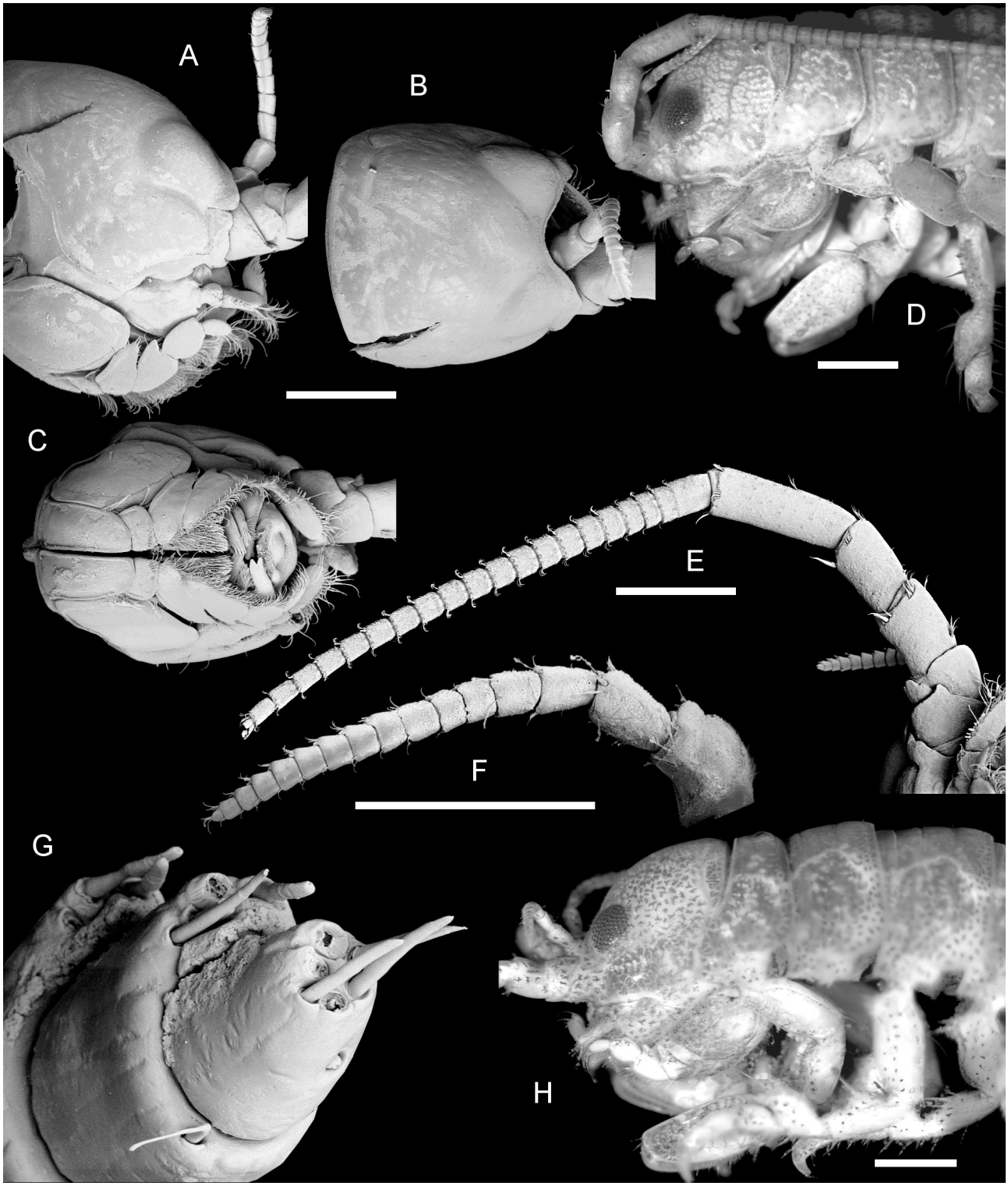

FIGURE 192. *Eophreatoicus warddebarrarn* sp. nov., head and antennae. Holotype male, AM P.76287: A–C, head lateral, dorsal and ventral; E, antenna; F–G, antennula with enlargement of tip. Paratype juvenile male, AM P.76567: D, anterior body lateral. Paratype female, AM P.76567: H, anterior body, lateral. Scales 1 mm.

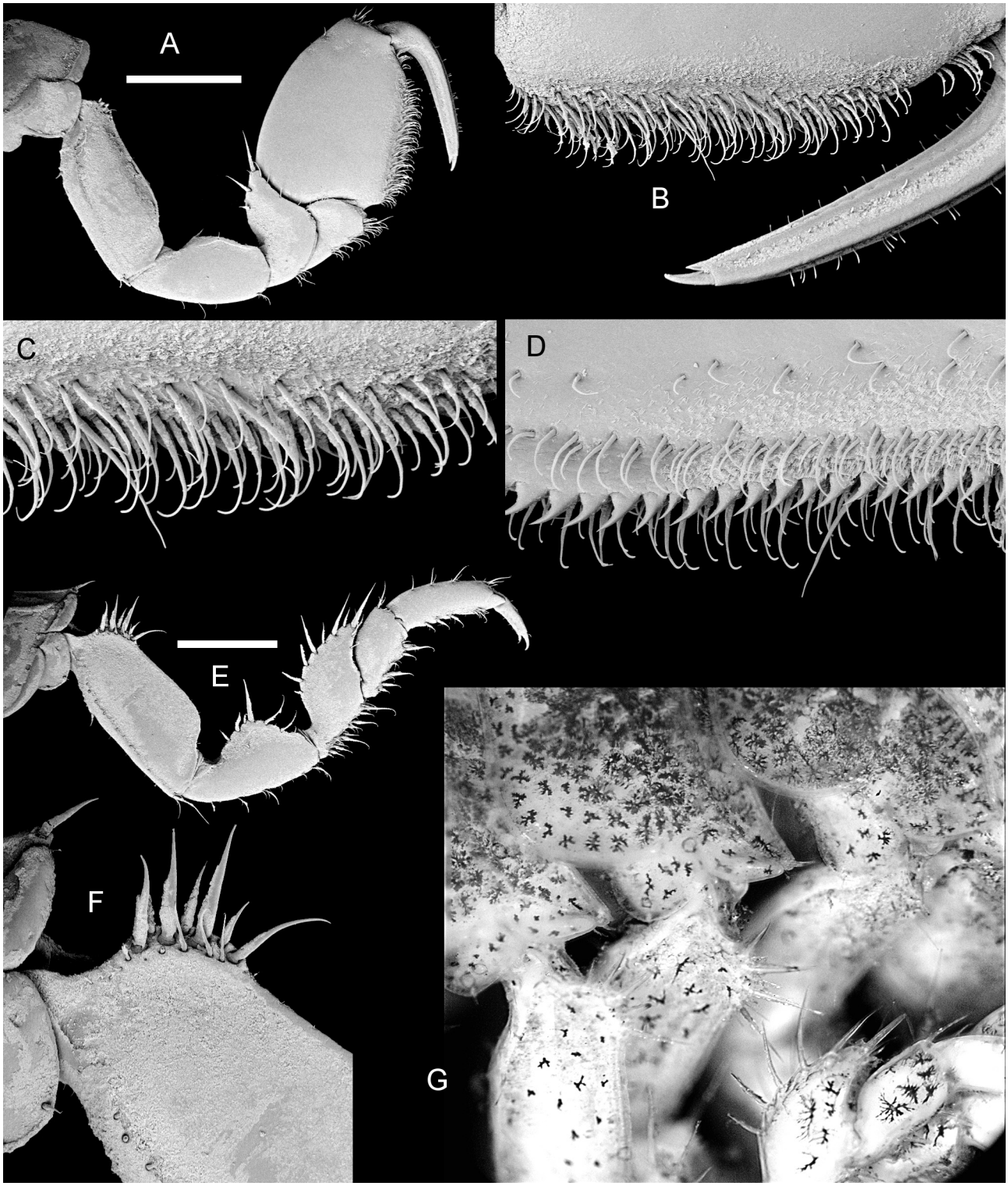

FIGURE 193. *Eophreatoicus warddebarrarn* sp. nov., pereopods I–III. Holotype male, AM P.76287: A–B, pereopod I with enlargement of palm; C–D, palm setae lateral and medial; E–F, pereopod II with enlargement of epaulet on basis. Paratype female, AM P.76567: G, pereopod II–III bases epaulets. Scales 1 mm.

Maxilliped. Epipod distal tip rounded, length 1.60 width (H). Endite medial margin with 3 coupling hooks on right side (H). Endite distal margin in fringe. Palp insertion on basis ventral surface without subdistal smooth setae, without ventral surface subdistal biserrate setae. Palp article 4 shape elongate-oval, length 1.30 width (H). Palp article 5 length 1.70 width (H), 0.65 article 4 length (H).

Pereopod I. Length:body length 0.41 male (H). Basis of male length 2.40 width (H); dorsal setae positioned

proximally, 6 dorsal setae altogether (H); ventrodistal margin with 2 elongate setae (H). Ischium of male dorsal margin with 1 simple seta, setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with numerous elongate simple setae, dorsal surface with setae along dorsal axis (robust simple); female dorsal surface with setae along dorsal axis. Propodus length:pereopod length 0.25 male (H). Propodus length:width 1.40 male (H). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 3 setae altogether (excluding distal group) (H), proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally inflated setae, stout robust setae articulated, 28 altogether. Propodal palm of female margin convex. Dactylus of male shorter than palm, length:palm length 0.91 (H). Dactylus claw length:dactylus length 0.11 male (H). Dactylus of male large, positioned ventrally, 0.37 length of primary claw.

Pereopods II–III ratios. Pereopod II. Length:body length 0.41 male (H). Basis length:pereopod length 0.28 male (H); length:width 2.30 male (H). Carpus length:pereopod length 0.12 male (H); length:width 1.50 male (H). Propodus length:pereopod length 0.16 male (H); length:width 2.80 male (H). Dactylus length:propodus length 0.53 male (H); primary claw length:dactylar length 0.24 male (H). *Pereopod III.* Length:body length 0.30 male (H), 0.31 female (F2). Basis length:pereopod length 0.27 male (H), 0.30 female (F2); length:width 1.80 male (H), 2.40 female (F2). Carpus length:pereopod length 0.11 female (F2); 1.70 female (F2). Propodus length:pereopod length 0.16 female (F2); 3.00 female (F2). Dactylus length:propodus length 0.45 female (F2). *Pereopods II–III.* Penicillate setae scattered on dorsal ridge of basis, ischium, propodus; basis dorsal ridge with Setae forming 2 rows on proximal projection, 7 setae anteriorly and 4 setae posteriorly. Ischium II–IV of male dorsal margin with 5–6 simple setae (H pereopod IV, pereopod II), none robust. Dactylus ventral to primary claw, 0.32 length of primary claw, without spines or scales on ventral margin.

Pereopod II. Basis lateral face with 6 short robust setae widely spaced along margin. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 3 minor setae (H), submarginal setal row with 4 setae (H), without major setae distal to epaulet. Basis of female dorsal ridge epaulet without setal row below dorsal margin, main setal row with 4 minor setae, without major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on dorsal margin of basis or anterodorsal margin of propodus or anterodorsal margin of carpus. Basis of male dorsal ridge with 12 setae (H), dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 5 setae (H). Carpus of male ventral margin with simple setae only. Propodus of male distal width 0.63 maximum width (H), setae on ventral margin robust, 2 distinctly larger than remainder, subequal in length to dactylar claw. Dactylus of male distal accessory claw approximately 0.33 primary claw length. *Pereopod IV ratios.* Length:body length 0.37 male (H). Basis length:width 2.30 male (H). Carpus length:pereopod length 0.19 male (H). Propodus length:pereopod length 0.30 male (H). Propodus length: width 2.10 male (H).

Pereopods V–VII ratios. Pereopod V. Length:body length 0.31 male (H), 0.30 female (F2). Basis length:width 1.00 male (H), 1.20 female (F2). Carpus length:pereopod length 0.13 male (H), 0.14 female (F2). Propodus length: pereopod length 0.24 male (H), 0.18 female (F2). Dactylus claw length:dactylar length 0.31 male (H). *Pereopod VI.* Length:body length 0.41 male (H). Basis length:width 1.20 male (H). Carpus length:pereopod length 0.13 male (H). Propodus length:pereopod length 0.18 male (H). *Pereopod VII.* Length:body length 0.52 male (H). Basis length: width 1.20 male (H). Carpus length:pereopod length 0.15 male (H). Propodus length:pereopod length 0.20 male (H). Dactylus claw length:dactylar length 0.26 male (H).

Pereopods V–VII. V–VII penicillate setae not on dorsal ridge of basis, penicillate setae not on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 5–6 setae (H pereopod V, pereopod VII). Propodus distal margins with 5 elongate robust or robust-based setae (H pereopod V, pereopod VII). Dactylus accessory claw 0.27 dorsal claw length (H pereopod V). Pereopod VII basis dorsal ridge distal margin rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with no setae, dorsal margin with 6 setae (H).

Penes. Distally tapering; distal tip truncate.

Pleopods. Pleopod II endopod of male appendix masculina distally with 8 setae; 46 setae altogether (H).

Uropod. Of male total length 1.10 pleotelson length (H); protopod of male length 0.42 uropod total length (H). Uropod of female total length 1.00 pleotelson length (F2), protopod length 0.44 uropod total length (F2). Protopod dorsomedial ridge length:endopod length 0.61 male (H). Protopod of male dorsolateral margin shorter than dorsomedial margin setae; of female dorsolateral margin shorter than dorsomedial margin setae. Protopod distoventral

margin with 3 robust setae, with spinose setae, 3 robust spinose setae. Protopod lateral face with ventrolateral ridge (very faint). Endopod longer than protopod. Endopod of male dorsal margin with robust setae occurring along length, 8 altogether (H); female dorsal margin with 7 robust setae (F2). Exopod length:endopod length 0.80 male (H), 0.95 female (F2). Exopod of male dorsal margin with 5 robust setae (H), female 4 robust setae (F2).

Distribution. Australia, Northern Territory, Kakadu National Park, Rockhole Mine Creek, a small stream feeding directly into the upper South Alligator River catchment.



FIGURE 194. *Eophreatoicus warddebarrarn* sp. nov., posterior pereopods and appendix masculina, holotype male, AM P.76287. A–B, pereopod V with enlargement of distal segments. C–D, pereopods V and VII. E, pene, pereopod VII, anterior. F–G, pleopod II endopod appendix masculina with enlargement of distal tip. All scales 1 mm.

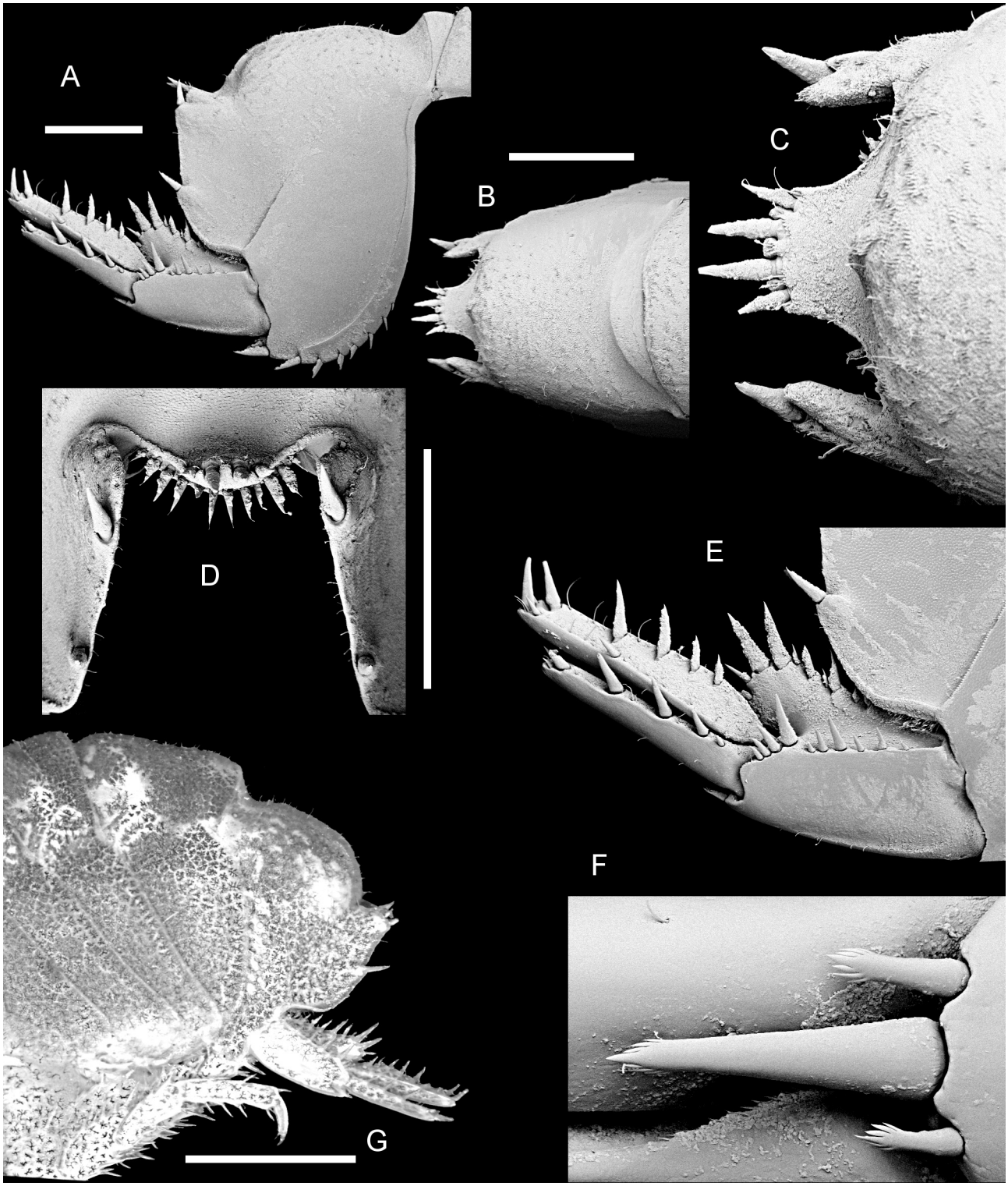

FIGURE 195. *Eophreatoicus warddebarrarn* sp. nov., pleotelson and uropods. Holotype male, AM P.76287: A–B, pleotelson, dorsal and lateral; C, pleotelson terminal apex, dorsal; D, pleotelson apex and posterolateral margin, posterior showing postanal setae. E, uropod, lateral in situ. F, uropodal protopod distoventral setae. Paratype female, AM P.76567: G, posterior pleon. Scales 1 mm.

Habitat. Among roots, leaf litter, cobbles and pebbles in the streambed of Rockhole Mine Creek.

Remarks. *Eophreatoicus warddebarrarn* sp. nov. is a large species with light maculate cuticle that was obscured in several larger individuals in the available collection by a red precipitate (Fig. 191). The type locality is the site of an experimental ecology project that evaluated mining impacts in Kakadu National Park (Faith *et al.* 1995).

The morphological analysis found this species in a clade with *E. barrkmarlam* sp. nov. and *E. balbun* sp. nov., although weakly supported by several homoplastic apomorphies explaining why the clade did not appear in the symmetric jackknife analysis. The combined analysis also found this clade although we have no genetic data for *E. warddebarrarn* sp. nov. The differences are worth considering because the type locality, Rockhole Mine Creek, is ~40 km south of the Twin Falls/Jim Jim Falls region. This species can be distinguished from *E. barrkmarlam* sp. nov. and *E. balbun* sp. nov. by these characters: the cuticle of the pereon smooth without tubercles or roughness; the pleotelson dorsal cuticle with small irregular rugose regions (not elongate ridge-like tubercles); the pleotelson postanal ridge with 13 robust setae (7–9 setae); the male pereopod II basis epaulet with 4 major setae (3 setae); and male pereopod IV propodal palm with 4 robust setae (6–7 setae). No DNA data are available for this species.

Eophreatoicus wurrkbaba sp. nov.

(Figs 8C, 196–201)

urn:lsid:zoobank.org:act: 45F44BD5-9AA3-45FC-AA73-A6269ABF75E0
Eophreatoicus sp. "13".—Wilson *et al.*, 2009: 361–362.

Type material. Holotype male, bl 16.8 mm, AM P.76283. Paratypes collected with holotype: male (M2), bl 16.6 mm, AM P.76284, DNA E102 Genbank COI EU263159 16S EU263229, SEM stubs AW656–661; male, AM P.76282, DNA E62 COI EU263158 16S EU263228; female (F3), bl 15.1 mm, AM P.76285, DNA E103 Genbank COI EU263160 16S EU263230, SEM stubs AW662–664; juvenile female, DNA E76; juvenile female, DNA E77; 76 inds, AM P.76281.

Remarks on the Type material. The paratype male (AM P.76284) has an additional robust seta on the left posterolateral margin of the pleotelson (Fig. 201A). The holotype male (AM P.76283) lacks this extra seta. The paratype female (AM P.76285) also has an additional pair of robust setae between the pleotelson terminal apex and the ventral postanal ridge setae (Fig. 201H).

Type locality. Australia, Northern Territory, Kakadu National Park, NT245, spring in side branch of Dinner Ck, ~200m NW of lower waterfalls, among silt and roots of ferns, 13°38.80'S, 132°36.20'E, coll. G. Wilson & C. Humphrey, 4.vii.1999.

Etymology. "Wurrkbaba" is named after the Jawoyn clan who own this place. The name is pronounced "woorrk-bah-bah".

Diagnosis. *Head.* Eyes bulging dorsolaterally, height large, in lateral view greater than width of basal antennal articles, height greater than length in lateral view, slightly protruding in dorsal view, projecting from head in low or flattened arc. Cervical groove in lateral view extending nearly to dorsal margin of head. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally. *Pereon.* Dorsal cuticular surface smooth (without roughness or tubercles); pereonites 1–4 transverse dorsal ridges not expressed; pereonites 5–7 transverse dorsal ridges low without transverse trough. *Pleonites.* 1–4 transverse dorsal ridges low without transverse trough. *Pleotelson.* Dorsal surface in lateral view margin below dorsal inflection linear. Dorsal surface rugose, with elongate ridge-like tubercles, with several median tubercles, not merging into ridge. Posterior apex in lateral view obscured by posterolateral margin. Posterior apex in lateral view distinctly narrowing distally, proximal depth greater than distal depth, with two pairs of robust setae (aberrant female with pair of smaller robust setae below apex and between medial and lateral setal pairs), with interdigitating fine setae in same row as robust setae. *Antenna.* Article 5 shorter than article 4. *Pereopod I.* Dactylus of male ventrodistal margin with row of thin scale-like spines; female ventrodistal margin with multiple rows of thin scale-like spines (1 row distally, 2 rows proximally). *Pereopod II.* Basis of male dorsal ridge epaulet length less than quarter length of basis, main setal row with 4–5 major setae. Basis of female dorsal ridge epaulet length greater than quarter basis length, main setal row with 5–6 major setae. *Pereopod IV.* Propodus of male ventral margin with projection, with 6 robust setae on ventral margin. Dactylus of male length subequal to propodal palm length. *Pereopods V–VII.* Pereopod VII ischium dorsal ridge plate subequal to shaft width. *Uropod.* Protopod of female extending posteriorly subequal to pleotelson apex. Protopod dorsomedial ridge distinctly elongate posteriorly with posterior margin not exposed but extending posteriorly, concave, in lateral view distal part distinctly curving dorsally; distal margin with 2 adjacent robust setae distinctly larger than others.

Description. Body pigmentation pleonites with dark background and 4 white patches in transverse pattern - gives rough 5 lined appearance to dorsal surface. Pleotelson with bright white patches; length of largest male 16.8 mm, length of largest preparatory female 15.1 mm.

Head. Length shorter than width in dorsal view; lateral profile of dorsal surface indented behind eye region. Dorsal surface pitted (shallow pits); setae tiny and sparse, setae fine. Eyes dorsal margin convex, ventral margin straight, orientation of longest axis vertical, maximum diameter 0.28–0.29–0.31 head depth (M2, F3, H), ocelli distinguishable as individual units, pigmentation dark. Cervical groove in lateral view straight. Mandibular (genal or cheek) groove smoothly indented. Maxillipedal ridge with distinct dorsal edge, region with several setae projecting dorsally.



FIGURE 196. *Eophreatoicus wurrkbaba* sp. nov., habitus, lateral. Top, holotype male, AM P.76283. Bottom, paratype female, AM P.76285. Scale 5 mm.

Pereon. Width near head width. Coxal articulation to pereonites 2–4 nearly fused.

Pleonites. Pleonites 2–4 in dorsal view respective lengths less than 0.5 pleonite 5 length, 1–4 relative lengths unequal, increasing in length from anterior to posterior. Pleonites depth:pereonite 7 depth 1.40–1.50 pleonite 1 (H, F3), 1.90–2.00 pleonite 2 (H, F3), 2.20–2.30 pleonite 3 (H, F3), 2.20–2.30 pleonite 4 (H, F3), 1.90–2.10 pleonite 5 (H, F3).

Pleotelson. Dorsal surface length 1.20–1.50 width in dorsal view (M2, F3). Dorsal surface sparsely covered with elongate simple setae; with cuticular combs on tubercles. Depth 1.10–1.40 pereonite 7 depth (F, H). Lateral length less than depth, in male 0.85 depth (M2), in female 0.87 depth (F3). Lateral length 0.14–0.16–0.17 body length (M2, H, F3). Lateral surface anterior to uropods with pleonite ridge diverging posteriorly from ventral margin. Ventral margin in lateral view anterior to uropods greater than width of uropodal insertion, length 1.80–1.90 width of uropodal insertion (M2, F3), with one row of distally denticulate robust setae, including 6–7 robust setae altogether

(M2, F3), posterior seta longer than anterior adjacent setae. Posterolateral margin medial length 0.19–0.20 pleotelson total length (F3, M2). Posterior apex length less than width, long. Posterior apex 0.16–0.17 pleotelson total length (F3, M2), width 0.48–0.63 pleotelson width (M2, F3). Posterior apex in lateral view forming an angle of 94–98° with immediately anterior dorsal surface (F3;H, M2), angled 162–172° from horizontal (F3, M2).

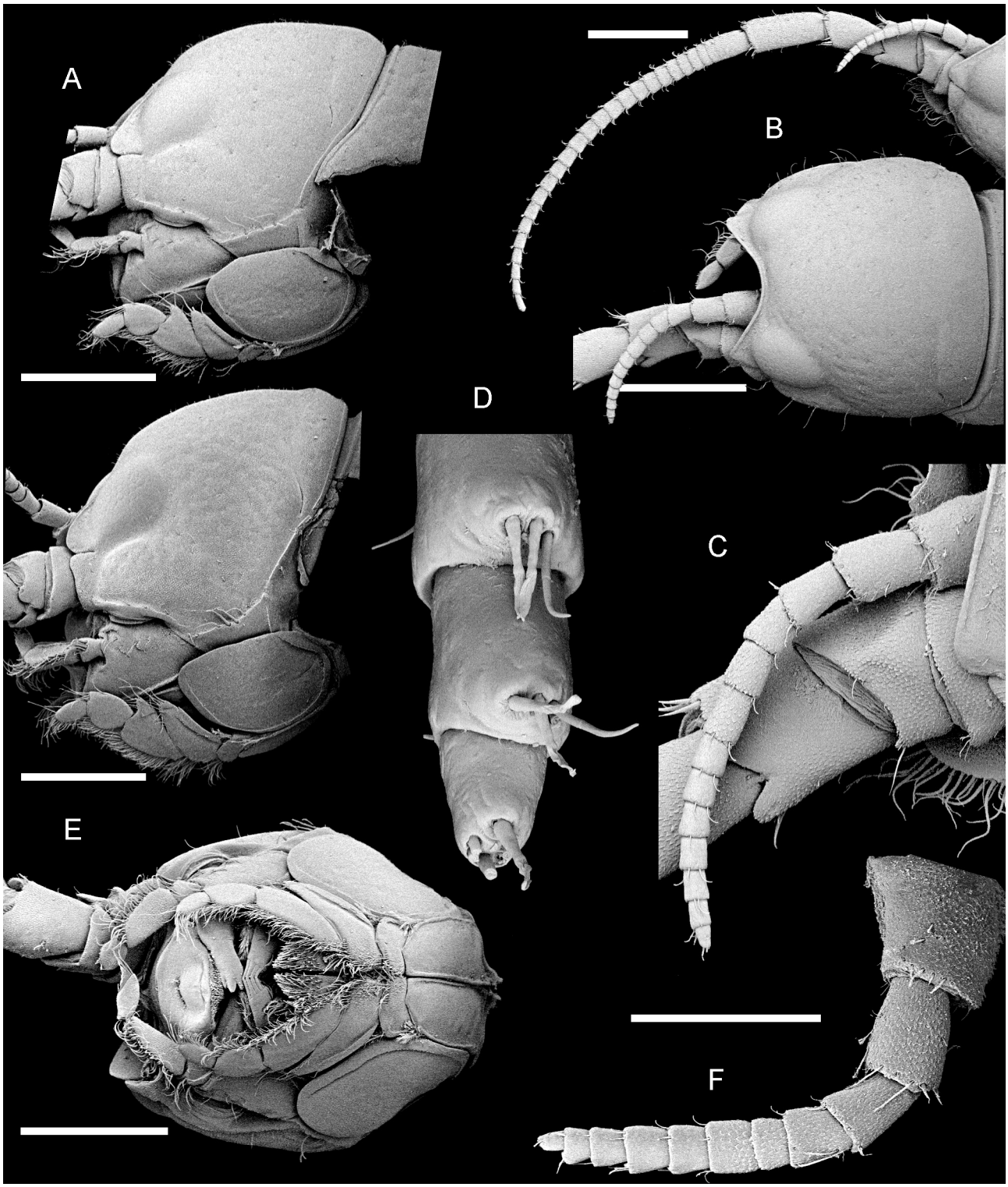

FIGURE 197. *Eophreatoicus wurrkbaba* sp. nov., head and antennae. Paratype male, AM P.76284: A, head, lateral; B, head dorsal with section including entire antenna, in situ; C–D, antennula, in situ, with enlargement of distal tip, medial view. Paratype female, AM P.76285: E, head, lateral and ventral; F, antennula. Scales 1 mm.

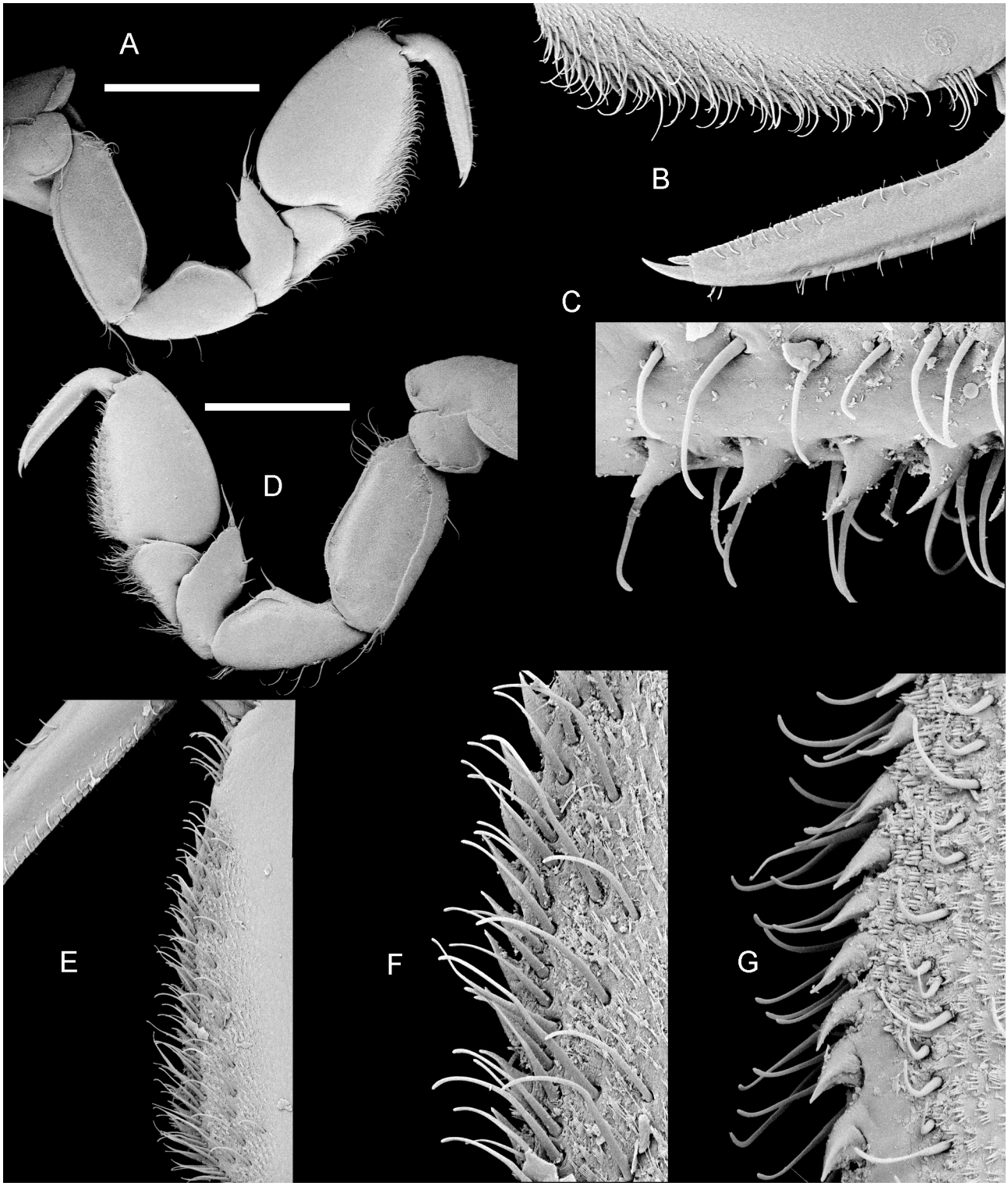

FIGURE 198. *Eophreatoicus wurrkbaba sp. nov.*, pereopod I. Paratype male, AM P.76284: A, lateral; B, palm and dactylus; C, palm setae, medial. Paratype female, AM P.76285: D, lateral; E, palm; F, palm setae lateral; G, palm setae medial. Scales 1 mm.

Antennula. Length 0.10 body length in male (M2), 0.10 body length in female (F3), with 13 articles in male (M2), with 11 articles in female (F3). Article 5 length 0.66–1.10 width (F3, M2). Article 6 length 0.85–1.40 width (F3, M2). Aesthetascs small (1–4) on distal margins, located mostly near antennula axis in distal articles of M2. Terminal article length subequal to penultimate article length, length 1.30–1.60 width (F3, M2), length 0.04–0.04 antennula total length (M2, F3). Distal articles oval in cross-section.

Antenna. Length 0.43 body length in male (H). Flagellum proximal articles surface finely scaled on sides, distal margin with rosette of short setae.

Mouthfield. Clypeus width 0.37 head width (M2).

Maxilliped. Epipod distal tip rounded, length 1.50 width (M2). Endite medial margin with 4 coupling hooks on right side (M2). Endite distal margin in fringe. Palp length 1.10–1.20 basis length (M2, F3). Palp article 4 shape elongate-oval, length 1.70–2.10 width (M2, F3). Palp article 5 length 2.00–2.10 width (M2, F3), 0.75–0.84 article 4 length (F3, M2).

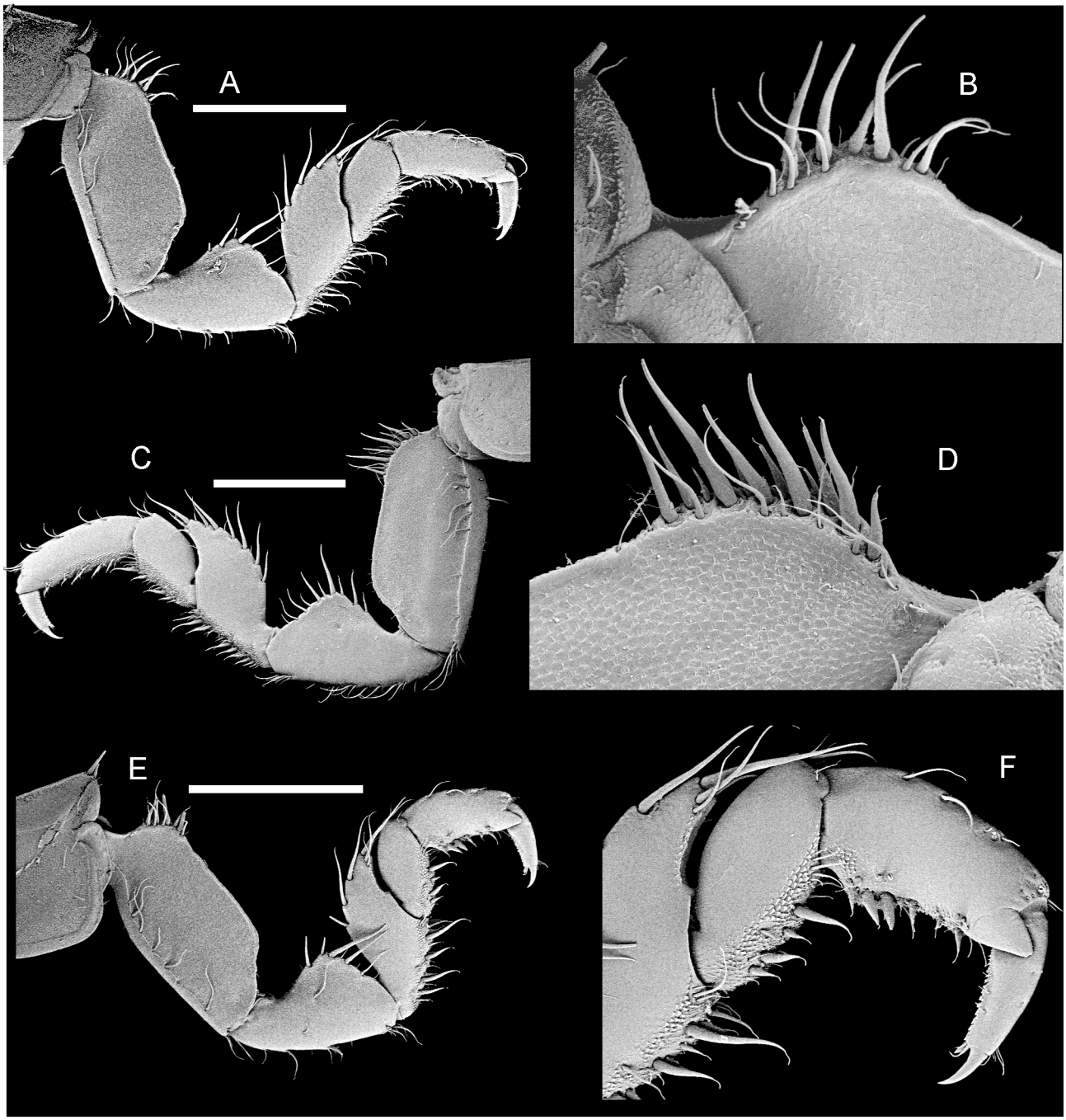

FIGURE 199. *Eophreatoicus wurrkbaba* sp. nov., pereopods II, IV. Paratype male, AM P.76284: A–B, pereopod II with enlargement of epaulet on basis; E–F, pereopod IV with enlargement of distal segments. Paratype female, AM P.76285: C–D, pereopod II with enlargement of epaulet on basis. All scales 1 mm.

Pereopod I. Length:body length 0.31 male (M2), 0.36 female (F3). Basis of male length 2.40 width (M2), female length 2.00 width (F3); dorsal setae positioned proximally, 9 dorsal setae altogether (M2); female dorsal setae positioned proximally, female 9 dorsal setae altogether (F3); ventrodistal margin with 3 elongate setae (M2),

female with 4 elongate setae (F3), elongate setae longer than ischium. Ischium of male dorsal margin with 1 simple seta, setae not robust. Ischium of female dorsal margin with 2 simple setae (F3), setae not robust. Merus of male distodorsal margin in cross section shelf-like, U-shaped and curving around proximal margin of propodus, with 1 or 2 robust simple setae, dorsal surface with setae along dorsal axis (1 robust simple 1 small); female distodorsal margin with few elongate simple setae, female dorsal surface with setae along dorsal axis (4 robust simple). Propodus length:pereopod length 0.21 male (M2), 0.20 female (F3). Propodus length:width 1.30 male (M2), 1.40 female (F3). Propodus of male dorsal margin setae in several groups between proximal and distal margin, with 7 setae altogether (excluding distal group) (M2), proximal region recurved and protruding to distodorsal margin of carpus, female dorsal margin proximal region recurved and protruding to distodorsal margin of carpus. Propodal palm of male margin straight, with marginal row of stout robust basally flattened distally curved spine-like setae, stout robust setae proximally on margin articulated, grading distally to articulation not expressed, 24 altogether (M2). Propodal palm of female margin convex, stout denticulate setae serrate, 10 altogether (F3), with stout robust conical setae, 8 altogether (F3, 4 distally 4 proximally). Dactylus of male shorter than palm, length:palm length 0.94 (M2), female shorter than palm, female length:palm length 0.89 (F3). Dactylus of male ventrodistal margin ventrodistal margin distal cuticular fringe length 0.41 total length (M2); female ventrodistal margin distal cuticular fringe length 0.62 total length (F3). Dactylus claw length:dactylus length 0.12 male (M2), 0.16 female (F3). Dactylus of male positioned ventrally, 0.37–0.39 (F3, M2) length of primary claw.

Pereopods II–III ratios. *Pereopod II*. Length:body length 0.30 male (M2), 0.38 female (F3). Basis length: pereopod length 0.29 male (M2), 0.30 female (F3); length:width 2.20 male (M2), 2.10 female (F3). Carpus length: pereopod length 0.11 male (M2), 0.12 female (F3); length:width 1.40 male (M2), 1.50 female (F3). Propodus length:pereopod length 0.16 male (M2), 0.17 female (F3); length:width 2.70 male (M2), 2.60 female (F3). Dactylus length:propodus length 0.57 male (M2), 0.57 female (F3); primary claw length:dactylar length 0.23 male (M2), 0.28 female (F3). *Pereopods II–III*. Penicillate setae scattered on dorsal ridge of basis, propodus., dactylus; basis dorsal ridge with setae forming 2 rows on proximal projection, anterior row with 4–9 larger setae and 4 simple setae, posterior row with 7 simple setae. Ischium II–IV of male dorsal margin with 6–7 simple setae (M2 pereopod IV, pereopod II), none robust. Dactylus ventral to primary claw, 0.24–0.45 length of primary claw, with scales on ventral margin; 15 altogether (M2 pereopod II, F3 pereopod II).

Pereopod II. Basis lateral face with 5 simple setae along margin in male and with 5 elongate simple setae proximally and 2 short setae distally in female. Basis of male dorsal ridge epaulet with 2 rows of setae, main setal row with 2–4 minor setae, submarginal setal row with 3–3–4 setae, without major setae distal to epaulet. Basis of female dorsal ridge epaulet with 2 rows of setae, main setal row with 2–6 minor setae, submarginal setal row with 2–3–4 setae, without major setae distally.

Pereopod IV. Penicillate setae in both sexes, of male occurring on anterodorsal margin of carpus. Basis of male dorsal ridge with 14 setae (12 of which on proximal projection), dorsal ridge setae positioned proximally. Ischium of male dorsal margin with 6 setae (M2). Carpus of male ventral margin with simple setae only. Propodus of male distal width 0.71 maximum width (M2), setae on ventral margin robust-based, 2 distinctly larger than remainder, longer than dactylar claw. Dactylus of male distal accessory claw approximately 0.33 primary claw length (M2, 0.31). *Pereopod IV ratios*. Length:body length 0.26 male (M2). Basis length:width 2.40 male (M2). Carpus length: pereopod length 0.11 male (M2). Propodus length:pereopod length 0.15 male (M2). Propodus length:width 1.90 male (M2).

Pereopods V–VII ratios. *Pereopod V*. Length:body length 0.27–0.29 male (M2, H), 0.31 female (F3). Basis length:width 1.20 male (H, M2). Carpus length:pereopod length 0.15 male (H, M2), 0.13 female (F3). Propodus length:pereopod length 0.16–0.18 male (M2, H), 0.16 female (F3). Dactylus claw length:dactylar length 0.28 male (M2). *Pereopod VI*. Length:body length 0.39 male (H), 0.39 female (F3). Carpus length:pereopod length 0.16 male (H), 0.14 female (F3). Propodus length:pereopod length 0.19 male (H), 0.17 female (F3). *Pereopod VII*. Length: body length 0.43–0.44 male (M2, H), 0.40 female (F3). Basis length:width 1.50 male (M2). Carpus length:pereopod length 0.15–0.16 male (H, M2), 0.15 female (F3). Propodus length:pereopod length 0.18 male (H, M2), 0.16 female (F3). Dactylus claw length:dactylar length 0.23 male (M2).

Pereopods V–VII. V–VII penicillate setae on dorsal ridge of basis, penicillate setae dorsodistally on carpus; penicillate setae dorsodistally on propodus. Basis V dorsal ridge proximal margin forming acute angle with axis of basis. V–VII ischium of male dorsal margin with 4–5 setae (M2 pereopod V, pereopod VII). Propodus distal margins with 3–4 elongate robust or robust-based setae (M2 pereopod VII, pereopod V). Dactylus accessory claw 0.23–0.27 primary claw length (M2 pereopod VII, pereopod V). Pereopod VII basis dorsal ridge distal margin

rounded. Pereopod VII ischium dorsal ridge margin produced into flattened plate, distal margin with no setae, dorsal margin with 5 setae (M2).

Penes. Distally tapering; distal tip truncate.

Pleopods. Pleopod II endopod of male appendix masculina basal musculature pronounced, distal length 1.50 endopod proximal margin length (approximately); distally with 8 setae; 42 setae altogether (M2).



FIGURE 200. *Eophreatoicus wurrkbaba* sp. nov., pereopods, pleopod II, uropods. Paratype male, AM P.76284: A, pereopod V; B–C, pereopod VII with enlargement of pene; D, pleopod II endopod with enlargement of appendix masculina; E, uropod, lateral in situ; F, uropod protopod ventrodistal setae. Paratype female, AM P.76285: G, uropod, lateral; H, uropod protopod ventrodistal setae. Scales: A–B, E, G, 1 mm; C–D, 0.5 mm; F, H, 0.1 mm.

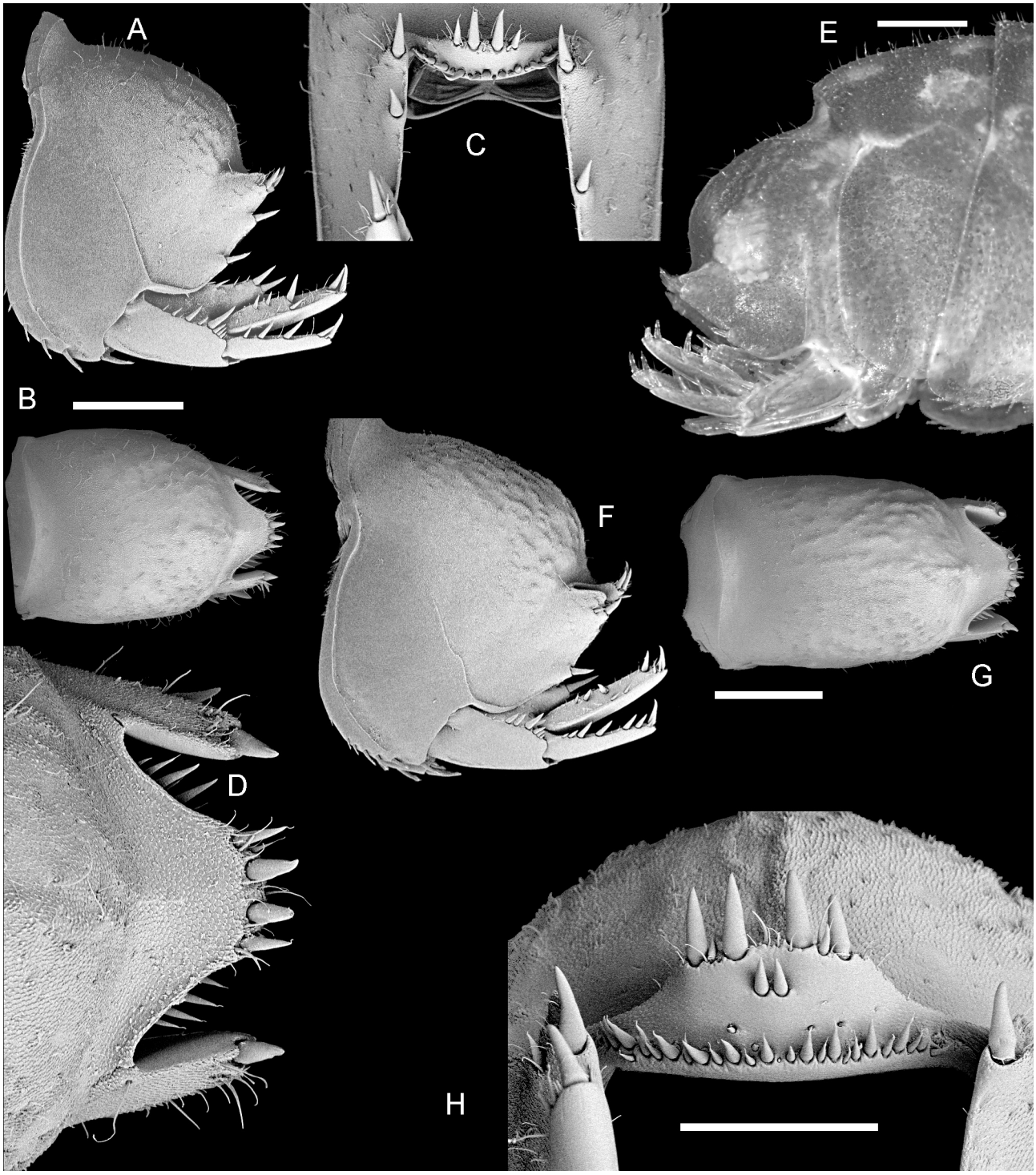

FIGURE 201. *Eophreatoicus wurrkbaba* sp. nov., pleotelson. Paratype male, AM P.76284: A–B, lateral and dorsal, scale 1 mm; C, apex, posterolateral margin and postanal ridge setae, posterior; D, apex, dorsal. Holotype male, AM P.76283: E, pleotelson and pereonites 4–5, lateral. Paratype female, AM P.76285: F–G, lateral and dorsal, scale 1 mm; H, apex and postanal ridge setae, posterior, scale 0.5 mm.

Uropod. Of male total length 0.90–0.93 pleotelson length (H, M2); protopod of male length 0.51–0.65 uropod total length (H, M2). Uropod of female total length 0.83 pleotelson length (F3), protopod length 0.51 uropod total length (F3). Protopod dorsomedial ridge length:endopod length 0.75 male (M2), 0.74 female (F3). Protopod of male dorsolateral margin longer than dorsomedial margin setae; of female dorsolateral margin shorter than dorsomedial margin setae. Protopod distoventral margin with 3 robust setae (F protopod on one side only 1, M2), with spinose

setae, 3–4 robust spinose setae (M2, F3 protopod on one side - extra spinose seta laterally). Protopod lateral face with ventrolateral ridge. Endopod shorter than protopod or longer than protopod (M2, F). Endopod of male dorsal margin with robust setae occurring along length, 7 altogether (M2); female dorsal margin with 11 robust setae (F3). Exopod length:endopod length 0.80 male (M2), 0.79 female (F3). Exopod of male dorsal margin with 6 robust setae (M2), female 7 robust setae (F3).

Distribution. Australia, Northern Territory, Kakadu National Park, side branch of Dinner Creek, a tributary of the upper South Alligator River.

Habitat. Spring in side branch of creek among silt and roots of ferns.

Remarks. *Eophreatoicus wurrkbaba* sp. nov. is the southernmost occurring species in Kakadu, although more species could be found if some of the less accessible areas were surveyed. This species is weakly associated with *E. warddebarrarn* sp. nov. by two nodes in the combined analysis cladogram (Fig. 12). The uropod protopod dorsomedial ridge of *E. wurrkbaba* sp. nov. and its setae projects posteriorly while most other *Eophreatoicus*, including *E. warddebarrarn* sp. nov., the ridge and its setae are more dorsal in orientation. *Eophreatoicus wurrkbaba* sp. nov. is also unusual in the genus by having the greatest number of robust setae on the pleotelson postanal ridge (20–27). The pleotelson dorsal surface of *E. wurrkbaba* sp. nov. has elongate ridge-like tubercles; *E. warddebarrarn* sp. nov. has only small irregular rugose regions.

The paratype male (AM P.76284) has an additional robust seta on the left posterolateral margin of the pleotelson (Fig. 201A) and the paratype female (AM P.76285) has an additional pair of robust setae between the pleotelson terminal apex and the ventral postanal ridge setae (Fig. 201H). Setae may be missing and the associated cuticle may have a shape different from a typical specimen. Extra robust setae or missing setae occur at a low frequency among all species and might be attributed to damage that occurred during the previous molt. Because the imaged paratypes are usually the largest specimens, they also are the oldest and therefore more likely to have suffered damage during their lifetime.

Discussion

Consequences of *Eophreatoicus* Life History

Isopods are peculiar among the Peracarida in that they have internal fertilization (Wilson 1991), whereas other orders have external fertilization (Johnson *et al.* 2001). Isopod males of most isopod suborders, phreatoicideans included, must inseminate the female during the first part of the biphasic ecdysis when the posterior part of the exuvium (pleon and pereonites 5-7) is cast off and the cuticle in the region of the oopore in pereonite 5 is soft. When the remainder of the exuvium (head and pereonites 1-4) is lost, the oostegites deploy and fertilized eggs are released into the female's brood pouch. A typical mating strategy for many isopods involves some sort of mate guarding by the male; precopula (mate holding) is the common premating behavior among the phreatoicideans. Phreatoicideans, including *Eophreatoicus* and the related Kimberly species *Eremisopus beei* Wilson & Keable, 2002a (Fig. 202A), typically have coupled pairs with the larger male holding a smaller female between its legs using a specialized fourth pereopod. This, however, is not the case with *Kakadubeh rangemyahwurd* gen. et sp. nov., where the male is much smaller than the female and lacks a specialized fourth pereopod. Multiple matings are precluded in species that practice precopula, so that offspring arise from a single pair of parents that mate only once. This behavior almost certainly limits genetic diversity in the population. During the dry season, these isopods live at high densities in small spring-fed pools, seeps or interstitial groundwaters, with little or no connectivity between adjacent streams or shallow groundwater aquifers. The isopods become active in the wet season and spread out into flowing streams (Fig. 2; Fig.202B - partially molted adult indicated), but no more than 2-6 km downstream (Wilson *et al.* 2009). At this time, they are observed to be moving actively and not in precopula; many juveniles have been observed in the streams at these times. We surmise that mating occurs during the dry season when the animals are in close proximity. This reproductive pattern reduces the likelihood of genetic intermixing between neighboring populations, explaining why the species described here are micro-endemic to the extent that separate but closely related species are found within a few kilometers of one another.

The presence of distantly-related congenors at single sites was another pattern that appeared in the genetic data. Because the isopods enter streams during the wet season, small propagules could colonize new locations

that are distant from the home site. We did not see much evidence of genetic introgression, although two new species (*E. nawurlandja* and *E. kurrih*) apparently interbred, so that one retained identical mitochondria of the other. Given that the former species is widespread, we suspect that its mitochondrion was transferred to the latter species fairly recently. This hypothesis is supported by the identity of the sequence between *E. kurrih* and the Nourlangie population of *E. nawurlandja*, which had identical sequences among all individuals (Wilson *et al.* 2009, e.g., fig. 5), while the widespread Gulunggul Creek population of *E. nawurlandja* was somewhat more variable and therefore unlikely to be the result of the opposite transfer of the mitochondrion.

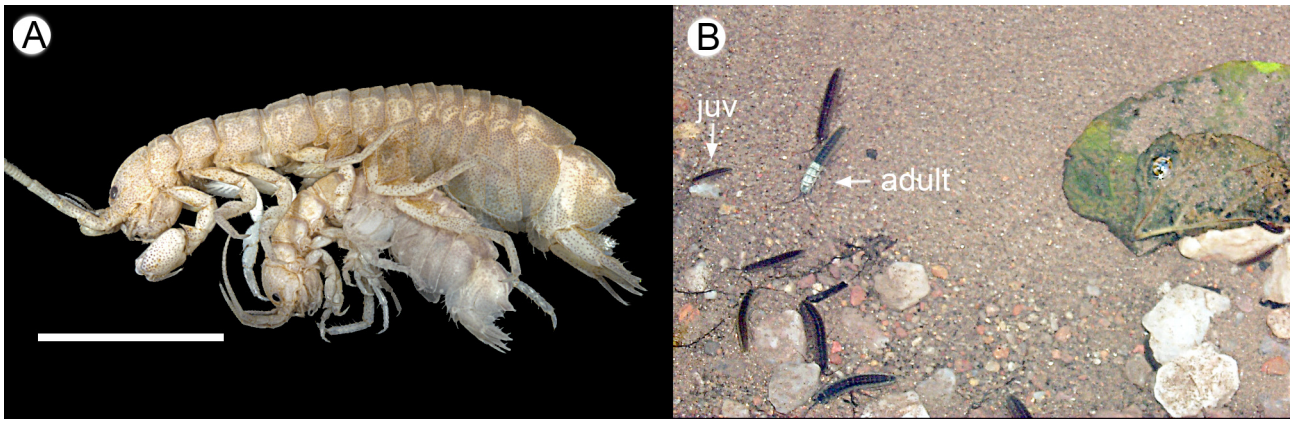

FIGURE 202. A, example of precopula in *Eremisopus beei* Wilson & Keable, 2002a. B, specimens of *Eophreatoicus nawurlandja* sp. nov. in stream near Nourlangie rock during the wet season 16 March 2000; arrows indicate a juvenile specimen and a partially molted adult; no adults were seen in precopula.

Changes in sea level and rainfall patterns over long periods of time may cause local extinctions or the spread of species over longer distances than normal. Dry periods (local extinctions) followed by wet periods (spread of propagules to open habitat) with multiple colonizations of single sites might explain the genetic observations. Because age-calibrated Bayesian analysis of the genetic data indicated that most terminal lineages have a minimum age of approximately 1 Ma (Wilson *et al.* 2009), *Eophreatoicus* lineages may have contracted or spread over long periods of time, ranging either from the middle Miocene or as early as the late Cretaceous (Wilson *et al.* 2009).

Species Richness

Has this research found all species of *Eophreatoicus*? The sampling in this study focused mostly on accessible areas in Kakadu National Park, suggesting that many more species exist, especially in the largely unexplored Arnhem Plateau region. Although *E. mok* sp. nov. is found deep into the plateau on the highly incised Liverpool River catchment, most known species of *Eophreatoicus* and *Kakadubeh* gen. nov. occur primarily in river catchments along the margins of the Arnhem Plateau. The perimeter of the Arnhem Plateau is approximately 2333 km based on an ImageJ (Rasband 2018) graphic measurement of the plateau outline, Fig. 3), while the distributions of species reported here (except for the non-Arnhem Plateau species *E. kershawi*) account for only 451 km, or approximately 19% of the perimeter. A simple linear extrapolation of beta diversity along the margin might indicate more than 150 species occurring in this region but two key caveats are necessary:

1. *Underestimation of diversity*. This figure could be conservative considering that the interior of the Arnhem Plateau and the sandstone ridges and outliers of the King River catchment and Borrodaile regions, both to the north and northwest of our study area, were excluded. Moreover, *Eremisopus* species in the Kimberley of Western Australia were found in lowland coastal waterways (Wilson & Keable 2002a), which also are unsurveyed in most of eastern Arnhem Land. Access to the Arnhem Plateau eastern margins and interior is difficult so that a thorough survey for these isopods is not feasible. A sampling program on an accessible part of the eastern margin could test or extend this beta diversity estimate for these taxa.
2. *Overestimation of diversity.* Wilson *et al.* (2009) suggested that the probability of isopod speciation in the study area most likely followed a gradient over the western Arnhem Plateau from a high in the northwest portion of the sandstone formations to a low in the south, coinciding with greater dissectedness, height and stability of

the plateau, and higher rainfall in the northwest. They found the highest number of distinct linages, and sympatric congeners around the Jabiluka area (Wilson *et al.* 2009: fig. 4) where highly dissected sandstone ridges and outliers with a myriad of associated small streams are particularly evident. This pattern in species richness coincides with a similar concentration of terrestrial endemic plants in the Northern Territory, associated with higher rainfall and the unique features of the western Arnhem Land plateau described above (Woinarski *et al.* 2006).

Is the species richness of *Eophreatoicus* a consequence of the unique geomorphology and climate of the Northern Territory, or is it indicative of a general propensity toward divergence among many phreatoicideans? Although the highly-incised Arnhem Plateau region geomorphology and climate are certainly factors, the latter possibility is also likely, owing to the life history patterns of most phreatoicideans discussed above and their current dependence on permanent groundwater. A survey of studies from different habitats supports this latter contention. Research on the genus *Crenoicus* Nicholls, 1944 (Wilson & Ho 1996) indicated that the Great Dividing Range in southeastern Australia might have many more than the four described species of this genus. The genus *Colubotelson* Nicholls, 1944 includes at least 18 described species, although a survey of Tasmanian streams, springs and lakes (GDFW, manuscript in prep) indicates that more may be present. *Mesamphisopus* Nicholls, 1943, endemic to the mountainous regions of South Africa, was recently increased from four species to 10 species (Gouws 2008), using both detailed morphological analysis and genetic data from other studies (Gouws *et al.* 2004, 2005, 2010). The currently monotypic genus *Phreatomerus* Sheppard, 1927, a well-known inhabitant of the South Australian mound springs, appears to be a complex of at least 9–11 species-level lineages, although Guzik *et al.* (2012) were unwilling to adjudicate on species status. Their estimated Miocene time scale for *Phreatomerus* divergence argues that this genus will prove to be another cluster of morphologically distinct species (King & Wilson, research in progress). Gouws & Stewart (2007) found the current taxonomy of the Western Australian lacustrine genus *Paramphisopus* Nicholls, 1943, which was originally assumed to include three species (subspecies named by Nicholls (1943) are considered to be species), to be invalid; their study found at least seven genetically distinct lineages in localities near Perth. A third species of *Amphisopus* Nicholls, 1926, common in wooded and coastal regions of southern Western Australia, was recently detected by Gouws and Stewart (2013), although their results for the "western clade" indicates that more species-level diversity may be present in this genus. This pattern can be expected wherever phreatoicideans are found in abundance.

Conservation of phreatoicidean isopods in the Northern Territory

Most phreatoicideans, wherever they are found, occur in , or are associated with, permanent groundwater (i.e. shallow aquifers), exploiting surface springs and seeps on a seasonal or year-round basis. *Eophreatoicus* and *Kakadubeh* gen. nov. are no exception. We are limited by a lack of established knowledge on conservation values for these freshwater invertebrates in Kakadu and Arnhem Land, especially for the latter region where site access is seasonal or subject to traditional owners' permission. Two reports on conservation in Kakadu National Park (Woinarski & Winderlich 2014; Winderlich & Woinarski 2014) dealt mostly with terrestrial plants and vertebrates. One of the contributions to Winderlich & Woinarski (2014), however, did list amongst risks to endemic macrocrustaceans, including phreatoicidean isopods, introduced species such as cane toads and their tadpoles (competition, impaired water quality), and any dewatering associated with potential mining in the region (Andersen *et al.* 2014). Humphrey *et al.* (2018) considered additional risks to the region's endemic isopods, including increasing surface water temperatures and potential loss of surface waters in the late dry season. They noted, however, that isopods can retreat to underground interstitial waters and that they are quite tolerant of poor water quality. Nevertheless, each of these papers emphasize that the lack of knowledge on freshwater invertebrates, including phreatoicidean isopods, has impaired further development of conservation strategies. As a result, criteria for conserving the endemic populations of *Eophreatoicus* and *Kakadubeh* gen. nov. have not been developed.

Phreatoicidean isopods, as a group, are survivors. They have a fossil record that reaches back into the Paleozoic (Schram 1970), with an increasing number of fossils found in Mesozoic strata that appear to be members of modern families (Ball *et al.* 1979; Wilson & Edgecombe 2003; Fu *et al.* 2010; unpublished data). Although trout (aggressive predatory species) were introduced into the Great Lake of Tasmania, where many species of Phreatoicidae were found (Nicholls 1944), a survey of the lake (2001, unpublished data) showed that most species and all genera known from the lake were still present. How *Eophreatoicus* and *Kakadubeh* will be impacted by multiple impacts

of introduced species, such as the cane toad, and climate change, remains unknown. We hope that our monograph on the distribution and identification of these isopods will contribute to the ongoing study of freshwater invertebrate conservation.

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References

Andersen, A.N., Humphrey, C. & Braby, M.F. (2014) Threatened invertebrates in Kakadu National Park. In Kakadu National Park Landscape Symposia Series. *In*: Winderlich, S. & Woinarski, J. (Eds.), *Symposium 7: Conservation of threatened species*, 26-27 March 2013, Bowali Visitor Centre, Kakadu National Park. Internal Report 623, June, Supervising Scientist, Darwin, pp. 13–32.

ANZECC & ARMCANZ (2000) Australian and New Zealand guidelines for fresh and marine water quality. Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

Ball, H.W., Borns, H.W.J., Hall, B.A., Brooks, H.K., Carpenter, F.M. & Delevoryas, T. (1979) Biota, age and significance of lake deposits, Carapace Nunatak, Victoria Land, Antarctica. *In*: Laskar, B. & Raja Rao, C.S. (Eds.), *Fourth International Gondwana Symposium, January 1977, Geological Survey of India, Calcutta; Section III - Gondwana Fauna*. Hindustan Publishing Corporation, Delhi, pp. 166–175.

Clamp, J.C. & Kane, J.R. (2003) Redescription of four species of lagenophryid peritrichs (Ciliophora) from Australia and New Guinea, with descriptions of two new species. *Records of the Australian Museum*, 55, 153–168. https://doi.org/10.3853/j.0067-1975.55.2003.1381

Dallwitz, M.J. (1980) A general system for coding taxonomic descriptions. *Taxon*, 29, 41–46. https://doi.org/10.2307/1219595

Dallwitz, M.J., Paine, T.A. & Zurcher, E.J. (2000) *User's guide to the DELTA system: a general system for processing taxonomic descriptions*. CSIRO, Canberra, 158 pp.

Dostine, P.L., Humphrey, C.L. & Spiers, A. (1993) Benthic macroinvertebrate communities in Rockhole Mine Creek: Review of 1992 data. Internal report 116, Supervising Scientist for the Alligator Rivers Region, Canberra.

Dreyer, H. & Wägele, W. (2001) Parasites of crustaceans (Isopoda: Bopyridae) evolved from fish parasites: Molecular and morphological evidence. *Zoology*, 103, 157–178.

Edgar, R.C. (2004) MUSCLE: multiple sequence alignment with high accuracy and high throughput. *Nucleic Acids Research*, 32, 1792–1797. https://doi.org/10.1093/nar/gkh340

Faith, D., Dostine, P.L. & Humphrey, C. (1995) Detection of mining impacts on aquatic macroinvertebrate communities: Results

of a disturbance experiment and the design of a multivariate BACIP monitoring programme at Coronation Hill, Northern Territory. *Australian Journal of Ecology*, 20, 167–180.
https://doi.org/10.1111/j.1442-9993.1995.tb00530.x

Fu, W.-L., Wilson, G.D.F., Jiang, D.-Y., Sun, Y.-L., Hao, W.-C. & Sun, Z.-Y. (2010) A New Species of *Protamphisopus* Nicholls (Crustacea, Isopoda, Phreatoicidea) from Middle Triassic Luoping Fauna of Yunnan Province, China. *Journal of Paleontology*, 84, 1003–1013.
https://doi.org/10.1666/10-042.1

Garde, M. (2014) Doing things with toponyms: The pragmatics of place names in Western Arnhem Land. *In*: Clark, I.D., Hercus, L. & Kostanski, L. (Eds.), *Indigenous and Minority Placenames: Australian and International Perspectives*. ANU Press, Canberra, Australia, pp. 97–122.
https://doi.org/10.22459/IMP.04.2014.06

Giribet, G., Carranza, S., Baguñà, J., Riutort, M. & Ribera, C. (1996) First molecular evidence for the existence of a Tardigrada + Arthropoda clade. *Molecular Biology and Evolution*, 13, 76–84.
https://doi.org/10.1093/oxfordjournals.molbev.a025573

Glauert, F.G.S. (1924) Contributions to the fauna of Western Australia, No.4. A freshwater isopod *Phreatoicus palustris* n.sp. *Journal of the Royal Society of Western Australia*, 10, 49–57. Available from: https://www.biodiversitylibrary.org/page/46488659 (accessed 2 July 2020)

Goloboff, P.A. (1993) Estimating character weights during tree search. *Cladistics*, 9, 83–91.
https://doi.org/10.1111/j.1096-0031.1993.tb00209.x

Goloboff, P.A. & Catalano, S.A. (2016) TNT version 1.5, including a full implementation of phylogenetic morphometrics. *Cladistics*, 32, 221–238.
https://doi.org/10.1111/cla.12160

Goloboff, P.A., Carpenter, J.M., Arias, J.S. & Esquivel, D.R.M. (2008) Weighting against homoplasy improves phylogenetic analysis of morphological data sets. *Cladistics*, 24, 1–16.
https://doi.org/10.1111/j.1096-0031.2008.00209.x

Goloboff, P.A., Farris, J.S., Källersjö, M., Oxelman, B., Ramírez, M. & Szumik, C.A. (2003) Improvements to resampling measures of group support. *Cladistics*, 19, 324–332.
https://doi.org/10.1111/j.1096-0031.2003.tb00376.x

Goloboff, P.A., Torres, A. & Arias, J.S. (2018) Weighted parsimony outperforms other methods of phylogenetic inference under models appropriate for morphology. *Cladistics*, 34, 407–437.
https://doi.org/10.1111/cla.12205

Gouws, G. (2008) New species of *Mesamphisopus*, an endemic South African freshwater isopod genus (Isopoda: Phreatoicidea: Mesamphisopidae). *Zootaxa*, 1690, 1–62.
https://doi.org/10.11646/zootaxa.1690.1.1

Gouws, G. & Stewart, B. (2007) From genetic structure to wetland conservation: a freshwater isopod *Paramphisopus palustris* (Phreatoicidea: Amphisopidae) from the Swan Coastal Plain, Western Australia. *Hydrobiologia*, 589, 249–263.
https://doi.org/10.1007/s10750-007-0742-2

Gouws, G. & Stewart, B.A. (2013) Molecular species boundaries in the phreatoicidean genus *Amphisopus* (Isopoda : Amphisopidae) and evidence for a new freshwater isopod species from Western Australia. *Invertebrate Systematics*, 27, 173–185.
https://doi.org/10.1071/IS12043

Gouws, G., Matthee, C.A. & Stewart, B.A. (2010) A multiple data set phylogeny for the endemic South African freshwater phreatoicidean isopod genus *Mesamphisopus*: Taxonomic and biogeographic implications. *Molecular Phylogenetics and Evolution*, 55, 541–551.
https://doi.org/10.1016/j.ympev.2010.01.017

Gouws, G., Stewart, B.A. & Daniels, S.R. (2004) Cryptic species within the freshwater isopod *Mesamphisopus capensis* (Phreatoicidea: Amphisopodidae) in the Western Cape, South Africa: allozyme and 12S rRNA sequence data and morphometric evidence. *Biological Journal of the Linnean Society*, 81, 235–253.
https://doi.org/10.1111/j.1095-8312.2003.00284.x

Gouws, G., Stewart, B.A. & Matthee, C.A. (2005) Lack of taxonomic differentiation in an apparently widespread freshwater isopod morphotype (Phreatoicidea : Mesamphisopidae : *Mesamphisopus*) from South Africa. *Molecular Phylogenetics and Evolution*, 37, 289–305.
https://doi.org/10.1016/j.ympev.2005.06.002

Guzik, M.T., Adams, M.A., Murphy, N.P., Cooper, S.J.B. & Austin, A.D. (2012) Desert Springs: Deep Phylogeographic Structure in an Ancient Endemic Crustacean (*Phreatomerus latipes*). *PLoS ONE*, 7, 1–13.
https://doi.org/10.1371/journal.pone.0037642

Hessler, R.R. (1969) Peracarida. *In*: Moore, R.C. (Ed.), *Treatise on Invertebrate Paleontology. Arthropoda 4, Part R, Crustacea (except Ostracoda), Myriapoda-Hexapoda*. The Geological Society of America and University of Kansas, Boulder, Colorado and Lawrence, Kansas, pp. R360–R393.

Hogan A., van Dam R.A., Markich S.J. & Camilleri C. (2005) Chronic toxicity of uranium to a tropical green alga (*Chlorella* sp.) in natural waters and the influence of dissolved organic carbon. *Aquatic Toxicology,* 75, 343–353.

https://doi.org/10.1016/j.aquatox.2005.07.012
Humphrey, C.L., Bishop, K.A. & Dostine, P.L. (2018) Vulnerability of fish and macroinvertebrates to key threats in streams of the Kakadu region, northern Australia: assemblage dynamics, existing assessments and knowledge needs. *Marine and Freshwater Research*, 69, 1092–1109.
https://doi.org/10.1071/MF16175
ICZN (1999) *International Code of Zoological Nomenclature*. The International Trust for Zoological Nomenclature 1999 Fourth Edition c/o The Natural History Museum, London, UK, 306 pp. Available from: https://www.iczn.org/the-code/the-international-code-of-zoological-nomenclature/the-code-online/ (accessed 2 July 2020)
Johnson, W.S., Stevens, M. & Watling, L. (2001) Reproduction and development of marine peracaridans. *Advances in Marine Biology*, 39, 107–220.
https://doi.org/10.1016/S0065-2881(01)39009-0
Kilpert, F. & Podsiadlowski, L. (2010) The Australian fresh water isopod (Phreatoicidea: Isopoda) allows insights into the early mitogenomic evolution of isopods. *Comparative Biochemistry and Physiology*, *Part D* 5, 36–44.
https://doi.org/10.1016/j.cbd.2009.09.003
Layton, R. (1981) Statement on the Alligator Rivers Stage Two land claim (1) Traditional foraging and camping patterns. (2) Rock paintings. *In*: Toohey, J. (Ed.), *Alligator Rivers Region Stage Two land claim*. Australian Government Publishing Service, Canberra, 98 pp.
Lewis, P.O. (2001) A likelihood approach to estimating phylogeny from discrete morphological character data. *Systematic Biology*, 50, 913–925.
https://doi.org/10.1080/106351501753462876
Lins, L.S.F., Ho, S.Y.W., Wilson, G.D.F. & Lo, N. (2012) Evidence for Permo-Triassic colonization of the deep sea by isopods. *Biology Letters*, 8, 979–982.
https://doi.org/10.1098/rsbl.2012.0774
Maddison, W.P. & Maddison, D.R. (2018) Mesquite: a modular system for evolutionary analysis. Version 3.6. Available from: https://www.mesquiteproject.org. (accessed March 2020)
Mattern, D. & Schlegel, M. (2001) Molecular evolution of the small subunit ribosomal DNA in Woodlice (Crustacea, Isopoda, Oniscidea) and implications for oniscidean phylogeny. *Molecular Phylogenetics and Evolution*, 18, 54–65.
https://doi.org/10.1006/mpev.2000.0861
Mertens, T., Kautz, J. & Van Reeth, F. (2009) Exposure Fusion: A Simple and Practical Alternative to High Dynamic Range Photography. *Computer Graphics Forum*, 28, 161–171.
https://doi.org/10.1111/j.1467-8659.2008.01171.x
Milatovic, M., Kostanjsek, R. & Strus, J. (2010) Ontogenetic Development of Porcellio scaber: Staging based on microscopic anatomy. *Journal of Crustacean Biology*, 30, 225–235.
https://doi.org/10.1651/09-3189.1
Nicholls, G.E. (1926) A description of two genera and species of Phreatoicidea, with a discussion of the affinities of the members of this family. *Journal of the Royal Society of Western Australia*, 12, 179–210, pls.25–28.
Nicholls, G.E. (1943) The Phreatoicoidea. Part I. The Amphisopidae. *Papers and Proceedings of the Royal Society of Tasmania*, 1942, 1–145.
Nicholls, G.E. (1944) The Phreatoicoidea. Part II. The Phreatoicidae. *Papers and Proceedings of the Royal Society of Tasmania*, 1943, 1–156.
Poore, G.C.B., Knott, B., Lew Ton, H.M. & Wilson, G.D.F. (2002) Suborder Phreatoicidea Stebbing, 1893. *In*: Poore, G.C.B. & Beesley, P.L. (Eds.), *Crustacea: Malacostraca: Syncarida, Peracarida: Isopoda, Tanaidacea, Mictacea, Thermosbaenacea, Spelaeogriphacea*. CSIRO Publishing, Melbourne, Australia, pp. 62–80.
Rasband, W. (2018) ImageJ, 1.52d National Institute of Health, USA. Available from: https://imagej.nih.gov/ij/index.html (accessed 22 June 2020)
Raupach, M.J., Mayer, C., Malyutina, M. & Wagele, J.-W. (2009) Multiple origins of deep-sea Asellota (Crustacea: Isopoda) from shallow waters revealed by molecular data. *Proceedings of the Royal Society B: Biological Sciences*, 276, 799–808.
https://doi.org/10.1098/rspb.2008.1063
Schram, F.R. (1970) Isopod from the Pennsylvanian of Illinois. *Science*, 169, 854–855.
https://doi.org/10.1126/science.169.3948.854
Schram, F.R. (1974) Paleozoic Peracarida of North America. *Fieldiana Geology*, 33, 95–124.
https://doi.org/10.5962/bhl.title.5322
Sheppard, E.M. (1927) Revision of the family Phreatoicidae (Crustacea), with a description of two new species. *Proceedings of the Zoological Society of London*, 1927, 81–124.
https://doi.org/10.1111/j.1096-3642.1927.tb02247.x
Short, J.W., Humphrey, C.L. & Page, T.J. (2013) Systematic revision and reappraisal of the Kakaducarididae Bruce (Crustacea : Decapoda : Caridea) with the description of three new species of *Leptopalaemon* Bruce & Short. *Invertebrate Systematics*, 27, 87–117.
https://doi.org/10.1071/IS12016
Short, J.W., Page, T.J. & Humphrey, C.L. (2019) Caridina biyiga sp. nov., a new freshwater shrimp (Crustacea: Decapoda: Atyidae) from Leichhardt Springs, Kakadu National Park, Australia, based on morphological and molecular data, with a

preliminary illustrated key to Northern Territory *Caridina*. *Zootaxa*, 4695 (1), 1–25. https://doi.org/10.11646/zootaxa.4695.1.1
Sober, E. (2004) The contest between parsimony and likelihood. *Systematic Biology*, 53, 644–653. https://doi.org/10.1080/10635150490468657
Sober, E. (2008) *Evidence and Evolution; the logic behind the science.* Cambridge University Press, Cambridge, UK, 392 pp. https://doi.org/10.1017/CBO9780511806285
Tuffley, C. & Steel, M. (1997) Links between maximum likelihood and maximum parsimony under a simple model of site substitution. *Bulletin of Mathematical Biology*, 59, 581–607. https://doi.org/10.1007/BF02459467
Väinölä, R., Witt, J., Grabowski, M., Bradbury, J., Jazdzewski, K. & Sket, B. (2008) Global diversity of amphipods (Amphipoda; Crustacea) in freshwater. *Hydrobiologia*, 595, 241–255. https://doi.org/10.1007/s10750-007-9020-6
White, H.L. (1917) North Australian Birds. *The Emu*, 16, 9–158. https://doi.org/10.1071/MU916117
Wilson, E.O. & Brown Jr, W.L. (1956) Character displacement. *Systematic Biology*, 5, 49–64. https://doi.org/10.2307/2411924
Wilson, G.D.F. (1991) Functional morphology and evolution of isopod genitalia. *In*: Bauer, R.T. & Martin, J.W. (Eds.), *Crustacean Sexual Biology*. Columbia University Press, New York/Oxford, pp. 228–245. https://doi.org/10.7312/baue90796-014
Wilson, G.D.F. (2008a) Global diversity of Isopod crustaceans (Crustacea; Isopoda) in freshwater. *In*: Balian, E.V., Lévêque, C., Segers, H. & Martens, K. (Eds.), *Freshwater Animal Diversity Assessment*. Springer, Netherlands, pp. 231–240. https://doi.org/10.1007/978-1-4020-8259-7_26
Wilson, G.D.F. (2008b) Gondwanan groundwater: subterranean connections of Australian phreatoicidean isopods (Crustacea) to India and New Zealand. *Invertebrate Systematics*, 22, 301–310. https://doi.org/10.1071/IS07030
Wilson, G.D.F. (2017) Macrofauna abundance, species diversity and turnover at three sites in the Clipperton-Clarion Fracture Zone. *Marine Biodiversity*, 47, 323–347. https://doi.org/10.1007/s12526-016-0609-8
Wilson, G.D.F. & Edgecombe, G.D. (2003) The Triassic isopod *Protamphisopus wianamattensis* (Chilton) and comparison with extant taxa (Crustacea, Phreatoicidea). *Journal of Paleontology*, 77, 454–470. https://doi.org/10.1017/S0022336000044176
Wilson, G.D.F. & Ho, E.L. (1996) Crenoicus Nicholls, 1944, (Crustacea, Isopoda, Phreatoicidea): Systematics and biology of a new species from New South Wales. *Records of the Australian Museum*, 48, 7–32. https://doi.org/10.3853/j.0067-1975.48.1996.279
Wilson, G.D.F. & Keable, S.J. (2002a) New Genera of Phreatoicidea (Crustacea: Isopoda) from Western Australia. *Records of the Australian Museum*, 54, 41–70. https://doi.org/10.3853/j.0067-1975.54.2002.1359
Wilson, G.D.F. & Keable, S.J. (2002b) New Phreatoicidea (Crustacea: Isopoda) from Grampians National Park, with revisions of *Synamphisopus* and *Phreatoicopsis*. *Memoirs of Museum Victoria*, 59, 457–529. https://doi.org/10.24199/j.mmv.2002.59.10
Wilson, G.D.F., Humphrey, C.L., Colgan, D.J., Gray, K.-A. & Johnson, R.N. (2009) Monsoon-influenced speciation patterns in a species flock of *Eophreatoicus* Nicholls (Isopoda; Crustacea). *Molecular Phylogenetics and Evolution*, 51, 349–364. https://doi.org/10.1016/j.ympev.2009.02.001
Winderlich, S. & Woinarski, J.C.Z. (2014) *Symposium 7: Conservation of threatened species, 26–27 March 2013*. Bowali Visitor Centre, Kakadu National Park, NT, Supervising Scientist, Darwin, NT, 123 pp.
Woinarski, J.C.Z. & Winderlich, S. (2014) *A strategy for the conservation of threatened species and threatened ecological communities in Kakadu National Park, 2014–2024*. National Environmental Research Program Environmental Hub, Kakadu National Park, NT, Australia, 282 pp.
Woinarski, J.C.Z., Hempel, C., Cowie, I., Brennan, K., Kerrigan, R., Leach, G. & Russell-Smith, J. (2006) Distributional pattern of plant species endemic to the Northern Territory, Australia. *Australian Journal of Botany*, 54, 627–640. https://doi.org/10.1071/BT05041
Wolff, C. (2010) The embryonic development of the malacostracan crustacean Porcellio scaber (Isopoda, Oniscidea). *Development Genes and Evolution*, 219, 545–564. https://doi.org/10.1007/s00427-010-0316-6

Appendices

APPENDIX 1. Water quality data (based on laboratory analyses) for several sites associated with sandstone springs, seeps and streams of the western Arnhem Land sandstone massif and outliers.

Site	Ngarradj spring	Jabiluka outlier	Winmurra (7–J)	Leichhardt Springs	Upper Magela Ck	Rockhole Mine Ck	Rockhole Mine Ck (polluted)
Site code (Appendix 4)	13	15	17	1	26	34	34
Date	8 Apr 2003	3 Apr 2003	11 Apr 2003	14 May 2003	10 May 2007	30 Apr 1992	30 Apr 1992
pH	4	-	4.86	-	6.61	5.16	4.06
Electrical conductivity ($\mu S.cm^{-1}$)	28	-	16.9	-	13	13.9	83.7
Turbidity (NTU)	0	-	1.72	-	8.5	0.26	0.34
Major ions (mg/L)							
Na	1.1	0.7	-	0.9	-	1.3	1.3
K	<0.1	<0.1	-	<0.1	-	0.13	0.28
Ca	-	-	-	-	0.2	0.18	1.1
Mg	0.2	0.1	0.3	0.3	0.7	0.29	3.3
NH_4-N	-	-	-	-	-	<0.03	<0.03
Alkalinity	-	-	-	-	-	0.62	<0.01
Cl	-	-	-	-	-	3.2	3.4
SO_4	0.2	0.4	0.6	0.2	0.2	0.38	23
NO_3-N	-	-	-	-	-	0.04	-
TOC	-	-	-	-	-	7.9	2.6
DOC	-	-	-	-	-	-	-
Heavy metals (µg/L)							
Mn	2.67	1.09	2.28	2.08	2.09	5.5	220
Ni	0.64	0.12	0.13	0.22	-	0.2	12
Cu	0.13	0.1	0.08	0.29	0.11	0.2	17
Zn	6.5	1.5	2.7	1.3	0.3	<0.5	18
Cd	-	-	-	-	-	0.1	<0.1
Pb	0.06	0.03	<0.01	<0.01	0.005	<0.5	<0.5
Al	54.2	29.5	53.5	18.4	21	20	295
Fe	<20	<20	<20	<20	100	79	370
U	0.033	0.002	0.002	0.014	0.01	0.8	120

APPENDIX 2. *Eophreatoicus* & *Kakadubeh* gen. nov. specimens and sequences

*S*pecimens, voucher numbers and GenBank sequence accession numbers, with map number (see Fig. 3). (indications: § sp. nov.; * No specimen voucher; only collection lot number given; - no sequence) GenBank Accession Numbers.

Species	ID 2009	Spec ID	AM voucher	Map no.	COI	16S	18S
K. rangemyahwurd §	21	E01	P.74563	1	EU263163	EU263235	-
K. rangemyahwurd §	21	E05	P.74568*	1	EU263164	EU263236	-
K. rangemyahwurd §	21	E57	P.72638	1	EU263166	EU263237	-
E. kershawi	same	E65	P.74570	2	EU263136	EU263206	-
E. kershawi	same	E66	P.74571	2	EU263137	EU263208	-
E. kershawi	same	E67	P.74572	2	EU263138	EU263207	-
E. kershawi	same	GW104	P.72631	2	MK967231	MK961104	-
E. mok §	new	GW094a	P.81110	3	MK967228	-	MK961118
E. mok §	new	GW094b	P.81110	3	MK967229	MK961106	-
E. mok §	new	GW103	P.86065	3	MK967230	MK961105	-
E. kudjamarndi §	new	GW106	P.98674	4	MK961107	MK961108	-
E. kudjamarndi §	new	GW107	P.98675	4	MK967233	MK961107	-
E. bodmemurrngkudji §	new	GW108	P.98676	5	MK967234	MK961109	-
E. bodmemurrngkudji §	new	GW109	P.98677	5	MK967235	MK961110	-
E. kurdabeyhmay §	10	E82	P.76306	6	EU263153	EU263223	-
E. gudjangah §	11	E84	P.76311	7	EU263154	EU263224	-
E. gudjangah §	11	E85	P.76312	7	EU263155	EU263225	-
E. indjangarlwurr §	12	E110	P.76315	8	EU263157	EU263227	-
E. indjangarlwurr §	12	E63	P.76317	8	EU263156	EU263226	-
E. karrkkanj §	14	E111	P.76320	9	-	EU263231	-
E. karrkkanj §	14	E112	P.76321	9	-	EU263232	-
E. karrkkanj §	14	new	P.76318	9	FJ790313	FJ790313	-
E. ngarradj §	N2	E89	P.76381	10	EU263194	EU263266	-
E. ngarradj §	N2	E90	P.76382	10	EU263195	EU263267	-
E. mawoenewoene §	C1	E113	P.76369	11	EU263169	EU263240	-
E. mawoenewoene §	C1	E36	P.76372	11	EU263168	EU263239	-
E. binjdjarrang §	C2	E38	P.76374	12	-	EU263241	-
E. binjdjarrang §	C2	E78	P.76376	12	EU263170	EU263242	-
E. binjdjarrang §	C2	E79	P.76377	12	EU263171	EU263243	-
E. djirrinjbal §	S1	E93	P.76355	13	EU263196	EU263268	-
E. djirrinjbal §	S1	E94	P.76356	13	EU263197	EU263269	-
E. boywek §	Zr	E86	P.76298	14	EU263198	EU263270	-

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APPENDIX 2. (Continued)

Species	ID 2009	Spec ID	AM voucher	Map no.	COI	16S	18S
E. boywek §	Zr	E87	P.76299	14	EU263199	EU263271	-
E. sp. Zi	Zi	E16	P.76292	15	-	EU263272	-
E. sp. Zi	Zi	E17	P.76293	15	EU263200	EU263273	-
E. sp. Zi	Zu	E21	P.76301*	15	EU263201	-	-
E. sp. Zu	new	E202	P.103569	16	MK967236	MK961111	-
E. sp. Zu	new	E204	P.103571	16	MK967237	MK961112	-
E. sp. Zu	new	E206	P.103565	16	MK967238	MK961113	-
E. sp. Zu	new	E207	P.103566	16	MK967239	MK961114	-
E. sp. Zu	new	E208	P.103567	16	MK967240	MK961115	-
E. sp. Zu	Zu	E59	P.76303	16	EU263202	EU263274	-
E. kudjaldordo §	new	E209	P.103497	17	-	MK961116	-
E. kudjaldordo §	J2	E28	P.76365	17	EU263181	EU263253	-
E. kudjaldordo §	J2	E91	P.76362	17	EU263182	EU263254	-
E. kudjaldordo §	J2	E92	P.76363	17	EU263183	EU263255	-
E. sp. J1	J1	E12	P.76325	18	EU263180	EU263252	-
E. sp. J3	J3	E114	P.74593	19	EU263184	EU263256	-
E. djurrukunja §	M1	E18	P.76384	20	EU263186	-	-
E. djurrukunja §	M1	E97	P.76388	20	EU263187	EU263258	-
E. djurrukunja §	M1	E98	P.76389	20	EU263188	EU263259	-
E. warnbi §	M2	E08	P.76391*	21	EU263189	EU263260	-
E. warnbi §	M2	E09	P.76391*	21	EU263189	EU263260	-
E. warnbi §	M2	E10	P.76392	21	EU263190	EU263265	-
E. warnbi §	M2	E13	P.76393	21	EU263191	EU263263	-
E. warnbi §	M2	E14	P.76394	21	-	EU263261	-
E. warnbi §	M2	E95	P.76396	21	EU263192	EU263264	-
E. warnbi §	M2	E96	P.76397	21	EU263193	EU263262	-
E. kurrih §	5	E115	P.74578	22	EU263185	EU263257	-
E. kurrih §	5	E60	P.74577	22	-	EU263217	-
E. galunggul §	Gb	E104	P.74603	23	EU263178	EU263249	-
E. galunggul §	Gb	E105	P.74604	23	EU263179	EU263250	-
E. nawurlandja §	Ga	E48	P.76276	24	EU263175	EU263247	-
E. nawurlandja §	Ga	E47	P.76270	24	EU263174	EU263246	-
E. nawurlandja§	Ga	E49	P.76272	24	EU263176	EU263248	-
E. nawurlandja §	Ga	E46	P.76268	24	EU263173	EU263245	-

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APPENDIX 2. (Continued)

Species	ID 2009	Spec ID	AM voucher	Map no.	COI	16S	18S
E. nawurlandja §	Ga	E44	P.76266	24	EU263172	EU263244	-
E. galunggul §	Gb	E45	P.74600	24	EU263177	EU263251	-
E. nawurlandja §	1	GW101	P.97200	24	MK995022	-	MK961119
E. nawurlandja §	1	E41	P.76440	24	EU263139	-	-
E. nawurlandja §	1	E80	P.76442	24	EU263140	EU263210	-
E. nawurlandja §	23	E40	P.76449	24	EU263167	EU263238	-
E. nawurlandja §	1	E81	P.76443	24	EU263141	EU263209	-
E. korokoro §	2	E37	P.74596	26	EU263142	EU263211	-
E. korokoro §	2	E88	P.74597	26	EU263143	EU263212	-
E. gubara§	6	-	-	27	-	-	-
E. namarrkon §	20	E109	P.72628	28	EU263162	EU263234	-
E. namarrkon §	20	E58	P.74573	28	EU263161	EU263233	-
E. namimminya §	8	E106	P.72642	29	EU263149	EU263219	-
E. namimminya §	8	E107	P.72641	29	EU263150	EU263220	-
E. namimminya §	8	E51	P.74580	29	EU263148	EU263218	-
E. namarden §	9	E108	P.72625	30	EU263152	EU263222	-
E. namarden §	9	E53	P.74586	30	EU263151	EU263221	-
E. barrkmarlam §	4	GW093	P.81109	31	MK995023	MN015023	MK961117
E. balbun§	4	E100	P.76454	32	EU263147	EU263216	-
E. balbun§	4	E99	P.76453	32	EU263146	EU263215	-
E. sp. 03DJ	3?	E73	P.76288	33	EU263144	EU263213	-
E. sp. 03DJ	3?	E74	P.53197	33	EU263145	EU263214	-
E. warddebarrarn §	3	-	-	34	-	-	-
E. wurrkbaba §	13	E102	P.76284	35	EU263159	EU263229	-
E. wurrkbaba §	13	E103	P.76285	35	EU263160	EU263230	-
E. wurrkbaba §	13	E62	P.76282	35	EU263158	EU263228	-

APPENDIX 3. *Eophreatoicus* & *Kakadubeh* gen. nov. genetic distances between described species.

taxon	*K rangemyahwurd*	*E kershawi*	*E mok*	*E kudjamarndi*	*E bodmemurr-ngkudji*	*E kurdabeyhmay*	*E gudjangah*
K rangemyahwurd		0.2351	0.2228	0.2293	0.2216	0.2035	0.2347
E kershawi	0.2351		0.1992	0.2003	0.2035	0.1801	0.1989
E mok	0.2228	0.1992		0.2167	0.2100	0.1914	0.2176
E kudjamarndi	0.2293	0.2003	0.2167		0.1210	0.1050	0.1727
E bodmemurrngkudji	0.2216	0.2035	0.2100	0.1210		0.1198	0.1691
E kurdabeyhmay	0.2035	0.1801	0.1914	0.1050	0.1198		0.1392
E gudjangah	0.2347	0.1989	0.2176	0.1727	0.1691	0.1392	
E Indjangarlwurr	0.2334	0.2137	0.2111	0.1757	0.1777	0.1377	0.0592
E karrkkanj	0.2163	0.2075	0.0526	0.2197	0.2170	0.1970	0.2108
E ngarradj	0.2060	0.2043	0.1770	0.2065	0.1962	0.1691	0.2024
E mawoenewoene	0.2100	0.2124	0.1824	0.2119	0.2043	0.1781	0.2051
E binjdjarrang	0.2222	0.2005	0.2097	0.2108	0.2127	0.2106	0.2176
E djirrinjbal	0.2160	0.2005	0.1055	0.2095	0.2032	0.1819	0.1978
E boywek	0.1495	0.1838	0.1712	0.1805	0.1811	0.1790	0.1811
E kudjaldordo	0.2122	0.2167	0.1775	0.2057	0.2035	0.1889	0.2043
E djurrukunja	0.1535	0.2000	0.1793	0.2035	0.1959	0.1750	0.1973
E warnbi	0.2249	0.2234	0.2300	0.2189	0.2382	0.1932	0.2257
E kurrih	0.1533	0.1927	0.1856	0.1854	0.1846	0.1719	0.1914
E galunggul	0.2084	0.2191	0.2162	0.2254	0.2177	0.1849	0.2105
E nawurlandja	0.1533	0.1941	0.1856	0.1867	0.1860	0.1746	0.1927
E nawurlandja gal	0.1479	0.1900	0.1856	0.1867	0.1860	0.1680	0.1900
E korokoro	0.2141	0.2204	0.2162	0.2051	0.2097	0.1726	0.2173
E namarrkon	0.1989	0.2131	0.1779	0.2073	0.2051	0.1765	0.2140
E namimminya	0.2175	0.2005	0.1975	0.2163	0.2154	0.1757	0.2317
E namarden	0.1902	0.2005	0.1707	0.2084	0.1981	0.1873	0.2102
E barrkmarlam	0.2338	0.2249	0.2086	0.2406	0.2329	0.2140	0.2460
E balbun	0.2351	0.2356	0.2248	0.2473	0.2477	0.2234	0.2487
E wurrkbaba	0.2117	0.1895	0.1908	0.2068	0.2059	0.2036	0.2022

APPENDIX 3. (continued)

taxon	*E indjangarlwurr*	*E karrkkanj*	*E ngarradj*	*E mawoenewoene*	*E binjdjarrang*	*E djirrinjbal*	*E boywek*
K rangemyahwurd	0.2334	0.2163	0.2060	0.2100	0.2222	0.2160	0.1495
E kershawi	0.2137	0.2075	0.2043	0.2124	0.2005	0.2005	0.1838
E mok	0.2111	0.0526	0.1770	0.1824	0.2097	0.1055	0.1712
E kudjamarndi	0.1757	0.2197	0.2065	0.2119	0.2108	0.2095	0.1805
E bodmemurrngkudji	0.1777	0.2170	0.1962	0.2043	0.2127	0.2032	0.1811
E kurdabeyhmay	0.1377	0.1970	0.1691	0.1781	0.2106	0.1819	0.1790
E gudjangah	0.0592	0.2108	0.2024	0.2051	0.2176	0.1978	0.1811
E Indjangarlwurr		0.2057	0.2122	0.2200	0.2216	0.1968	0.1770

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APPENDIX 3. (continued)

taxon	*E indjangarlwurr*	*E karrkkanj*	*E ngarradj*	*E mawoenewoene*	*E binjdjarrang*	*E djirrinjbal*	*E boywek*
E karrkkanj	0.2057		0.1786	0.1840	0.2127	0.1083	0.1726
E ngarradj	0.2122	0.1786		0.0094	0.1602	0.1786	0.1678
E mawoenewoene	0.2200	0.1840	0.0094		0.1653	0.1892	0.1719
E binjdjarrang	0.2216	0.2127	0.1602	0.1653		0.1924	0.1912
E djirrinjbal	0.1968	0.1083	0.1786	0.1892	0.1924		0.1753
E boywek	0.1770	0.1726	0.1678	0.1719	0.1912	0.1753	
E kudjaldordo	0.2070	0.1859	0.1919	0.1997	0.1983	0.1898	0.1875
E djurrukunja	0.1973	0.1807	0.1829	0.1897	0.1829	0.1813	0.0514
E warnbi	0.2338	0.2290	0.1707	0.1788	0.0376	0.2124	0.1867
E kurrih	0.1927	0.1843	0.1691	0.1743	0.1827	0.1835	0.0568
E galunggul	0.2159	0.2084	0.1142	0.1250	0.1653	0.2027	0.1730
E nawurlandja	0.1941	0.1843	0.1691	0.1743	0.1827	0.1849	0.0568
E nawurlandja gal	0.1954	0.1829	0.1691	0.1703	0.1762	0.1811	0.0528
E korokoro	0.2213	0.2233	0.1642	0.1705	0.0553	0.2153	0.1705
E namarrkon	0.2237	0.1822	0.0295	0.0430	0.1640	0.1819	0.1635
E namimminya	0.2280	0.2044	0.1277	0.1345	0.1673	0.2049	0.1848
E namarden	0.2221	0.1856	0.1757	0.1835	0.2014	0.1835	0.1633
E barrkmarlam	0.2476	0.2075	0.1895	0.1935	0.1723	0.2086	0.1959
E balbun	0.2503	0.2116	0.1895	0.1976	0.1911	0.2167	0.1986
E wurrkbaba	0.1978	0.1924	0.1536	0.1615	0.1518	0.1802	0.1646

APPENDIX 3. (continued)

taxon	*E kudjaldordo*	*E djurrukunja*	*E warnbi*	*E kurrih*	*E galunggul*	*E nawurlandja*	*E nawurlandja gal*
K rangemyahwurd	0.2122	0.1535	0.2249	0.1533	0.2084	0.1533	0.1479
E kershawi	0.2167	0.2000	0.2234	0.1927	0.2191	0.1941	0.1900
E mok	0.1775	0.1793	0.2300	0.1856	0.2162	0.1856	0.1856
E kudjamarndi	0.2057	0.2035	0.2189	0.1854	0.2254	0.1867	0.1867
E bodmemurrngkudji	0.2035	0.1959	0.2382	0.1846	0.2177	0.1860	0.1860
E kurdabeyhmay	0.1889	0.1750	0.1932	0.1719	0.1849	0.1746	0.1680
E gudjangah	0.2043	0.1973	0.2257	0.1914	0.2105	0.1927	0.1900
E Indjangarlwurr	0.2070	0.1973	0.2338	0.1927	0.2159	0.1941	0.1954
E karrkkanj	0.1859	0.1807	0.2290	0.1843	0.2084	0.1843	0.1829
E ngarradj	0.1919	0.1829	0.1707	0.1691	0.1142	0.1691	0.1691
E mawoenewoene	0.1997	0.1897	0.1788	0.1743	0.1250	0.1743	0.1703
E binjdjarrang	0.1983	0.1829	0.0376	0.1827	0.1653	0.1827	0.1762
E djirrinjbal	0.1898	0.1813	0.2124	0.1835	0.2027	0.1849	0.1811
E boywek	0.1875	0.0514	0.1867	0.0568	0.1730	0.0568	0.0528
E kudjaldordo		0.1986	0.2081	0.1900	0.1997	0.1900	0.1861
E djurrukunja	0.1986		0.1938	0.0676	0.1881	0.0676	0.0676
E warnbi	0.2081	0.1938		0.2003	0.1626	0.2003	0.1922
E kurrih	0.1900	0.0676	0.2003		0.1946	0.0000	0.0067
E galunggul	0.1997	0.1881	0.1626	0.1946		0.1946	0.1905

...Continued on the next page

APPENDIX 3. (continued)

taxon	*E kudjaldordo*	*E djurrukunja*	*E warnbi*	*E kurrih*	*E galunggul*	*E nawurlandja*	*E nawurlandja gal*
E nawurlandja	0.1900	0.0676	0.2003	0.0000	0.1946		0.0067
E nawurlandja gal	0.1861	0.0676	0.1922	0.0067	0.1905	0.0067	
E korokoro	0.1942	0.1789	0.0511	0.1784	0.1613	0.1784	0.1730
E namarrkon	0.1978	0.1813	0.1734	0.1727	0.1168	0.1727	0.1700
E namimminya	0.2068	0.1973	0.1832	0.2011	0.1372	0.2011	0.1929
E namarden	0.1876	0.1716	0.2189	0.1673	0.2038	0.1673	0.1646
E barrkmarlam	0.2116	0.2000	0.1812	0.1927	0.1989	0.1927	0.1846
E balbun	0.2156	0.2122	0.1938	0.2049	0.1922	0.2049	0.1954
E wurrkbaba	0.1899	0.1732	0.1644	0.1754	0.1629	0.1754	0.1730

APPENDIX 3. (continued)

taxon	*E korokoro*	*E namarrkon*	*E namimminya*	*E namarden*	*E barrkmarlam*	*E balbun*	*E wurrkbaba*
K rangemyahwurd	0.2141	0.1989	0.2175	0.1902	0.2338	0.2351	0.2117
E kershawi	0.2204	0.2131	0.2005	0.2005	0.2249	0.2356	0.1895
E mok	0.2162	0.1779	0.1975	0.1707	0.2086	0.2248	0.1908
E kudjamarndi	0.2051	0.2073	0.2163	0.2084	0.2406	0.2473	0.2068
E bodmemurrngkudji	0.2097	0.2051	0.2154	0.1981	0.2329	0.2477	0.2059
E kurdabeyhmay	0.1726	0.1765	0.1757	0.1873	0.2140	0.2234	0.2036
E gudjangah	0.2173	0.2140	0.2317	0.2102	0.2460	0.2487	0.2022
E Indjangarlwurr	0.2213	0.2237	0.2280	0.2221	0.2476	0.2503	0.1978
E karrkkanj	0.2233	0.1822	0.2044	0.1856	0.2075	0.2116	0.1924
E ngarradj	0.1642	0.0295	0.1277	0.1757	0.1895	0.1895	0.1536
E mawoenewoene	0.1705	0.0430	0.1345	0.1835	0.1935	0.1976	0.1615
E binjdjarrang	0.0553	0.1640	0.1673	0.2014	0.1723	0.1911	0.1518
E djirrinjbal	0.2153	0.1819	0.2049	0.1835	0.2086	0.2167	0.1802
E boywek	0.1705	0.1635	0.1848	0.1633	0.1959	0.1986	0.1646
E kudjaldordo	0.1942	0.1978	0.2068	0.1876	0.2116	0.2156	0.1899
E djurrukunja	0.1789	0.1813	0.1973	0.1716	0.2000	0.2122	0.1732
E warnbi	0.0511	0.1734	0.1832	0.2189	0.1812	0.1938	0.1644
E kurrih	0.1784	0.1727	0.2011	0.1673	0.1927	0.2049	0.1754
E galunggul	0.1613	0.1168	0.1372	0.2038	0.1989	0.1922	0.1629
E nawurlandja	0.1784	0.1727	0.2011	0.1673	0.1927	0.2049	0.1754
E nawurlandja gal	0.1730	0.1700	0.1929	0.1646	0.1846	0.1954	0.1730
E korokoro		0.1624	0.1603	0.2105	0.1734	0.1909	0.1575
E namarrkon	0.1624		0.1233	0.1752	0.1890	0.1917	0.1546
E namimminya	0.1603	0.1233		0.1924	0.1833	0.1878	0.1628
E namarden	0.2105	0.1752	0.1924		0.2251	0.2345	0.1826
E barrkmarlam	0.1734	0.1890	0.1833	0.2251		0.0602	0.1669
E balbun	0.1909	0.1917	0.1878	0.2345	0.0602		0.1709
E wurrkbaba	0.1575	0.1546	0.1628	0.1826	0.1669	0.1709	

APPENDIX 4. *Eophreatoicus* & *Kakadubeh* gen. nov. species, localities and map numbers
(See Fig. 3) Indications: § = new species; * = Arnhem Land, Northern Territory, other sites in Kakadu National Park, Northern Territory.

Species	2009 ident	Site name	Lat	Long	Map no.	tributary	sub-catchment	River catchment
K. rangemyahwurd §	21	Leichhardt Spring	-12.7775°	132.8583°	1	Burdulba Ck	Nourlangie Ck	S. Alligator
E. kershawi	same	Outlier King River*	-11.87692°	133.3949°	2	Unnamed	Unnamed	King
E. mok §	new	Cave Kabulwarnamyo Ck	-12.7667°	133.8333°	3	Unnamed	Kabulwarnamyo Ck	Liverpool
E. kudjamarndi §	new	Myra Sprngs*	-12.4476°	133.368°	4	Unnamed	Tin Camp Ck	E. Alligator
E. bodmemurrngkudji §	new	Myra Sprngs*	-12.5010°	133.3553°	5	Unnamed	Tin Camp Ck	E. Alligator
E. kurdabeyhmay §	10	S. of Gunbalanya*	-12.3833°	133.087°	6	Unnamed	Unnamed	E. Alligator
E. gudjangah §	11	S. of Gunbalanya*	-12.399°	133.08°	7	Unnamed	Unnamed	E. Alligator
E. indjangarlwurr §	12	Gorge nr. Gunbalanya Rd*	-12.3883°	133.0367°	8	Unnamed	Unnamed	E. Alligator
E. karrkkanj §	14	Stockyard Ck	-12.37506°	132.9367°	9	Unnamed	Stockyard Ck	E. Alligator
E. ngarradj §	N2	Ngarradj site 2	-12.46993°	132.9278°	10	Ngarradj Ck	Magela Ck	E. Alligator
E. mawoenewoene §	C1	Catfish Ck	-12.48667°	132.969°	11	Catfish Ck	Catfish Ck	E. Alligator
E. binjdjarrang §	C2	Catfish Ck	-12.48667°	132.969°	12	Catfish Ck	Catfish Ck	E. Alligator
E. djirrinjbal §	S1	Ngarradj Ck Sprng	-12.51357°	132.9487°	13	Ngarradj Ck	Magela Ck	E. Alligator
E. boywek §	Zr	Zac's Retreat	-12.519°	132.9020°	14	Unnamed	Magela Ck	E. Alligator
E. sp. Zi	Zi	Jabiluka Outlier	-12.52272°	132.9048°	15	Unnamed	Magela Ck	E. Alligator
E. sp. Zi	Zi	Jabiluka Outlier	-12.5452°	132.9117°	15	Unnamed	Magela Ck	E. Alligator
E. sp. Zu	new	Jabiluka Outlier	-12.53708°	132.9279°	16	Unnamed	Magela Ck	E. Alligator
E. sp. Zu	new	Jabiluka Outlier	-12.53718°	132.9279°	16	Unnamed	Magela Ck	E. Alligator
E. kudjaldordo §	new	North of Wirnmuyurr Ck	-12.5771°	132.9631°	17	Wirnmuyurr Ck	Magela Ck	E. Alligator
E. kudjaldordo §	J2	Wirnmuyurr Ck Scree (7J)	-12.57808°	132.9669°	17	Wirnmuyurr Ck	Magela Ck	E. Alligator
E. sp. J1	J1	Wirnmuyurr Ck site (7J) 2	-12.57781°	132.9668°	18	Wirnmuyurr Ck	Magela Ck	E. Alligator
E. sp. J3	J3	Wirnmuyurr Ck Scree (7J)	-12.57808°	132.9669°	19	Wirnmuyurr Ck	Magela Ck	E. Alligator
E. djurrukunja §	M1	N Magela site 1	-12.60801°	132.987°	20	N Magela Ck	Magela Ck	E. Alligator
E. warnbi §	M2	N Magela site 2	-12.60501°	132.988°	21	N Magela Ck	Magela Ck	E. Alligator
E. kurrih §	05	Mt. Brockman	-12.75°	132.933°	22	Gulunggul Ck	Magela Ck	E. Alligator

APPENDIX 4. (Continued)

Species	2009 ident	Site name	Lat	Long	Map no.	tributary	sub-catchment	River catchment
E. galunggul §	Gb	Gulunggul Ck site 3	-12.7453°	132.9243°	23	Gulunggul Ck	Magela Ck	E. Alligator
E. galunggul §	Gb	Gulunggul Ck site 1	-12.75467°	132.9083°	23	Gulunggul Ck	Magela Ck	E. Alligator
E. nawurlandja §	new	Gubara Pools	-12.8267°	132.8789°	24	Burdulba Ck	Nourlangie Ck	S. Alligator
E. nawurlandja §	01	Nanguluwur	-12.84233°	132.8172°	24	Unnamed	Nourlangie Ck	S. Alligator
E. nawurlandja §	23	Nourlangie Rock Cave	-12.85°	132.80°	24	Namarrgon Ck	Nourlangie Ck	S. Alligator
E. nawurlandja §	01	Cave stream, Nawurlandja	-12.85°	132.80°	24	Unnamed	Nourlangie Ck	S. Alligator
E. nawurlandja §	Ga	Gulunggul Ck site 4	-12.7365°	132.9217°	25	Gulunggul	Magela Ck	E. Alligator
E. nawurlandja §	Ga	Gulunggul Ck site 3	-12.7453°	132.9243°	25	Gulunggul	Magela Ck	E. Alligator
E. nawurlandja §	Ga	Gulunggul Ck site 5	-12.74617°	132.9025°	25	Gulunggul	Magela Ck	E. Alligator
E. nawurlandja §	Ga	Gulunggul Ck site 2	-12.75433°	132.9167°	25	Gulunggul	Magela Ck	E. Alligator
E. nawurlandja §	Ga	Gulunggul Ck site 1	-12.75467°	132.9083°	25	Gulunggul	Magela Ck	E. Alligator
E. korokoro §	02	Up. Magela Ck	-12.77°	133.08°	26	Magela Ck	Magela Ck	E. Alligator
E. gubara §	06	~1 km from Gubara Pools	-12.828°	132.88°	27	Burdulba Ck	Nourlangie Ck	S. Alligator
E. namarrkon §	20	Namarrgon Ck	-12.90278°	132.9558°	28	Namarrgon Ck	Nourlangie Ck	S. Alligator
E. namimminya §	08	Lightning Dreaming	-12.91267°	132.9297°	29	Namarrgon Ck	Nourlangie Ck	S. Alligator
E. namimminya §	08	Lightning Dreaming #3	-12.91267°	132.9297°	29	Namarrgon Ck	Nourlangie Ck	S. Alligator
E. namarden §	09	Lightning Dreaming #4	-12.91267°	132.9297°	30	Namarrgon Ck	Nourlangie Ck	S. Alligator
E. barrkmarlam §	04	Jim Jim Falls	-13.27277°	132.8397°	31	Jim Jim Ck	Jim Jim Ck	S. Alligator
E. balbun §	04	Twin Falls	-13.3215°	132.7808°	32	Twin Falls Ck	Jim Jim Ck	S. Alligator
E. sp. 03DJ	3?	Jackpot Ck	-13.39133°	132.3935°	33	Jackpot Ck	S. Alligator	S. Alligator
E. sp. 03DJ	3?	Dogleg Ck	-13.40317°	132.4072°	33	Dogleg Ck	S. Alligator	S. Alligator
E. warddebarrarn §	03R	Rockhole Mine Ck	-13.528°	132.46°	34	Rockhole Mine Ck	S. Alligator	S. Alligator
E. wurrkbaba §	13	Dinner Ck	-13.6467°	132.6033°	35	Dinner Ck	S. Alligator	S. Alligator

APPENDIX 5. Morphological characters

Characters are numbered in order of appearance in the analysis with the database record number in brackets.

#1(16). Body length of largest male (male-female size difference); 1. greater than body length of largest female (most phreatoicideans); 2. subequal to body length of largest female; 3. less than body length of largest female.
#2(19). (Head length to width in dorsal view); 1. length shorter than width in dorsal view; 2. length subequal (0.95-1.05) to width in dorsal view; 3. length greater than width in dorsal view.
#3(20). Head lateral profile of dorsal surface (shape); 1. smoothly curved; 2. angularly curved; 3. flattened curve; 4. indented behind eye region.
#4(22). (Head cuticle) dorsal surface (appearance); 1. smooth; 2. pitted; 3. granular (microscopically tuberculate); 4. with cuticular combs on irregular ridges; 5. with dense cuticular hairs; 6. with fine cuticular combs.
#5(23). Head dorsal surface (tubercles presence); 1. present; 2. lacking tubercles.
#6(24). Head dorsal surface (tubercles type); 1. with numerous tubercles; 2. with several tubercles.
#7(25). Head dorsal surface (tubercles, if present, position); 1. in rows; 2. scattered evenly.
#8(27). Head dorsal surface setae (type if present); 1. dense dorsally and laterally; 2. tiny and sparse (often in shallow pits as seen in SEM); 3. scattered and elongate (setae much longer than wide basally).
#9(28). Head dorsal surface setae (type); 1. fine (thin, flexible); 2. robust (thick, rigid).
#10(30). Head eyes (profile); 1. fully sessile; 2. bulging dorsolaterally; 3. projecting anteriorly.
#11(31). Head eyes (shape in lateral view); 1. approximately round; 2. oval; 3. dorsal margin convex, ventral margin concave; 4. dorsal margin convex, ventral margin straight; 5. approximately triangular (apex ventral) .
#12(32). Head eyes (height compared to width of base of antenna); 1. height small, in lateral view less than width of basal antennal articles; 2. height medium, in lateral view subequal to width of basal antennal articles; 3. height large, in lateral view greater than width of basal antennal articles.
#13(33). Head eyes (approx. height ratio in lateral view); 1. height greater than length in lateral view; 2. height subequal to length in lateral view (~ 5%); 3. height less than length in lateral view.
#14(34). Head eyes (if present) orientation of longest axis (if applicable); 1. horizontal; 2. vertical; 3. between horizontal and vertical.
#15(36). Head eyes (projecting from head shape); 1. bulging in dorsal view, projecting from head in distinct arc; 2. slightly protruding in dorsal view, projecting from head in low or flattened arc; 3. not protruding in dorsal view, spread-out, surface confluent with head surface.
#16(37). Head eyes (if present) ocelli; 1. distinguishable as individual units; 2. not distinguishable as individual units.
#17(39). Head cervical groove in lateral view (presence); 1. straight, or sigmoidal, or smoothly curved; 2. absent.
#18(40). Head cervical groove in lateral view (length); 1. extending just above antero-lateral margin of pereonite 1; 2. extending nearly to dorsal margin of head; 3. extending over dorsal margin of head and connecting medially.
#19(41). Head mandibular (genal or cheek) groove (indentation); 1. smoothly indented, or with acute indentation; 2. not indented.
#20(42). Head mandibular notch (presence); 1. present; 2. absent.
#21(43). Head clypeal notch (presence); 1. present; 2. absent.
#22(44). Head antennal notch (presence); 1. present; 2. absent.
#23(48). Head maxillipedal ridge; 1. with distinct dorsal edge; 2. with indistinctly rounded margin; 3. without dorsal edge.
#24(49). Head maxillipedal ridge region (setation); 1. without obvious setae; 2. with several setae projecting dorsally (often short, hard to see); 3. with elongate setae projecting laterally or dorsolaterally.
#25(55). Pereon dorsal cuticular surface (scales, roughness, tubercles); 1. smooth (without roughness or tubercles), or with undulating or dimpled surface; 2. with scattered small scales or roughness; 3. with tubercles and small scales, increasing posteriorly, less so in younger stages; 4. scaly or tuberculate, increasing posteriorly, apparent on all life stages; 5. strongly tuberculate in all life stages with two or more transverse rows of rounded tubercles.
#26(56). Pereon pereonites 1–4 transverse dorsal ridges ; 1. not expressed (or if present, not carinate and not occurring toward segment center); 2. well developed with transverse trough; 3. low without transverse trough; 4. rounded, expressed as transverse trough only.
#27(57). Pereon pereonites 5–7 transverse dorsal ridges ; 1. not expressed (or if present, occurring toward segment anterior articular margin); 2. carinate with transverse trough; 3. low without transverse trough; 4. expressed only as transverse trough (no carinate ridge).
#28(58). Pereon setae on dorsal surface (presence); 1. present; 2. not visible (not visible in light microscope - minute setae may be seen in SEM).
#29(59). Pereon setae on dorsal surface (arrangement on surface); 1. in transverse rows; 2. scattered; 3. in paired longitudinal rows dorsally and scattered laterally.
#30(60). Pereon setae on dorsal surface (type); 1. fine (thin, flexible); 2. robust (thick, rigid); 3. robust on low cuticular bumps.
#31(81). Coxal articulation to pereonites 2–4; 1. free (complete suture laterally and medially, deeply incised, v-shaped in cross-section); 2. nearly fused (complete suture laterally, fused medially, suture shallow, u-shaped in cross-section); 3. fused (with

no suture, or incomplete suture laterally and medially).

#32(82). Coxal articulation to pereonites 5–7; 1. free (complete suture laterally and medially, deeply incised, v-shaped in cross-section); 2. nearly fused (complete suture laterally, fused medially, suture shallow, u-shaped in cross-section), or fused (with no suture, or incomplete suture laterally and medially).

#33(89). Pleonites (2–5 relative lengths); 1. 2–4 in dorsal view respective lengths less than 0.5 pleonite 5 length; 2. 2–4 in dorsal view respective lengths equal to or more than 0.5 pleonite 5 length; 3. 2–3 in dorsal view respective lengths less than 0.5 pleonite 5 length, pleonite 4 length (equal to or) more than 0.5 pleonite 5 length; 4. 2 in dorsal view length less than 0.5 pleonite 5 length, 3–4 respective lengths more than 0.5 pleonite 5 length.

#34(90). Pleonites 1-4 transverse dorsal ridges ; 1. not expressed; 2. well developed with transverse trough; 3. low without transverse trough.

#35(91). Pleonites 1–4 relative lengths; 1. subequal (0.95–1.05 each other); 2. unequal, pleonite 4 length greater than pleonites 1–3; 3. unequal, increasing in length from anterior to posterior; 4. unequal, pleonites 1–2 subequal, pleonite 3 longer than 1–2 and 4, pleonite 4 longer than 1–2; 5. unequal, increasing in length from 1–3, pleonite 4 longer than 1-2 and shorter than 3.

#36(103). Pleonite 5 dorsal median ridge (presence); 1. present; 2. absent.

#37(104). Pleonite 5 ventral margin in lateral view (shape of ventral margin constricting posteriorly or not); 1. subparallel to dorsal margin along length (not constricting posteriorly, not much shallower anteriorly than posteriorly); 2. constricting posteriorly with anterior depth noticeably greater than posterior depth.

#38(107). Pleotelson dorsal surface in lateral view (shape); 1. evenly curving and not inflected ventrally (without strong bend at level of or posterior to insertion of uropods); 2. inflected ventrally, posterior to insertion of uropods - distinct rounded angle in dorsal surface.

#39(109). Pleotelson dorsal surface in lateral view (shape, if dorsal inflection present); 1. margin below dorsal inflection convex; 2. margin below dorsal inflection linear; 3. margin below dorsal inflection concave (so that posterodorsal margin projects posteriorly).

#40(110). Pleotelson dorsal surface (setae density); 1. lacking observable simple setae; 2. sparsely covered with setae (most species); 3. sparsely covered with elongate simple setae; 4. hirsute, covered with abundant elongate setae; 5. densely covered with elongate cuticular hairs and setae; 6. with abundant robust setae (thick, rigid).

#41(111). Pleotelson dorsal surface anterior width (relative to posterior width); 1. near posterior width, (or greater) not wider posteriorly; 2. much less than posterior width, distinctly wider posteriorly.

#42(112). Pleotelson dorsal surface (median ridge presence); 1. without median ridge; 2. with median ridge.

#43(113). Pleotelson dorsal surface (presence); 1. with lateral ridges continuous with posterior apex; 2. without lateral ridges.

#44(114). Pleotelson dorsal surface (cuticular structure); 1. without tubercles or short ridges; 2. rugose (with ridges or tubercles).

#45(115). Pleotelson dorsal surface (tubercle form); 1. with elongate ridge-like tubercles (much longer than wide, not median ridge); 2. with oblong tubercles, or with rounded tubercles; 3. with small irregular rugose regions; 4. with regularly spaced rugose patches on dorsal surface only.

#46(116). Pleotelson dorsal surface (elongate median or dorsolateral cuticular ridges, on rugose species); 1. with smoothly rounded posteromedial ridge (may be indistinct in juveniles individuals with smoother cuticle); 2. with several median tubercles, not merging into ridge; 3. with one posteromedial median ridge and paired dorsolateral ridges ; 4. lacking posteromedial ridges or median groups of tubercles.

#47(117). Pleotelson dorsal surface (with cuticular combs on tubercles); 1. lacking cuticular combs on tubercles; 2. with cuticular combs on tubercles.

#48(123). Pleotelson lateral surface anterior to uropods (pleonite ridge); 1. (pleonite ridge present); 2. without pleonite ridge.

#49(124). Pleotelson lateral surface anterior to uropods with pleonite ridge (extension to ventral margin); 1. extending to ventral margin anterior to penultimate robust seta; 2. extending to ventral margin at penultimate robust seta; 3. extending to ventral margin posterior to penultimate robust seta; 4. not extending to ventral margin.

#50(125). Pleotelson lateral surface anterior to uropods with pleonite ridge (parallel or not with ventral margin); 1. following curve of ventral margin; 2. diverging posteriorly from ventral margin.

#51(128). Pleotelson ventral margin in lateral view anterior to uropods (of margin compared to insertion of uropod); 1. less than width of uropodal insertion; 2. subequal to width of uropodal insertion (within 5%); 3. greater than width of uropodal insertion; 4. substantially greater than width of uropodal insertion (greater than 2×).

#52(130). Pleotelson ventral margin in lateral view anterior to uropods (setal row seta types); 1. with single row of simple robust setae ; 2. with single row of simple robust setae grading anteriorly to fine setae; 3. with single row of simple robust setae grading anteriorly to distally denticulate robust and fine setae; 4. with one row of distally denticulate robust setae; 5. with two rows of distally denticulate robust setae mixed with fine and robust simple setae; 6. with fine setae (only); 7. with simple fine setae grading anteriorly to simple robust setae; 8. with simple fine setae grading anteriorly to denticulate robust setae .

#53(132). Pleotelson ventral margin in lateral view anterior to uropods medial side of main row (presence); 1. (with setae); 2. without setae.

#54(133). Pleotelson ventral margin in lateral view anterior to uropods setae on medial side medial to main row (distally denticulate or not); 1. distally denticulate; 2. distally simple.

#55(137). Pleotelson postanal ventral surface (ornamentation); 1. without ridge or cleft; 2. with ridge parallel to anal opening; 3. with cleft in posterior margin.
#56(138). Pleotelson postanal ventral surface (setae present?); 1. without setae; 2. (with setae).
#57(139). Pleotelson postanal ventral surface (setal type); 1. with fine setae only; 2. (with robust setae).
#58(140). Pleotelson postanal ventral surface with (count robust setae); 1. up to 6 robust setae on ridge; 2. 7 robust setae on ridge or more .
#59(142). Pleotelson lateral uropodal ridge (shape); 1. terminating at pleotelson margin above uropods; 2. curving strongly and extending posteriorly from uropods on pleotelson margin.
#60(143). Pleotelson lateral uropodal ridge (setae presence); 1. without setae; 2. (with setae).
#61(146). Pleotelson posterolateral margin dorsal surface (differentiation from apex); 1. uninterrupted (without major inflection in margin differentiating apex); 2. with distinct inflection differentiating apex.
#62(147). Pleotelson posterolateral margin (shape); 1. forming rounded process with dorsally projecting setae; 2. crenate; 3. forming vertical plate (if robust setae present in multiple groups and posteriorly projecting); 4. forming rounded lobe (if robust setae present then in one group and posteriorly projecting); 5. projecting in lateral view but continuous with indented apex; 6. unelaborated.
#63(152). Pleotelson posterolateral margin vertical plate; 1. inner margin in dorsal view projecting posteriorly relative to apex, or inner margin in dorsal view curving toward apex; 2. inner margin in dorsal view projecting strongly toward apex (gap between them only small slit); 3. inner margin not visible in dorsal view (below posterior apex).
#64(154). Pleotelson posterolateral margin (if plates or rounded lobes present, robust setae positions); 1. with one position defined by major robust setae; 2. with two positions defined by major robust setae with intermediate setae anteriorly and posteriorly; 3. with two positions defined by major robust setae without intermediate setae anteriorly and posteriorly; 4. with more than two positions defined by major robust setae with intermediate setae anteriorly and posteriorly to these.
#65(155). Pleotelson posterolateral margin dorsal setal position (number of robust setae if plates or lobes present); 1. with one robust seta; 2. with two robust setae; 3. with three robust setae, two anterior setae adjacent, projecting laterally and medially; 4. with four robust setae (add states as necessary).
#66(156). Pleotelson posterolateral margin dorsal major seta (size of dorsal seta); 1. near length of other seta; 2. much longer than other seta (2× or greater).
#67(157). Pleotelson posterolateral margin dorsal setal position (positioning of robust setae if plates or lobes present and if with multiple robust setae); 1. marginal seta larger than submarginal seta; 2. more ventral setae subequal to dorsally-placed setae; 3. posterior seta subequal to submarginal seta.
#68(158). Pleotelson posterolateral dorsal margin (presence of dorsal lobe if plates or lobes present); 1. forming lobe medial to seta (typically height less than robust seta); 2. forming large plate dorsal to seta; 3. not projecting dorsal to seta.
#69(159). Pleotelson posterolateral dorsal margin (seta presence if plates present); 1. with seta near inflection point; 2. without seta near inflection point.
#70(160). Pleotelson posterolateral dorsal margin (submarginal robust setae presence); 1. without robust setae on dorsolateral surface; 2. with robust seta on dorsolateral surface adjacent to margin; 3. with robust seta on dorsolateral surface set anteriorly from margin.
#71(161). Pleotelson posterior apex (shape in dorsal view if postanal ventral surface present); 1. projecting in dorsal view; 2. indented in dorsal view, or indented in dorsal view with small median projection ; 3. transverse in dorsal view.
#72(162). Pleotelson posterior apex in dorsal view (shape if postanal ventral surface absent); 1. projecting, dorsal surface of anal ring projecting posteriorly; 2. transverse or weakly projecting; 3. projecting laterally and medially concave.
#73(165). Pleotelson posterior apex (visibility in lateral view); 1. in lateral view visible; 2. in lateral view obscured by posterolateral margin (setae may protrude further).
#74(167). Pleotelson posterior apex (length:width in dorsal view if protruding freely and posterolateral margin inflected); 1. length greater than width; 2. length approximately subequal to width; 3. length less than width.
#75(168). Pleotelson posterior apex (length if projecting); 1. extremely long (length more than 0.295 pleotelson length in lateral view); 2. long (length 0.120–0.295 pleotelson length in lateral view; 3. short (0.075–0.119 pleotelson length in lateral view); 4. rudimentary (less than 0.075 pleotelson length in lateral view).
#76(173). Pleotelson posterior apex in lateral view (shape); 1. distinctly narrowing distally, proximal depth greater than distal depth; 2. distinctly broadening distally, proximally shallower than distal tip ; 3. weakly narrowing distally, dorsal and ventral surfaces approximately parallel.
#77(175). Pleotelson posterior apex (robust setae presence); 1. with one pair of robust setae (some Phreatoicidae); 2. with one pair of robust setae and one median robust seta; 3. with two pairs of robust setae; 4. with two pairs of widely separated robust setae; 5. with two pairs of robust setae and one median robust seta; 6. with three pairs of robust setae; 7. with four pairs of robust setae.
#78(176). Pleotelson posterior apex (fine setae presence); 1. with interdigitating fine setae in same row as robust setae; 2. with numerous fine setae above and below robust setae; 3. without fine setae.
#79(207). Antenna flagellum proximal articles surface (type - smooth, scales, hairy); 1. smooth (cuticle appears shiny or at least not rough), or finely scaled on sides (cuticle appears rough); 2. scaled only on distal margin; 3. densely covered with elongate cuticular hairs (looks hairy); 4. densely covered with short cuticular hairs (looks fuzzy).
#80(208). Antenna flagellum proximal articles distal margin (setation add states as necessary); 1. with groups of elongate setae

(longer than half article width); 2. with one medial dense group of elongate setae (longer than half article width); 3. with groups of short fine setae (less than half article width); 4. with rosette of short setae (less than half article width); 5. with single short fine setae set on opposite sides of segments.

#81(334). Pereopod I propodus (sexually dimorphic or not); 1. not sexually dimorphic, male and female pereopods similar ; 2. sexually dimorphic, male propodus more robust than in females (most Phreatoicidea); 3. sexually dimorphic, female propodus broader than in male.

#82(337). Pereopod I basis of male (dorsal setae); 1. (with dorsal setae); 2. absent.

#83(338). Pereopod I basis of male (dorsal setae position); 1. dorsal setae positioned proximally; 2. dorsal setae positioned distally; 3. dorsal setae positioned along ridge.

#84(357). Pereopod I merus of male distodorsal margin (setae); 1. with numerous elongate simple setae; 2. with 1 or 2 robust simple setae; 3. with few (1–2) elongate simple setae.

#85(358). Pereopod I merus of male dorsal surface (robust setae); 1. with setae along dorsal axis; 2. with setae only on distal margin.

#86(359). Pereopod I merus of female distodorsal margin projection in cross-section (spine presence - look at in anterior-dorsal view); 1. shelf-like and U-shaped in cross-section (distal margin not extending over carpus to propodus); 2. U-shaped in cross-section and curving over carpus around proximal dorsal margin of propodus (distally concave); 3. spine-like and pointed; 4. rounded not projecting dorsally; 5. thin and acute (not shelf-like).

#87(368). Pereopod I propodus of male dorsal margin proximal region (protrusion presence); 1. recurved and protruding to distodorsal margin of ischium; 2. recurved and protruding to distodorsal margin of carpus; 3. not protruding (i.e. most proximal region of propodus dorsal margin is where it joins carpus).

#88(369). Pereopod I propodus of female dorsal margin proximal region (proximal protrusion); 1. recurved and protruding to distodorsal margin of ischium; 2. recurved and protruding to distodorsal margin of carpus; 3. not protruding (i.e. most proximal region of propodus dorsal margin is where it joins carpus).

#89(370). Pereopod I propodal palm of male margin (shape); 1. concave; 2. straight; 3. convex; 4. sinusoidal.

#90(383). Pereopod I propodal palm of male margin (stout setae count); 1. up to 13 altogether; 2. 14 altogether or more .

#91(387). Pereopod I propodal palm of male margin (two groups of setae next to palm margin); 1. with groups of elongate distally thick setae on either side of palm margin; 2. with groups of elongate distally thick setae on either side of palm margin, medial group much shorter than lateral group; 3. without groups of distally thick setae on either side of palm margin.

#92(390). Pereopod I propodal palm of female margin (shape); 1. concave; 2. convex; 3. straight; 4. sinusoidal.

#93(397). Pereopod I propodal palm of female margin (presence); 1. with cuticular fringe well developed (visible in lateral view for half length of palm or more); 2. with cuticular fringe weakly developed (or absent, if visible in lateral view then not occurring along at least half of margin) .

#94(399). Pereopod I propodal palm of female margin (stout denticulate setae presence); 1. present; 2. without stout denticulate setae.

#95(408). Pereopod I dactylus of male (length measured along inner margin of dactylus); 1. longer than palm, or length subequal (0.95-1.05) to palm; 2. shorter than palm.

#96(411). Pereopod I dactylus of female (length); 1. longer than palm, or length subequal (0.95–1.05) to palm; 2. shorter than palm.

#97(417). Pereopod I dactylus of male ventrodistal margin (cuticular fringe presence); 1. smooth (cuticular fringe absent); 2. (with rows of spines or cuticular fringe).

#98(420). Pereopod I dactylus of female ventrodistal margin (cuticular fringe presence); 1. smooth (cuticular fringe absent); 2. (with rows of small spines or cuticular scales).

#99(421). Pereopod I dactylus of female ventrodistal margin (cuticular fringe form); 1. with multiple rows of minute sharp spines; 2. with row of sharp spines; 3. with multiple rows of thin scale-like spines; 4. with single row of thin scale-like spines.

#100(469). Pereopods II–III basis dorsal ridge in cross-section (shape); 1. rounded; 2. angular but not forming distinct plate (i.e. two flat surfaces meeting in a line raised from the main shaft); 3. forming distinct plate (i.e. a flat or concave surface raised from the main shaft).

#101(471). Pereopods Ischium II–IV of male dorsal margin (simple setae presence); 1. present; 2. without simple setae.

#102(473). Pereopods Ischium II–IV of male dorsal margin (robust setae presence); 1. (setae) none robust; 2. (with robust setae).

#103(511). Pereopod II basis lateral face (ventral carina shape); 1. complete (extending along basis margin); 2. incomplete (not extending along margin).

#104(512). Pereopod II basis lateral face (ventral carina setae presence); 1. (with setae); 2. without setae.

#105(514). Pereopod II basis dorsal ridge proximal margin (epaulet presence structure on proximal part of dorsal ridge -); 1. with epaulet; 2. without epaulet (most phreatoicideans).

#106(515). Pereopod II basis of male dorsal ridge epaulet (length); 1. length less than quarter length of basis; 2. length subequal to quarter basis length (~ 5%); 3. length greater than quarter basis length.

#107(516). Pereopod II basis of male dorsal ridge epaulet (number of setal rows); 1. with 2 rows of setae; 2. without submarginal setal row.

#108(517). Pereopod II basis of male dorsal ridge epaulet main setal row (count major setae); 1. (with major setae); 2. without major setae.
#109(518). Pereopod II basis of male dorsal ridge epaulet main setal row with (count major setae); 1. up to 1 major seta; 2. 2 major setae; 3. 3 to 4 major setae; 4. 5 to 8 major setae; 5. 9 major setae or more .
#110(519). Pereopod II basis of male dorsal ridge epaulet main setal row (minor setae); 1. (with minor setae); 2. without minor setae.
#111(524). Pereopod II basis of female dorsal ridge epaulet (length); 1. length less than quarter length of basis; 2. length subequal to quarter basis length (~ 5%); 3. length greater than quarter basis length.
#112(525). Pereopod II basis of female dorsal ridge epaulet (number of setal rows); 1. with 2 rows of setae; 2. without setal row below dorsal margin.
#113(526). Pereopod II basis of female dorsal ridge epaulet main setal row (count major setae); 1. (with major setae); 2. without major setae.
#114(527). Pereopod II basis of female dorsal ridge epaulet main setal row with (count major setae); 1. up to 1 major seta(e); 2. 2 major seta(e); 3. 3 to 4 major seta(e); 4. 5 to 8 major seta(e); 5. 9 major seta(e) or more .
#115(528). Pereopod II basis of female dorsal ridge epaulet main setal row (count minor setae); 1. (with minor setae); 2. without minor setae.
#116(533). Pereopod IV (with distinct prehensile palm - sexual dimorphism); 1. sexually dimorphic (generally with distinct prehensile palm in adult males;); 2. not sexually dimorphic (without palm, not prehensile) (in male and female).
#117(534). Pereopod IV of male (if sexually dimorphic, prehensility in male); 1. prehensile with major hinges between dactylus to carpus; 2. prehensile with major hinges between dactylus and propodus; 3. prehensile with major hinges between propodus and carpus; 4. with propodus more robust than in female.
#118(551). Pereopod IV carpus of male ventral margin (setation); 1. with simple setae only; 2. with robust-based setae in addition to simple; 3. with robust setae in addition to simple setae.
#119(557). Pereopod IV propodus of male ventral margin; 1. with projection (often angular); 2. without projection.
#120(560). Pereopod IV propodus of male setae on ventral margin (presence -); 1. robust-based (basally thick - distally curved), or robust (basally thick - straight sided); 2. simple (thin and curved).
#121(622). Pereopods V–VII basis dorsal ridge (shape); 1. distinctly separated from basis shaft; 2. not distinctly separated from basis shaft.
#122(631). Pereopods V–VII ischium of male dorsal margin (robust setae presence in male); 1. none robust; 2. with robust setae.
#123(637). Pereopod VII basis dorsal ridge distal margin (shape); 1. indented (i.e. distal extent of ridge is where it connects to shaft, normal case is Platypyga, extreme case where it is almost rounded is Amphisopus annectans); 2. rounded (i.e. margin produced into distal lobe that is more distal than extent of where it connects to shaft).
#124(638). Pereopod VII ischium dorsal ridge (ridge plate present); 1. margin not produced into plate; 2. margin produced into flattened plate.
#125(639). Pereopod VII ischium dorsal ridge (ridge plate width if present); 1. plate greater than shaft width, or plate subequal to shaft width; 2. plate less than shaft width.
#126(642). Penes (form); 1. straight; 2. curved posteriorly.
#127(644). Penes extending; 1. near midline, or to midline; 2. past midline and onto pleonite 1.
#128(645). Penes (cuticle); 1. cuticle smooth; 2. with cuticular hairs on shaft; 3. shaft denticulate.
#129(648). Penes distal tip (shape); 1. rounded; 2. pointed; 3. flattened; 4. truncate.
#130(758). Pleopod II endopod of male appendix masculina (stylet - distal extent of trough if cross-sectional shape concave) (in male); 1. (stylet channel) forming tube along most of distal margin; 2. (stylet channel) not forming tube, groove open distally.
#131(759). Pleopod II endopod of male appendix masculina (stylet - proximal article) basal musculature (in male); 1. pronounced; 2. not pronounced.
#132(760). Pleopod II endopod of male appendix masculina length (stylet - distal article - if NOT geniculate) (length relative to endopod) (in male); 1. less than half endopod length; 2. more than half endopod length; 3. more than endopod length.
#133(761). Pleopod II endopod of male appendix masculina distal length (relative to endopod II proximal margin (indurate bar) length - medial insertion of appendix masculina to insertion of endopod) (in male); 1. approximately half endopod proximal margin length; 2. approximately subequal to endopod proximal margin length; 3. greater than endopod proximal margin length (other phreatoicideans).
#134(763). Pleopod II endopod of male appendix masculina (stylet - distal article) distal tip (shape) (in male); 1. truncate, or broadly rounded; 2. acutely rounded (if concave in cross-section then ventral channel not enclosed by rolled margins); 3. conical (tapered to a fine acute point, proximal cross-section of appendix masculina concave, margins enclosing or almost enclosing ventral channel at distal tip); 4. sharply pointed and spine-like, or pointed and distally spatulate.
#135(765). Pleopod II endopod of male appendix masculina (marginal setae presence) (in male); 1. (with marginal setae most phreatoicideans); 2. without marginal setae.
#136(766). Pleopod II endopod of male appendix masculina (setae position on margin) (in male); 1. setae continuous around margin; 2. (setae discontinuous with gaps between apex and margins); 3. setae restricted to apex.
#137(767). Pleopod II endopod of male appendix masculina (presence of stiff shafted setae in male); 1. present; 2. without

elongate stiff (rod-like) setae.

#138(771). Pleopod II endopod of male appendix masculina lateral margin (setae presence) (in male); 1. (with 1 or more setae); 2. without simple setae.

#139(773). Pleopod II endopod of male appendix masculina medial margin (setae presence) (in male); 1. (with 1 or more simple setae); 2. without simple setae.

#140(783). Uropod protopod of female (in lateral view extension posteriorly); 1. extending posteriorly beyond pleotelson apex, or extending posteriorly subequal to pleotelson apex; 2. not reaching pleotelson apex.

#141(784). Uropod protopod dorsomedial ridge (shape); 1. produced dorsally, plate-like; 2. produced medially, spur-like; 3. produced dorsally, forming bump (usually with robust setae but these may be absent, distally concave), or not produced (margins not projecting noticeably distally or distodorsally).

#142(785). Uropod protopod dorsomedial ridge (shape if medially directed); 1. opposing denticulate posterior margin on pleotelson; 2. dorsally directed.

#143(786). Uropod protopod dorsomedial ridge (shape, if plate-like projection above protopod lateral margin in lateral view); 1. not especially projecting dorsally with plate low above shaft; 2. projecting dorsally with plate above shaft but posterior margin hardly exposed, or distinctly projecting dorsally with posterior margin exposed above shaft; 3. distinctly elongate posteriorly with posterior margin not exposed but extending posteriorly.

#144(793). Uropod protopod dorsomedial ridge (if produced, plate-like - longitudinal margin shape in lateral view); 1. in lateral view approximately straight; 2. concave, in lateral view distal part distinctly curving dorsally; 3. convex, in lateral view distal part distinctly curving ventrally .

#145(794). Uropod protopod dorsomedial ridge (longitudinal margin shape in dorsal view); 1. in dorsal view parallel to ventral margin; 2. in dorsal view laterally concave at midpoint exposing ventral margin .

#146(796). Uropod protopod dorsomedial ridge setae on margin (presence) (may be limited to a group of submarginal setae); 1. robust and spinose distally; 2. robust and simple; 3. fine and simple (flexible, not robust).

#147(797). Uropod protopod dorsomedial ridge distal margin (robust setae distinctly larger than others); 1. with all robust setae approximately same size; 2. with 2 adjacent robust setae distinctly larger than others; 3. with 2 robust setae distinctly larger than others, separated by shorter seta; 4. with only 1 robust seta distinctly larger than others.

#148(799). Uropod protopod dorsolateral margin with (setal type); 1. robust setae; 2. fine setae.

#149(800). Uropod protopod of male dorsolateral margin (setae length relative to dorsomedial setae in male); 1. shorter than dorsomedial margin setae, or subequal to dorsomedial margin setae (~ 5%); 2. longer than dorsomedial margin setae.

#150(801). Uropod protopod of female dorsolateral margin (setae length relative to dorsomedial setae in female); 1. shorter than dorsomedial margin setae; 2. subequal to dorsomedial margin setae (~ 5%); 3. longer than dorsomedial margin setae.

#151(802). Uropod protopod distomedial margin (with robust setae elongate distal spinules submarginal and distal to dorsomedial ridge); 1. without robust spinose setae; 2. with robust setae having elongate distal spinules.

#152(803). Uropod protopod distoventral margin (robust setae); 1. (with robust setae); 2. without robust setae.

#153(804). Uropod protopod distoventral margin with (robust seta number); 1. 1 robust seta; 2. 2 robust setae; 3. 3 robust setae; 4. 4 robust setae or more.

#154(805). Uropod protopod distoventral margin ; 1. with spinose setae; 2. without spinose setae.

#155(808). Uropod protopod lateral face (ventrolateral ridge) (presence); 1. with ventrolateral ridge; 2. without ventrolateral ridge.

#156(809). Uropod protopod ventrolateral margin (long setae presence); 1. with longitudinal row of setae; 2. without longitudinal row of setae.

#157(810). Uropod protopod lateral face setae (long setae if present, direction of projection); 1. projecting laterally; 2. projecting ventrally (often on ventral margin, but in longitudinal row, not as transverse rows).

#158(815). Uropod endopod (length relative to protopod); 1. shorter than protopod; 2. subequal (0.95–1.05) to protopod length; 3. longer than protopod.

#159(819). Uropod endopod of male dorsal margin with robust setae (position if present); 1. occurring along length; 2. placed midlength; 3. placed proximally at endopod insertion).

#160(824). Uropod endopod ventral margin in medial view (shape); 1. sinuate proximally (also broadly attached to protopod and laterally compressed just posterior to attachment with protopod); 2. convex or straight proximally.

APPENDIX 6. 18S primers and protocol

These primers were used to generate small subunit sequences (18S) for Eophreatoicus species (5' to 3'). Several primers were designed by the *Evolutionary Biology Unit* of the Australian Museum (AM).

1F	TACCTGGTTGATCCTGCCAGTAG	Giribet *et al.* (1996)
18S H2	CCSCKYRWGRCGAGGRCKCGCCTTG	R. Johnson (AM)
18S F1	CGGTAATTCCAGCTCCAATAGC	Mattern *et al.* (2001)
1500 R	CATCTAGGGCATCACAGACC	Raupach *et al.* (2009)
18S L4	GTGCATGGCCGTTCTTAGTTG	R. Johnson (AM)
1800	TAATGATCCTTCCGCAGGTT	Dreyer & Wägele (2001)
18S L3	ACGCYTGAATGGTRRTGCATRGAATGA	R. Johnson (AM)
ISO337	CTGTCGATTGTAAGATATACGC	A. King (AM)
1155R	CCGTCAATTCCTTTAAGTTTCAG	Dreyer & Wägele (2001)

All extractions were performed as per Qiagen DNEasy Blood and Tissue Protocol (https://www.qiagen.com, accessed 20 June 2019).

PCR Reactions conditions: 1 × CL buffer (Qiagen), 0.5 × Q solution (Qiagen), 3.5 mM $MgCl_2$, 0.05 mM of each dNTP, 10 um of each primer, 2 x BSA and 5U of Taq polymerase (Qiagen).

PCR cycling conditions: 94°C for 2 min, 35 cycles of 94°C for 30 s, variable° * C for 30 s and 72°C for 1 min, final extension of 72°C for 5 min. PCR product was checked using 1% TAE agarose gel electrophoresis and purified using ExoSap-IT (USB Corporation, USA). Purified PCR product was sequenced by Australian Genome Research Facility (AGRF) using an AB-3730xl (Applied Biosystems, USA).

* This temperature was dependent on the primer set used. The following temperatures were used for the corresponding primer sets.

1F/18S H2: 65°C
18SF1/1500R: 60°C
18SL4/1800: 60°C
18SL3/1800: 60°C
ISO337/1155R: 62°C