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Pilbarophreatoicus platyarthricus n.gen., n.sp. (Isopoda: Phreatoicidea: Amphisopodidae) from the Pilbara Region of Western Australia

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ABSTRACT. *Pilbarophreatoicus platyarthricus*, a subterranean phreatoicidean isopod from an intermittent stream in the arid Pilbara region of northwestern Western Australia, is described. With subterranean morphofacies, namely slender vermiform body, eyeless, anteroventral lobe on pereonite 1, reduced abdominal epimera, clearly demarcated pleotelson and lacking in pigment, the species is distinguished particularly by details of the pleotelson. *Pilbarophreatoicus platyarthricus* is a Gondwanan relic surviving in an aquifer in a region with marked surface aridity. Discovery of *P. platyarthricus* highlights the importance of groundwater as a reservoir of biological diversity.

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The Phreatoicidea are ancient isopods, constituting the earliest derived members (Brusca & Wilson, 1991) and having the longest known fossil record of all living isopods. Their fossil record dates from the Essex fossil beds at Mazon Creek, Illinois, USA, of the Upper Carboniferous (Schram, 1970). Pre-Triassic representatives are known from marine deposits in the Northern Hemisphere (Birstein, 1962; Glaessner & Malzhan, 1962) but their post-Triassic record is exclusively from fresh waters of several of the Gondwanan fragments (Australia, New Zealand and South Africa), with maximum species diversity and abundance in the Bassian zoogeographic province of southern Australia (Knott, 1975). Phreatoicidean diversity in northern, by comparison with that of southern, Australia seems much reduced with the only records, until recently, from the South Alligator River area of the Northern Territory (Nicholls, 1943; Knott, 1975). However, information about the groundwater fauna of north-western Australia is increasing and more phreatoicideans are being found. *Crenisopus acinifer*, from a freshwater spring in the Kimberley region of Western Australia, was described by Wilson & Keable (in press). In addition, Wilson & Ponder (1992) described two species of *Tainisopus* from a cave pool and a spring outflow in the Kimberley that resembled phreatoicoideans, although they were not assigned to a currently described isopod suborder or family.

Annual rainfall in southern Australian sites, on the South Alligator River and at Kimberley sites where phreatoicideans have been collected is comparatively high (600–1,000 mm). The discovery of a new phreatoicidean from an intermittent stream in the arid Pilbara region (annual rainfall < 300 mm) is biogeographically significant. This paper provides a description of the new species, for which a new genus is described, and highlights the zoological importance of groundwater in arid areas.

Family AMPHISOPODIDAE Nicholls, 1943

Pilbarophreatoicus n.gen.

Type species. *Pilbarophreatoicus platyarthricus* n.sp. by monotypy

Diagnosis. Body slender, vermiform, smooth dorsally with scattered setae. Head longer than deep, with sub-antennary lobe lacking incisure on anterior margin; eyes absent; mandible placed anteriorly; cervical groove weakly developed. Pereonite 1 free from the head with anteroventral lobe prominent and overlapping head; pereonites 3 and 4 longest, pereonites 5–7 short but deeper than other pereonites; epimera of pleonites 1–5 short; pleotelson long, emarginate and not upturned, telsonic pleura broadly bilobed. Left and right mandibles with *lacinia mobilis*, gnathopod with oblique palm and two strong buttresses, mid-appendage articles (particularly the merus) of pereopods 2–4 broadly expanded; pleopods without epipodites. Uropods robust, distal corner of upper margins marked by stout simple seta and with simple seta below insertion of endopod and exopod, which both terminate in one robust seta; exopod rotated to lie below endopod.

Etymology. The generic name is derived from the Greek *phreatoic*, meaning well-dweller, and from Pilbara, referring to the geographical area where the specimens were collected. Gender: masculine.

Remarks. Hypogean phreatoicideans are known from all three extant families (Amphisopodidae, Nichollsiidae, Phreatoicidae) (Nicholls, 1943, 1944; Tiwari, 1955). *Pilbarophreatoicus platyarthricus* clearly belongs to the lineage retaining a *lacinia mobilis* on both left and right mandibles (Amphisopodidae and Nichollsiidae) but lacks elongate uropodal exopods and cleft pleopodal endopods, which are characteristic of males of species of Nichollsiidae (recorded only from deep wells in a small area of the Gangetic Plain between Varanasi and Patna in India) (Tiwari, 1955). *Pilbarophreatoicus platyarthricus* is therefore assigned to the family Amphisopodidae.

Pilbarophreatoicus platyarthricus n.sp.

Figs. 1–6

Type material. HOLOTYPE: male, 12 mm, partially dissected with appendages on 2 slides, Western Australian Museum of Natural Science WAM C 23241, Nyeetberry Pool (21°51.6'S 116°30.7'E by GPS) on Jimmawurrada Creek, tributary of Robe River, Pilbara, 2 May 1995, W.R. Kay & M.R. Smith. PARATYPES: 2 juveniles, WAM C 23242, same location, 2 May 1995, W.R. Kay & M.R. Smith. 3 juveniles, WAM C 23243, same location, W.R Kay & M.R. Smith, 11 May 1996.

Additional material examined: 5 males (7.4–11.4 mm long), 10 females (5.7–7.7 mm), 2 juveniles (5.3, 5.7 mm), WAM C 24156, Chalyarn Pool, Robe River (21°45.2'S 116°02.1'E, ≈50 km E of Nyeetberry Pool), 18 April 1998, J.M. McRae. 1 male, 1 female, Australian Museum P 53154, Chalyarn Pool, 18 April 1998, J.M. McRae.

Description of holotype male. Body (Fig. 1) slender, attenuated with parallel sides, smooth with scattered short setules dorsally, particularly on the anterior margins of thoracomeres 2–5; lacking pigment in 70% ethanol.

Head longer than deep; cervical groove weakly developed; prominent sub-antennary lobe lacking incisure on anterior margin; ventral margin slightly concave along line of articulation with mandible and also over remaining mouthparts; eyeless.

Antenna 1 (Fig. 2) short, reaching to base of peduncle article 5 of antenna 2; with 7 articles, 1–4 decreasing in length, 5 just shorter than 1, 6 longest and widest, 7 shortest; aesthetascs single on articles 7 and 5, clumped on 6; plumose setae on articles 2 (predominantly) and 1, large seta on 3. Antenna 2 (Fig. 2) peduncle with 5 articles, 3–5 being particularly setose; flagellum of 21 articles, each bearing setae sub-terminally. Upper lip (Fig. 3) slightly asymmetrical. Both mandibles stout and with triturative molar process. Left mandible (Fig. 2) incisor process with 4 teeth; *lacinia mobilis* with 3 teeth; spine row of 5 denticulate and several simple spines; molar process with convex grinding surface, armed with 3 plumose setae and 1 simple seta; palp of 3 articles, 1 shortest, 2 (rectangular) and 3 (ensate) approximately equal in length along the midline; palp article 1 with 2 setae, 2 with 3 prominent bipectinate setae distolaterally and row of setae mesially, 3 with sub-apical plumose setae extending to apical brush of long setae. Right mandible (Fig. 2) incisor process with 4 robust teeth; *lacinia mobilis* well developed with 3 teeth; spine row with 8 denticulate setae; molar process prominent and with concave triturating surface; palp similar to that of left mandible. Lower lip (Fig. 3) bilobed, setae apically and mesially. Maxilla 1 (Fig. 3) endopod with 4 long and 1 short plumose apical setae, mesial margin lined with row of short setae; exopod with 13 stout teeth apically, lacking palp. Maxilla 2 (Fig. 3) exopod bilobed, each lobe armed apically with a row of long pectinate setae; endopod with two rows of long seto-spines, simple and pectinate, on apical and mesial margins. Maxilliped (Fig. 3) endopod long and narrow, with pectinate setae along the distolateral and apical margins;

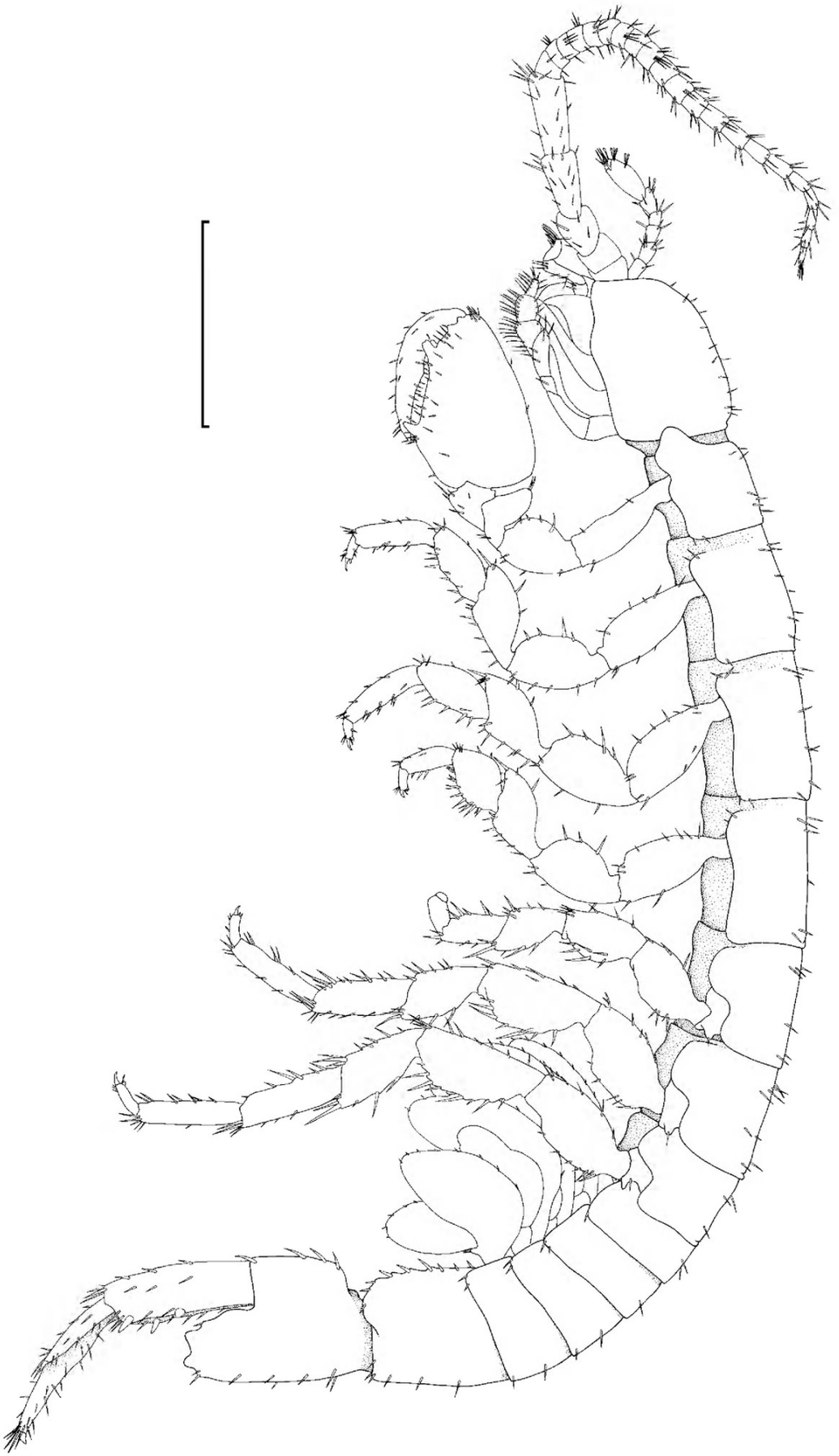

Figure 1. *Pilbarophreatoicus platyarthricus*, holotype male, lateral view, scale = 1 mm. Whole animal.

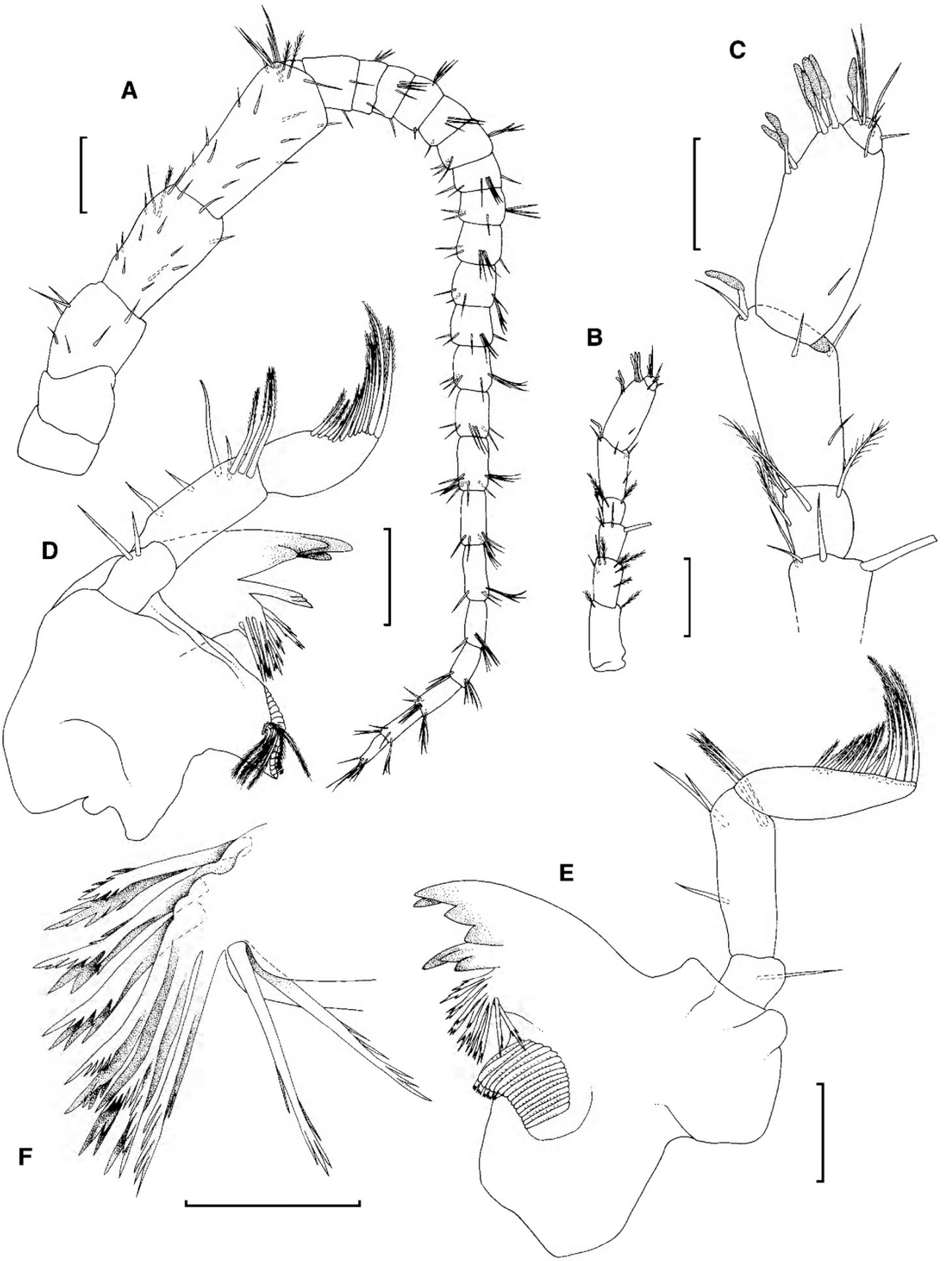

Figure 2. *Pilbarophreatoicus platyarthricus*, holotype male. A, left antenna 2. B, left antenna 1. C, detail of aesthetascs on antenna 1. D, left mandible. E, right mandible. F, spine row of right mandible. A, B scale = 0.2 mm, C–E scale = 0.1 mm; F scale = 0.05 mm.

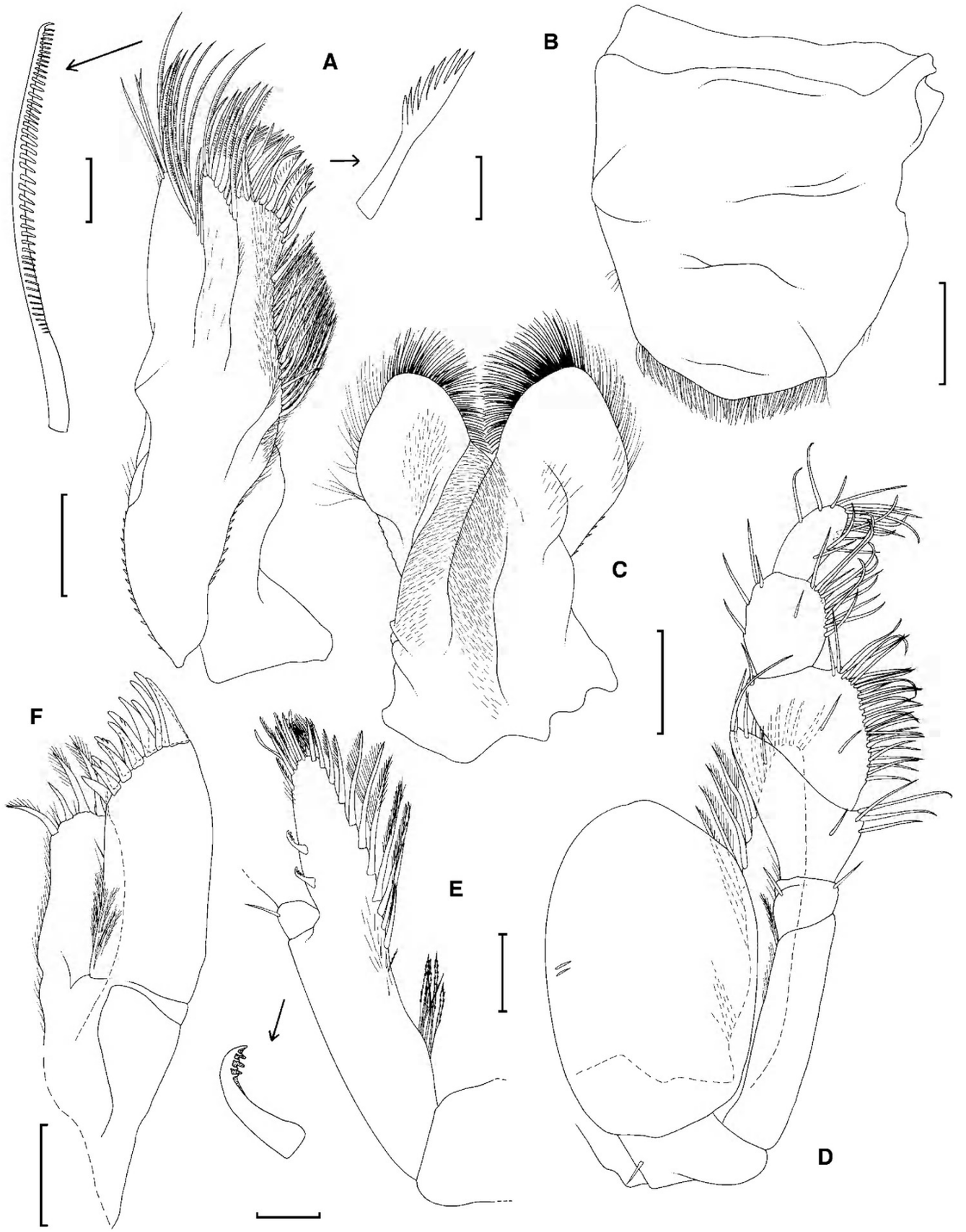

Figure 3. *Pilbarophreatoicus platyarthricus*, holotype male. A, left maxilla 2, showing detail of two types of setae. B, upper lip. C, lower lip. D, ventral view of maxilliped. E, medial view of maxilliped with detail of seta. F, right maxilla 1. A–F scale = 0.1 mm; A, E enlargements scale = 0.02 mm.

palp of 5 articles, 1 short, 2 expanded laterally, 3 with prominent inner margin lined with row of long setae, 4 and 5 with marginal setae.

Pereonites 3 and 4 longest, 1 and 7 shortest. Tergites of all pereonites longer than deep; when depth to sternite is considered depth of pereonites 1, 6 and 7 just greater than length, length of pereonites 2–5 greater than depth. Pereonite 1, free from head, anterior margin of tergite expanded ventrally into pronounced lobe overlapping head. Ventral margins of pereonites 2–4 slightly concave between small lobes at anterior and posterior corners of each body segment; pereonites 5–7, convex anteriorly and strongly concave along junction with coxa. Sternites of pereonites 5–7 with prominent midventral protuberance. Coxae 1–4 are inserted anteriorly on pereonite, coxae 5–7 are inserted on posterior half of the respective pereonite. Coxae 1–4 immovable, 5–7 movable with a seta on the posterior lobe.

Gnathopod (Fig. 4) with basis not expanded, ischium expanded anteriorly, merus expanded anteriorly and buttressing against enlarged propodus, carpus small and articulating with the posterior margin of propodus; propodus longer than wide with an oblique, crenulated palm delineated distally by prominent buttress and proximally by a large spur; on each side of palm are two rows of setae, dactylus has dagger-shaped terminal section carrying 2 setae. Pereopods 2 and 3 (Fig. 4) similar, ischium expanded anteriorly, merus with prominent anterodistal expansion, dactylus bearing secondary unguis. Pereopod 4 (Fig. 4) with broadened carpus with row of spines on posterior margin, dactylus with 2 pegs. Pereopods 5 and 6 (Fig. 4) with anterior margin of basis curved convexly, posterior margin expanded proximally through convex curve and narrowing distally through concave curve; ischium broadly triangular with posterior expansion. Pereopod 7 longest. Margins of all articles, particularly of pereopods 2–7, armed with stout setae. Penis broad, rectangular, unarmed, attached at the coxa/sternite junction; both penes meeting in the midline of the body.

Pleonites 1–6 increasing slightly in depth (Fig. 1). Pleonite 5 is >2 × length of each of pleonites 1–4. Epimera short, covering pleopod peduncles; posteroventral lobes bearing 1 or 2 setae; posteroventral lobe and ventral margin of epimeron of pleonite 5 with row of setae. Pleotelson with anterior waist; ventro-lateral margin with 3 marginal and 2 submarginal setae; posteriorly, lateral margins bilobed, dorsal lobe bigger than ventral; posterodorsal margin produced into broad, short pleotelson, which is shallowly and asymmetrically cleft and turned downwards, with several fine setae on margin of cleft. Anus lies at base of tube formed from the pleotelson dorsally and ventrally by a cuticular ridge (Fig. 5).

Pleopods (Fig. 6) biramous with length decreasing from 1 to 5; peduncles arranged nearly transverse to main body axis with mesodistal corner rotated posteriorly. Exopod of pleopod 1 simple, pleopods 2–4 with medial lobe. *Appendix masculinis* of pleopod 2 short and curved, reaching just beyond edge of endopod. Uropod (Fig. 5) peduncle with 3 small setae ventrally, both upper margins lined with setae and large robust seta at distal corner (outer, submarginally); 1 simple seta and several setae ventrally below the insertion of the rami; exopod 2/3 length of endopod, rotated to lie ventral to endopod, which has lateral subterminal setal tuft and terminates in movable seta.

Females. Oostegites on pereonites 1–4 inclusive; differs from male in gnathopod—propodus markedly triangular and palm lacking spine and buttress but with long setae on the lobe; carpal lobe of pereopod 4 lobe not pronounced, spine row less distinct; sternite of only pereonite 7 is prominently ridged; pleopods similar in length.

Juveniles carry same-shaped gnathopods as females.

Etymology. The name *platyarthricus* is derived from the Greek meaning broad articles, referring to the expanded articles, particularly the merus, of several pereopods.

Remarks. Some character variation is evident among specimens from Nyeetberry Pool. For example, in males, number of articles in the flagellum of antenna 2 varies between 18 and 30, and in the 2 specimens with both flagella intact, number on either side differs. Setation is more pronounced in larger specimens, with an anterior line of short setae across each pereonite. Numbers of setae on limb articles and tergites is variable.

Pilbarophreatoicus platyarthricus is distinguished from other Australian groundwater isopods within the genera *Hyperoedesipus*, *Hypsimetopus* and *Phreatoicoides* by robust antennae 1 and 2, two prominent spurs on buttresses on the palm of the gnathopod, degree of expansion of ischium and merus (in *Phreatoicoides* only merus is expanded) and, particularly, in details of the pleotelson, which is emarginate (truncated in *Hypsimetopus*) with anus at base of a well defined tube (in other phreatoicideans anus is positioned close to the level of the body surface), broadly bilobed posterolateral margin, and uropod endopods and exopods terminating in movable setae (in *Hyperoedesipus* there is an indication of a terminal seta but it is immovable).

Groundwater phreatoicideans have few characters that indicate relatedness to surface dwelling forms, although Knott (1975) found the condition of the gut, whether with typhlosole and/or gut caecae, to be a reliable indicator of subfamily (*sensu* Nicholls, 1943, 1944) relationships. The faecal strand in the anus of *P. platyarthricus* is round, indicating an alimentary tract lacking a typhlosole; the specimen was not dissected to observe the gut caecae. Members of the Mesamphisopodinae and Amphisopodinae lack a typhlosole and hind gut caecae, whereas at least some representatives of the Hypsimetopinae from southeastern Australia have a typhlosole and numerous, small hind gut caecae. Given the present distribution of the subfamilies Mesamphisopodinae (South Africa, Northern Territory and southern Western Australia) and Amphisopodinae (southern Western Australia and mound springs near Lake Eyre, South Australia), *P. platyarthricus* appears to represent a subterranean invasion of ancestors originally spread across the African/Western Australian region of Gondwana.

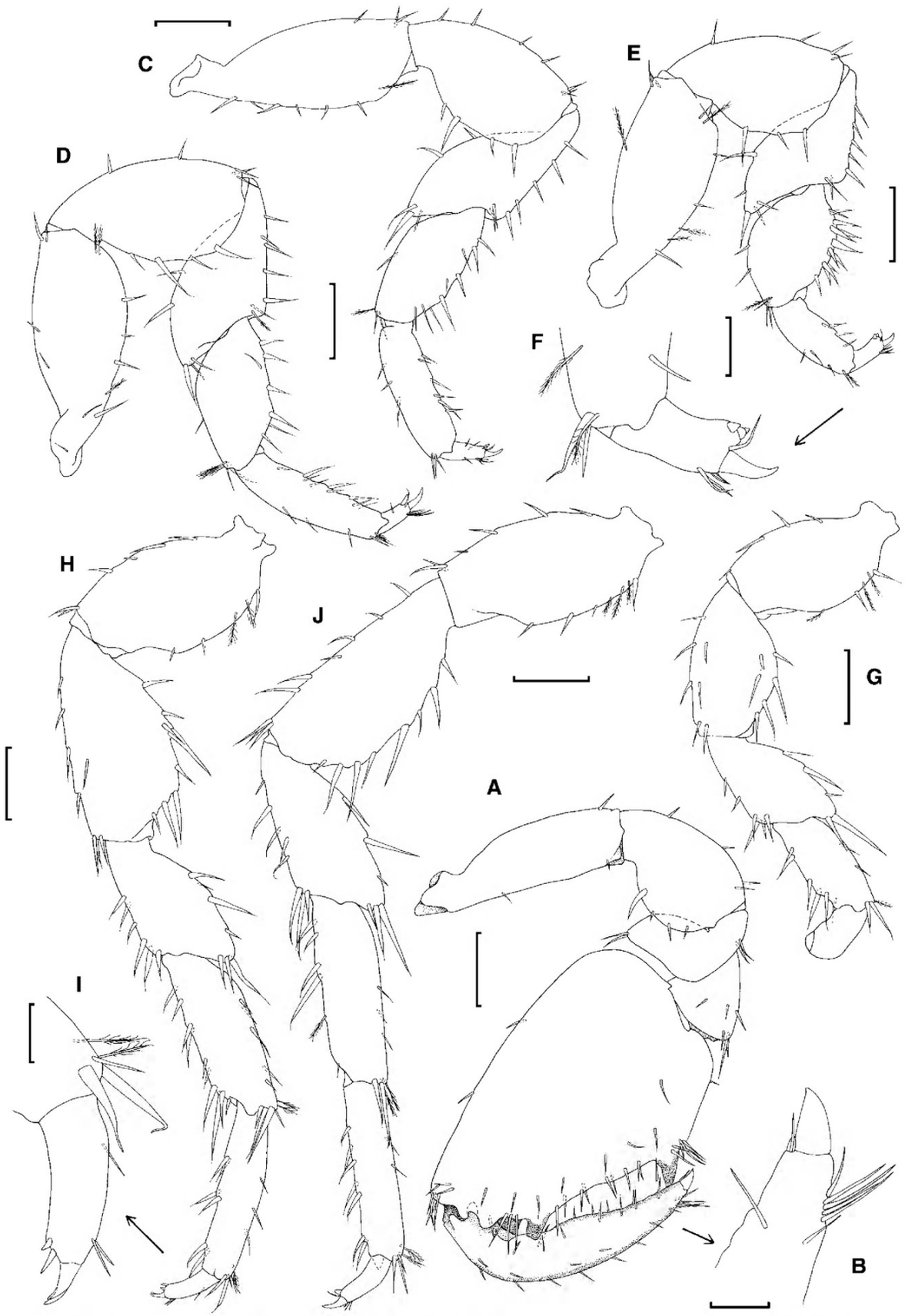

Figure 4. *Pilbarophreatoicus platyarthricus*, holotype male. A, right gnathopod. B, detail of dactylus of right gnathopod. C, right pereopod 2. D, right pereopod 3. E, right pereopod 4. F, detail of dactylus and unguis of right pereopod 4. G, right pereopod 5, dactylus and unguis regenerating. H, right pereopod 6. I, detail of dactylus and unguis of right pereopod 6. J, right pereopod 7. A, C–E, G, H, J scale = 0.2 mm; B, F, I scale = 0.05 mm.

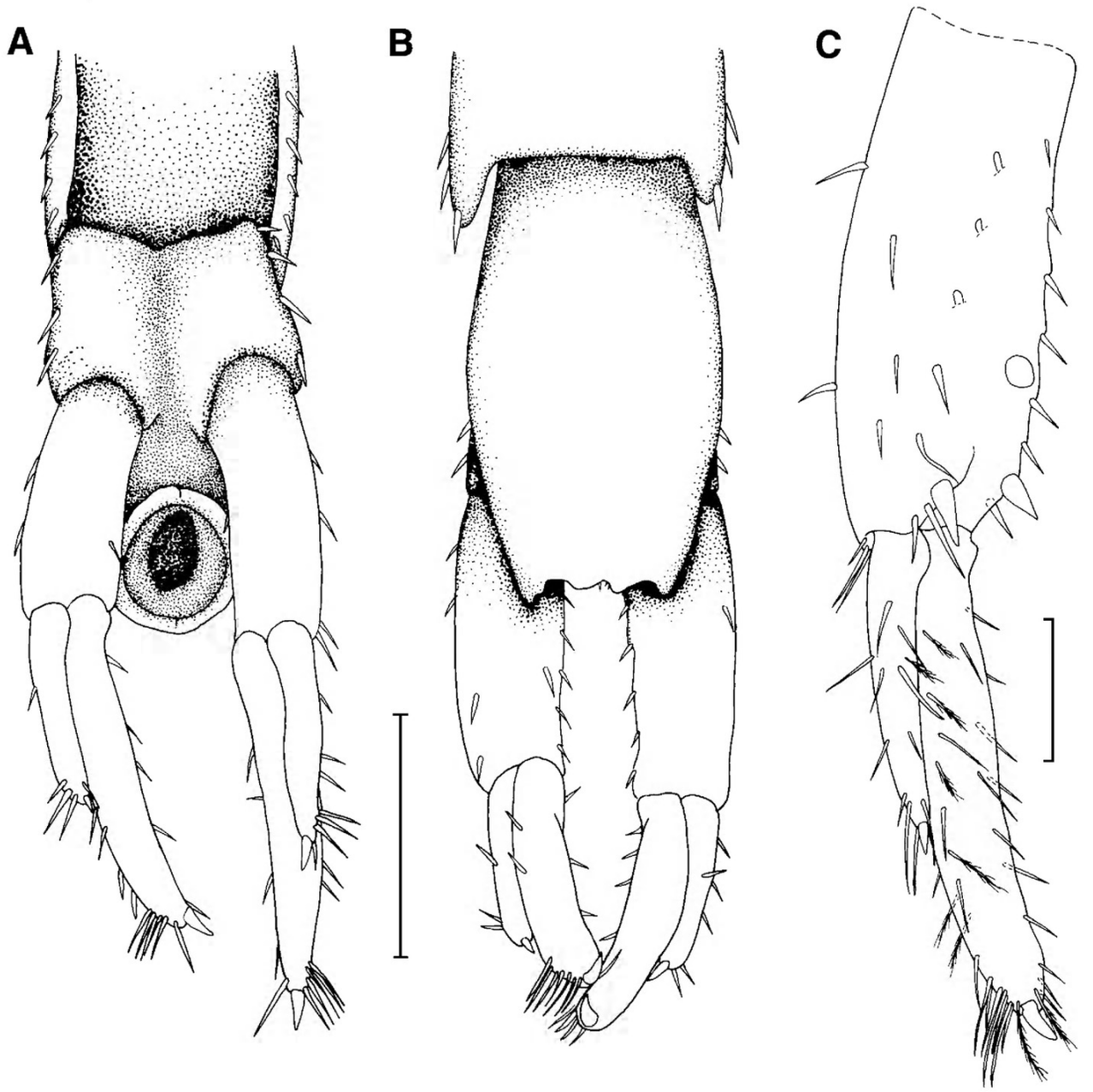

Figure 5. *Pilbarophreatoicus platyarthricus*, holotype male. A, pleotelson and uropods, ventral view. B, dorsal view. C, detail of right uropod, lateral view. A, B scale = 0.5 mm; C scale = 0.2 mm.

Discussion

Pilbarophreatoicus platyarthricus was collected from part of the Pilbara with median annual rainfall of about 300 mm and maximum temperatures often exceeding 45°C. All specimens were collected during the wet season (summer/autumn) from under cobbles in slow-flowing riffles in small pools of permanent water, maintained by groundwater discharge, on the Robe River. Other sections of the river, like streams elsewhere in the Pilbara, dry between periods of flow. Water in Nyeetberry Pool was fresh (780 µS/cm in 1995, 675 µS/cm in 1996) with alkalinities of 330–320 mg/L and pH values of 7.8–7.6. Water in Chalyarn Pool was also fresh (1144 µS/cm) with pH 7.6 in 1998. Most subterranean phreatoicideans in southern Western Australia occur in freshwater of similar, or slightly higher, salinity (B. Knott, unpublished data).

This is the first account of a phreatoicidean from the Pilbara region of Western Australia. The species was not found during the dry season when, presumably, animals had retreated deeper in the riverbed. The slender vermiform body, lack of eyes and pigment, reduced abdominal epimera, and anteroventral lobe on pereonite 1 are typical of hypogean phreatoicideans (Knott, 1975) and provide

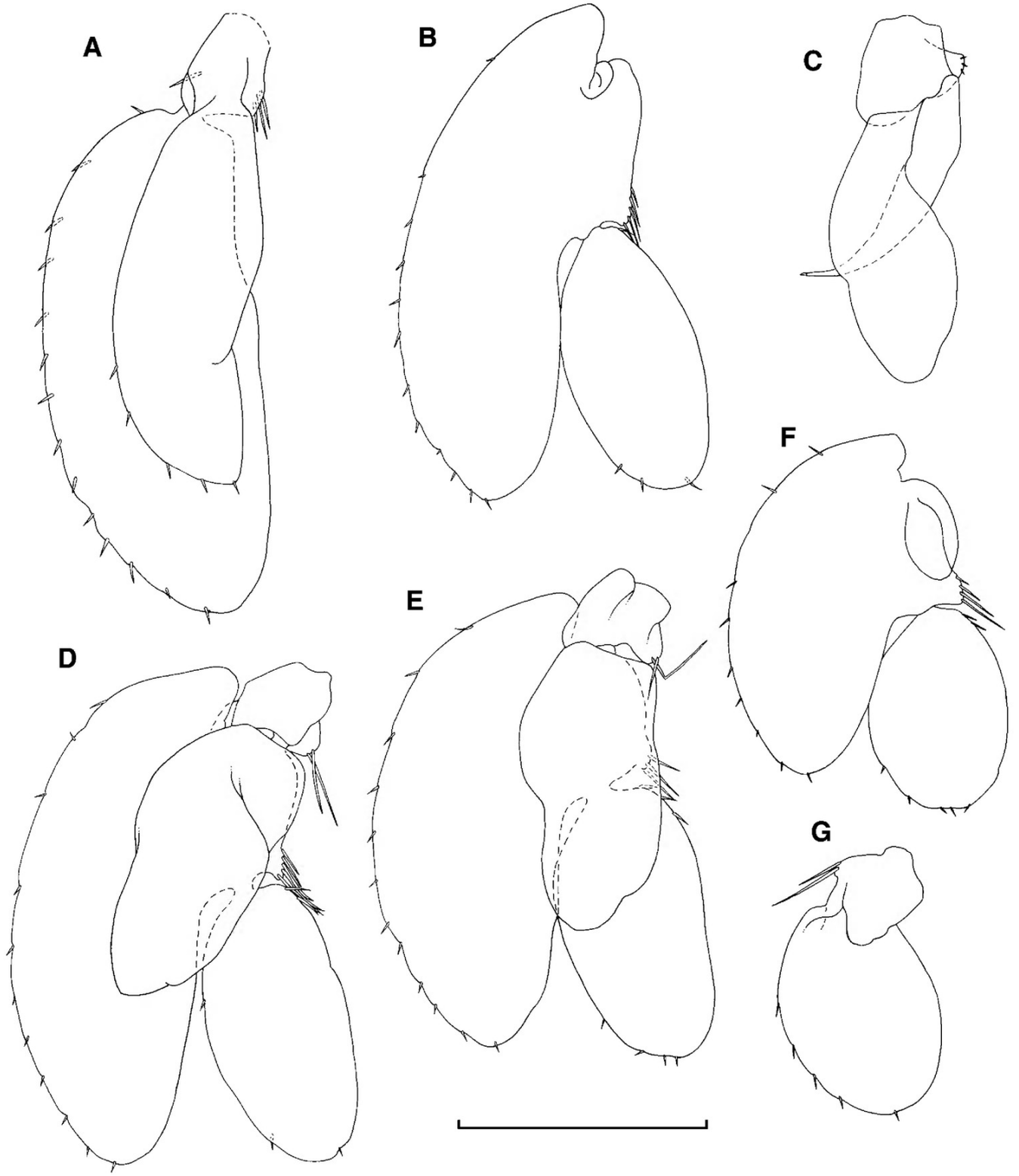

Figure 6. *Pilbarophreatoicus platyarthricus*, holotype male. A, right pleopod 1. B, exopod of right pleopod 2. C, endopod of right pleopod 2 with *appendix masculinis*. D, right pleopod 3. E, right pleopod 4. F, exopod of right pleopod 5. G, endopod of right pleopod 5. A–G scale = 0.5 mm.

morphological evidence, in addition to the habitat data, that *Pilbarophreatoicus platyarthricus* lives in groundwater. Its hypogean habits enable survival in an arid environment where surface water may occasionally dry out even in the deepest groundwater-fed pools.

Other relict, ancient freshwater crustaceans have also been recorded from the extensive groundwater reservoirs of the Pilbara (Poore & Humphreys, 1998), which seems to be a region of particular biogeographic importance, although its aquatic fauna is poorly known. Karst systems (Poore &

Humphreys, 1998), peat accumulations associated with outflow points of palaeorivers now flowing predominantly underground (Wyrwoll *et al.*, 1986), and groundwater discharge sites in modern rivers (Kay *et al.*, 1999) are likely to harbour phreatoicideans which, if their pattern of diversity elsewhere is a reliable guide, are likely to represent monotypic genera, each with limited distribution.

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