

A New Species of the Genus *Diaphanosoma* Fischer (Crustacea: Cladocera: Sididae) from Claypans in Western Australia

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Diaphanosoma hamatum sp. nov. is described from material from claypans of a restricted area near Onslow in the north-west of Western Australia. It is characterized by some peculiar features, such as presence of well developed rostrum, small reduced eye, and large hooked spine on the apical end of upper two-segmented antennal branch, which distinguish it from other known species of the genus. The new species is probably closely related to the Australian *D. unguiculatum* and may be considered as the additional member of the Australian endemic fauna. The ecological significance of morphological features of the species is discussed.

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KEYWORDS: Cladocera, claypans, *Diaphanosoma hamatum*, morphological adaptations, new species, Onslow, Western Australia

INTRODUCTION

Previous revisions of genus *Diaphanosoma* in Australia recorded five species (Korovchinsky 1981; Kořinek 1983) among which two species, *D. unguiculatum* Gurney, 1927 and *D. australiensis* Korovchinsky, 1981, appeared to be endemic. At that time only a small set of samples from the eastern part of Australia was studied. It was suggested that other species could occur in the centre, north and west of the continent (Korovchinsky 1981).

The recent collection of samples from the north-west of Western Australia has yielded three samples with the representatives of *Diaphanosoma*, one of which contained *D. excisum*, Sars, 1885 (a paperbark swamp near Onslow, clear open water) while in two others from the claypans with very turbid water the specimens of a new peculiar species were found

which is described herein. This species is common in claypans of the Ashburton River delta near Onslow (Timms, 2009).

DESCRIPTION OF LOCALITIES, MATERIAL AND METHODS

The localities are two claypans a little south of Onslow (northwest Western Australia), one 13.8 km and the other 18.6 km south. The first is 0.8 ha and the second 5.6 ha in area and both are usually less than 0.5 m deep. They fill after summer cyclones for a few to many weeks (about 10 weeks early February to late April in 2009). Water was red-brown, always very turbid (average 1725 NTU in the first and > 6000 NTU in the second), alkaline (pH = 7.6 and 7.8 respectively at time of collection and between 7.4 and

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9.6 for the season) and quite fresh (conductivity 88 and 166 mS/cm respectively). Associated zooplankters include the copepod *Calamoecia halsei* Bayly 1998, the cladoceran *Moina* sp., the ciliate *Epistylis* sp. and the anostracan *Branchinella pinderi* Timms, 2008.

Zooplankton was collected with a net of mesh 35 µm on a rectangular frame 27 x 15 cm designed especially for sampling shallow waters. Samples were examined under the dissecting microscope Lomo MBS-10 and compound microscope Olympus BX51 with *camera lucida*. Body measurements were made according to Korovchinsky (2004a) mostly on specimens from the claypan No. 1. To count the number of eye ommatidia, the eye pigment was dissolved with NaOH. Molar structure of mandibles was described according to Edwards' (1980) terminology. Some specimens from both localities were prepared according to method proposed by Laforsch and Tollrian (2000), mounted on an aluminium stub, coated with gold, and examined under a scanning electron microscope (SEM) Vega-Tescan at the Institute of Ecology and Evolution.

Type material

Holotype. Female, claypan 18.6 km south of Onslow, WA, 21°48'12"S and 115°06'01"E, 15 February 2009, coll. B.V. Timms, WAM 45117. Paratypes. 10 females, same data as for holotype, WAM 45118 and 10 other females from the same sample were placed in the Zoological Museum of Moscow State University (MI 107).

Other material

50 adult females, many deformed, from claypan 18.6km south of Onslow, WA, 21°48'12"S and 115°06'01"E, 15 February 2009, coll. B.V. Timms and 19 adult females and six juveniles from claypan 13.8 km south of Onslow, WA, 21°45'40"S and 115°05'40"E, 12 March 2009, coll. B.V. Timms have been placed in the collection of NMK.

Abbreviations

AnL – length of swimming antennae, BL – body length, BaL – length of basipodite, D – diagonals of molar surface, DE – diameter of eye, F – fishbones of molar surface, HH – head height, HL – head length, I – large two-segmented setulated seta on distal corner of gnathobases of tl I – tl V, J – modified thorn-like naked, hooked seta on distal corner of gnathobases of tl III – tl V, LAn – length of lower antennal branch, *n* – number of filtering setae of endopodite and gnathobase of thoracic limbs, p – not setulated setae on proximal corner of gnathobases of tl II – tl V; Pa – pales of molar surface, Pe – pegs of molar surface, PL – length of postabdomen, PSL – length of postabdominal setae, tl I...tl VI – thoracic limbs of first...sixth pairs, UAn – length of upper antennal branch.

DESCRIPTION AND REMARKS

Diaphanosoma hamatum sp. nov.

Body measurements of specimens are presented in Table 1.

Parthenogenetic female. Body oval-elongated with comparatively small head (length 32.1 – 37.5% and height 22.7 – 30.8% of body length), having massive and slightly protruding dorsal part (Figs 1a and 1b) and quite developed triangular rostrum (Figs 1b and 1c) (in two studied populations the shape of rostrum was slightly different, being more sharply narrowed in representatives from population No. 2). Eye comparatively very small (2.3 – 3.4% of body length), consisting of 10 ommatidia, and situated closer to the ventral head margin (Figs 1a and 1b). Antennules small situated close to rostrum's base and with sensory seta sitting on the prominent apical end of their base (Figs 1b and 1d).

Swimming antennae long (63.8 – 75.4% of body length) with massive basipodite, having long, naked

Table 1. Measurements of body size and body parts' proportions of *Diaphanosoma hamatum* from a claypan No. 1 near Onslow, 15 February 2009 (n = 17) (in each column from top to down: range, M, SD, CV).

BL	HL: BL, %	HH: BL, %	AnL:BL, %	UAn:BaL, %	LAn:BaL, %	DE:BL, %	PL:BL, %	PSL:BL %
0.82- 1.16	32.1- 37.5	22.7- 30.8	63.8- 75.4	71.2-87.7	46.2-56.5	2.3 - 3.4	13.8- 18.9	51.1- 64.2
0.95	34.5	27.1	69.3	79.5	51.0	2.9	16.0	59.0
0.09	1.8	2.4	3.5	5.0	2.9	0.3	1.4	4.2
10.0	5.2	8.8	5.1	6.3	5.8	10.0	8.7	7.1

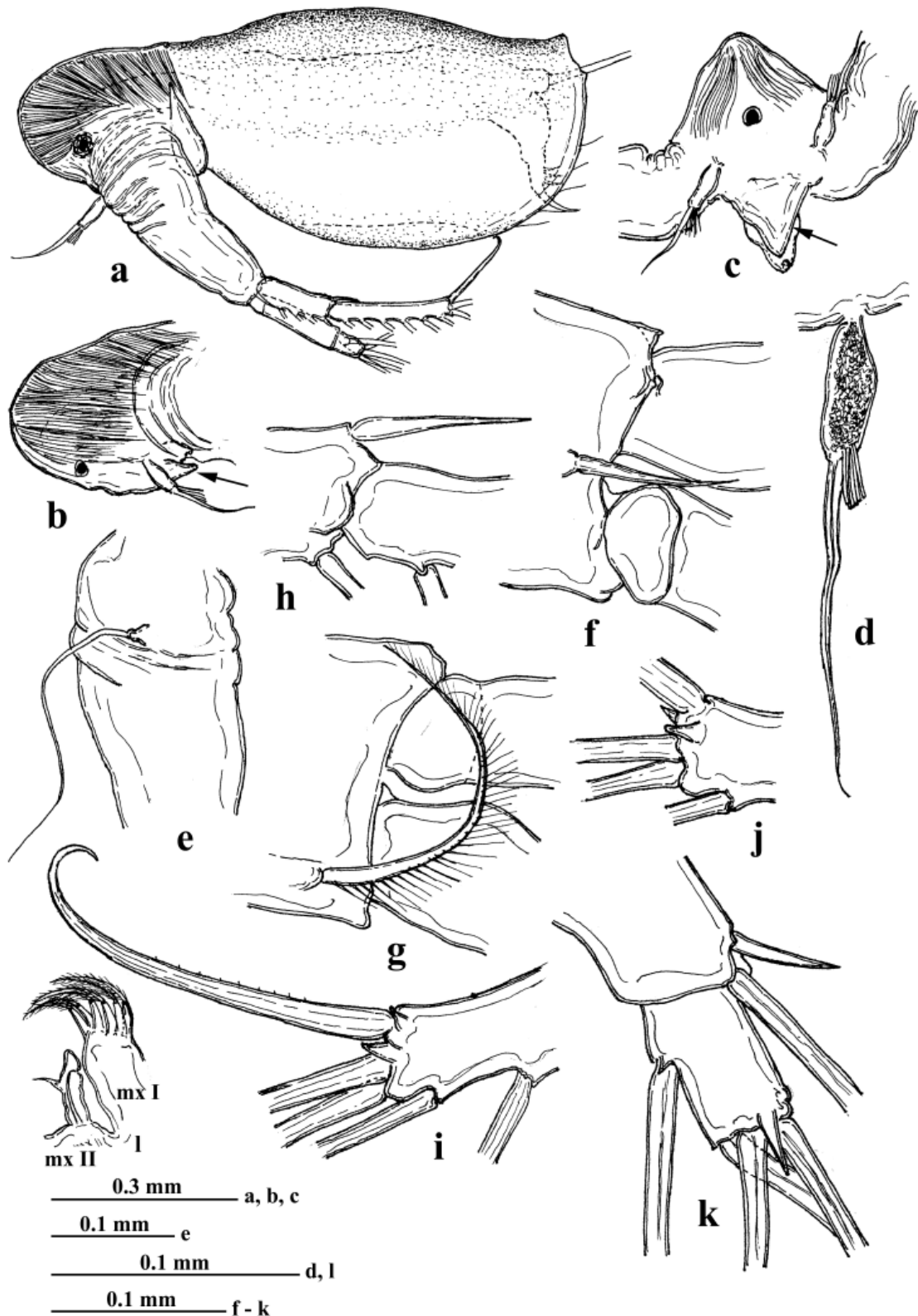


Figure 1. *Diaphanosoma hamatum* sp. nov., parthenogenetic females, claypan No. 1 near Onslow (Western Australia). a– general lateral view; b– head, lateral view (rostrum is indicated by arrow); c– head, ventral view (rostrum is indicated by arrow); d– antennule; e– basal part of antennal basipodite, dorsal view; f– distal part of antennal basipodite, outer side; g– the same, inner side; h– distal part of proximal segment of upper antennal branch; i– apical part of distal segment of upper antennal branch, inner side; j– the same, outer side; k– distal part of lower antennal branch; l– maxillula (mx I) and maxilla (mx II).

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seta on dorsal side of its base (Fig. 1e). Distal part of antennal basipodite with rather long and stout spine on its outer middle side and small prominence in front of upper branch, and with a small correspondent prominence on the basal part of the latter as well (Fig. 1f). Inner side of basipodite distal end with long feathered seta (Fig. 1g). Upper two-segmented antennal branch (exopodite) comparatively long (71.2 – 87.7% of basipodite length), its proximal segment with dorsally large spine and wide rounded prominence laterally (Fig. 1h). Distal segment of this branch apically with a very long, massive, distally curved spine, bearing dorsally a row of tiny denticles (14.2 – 14.5% of body length and 20.5 – 21.3% of antennae length) (Figs 1i and 4a). Three small prominences near the base of this spine, one on outer side of segment's apical end (Fig. 1j) and two on its inner side (Fig. 1i). All lateral setae of both segments armed uniformly with comparatively stout setules of swimming type while two longest apical setae armed proximally with similar setules but distally – with thin sparsely situated setules of sensory type. Lower three-segmented antennal branch (endopodite) shorter (46.2 – 56.5% of basipodite length), its second segment most developed, long and stout, bearing apically one long seta and a strong spine while distal segment with four long setae, one spine and small prominence near the base of middle apical seta (Figs 1k and 4b). Apical setae of the branch armed distally with thin, sparsely situated setules of sensory type similar to those of apical seta of upper antennal branch. Formula of antennal setae: 4 – 8 / 0 – 1 – 4. In juvenile specimens with body length about 0.6 mm, the proximalmost seta of both segments of upper antennal branch rudimental.

Mouthparts of maxillules (mx I), each with 6 – 7 densely situated feathered setae incurved forward, small maxillae (mx II) (Fig. 1l) situated just near base of tl I, having seta-like outgrowth in the middle of its anterior side and opening of maxillary gland on its posterior side, and mandibles. Right mandible (Fig. 4d) with triangular molar plate, having one large thorn (peg – Pe) posteriorly, a row of about seven conical prominences (pales – Pa) along dorsal margin which soon disappear and then appear again on the anterior margin of the mandible as three short, massive prominences with some apical digitiform appendages. Ventral margin of the mandible apparently lacks any prominences; central part deeply concave with parallel rows of ribbed diagonals (D). Left mandible (Fig. 4c) wider, with a group of pegs, consisting of two, larger and conical, and two other ones, both thinner with small apical prominences, at its dorso-posterior angle. Some parallel rows of wide pales mostly fused

together and forming almost entire ventral molar margin. Small group of long fishbones with divided apical ends near pegs. Most parts of molar surface with some parallel diagonals, diminishing in size anteriorly and becoming smoother.

Shell with arched dorsal side, having two strong dorso-lateral muscular bands (Figs 1a and 2a) and a conspicuous dorso-posterior angle. Valves with rather short posterior margin smoothly connected with ventral margin (Fig. 2b) and forming narrow inner inflexion bearing about 12 long feathered setae with very thin setules. Ventro-posterior valve margin armed with numerous small marginal and submarginal spinules, becoming even more submarginal dorsally, and a row of 10 – 12 long, thin setula-like setae (Fig. 2b and 2c). Posterior valve margin with wide rounded or bilobed prominence and a group of usually three, rarely two or four, thorn-like finely denticulated setae on its inner side (Figs 2b and 2d).

Six pairs of thoracic limbs, all with epipodites. Their structure and armament are shown in Table 2. Exopodite of tl I comparatively narrow at its end (Fig. 3a) while from tl II to tl VI epipodite widened terminally (Figs 3b and 3f). Endopodites of tl I and tl II more or less clearly subdivided in four parts (“segments”), the proximal part the largest (I), bearing numerous filtering setae (29 – 50), while three terminal segments (II – IV) with from four to eight such setae each. Terminal segment (IV) from tl II to tl V and subterminal segment (III) from tl I to tl V with also outer setae each, similar with those of exopodite, of which usually the former one, except tl I, especially long (Figs 3a and 3b). No small naked seta on the end of basal segment IV above the row of filtering setae. Endopodite filtering setae with a fascicle of more rough setules terminally (Fig. 3c). Gnathobases of tl I with outer row of 8–9 filtering finely setulated setae, setules of which apparently disposed in two rows situated under the right angle one to another together with a parallel row of small sharp denticles (Fig. 3g). Inside of these filtering setae the gnathobase with two other setae, one of which (I) is long, two-segmented with short setules distally and another one (i) curved and setulated as well. Gnathobase of tl II large with 33–36 filtering setae, ending proximally with one small naked seta (p) and distally with one long, two-segmented setae with quite rough setules (Fig. 3b). Gnathobases of tl III – tl V smaller, bearing only 16–20 filtering setae each, one small naked seta proximally (p) (Fig. 3e), and one additional naked, hooked seta distally (J) near long setulated seta (Fig. 3d). Tl VI small and strongly modified (Fig. 3f). Its exopodite reduced up to terminal plate, arming with six marginal setae.

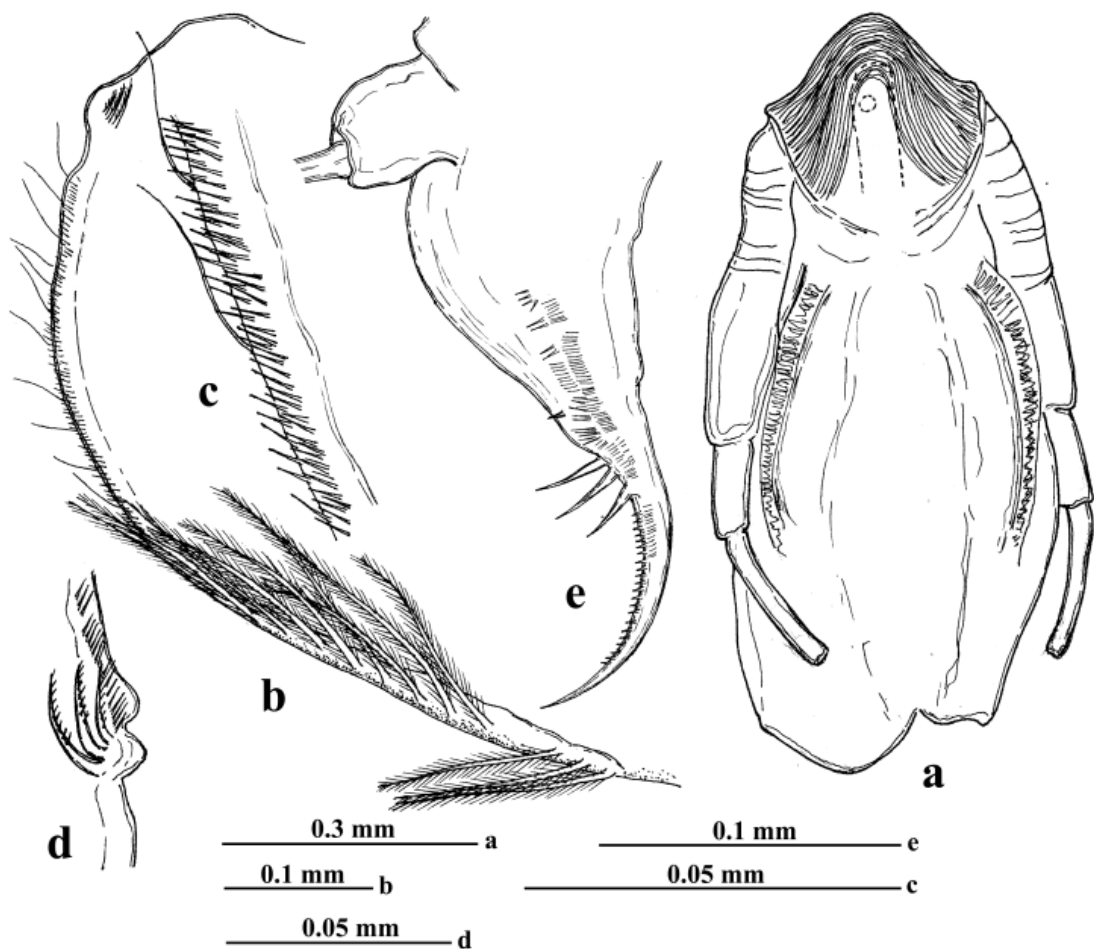


Figure 2. *Diaphanosoma hamatum* sp. nov., parthenogenetic females, claypan No. 1 near Onslow (Western Australia). a – general dorsal view; b – structure and armament of shell valve, inner view; c – armament of ventro-posterior valve margin; d – thorn-like setae near posterior valve margin; e – postabdomen, lateral view.

Endopodite with seven similar setae and one thorn, situating proximally. Gnathobase with two long setae and three thorns of different shape.

Postabdomen comparatively short (13.8 – 18.9% of body length) and cone-shaped with long postabdominal setae (51.1 – 64.2% of body length) (Fig. 2e). Postabdomen armed with longitudinal rows of rough spinules and small, thin anal teeth (Figs 2e and 4e) whose number and disposition vary considerably, from few to numerous and form solitary to clustered (Fig. 4e). In specimens from population No. 2 these teeth were more numerous. Terminal postabdominal claws with three long basal spines of almost equal size, though the distal one seems slightly shorter (Figs 2e and 4f). A row of rough spinules near the basal spines. Distally claws with a dorsal row of comparatively large denticles, diminishing terminally.

Body length 0.82 – 1.16 mm. All females lacked eggs or embryos in their brood pouches. Gamogenetic females and males are not known.

Differential diagnosis

The described new species differs from all known species of the genus by the presence of well developed rostrum, very small eye, and unusual long hooked spine on the end of upper two-segmented antennal branch. The closest species, *D. unguiculatum* (see Korovchinsky 1981, 1992), has a larger body size (up to 1.51 mm), and similar long spines on the end of antennal basipodite and on the ends of each segment of antennal branches. However its terminal spine of the upper branch is not so developed and possesses only tiny rudimental hook. The eye of the latter species is large and anal teeth are larger and usually more numerous.

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Table 2. Data on structure and armament of thoracic limbs of *Diaphanosoma hamatum* from claypan No. 1 near Onslow (WA)

Limb pairs	Exopodite (apical+ lateral setae)	Endopodite	Gnathobase	Epipodite
I	6 + 5	$(n6-8)+(n4+1)+(n4n)+(n48-50)$	$n8 + (I + i)$	+
II	7 + 5	$(n8+1)+(n4-5+1)+(n29-30)$	$n33-36 + p + (I)$	+
III	7 + 4	$n39 + 1 + 1$	$n19 + p + (I + J)$	+
IV	7 + 4	$n33 + 1 + 1$	$n18-20 + p + (I + J)$	+
V	6 + 4	$n27-28 + 1 + 1$	$n16-18 + p + (I + J)$	+
VI	5 + 1	7 + one thorn	2 + three thorns	+

Etymology

The species name ‘*hamatum*’ meaning ‘supplied with a hook’ in Latin, is suggested by the presence of a large hooked spine on the apex of the upper antennal branch.

DISCUSSION

The new species occurs only in claypans of the Onslow area, not in other local biotypes, and is one of the characteristic species of this biotype along with *Calamoecia halsei*, *Daphnia projecta* Hebert, 1977, *Branchinella pinderi*, *B. mcraeae* Timms, 2007 and the clam shrimp *Caenestheria sarsii* (Sayce, 1903). It was present in most claypans for most of their hydroperiod, unlike the large branchiopods which only live for the first few weeks of the hydroperiod.

Certainly, this species is highly specialized ecologically as well as morphologically. As it was described above, *D. hamatum* has well developed rostrum which probably protects the area of mouth parts from the mechanical damage possible at life in such shallow turbid environment, the water of which is saturated with inorganic clay particles. All other known species of *Diaphanosoma* lack a rostrum except *D. freyi* which possesses two rostrum-shaped prominences on the ventral side of head (Korovchinsky 2004b). The presence of a small eye with only 10 ommatidia is also understandable because light hardly penetrates such turbid water. The structure of the eye differs sharply from that of other species of the genus, having normally large eye with 50 – 67 ommatidia (see Korovchinsky 2004a). Interestingly another crustacean inhabitant

of these very turbid claypans, *Branchinella pinderi*, also has markedly reduced eyes (Timms, 2008). The unusual dorso-lateral bands of shell valves possibly serve for their better closing needed to protect the filtering structures of thoracic limbs. Meanwhile, the adaptive significance of enormous hooked spine on the end of upper antennal branch is not clear. It may be suggested that it serves for the attaching to the substrate but judging by body structure of the species and structure and armament of its appendages (elongated body, large head with developed dorsal muscular part, small antennules, long and powerful swimming antennae with long terminal setae on both branches, having differentiated setular armament, and long postabdominal setae), *D. hamatum* seems to be purely planktonic. On the other hand, such mode of life requires a minimum body weight so that the presence of such massive structure, having no vital significance, is presently inexplicable. Many claypans of the area, including the second claypan, have some aquatic macrophytes, which may allow the new species to temporarily anchor to a plant. All other cladocerans, having the attaching organs, are littoral- or bottom-dwellers. For instance, some littoral-benthonic Sididae have attaching structures but of different types – as the head anchoring organs (*Sida*) or long antennal setae with hooked ends (*Pseudosida*, *Latonopsis*, *Sarsilatona*) (Korovchinsky 2004a). The representatives of *Simocephalus* (Daphniidae) and *Moinodaphnia* (Moinidae) use for the attachment the special modified seta or enlarged spine situated apically on the upper antennal branch (Fryer 1991; Orlova-Bienkowskaja 2001). The enlarged terminal antennal spine of *Moinodaphnia* mostly resembles that

of
D.

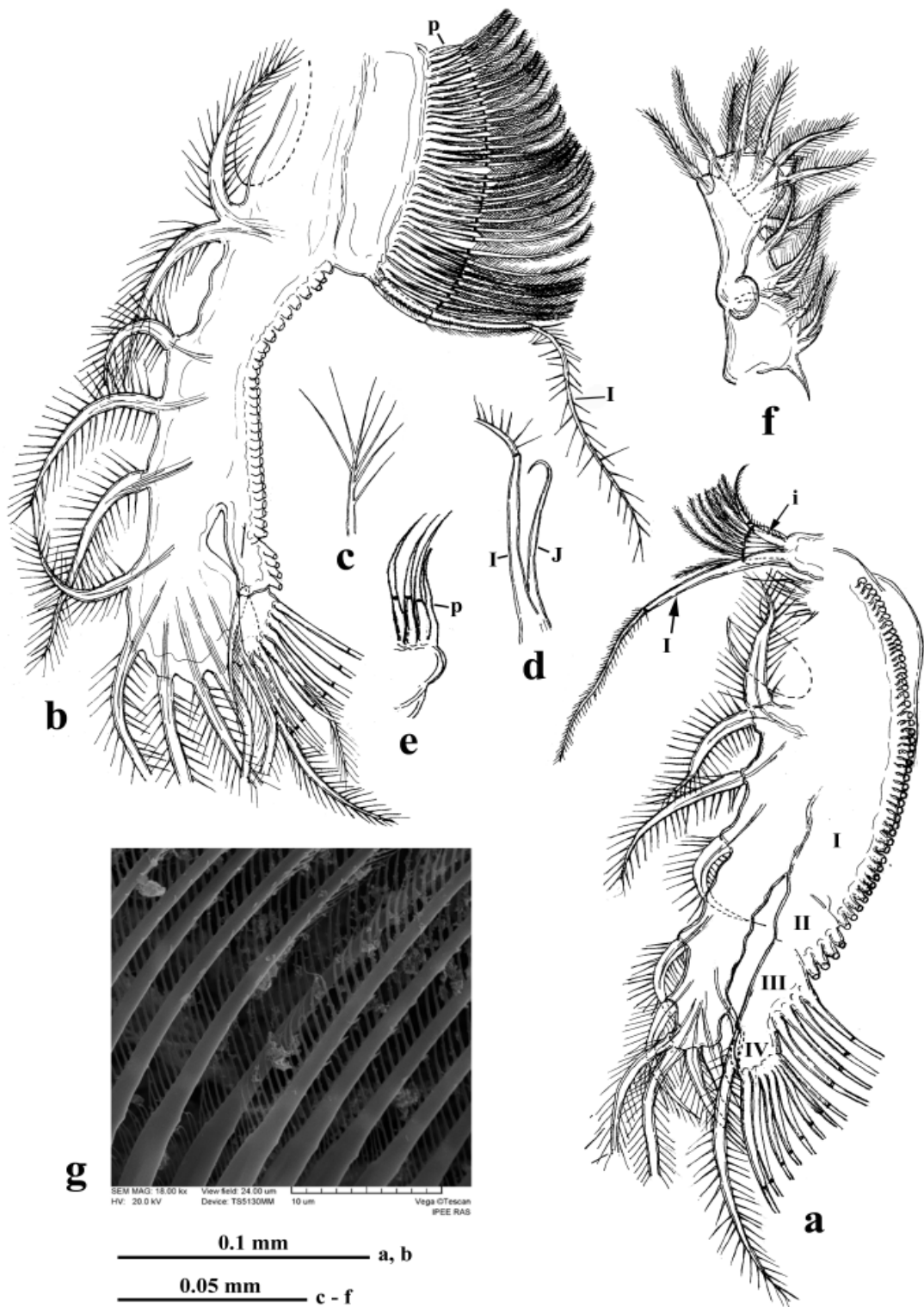
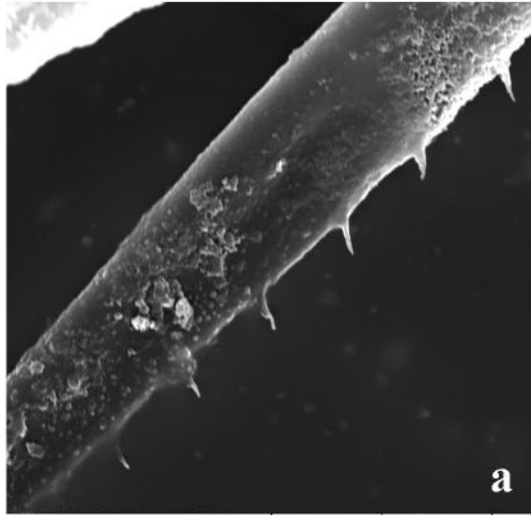
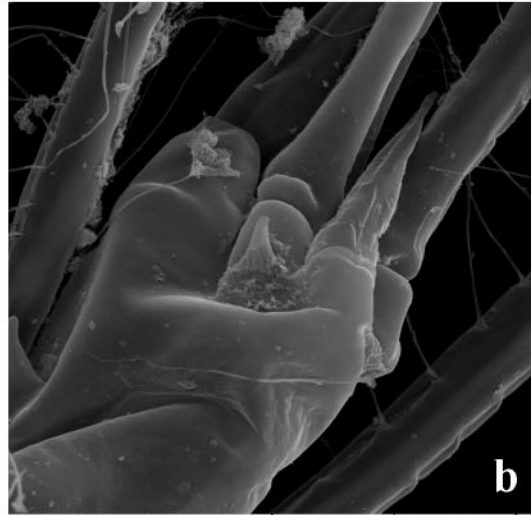


Figure 3. *Diaphanosoma hamatum* sp. nov., parthenogenetic females, claypan No. 1 near Onslow (Western Australia) (I – IV – numbers of endopodital segments, other explanations see in “Abbreviations”). a – thoracic limb of first pair; b – thoracic limb of second pair; c – fascicle of rough setules on the end of endopodital filtering setae; d – setae on the distal corner of gnathobase of tl III; e – setae on the proximal corner of gnathobase of tl IV; f – thoracic limb of sixth pair; g – armament of gnathobasic setae.

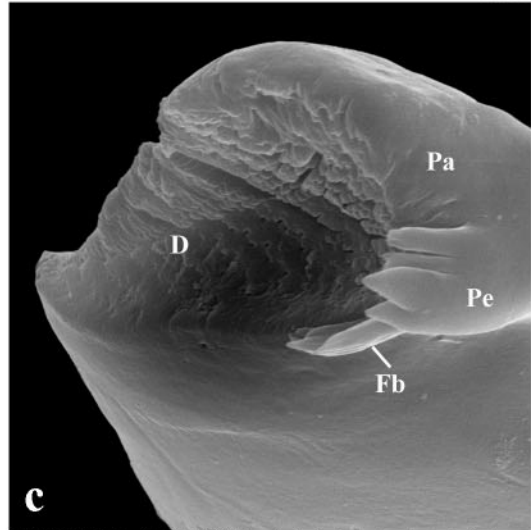
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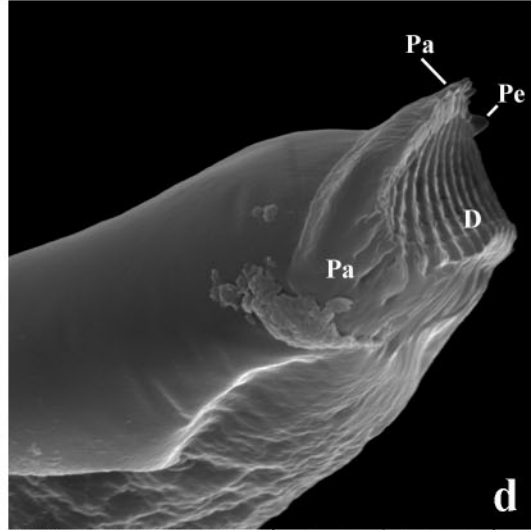
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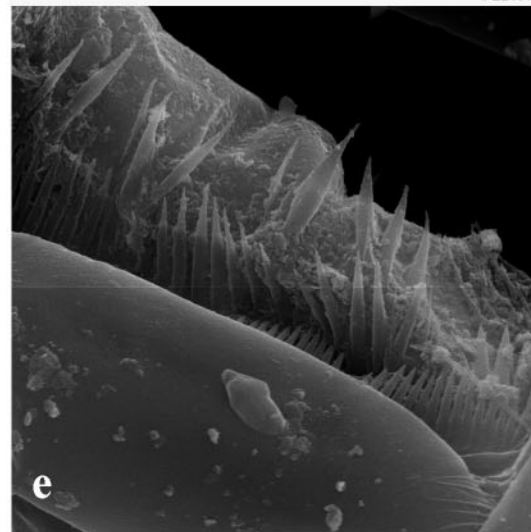
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hamatum. Probably only the direct observation of the living animals can resolve the problem.

One another specific feature of *D. hamatum* is the sharp difference in number of gnathobasic filtering seta between tl II with 33–36 such setae and tl III–tl V with only 16–20 setae. In other diaphanosomas studied in this respect (*D. brachyurum* (Lievin, 1848), *D. freyi* Korovchinsky, 2002, *D. amurensis* Korovchinsky et Sheveleva, 2009) the patterns of gnathobasic setation of different limbs are more similar (see Korovchinsky 2004a, b; Korovchinsky and Sheveleva 2009). Again, this peculiarity may indicate specialization in the new species.

In spite of having a number of specialized probably apomorphic features (small reduced eye, large hooked spine of the upper antennal branch), the primitive (plesiomorphic) characteristics in *D. hamatum* seem to predominate. The latter includes the rostrum (though it may be also suggested its secondary origin), long antennal spines, poor development of the ventral valve inflexion and its uniform setae armament, presence of some thorn-like setae near the posterior valve margin, anal denticles on postabdomen (their state seem more advanced than in *D. unguiculatum* due to comparatively smaller size and small number), and large uniform basal spines of terminal claws.

Undoubtedly *D. hamatum* demonstrates the closest morphological similarity with the Australian species *D. unguiculatum* in armament of swimming antennae, structure and armament of shell valves, postabdomen and postabdominal claws. This implies that within the genus both species have the commonest evolutionary relationship. At the same time, ecological preferences and geographic distribution of these species are different. The latter of them lives in various types of water bodies, demonstrating the high tolerance to the environmental factors, all over the Australian continent and possibly even in New Guinea (Korovchinsky 2004a) while *D. hamatum* is probably adopted for living in quite specific water bodies situated in restricted region of north-west Australia. In this respect it is reminiscent of *D. australiensis* also narrowly distributed in the region of Cape York (the extreme north of Queensland). Together with *D. unguiculatum* and *D. australiensis*, *D. hamatum* constitutes the small set of the Australian endemics of the genus.

Figure 4 (opposite). *Diaphanosoma hamatum* sp. nov., parthenogenetic females, claypans No. 1 and 2 near Onslow (Western Australia) (explanations see in “Abbreviations”).

a – tiny denticles on the lateral side of large hooked apical spine of upper antennal branch; b – apical part of distal segment of lower antennal branch; c – molar plate of left mandible; d – molar plate of right mandible; e – armament of lateral side of postabdomen; f – basal part of postabdominal claws.

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