

3.4. Taxonomy of the Raptornungidae n. fam. (Syncarida: Crustacea), a New Family of Anaspidacea (Syncarida, Crustacea) from North East, New South Wales, Australia.

Introduction

It has been 39 years since Schminke described the first species of Anaspidacea, *Psammaspides williamsi*, from New South Wales, Australia from the hyporheic zone of a small baseflow fed gravel bed stream on the south western edge of the New England Tablelands in North East NSW. This discovery dispelled the general belief of the time that NSW, and the eastern half of Australia for that matter, was devoid or at least depauperate in groundwater biodiversity. *P. williamsi* was the catalyst that opened the door to a period of significant discoveries in eastern Australia however, most of this new biodiversity has still not been described.

This paper presents a new family of anaspidacean Syncarida, including two new genera and three new species from the shallow groundwaters of the north east of New South Wales, Australia. This new family substantially increases our understanding of the biodiversity of the subterranean ecosystems in Australia, the range and diversity of the Anaspidacea, and represents a possible the link between the Koonungidae and the Psammaspididae. It also raises questions about the evolutionary pathways of the Anaspidacea and introduces the first anaspidacean morphologically adapted to being an active predator.



Figure 3.4.1. Raptornungidae n. fam. *Raptornunga timorensi* n. sp. Timor Caves, NSW. 10.7mm.

Abbreviations

Institutional Abbreviations

P - Australian Museum, Sydney, NSW, Australia.

Classification of the Raptornungidae n.fam

Table 3.4.1. Checklist of Species

Superorder SYNCARIDA Packard 1885

Order ANASPIDACEA Calman 1904

Suborder STYGOCARIDINEA Knott & Lake 1980

Family Raptornungidae fam.n.

Genus Raptornunga n. gen.

Raptornunga timorensi n. sp.

Genus Phreatonunga n. gen.

Phreatonunga neverensis n. sp.

Phreatonunga boultoni n. sp.

Taxonomy

Family RAPTORNUNGIDAE n. fam (= Family A Serov 2002)

Synonymy: Family A Serov, P. 2002. "A Preliminary Identification of Australian Syncarida (Crustacea)." Cooperative Research Centre for Freshwater Ecology. Identification and Ecology Guide 44: 1-30, pls 1f, fig 49. [20].

Etymology

The name is a hybrid of 'Raptor', a Latin noun for thief or robber and predatory nature to describe the large, modified grasping thoracopods 1 and 2, and 'Koonunga', due to the resemblance of the triangular telson of the family Koonungidae.

Diagnosis

Interstitial phreatic, hyporheic and cavernicolous anaspidaceans; body elongate with no dorsal flexure; medium size species up to 15 mm; pleon subequal to peron; pereonites similar in length; pleonites increasing in length posteriorly, pereonites narrower than pleonites; pleonite 6 approximately 1/3-1/2 length of pleonite 5; pleonite 6 posterior margin deeply concave with a row of 10-15 elongate spines alternating in length; weakly sclerotised with a thin and flexible cuticle surface covered in small pits; no epimeral expansions; no cephalic groove; mandibular groove on ventro-posterior margin; eyes absent; cephalon sub-rectangular with triangular anterior margin; rostrum triangular, produced by extension of cephalic plate and small triangular vertex; scaphocerite absent; labrum round, with a flat surface which does not project anterior, and 3 vertical, concave grooves consisting of 2 short, lateral grooves and 1 longer, central groove; mandible without palp; spine row and incisor accessory process absent; incisor process forms a concave cleaving structure; maxillule with two unequal endites on basal podomere and one segmented palp with one enlarged plumose setae; maxilla with 2 lobes; maxilliped robust, elongate with a modified propodal spine and dactylus forming a grasping appendage capable of being folded under the cephalothorax; maxilliped coxa without epipodite; maxilliped basis with 1 tubular exopodite; thoracopod 2 robust and enlarged for grasping in coordination with the maxilliped; thoracopods 2-7 coxa with 1 tubular epipodites; thoracopods 2-6 basis with 1 multisegmented exopodite; thoracopods 8 without epipodites or exopodites; female spermatheca forming prominent cone shaped sternal extension positioned between the coxae of thoracopod 6; pleopods 1-5 without exopodites; pleopods 1-2 with endopodites only; pleopod 1 consists of a short broad coxa and a single spatulate-shaped segment; pleopod 2 endopodite 2 segmented and styliform; proximal segment elongate with coupling hooks on the subdistomedial corner; distal segment elongated, truncated with an acutely pointed syringe-like apex; pleopod 2 with subapical coupling hooks on basal segment; uropod rami elongate and subtubular; uropod lateral rami 2 segmented; uropod medial rami 1 segmented; telson elongate and triangular with or without

a shallow concavity on the subdistal margin to apex; spinose setae extending along the length of the lateral margins of the telson.

Remarks

The Syncarida in general are one of the quintessential groundwater dependent groups that dominate the subterranean aquatic environments of aquifers and riverine hyporheic zones around the world. This is particularly the case in South Eastern Australia where the states of New South Wales, Victoria, Tasmania and South Australia are the epicenter of global diversity for the Order Anaspidacea, containing five of the six families. This group of freshwater crustaceans share characteristics with other primitive Australian crustacean groups including the freshwater Amphipoda and the Phreatoicoidea Isopoda in having an ancient lineage with Gondwanan distributions and morphological adaptations for inhabiting subterranean environments. The late Professor Williams described the Syncarida, referring specifically to the Anaspidacea “as a rare ubiquitous group”. The Superorder currently consists of five families within the Order Anaspidacea, and includes the Anaspididae, Koonungidae, Psammaspididae, Stygocarididae and Patagonaspididae. In this paper I propose an additional new family, the Raptornungidae.

The discovery of the Raptornungidae was the result of a growing interest in recent years in the inventory and preservation of groundwater ecosystems such as caves and aquifers and their biodiversity in Australia. In 1992, the NSW National Parks and Wildlife Service began a program surveying the subterranean invertebrate fauna of NSW caves (Eberhard 1993; Eberhard & Spate 1995). This project was conducted in order to determine the conservation status of each cave system. These surveys led to the discovery of a diverse and widespread fauna containing significant distributional and phylogenetic relic species. It is these surveys that first uncovered a number of anaspidaceans that did not fit within the diagnostic constraints of the other families.

The Raptornungidae is the first extant predatory syncarid to be described, and the first new family to be added to the Syncarida in 11 years following the discovery of Patagonaspididae in southern South America. In addition it is the first new taxa to be described from Australia in 33 years. The family exhibits a unique combination of autapomorphic characters such as the enlarged raptorial maxilliped and thoracopod 2 and mouthpart structures that do not exist within the other five families of Anaspidacea. It does however share a number of characteristics with the Psammaspididae and the Koonungidae. The new genera include: *Raptornunga* with *R. timorensis* and *Phreatonunga* with *P. neverensis* and *P. boultoni*.

The family was collected from limestone caves, the hyporheic zone of sand and gravel bed streams and within alluvial aquifers to depths of 70m. Their distribution is exclusive of all other anaspidaceans and extends East and West of the Great Dividing Range. The species are highly endemic and restricted to small hydrogeological units.

The autapomorphic characteristics of the family include: a cephalon with a triangular vertex with concave distolateral margin; mandible without a palp; mandible molar process with a row of triangular spines; maxillule with one segmented palp; maxilla with 2 lobes; maxilliped enlarged and robust with the dactylus and propodus forming a cheliped-like clasping structure; thoracopod 2 enlarged and robust; thoracopods 3-8 coxa with 1 tubular epipodite, thoracopods 2-6 with 1 multisegmented exopodite; thoracopods 7 with 1 tubular exopodite; pleopods 1-2 with endopodites; uropod exopodites 2 segmented; uropod endopodites 1 segmented; distal margin of pleonite 6 with a row of elongate movable setae that extend the telson; telson triangular and elongate; telson lateral margin with spinose setae extending along its length.

Typically the syncarids are considered entirely omnivorous detritivores that feed principally by consuming the biofilm attached to the sediment (Swain & Reid 1983) although some species such as *Anaspides tasmaniae* will consume animal matter including opportunistic cannibalism (Serov 1988, Manton 1930). The most distinctive features of this new family is the massive development of the first two pairs of legs into raptorial grasping appendages and the elongate, triangular telson equipped with an extensive array of defensive spines. A comparison of the differences between this family and other Anaspidacea can be strikingly seen between the appendages of the new taxa and the group to which they most closely resemble the unspecialised general structure of the families Koonungidae and Psammaspididae, found in SE South Australia, Victoria and Tasmania.

One of the most remarkable morphological modifications in this family is the specialisation of the dactylus and propodus of the first thoracopod (maxilliped) into a chelate grasping appendage. The maxilliped has also increased in size and musculature as well as having the one small dactyl claw being modified into a large, long, robust terminal claw. The differences that separate this group from the rest of the Syncarida however, don't stop there. The telson is elongate and sharply triangular, with a row of very long setae on the posterior margin of the last abdominal segment. These lance-like setae extend up to and over the end of the telson forming a formidable defensive array protecting the animal from behind. These setae are articulated enabling the animal to move them from horizontal to almost vertical. The suggested advantage of this articulation is that it allows the animal to present a rear vertical barrier to any prospective predator irrespective of the width of the void it is travelling through. The maximum advantage of this armature however, is most likely come into play in the confines of the interstitial environments of either the coarse grained hyporheic zone or phreatic zone where narrow pathways prevent the animal turning to face an attacker.

As these are all subterranean species occupying either cavernous pools and voids in caves or narrow tunnels through the sediment they can either present an array of sharp barbs or a vertical fence to prevent a predator from accessing the soft body. As these species are the largest and potentially the only active predators within these environments it is likely that these species are also cannibalistic. This behaviour has been noted as a characteristic of other anaspidacean such as *Anaspides tasmaniae*.

The defensive armaments also extend to the lateral margins of the telson and the uropods which have an array of variable spinose setae along most of the margin culminating at the posterior margins of the telson and uropods. The Raptornungidae share these features with the Psammaspididae however, the size and complexity of these structures are greatest within the Raptornungidae. Although these features are only found within these two extant families, similar defenses are commonly found within the extinct Palaeocaridacea. In particular within the species such as: *Pleurocaris annulatus*; *Praenaspides praecursor*; and to a lesser degree species in such as *Williamocalmania vandergrachti*, *Eurythrogaulus carrizoensis*, *Palaeosyncaris dakotensis*, and *P. micra*, *Nectotelson krejci*, and *Squillites spinosus*. *Palaeosyncaris dakotensis* and *P. micra* also have enlarged thoracopods 1 and 2 although not to the same development as seen within the Raptornungidae. The elongate spines on pleonite 6 are synapomorphic for the Raptornungidae and Psammaspididae.

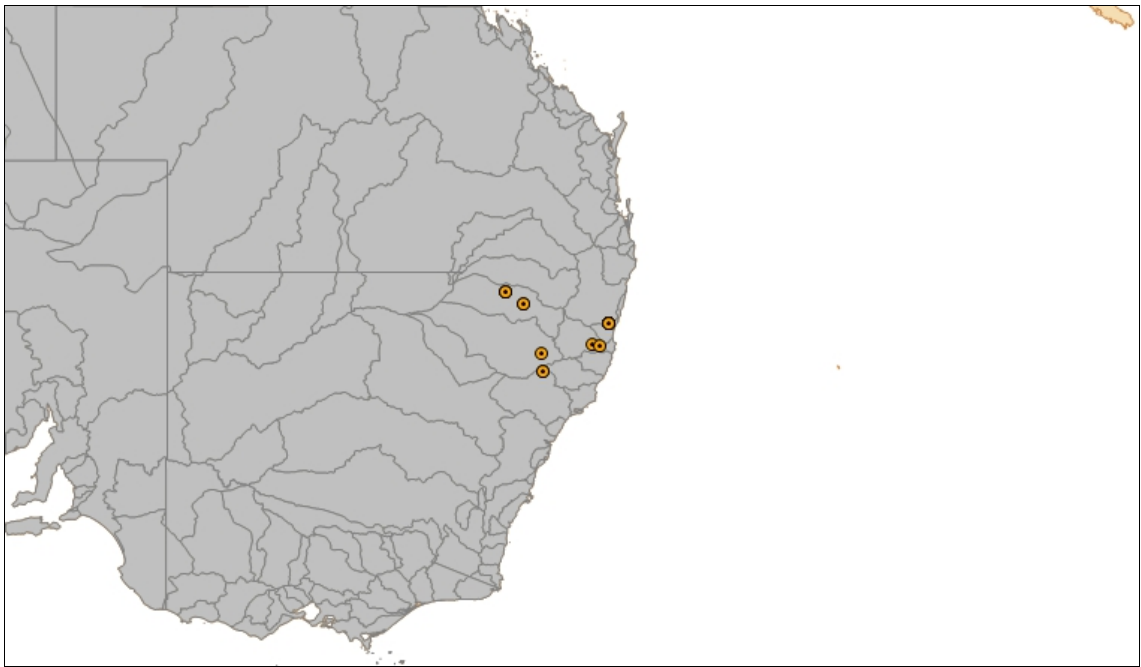
The uropod possesses a single articulated endopod and a two articulated exopod, which is a feature only found in some species of stygocarids from South America and the Psammaspididae. All other syncarids except the Psammaspididae have single article rami.

The mandible is unique among the Anaspidacea in possessing a row of strong elongate spines in place of the typical finely setose molar process. The lack of a palp on the mandible is distinctive and separates this group from the Koonungidae, whereas the presence of a palp on the Maxillulae is a main linking feature between the new genus and the Koonungids. The structure of the maxilla is also unparalleled among the Division Syncarida in that it possesses only two endites whereas all others possess four.

The male genitalia differ from the Koonungidae by having the second pleopod coxa free whereas they are fused in all koonungids and incidentally also in all of the Anaspididae including *Anaspides tasmaniae*. There is however, a striking similarity in structure of the pleopod 2 with that of the NSW cave psammaspids.

The shape of the telson is unique and highly variable among the Anaspidacea. The four features of the telson that distinguish this group are the length, the sharply triangular shape, the concave distolateral margins, and a diverse spinose setae row along almost the entire length of the telson. While the koonungids have a triangular telson whose length is shorter than width, they do not have lateral concavities on the lateral margins and the marginal spine row terminates well before the junction with the pleonite 6. Therefore as a result of these major differences in morphology I am proposing the creation a new sister family to the Psammaspididae, the Raptornungidae. The Raptornungidae is named after the predatory-like talons formed by the first two pairs of thoracic appendages.

Geographic Distribution.



Map 3.4.1. Distribution of the Raptornungidae in NSW, Australia.

Legend symbol: Raptornungidae - ☉ hollow circle with central dot.

The new family is currently restricted to an area that straddles the Great Dividing Range with locations in both the eastern catchments of the North Coast of NSW and the western catchments of the North Western Slopes and Plains.

The Eastern locations include: The Macleay River Catchment upstream of the township of Kempsey. The habitats include Stormpipe Cave at Willi Willi and the cobble/gravel bed hyporheic zone of river near Sebastopol and Temagog, and Never Never River Catchment on the North Coast of NSW where they are found in the cobble/gravel bed hyporheic zone of river near Bellingen; Isaacs Creek, an upper tributary of the Pages River, Upper Hunter Valley where it inhabits Lake Cave in Timor Caves, in water table pools, off Isaacs Creek, Timor Road, NSW.

The Western locations include: Halls Creek, in the hyporheic zone a small groundwater fed perennial baseflow tributary of Gwydir River catchment, at Bingara, east of Narrabri NSW; Alluvial aquifer of the Gwydir River north and east of Moree, north western NSW; The upper reaches of the Peel River, in the sand and gravel hyporheic zone and alluvial aquifer of a tributary of the Namoi River catchment, east of Tamworth, NSW.

The distribution of each anaspidacean taxa including the Raptornungidae is exclusive of other families of

Anaspidacea, except for very small areas such as the upper Pages River and Namoi Rivers where a very narrow transition zone exists between the Raptornungidae and the Psammaspididae and limited cohabitation does occur. The reasons for this separation are unclear as the water quality, chemistry and geomorphology appear similar across the transition zones.

Key to Genera of the Raptornungidae

1. Anaspidacean with an elongate triangular telson with long spines on the posterior margin of pleonite 6.

2.
2. Telson with moderate concavity subdistal to apex; male pleopod 2 apex bilobed; anal lobes triangular.

***Raptornunga* n. gen. 3.**
3. Telson with only minor or lacking a concavity subdistal to apex; male pleopod 2 apex single stylet; anal lobes circular

***Phreatonunga* n. gen.**

Genus *Raptornunga* n. gen.

Type species

Raptornunga timorensis n. sp.

Etymology

The name is a generic variant of the family i.e. a hybrid of 'Raptor', a Latin noun for thief or robber or predatory nature to describe the large, modified grasping thoracopods 1 and 2, and '*Koonunga*', due to the resemblance of the triangular telson of the family Koonungidae

Diagnosis

Distinctive sexually dimorphic colour patterns; female cephalothorax divided partially into two unequal regions by transverse cephalic groove; right mandible incisor process with 8 denticles divided into 4 large, subequal, lateral denticles, widely separated by a large central denticle with 3 medial denticles with a diastema separating the terminal single denticle; right molar process with 6 elongate, medially directed, acutely pointed denticles consisting of 1 lateral, bifid denticle, 3 equal, elongate, acutely pointed denticles and 1 large, medial, denticles with 5 small, apical spines or denticles; left mandible incisor process with 4 large denticles divided into a lateral row of 3 and a medial 4th; incisor process and molar process separated by a narrow v-shaped diastema; left molar process with 6 denticles consisting of 3 lateral, straight, equal, acutely pointed denticles, 1 mid, medially curved, acutely pointed denticles and 2 medial, short, blunt

denticles; maxillula medial endite with 2 apical, large, hirsute spines, two small, narrow serrate spines, and 3 simple spines; paragnath bilobed without notch on medial margin; pleopods 1-5 in both sexes without exopodites; pleonites 1-4 each with one pair of pleopods; pleonites 1-4 in females a 1 segment appendage; pleopod 1 consists of a short broad coxa and a single spatulate-shaped segment; pleopod 1 medial margins folded medially to form a medial groove running the length of the segment opening subdistodorsally; medial surfaces adjacent to the groove covered in fine setules and a round distomedial patch of coupling setae; distodorsal margin with 3 short, pointed, vertically orientated, proximally directed spines; pleopod 2 endopodite 2 segmented and styliiform; coxal plate flat with 2 elongate and 2 short setae lateral to endopodite with basal segment rising directly from ventral surface; distal segment elongated, truncated with an acutely pointed syringe-like apex; apex consists of an internal medial groove and a small subdistal medial pointed projection; pleonite 6 approximately 1/3 dorsal length of pleonite 5; telson sharply triangular, elongate with moderate concavity subdistal to apex; telson dorsal surface with 2 subdistal large, simple spines; dorsal surface with 2 submarginal lateral simple spines on each side; anal lobes triangular.

Species Composition

Raptornunga timorensis n. sp.

Remarks

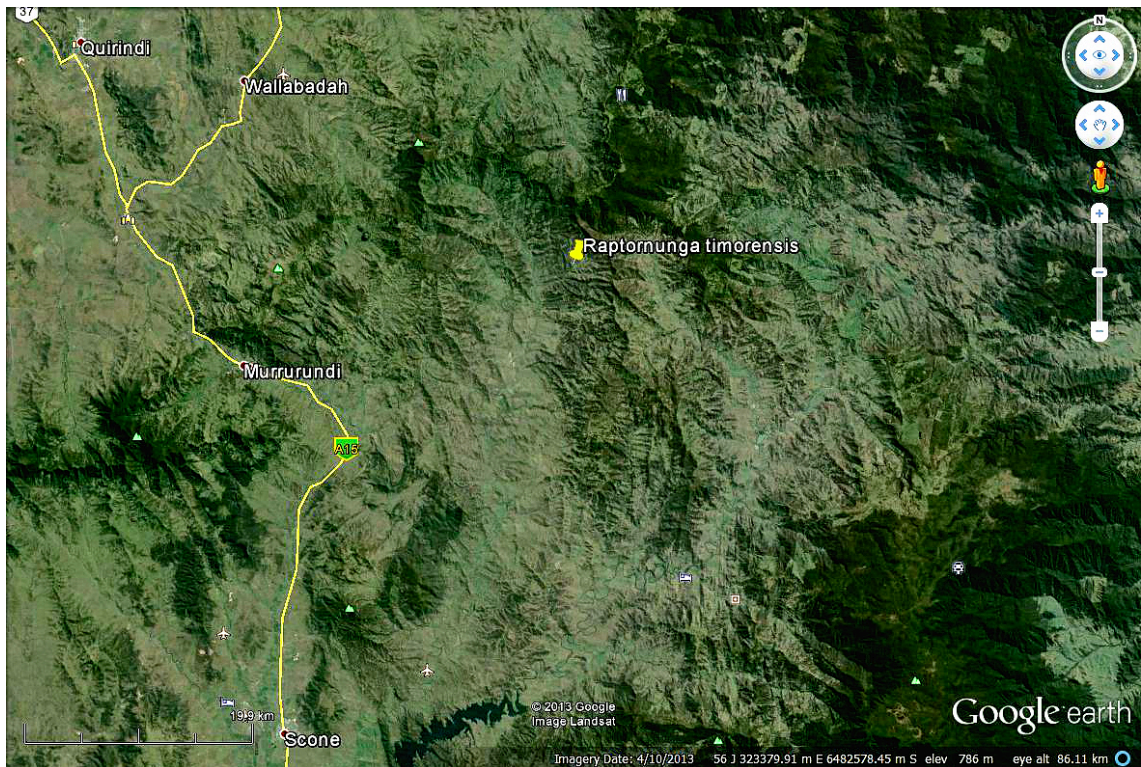
The Raptornungidae fam. n. are entirely stygobitic inhabiting caves, the hyporheic zone in gravel and cobble-bed rivers and aquifers.

Raptornunga timorensis n. sp

(Figs 3.4.2-10)

Type Locality

Timor Caves, Lake Cave, Timor, Isaacs Creek, NSW, Australia.



Map 3.4.2. Regional map showing the type locality of *Raptornunga timorensis* n. sp at Timor caves. (Google Earth 2013).

Material Examined

Type Material: Holotype: 1 male, 10.7mm, P45753, TR3013, Timor Caves, Lake Cave, Timor, Isaacs Creek, NSW, Australia, water table pool, -31.6833, 151.1333. Collector, S. Eberhard, 25/5/95, preserved in 70% ethanol. Allotype: 1 female, 10.2 mm, same as type locality.

Etymology

The species is named after the cave complex and the geographic area in which it was discovered.

Diagnosis

The diagnosis of the species is the same as the genus at this time.

Description

Based on holotype male.

Body elongate with no dorsal flexure; holotype male 10.7mm; allotype female 10.2mm; male body length to width ratio 6.68; female body length to width ration 6.72 first thoracic somite fused to head; all somites have lateral simple setae; pereon consists of seven free somites; pleon has 6 free somites and a telson; pleon subequal to peron with a pereon length to pleon ratio of 1.05; weakly sclerotised with a thin and

flexible cuticle surface covered in small pits; colouration- male and female with sexually dimorphic colour patterns; male cephalon with small round dark patches on the distolateral corner with minute, unpigmented dots in the middle which gives the impression of eyes; male pereonites 2-6 with dark, lateral patches on each side with mid clear dots on pereonites 1-3 pereonite 7 and all pleonites unpigmented; female cephalon with dark pigmented strip across the anterior margin with 1 black dot on each distolateral corner, again giving the impression of eyes; female pereonites 1-3 with patchy pigmentation across dorsal surface; female pereonites 4-7 with lateral pigmented patches; pleonite 1-3 with faint lateral and mid dark patches; pleonites 4-6 unpigmented.; pereon- pereonites similar in length and width to each other; pereonite 2-3 the narrowest and shortest; somites become slightly longer and broader posteriorly; pleon slightly flattened, somites subequal in length and width; pleonite 5 the longest and widest; no epimeral expansions but with small flanges with setae laterally on ventro-posterior margin of pleonite 1-5; pleonite 6 approximately 1/3 dorsal length of pleonite 5; pleonite 6 posterior margin deeply concave.

Telson elongate, triangular with a shallow concavity in the margin 1/3 of telson anterior to apex; margin fringed by single row of spines lateral margin without setae length to telson length ratio 0.16; telson length to width ratio of 1.3; lateral margin going from anterior to posterior consists of 8-10 simple, robust spines, 3 small dentate spines, 1 large dentate spine, 7 smaller dentate spines and 5 large, terminal dentate spines; dorsal surface with 2 subdistal large simple spines; dorsal surface with 2 submarginal lateral simple spines on each side.

Cephalon- eyes absent; cephalon sub-rectangular with triangular anterior margin; female cephalothorax divided partially into two unequal regions by transverse cephalic groove; male cephalothorax not divided by transverse cephalic groove; mandibular groove on ventro-posterior margin.

Rostrum triangular produced by a rounded extension of cephalic plate and small triangular vertex with sharply pointed apex.

Antennule peduncle tapered with three segments; basal peduncle segment tapered with a length to width ratio of 2.1; lateral margin with 2 plumose setae and 2 small, unequal simple setae; medial margin setose with 11 simple setae and 1 robust, simple setae on distomedial corner; dorsal surface with 4 simple setae in distomedial area; statocyst contains 3 small round sensory setae and opens distally through a pore; second peduncle segment elongate, rectangular, with a length to width ratio of 2.6; lateral margin with 2 simple setae and 1 plumose seta; medial margin with 4 short spines and 6 simple setae of varying lengths on distomedial corner; third peduncle segment elongate with a laterally inclined distal margin; length to width ratio of 2.37; distolateral corner with 1 robust, simple setae; medial margin with 1 small seta and 3 simple setae on distomedial surface; lateral flagellum robust with 20-22 segments; medial margin of each segment with 1-2 aesthetascs per segment; terminal segment apex with 4 simple setae and 2 aesthetascs; length of peduncle and outer flagellum length to body length ratio 0.44; medial flagellum with 7 segments; male antennules with no sensory organ on proximal margin of lateral flagellum; medial flagellum length of lateral flagellum length ratio of 0.3.

Antenna scaphocerite absent; peduncle with 4 segments; flagellum with 13-14 segments; basal peduncle

segment short, rectangular without setae with length to width ratio of 0.5; second peduncle segment elongate, rectangular with a length to width ratio of 2.0; lateral margin with 7 simple setae; medial margin with 2 small spines; third peduncle segment elongate, rectangular with a length to width ratio of 2.4; lateral margin with 2 spines and 5 short, simple setae; medial margin with 2 distomedial plumose setae and 5 short spines; fourth peduncle segment elongate, rectangular with a length to width ratio of 1.5; lateral margin with diagonal distolateral corner with 2 simple setae and 1 large, plumose setae; medial margin with 1 short spine and 3 simple setae.

Labrum round, with a flat surface which does not project anterior, and 3 vertical, concave grooves consisting of 2 short, lateral grooves and 1 longer, central groove; mandible without palp; spine row and incisor accessory process absent; incisor process forms a concave cleaving structure.

Right mandible incisor process with 8 denticles divided into 4 large lateral denticles, widely separated from 4 medial denticles; right molar process with 6 elongate, medially directed, acutely pointed denticles consisting of 1 lateral, bifid denticle, 3 equal, elongate, acutely pointed denticles and 1 large, medial, denticles with 5 small, apical spines or denticles; left mandible incisor process with 4 large denticles divided into a lateral row of 3 and a medial 4th; incisor process and molar process separated by a narrow v-shaped diastema; left molar process with 6 denticles consisting of 3 lateral, straight, equal, acutely pointed denticles, 1 mid, medially curved, acutely pointed denticles and 2 medial, short, blunt denticles.

Maxillula with two unequal endites on basal podomere; maxillule with a 1 segmented palp; palp elongate and tapered, with length to width ration of 2.2; palp with 1 large plumose spine subequal to length of lateral endite and 1 small, robust setae on the distomedial corner; lateral endite broad with two rows of spines consisting on 9 medially directed, apical spine without serrations; medial endite width to lateral endite width ratio 0.55; medial endite with 2 apical, large, hirsute spines, two small, narrow serrate spines, and 3 simple spines.

Maxilla with 2 lobes; lateral endite with 7 plumose setae and 3 simple setae; medial endite with 4 simple setae, 1 large, elongate, plumose setae and 2 small plumose setae; no medial lobe; female spermatheca forming prominent cone shaped sternal extension positioned between the coxae of thoracopod 6.

Maxilliped robust, elongate with a modified propodal spine and dactylus forming a grasping appendage capable of being folded under the cephalothorax; maxilliped coxa with 1 epipodite; coxa short, triangular with a length to width ratio of 1.0; coxa without setae; epipodite 2 segmented, tubular, spatulate, and distally pointed; basis without exopodites; basis rectangular, with length to width ratio of 1.1; medial margin with 5 simple setae increasing in size distally; no preischium; ischium elongate with length to width ratio of 2.05; dorsomedial surface with shallow groove that accommodates the merus; distolateral corner with 2 simple setae; distal half of medial margin with 7 short, robust spines; merus proximally narrow, broadening to elongate segment, with length to width ratio of 3.0; merus medial margin with 13 short robust, subequal spines, except 1 mid distal spine larger than the others; carpus robust and elongate with a length to width ratio of 2.8; carpus without setae; propodus proximally narrow, rapidly widening medially to a robust elongate segment, with length to width ratio of 1.9; ventromedial surface with shallow

groove along proximal half of segment that accommodates the carpus; setae restricted to 3 simple setae on lateroventral surface, 2 simple setae on distolateral margin and 1 simple and 2 dentate setae in diastema between dactylus and propodal spine; distomedial corner with very large, truncated and apically point spine almost as long as propodus; spine length to propodal length ratio of 0.86; propodal spine with a fringe of short fine, comb-like, setules along 0.78 length of lateral or inner margin; dactylus elongate with a length to width ratio of 2.1 forming opposing edge of grasping appendage; medial margin with 4 single sided dentate spines which increase in size distally and 1 simple, distomedial setae; apex with 1 very large, medially curved spine and 2 small simple setae on distolateral margin.

Paragnath bilobed; each lobe bears fine setules on medioventral surface and medial margin;

thoracopods- all thoracopods have seven segments; thoracopod 2 coxa with 1 multisegmented epipodites; thoracopods 3-7 coxa with 1 tubular epipodites; thoracopods 2-6 basis with 1 multisegmented exopodite; thoracopods 8 without epipodites or exopodites.

Thoracopod 2 exopodite with a 2 segmented peduncle and 7 segmented flagellum, each segment with a plumose setae on each distolateral corner; coxa a sub equilateral triangle with no setae or medial lobes; basis short with a length to width ratio of 0.56; distomedial corner with 3 long and 2 short simple setae; ischium short with a length to width ratio of 0.6; distal margin slightly inclined laterally; medial margin with 11 short, robust spines which increase in size distally; merus elongate and robust, proximally broad and narrowing distally; length to width ratio of 1.9; mid distal margin with a small triangular condyle to control lateral movement of the carpus and a short distomedial groove to accommodate the carpus; medial margin with 25 short robust simple spines; carpus length to width ration of 1.5 with a proximomedial groove that corresponds with the condyle on the merus; propodus shorter than carpus with a length to width ratio of 1.25; medial margin with 7 robust spines with length increasing distally; medial surface with 1 mid row of 8 simple setae, 1 proximal row of 2 simple setae, 1 distal row of 5 simple setae and 4 setae on the distolateral corner; dactylus very short with very large, robust, terminal spine length to propodal length 1.5, 2 shorter spines and 5 simple setae.

Thoracopods 3 coxa broad and short with a 2 segmented tubular epipodite and no setae basis with multisegmented exopodite with 9 segments; ventral margin with 2 small simple setae medially and 3 longer simple setae on distoventral corner ischium elongate with 4 simple setae on distoventral corner and 1 small simple setae on distodorsal corner; merus elongate with 3 sparsely distributed simple setae on ventral margin and 1 small simple setae on distodorsal corner; carpus elongate with 1 simple setae on the dorsal margin, 2 small simple setae on distodorsal and 1 on the distoventral corner; propodus elongate with 4 equally spaced, simple setae on ventral margin, 2 small simple setae on the dorsal margin, 1 small simple setae on distodorsal corner, and 2 small simple setae on distoventral corner; dactylus with 2 unequal, large, robust terminal spines and 1 simple setae.

Thoracopods 4 coxa broad and short with a 2 segmented, tubular epipodite and no setae; basis with multisegmented exopodite with 9 segments; ventral margin with 3 simple setae on distoventral corner; ischium elongate with 4 simple setae on distoventral corner ; merus elongate with 3 sparsely distributed

simple setae on ventral margin, 1 on the distoventral corner and 2 small simple setae on distodorsal corner; carpus elongate with 1 simple setae on the dorsal margin, 2 small simple setae on distodorsal and 1 larger spine on the subdistoventral margin. propodus elongate with 4 equally spaced, simple setae on ventral margin, 2 small simple setae on the dorsal margin and 2 small simple setae on distodorsal corner; dactylus with 2 unequal, large, robust terminal spines and 4 simple setae.

Thoracopods 5 coxa broad and short with a 2 segmented, tubular epipodite and no setae; basis with multisegmented exopodite with 9 segments; ventral margin with 1 simple setae on ventral margin and 4 simple setae on distoventral corner; ischium elongate with a row of 5 simple setae on distoventral corner; merus elongate with 4 sparsely distributed simple setae on ventral margin and 2 small, simple setae on distodorsal corner; carpus elongate with, 3 small simple setae on distoventral corner, 2 small simple setae on distoventral corner and 1 simple seta on the subdistoventral margin; propodus elongate with 4 equally spaced, simple spines on ventral margin, and 5 small, simple setae on the dorsal margin; dactylus with 2 unequal, large, robust terminal spines and 2 simple setae.

Thoracopods 6 coxa broad and short with a 2 segmented, tubular epipodite and no setae; basis with multisegmented exopodite with 8 segments; ventral margin with 1 simple setae on ventral margin and 2 simple setae on distoventral corner; ischium elongate with a row of 4 simple setae on distoventral corner and 2 simple setae on distodorsal margin; merus elongate with 4 sparsely distributed simple setae on ventral margin and 2 small, simple setae on dorsal margin; carpus elongate with 1 small simple setae on distoventral corner and 1 simple seta on the ventral margin; propodus elongate with 4 equally spaced, simple spines on dorsal margin; dactylus with 2 unequal, large, robust terminal spines and 1 simple setae.

Thoracopods 7 coxa broad and short with a 2 segmented, tubular epipodite and no setae; basis without exopodite; ventral margin with 2 mid, simple setae and a row of 5 robust, simple setae on the subdistal margin; ischium elongate with a row of 5 simple setae below the distoventral margin and 2 simple setae on distodorsal margin; merus elongate with 4 sparsely distributed simple spines on ventral margin and 2 small, simple spines on distodorsal corner and 1 small spine on mid dorsal margin; carpus elongate with 2 small simple spines on distoventral corner and 1 simple spine on the distoventral corner and 1 small seta on the mid dorsal margin; propodus elongate with 4 equally spaced, simple spines on dorsal margin, 1 simple seta in each distal corner and 1 small seta on the dorsal margin; dactylus with 2 unequal, large, robust terminal spines and 1 simple setae; thoracopods 8 coxa broad and short without epipodite (not illustrated); basis without exopodite; ventral margin with 1 mid, simple setae and 2 robust, simple setae on the subdistal margin; ischium elongate with 2 simple setae below the distoventral margin and 2 simple setae on dorsal margin; merus elongate with 1 robust simple spine distal on ventral margin and 2 small, simple spines on distodorsal corner; carpus elongate with 3 small simple spines on distoventral corner and 2 simple spine on the distoventral corner; propodus elongate with 4 equally spaced, simple spines on dorsal margin and 2 simple seta on the distodorsal corner; dactylus with 2 unequal, large, robust terminal spines and 1 simple setae.

Pleon- pleonite 6 $\frac{1}{3}$ length of pleonite ; pleonite 6 posterior margin deeply concave with a row of 13

elongate spines alternating in length; the longest spines length to telson length ratio 0.9; the smaller spines length to telson length ratio 0.45; subdistal margin with mid row of 3 short spines; 1 small simple seta in each proximolateral surface and 3 small setae on mid lateral margin; anus opens at the posterior limit of pleonite 6; pleopods 1-5 in both sexes without exopodites; pleonites 1-4 each with one pair of pleopods; pleonites 5 in both sexes without a pleopod; pleonites 1-4 in females a 1 segment appendage with 2 simple setae.

Pleopods 1 and 2 with 1 pair of modified endopodites to form a petasma; pleonites 3-5 in males a 1 segment appendage with two simple setae; pleopod 1 in males at rest, the two endopodites of pleopod 1 are held obliquely with their medial surfaces joined and directed anteriorly between bases of thoracopod 8; at rest, the two endopodites of pleopod 2 are held within the shallow depression formed by pleopod 1. Male pleopod 1 consists of a short broad coxa and a single spatulate-shaped segment; endopodite length to width ratio of 3.52; medial margins folded medial to form a medial groove running the length of the segment opening subdistodorsally; medial surfaces adjacent to the groove covered in fine setules and a round distomedial patch of coupling setae; distodorsal margin with 3 short, pointed proximally directed spines.

Pleopod 2 in males- pleopod 2 endopodite 2 segmented and styliform coxal plate flat with 2 elongate and 2 short setae lateral to endopodite with basal segment rising directly from ventral surface; basal segment very elongated with a length to width ration of 4.8; round patch of coupling hooks on the subdistomedial corner; distal segment elongated, truncated with an acutely pointed syringe-like apex; apex consists of an internal medial groove and a small subdistal medial pointed projection; distal half of ventral surface and margin with many rows of minute setules.

Uropod rami elongate and subtubular; uropod lateral rami 2 segmented; uropod medial rami 1 segmented; uropod lateral rami length to telson length ratio of 1.85; protopod and rami dorsal surface flattened; protopod and rami ventral surfaces rounded; medial ramus slightly shorter than lateral ramus; protopod length to total length of lateral rami 0.46 protopod elongate, length to width ratio 3.7; protopod lateral margin with 14 short, robust, simple spines; distolateral corner with 4 simple setae; distal margin with 2 short distal spines; protopod medial margin concave with the ventromedial margin with 3 robust spines increasing size distally; lateral rami with 2 subequal segmented rami; proximal segment length to width ratio of 6.7; lateral margin with 11 slender simple setae of variable lengths; dorsal surface with 2 robust, simple spines; medial margin with 9 plumosetae setae of subequal lengths; distal segment length to width ratio 5.3; lateral margin with 11 simple setae and 3 plumosetae setae of increasing lengths distally; medial margin with 4 subequal plumosetae; apex with 4 elongate plumosetae; medial rami 1 segmented; medial rami very elongate with a length to width ratio of 8.75; lateral margin with 9 short, simple spines of variable lengths and 2 subequal, distal, plumose setae; dorsal surface with 2 lateral, elongate, slender, simple setae; medial margin with 21 short, robust, subequal, dentate spines, 3 larger spines interspersed between every 3-5 short setae and 2 distal plumosetae; apex with 3 elongate plumosetae.

Habitat

This species was collected from deep pools with the caves.

Distribution

This species is endemic to Timor Caves.

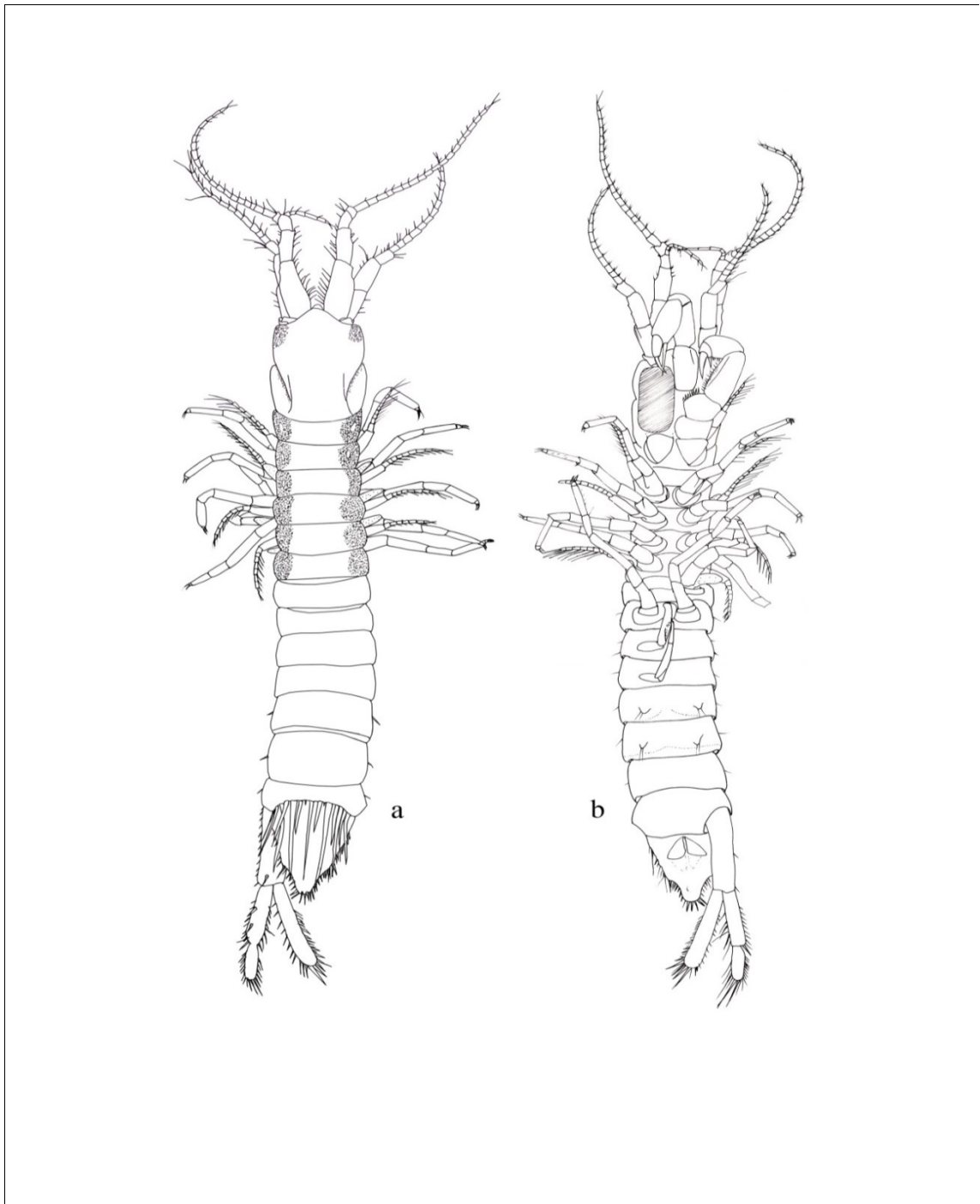


Figure 3.4.2. *Raptornunga timorensis*. Holotype male 10.7mm (all drawings are male except those indicated). Body: a- dorsal view stippling represents colour pattern); b- ventral view (shaded area is where the mouthparts were removed).

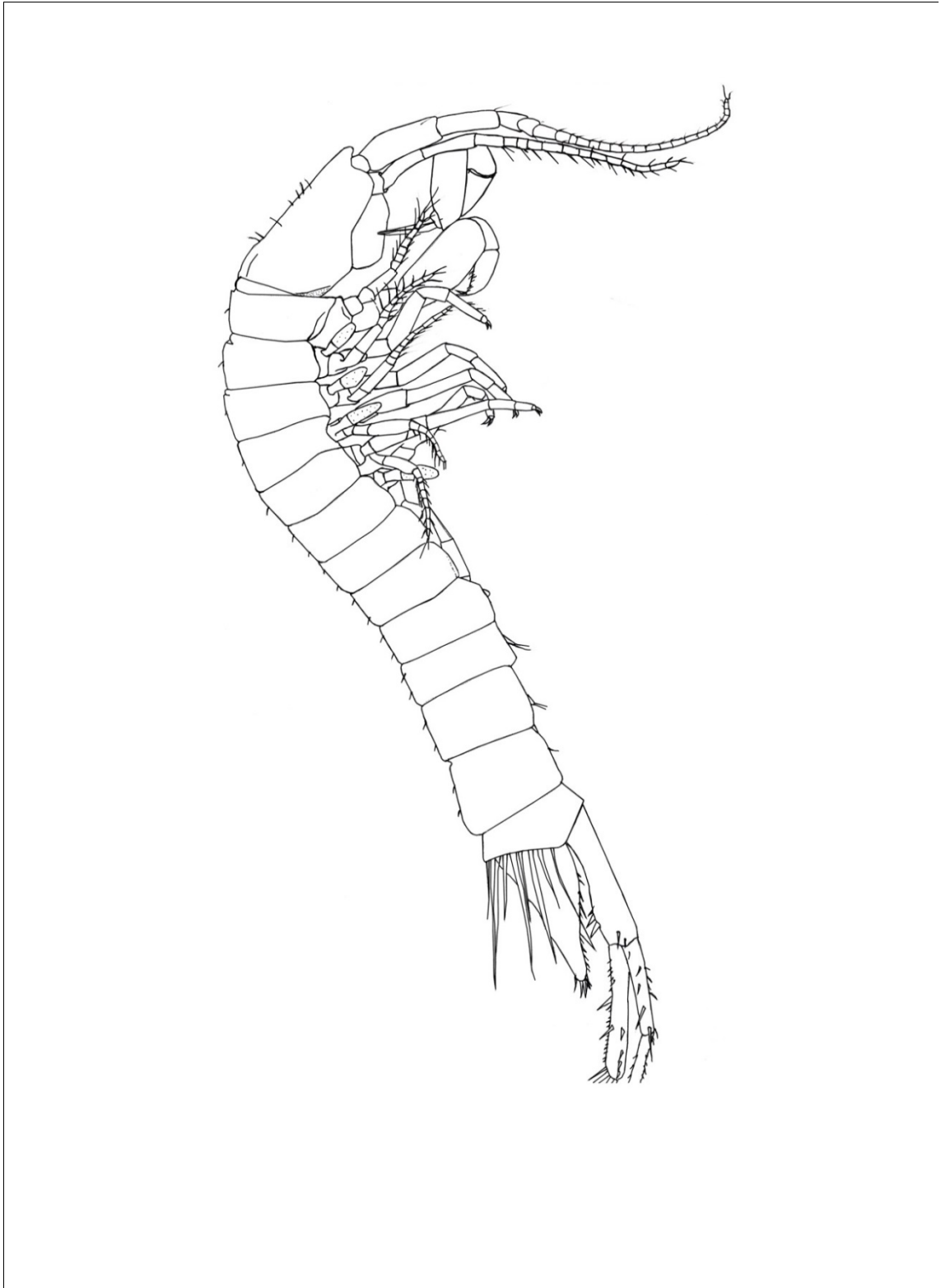


Figure 3.4.3. *Raptornunga timorensis*. Holotype male 10.7mm. Body lateral view.

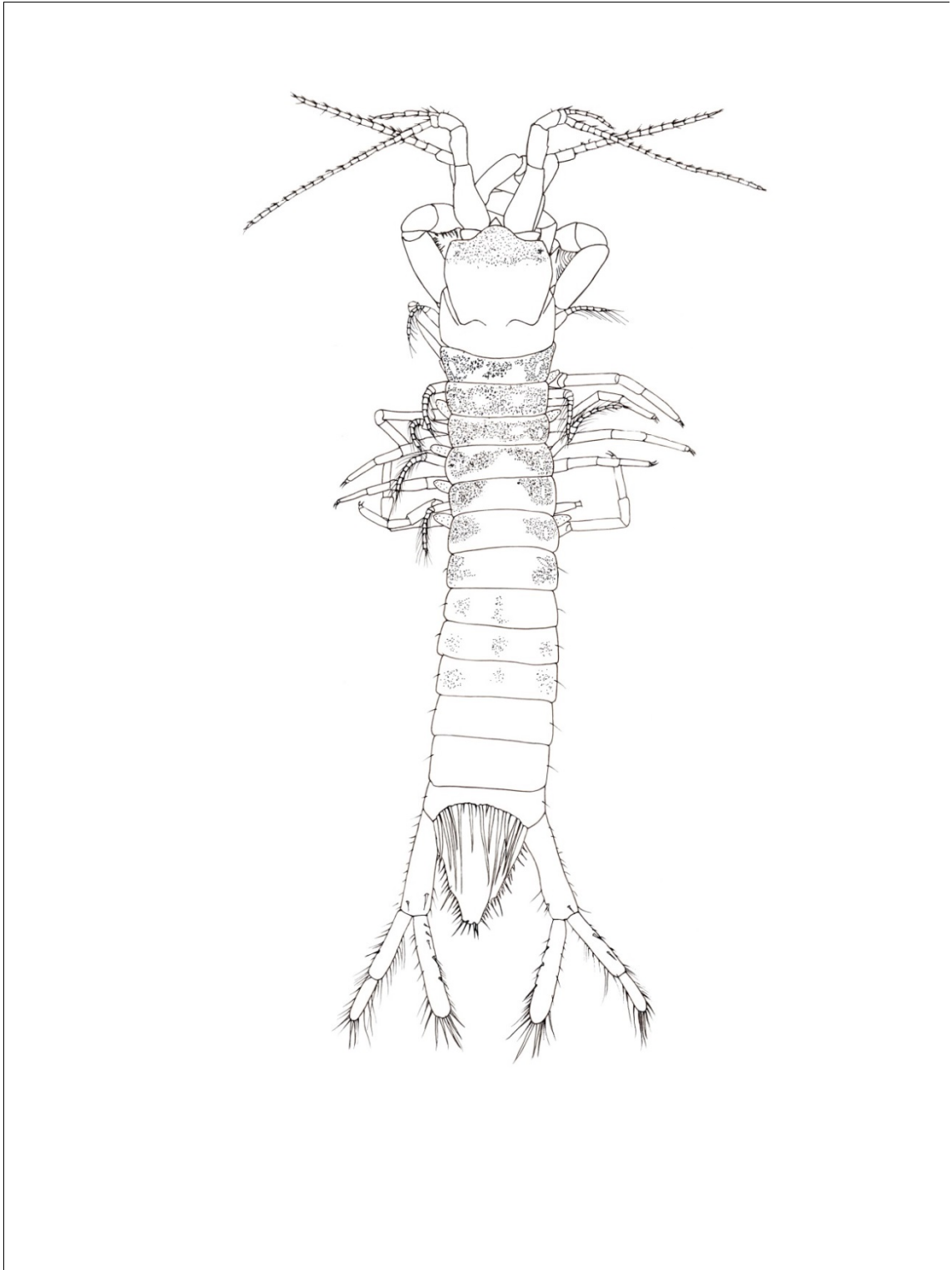


Figure 3.4.4. *Raptornunga timorensis*. Allotype female 10.2mm. Body dorsal view.

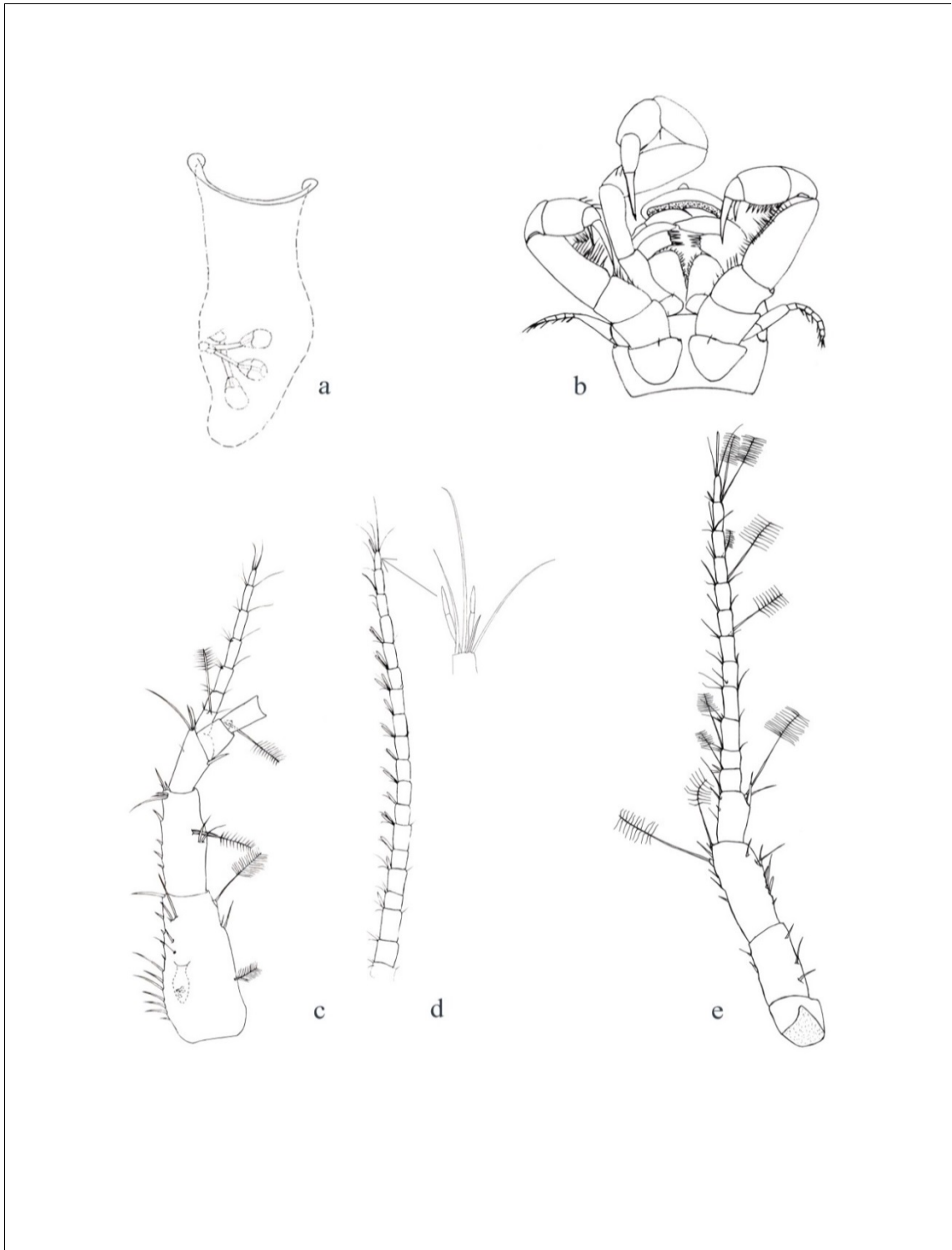


Figure 3.4.5. *Raptornunga timorensis*. Holotype male 10.7mm. Antennae and mouthparts: a- antennula statocyst; b- cephalon, ventral view of mouthparts; c- A1; d- A1 lateral flagellum with close-up of terminal segment; e- A2..

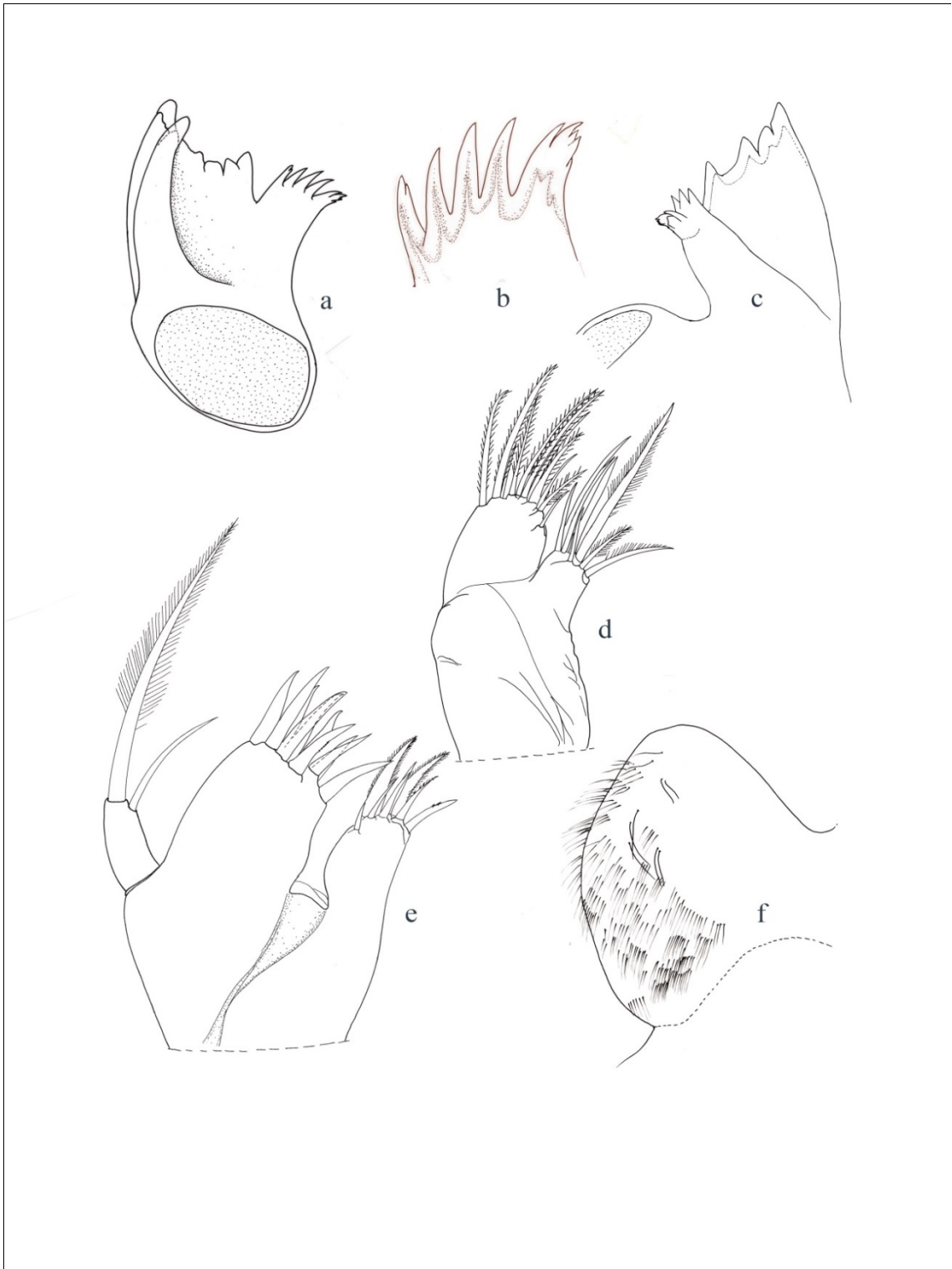


Figure 3.4.6. *Raptornunga timorensis*. Holotype male 10.7mm. Mouthparts: a- left mandible; b- left mandible molar process; c- right mandible; d- Mx 2; e- Mx1; f- paragnath.

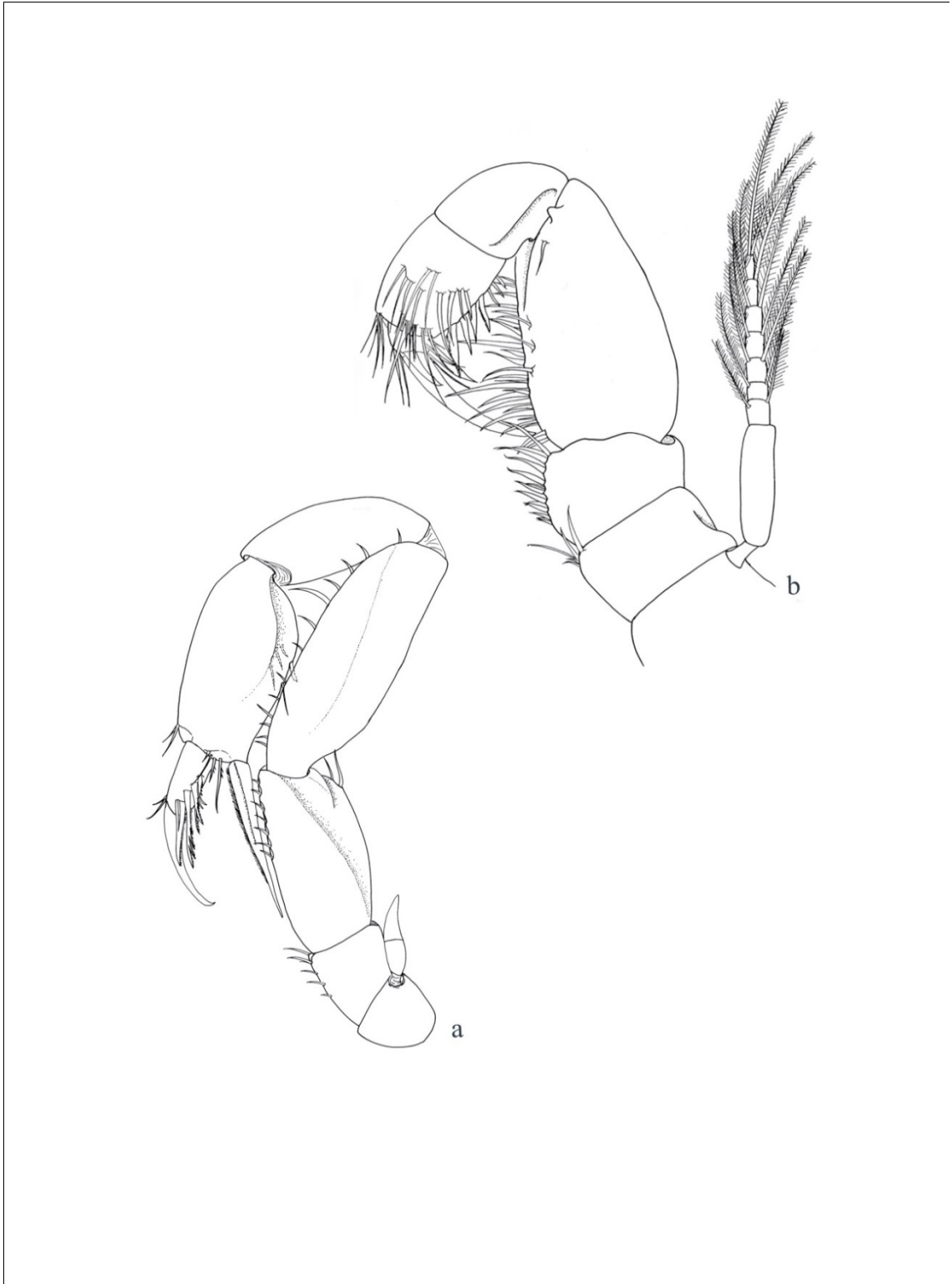


Figure 3.4.7. *Raptornunga timorensis*. Holotype male 10.7mm. Thoracopods a: a- Mxp; b- Th 2.

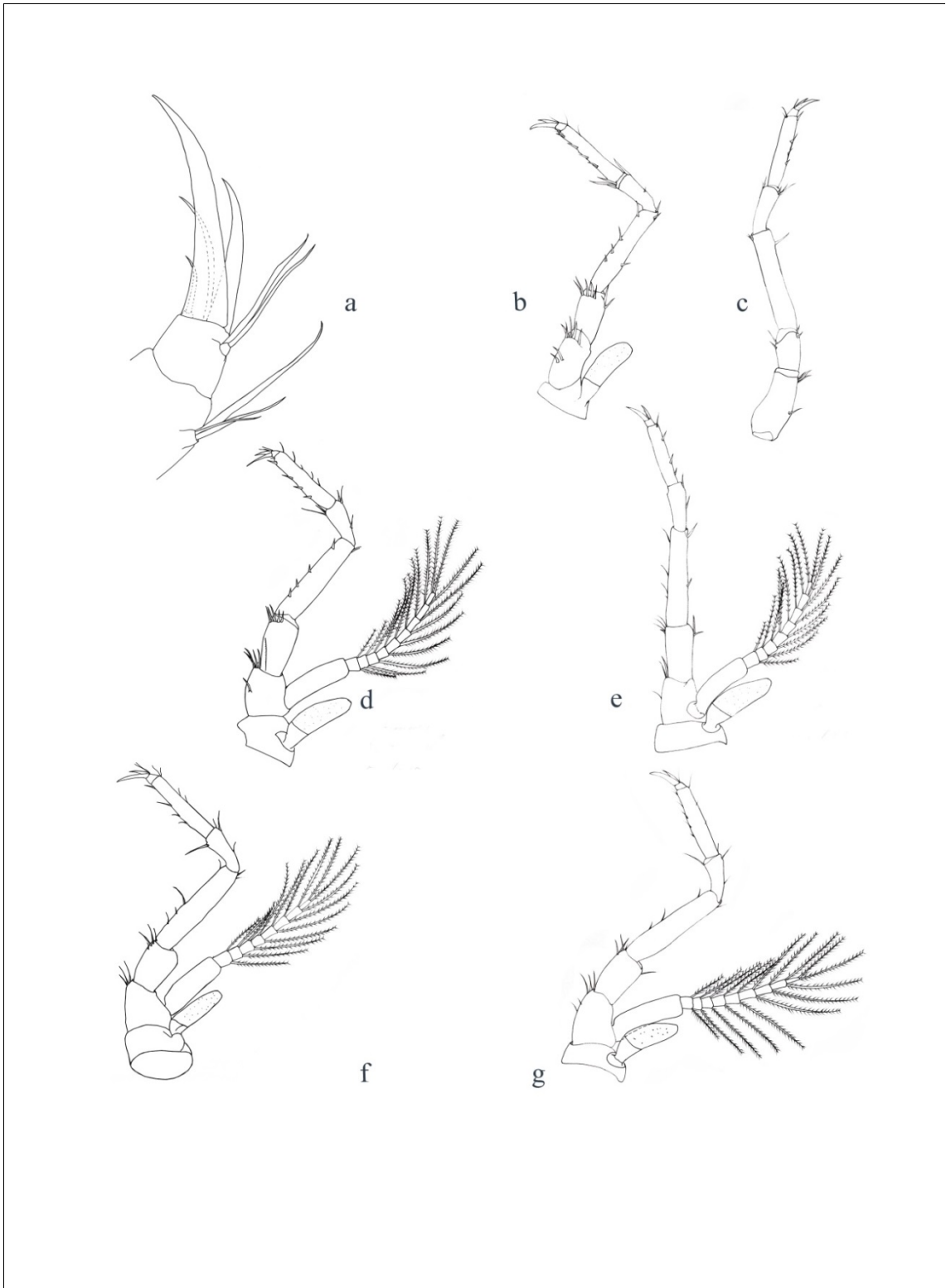


Figure 3.4.8. *Raptornunga timorensis*. Holotype male 10.7mm. Thoracopods b: a- close-up of dactylus of Th 4; b- Th 7; c- Th 8; d- Th 5; e- Th 6; f- Th 4; g- Th 3.

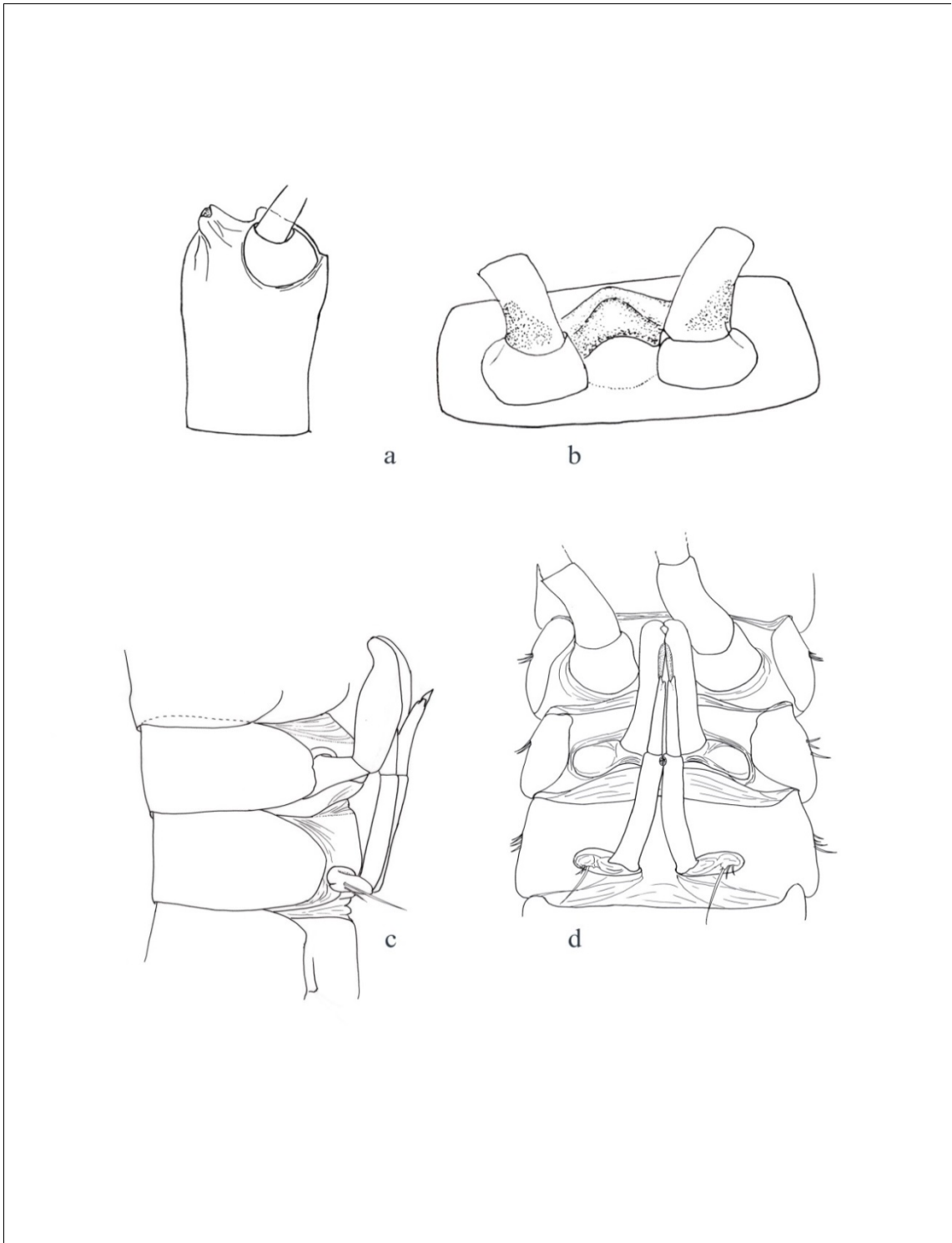


Figure 3.4.9. *Raptornunga timorensis*. Holotype male 10.7mm. Genitalia: a- female spermatheca, lateral view; b- female spermatheca, ventral view; c- petasma, lateral view; d- petasma, ventral view.

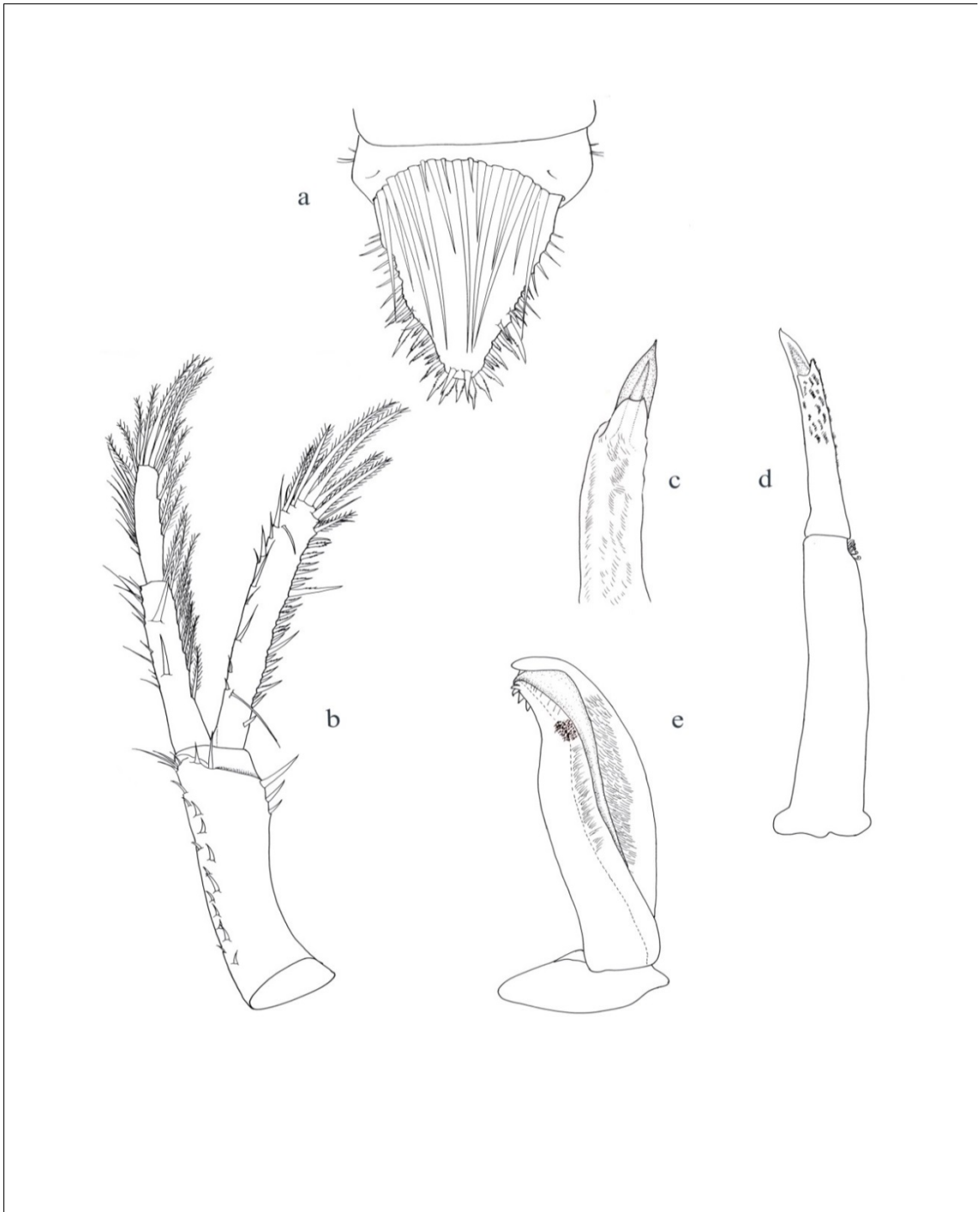


Figure 3.4.10. *Raptornunga timorensis*. Holotype male 10.7mm. Telson and petasma: a- telson, dorsal view; b- uropod; c- P1 2 distal tip; d- P12; e- P11.

Genus *Phreatonunga* n. gen

Type species

Phreatonunga neverensis n. sp

Etymology

The name is a combination of 'phreatos', meaning a pit or well, to describe the obligate groundwater habitat occupied by this genus and the similarity of the resemblance to the Koonungidae, particularly the triangular telson.

Diagnosis

Female cephalothorax not divided partially into two unequal regions by transverse cephalic groove; paragnath bilobed with notch on medial margin; males pleopods 3-5 without pleopods; female pleomeres 1-5 without pleopods; male pleopod 1 consists of medial margins folded medially to form a medial groove running the length of the segment opening distolaterally; distodorsal margin with 3 short, bluntly pointed, horizontally orientated, proximally directed spines; male pleopod 2 endopodite 2 segmented and styliform; coxal plate flat without setae; distal segment elongated, truncated with a singly, acutely pointed syringe-like apex with an external mediodistal groove without a small subdistal medial pointed projection; pleonite 6 approximately 1/3-1/2 dorsal length of pleonite 5; telson sharply triangular, elongate with minor or lacking a concavity subdistal to apex; telson dorsal surface with no subdistal large simple spines; dorsal surface with no submarginal lateral simple spines on each side; anal lobes circular.

Species Composition

Phreatonunga neverensis, n. sp.

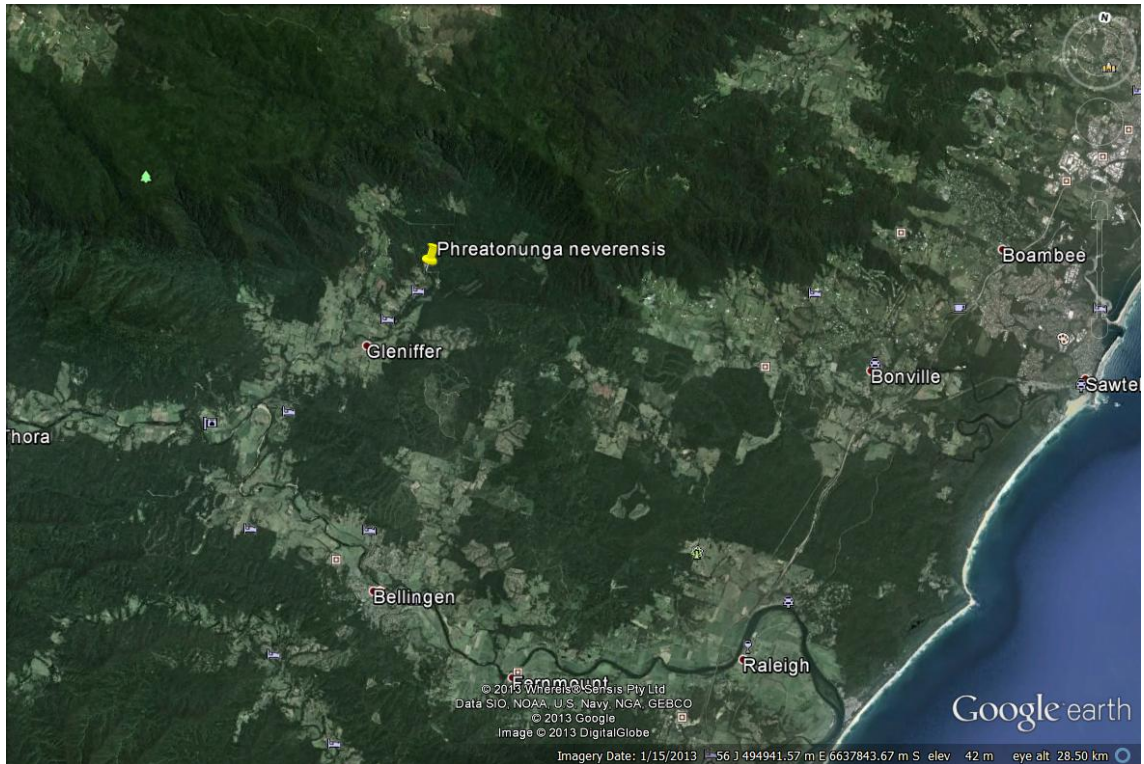
Phreatonunga boultoni, n. sp.

Phreatonunga neverensis n. sp

(Figs. 3.4.11-16)

Type Locality

Tributary of the Never Never River at Tallowood Bar, hyporheic zone, near Gleniffer, upstream of Bellingen, NSW, Australia.



Map 3.4.3. Regional map showing the type locality on the Never Never River near Bellingen. (Google Earth 2013).

Material Examined

Type Material

Holotype. 1 male, Never Never River, at Tallowood Bar, hyporheic zone, Bellingen, NSW. -30.3678, 152.8982. Collector -Boulton, A and Cord, J. June 1999.

Paratypes: type locality: 1 male, 3 females, 1 juvenile Never Never River, at Tallowood Bar, hyporheic, Bellingen, NSW. -30.3678, 152.8982. Col -Boulton, A and Cord, J. June 1999; 3 males. Never Never River, at 90cm depth, hyporheic, Bellingen, NSW, -30.3678, 152.8982, Col - P. Jarman, 14 August 1998; 3 males, NN54, Never Never River, hyporheic, Bellingen, NSW, -30.3678, 152.8982, Col - Boulton, A and Lisle, P. 30 June 1995; 1 female, NN24. Never Never River, hyporheic, Bellingen, NSW. -30.3678, 152.8982, Col - Boulton, A and Lisle, P. 23 March 2001; 1 juvenile, Never Never 14, Never Never River, hyporheic, Bellingen, NSW, -30.3678, 152.8982, Col - Boulton, A and Lisle, P, 30 June 1995; 3 juv. NN36. Never Never River, hyporheic, Bellingen, NSW. -30.3678, 152.8982, Col - Boulton, A and Lisle, P. March 2001; 1 male, #303re, Never Never River, hyporheic, Bellingen, NSW, -30.3678, 152.8982, Col - Boulton, A and Lisle, P. March 2001; 2 males; Never Never River 2, Never Never River, hyporheic, Bellingen, NSW, -30.3678, 152.8982, Col - Boulton, A and Lisle, P, 30 June 1995; P56265, 1 juvenile; Never Never River, hyporheic, Bellingen, NSW. -30.3678, 152.8982; Col - Boulton, A and Lisle, P, 30 June 1995.

Etymology

Named after the type locality, the Never Never River in which the type specimens were collected.

Diagnosis

Male and female without colour patterns; mandible right incisor process medial, terminal single denticle; right molar process with 5 subequal, elongate, medially directed, acutely pointed denticles; maxillula medial endite with 2 apical, large, hirsute spines, and 3 simple spines. maxillula palp with 1 large plumose spine subequal to length of lateral endite with setules only on medial margin and 2 large, robust, simple setae on the distomedial corner; maxillula medial endite with 2 apical, large, hirsute spines, and 3 simple spines; maxilla lateral endite with 1 simple, spine on mid lateral margin, 10 apical, plumose setae and 1 simple setae on distomedial margin. Maxilla medial endite medial margin with 3 sparsely plumose setae and 2 simple setae; maxilliped merus distal margin with large, acutely pointed, thorn like condyle controlling the lateral articulation of the carpus; male pleopod 1 round distomedial patch of coupling setae; male pleopod 2 endopodite 3 segmented and styliform with distal tip curved dorsally distal segment elongated with an acutely pointed apex; apex consists of an internal medial groove and no subdistal medial pointed projection; telson elongate, triangular with a shallow concavity in the margin 1/3 of telson anterior to apex; dorsal surface with 2 subdistal large simple spines; dorsal surface with 5 submarginal lateral simple spines on each side.

Description

Based on holotype male.

Body elongate with no dorsal flexure; largest male 8.7mm; largest female 11.7mm; male body length to width ratio 7.1; first thoracic somite fused to head; all somites have lateral simple setae; pereon consists of seven free somites; pleon has 6 free somites and a telson; pleon subequal to pereon with a pereon length to pleon length ratio of 1.04; weakly sclerotised with a thin and flexible cuticle; cuticle surface covered in small pits; colouration- male and female without colour patterns; pereon- pereonites subequal in length and width; pereonites 2-4 the narrowest and shortest; pereonites become slightly longer and broader posteriorly pleon; pleon slightly flattened, somites subequal in length and width; pleonites become slightly longer and broader posteriorly; pleonite 4-5 the longest and widest; no epimeral expansions but with small flanges with setae laterally on ventro-posterior margin of pleonite 1-5.

Cephalon sub-rectangular with triangular anterior margin; male cephalothorax not divided by transverse cephalic groove; mandibular groove on ventro-posterior margin.

Rostrum triangular produced by a rounded extension of cephalic plate and small triangular vertex with slightly round apex; eyes absent.

Antennule peduncle tapered with three segments; basal peduncle segment tapered with a length to width ratio of 1.87; lateral margin with a subdistal tuft of 3 plumose setae and 1 larger plumosetae below distal corner; medial margin setose with 8 simple setae and 1 robust, simple setae on distomedial corner; dorsal

surface with 3 simple setae in distomedial area; statocyst contains 2 small round sensory setae and opens distally through a pore.; second peduncle segment elongate, rectangular, with a length to width ratio of 1.6; lateral margin with 2 tufts of 5 and 3 simple setae; medial margin with 5 short spines along margin and 5 simple setae of varying lengths and a plumose setae on distomedial corner; third peduncle segment elongate with a laterally inclined distal margin; length to width ratio of 1.8; distolateral corner with 1 robust, simple setae; medial margin with 8 simple seta and 1 small, simple setae on distomedial surface; lateral flagellum robust with 22-23 segments; medial margin of each segment with 1-2 aesthetascs per segment ; terminal segment apex with 4 simple setae and no aesthetascs; length of peduncle and outer flagellum length to body length ratio 0.45; medial flagellum with 6 segments; male antennules with no sensory organ on proximal margin of lateral flagellum; medial flagellum length to lateral flagellum length ratio of 0.25.

Antenna scaphocerite absent; peduncle with four segments; flagellum with 13-14 segments; basal peduncle segment short, rectangular without setae with length to width ratio of 0.47; second peduncle segment elongate, rectangular with a length to width ratio of 2.2; lateral margin with 2 simple setae; medial margin without spines; third peduncle segment elongate, rectangular with a length to width ratio of 2.3; lateral margin with 2 spines and 5 short, simple setae; medial margin with 2 distomedial plumose setae and 5 short spines; fourth peduncle segment elongate, rectangular with a length to width ratio of 1.8; lateral margin with diagonal distolateral corner with 2 simple setae and 1 large, plumose setae; medial margin with 3 simple setae.

Labrum round, with a flat surface which does not project anterior, and 3 vertical, concave grooves consisting of 2 short, lateral grooves and 1 longer, central groove.

Mandible without palp; spine row and incisor accessory process absent; incisor process forms a concave cleaving structure; right mandible incisor process with 8 denticles divided into 3 large lateral denticles, widely separated from 4 small, medial denticles and 1 larger, terminal denticles; right molar process with 5 elongate, medially directed, subequal, acutely pointed denticles ; left mandible incisor process with 4 large denticles divided into a lateral row of 3 subequal, triangular and a large medial, triangular 4th denticles; incisor process and molar process separated by a narrow v-shaped diastema; left molar process with 7 denticles divided into 2 rows; dorsal row of 4 denticles, 1 mid, medially curved, acutely pointed denticles and 2 middle, short, blunt denticles and 1 larger, blunt lateral denticles; ventral row of 3 subequal, pointed denticles.

Maxillula- two unequal endites on basal podomere; maxillule with a 1 segmented palp; palp elongate and tapered, with length to width ratio of 2.5; palp with 1 large plumose spine subequal to length of lateral endite with setules only on medial margin and 2 large, robust, simple setae on the distomedial corner; lateral endite length to width ratio 2.6; lateral endite broad with two rows of spines consisting of 9 medially directed, apical spine without serrations; medial endite width to lateral endite width ratio 0.62; medial endite length to width ratio, 2.5; medial endite with 2 apical, large, hirsute spines, and 3 simple spines. Maxilla with 2 lobes; lateral endite with 1 simple, spine on mid lateral margin, 10 apical, plumose setae and

1 simple setae on distomedial margin; medial endite apical margin with 4 simple setae, 1 large, elongate, plumose setae and 2 small plumose setae; medial endite medial margin with 3 sparsely plumose setae and 2 simple setae; no medial lobe.

Female spermatheca forming prominent cone shaped sternal extension positioned between the coxa of thoracopod 6.

Maxilliped robust, elongate with a modified propodal spine and dactylus forming a grasping appendage capable of being folded under the cephalothorax; maxilliped coxa with 1 epipodite; coxa short, triangular with a length to width ratio of 1.0; coxa without setae; epipodite 2 segmented, tubular, spatulate, and distally pointed ; basis without exopodites; basis rectangular, with length to width ratio of 1.5 ; medial margin with 5 simple setae increasing in size distally and 3 simple setae on the medial side of the distal margin; no preischium; ischium elongate with length to width ratio of 1.4; dorsomedial surface with shallow groove that accommodates the merus ; distolateral corner with 4 simple setae and small spine; distal medial margin with 3 short, robust spines and 5 simple setae of variable sizes scattered along margin; medial surface with 3 small spines in proximal half; merus proximally narrow, broadening to elongate segment, with length to width ratio of 3.04; merus medial margin with 12 short, robust, subequal spines , without a mid-distal spine larger than the others; merus distal margin with large, acutely pointed, thorn like condyle controlling the lateral articulation of the carpus; carpus robust and elongate with a length to width ratio of 2.1; carpus with 2 short, penicillate setae on the distomedial margin; propodus proximally narrow, rapidly widening medially to a robust elongate segment, with length to width ratio of 2.0; ventromedial surface with shallow groove along proximal half of segment that accommodates the carpus; setae restricted to 1 simple setae on lateroventral surface, 1 large and 1 small simple setae on distolateral margin and 1 plumose setae in diastema between dactylus and propodal spine; distomedial corner with very large, truncated and apically point spine almost as long as propodus; spine length to propodal length ratio of 0.92; propodal spine without a fringe of short fine, comb-like, setules along lateral or inner margin; dactylus elongate with a length to width ratio of 2.3 forming opposing edge of grasping appendage; medial margin with 4 single sided, subequal, dentate spines ; apex with 1 very large, medially curved spine and 2 small simple setae on distolateral margin.

Paragnath (not illustrated) bilobed; each lobe bears fine setules on medioventral surface and medial margin.

Thoracopod 2 coxa with 1 multisegmented epipodite; thorcapods 3-7 coxa with 1 tubular epipodite; thorcapods 2-6 basis with 1 multisegmented exopodite; thorcapods 8 without epipodites or exopodites; thoracopod 2 epipodite with a 2 segmented peduncle and 8 segmented flagellum, each segment with a plumose setae on each distolateral corner; coxa ovoid with a small triangular condyle on mid distal margin and no setae or medial lobes; basis short with a length to width ratio of 0.6; distomedial corner with 2 short simple setae; ischium short with a length to width ratio of 0.76; distal margin slightly inclined laterally.; medial margin with 16 short, robust spines which increase in size distally; merus elongate and robust, proximally broad and narrowing distally; length to width ratio of 1.8; mid distal margin with a small

triangular condyle to control lateral movement of the carpus and a short distomedial groove to accommodate the carpus; medial margin with 31 short robust simple spines of variable length; carpus length to width ratio of 1.05 with a proximomedial groove that corresponds with the condyle on the merus and no setae; propodus subequal to carpus with a length to width ratio of 1.25; medial margin with 4 robust spines with length increasing distally and 5 slender simple setae; medial surface without row of setae, but 3 setae on the mid medial margin; lateral margin with 4 simple setae on distolateral corner; dactylus very short with very large, robust, terminal spine length to propodal length 1.1, 2 shorter spines and 5 simple setae.

Thoracopods 3 coxa broad and short with a 2 segmented tubular epipodite and no setae; basis with multisegmented exopodite with 9 segments; ventral margin with 2 small simple setae medially and 3 longer simple setae on distoventral corner; ischium elongate with 4 simple setae on distoventral corner and 1 small simple setae on distodorsal corner; merus elongate with 3 sparsely distributed simple setae on ventral margin and 1 small simple setae on distodorsal corner; carpus elongate with no setae on the dorsal margin, 3 small simple setae on distodorsal and 2 larger spines on the subdistoventral corner; propodus elongate with 7 equally spaced, simple setae on ventral margin, 2 small simple setae on the dorsal margin and 3 small simple setae on distodorsal corner; dactylus with 1 large, robust terminal spine, 2 small, slender spines and 2 simple setae.

Thoracopods 4 coxa broad and short with a 2 segmented, tubular epipodite and no setae; basis with multisegmented exopodite with 10 segments; ventral margin with row of 4 simple setae below distoventral corner; ischium elongate with 5 simple setae on distoventral corner and 1 simple seta on the distolateral corner; merus elongate with 4 sparsely distributed simple setae on ventral margin, 1 on the distolateral corner; carpus elongate with no setae on the dorsal margin, 2 small simple setae on distodorsal and 2 larger spines on the subdistoventral corner; propodus and dactylus missing;

Thoracopods 5 coxa broad and short with a 2 segmented, tubular epipodite and no setae; basis with multisegmented exopodite with 10 segments; ventral margin with no setae on distal ventral margin and 7 simple setae on distoventral corner; ischium elongate with a row of 6 simple setae on distoventral corner and 2 simple setae on the distolateral corner; merus elongate with 4 sparsely distributed simple setae on ventral margin and 2 small, simple setae on distodorsal corner; carpus elongate with 2 small simple setae on distoventral corner, 2 small simple setae on distoventral corner and no seta on the subdistoventral margin; propodus elongate with 5 equally spaced, simple spines on ventral margin, and 2 small, simple setae on the dorsal margin; dactylus with 3 unequal, large, robust terminal spines, 2 simple setae.

Thoracopods 6 coxa broad and short with a 2 segmented, tubular epipodite and no setae; basis with multisegmented exopodite with 9 segments; ventral margin with 2 simple setae on ventral margin and a row 4 simple setae on distoventral corner; ischium elongate with a row of 4 simple setae on distoventral corner and 2 simple setae on distodorsal margin; merus elongate with 3 sparsely distributed simple setae on ventral margin and 2 small, simple setae on distolateral corner; carpus elongate with 2 simple setae on distoventral corner, 2 simple setae on distolateral corner and no seta on the ventral margin; propodus

elongate with 4 equally spaced, simple spines on ventral margin and 1 simple setae on the mid dorsal margin and 2 slender, simple setae on the distolateral corner; dactylus with 3 unequal, large, robust terminal spines and 2 simple seta on each distal corner.

Thoracopods 7 coxa broad and short with a 2 segmented, tubular epipodite and no setae; basis without exopodite; ventral margin with 1 mid, simple setae and a row of 7 robust, simple setae on the subdistal margin; ischium elongate with a row of 5 simple setae below the distoventral margin and 2 simple setae on distodorsal margin; merus elongate with 5 sparsely distributed simple spines on ventral margin and 2 small, simple spines on distodorsal corner and no spine on mid dorsal margin; carpus elongate with 3 small simple spines on distoventral corner and 2 simple spine on the distoventral corner and no seta on the mid dorsal margin; propodus elongate with 6 equally spaced, simple spines on dorsal margin, 1 simple setae on the distolateral corner and 1 small seta on the dorsal margin; dactylus with 3 unequal, large, robust terminal spines and 1 simple setae.

Thoracopods 8 coxa broad and short without epipodite; basis without exopodite; ventral margin with 1 simple setae on the distomedial corner and 2 simple setae on the distal dorsal margin; ischium elongate with 2 simple setae below the distoventral margin and 2 simple setae on dorsal margin; merus elongate with no robust simple spine distal on ventral margin and 2 small, simple spines on distodorsal corner and 8 short, robust spines ventral on the lateral surface; carpus elongate with 3 small simple spines on distoventral corner and 3 simple spine on the distoventral corner and 1 short spine ventral on the lateral surface; propodus elongate with 4 equally spaced, simple spines on dorsal margin and 2 simple seta on the distodorsal corner; dactylus with 2 unequal, large, robust terminal spines and 1 simple setae;.

Pleon- pleonite 6 $1\frac{1}{2}$ length of pleonite; pleonite 6 posterior margin deeply concave with a row of 14 elongate spines alternating in length; the longest spines equal to length of telson with a length to telson length ratio 1.0; the smaller spines length to telson length ratio 0.34; subdistal margin without mid row of short spines; 1 small simple seta in each proximolateral surface and 2 small setae on mid lateral margin; anus opens at the posterior limit of pleonite 6; pleopods- pleopods 1-5 in both sexes without exopodites (not illustrated) pleonites 1-4 each with one pair of pleopods; pleonites 5 in both sexes without a pleopod; pleonites 1-4 in females a 1 segment appendage with 2 simple setae.

Male pleopods 1 and 2 with 1 pair of modified endopodites to form a petasma; pleonites 3-5 in males a 1 segment appendage with 2 simple setae.

Pleopod 1 in males at rest, the two endopodites of pleopod 1 are held obliquely with their medial surfaces joined and directed anteriorly between bases of thoracopod 8 and held within the shallow depression formed by pleopod 1; pleopod 1 consists of a short broad coxa and a spatulate-shaped segment; endopodite length to width ratio of 3.9; medial margins folded medial to form a medial groove running the length of the segment opening distally; medial surfaces adjacent to the groove covered in fine setules and groove containing a round distomedial patch of coupling setae; lateral surface covered $\frac{3}{4}$ in fine setules; distodorsal margin forms a concavity with 5 short, blunt proximally directed spines.

Pleopod 2 in males- pleopod 2 endopodite 3 segmented and styliform with distal tip curved dorsally; coxal

plate extended with 2 elongate and 2 short setae lateral to endopodite with basal segment rising directly from ventral surface; basal segment very elongated with a length to width ratio of 5.0; round patch of coupling hooks on the subdistomedial corner; medial segment elongated, truncated with a length to width ratio of 2.76; medial segment with a row of fine setules forming a ridge on the distomedial surface; distal segment elongated with an acutely pointed apex; apex consists of an internal medial groove and no subdistal medial pointed projection.

Uropod rami elongate and subtubular; uropod lateral rami 2 segmented; uropod medial rami 1 segmented; uropod lateral rami length to telson length ratio of 1.65; protopod and rami dorsal surface flattened; protopod and rami ventral surfaces rounded; medial ramus slightly shorter than lateral ramus; protopod length to total length of lateral rami 0.63; protopod elongate, length to width ratio 2.3; protopod lateral margin with 11 short, robust, simple spines; distolateral corner without simple setae; distal margin without distal spines; protopod medial margin straight with 2 robust spines increasing size on the ventromedial margin distally; lateral rami with 2 subequal segmented rami; proximal segment length to width ratio of 2.8; lateral margin with 14 slender simple setae of variable lengths and 7 spines; dorsal surface with 2 robust, simple spines; medial margin with 1 distal plumosetae setae and 8 elongate, simple setae of subequal lengths; distal segment length to width ratio 5.0; lateral margin with 9 short, simple setae of equal lengths; medial margin with 7 subequal plumosetae; apex with 4 elongate plumosetae; medial rami 1 segmented; medial rami very elongate with a length to width ratio of 5.0; lateral margin with 12 short, simple spines of variable lengths and 4 subequal, distal, plumose setae; dorsal surface with 2 distolateral, elongate, slender, simple setae; medial margin with 20 short, robust, subequal, dentate spines, 3 larger spines interspersed between every 3-5 short setae; apex with 4 elongate plumosetae; telson elongate, triangular with a shallow concavity in the margin 1/3 of telson anterior to apex; margin fringed by single row of spines; lateral margin without setae length to telson length ratio 0.24; telson length to width ratio of 1.2; lateral margin going from anterior to posterior consists of 6 simple, robust spines, 1 large dentate spine, 3 smaller dentate spines, 1 large dentate spine, 5 smaller dentate spines and 5 large, terminal dentate spines; dorsal surface with 2 subdistal large simple spines; dorsal surface with 5 submarginal lateral simple spines on each side.

Habitat

Hyporheic zone of cobble and gravel bed streams.

Distribution

Currently only known from type locality.

Remarks

The Never Never River is characterised by extensive and deep, coarse grained alluvial material composed of cobbles, gravels and coarse sands with outcrops of bed rock along its length.

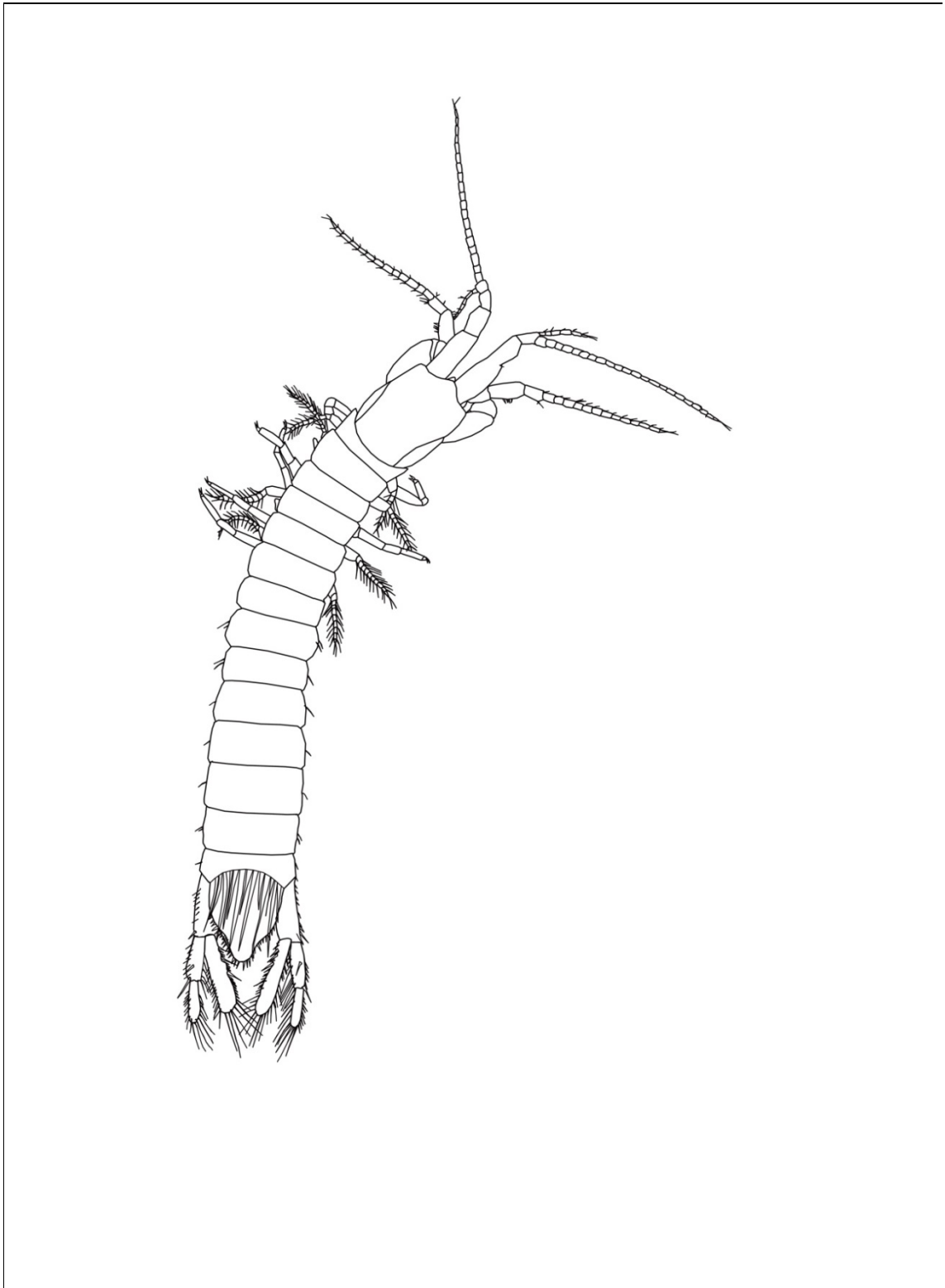


Figure 3.4.11. *Phreatonunga neverensis*. Holotype male 8.7mm. Body of male, dorsal view.

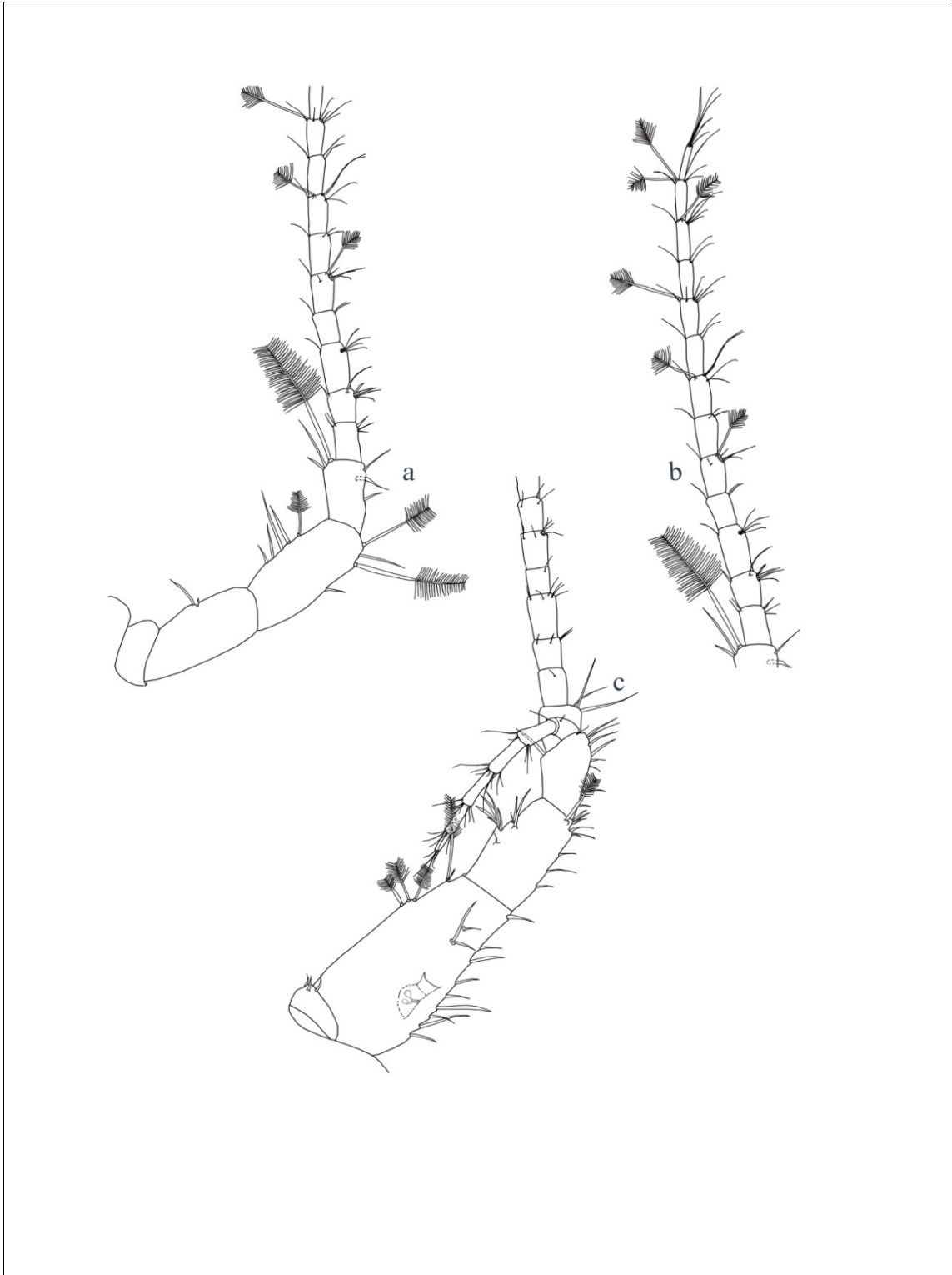


Figure 3.3.12. *Phreatonunga neverensis*. Holotype male 8.7. Antennae a: a- A1; b- A2 terminal section of lateral flagellum; c- A2 peduncle and medial part of flagellum.

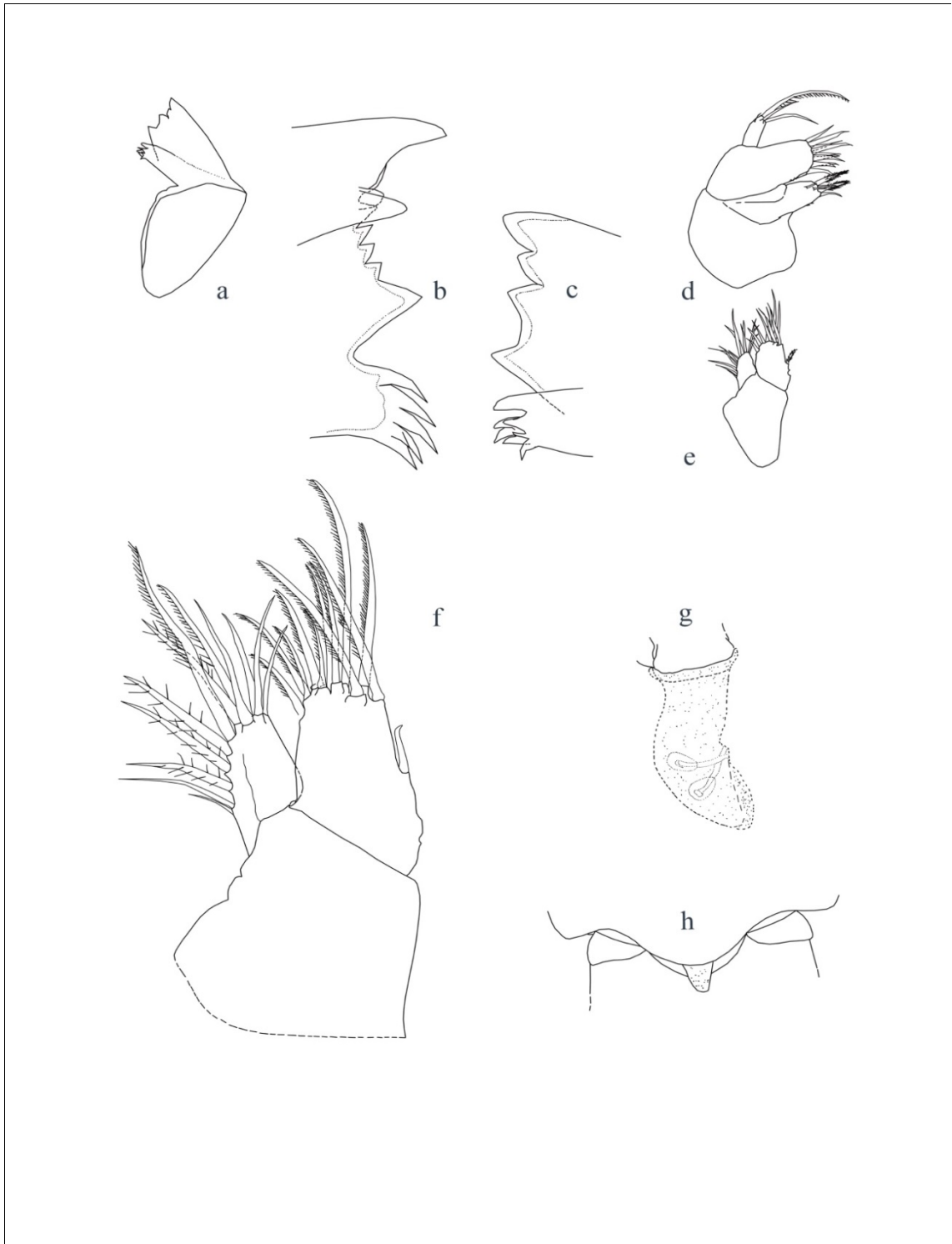


Figure 3.4.13. *Phreatonunga neverensis*. Holotype male 8.7. Mouthparts b: a- right mandible; b- left mandible; c- right mandible incisor process; d- Mx 1; e- Mx2; f- Mx 2 enlarged; g- statocyst; h- cephalon frontal margin with triangular rostrum.

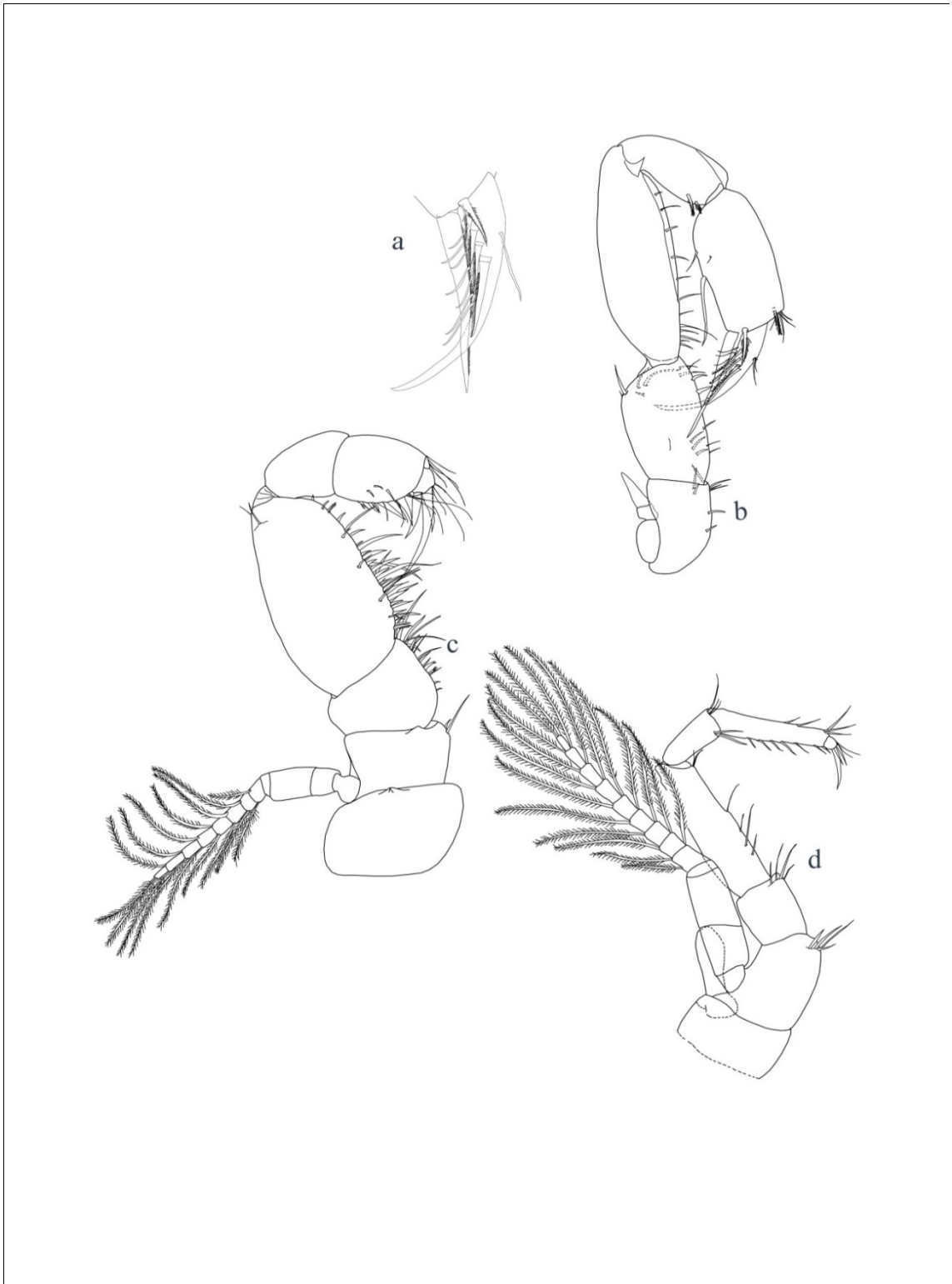


Figure 3.4.14. *Phreatonunga neverensis*. Holotype male 8.7mm. Thoracopods: a- close-up of Mxp dactylus; b- Mxp; c- Th 2; d- Th 3.

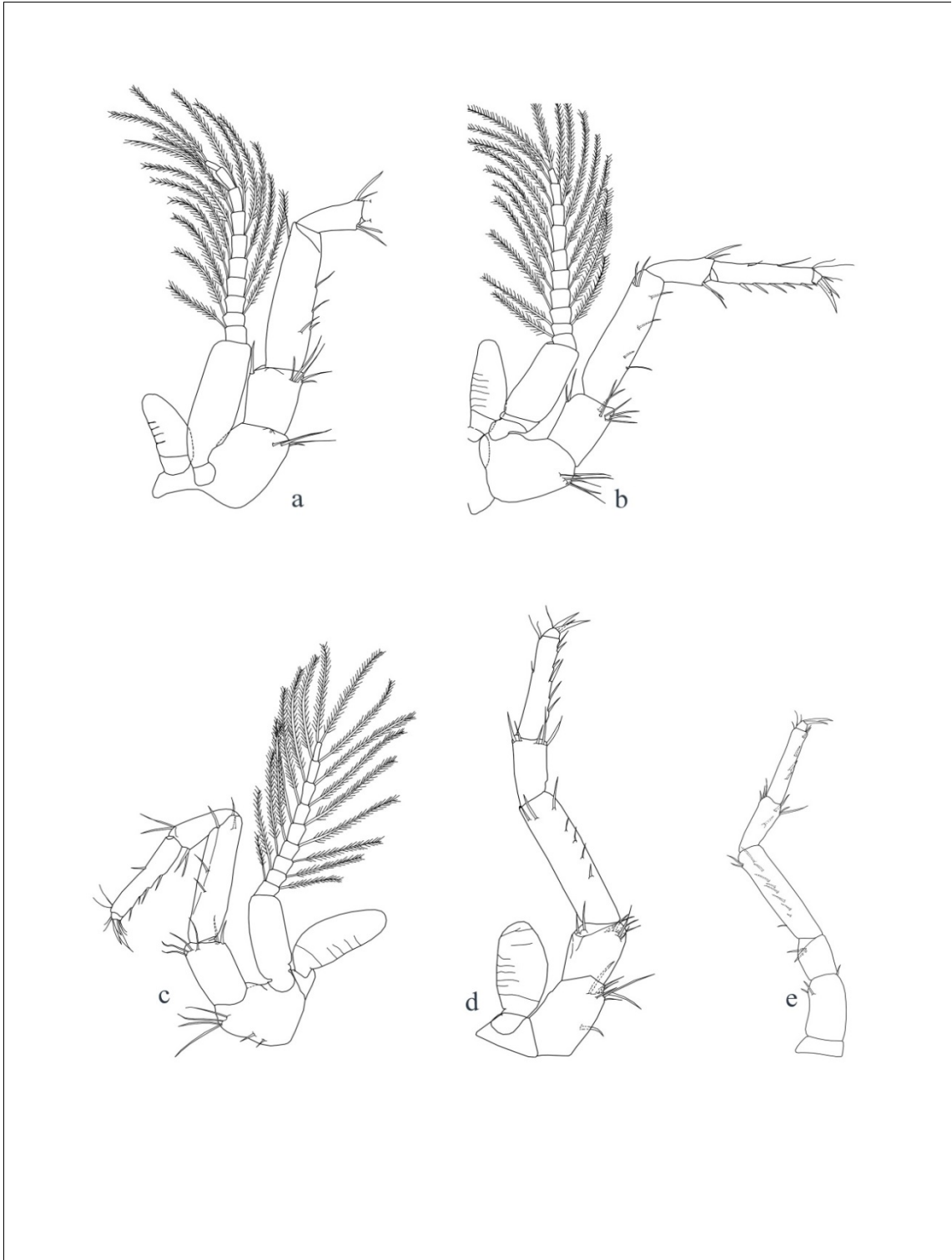


Figure 3.4.15. *Phreatonunga neverensis*. Holotype male 8.7mm. Thoracopods: a- Th 4 (damaged); b- Th 5; c- Th 6; d- Th 7; e- Th 8.

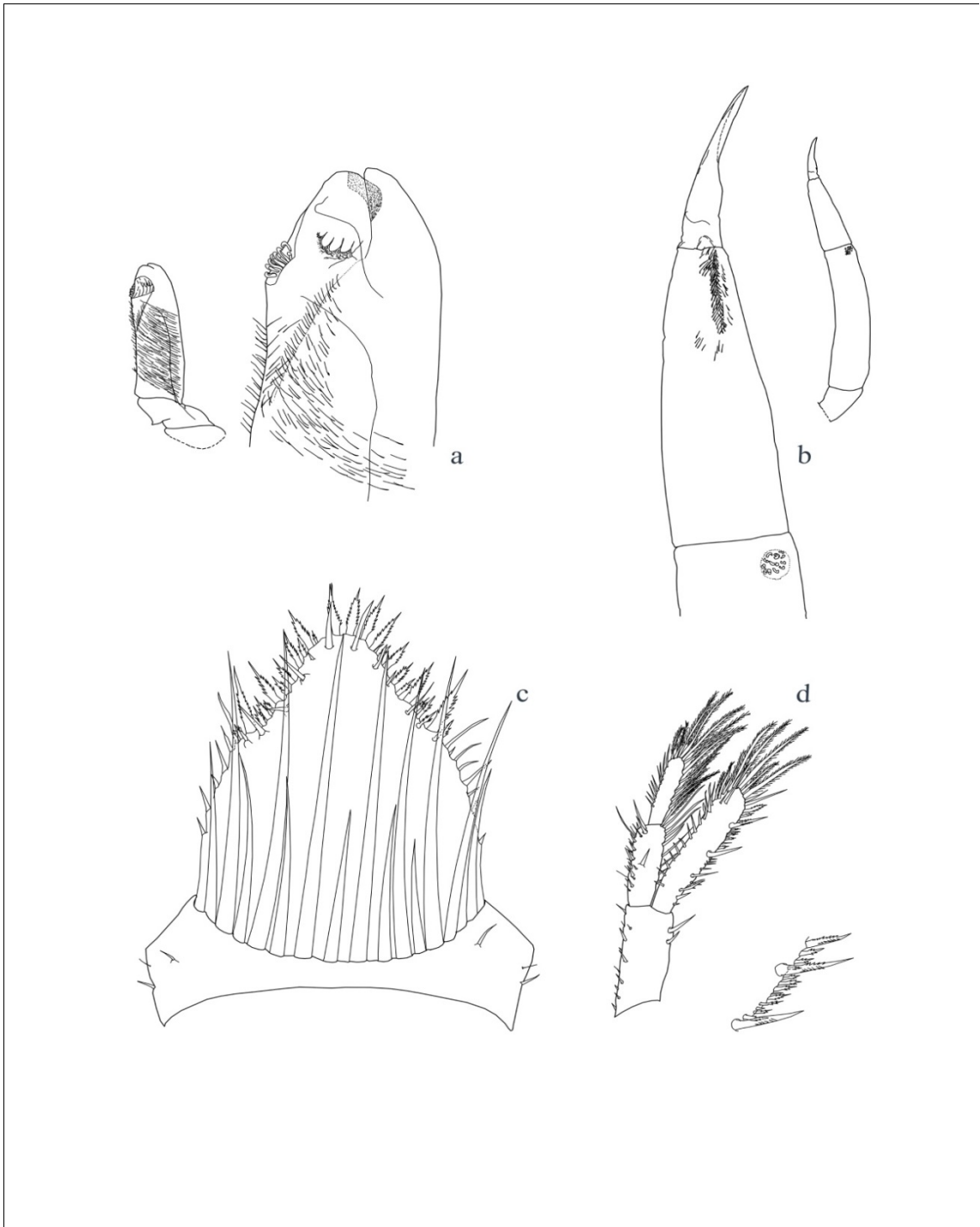


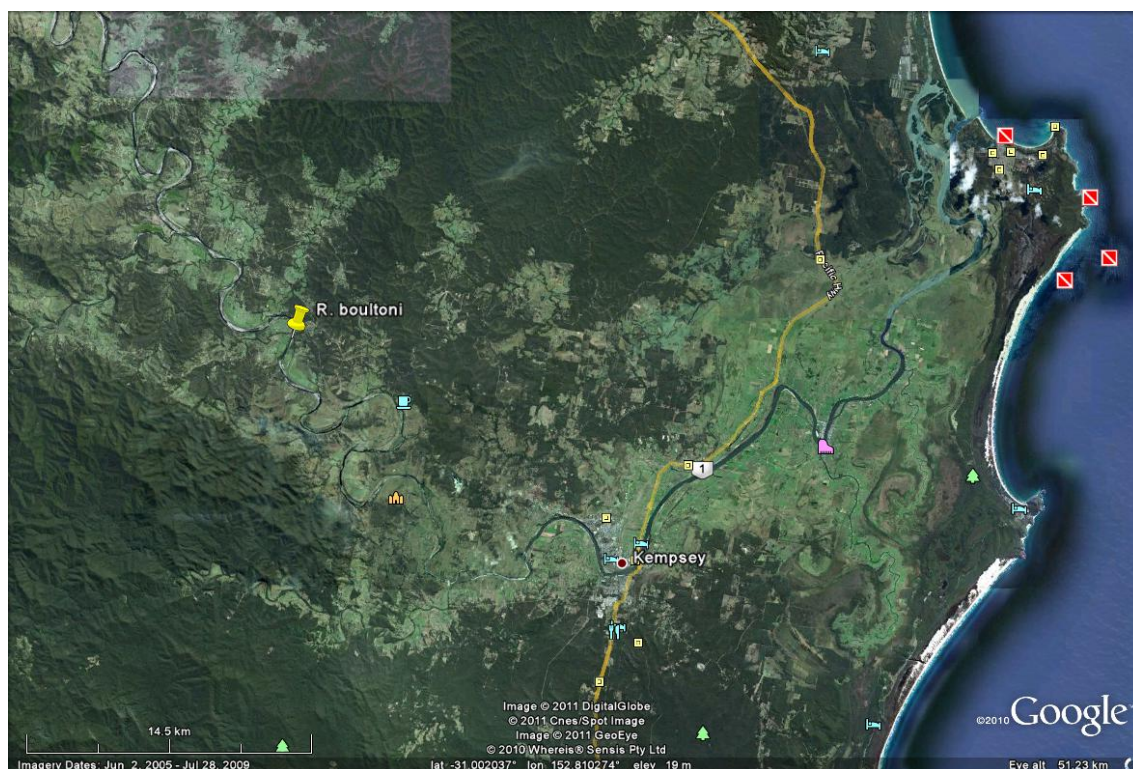
Figure 3.4.16. *Phreatonunga neverensis*. Holotype male 8.7mm. Pleopods and telson: a-Pl 1 with enlargement of distal tip; b- Pl 2 with enlargement of distal tip; c- telson, dorsal view; d-uropod with enlargement of spine row of lateral margin of medial rami.

Phreatonunga boultoni n. sp

(Figs. 3.4.17-20)

Type Locality

Macleay River, Temagog, NSW, Australia.



Map 3.4.4. Regional map showing the type locality on the Macleay River near Kempsey. (Google Earth 2013).

Material Examined

Type Material

Holotype, 1 male, P.56293, Macleay River, Temagog, near Kempsey, NSW, A. Boulton, P. Lisle, 21/8/1995.

Etymology

Named after Dr. Andrew Boulton, who collected the first specimens from the hyporheic zone and because of his contributions to our understanding of Australian hyporheic faunas.

Diagnosis

Male with mottled colour patterns on the dorsal and ventral surfaces; small round clear areas on each pleura; cephalon with a circle of black dots on each anterolateral corner of the cephalon giving the

impression of eyes; ventral pleonites 3-5 with ventral plates. ventral pleonites 3-4 with bilobed medial plates and pleonite 5 with small square plate; small triangular vertex with slightly round apex; right mandible incisor process with 4 denticles divided into 1 terminal bifid denticle and 2 large medial denticles; right molar process with a terminal row of 2 large, subequal, acutely pointed denticles and 2 medial, short, blunt denticles ; left mandible incisor process consists of 1 large bifid ventral denticle separated from a large central denticle by a diastema (notch), and 4 subequal triangular denticles on the dorsal surface; incisor process and molar process separated by a narrow v-shaped diastema; left molar process with 2 acutely pointed subequal denticles and a medial triturating surface; maxilliped merus distal margin without large, acutely pointed, thorn like condyle; pleopods 3-5 in both sexes absent; pleopod 1 in males with no patch of coupling setae; pleopod 2 endopodite 3 segmented and styliform with distal tip curved laterally
distal segment elongated, truncated with an acutely pointed apex with subdistal, minute diagonal groove and no subdistal medial pointed projection; triangular with no concavity in the subdistal margin; dorsal surface without spines; anal lobes circular; anus opens at ventral midpoint of the telson.

Description

Based on holotype male.

Body elongate with no dorsal flexure; largest male 8.9mm; male body length to width ration 10.1; first thoracic somite fused to head; all somites have lateral simple setae; pereon consists of seven free somites; pleon has 6 free somites and a telson; pleon slightly longer than pereon with a pereon length to pleon length ratio of 0.93; weakly sclerotised with a thin and flexible cuticle; cuticle surface covered in small pits; colouration- male with mottled colour patterns on the dorsal and ventral surfaces; small round clear areas on each pleura; cephalon with a circle of black dots on each anterolateral corner of the cephalon giving the impression of eyes however, the animal is blind with no ocelli.

Pereon- pereonites subequal in length and width; pereonites 2-4 the narrowest and shortest; pereonites become slightly longer and broader posteriorly pleon.

Pleon slightly flattened, somites subequal in length and width; pleonites become slightly longer and broader posteriorly; pleonite 5 the longest and widest; no epimeral expansions but with small flanges with setae laterally on ventro-posterior margin of pleonite 1-5; ventral pleonites 3-5 with ventral plates; ventral pleonites 3-4 with bilobed medial plates and pleonite 5 with small square plate.

Cephalon sub-rectangular with triangular anterior margin; male cephalothorax not divided by transverse cephalic groove; mandibular groove on ventro-posterior margin; rostrum triangular produced by a rounded extension of cephalic plate and small triangular vertex with slightly round apex; eyes absent.

Antennule peduncle tapered with three segments; basal peduncle segment tapered with a length to width ration of 2.33; statocyst contains 2 small round sensory setae and opens distally through a pore; second peduncle segment elongate, rectangular, with a length to width ration of 2.5; third peduncle segment elongate with a laterally inclined distal margin; length to width ratio of 1.6; lateral flagellum robust with

16-18 segments; medial margin of each segment with 1-2 aesthetascs per segment ; terminal segment apex with 4 simple setae and no aesthetascs; length of peduncle and outer flagellum length to body length ratio 0.48; medial flagellum with 6-7 segments; male antennules with no sensory organ on proximal margin of lateral flagellum; medial flagellum length to lateral flagellum length ratio of 0.32.

Antenna scaphocerite absent; peduncle with four segments; flagellum with 9 segments; basal peduncle segment short, rectangular without setae with length to width ratio of 0.45; second peduncle segment elongate, rectangular with a length to width ratio of 1.8; lateral margin with 3 simple setae; medial margin with one simple seta; third peduncle segment elongate, rectangular with a length to width ratio of 1.67; lateral margin with 6 short, simple setae; medial margin with 2 distomedial plumose setae and 2 short simple setae; fourth peduncle segment elongate, rectangular with a length to width ratio of 1.6; lateral margin with diagonal distolateral corner with 2 simple setae and 1 large, plumose setae; medial margin with 2 simple setae.

Labrum round, with a flat surface which does not project anterior, and 3 vertical, concave grooves consisting of 2 short, lateral grooves and 1 longer, central groove.

Mandible without palp; spine row and incisor accessory process absent; incisor process forms a concave cleaving structure; right mandible incisor process with 4 denticles divided into 1 terminal bifid denticle and 2 large medial denticles; right molar process with a terminal row of 4 small, subequal, acutely pointed denticles and 2 medial, short, blunt denticles ; left mandible incisor process consists of 1 large bifid ventral denticle separated from a large central denticle by a diastema (notch), and 4 subequal triangular denticles on the dorsal surface; incisor process and molar process separated by a narrow v-shaped diastema; left molar process with 2 acutely pointed subequal denticles and a medial triturating surface; maxillula two unequal endites on basal podomere.

Maxillule with a 1 segmented palp; palp elongate and tapered, with 1 large plumose spine subequal to length of lateral endite with 1 small, robust, simple setae on the distomedial corner; lateral endite broad with two rows of spines consisting of 9 medially directed, apical spine without serrations; medial endite width to lateral endite width ratio 0.75; medial endite length to width ratio, 1.33; medial endite with 1 apical, large, hirsute spine, and 8 simple spines. Maxilla with 2 lobes; lateral endite without simple, spine on mid lateral margin, 8 apical, simple setae and no setae on distomedial margin; medial endite apical margin with 7 simple setae, and 1 small plumose setae; medial endite medial margin with no setae; no medial lobe.

Female spermatheca forming prominent cone shaped sternal extension positioned between the coxa of thoracopod 6.

Maxilliped robust, elongate with a modified propodal spine and dactylus forming a grasping appendage capable of being folded under the cephalothorax; maxilliped coxa with 1 epipodite; coxa short, triangular with a length to width ratio of 1.0; coxa without setae; epipodite segmented, tubular, spatulate, and distally pointed ; basis without exopodites; medial margin with 4 simple setae increasing in size distally and 7 simple setae on the medial side of the distal margin; no preischium; ischium elongate with length to width

ratio of 1.57; dorsomedial surface with shallow groove that accommodates the merus ; distolateral corner with 2 simple setae and small spine; merus proximally narrow, broadening to elongate segment, with length to width ratio of 2.47; merus medial margin with 8 short, setae of variable size , without a mid-distal spine larger than the others; merus distal margin without large, acutely pointed, thorn like condyle controlling the lateral articulation of the carpus; carpus robust and elongate; carpus without 2 short, penicillate setae on the distomedial margin; propodus proximally narrow, rapidly widening medially to a robust elongate segment, with length to width ratio of 1.85; ventromedial surface with shallow groove along proximal half of segment that accommodates the carpus; setae restricted to 3 simple setae on lateroventral surface, no setae on distolateral margin; distomedial corner with very large, truncated and apically point spine almost as long as propodus; propodal spine without a fringe of short fine, comb-like, setules along lateral or inner margin; dactylus elongate with a length to width ratio of 1.6 forming opposing edge of grasping appendage; medial margin with 4 single sided, subequal, dentate spines ; apex with 1 very large, medially curved spine and 2 small simple setae on distolateral margin; paragnath bilobed; each lobe bears fine setules on medioventral surface and medial margin and a notch approximately 1/3 along medial surface and a triangular gap formed between the lobes; thoracopods- all thoracopods have seven segments.

Thoracopod 2 coxa with 1 multisegmented exopodite; thorcapods 3-7 coxa with 1 tubular exopodite; thorcapods 2-6 basis with 1 multisegmented exopodite; thorcapods 8 without epipodites or exopodites; thoracopod 2 exopodite with a 2 segmented peduncle and 8 segmented flagellum, each segment with a plumose setae on each distolateral corner; coxa ovoid with a small triangular condyle on mid distal margin and no setae or medial lobes; basis short; ischium short; merus elongate and robust, proximally broad and narrowing distally; mid distal margin with a small triangular condyle to control lateral movement of the carpus and a short distomedial groove to accommodate the carpus; dactylus very short with very large, robust, terminal spine and, 2 shorter spines and 4 simple setae; pleon- pleonite 6 1/3 length of pleonite; pleonite 6 posterior margin deeply concave with a row of 17 elongate spines alternating in length; the longest spines equal to length of telson with a length to telson length ratio 1.0; the smaller spines length to telson length ratio 0.5; subdistal margin without mid row of short spines; 1 small simple seta in each proximolateral surface.

Pleopods- pleopods 3-5 in both sexes absent; pleonites 1-2 each with one pair of pleopods; pleopod 1 in males at rest, the two endopodites of pleopod 1 are held obliquely with their medial surfaces joined and directed anteriorly between bases of thoracopod 8 and held within the shallow depression formed by pleopod 1.

Male pleopod 1 consists of a short broad coxa and a spatulate-shaped segment; endopodite length to width ratio of 3.6; medial margins folded medial to form a medial groove running the length of the segment opening distally; medial surfaces adjacent to the groove covered in fine setules; no patch of coupling setae; lateral surface covered 1/2 in fine setules; distodorsal margin forms a concavity with 3 short, blunt proximally directed spines; distal end rounded with subdistal groove. Pleopod 2 in males- endopodite 3

segmented and styliform with distal tip curved laterally; coxal plate extended, without setae lateral to endopodite with basal segment rising directly from ventral surface; basal segment very elongated with a length to width ratio of 4.0; medial segment elongated, truncated with a length to width ratio of 4.5; round patch of coupling hooks on the subdistomedial corner; distal segment elongated, truncated with an acutely pointed apex with subdistal, minute diagonal groove and no subdistal medial pointed projection; uropod rami elongate and subtubular.

Uropod lateral rami 2 segmented; uropod medial rami 1 segmented; uropod length to telson length ratio of 1.8; protopod and rami dorsal surface flattened; protopod and rami ventral surfaces rounded; medial ramus slightly shorter than lateral ramus; protopod lateral margin with 4 short, robust, simple spines; distal margin without distal spines; protopod medial margin straight with 3 robust, subequal on the medial margin distally; lateral rami with 2 subequal segmented rami; lateral margin with 5 spines on proximal rami and 5 plumose setae of distal rami; dorsal surface with 1 robust, simple spines; medial margin with 1 distal robust setae, 1 plumose setae and 10 robust, simple setae of subequal lengths; medial rami 1 segmented; medial rami very elongate with a length to width ratio of 5.2; lateral margin with 15 short, simple spines of variable lengths and 7 subequal, distal, plumose setae; dorsal surface with 7, elongate, slender to robust, simple setae; medial margin with 9 short, robust, subequal, dentate spines; telson elongate, triangular with no concavity in the subdistal margin; margin fringed by single row of spines; telson length to width ratio of 1.07; lateral margin going from anterior to posterior consists of 6 simple, robust spines, 3 large dentate spine, 6 smaller dentate spines, and 4 large, terminal dentate spines; dorsal surface without spines; anal lobes circular; anus opens at ventral midpoint of the telson.

Habitat

Hyporheic zone of cobble and gravel bed streams

Distribution

Currently only known from type locality.

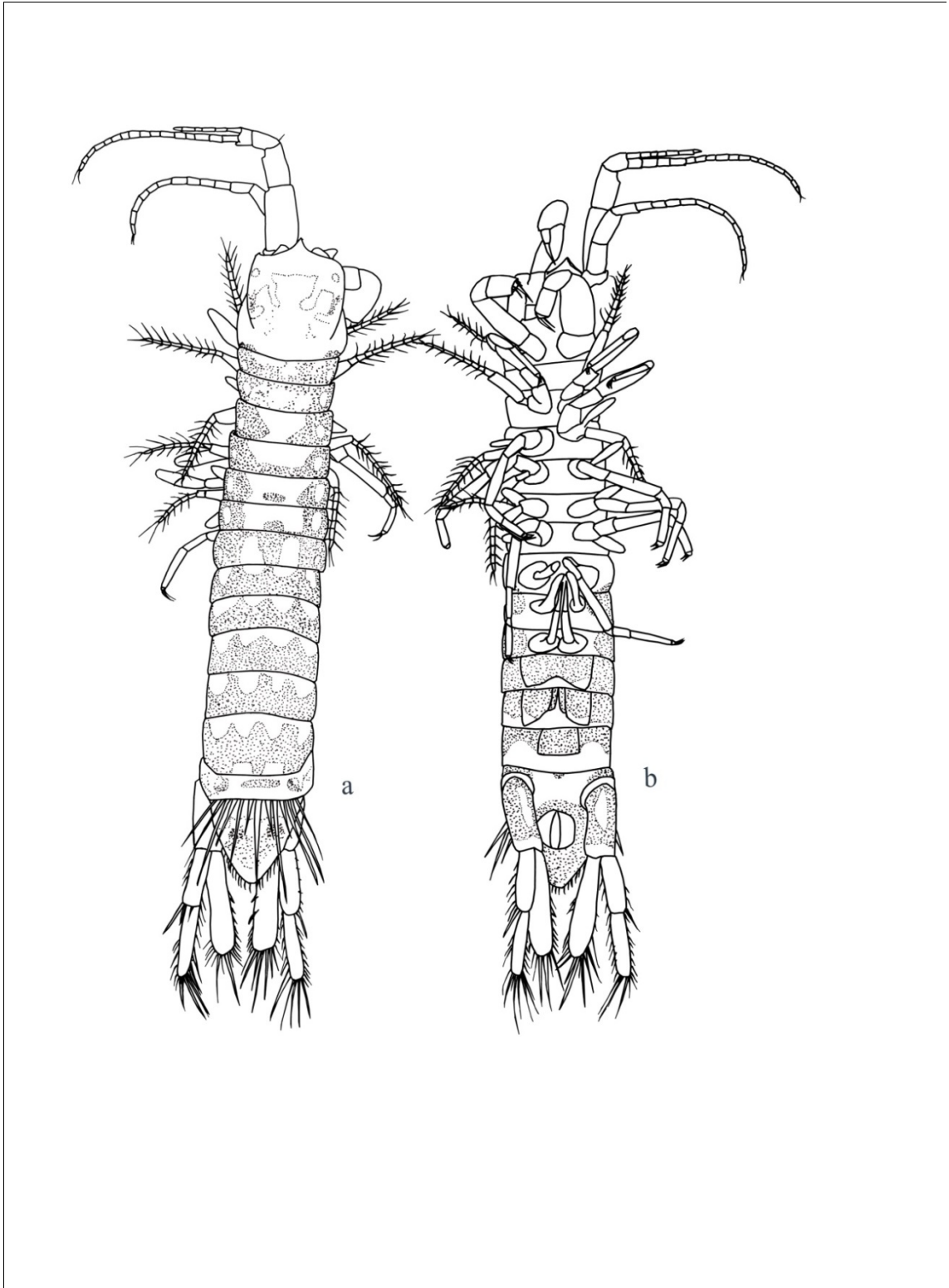


Figure 3.4.17. *Phreatonunga boultoni*. Holotype male 8.9mm. Body: a- body dorsal view; b- body ventral view. Stippling represents colour pattern.

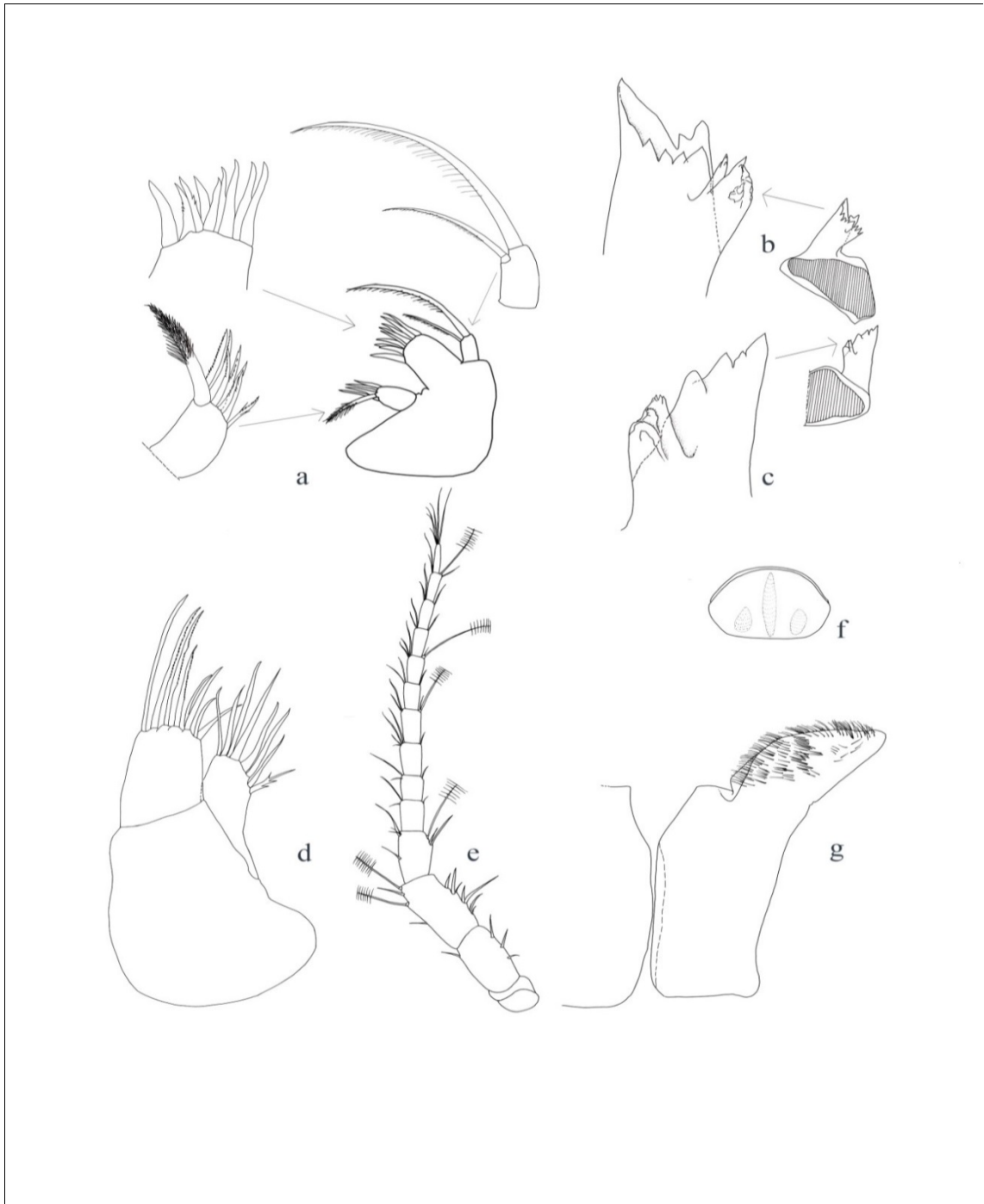


Figure 3.4.18. *Phreatonunga boultoni*. Holotype male 8.9mm. a- Mx1 with enlargements of medial and lateral lobes and palp ; b- left mandible with enlargement of incisor process; c- right mandible with enlargement of incisor process; d- Mx 2; e- A2; f- Labrum; g- paragnath.

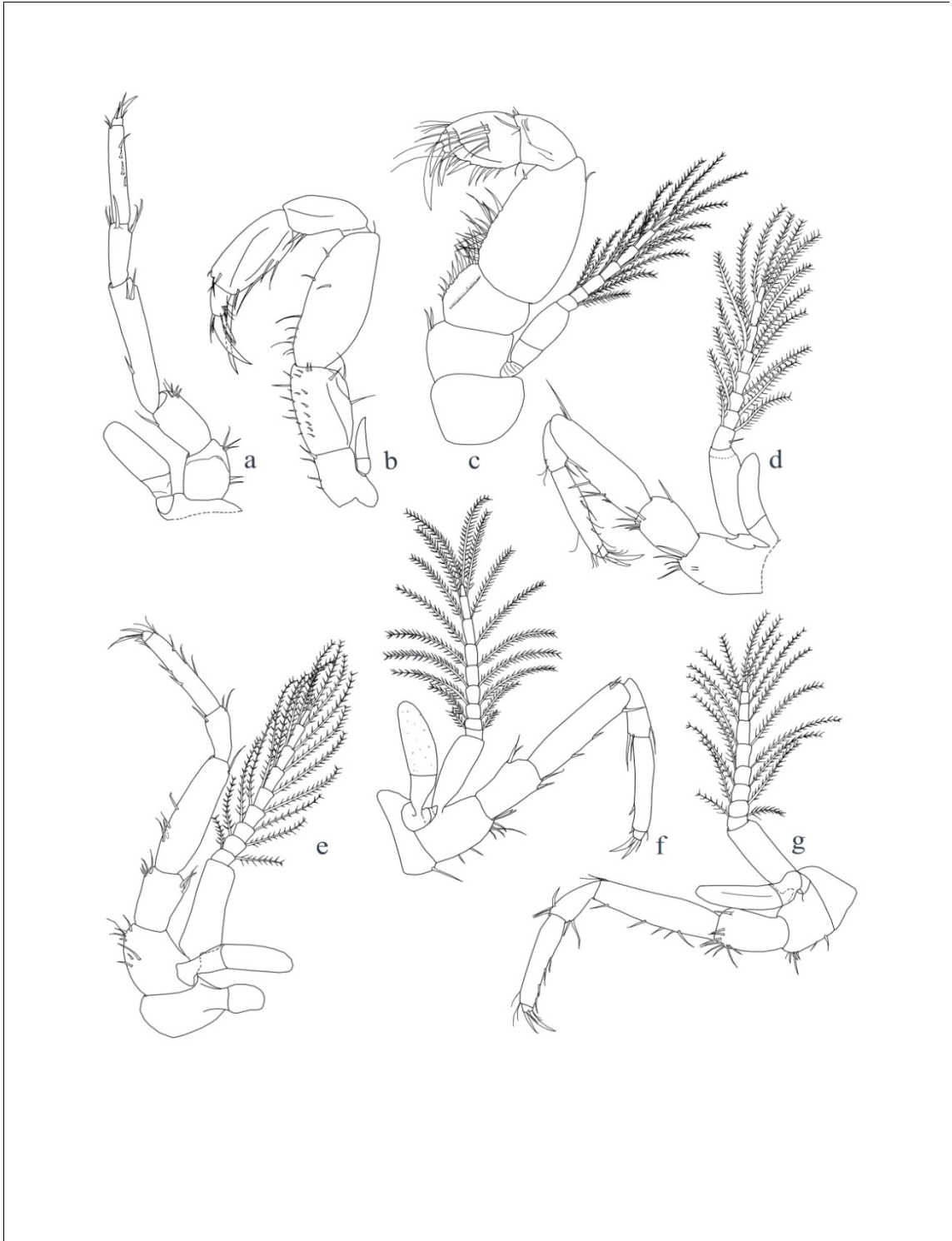


Figure 3.4.19. *Phreatonunga boultoni*. Holotype male 8.9mm. Thoracopods: a- Th 7; b- Mxp; c- Th 2; d- Th 3; e- Th 4; f- Th 5; g- Th 6.

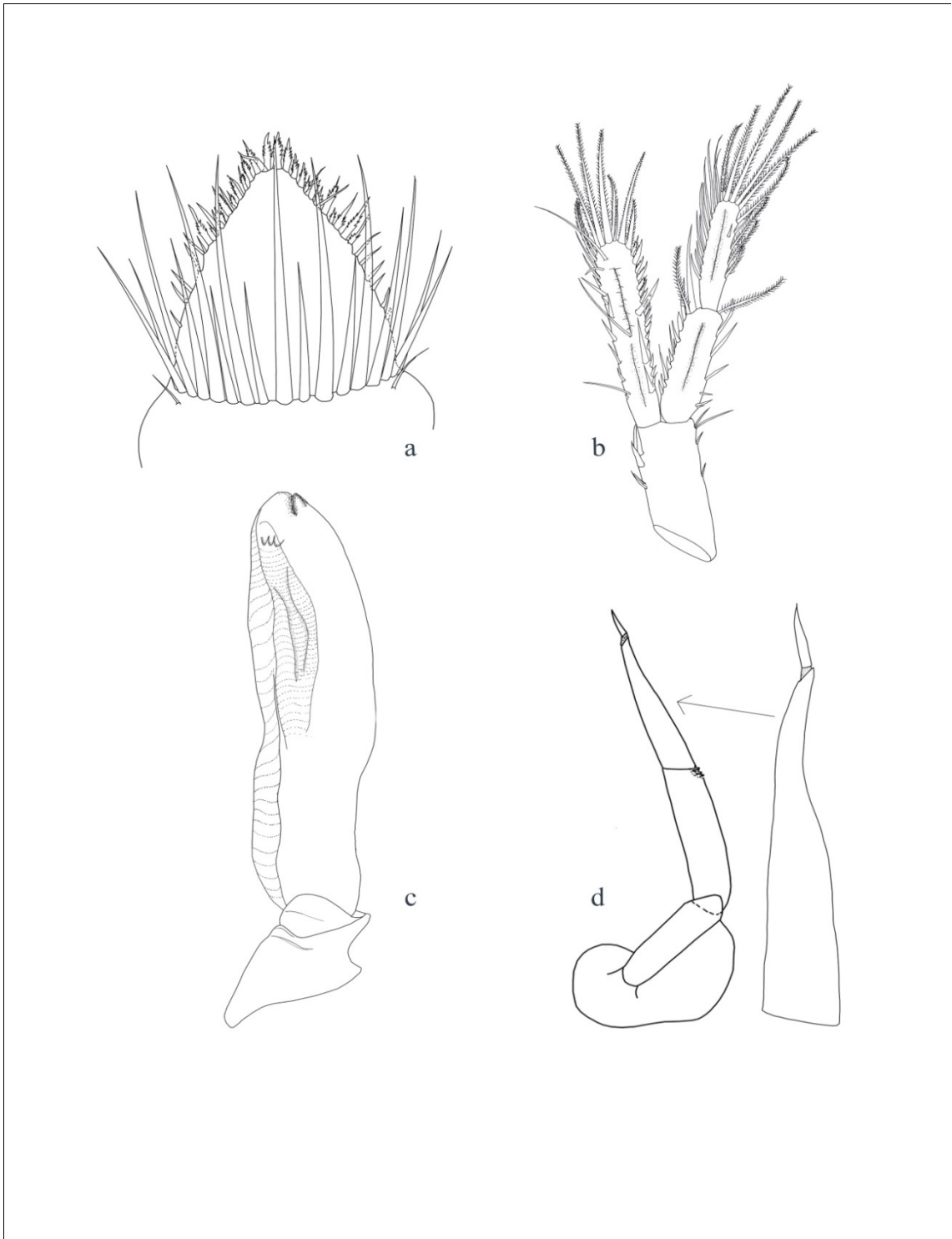


Figure 3.4.20. *Phreatonunga boultoni*. Holotype male 8.9mm. Petasma and telson: a- telson, dorsal view; b- uropod; c- Pl 1; d- Pl 2 with enlargement of distal tip.