

# Revision of the genus *Bathybadistes* (Isopoda: Asellota: Munnopsidae), with descriptions of two new species from the southern hemisphere

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**Abstract.** The munnopsid isopod genus *Bathybadistes* Hessler & Thistle has undergone several rearrangements since its initial inception. This genus was originally established for *Bathybadistes hoplitis* Hessler & Thistle and included eight species transferred from *Ilyarachna* Sars. Kussakin (2003) transferred four species to *Echinozone* Sars and one species back to *Ilyarachna*; he did not examine the other *Bathybadistes* species. The discovery of two new species of *Bathybadistes* has provided additional information on this genus. Using new and existing data, the present study used phylogenetic methods to test the validity and composition of *Bathybadistes*. Two outgroup and 15 ingroup taxa were analysed, including all nine species originally designated as *Bathybadistes*. The result of this analysis supports the validity of *Bathybadistes*. *Echinozone* appears to be paraphyletic because the four species moved to this genus by Kussakin (2003) do not align themselves with its type species, *Echinozone coronata* (Sars). *Bathybadistes* is rediagnosed and two new species, the first from the southern hemisphere, are described: *Bathybadistes andrewsi*, sp. nov. from ~3300-m depth off the west coast of New Zealand; and *Bathybadistes fragilis*, sp. nov. from ~4750-m depth in the eastern Weddell Sea, Antarctica.

## Introduction

Of all the asellote isopod families, the predominately deep-sea group Munnopsidae Lilljeborg, 1864 is the largest, with 39 genera and close to 300 species. Our knowledge of the higher order systematics of this family stems largely from Wilson (1989), who defined seven subfamilies. A subsequent study by Kussakin (2003) established a further two subfamilies. These subfamilies encompass nearly all the genera of the Munnopsidae.

One of these subfamilies, the Ilyarachninae Hansen, 1916, has a worldwide distribution and is found between ~35 and 5500-m depth. The Ilyarachninae comprises six genera: *Aspidarachna* Sars, 1897; *Ilyarachna* Sars, 1870; *Bathybadistes* Hessler & Thistle, 1975; *Notopais* Hodgson, 1910; *Echinozone* Sars, 1897; and *Pseudarachna* Sars, 1897. The genera *Notopais* and *Pseudarachna* have been the subjects of recent reviews (see Merrin 2004, 2006).

The genus *Bathybadistes* was established by Hessler and Thistle (1975) to include one new species, *B. hoplitis* Hessler & Thistle, 1975, and eight species transferred from *Ilyarachna*:

*Ilyarachna argentinae* Menzies, 1962; *I. gurjanovae* Menzies, 1962; *I. multispinosa* Menzies, 1962; *I. longipes* Birstein, 1963; *I. scabra* Birstein, 1971; *I. tuberculata* Birstein, 1971; *I. venusta* Birstein, 1971; and *I. spinosissima* Hansen, 1916. In their paper, however, Hessler and Thistle used question marks to indicate their reservations about the placement of three species: *I. scabra*; *I. tuberculata*; and *I. venusta*. Kussakin (2003) recently reviewed the Munnopsidae and transferred *B. spinosissima* to *Ilyarachna* and *B. scabra*, *B. tuberculata*, *B. venusta* and *B. longipes* to *Echinozone*. *Bathybadistes hoplitis*, *B. argentinae*, *B. gurjanovae* and *B. multispinosa* remained in *Bathybadistes*.

The aim of the present study is to test the validity and composition of *Bathybadistes* and present a new classification on the basis of a phylogenetic analysis using new and existing species. Two new species, *Bathybadistes andrewsi*, sp. nov. from off the west coast of New Zealand and *Bathybadistes fragilis*, sp. nov. from the eastern Weddell Sea, Antarctica, are described. These two discoveries are significant because they are the first species from this genus to be described from the southern hemisphere.

## Methods

### Phylogenetic analysis

#### Taxa included

The ingroup for the analysis consisted of all species that were considered to belong to *Bathybadistes* according to Hessler and Thistle (1975), and included those species for which they held reservations. The ingroup also included: two species of *Notopais*; the type species for *Echinozonia*, *Echinozonia coronata* (Sars, 1870), to test Kussakin's reassignment of some former *Bathybadistes* to this genus; and two species of *Ilyarachna*, which included the type, *Ilyarachna longicornis* (Sars, 1864), because all except one species in Hessler and Thistle's (1975) grouping were originally attributed to *Ilyarachna*. The two new species described in this paper were also included in the analysis. See Table 1 for the complete list.

Wilson and Thistle (1985) postulated that *Amuleta abyssorum* (Richardson, 1911) was the sister taxon to *Ilyarachna*. In his subsequent phylogenetic analysis of the Munnopsidae, Wilson (1989), using *Ilyarachna* as the representative of Ilyarachnidae (then considered a family),

**Table 1. Taxa used in the phylogenetic analysis**

Species	Literature references	Type material studied
<i>Bathybadistes andrewsi</i> , sp. nov.	N/A	Y
<i>B. fragilis</i> , sp. nov.	N/A	Y
<i>B. gurjanovae</i> (Menzies, 1962)	Menzies 1962	N
<i>B. hoplitis</i> <sup>A</sup> Hessler & Thistle, 1975	Hessler and Thistle 1975	N
<i>B. multispinosa</i> (Menzies, 1962)	Menzies 1962	N
<i>B. spinosissima</i> (Hansen, 1916)	Hansen 1916; Menzies 1962	Y
<i>Echinozonia coronata</i> <sup>A</sup> (Sars, 1870)	Sars 1897	Y
<i>E. longipes</i> (Birstein, 1963)	Birstein 1963	N
<i>E. scabra</i> (Birstein, 1971)	Birstein 1971	N
<i>E. tuberculata</i> (Birstein, 1971)	Birstein 1971	N
<i>E. venusta</i> (Birstein, 1971)	Birstein 1971	N
<i>Ilyarachna hirticeps</i> Sars, 1870	Sars 1897; Svavarsson 1988	Y
<i>I. longicornis</i> <sup>A</sup> (Sars, 1864)	Sars 1897	Y
<i>Notopais minya</i> Merrin, 2004	Merrin 2004	Y
<i>N. spicata</i> <sup>A</sup> Hodgson, 1910	Merrin 2004; Schultz 1976. Additional material was also studied	Y
<i>Amuleta abyssorum</i> <sup>A</sup> (Richardson, 1911)	Wilson and Thistle 1985	N
<i>Betamorpha characta</i> <sup>A</sup> Hessler & Thistle, 1975	Hessler and Thistle 1975; Thistle and Hessler 1977	N

<sup>A</sup>Type species for the genus.

found that this genus formed a polytomy with *Amuleta* Wilson & Thistle, 1985, *Betamorpha* Hessler & Thistle, 1975 and *Storhyngura* Vanhöffen, 1914. Thus *A. abyssorum* and *Betamorpha characta* Hessler & Thistle, 1975 were selected as outgroups.

#### Characters

The 27 morphological characters listed below were used in the analysis, with data for the majority taken from illustrations in the literature. For some species, the type material was also referred to (see Table 1 for literature and type material used). All characters were treated as unordered and unweighted, 22 characters were binary and five had three states, with the numbers in brackets representing character states (see Table 2 for character matrix).

(1) *Pereonites 1–4 length*: less than length of pereonites 5–7 (1); similar in length to pereonites 5–7 (2); longer than length of pereonites 5–7 (3).

(2) *Mid-dorsal pereonite 5 length*: shorter than pereonite 6 (1); similar in length to pereonite 6 (2); longer than pereonite 6 (3).

(3) *Cephalon*: with dorsal spines or tubercles (= small dorsal protrusions) (1); without dorsal spines or tubercles (2).

(4) *Pereonites 1–4*: with spines (1); without spines (2).

(5) *Pereonites 5–7*: with spines (1); pereonite 5 with spines only (2); without spines (3).

(6) *Spines/tubercles*: with apical setae (1); without apical setae (2).

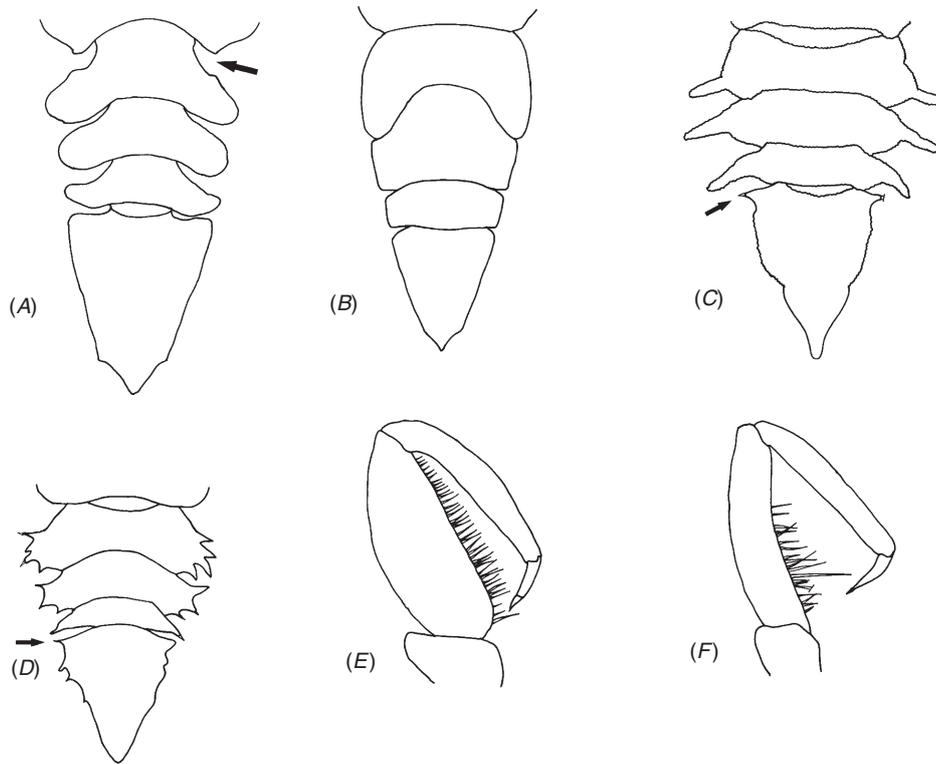
(7) *Pereonite 5*: lateral margins narrowing anteriorly, forming a neck-like elongation (1; Fig. 1A, see arrow); lateral margins not forming an anterior neck-like elongation (2; Fig. 1B).

(8) *Pereonites 5–7*: pereonites laterally distinct, do not 'fit' into each other (1; Fig. 1A, C, D); pereonites not laterally distinct from each other, pereonites 'fit' into each other (2; Fig. 1B).

**Table 2. Character matrix of 17 taxa and 27 characters used in this analysis**

Respective states are represented in the matrix as either 1, 2 or 3, with unknowns represented by '?' (entered as a 'U' in DELTA) and inapplicable characters by '-'

Taxa	Characters		
	0000000001	1111111112	2222222
	1234567890	1234567890	1234567
<i>Bathybadistes andrewsi</i>	3111112121	2111122221	1111111
<i>B. fragilis</i>	3111112121	2111122221	1111111
<i>B. gurjanovae</i>	2311112131	2111122???	11??111
<i>B. hoplitis</i>	3211112131	21111222??	11??111
<i>B. multispinosa</i>	?111112131	?111122???	11??111
<i>B. spinosissima</i>	3211112131	21111222??	11??111
<i>Echinozonia coronata</i>	3121222211	2121122221	2221112
<i>E. longipes</i>	2312311112	21212–2112	121121–
<i>E. scabra</i>	3311311112	212112211?	122121–
<i>E. tuberculata</i>	3312211112	21212–211?	121121–
<i>E. venusta</i>	3311111112	2121122112	122121–
<i>Ilyarachna hirticeps</i>	11223–2211	2111122221	2211111
<i>I. longicornis</i>	11223–2211	2111122221	2211111
<i>Notopais minya</i>	1111312211	22212–2221	2221112
<i>N. spicata</i>	3111212211	222122222	2221112
<i>Amuleta abyssorum</i>	11223–2211	112211111?	2221122
<i>Betamorpha characta</i>	31223–2211	11121112?1	2221122



**Fig. 1.** (A) *Echinozone venusta* (Birstein, 1971) (modified after Birstein 1971), (B) *Ilyarachna longicornis* (Sars, 1864) (modified after Sars 1897), (C) *Bathybadistes andrewsi*, sp. nov., (D) *Bathybadistes spinosissima* (Hansen, 1916) (modified after Menzies 1962), (E) pereopod 1 of *E. venusta* (modified after Birstein 1971), (F) pereopod 1 of *B. andrewsi*, sp. nov.

(9) *Pereonites 5–7 lateral margins*: rounded, sometimes almost square (1; Fig. 1B); narrow, elongate, akin to a single spine (2; Fig. 1C); jagged, with many spines (3; Fig. 1D).

(10) *Antenna 1 article 3 length*: less than article 1 (1); equal or more than article 1 (2).

(11) *Antenna 2 article 1*: without spine-like robust seta/e (1); with spine-like robust seta/e (2).

(12) *Antenna 2 article 1*: with no lateral horn-like prominent spine (1); with lateral horn-like prominent spine (2).

(13) *Mandibular palp*: present (1); absent (2).

(14) *Incisor process*: enlarged and rounded, no differentiation of cusps (1); dentate (2).

(15) *Left mandible with lacinia mobilis*: present (1); absent (2).

(16) *Lacinia mobilis (if present)*: large, length similar to that of incisor process (1); reduced, smaller than incisor process (2).

(17) *Mandibular molar*: large, square, distally broad (1); small, narrow, flap-like (2).

(18) *Pereopod 1*: robust, carpus expanded (1; Fig. 1E); not robust, more ambulatory, carpus not expanded (2; Fig. 1F).

(19) *Pereopod 1 carpus, inferior margin with*: a continual row of setae (1; Fig. 1E); not a continual row of setae, setae more dominant in proximal half (2; Fig. 1F).

(20) *Pereopod 5 carpus length*: less than twice width (1); more than twice width (2).

(21) *Pleon*: with dorsal spines or tubercles (1); without dorsal spines or tubercles (2).

(22) *Pleon anterolateral margin*: with spine (1; Fig. 1C, D, see arrows); smooth, with no anterolateral spine (2).

(23) *Pleopod 3 endopod*: three or less plumose setae (1); more than three plumose setae (2).

(24) *Pleopod 3 exopod distally with*: more than three plumose setae (1); two or three plumose setae (2); one plumose seta (3).

(25) *Uropod*: biramous (1); uniramous (2).

(26) *Uropod protopod*: flattened (1); tubular (2).

(27) *Uropod exopod*: tiny or rudimentary (1); large, articulating article (2).

The differences in ratios of pereonite sizes (characters 1 and 2) are useful in separating genera, although the states have been arbitrarily selected.

Within the Ilyarachninae, many species have dorsal spines and/or tubercles on their cephalon (character 3). Many species also have prominent pereonite spines (characters 4 and 5) and their patterning is species specific. In their generic description of *Bathybadistes*, Hessler and Thistle (1975) stated that the genus can be diagnosed by: the dorsal body surface with pedestals (here considered as spines) topped with a seta (character 6); and the natasomal pereonites (pereonites 5–7) reduced (character 8, Fig. 1A, C, D). This reduction of pereonites 5–7 as opposed to the more enlarged *Ilyarachna* shape (character 8, Fig. 1B), has led to some interesting patterns and features of the lateral margins (characters 7 and 9, Fig. 1A, C, D).

Article 3 of antenna 1 is usually smaller than article 1 (character 10), except in the group of species that Kussakin

(2003) moved from *Bathybadistes* into *Echinozone*. Characters 11 and 12 deal with ornamentation of article 1 of antenna 2.

In the munnopsids, the mandible displays a wide variety of morphologies and in the Ilyarachninae it is characterised by the massive, rounded incisor process (character 14 state 1) and the narrowed mandibular molar (character 17 state 2). Owing to the range of morphologies seen within the subfamily, mandibular characters have featured in all of Sars' generic descriptions (for example, see Sars 1897). In many genera of the Ilyarachninae, the presence or absence of the mandibular palp is a generic level character, but both the presence and absence of the mandibular palp were included in the description of *Bathybadistes* by Hessler and Thistle (1975). Characters 13–17 refer to the differences in mandibular morphologies found among these animals.

Appendages of deep-water asellotes are frequently damaged or lost during the collecting process and pereopods are quite often absent. In ilyarachnines often only pereopod 1 and the odd natatory pereopod remains while pereopods 2–4 are almost always lost. Consequently it is pereopod 1 that is most commonly illustrated, followed by a natatory pereopod, usually either 5 or 6. A robust pereopod 1 and an expanded carpus with a continual row of setae (characters 18 and 19 respectively, Fig. 1E, F) are characteristic of the species moved to *Echinozone* from *Bathybadistes* by Kussakin (2003). The expanded carpus of pereopod 5 is a family level character, but the degree of expansion with respect to the length differs within the Ilyarachninae (character 20).

Pleon shape and ornamentation (characters 21–22) are useful in grouping these animals and have not previously been mentioned in the description of *Bathybadistes*. One possible synapomorphy that emerges among those species retained in *Bathybadistes* is a spine on the anterolateral margins of the pleon (character 22, Fig. 1C).

Characters 23 and 24 deal with pleopods; pleopod 3 with three long plumose setae (character 23) on the endopod is the plesiomorphic state in the Janiroidea although, Wilson (1989) considers it to be an apomorphy within the Munnopsidae.

A synapomorphy for the subfamily Ilyarachninae is the flattened uropodal protopod as opposed to the tubular protopod found in genera such as *Amuletta* and *Betamorphia* (see Wilson and Thistle 1985) (character 26). In their generic description, Hessler and Thistle (1975) also referred to the uropods being either uniramous or biramous (character 25) and if they were biramous, the exopod was a tiny bump (character 27). This tiny bump is a rudimentary exopod and can be found in *Bathybadistes* and in several other members of the subfamily.

### Analysis

For the analysis, a data matrix was constructed in DELTA (Dallwitz *et al.* 1997) and a NEXUS file was generated for analysis in PAUP\* version 4.0 ( $\beta$  10 for Windows; Swofford 2001). A treespace search (Swofford and Begle 1993; as in Reid 1996; Edgecombe *et al.* 2000) was conducted under a heuristic search method with 1000 random addition sequence repetitions (nreps = 1000 addseq = random), saving no more than three trees of equal or one step greater than the minimum-length tree at each

iteration (nchuck = trees chuckscore = 1 randomise = trees). Branch swapping occurred in the saved trees and all minimum-length trees were saved (hsearch nchuck = 0 chuckscore = 0 start = current). A strict consensus was generated. Character transformations were analysed using the trace character history module (character source = stored characters; ancestral state reconstruction method = parsimony ancestral states) in Mesquite version 1.11, build h64 (Maddison and Maddison 2006). Trees were displayed in TreeView version 1.6.6 (Page 1996).

### Taxonomic descriptions

For *B. andrewsi*, sp. nov., the conserved holotype and dissected paratypes were illustrated using a Zeiss Stemi SV 11 dissecting microscope (Carl Zeiss, www.zeiss.com.au) and a Nikon Optiphot-2 compound microscope (Nikon, www.nikon.com), both fitted with a camera lucida. Descriptions were based on both the holotype and paratypes and are identified in the figure captions. For *B. fragilis*, sp. nov. the dissected holotype was illustrated using a Wild M5 dissecting microscope (Wild Heerbrugg, www.wild-heerbrugg.com) and a Leitz Dialux compound microscope (Leitz, leitzmicroscope.com), both equipped with a camera lucida. Written descriptions were prepared in DELTA and ratios were calculated using the maximum widths and lengths for the segment unless otherwise mentioned in the text. Antennal articles are referred to in terms of total number, with the most basal article referred to as article 1, the next article as article 2 and so on. Directional information regarding pereopods follows Brusca *et al.* (1995).

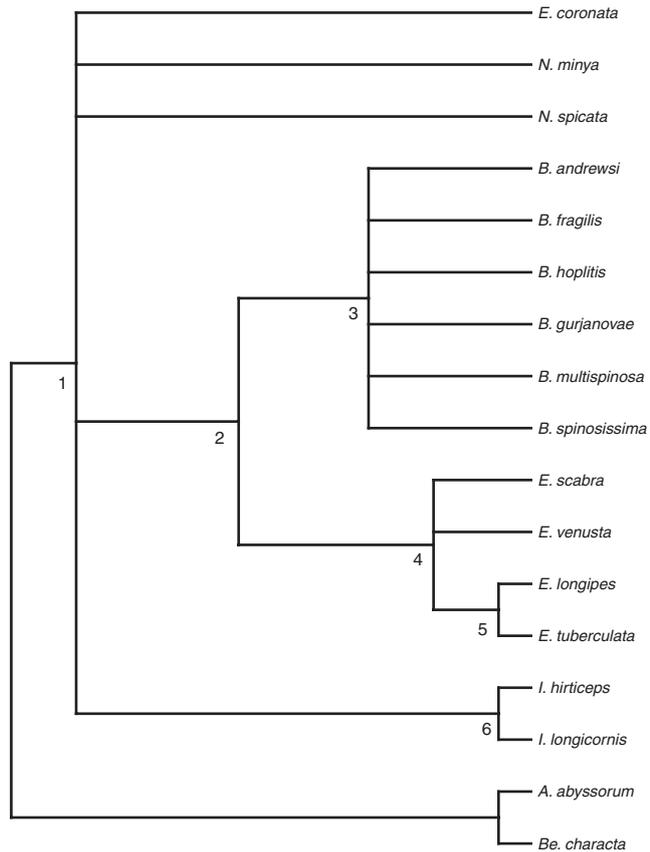
Previously fixed material used for scanning electron micrographs was dehydrated in an ethanol series using the same method as suggested by Felgenhauer (1987), with the specimens being air-dried and mounted onto an entomological pin with super glue. Specimens were studied under a Leica S440 scanning electron microscope (Leica Microsystems, www.leica-microsystems.com.au).

Abbreviations used in text are as follows: NIWA – National Institute of Water and Atmospheric Research; ZMH – Zoological Museum, Hamburg; SEM – scanning electron microscope; PS – penicillate seta/ae; SRS – sensillate robust seta/ae; RS – robust seta/ae; SS – simple seta/ae.

### Results and discussion

The analysis generated 243 equally parsimonious trees, each of 47 steps, with a consistency index of 0.638 and a retention index of 0.811. The strict consensus tree is well resolved (Fig. 2) with all six species of *Bathybadistes* grouping together in a single clade.

The following results refer to the strict consensus (Fig. 2) with only characters that are common to all 243 trees mentioned (clade number in brackets). For a full description of characters defining clades, see Table 3, because not all clades will be discussed here in detail. The character analysis shows there are numerous characters to support the generic status of *Bathybadistes* (clade 3). This clade is defined by: pereonites 5–7 with spines; mandibular palp present; the anterolateral margins of the pleon with a spine; and the uropodal exopod



**Fig. 2.** A strict consensus of 243 equally parsimonious trees. Numbers below the line refer to clades mentioned in the text and Table 3.

**Table 3.** Character states defining clades in the strict consensus (Fig. 2)

Those characters with a superscript 1 refers to a transformation from state 2 to 1 and those with a superscript 2 refers to a transformation from state 1 to 2.

Characters in bold have a consistency index (CI) = 1

Clade number	Characters defining clade
1	<b>11<sup>2</sup> 14<sup>1</sup> 16<sup>2</sup> 17<sup>2</sup> 26<sup>1</sup></b>
2	<b>3<sup>1</sup> 8<sup>1</sup> 21<sup>1</sup></b>
3	<b>5<sup>3</sup> &gt;<sup>1</sup> 13<sup>1</sup> 22<sup>1</sup> 27<sup>1</sup></b>
4	<b>2<sup>1</sup> &gt;<sup>3</sup> 7<sup>1</sup> 10<sup>2</sup> 18<sup>1</sup> 19<sup>1</sup> 25<sup>2</sup></b>
5	<b>4<sup>2</sup> 15<sup>2</sup></b>
6	<b>13<sup>1</sup> 23<sup>1</sup> 27<sup>1</sup></b>

tiny or rudimentary. Clade 4 is made up of those former members of *Bathybadistes* that Kussakin (2003) moved out into *Echinozone*. The characters that define clade 4 are: pereonite 5 mid-dorsally longer than pereonite 6; lateral margins narrowing anteriorly, forming a neck-like elongation; antenna 1 article 3 length equal or longer than article 1; pereopod 1 robust, carpus expanded; pereopod 1 carpus, inferior margin with: a continual row of setae; and uropod uniramous.

This study has resolved the uncertainty surrounding the original inclusion of the then-considered *Ilyarachna* species

*I. scabra*, *I. tuberculata* and *I. venusta* in *Bathybadistes* as proposed by Hessler and Thistle (1979). This analysis shows that Kussakin (2003) was correct in removing *E. scabra*, *E. tuberculata*, *E. venusta* and *E. longipes* from *Bathybadistes*. *Echinozone*, however, appears to be paraphyletic because these four species reassigned to this genus by Kussakin (2003) do not align themselves with the type species, *E. coronata*. The current composition of *Echinozone* is, however, provisionally retained pending further study. This analysis indicates that *Notopais* is also paraphyletic; however, with only two species included in this analysis, it is not possible to draw any definite conclusions on the genus and its current composition is retained.

### Taxonomy

Family **MUNNOPSIDAE** Lilljeborg, 1864

Subfamily **ILYARACHNINAE** Hansen, 1916

Genus ***Bathybadistes*** Hessler & Thistle, 1975

*Bathybadistes* Hessler & Thistle, 1975: 163.

Type species: *Bathybadistes hoplitis* Hessler & Thistle, 1975, by original designation.

### Description

Cephalic frons wide, rectangular; anterior cephalic flanges small. Pereonites with spines, each topped with an apical seta; pereonites 5–7 lateral margins narrow and distinct from each other, either with elongate spine-like extensions or jagged; natasome somewhat reduced. Pleon longer than wide, with dorsal spines, anterolateral margins also with spine. Antenna 1 article 1 lateral flange absent, distally with two rounded points; antenna 2 article 1 with short distolateral spine topped with robust seta. Mandible incisor massive, rounded; lacinia mobilis reduced; spine row and mandibular palp both present. Pereopod 2 ambulatory, not enlarged; pereopods 5–6 with carpus expanded, paddle-like, propodus elongate; at least superior margin of ischium and both margins of carpus and inferior margin of propodus with row of plumose setae; pereopod 7 carpus and propodus slender, setation generally similar to that of pereopods 5–6. Operculum large, with median keel; pleopod 4 exopod with more than one plumose seta; pleopod 5 simple lobe. Uropod biramous, with rudimentary exopod.

### Species included

*Bathybadistes andrewsi*, sp. nov.; *B. fragilis*, sp. nov.; *B. gurjanovae* (Menzies, 1962); *B. hoplitis* Hessler & Thistle, 1975 (type species); *B. multispinosa* (Menzies, 1962); and *B. spinosissima* (Hansen, 1916).

*Species now excluded:* Kussakin (2003) was correct to remove the four similar species, *E. scabra*, *E. tuberculata*, *E. venusta* and *E. longipes* from *Bathybadistes*. Although *E. coronata* does not fall within their distinct clade (Fig. 2, clade 4) rendering *Echinozone* paraphyletic, it is not within the scope of this paper to redefine the generic status of this clade. Therefore, the

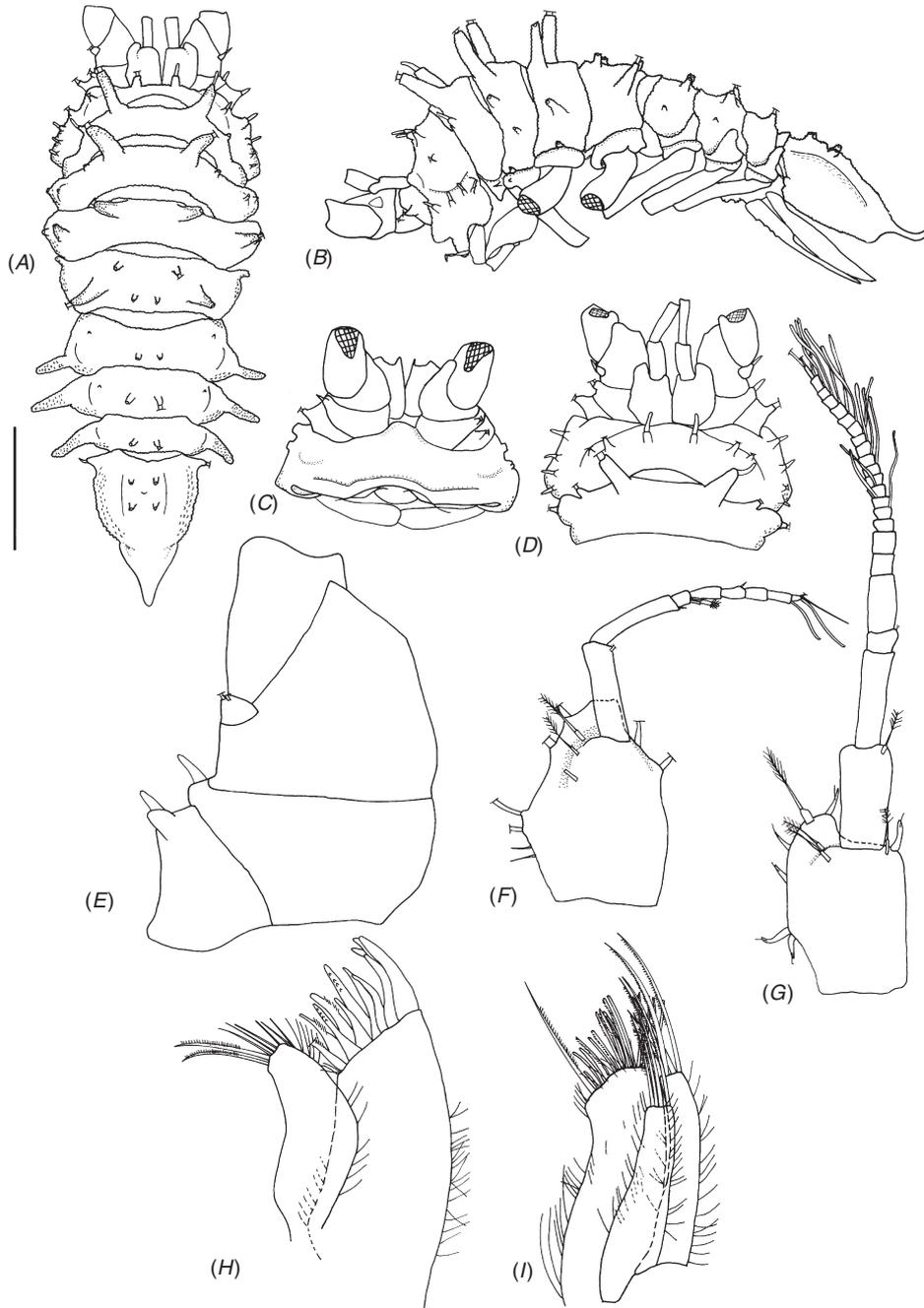
composition of *Echinozone* is provisionally retained until a more detailed study can be made.

#### Remarks

*Bathybadistes* can be distinguished from other Ilyarachninae genera by the combination of: pereonites dorsally with spines,

each possessing an apical seta (which Hessler and Thistle (1975) referred to as a pedestal seta); pereonites 5–7 with narrow lateral margins, distinct from each other, natasome somewhat reduced; anterolateral margin of the pleon with a spine; and uropod with rudimentary exopod.

The dorsal spines of *Bathybadistes*, each with a distal seta, are similar to those found in many species of *Notopais*



**Fig. 3.** *Bathybadistes andrewsi*, sp. nov. (A–D) Male holotype (NIWA 23810), (E, F) and (H, I) female paratype (NIWA 23811), (G) male paratype (NIWA 23811). (A) Dorsal view, (B) lateral view, (C) ventral oblique view of cephalon, (D) dorsal view of cephalon, (E) left antenna 2, (F) left antenna 1, (G) left antenna 1, (H) left maxilla 1, (I) left maxilla 2. Habitus scale bar = 1 mm.

Hodgson, 1910, but *Notopais* does not have a mandibular palp or the reduced posterior three pereonites as seen in *Bathybadistes*. The patterning and spines found on the lateral margins of the posterior three pereonites is unique within the Ilyarachninae, although the elongated spine-like lateral margin is not unique within the Munnopsidae as it is displayed by many other genera, such as those in the Acanthopocipinae Wolff, 1962 and Storthingurinae Kussakin, 2003.

*Bathybadistes* is distributed worldwide and is found between depths of 2700 and 5024 m.

### Key to the species of *Bathybadistes*

1. Pereonites 5–7 lateral margins each narrowing to a single elongate narrow extension ..... 2  
Pereonites 5–7 lateral margins jagged, laterally with several small spines..... 3
2. Pereonites 1–3 anterior margins with four large sub-equal spines, pereonites 5 and 6 with four and pereonite 7 with six spines; pereonite 6 dorsally longer than pereonite 5; pleon surface spiny, with row of four spines towards anterior margin, centrally with a pair of spines..... *B. fragilis*, sp. nov.  
Pereonites 1–3 anterior margins with two large central spines, 5–7 centrally with two spines; pereonite 6 dorsal length sub-equal to 5; pleon surface granular with four central spines ..... *B. andrewsi*, sp. nov.
3. Pereonites 5–7 lateral margins rounder, with small protrusions, jagged margins less defined ..... 4  
Pereonites 5–7 lateral margins angular, with larger protrusions, jagged margins well defined ..... 5
4. Pereonite 5 dorsally longer than 6; pleon with two rows of small spines down either side of mid-line ..... *B. gurjanovae*  
Pereonite 6 dorsally longer than 5; pleon with numerous small spines scattered ..... *B. multispinosa*
5. Pereonites 3 and 4 with many small lateral spines; pereonite 7 narrow strip, length similar throughout width; pleon distal margin coming to a narrow point ..... *B. spinosissima*  
Pereonites 3 and 4 with few small lateral spines; pereonite 7 longer centrally than laterally; pleon distal margin rounded..... *B. hoplitis*

### *Bathybadistes andrewsi*, sp. nov.

(Figs 3–6)

#### Material examined

*Holotype*. ♂ (4.0 mm), Stn P937, Bellona Trough, Tasman Sea, New Zealand, 41°19.2'S, 166°27.9'E, 21.iv.1980, epibenthic sled, 3253–3347 m, R.V. *Tangaroa* (NIWA 23810).

*Paratypes*. 5 ♂ (dissected paratype 3.5 mm), 6 ♀ (dissected paratype 5.0 mm), 3 fragments, type locality (NIWA 23811).

#### Description of male

*Body*. Cuticle calcified, granular. Cephalon with six dorsal and eight lateral spines; Pereonite 1 dorsally with two large and two small spines, pereonite 2 with two large and four small spines, pereonite 3 with four large spines, pereonite 4 with two large and four small dorsal spines. Pereonites 2 and 3 with pairs of small lateral spines. Coxae of pereopods 1 and 2 each with spine. Pereonite 5 posterior margin with dorsal pair of spines. Pereonites

5–7 lateral margins with posterior facing narrow spine-like extensions; dorsally each with pair of spines, pereonites 5–6 with additional pair of tubercles. Pereonite 7 ventrally with two spines on central swelling between pereopods. Pleon distal third triangular, somewhat flattened, coming to a narrow dorsally directed posterior tip.

*Antenna 1*. 22 articles; article 1 distomesial margin with one PS and one SRS, surface with two PS, lateral margin with five SRS and one PS; article 2 distal margin with one PS.

*Pleopods*. Pleopod 1 with two medial rows of setae and distally with numerous simple setae. Pleopod 2 protopod lateral margin with three proximal SS and distally with many plumose setae; stylet 0.6 times as long as protopod, not extending beyond protopod, terminating to a rounded point.

#### Description of female

*Antennae*. Antenna 1 of nine articles; article 1 mesial margin with two distal SRS, surface with three PS, lateral margin with four SRS and two SS; article 2 distomesial margin with one PS. Antenna 2 article 2 with spine similar to article 1.

*Mouthparts*. Mandible without cuticular scales; left lacinia mobilis smooth, truncate; spine row with seven spines; molar large; mandibular palp short, not extending beyond incisor. Maxilliped basis elongate, 2.8 times as long as wide (including endite); endite with five coupling hooks; palp article 2 with mesial margin with distal clump of distally pappose setae; epipod 1.6 times as long as wide, and 1.1 times as long as basis, with marginal cuticular scales and a few SS.

*Pereopods*. Pereopod 1 basis inferior margin with one long SS at midpoint and two distoinferior SRS; ischium superior margin with two SRS; merus distosuperior margin with two SRS.

Pereopod 5 basis inferior margin with three PS; carpus with one distosuperior SRS; propodus with weakly plumose setae on inferior margin, superior margin lacking plumose setae, distal corner with one PS.

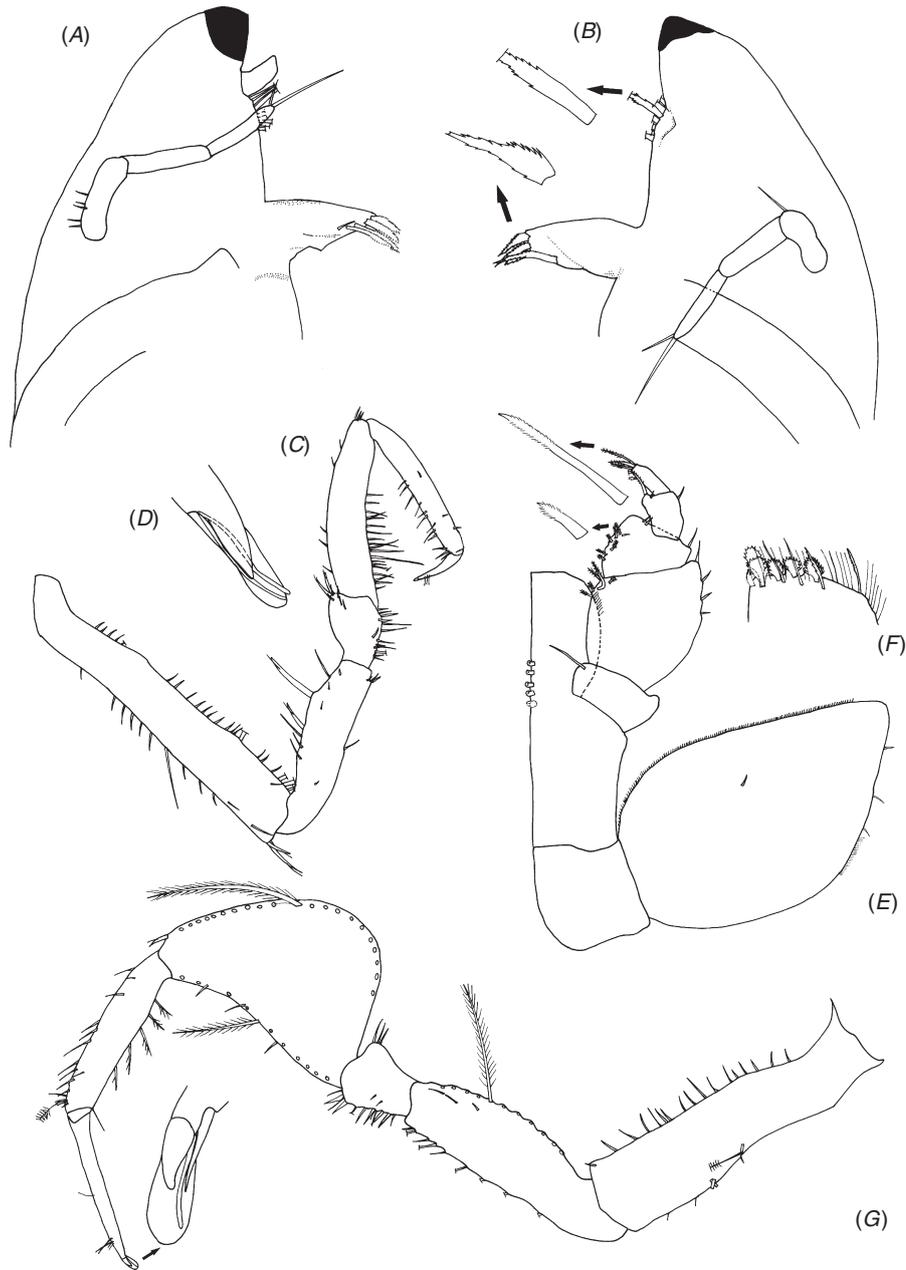
Pereopod 7 basis inferior margin with numerous long SS; ischium, superior margin with weakly plumose setae; carpus with sparsely plumose plumose setae; propodus with one distosuperior PS.

*Pleopods and uropods*. Operculum medial keel with row of RS, distal surface with plumose setae; lateral margins with numerous plumose setae. Pleopod 3 distally with seven long plumose setae; endopod with three long plumose setae. Pleopod 4 exopod distally with three terminal long plumose setae.

Uropod protopod sub-triangular, lateral margin with row of evenly spaced plumose setae distally with six SS and two RS; endopod with three SS and six PS.

#### Remarks

*Bathybadistes andrewsi*, sp. nov. is most similar to *Bathybadistes fragilis*, sp. nov. (described below) and these two species are easily distinguished from all other *Bathybadistes* species by the shape of the lateral margins of pereonites 5–7 and the prominent dorsal spines. They share many similarities, such as having a highly granular body surface, large prominent spines

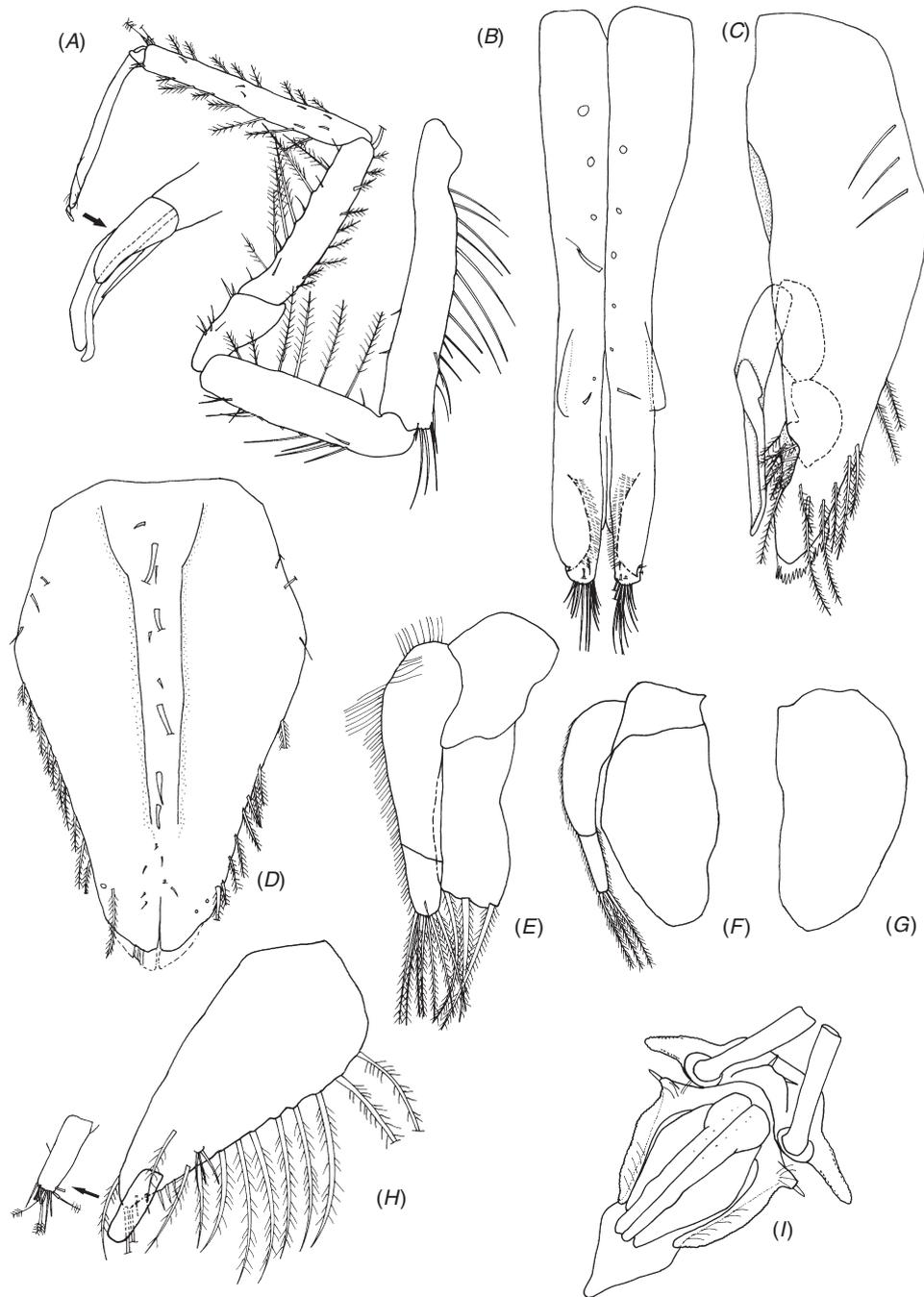


**Fig. 4.** *Bathybadistes andrewsi*, sp. nov. female paratype (NIWA 23811). (A) Left mandible, (B) right mandible, (C) right pereopod 1, (D) unguis of right pereopod 1, (E) left maxilliped, (F) distal part of endite of left maxilliped, (G) left pereopod 5.

on the dorsal surface of the pereonites, narrow and elongate lateral margins of pereonites 5–7 and the distal tip of the pleon pointing upwards in both species. *B. andrewsi* can be distinguished from *B. fragilis* by: the unique dorsal spine pattern on the pereonites and pleon; antenna 1 article 1 with a less angular lateral margin and a different arrangement of setae; no penicillate setae on the basis of pereopod 7; and more long plumose setae on the exopods of pleonites 3 and 4.

The female operculum of the Ilyarachninae has a medial boat-shaped keel that often (but not always) has a row of

robust setae. The SEMs of *B. andrewsi* show that the cuticular surface of the operculum changes (Fig. 6A), with the keel being covered in scales as opposed to the rest of the operculum, which is relatively smooth. The distally pappose setae of the mesial margin of the maxilliped palp have been illustrated for several other species within the family Munnopsidae (for example, see *Coperonus pulcher* Brandt, 1992, *Notopais zealandica* Merrin, 2004, and *Storothyngura parka* Malyutina & Wägele, 2001). SEMs show that such setae are a complex structure of many tiny lobes (Fig. 6C, D). These setae occur in



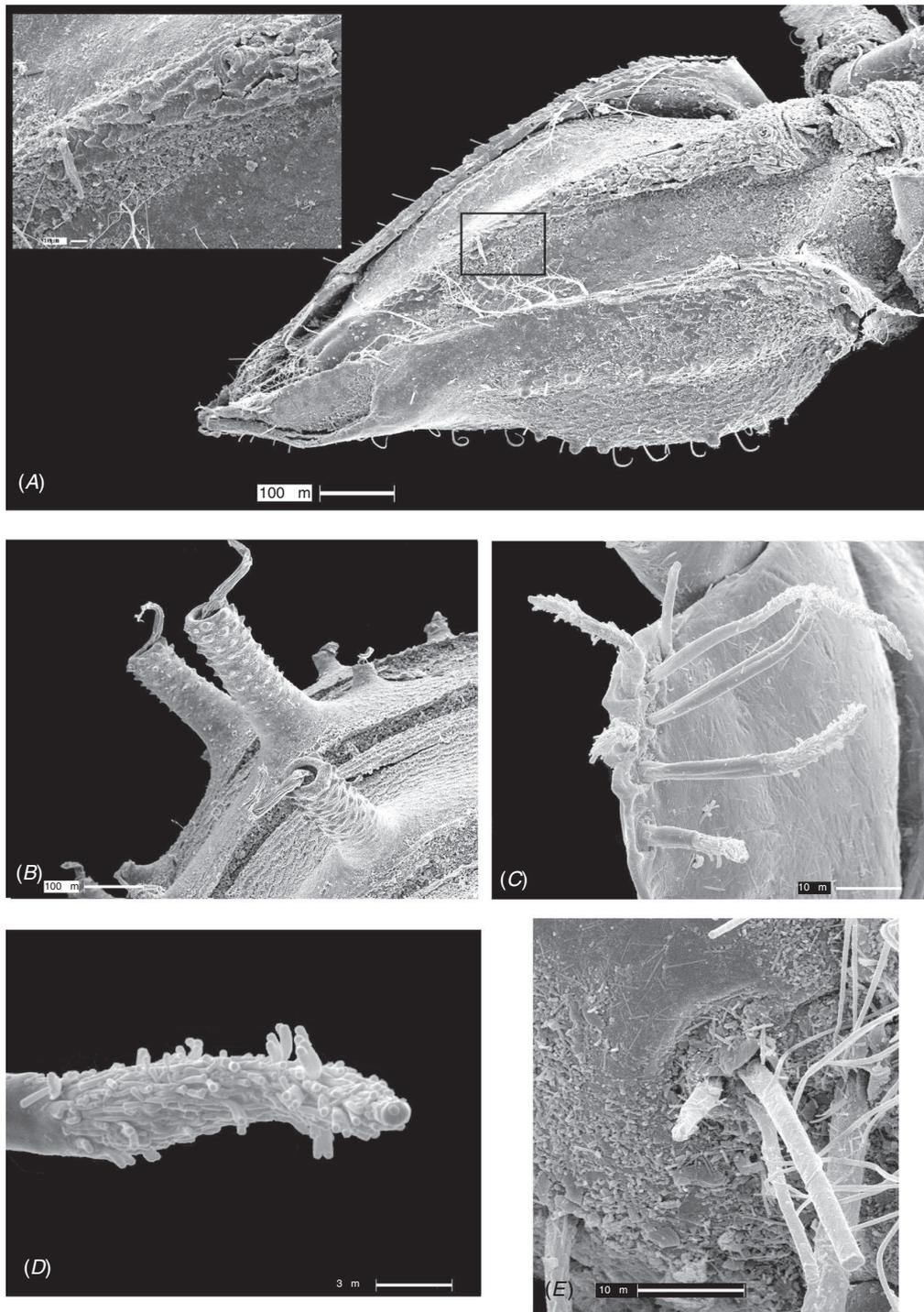
**Fig. 5.** *Bathybadistes andrewsi*, sp. nov. (A, D–H) Female paratype (NIWA 23811), (B, C, I) male paratype (NIWA 23811). (A) Left pereopod 7, (B) pleopod 1, (C) left pleopod 2, (D) operculum, (E) right pleopod 3, (F) right pleopod 4, (G) right pleopod 5, (H) right uropod, (I) ventral view of pleon.

many munnopsid genera, but as yet, their phylogenetic significance is unknown. The rudimentary uropodal exopod of *Bathybadistes* occurs in other genera of the Ilyarachninae (e.g. *Ilyarachna hirticeps* Sars, 1870; see Svavarsson 1988). The exopod of *B. andrewsi* (Fig. 6E) is fused and sunken into the uropod with the setae embedded into it, but whether

this structure is similar to that found in *I. hirticeps* is, as yet, unknown.

#### Distribution

Known only from the type locality.



**Fig. 6.** *Bathybadistes andrewsi*, sp. nov., female paratype (NIWA 23811). (A) The operculum *in situ*. The inset is a higher magnification of the medial keel showing the scales, this surface is notably different to the smoother surface either side. (B) Dorsal spines and setae (which have been affected by the dehydration process) on the anterior pereonites. Notice the difference in scales when comparing the spines with the dorsal surface. (C) Distally pappose setae on the mesial margin of article 3 of the maxilliped palp. (D) A close-up of a distally pappose seta; E, the rudimentary exopod embedded into the uropodal protopod.

*Etymology*

For Neil Andrews, SEM technician at the University of Canterbury, in thanks and recognition of his assistance to the first author.

*Material examined*

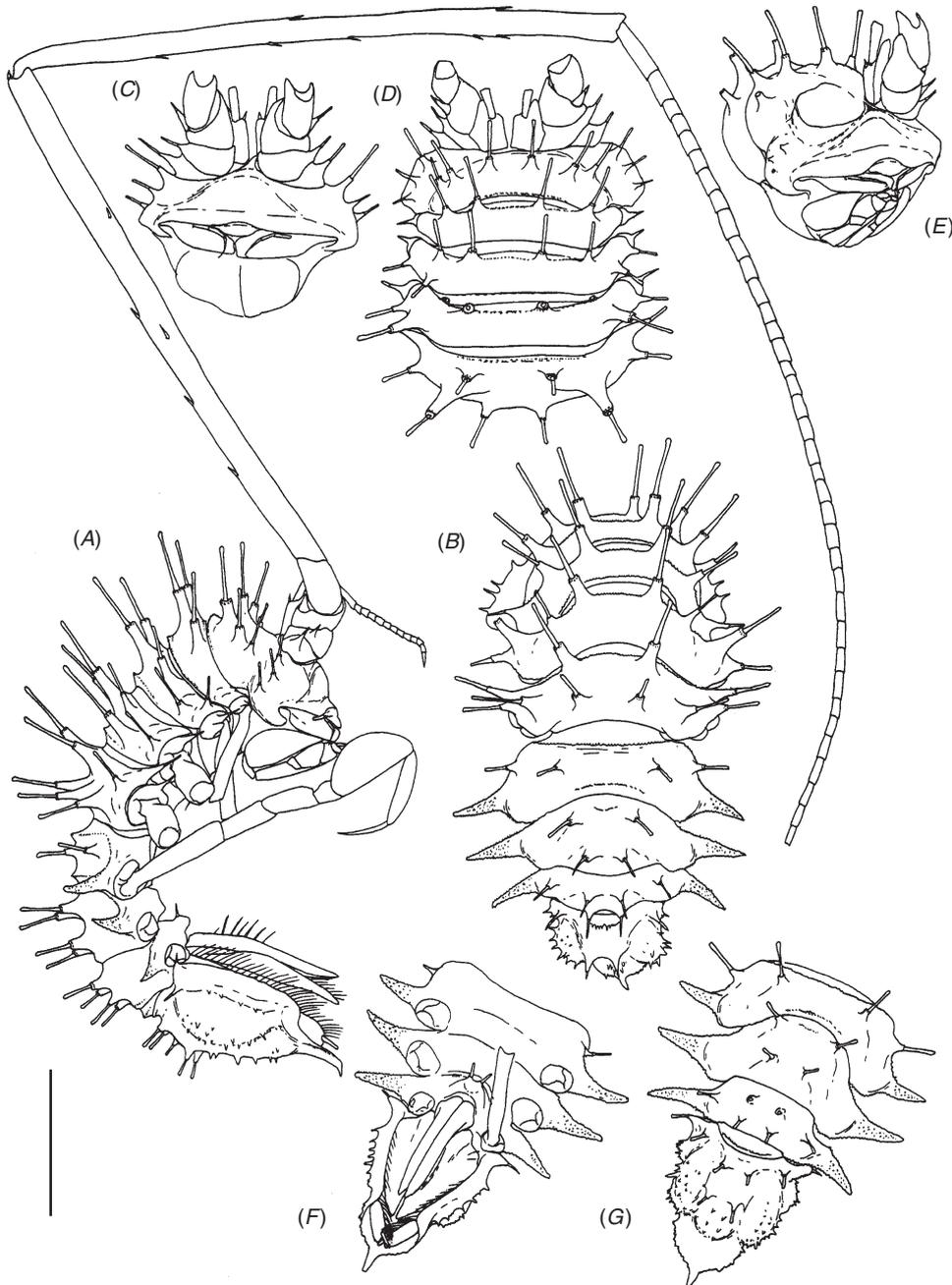
*Holotype*. ♂ (dissected; 4.9 mm), Stn 136-4-S, northern Weddell Sea, Antarctica, 64°01.45–01.51'S, 39°6.66–06.88'W, 4742–4745 m, R.V. *Polarstern* (ZHM K-40785).

*Description of holotype*

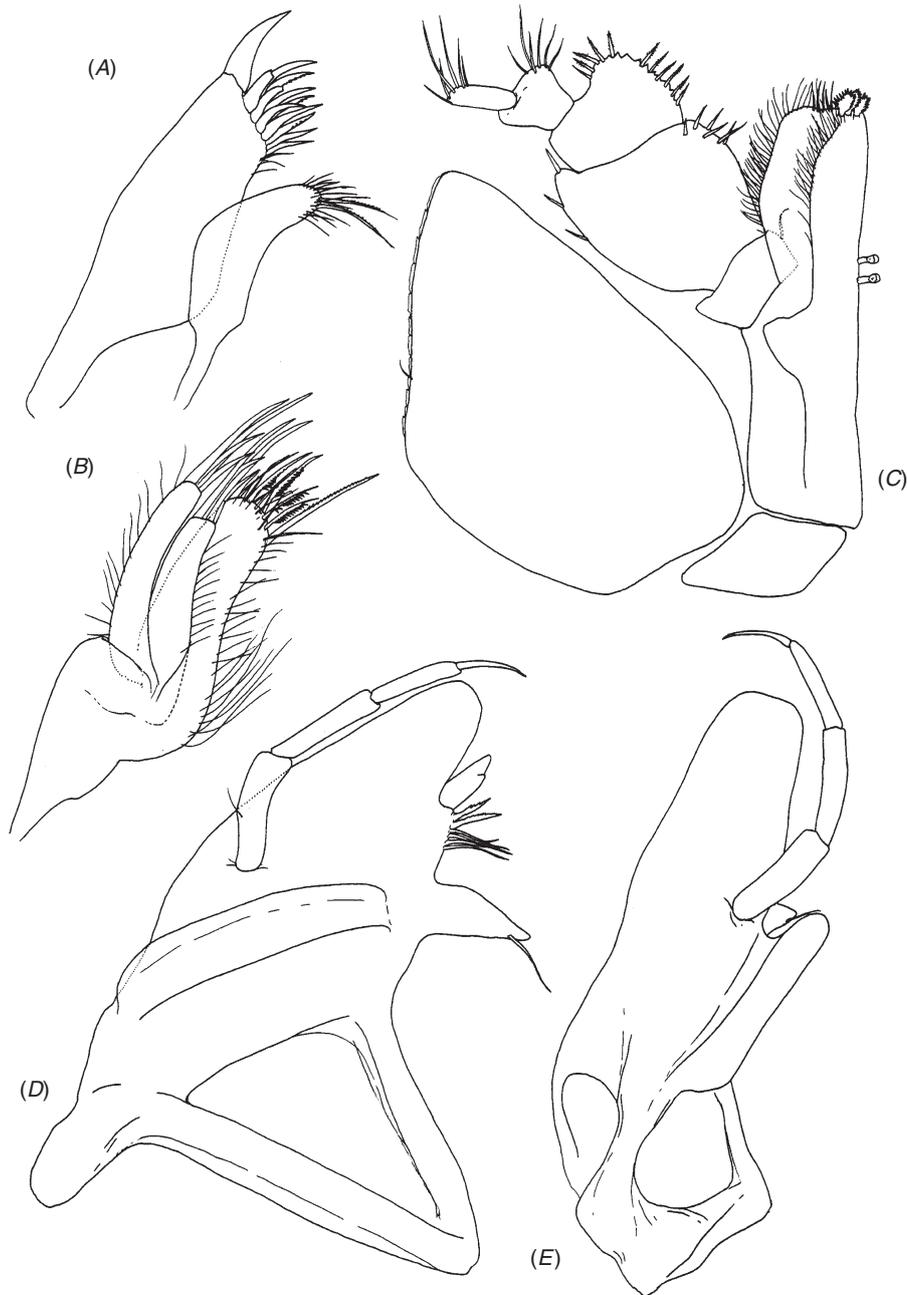
*Body*. Cuticle calcified, granulated. Cephalon with six dorsal and six lateral spines; posterolateral margins broadly truncate. Pereonites 1–3 each dorsally with four well

***Bathybadistes fragilis***, sp. nov.

(Figs 7–11)



**Fig. 7.** *Bathybadistes fragilis*, sp. nov., male holotype (ZMH K-40785). (A) Lateral view, (B) dorsal view, (C) frontal view of cephalon, (D) dorsal view of anterior half, (E) oblique frontal view of cephalon, (F) ventral view of pleon, (G) dorsal view of pleon. Habitus scale bar = 1 mm.



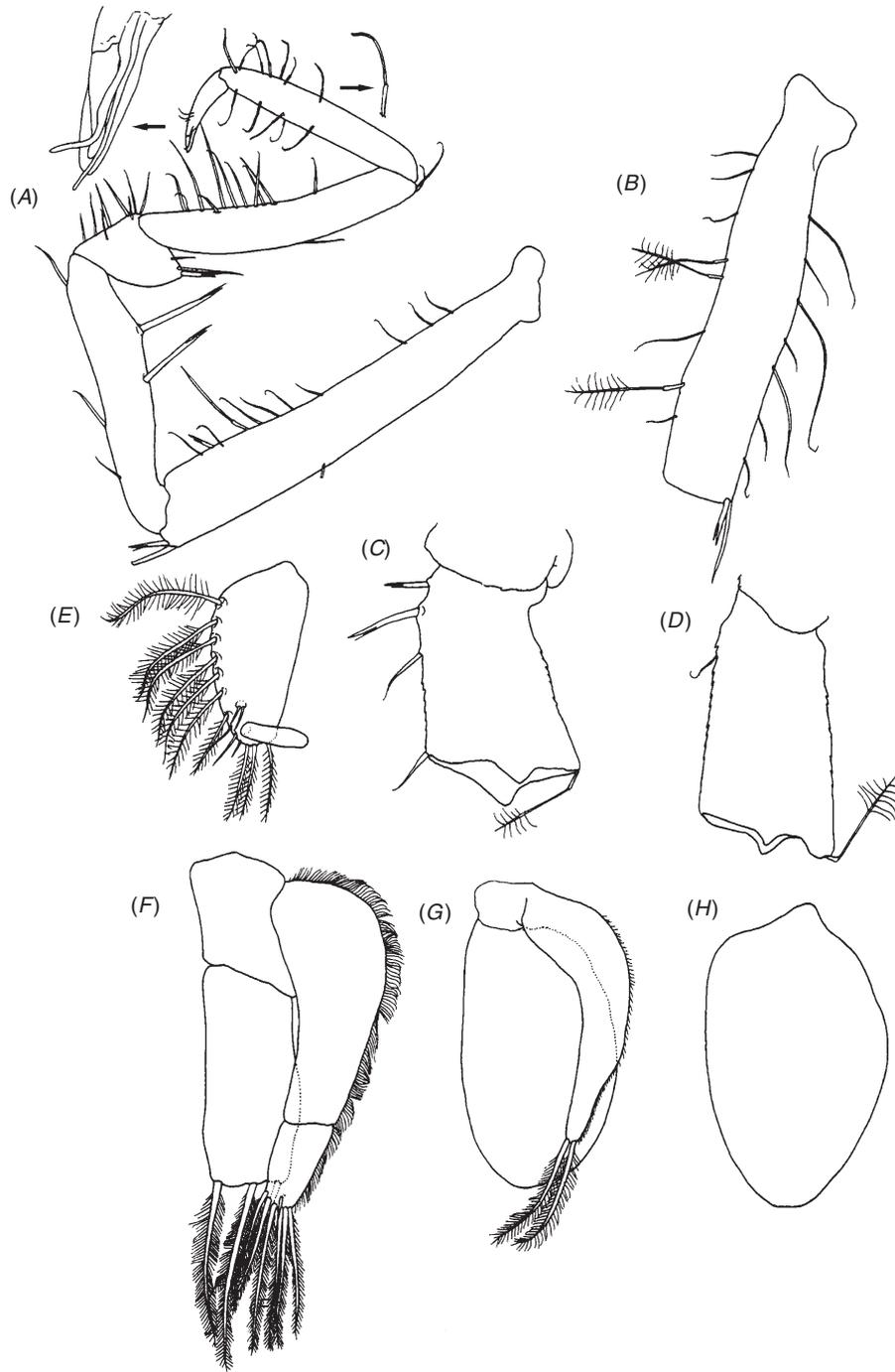
**Fig. 8.** *Bathybadistes fragilis*, sp. nov., male holotype (ZMHK-40785). (A) Left maxilla 1, (B) left maxilla 2, (C) left maxilliped, (D) left mandible, (E) lateral view of left mandible.

developed spines near anterior margin, pereonite 4 anteriorly with two spines and posteriorly with four. Pereonites 2–4 with two pairs of lateral spines (one pair is sub-marginal). Coxae of pereopods 1–4 with anterolateral spines. Pereonite 5 with pair of dorsal spines. Pereonites 6 and 7 with two pairs of dorsal spines, pereonites 5 and 7 each with additional pair of sub-marginal lateral spines. Pereonite 7 ventrally with two spines on central swelling between pereopods. Pleon anterior two-thirds rounded, swollen, with six dorsal spines, distal third triangular, flattened, coming to a narrow posterior tip, which points up.

*Antennae.* Antenna 1 of 21 articles; article 1 distolateral lobe distally truncated, mesial margin with one PS and one RS, surface with two PS, lateral margin with one RS and two SS, distal margin with one SRS and one PS; article 2 with two distolateral PS.

Antenna 2 article 2 with lateral spine smaller than found in article 1.

*Mouthparts.* Mandible lacinia mobilis with two small cusps; spine row with six spines; mandibular palp extending beyond incisor. Maxilliped basis 3.7 times as long as wide



**Fig. 9.** *Bathybadistes fragilis*, sp. nov., male holotype (ZMHK-40785). (A) Left pereopod 1, (B) basis of left pereopod 2, (C) basis of left pereopod 3, (D) basis of left pereopod 4, (E) left uropod, (F) left pleopod 3, (G) left pereopod 4, (H) left pereopod 5.

(including endite); endite with two coupling hooks; palp article 2 with distal group of setae; epipod 1.6 times as long as wide, and 1.1 times as long as basis, lateral margin cuticular scales and one SS.

*Pereopods.* Pereopod 1 basis inferior margin with one distal PS, superior margin with two distal SRS; ischium superior margin

with two long SRS; merus distosuperior margin with one SRS and two SS; propodus with all SS in distal half.

Pereopod 5 basis two distal SRS, mesial surface with three PS; ischium inferior margin with eight RS; merus inferior margin with seven RS; plumose setae on ischium, carpus and propodus are heavily plumose.



**Fig. 10.** *Bathybadistes fragilis*, sp. nov., male holotype (ZMH K-40785). (A) Left pereopod 5, (B) left pereopod 6, (C) left pereopod 7.

Pereopod 6 basis inferior margin with two PS, superior margin with evenly spaced long SS; ischium inferior margin with eight RS; carpus distosuperior margin with one SRS; propodus superior margin lacking plumose setae; plumose setae on ischium, carpus and propodus are heavily plumose.

Pereopod 7 superior margin with five sub-marginal PS in proximal half; ischium inferior margin with evenly spaced SS; carpus and propodus superior margins lacking plumose setae; propodus with one distosuperior PS.

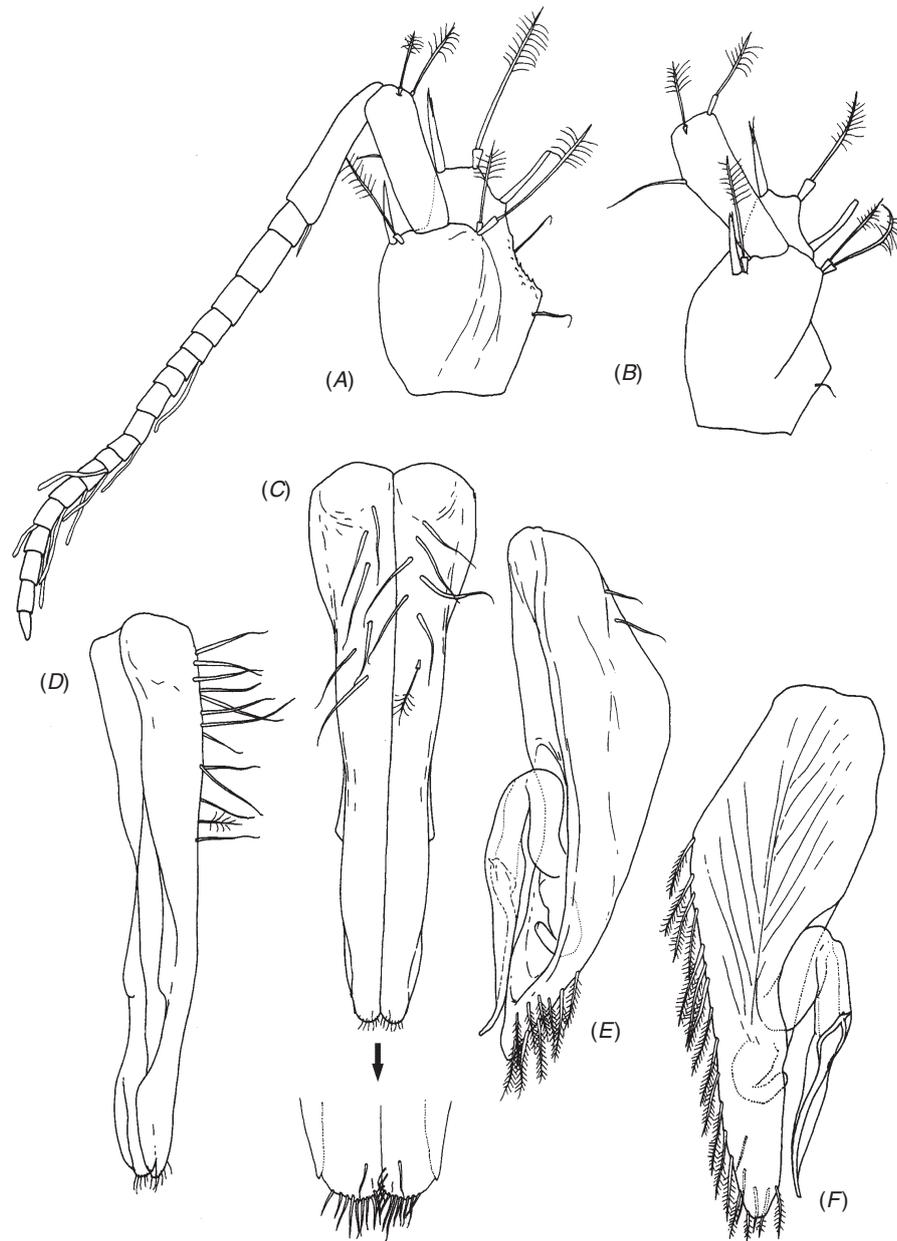
*Pleopods and uropods.* Pleopod 1 with SS scattered randomly in proximal half, distal ends with numerous small SS. Pleopod 2 protopod lateral margin with row of plumose setae in distal two-thirds; exopod elongate and hooked; stylet

0.6 times as long as protopod, not extending past protopod, terminating to a narrow point. Pleopod 3 exopod distally with six long plumose setae and one sub-marginal SS; endopod with three long plumose setae. Pleopod 4 exopod distally with two long plumose setae.

Uropod protopod sub-triangular, lateral margin with row of long plumose setae and three distal SS; exopod with two SS.

#### Remarks

*Bathybadistes fragilis*, sp. nov. is most closely related to *B. andrewsi*. For further discussion, refer to remarks section for *B. andrewsi*.



**Fig. 11.** *Bathybadistes fragilis*, sp. nov., male holotype (ZMH K-40785). (A) Left antenna 1, (B) lateral view of left antenna 1, (C) pleopod 1, (D) lateral view of pleopod 1, (E) pleopod 2, (F) dorsal view of pleopod 2.

#### Distribution

Known only from the type locality.

#### Etymology

From Latin, *fragilis*, referring to the fragility of these animals.

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