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Carraroenia ruthae gen. et sp. nov. (Copepoda, Harpacticoida, Laophontidae) from maerl substrates of the Irish west coast

EDWARD McCORMACK
Zoology Department, National University of Ireland, Galway, Ireland. E-mail: eddiemccormack@yahoo.com

Abstract

Carraroenia ruthae gen. et **sp. nov.** is described from maerl beds at An Dóilín, Carraroe, County Galway, Ireland. This genus is considered to be closely related to the genus group comprising *Psammplatypus*, *Coullia*, *Phycolaophonte*, *Hemilaophonte* and *Robustunguis*, which had been linked based on the reduced P2 endopod and the primitive setation of the male P5 baseoendopod. *Carraroenia* is regarded as the most primitive genus of this lineage, as evidenced by the 3-segmented male P3 endopod, the lack of reduction in the P3–P4 endopods, the retention of the inner seta on P2–P4 exp-2 and the presence of 2 inner setae in P4 enp-2.

Key words: Copepoda, Harpacticoida, *Carraroenia* gen. nov., maerl, Ireland.

Introduction

Maerl beds in the northeast Atlantic are concentrated on the westernmost coasts of Europe. In Irish waters, they occur along the southwest and west coasts, most notably Bantry Bay, County Cork and Galway Bay (Maggs 1983). Maerl beds are made up of slow-growing, free-living, unsegmented coralline algae. The maerl beds of Brittany and the Mediterranean have long been recognised as communities with a particularly high diversity of plant and animal species. The branching of maerl thalli provides a three dimensional structure for small plant and animal species, and the communities in the maerl deposits are much richer than those on gravel or shell bottoms of an equivalent granulometry (Cabioch 1969). The macrofauna of Irish maerl beds have been extensively studied (Keegan 1974; Bosence 1979; Könnecker & Keegan 1983; O'Connor *et al.*, 1993; De Grave 1999) but the meiofauna remains unknown. Frequent use of large mesh sizes (>0.5 mm) for sieving of samples typically results in the absence of meiofauna from benthic community studies. During a study of the harpacticoid copepods of the maerl beds

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at Carraroe, County Galway, a number of new taxa were discovered. A new genus and species of Laophontidae Scott, 1905 is described herein.

Study Area

The maerl bed studied is located on the northern shore of Galway Bay on the Irish west coast. The geographic coordinates of the area are 53°15' N, 9°38' W. The sampling site at Coral Strand, An Dóilín, Carraroe, County Galway is a beach composed entirely of dead fragments of maerl, primarily *Phymatolithon calcareum* with some *Lithothamnion corallioides.*

Material and methods

Material was collected on May 22, 2001. Specimens were collected by gathering maerl debris and interstitial water from exposed maerl banks at low tide. Filtered seawater was added to wash the maerl in the lab. Washings were filtered through a 63 µm mesh sieve to extract the meiofauna. Animals were fixed and preserved in 10% buffered formalin. Copepods were dissected in lactic acid and mounted in lactophenol mounting medium. Preparations were sealed with clear varnish. All illustrations were drawn with the aid of a drawing tube on a Leitz Diaplan microscope with differential interference contrast. The descriptive terminology for the segmentation and armature of appendages is adopted from Huys and Boxshall (1991). Abbreviations used throughout the text are: P1–P6 for swimming legs 1–6; ae for aesthetasc; exp, exopod; enp, endopod; exp(enp)-1(2, 3) to indicate the proximal (middle, distal) segment of a ramus.

Order Harpacticoida Sars, 1903

Family Laophontidae Scott, 1905

Subfamily Laophontinae Lang, 1944

Genus *Carraroenia* gen. nov.

Diagnosis

Laophontidae. Body elongate, cylindrical, not dorsoventrally depressed. Posterolateral corners of cephalothorax produced into lobate extensions. Posterior margin of cephalothorax and pedigerous somites with rows of long sensillae interspersed with small setules. Genital double-somite with transverse surface ridge with row of setules and pairs

of sensillae dorsally and laterally indicating original segmentation. Genital field with copulatory pore located medially with cone-shaped extension. Anal operculum well developed. Rostrum bell-shaped, defined at base. Antennule without spinous processes on segment 2; 6-segmented in ♀, 8-segmented and subchirocer in ♂; aesthetascs on segments 4 and 7 in ♀, and 5 and 8 in ♂; apical trithek consisting of small aesthetasc and 2 setae. Antennary exopod well developed with 4 setae. Mandibular palp small with exopod and endopod fused to basis, represented by 1 and 3 naked setae respectively; basal armature represented by naked seta. Maxillule with seta and spine on coxa; basis with 2 setae and 1 spine; endopod incorporated into basis, represented by 3 setae; exopod with 2 setae. Maxillary syncoxa with 2 cylindrical endites each with 3 setae; praecoxal endite absent; allobasis drawn out into strong, slightly curved distally pinnate claw; accessory armature consisting of 2 naked setae; endopod small with 3 naked setae. Maxilliped with 2 setae on syncoxa; endopodal claw long, bearing seta at base. Swimming legs P1–P4 with 3-segmented exopods and 2-segmented endopods (except ♂ P3 endopod is 3-segmented); chaetotaxy of swimming legs described below. P5 with separate exopod and baseoendopod; exopod elongate with 6 setae in ♀ (2 proximal setae superimposed), 5 in ♂; endopodal lobe well developed, subrectangular with 4 setae in ♀, rudimentary with 2 setae and 1 tube pore in ♂. P6 forming well developed opercula with small seta in ♀; asymmetrical in ♂ represented on both sides by small plate (fused to ventral wall of supporting somite along one side; articulating at base and covering gonopore along other side), outer distal corner produced into cylindrical process bearing 2 setae. Caudal rami cylindrical, more than 5 times longer than wide. Sexual dimorphism in antennule, P3, P4, P5, P6 and genital segmentation.

***Carraroenia ruthae* gen. et sp. nov.**
(Figures 1–6)

Material examined

Two females and one male from Coral Strand, An Dóilín, Carraroe, County Galway, Ireland (53°15’ N, 9°38’ W), collected by E. McCormack, 22 May 2001.

Holotype: adult female (BNHM 2004.69), completely dissected and mounted on 4 slides.

Paratypes: adult female (BNHM 2004.70) and adult male (BNHM 2004.71) dissected and mounted on 4 and 5 slides respectively. All specimens deposited in the British Natural History Museum, London.

Etymology

The genus name alludes to the type locality at Carraroe, County Galway. The type species is named after the author’s little sister Ruth.

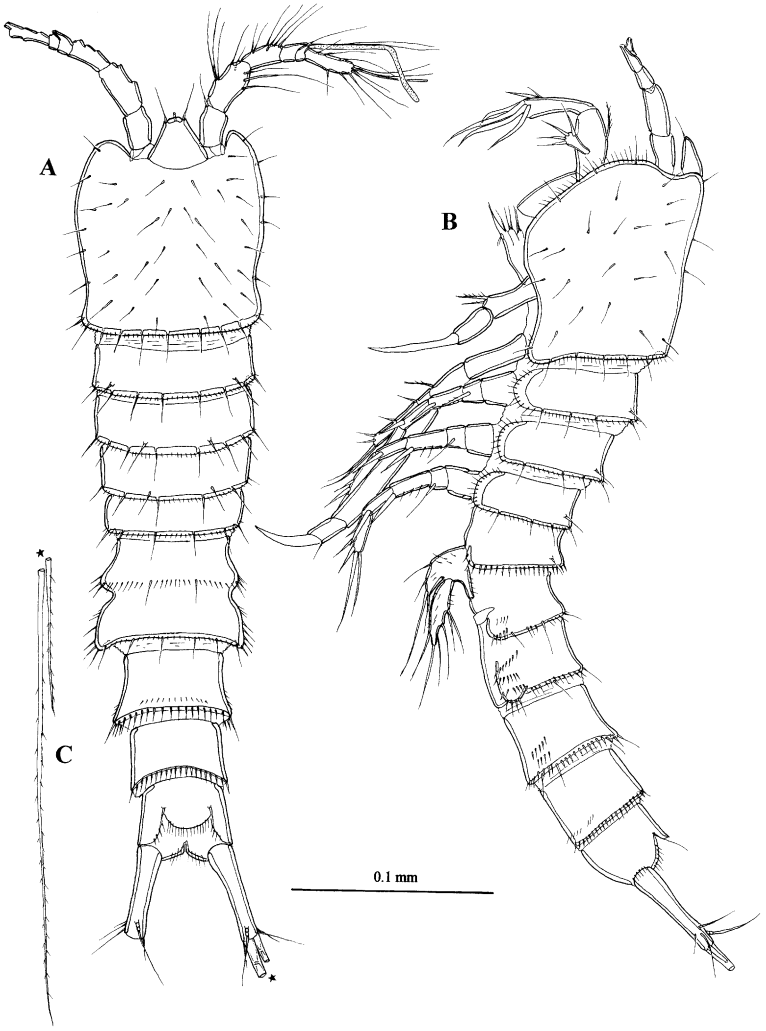

FIGURE 1. *Carraroenia ruthae* **gen. et sp. nov.**, female (holotype): A, habitus, dorsal; B, habitus, lateral; C, caudal setae IV and V.

Description of female

Body length measured from anterior margin of cephalothorax to posterior margin of caudal rami 410 µm. Maximum width measured midway along cephalothorax, 94 µm. Body (Figs 1A–C) cylindrical, not dorsoventrally depressed, tapering slightly posteriorly. Cephalothorax marginally wider than free somites, with symmetrical distribution of sensillae. Posterolateral corners of cephalothorax produced into lobate extensions. Posterior margin of cephalothorax and pedigerous somites with rows of long sensillae interspersed with small setules. Urosome 5-segmented, comprising P5-bearing somite, genital double-somite and 3 free abdominal somites. Posterior ventral margins of urosomites, penultimate and anal somites excepted, with large spinules.

Genital double-somite with transverse surface ridge with row of setules and pairs of sensillae dorsally and laterally indicating original segmentation; completely fused ventrally. Genital field (Fig. 2F) with copulatory pore located medially, with cone-shaped extension. Gonopores covered by opercula derived from sixth legs. P6 bearing small, naked seta.

Anal somite (Fig. 2G) with well developed operculum-bearing row of fine spinules and flanked by pair of sensillae.

Caudal rami (Fig. 2G) cylindrical, length more than 5 times width; each ramus with 7 setae: seta I naked, shortest; seta II and III naked; seta IV and V (Fig. 1C) well developed, bipinnate with fracture planes (seta V longest; longer than urosome); seta VI naked; seta VII located dorsally, naked and triarticulate at base. Each ramus with row of spinules on distal ventral surface.

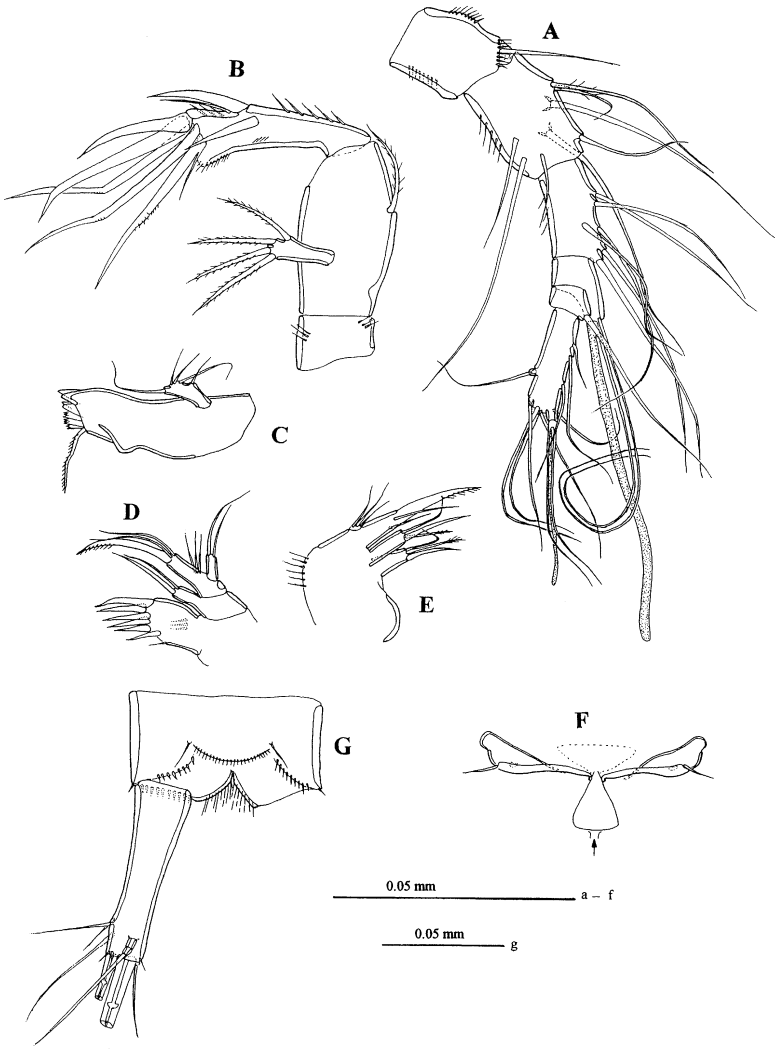

FIGURE 2. *Carraroenia ruthae* gen. et **sp. nov.**, female (holotype): A, antennule; B, antenna; C, mandible; D, maxillule; E, maxilla; F, genital field; G, caudal rami.

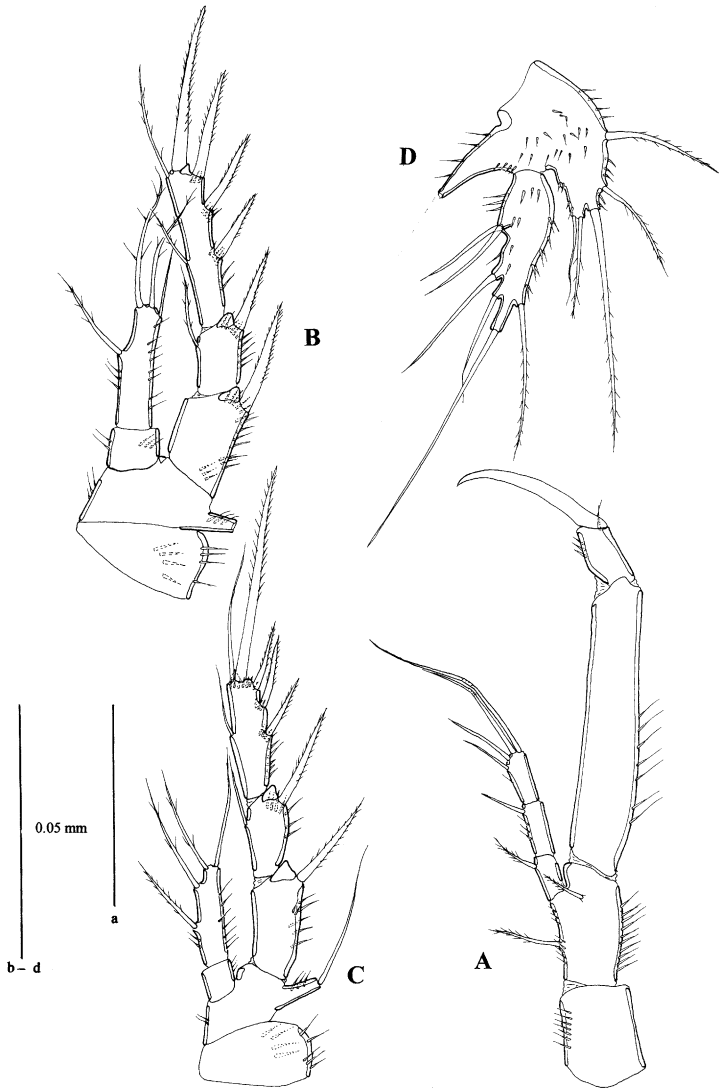

FIGURE 3. *Carraroenia ruthae* gen. et **sp. nov.**, female (holotype): A, P1; B, P3; C, P4; D, P5.

Rostrum (Fig. 1A) bell-shaped, delimited at base by transverse suture; with pair of sensillae and tube pore apically.

Antennule (Fig. 2A) 6-segmented. Segment 1 with spinular rows on anterior and posterior margins and anterior distal corner. Segments 2 and 3 equal length with rows of spinules on posterior margin. Segment 4 with pedestal bearing aesthetasc fused basally to naked seta. Armature formula: 1-[1], 2-[7 + 1 pinnate], 3-[6], 4-[1 + (1 + ae)], 5-[1], 6-[9 + trithek]. Apical trithek consisting of small aesthetasc fused to 2 naked setae.

Antenna (Fig. 2B) 3-segmented, comprising coxa, allobasis and free 1-segmented endopod. Coxa with rows of spinules on anterior and posterior margins. Allobasis robust with 1 pinnate abexopodal seta in distal half. Exopod slender with 4 elongate pinnate setae

(2 laterally, 2 apically). Endopod of equal length with allobasis; lateral armature arising in distal half, consisting of 2 naked spines and 1 long, naked seta; apical armature consisting of 2 naked spines and 3 geniculate setae, outermost fused at base to small naked seta. Endopod with rows of spinules on anterior and posterior margins.

Mandible (Fig. 2C) with robust gnathobase bearing 2 bicuspidate and several multicuspidate teeth around distal margin and long, pinnate seta at distal corner. Palp with exopod and endopod fused to basis, represented by 1 and 3 naked setae respectively; basal armature represented by naked seta.

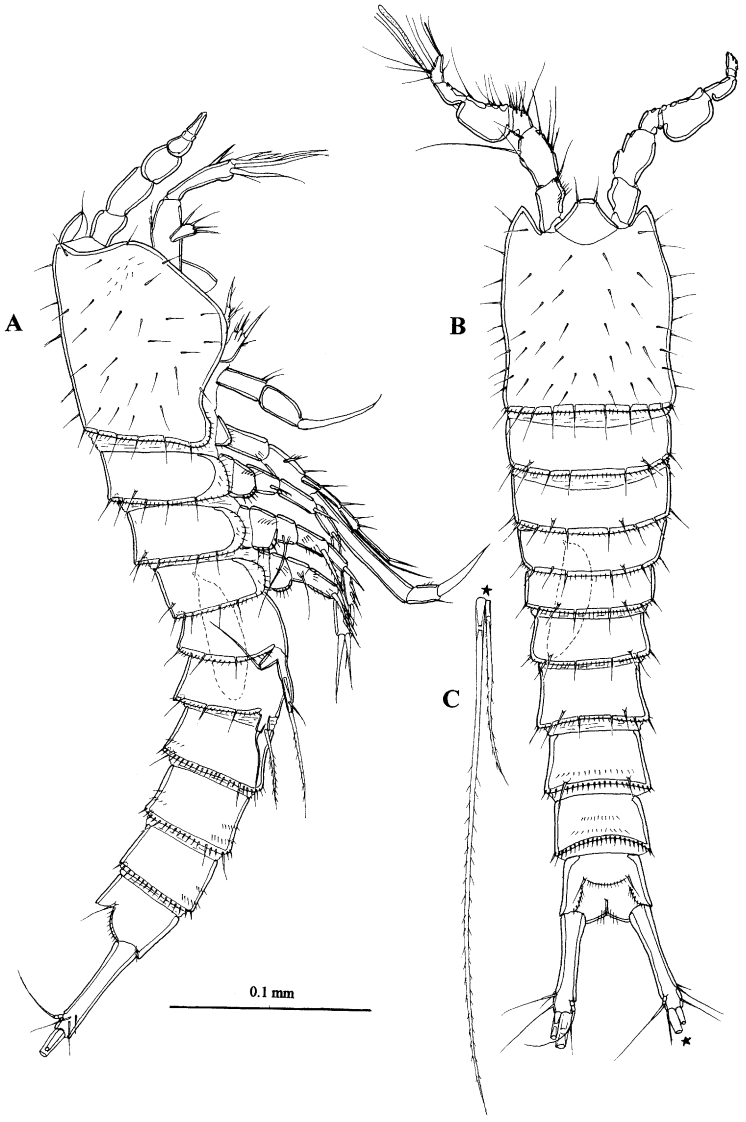

FIGURE 4. *Carraroenia ruthae* gen. et **sp. nov.**, male (paratype): A, habitus, lateral; B, habitus, dorsal; C, caudal setae IV and V.

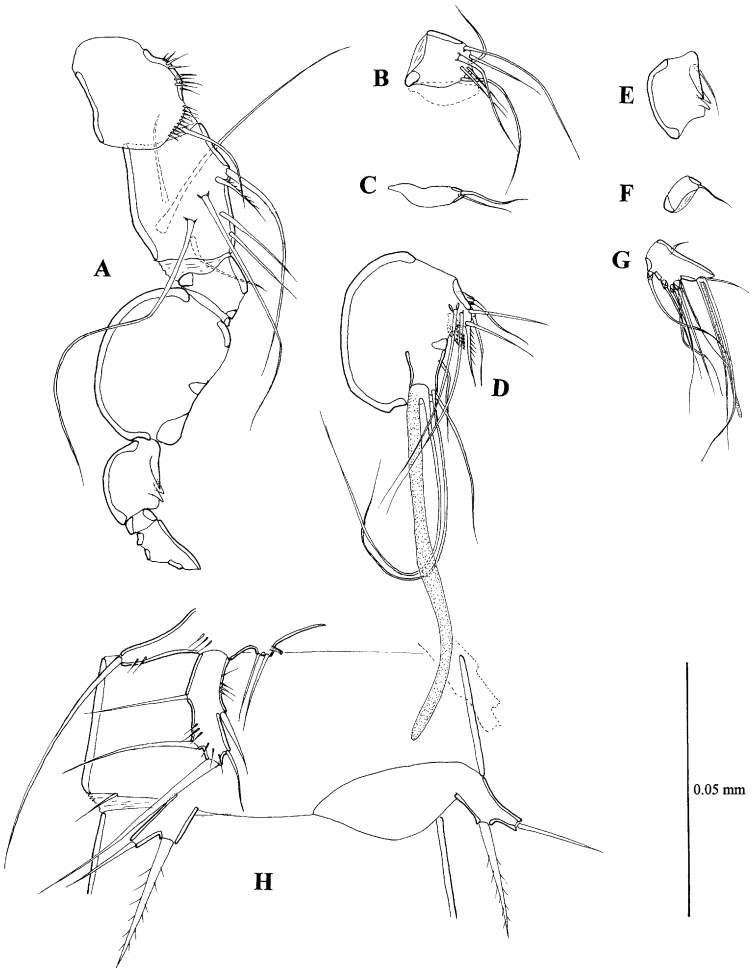

FIGURE 5. *Carraroenia ruthae* gen. et **sp. nov.**, male (paratype): A, antennule; B–G, antennulary segments 3–8; H, P5 and P6.

Maxillule (Fig. 2D) small with praecoxal arthrite bearing row of spinules on anterior surface and 7 elements around distal margin. Coxa with cylindrical endite bearing naked spine and naked seta. Basal endite produced into strong pinnate claw with 2 naked accessory setae. Endopod incorporated into basis, represented by 3 naked setae. Exopod 1-segmented with 1 long and 1 shorter, naked seta.

Maxilla (Fig. 2E), syncoxa with row of spinules around outer margin; with 2 cylindrical endites. Praecoxal endite absent. Proximal endite with naked spine, 1 naked and 1 bipinnate seta; armature of distal endite same as for proximal endite. Allobasis strong with pinnate claw, slightly curved distally; accessory armature 2 naked setae. E ndopod small with 3 naked setae.

Maxilliped (Fig. 6D) with 2 bipinnate setae at distal end of syncoxa and rows of spinules on outer margin and anterior surface. Basis length almost 3 times width, with row

of spinules on outer margin. Endopod drawn out into long claw; accessory armature consisting of proximal naked seta.

P1 (Fig. 3A), coxa large with row of spinules along outer margin. Basis with bipinnate spine on distal pedestal, bipinnate spine along outer margin and rows of spinules along outer and inner margins. Exopod 3-segmented; exp-1 with bipinnate spine; exp-2 with naked outer spine; exp-3 with 2 naked spines and 2 geniculate setae. Endopod 2-segmented; enp-1 twice as long as exopod, with long spinular rows along inner margin; enp-2 with strong claw and small, naked seta.

P2–P4 (Figs 3B–C, 6A). Coxae with spinular rows along outer margin. Bases with spinular rows along inner and outer margins; outer margin of basis with bipinnate spine (P2) or naked seta (P3–P4). Exopods 3-segmented, endopods 2-segmented. Outer margins of exopods, and outer and inner margins of endopods with rows of spinules as figured. Armature formula:

	Exopod	Endopod (female)	Endopod (male)
P2	0.1.023	0.010	0.010
P3	0.1.123	0.121	0.0.020
P4	0.1.123	0.220	0.111

P5 (Fig. 3D) with separate exopod and baseoendopod, each with sparse spinular ornamentation as figured. Baseoendopod forming long outer setophore bearing basal, naked seta (lost during dissection). Endopodal lobe with 2 apical setae (1 naked, 1 bipinnate) and 3 lateral, bipinnate setae. Exopod elongate, length approximately 4 times width; bearing 6 setae (innermost bipinnate); apical seta considerably longer than others and set on a tubular extension; 2 proximal setae superimposed.

Description of male

Body (Figs 4A–C) length measured from anterior margin of rostrum to posterior margin of caudal rami 404 µm. Maximum width measured at posterior margin of cephalothorax 87 µm. Sexual dimorphism in antennule, P3, P4, P5, P6 and genital segmentation. Thoracic somites as in female. Urosome 6-segmented, comprising P5-bearing somite, genital somite and 4 free abdominal somites.

Antennule (Figs 5A–G) 8-segmented; subchirocer with geniculation between segments 5 and 6. Segment 1 with rows of spinules along anterior margin and anterior distal corner. Segment 4 (Fig. 5C) represented by small sclerite along anterior margin. Segment 5 swollen. Armature formula: 1-[1], 2-[8 + 1 pinnate], 3-[7], 4-[2], 5-[9 + 1 pinnate + 1 modified + (1 + ae)], 6-[1 + 3 spinous processes], 7-[1], 8-[8 + trithek]. Apical trithek consisting of small aesthetasc and 2 naked setae.

P2–P4 (Figs 6B–C) exopods 3-segmented, endopods 2-segmented in P2 and P4 and 3-segmented in P3. P2 as in female (Fig. 6A). P3 (Fig. 6B) enp-1 without seta; enp-2

produced into bifurcate apophysis; enp-3 with short, naked inner seta and long, bipinnate outer seta located apically. P4 (Fig. 6C) exp-1 and exp-2 with modified spines. Enp-1 without seta; enp-2 with 3 apical, bipinnate setae.

P5 (Fig. 5H) fused medially; defined at base. Baseoendopod with setophore bearing long, naked seta, and rudimentary endopodal lobe bearing 2 naked setae and inner tube pore; few spinular rows along surface. Exopod length approximately 3 times width; with 5 naked setae (2 outer, 1 apical and 2 inner); sparse spinular ornamentation on anterior surface as figured.

P6 (Fig. 5H) asymmetrical; represented on both sides by small plate (fused to ventral wall of supporting somite along one side; articulating at base and covering gonopore along other side); outer distal corner produced into cylindrical process bearing bipinnate inner spine and outer naked seta.

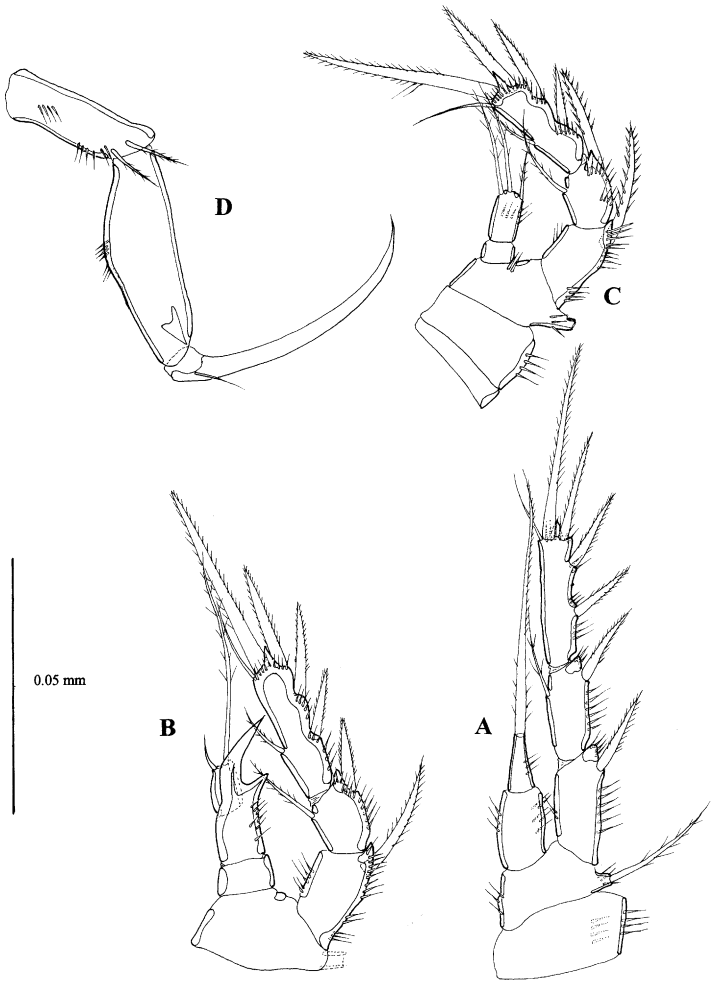

FIGURE 6. *Carraroenia ruthae* gen. et **sp. nov.**, female (holotype): A, P2; male (paratype): B, P3; C, P4; female (holotype): D, maxilliped.

Discussion

Some notable features of *Carraroenia ruthae* **gen. et sp. nov.** include the reduced endopod of the P2, the nature of the apophysis in the male P3 endopod and the sexual dimorphism of the P4 endopod. The two superimposed, proximal setae on the female P5 exopod are known in other unrelated members of the Laophontidae (members of the Esolinae as well as *Laophonte parvula* Sars, 1908) and their presence in *C. ruthae* is probably because of convergence.

Other members of the Laophontidae possessing a reduced P2 endopod include: *Laophonte acutirostris* Lang, 1965; *Arenophonte stygia* Lang, 1965; *Coullia heteropus* Hamond, 1973; *Coullia platychelipes* (Noodt, 1958); *Coullia clysmae* (Por & Marcus, 1972); *Phycolaophonte insularis* Pallares, 1975; *Hemilaophonte janinae* Jakubisiak, 1932; *Robustunguis ungulatus* Fiers, 1992b; *Robustunguis minor* Fiers, 1992b; *Psammoplatypus discipes* (Noodt, 1958) and *Psammoplatypus propius* (Lang, 1965).

Laophonte acutirostris was regarded by Lang (1965) as occupying an intermediate position in the Laophontidae between the *denticornis* and *inopinata* groups. A close relationship with *Carraroenia* is considered unlikely due to such features as the shape and setation of the P5, the lack of a spinous process on the antennule and the reduced nature of the endopods of P3 and P4.

Arenolaophonte holds an isolated position within the family due to the presence of a terminal spine on the P3-enp of the male (Lang 1965), rather than the typical apophysis (which is homologous with the outer seta of the female P3 enp-2) usually found within the Laophontidae. In *Arenolaophonte* however, there is no inner seta in the female and because of the presence of a transformed seta in the male, it is assumed the inner seta has migrated to a terminal position. This, in conjunction with the variability of setation, the reduced nature of the endopods and the spinous projection on the second segment of the antennule, would preclude a close relationship with *Carraroenia*.

In their discussion of the polyphyly of *Paronychocamptus*, Lee & Huys (1999) established the genus *Psammoplatypus* to accommodate *Klieonychocamptus discipes* Noodt, 1958 and *Paronychocamptus propius* Lang, 1965. This new genus was placed in the genus group comprising *Coullia, Phycolaophonte, Hemilaophonte* and *Robustunguis* (CPHR), which had been linked by Fiers (1992a, 1992b) based on the reduced P2 endopod. In general, within the Laophontidae, the endopodal lengths decrease from P2 towards P4 and if any endopod is smaller than the others it is typically the P4 endopod. This is not the case in the genera *Coullia*, *Phycolaophonte*, *Hemilaophonte* and *Robustunguis*, where the P2 endopod is the most reduced. Members of the CPHR lineage share other synapomorphies in addition to the reduced P2 endopod. Males of these genera have a 2-segmented P3 endopod, typically bearing a slightly curved apical or subapical apophysis on the distal segment, which is closely associated with 2 terminal setae. They possess 6 setae on the female P5 exopod and 5 setae in the male (Table 1). Lee & Huys (1999) demonstrated the close relationship of *Psammoplatypus* to the CPHR lineage,

TABLE 1. Genera related to *Carraroenia* gen. nov. Female antennule segmentation and armature of P2–P5 of both sexes. exp = exopod; enp = endopod; b = baseoendopod.

	Sex	A1	P2 exp	P2 enp	P3 exp	P3 enp	P4 exp	P4 enp	P5 exp	P5 b
Carraroenia	♀	6	0.1.023	0.010	0.1.123	0.121	0.1.123	0.220	6	5
Carraroenia	♂		0.1.023	0.010	0.1.123	0.0.020	0.1.123	0.111	5	2
Psammoplatypus	♀	6	0.0.023	0.020	0.1.023	0.121	0.1.122	0.121	4	5
Psammoplatypus	♂		0.0.023	0.120	0.1.023	0.0.[0–1]20	0.1.023	0.[1–2]2[0–1]	5	2
Phycolaophonte	♀	6	0.0.023	0.020	0.0.023	0.021	0.0.023	0.021	6	5
Phycolaophonte	♂		0.1.023	0.020	0.1.023	0.020	0.0.022	0.021	5	2
Coullia	♀	6	0.0.023	0.020	0.0.023	0.02[0–1]	0.0.022	0.020	6	3–5
Hemilaophonte	♀	6	0.0.023	0.020	0.0.023	0.020	0.022	0.021	6	4
Hemilaophonte	♂		0.0.023	0.020	0.0.023	0.020	0.022	0.021	5	2
Robustunguis[1]	♀	6	0.0.022	010	0.0.022	020	0.0.022	020	6	4
Robustunguis[1]	♂		0.1.022	0.010	0.0.022	020	0.0.022	0.021	5	2

[1]Based on the most primitive species *R. ungulatus* Fiers, 1992

in the reduction of P2 endopod, absence of inner setae on P2–P4 exp-3, sexual dimorphism on P2–P4 exopod involving the reduction of inner distal seta of exp-3, elongate-oval P5 exopod of female, the 6-segmented female antennule, the absence of distinct processes on the first two segments of the antennule and the baseoendopod of the male P5 bearing the ancestral 2 setae. *Psammoplatypus* was considered the most primitive in this lineage, demonstrated by the swimming leg armature, 3-segmented male P3 endopod, retention of the inner seta on P3–P4 exp-2 and the retention of the inner seta on P4 enp-2.

Carraroenia also shares some of these characters with *Psammoplatypus* and the CPHR lineage (PCPHR). It too possesses the reduced P2 endopod, the primitive setation of 6 setae on female P5 exopod and 5 setae on P5 exopod and 2 setae on baseoendopod of male P5. It has a 6-segmented female antennule without spinous processes. Like *Psammoplatypus, Carraroenia* also retains the inner seta on P3–P4 exp-2 and inner setae on P4 enp-2. *Carraroenia* should be regarded as the most primitive genus in the lineage, rather than *Psammoplatypus*, as evidenced by the 3-segmented male P3 endopod, the lack of reduction in the P3–P4 endopods, 2 inner setae on P4 enp-2, the retention of the inner seta on P2–P4 exp-2, and the primitive P5.

While *Carraroenia* shares these characters with the PCPHR lineage, one notable difference is in the structure of the apophysis—a robust bifurcate structure arising from the outer distal edge of the second segment of a 3-segmented endopod. In fact, the only other laophontid species which displays an apophysis similar to *Carraroenia* is *Hoplolaophonte aculeata* Hamond, 1973. A close relationship between these two genera is unlikely however, considering the reduced setation of the distal exopods of the swimming legs, the presence of a spinous process on the second antennular segment, the opercular thorn, the single large terminal furcal seta, the reduced endopod of the P1 and the reduced baseoendopod of the male P5 in *Hoplolaophonte*. Hamond (1973) described *Hoplolaophonte* from *Lithothamnion* substrates at depths of 50–100 m on the continental shelf off Beaufort, North Carolina and considered it to be adapted to the *Lithothamnion* habitat. The similarities of the apophyses in both of these species is probably as a result of convergent evolution and may be an adaptation to their maerl habitat.

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