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Kirnesius groenlandicus (Copepoda, Calanoida): a new genus and new species from the abyssal of the Greenland Sea

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ABSTRACT. – *Kirnesius groenlandicus* gen. et sp. nov. is based on a male specimen collected at abyssal depths above the sea bed in a rift valley of the Knipovich Ridge located in the north-eastern part of the Greenland Sea. Although the new genus shares the presence of sensory setae on maxilla and maxilliped with the clausocalanoidean families Diaixidae, Parkiidae, Phaennidae, Tharybidae and Scolecitrichidae, it does not fit the diagnosis of any of these families. *K. groenlandicus* is only provisionally placed within Phaennidae due to the presence of rudimentary oral parts and the uniramous P5. Segmentation and setation of swimming legs and the structure of the antennule of the new species are typical of the superfamily Clausocalanoidea. The presence of antennulary brush-like aesthetascs is unique in the order Calanoida, and is an apomorphy that separates the new genus from all other described clausocalanoideans.

KEYWORDS: Calanoida; *Kirnesius* gen. nov., benthopelagic, Greenland Sea.

Introduction

Among Copepoda Calanoida a group of clausocalanoidean families possess brush-like sensory setae on maxilla and maxilliped. However, brush-like aesthetascs on the antennule are observed for the first time in a new clausocalanoidean species, *Kirnesius groenlandicus,* of the order Calanoida. In the sub-class Copepoda aesthetascs with brush-like tips in the proximal part of antennule are reported in several species of cyclopoids *Eucyclops* CLAUS, 1893, *Macrocyclops* CLAUS, 1893 and *Austriocyclops* KIEFER, 1964 (KIEFER 1978; POSPISIL & STOCH 1997) and in the poecilostomatoid copepod *Pachos* (GIESBRECHT 1892; MORI 1964).

Since males of clausocalanoideans are typically rarer in zooplankton samples than females, their morphology is described in less detail. Thus, diagnoses of the families of Clausocalanoidea are primarily based on female morphology, particularly on the characteristics of their oral parts. This often causes difficulties in attributing to family sexually dimorphic males, e.g., those with rudimentary oral parts, such as in the case of a present, apparently, dimorphic male described here.

The calanoid copepod family Phaennidae contains the genera: *Brachycalanus* FARRAN, 1905; *Cephalophanes* SARS, 1907; *Cornucalanus* WOLFENDEN, 1905; *Onchocalanus* SARS, 1905; *Phaenna* CLAUS, 1863; *Phaennocalanus* MARKHASEVA, 2002; *Talacalanus* WOLFENDEN, 1911 and *Xanthocalanus* GIESBRECHT, 1892.

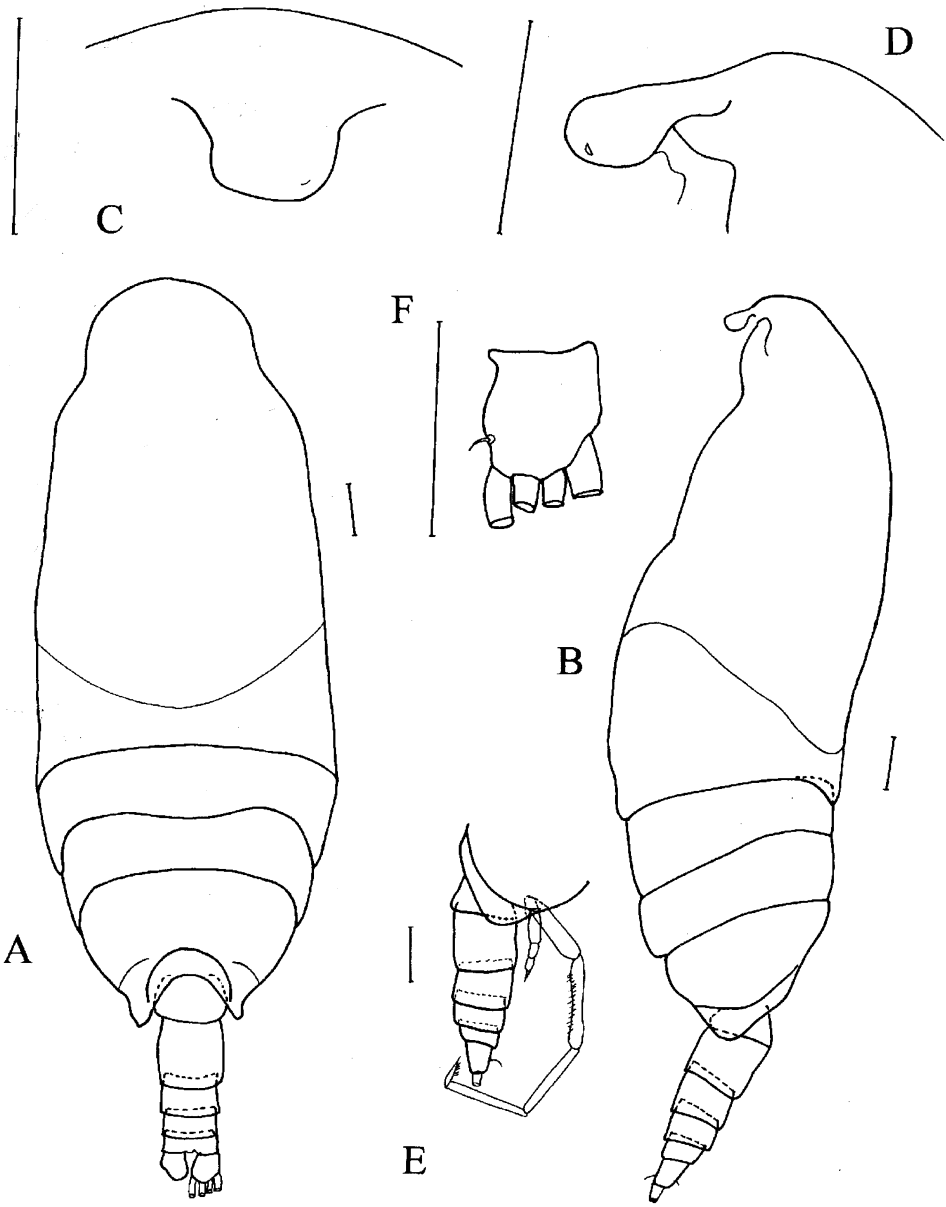

Fig. 1. *Kirnesius groenlandicus* gen. et sp. nov. Male. **A**, habitus, dorsal view; **B**, habitus, left lateral view; **C**, rostrum, ventral view; **D**, rostrum, left lateral view; **E**, posterior corners of prosome and urosome, right lateral view; **F**, right caudal ramus, ventral view. Scale bars: 0.1 mm.

Fig. 2. *Kirnesius groenlandicus* gen. et sp. nov. Male. Left antennule, articulated segments 1-6 (ancestral segments I-VIII). Articulated segment 2 is a complex of ancestral segments II-IV. Scale bar: 0.1 mm.

A new genus is proposed for this calanoid copepod. Although it is tentatively placed in Phaennidae it is very probable that after description of the female a new family will be established for this genus.

Material and methods

A single male was collected during the 40th cruise of the R/V "Akademik Mstislav Keldysh" close to the sea bed at abyssal depths (3480-3530 m) of the rift valley of the Knipovich Ridge, located in the north-eastern part of the Greenland Sea (76° 46' N 07°29' E), with a modified JUDAY's plankton net BR 113/140 with mouth-opening of 1 m^2.

The material was fixed in 4% formalin solution. The specimen was stained by adding a solution of chlorazol black E dissolved in 70% ethanol/30% water. Oral parts and swimming legs were dissected and all figures were prepared using a *camera lucida*.

The following abbreviations are used in the descriptions: P1-P5, swimming legs 1-5. Articulated (free) segments of antennule are designated by Arabic numerals, ancestral segments by Roman numerals (in parentheses) as 3(V). One seta and one aesthetasc on a segment of the antennule are designated: 1s + 1ae; "1?" indicates that a setal element was broken so that its identity on antennule could not be determined and only the scar at the location of its attachment was counted. Ramal segments of maxilla are considered exopodal (FERRARI 1995) and the tip of maxilla is considered a complex of the sixth enditic lobe of the basis plus exopodal segments (FERRARI & MARKHASEVA 1996); the maxilliped syncoxa is considered having 3 praecoxal lobes and 1coxal lobe (FERRARI & MARKHASEVA 2000a, b; FERRARI & IVANENKO 2001).

Taxonomy

Superfamily Clausocalanoidea GIESBRECHT, 1892
Family Phaennidae SARS, 1902
Genus *Kirnesius* gen. nov.

D i a g n o s i s. – Male. Cephalosome and first pedigerous somite separated, pedigerous somites 4 and 5 incompletely separated. Rostrum large, thick, oval-rectangular and lacking filaments. Antennule non-geniculate on both sides. Brush-like aesthetascs present in proximal part of antennule on articulated segments 2 and 5 (ancestral segments II-IV and VII respectively). Antennule slightly asymmetrical, 23 segmented on right, 22 segmented on left side, due to fusion of free segments 18 and 19 (ancestral segments XXII-XXIII).

Mouthparts moderately reduced. Maxilla with 8 sensory setae on exopod, praecoxal endite with 5 setae. Syncoxa of maxilliped with 4 setae on praecoxal lobes: 1 sclerotized seta on proximal lobe, 1 sensory worm-like plus 1 sclerotized on medial lobe and 1 sclerotized on distal lobe. P1 endopod one segmented, P2 endopod two segmented, and P3-P4 endopods three segmented. P1-P2 exopods three segmented, P3-P4 exopods broken. P1 exopod segment 3 with 3 medial setae, P2 exopod segment 3 with 4 medial setae. P2-P4 endopods and coxopods poorly spinulated. P5 uniramous, five segmented on both sides, of simple structure.

Female unknown.

E t y m o l o g y. – The generic name is given to honour Dr. KIR NESIS (1934-2003), for his significant contributions in the study of the oceanic pelagic communities, in the systematics and zoogeography of cephalopods.

T y p e s p e c i e s. – *Kirnesius groenlandicus* sp. nov., by monotypy.

Kirnesius groenlandicus sp. nov.
(Figs 1-7)

H o l o t y p e. – Male, body length 1.6 mm. Reg. no. 90750. Collected on 20 July 1998a, above the sea bed at abyssal depths (3480 m) of the rift valley of the Knipovich Ridge, located in the north-eastern part of the Greenland Sea (76°46' N 07°29' E). The holotype is deposited at the Zoological Institute of the Russian Academy of Sciences, St. Petersburg.

E t y m o l o g y. – The species is named after the Greenland Sea where it was found.

D e s c r i p t i o n. – Male: total length 1.6 mm. Prosome 3.7 times longer than urosome. Rostrum a well developed blunt plate with small chitinous semicircular ridge on the left distal edge (Fig. 1C-D). Somites 4 and 5 of prosome incompletely fused, suture clearly visible laterally; posterior corners as short lobes (Fig. 1A-B, E). Caudal rami with 4 terminal setae, 1 short ventral (Fig. 1F) seta and a small dorsal sensilla (Fig. 1B, E).

Antennule nearly as long as body with two brush-like aesthetascs in proximal part on second and fifth free segments. Right antennule (Fig. 3, 4A-E) of 23 articulated segments. Armature of right antennule as follows: 1(I) – 1s+1ae, 2(II-IV) – 6s+4ae (1 ae brush-like), 3(V) – 2s+2ae, 4(VI) – 2s+2ae, 5(VII) – 1s+2ae+1?, 6(VIII) – 1s+1ae, 7(IX) – 2s+2ae, 8(X-XII) – 3s+4ae, 9(XIII) – 1?, 10(XIV) – 2s, 11(XV) – 1?, 12(XVI) – 2s, 13(XVII) – 1?, 14(XVIII) – 1s, 15(XIX) – 1s, 16(XX) – 1s, 17(XXI) – 1?, 18(XXII) – 0, 19(XXIII) – 1s,

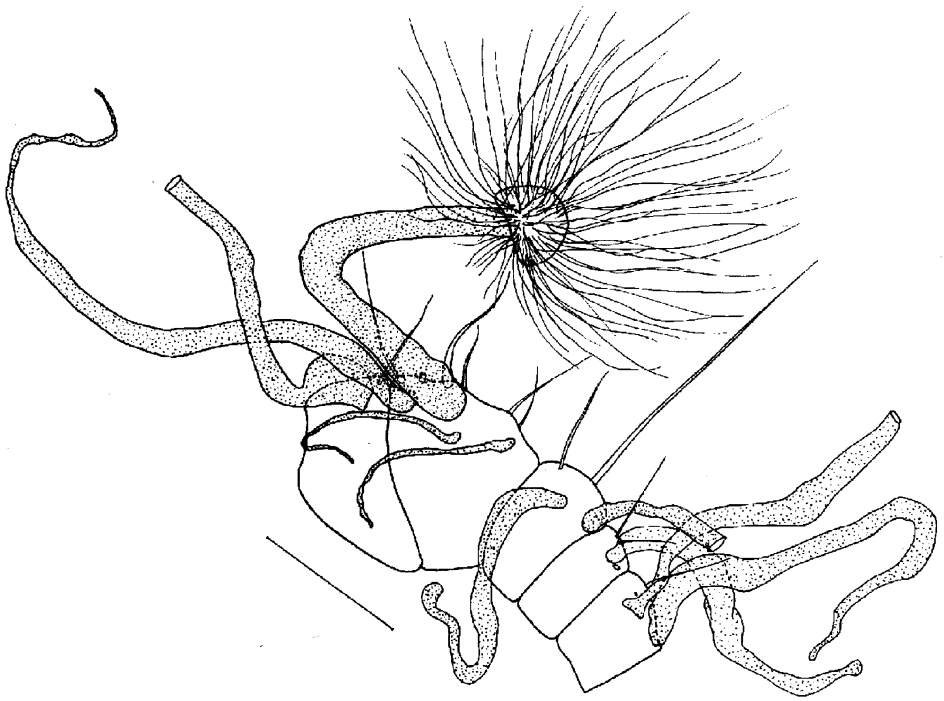

Fig. 3. *Kirnesius groenlandicus* gen. et sp. nov. Male. Right antennule, articulated segments 1-5 (ancestral segments I-VII). Articulated segment 2 is a complex of ancestral segments II-IV. Scale bar: 0.1 mm.

20(XXIV) – 2s, 21(XXV) – 2s, 22(XXVI) – 2s, 23(XXVII-XXVIII) – 4s+1ae. Left one (Fig. 2, 4F) of 22 articulated segments with minor differences in setation: 5(VII) - one of aesthetascs brush-like (its tip broken on right), 7(IX) – 2s+1ae+1?, 8(X-XII) – 2s+2ae+3?, 13(XVII) – 1s, 17(XXI) – 1s, 18(XXII-XXIII) – 1s, one of the setae on the articulated segment 12 (XVI ancestral segment) is strongly curved on both sides (Fig. 4C).

Antenna (Fig. 5A), coxa and basis with 1 setae each, exopod of seven segments with 0, 2, 1, 1, 1, 1 and 3 setae, about 1.9 times as long as endopod; first endopodal segment without setae, second with 6+1 and 6 setae (13 setae in total).

Mandible (Figs. 5B-C), basis with one seta, exopod of five segments with 1, 1, 1, 1 and 2 setae; endopod segment 1 with 1 seta, segment 2 with 8 setae. Gnathobase with 5 spine-like teeth, without dorsal articulated seta.

Maxillule (Fig. 5D), praecoxal endite with 7 terminal spines; coxal and proximal basal endites each with 2 setae, distal basal endite with 4 setae, endopod with 3 setae; exopod with 8 setae, coxal epipodite with 5 setae.

Maxilla (Fig. 5E), proximal praecoxal endite with 5 setae, distal praecoxal endite with 3 setae, proximal coxal endite with 3 setae each, distal coxal endite and proximal basal endites with 3 setae, of these, 1 seta is more sclerotized; distal basal endite plus exopod with 8 sensory setae: 6 longer worm-like, 1 shorter worm-like and 1 shorter worm-like with bifurcated tip.

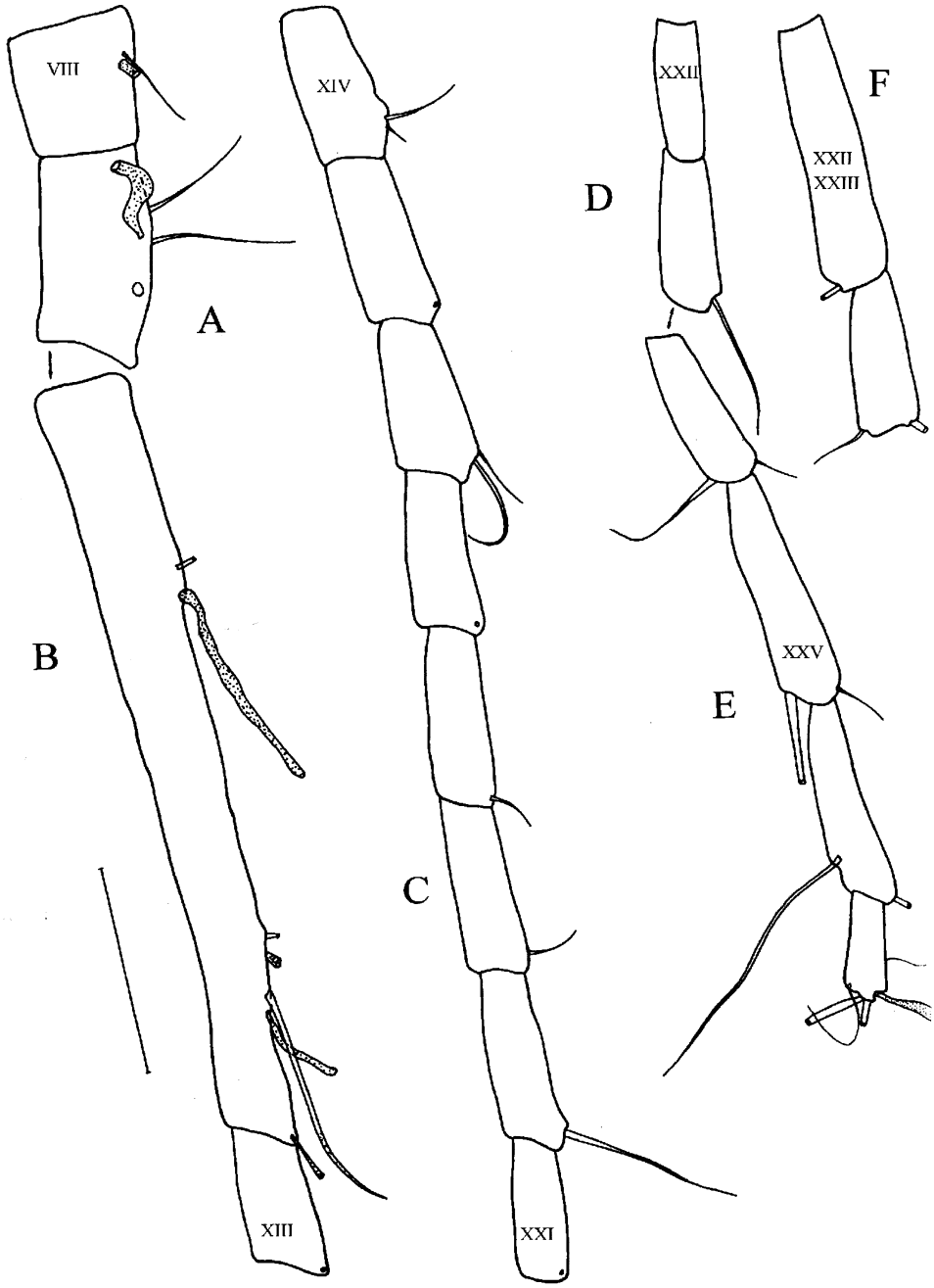

Fig. 4. *Kirnesius groenlandicus* gen. et sp. nov. Male. **A**, right antennule, articulated segments 6 and 7 (ancestral segments VIII and IX); **B,** right antennule, articulated segments 8 and 9 (ancestral segments X-XII and XIII); **C**, right antennule, articulated segments 10-17 (ancestral segments XIV-XXI); **D**, right antennule, articulated segments 18 and 19 (ancestral segments XXII and XXIII); **E**, right antennule, articulated segments 20-23 (ancestral segments XXIV-XXVIII); **F**, left antennule articulated segments 18 and 19 (ancestral segments XXII-XXIII and XXIV). Scale bars: 0.1 mm.

Maxilliped (Fig. 6A-B), syncoxa with 1 sclerotized seta on proximal praecoxal lobe, 1 long sensory and 1 short sclerotized setae on middle lobe and 1 sclerotized seta on distal praecoxal lobe; coxal lobe with 2 setae: 1 long and 1 small and short. Basis with 1 medial seta, 1 small sensilla near its base, and 2 setae distally. Endopod of five segments with 4, 4, 2, 3+1 and 4 setae.

P1 (Fig. 6C), basis with medial seta strongly curved; exopod segments 1 and 2 with long lateral spines exceeding base of following spine in length; lateral lobe of endopod without denticles.

P2 (Fig. 7A-B), endopod segment 2 poorly spinulated on posterior surface; terminal spine of exopod segment 3 longer than segment itself.

P3-P4 (Fig. 7C-D), endopods of three segments, endopod segment 3 of P3 poorly spinulated on posterior surface; exopod segments 2 and 3 broken.

P5 (Fig. 6D-F) uniramous, five segmented on both sides. Left leg much longer than urosome. Left leg segment 2 (basis) longest, with row of spinules along medial margin; segment 5 (exopod segment 3) with a thin and short terminal spine and a row of spinules subdistally. Right leg short, slightly exceeding distal edge of left leg segment 1 (coxopod); penultimate segment (exopod segment 2) about three times wider than terminal segment (exopod segment 3), the latter supplied with 2 small, thin spines distally, one shorter than other.

R e m a r k s. – The male of the new genus shares sensory setae on the maxillary exopod (8 worm-like setae) and the syncoxa of the maxilliped (1 worm-like seta) with a group of clausocalanoidean families including Diaixidae, Parkiidae (males unknown for this family), Phaennidae, Scolecitrichidae and Tharybidae. However the sensory setae composition of the maxillary exopod is not typical for males of these families. Described scolecitrichid males usually have 3 worm-like plus 5 brush-like sensory setae, tharybid males possess 3 worm-like plus 5-6 brush-like sensory setae or 3 worm-like plus 5 brush-like sensory plus 1 sclerotized setae (SCHULZ 1981, FERRARI & MARKHASEVA 2005), and for phaennid males the typical pattern is 1 worm-like and 7 brush-like setae.

Oral parts of the male of *Kirnesius groenlandicus* are probably rudimentary compared to those of the unknown female. Its maxillule, for example, shows the same trend in reductions as in phaennid and scolecitrichid males (PARK, 1983a, b).

Kirnesius groenlandicus shares five setae on the maxillary proximal praecoxal endite with all phaennids and some scolecitrichids (*Xantharus renatehaassae* SCHULZ, 1998, *Grievella shanki* FERRARI & MARKHASEVA, 2000, *Falsilandrumius bogorovi* VYSHKVARTZEVA, 2001, *Landrumius antarcticus* PARK, 1983, and species of *Neoscolecithrix* CANU, 1896 and *Cenognatha* BRADFORD-GRIEVE, 2001). The remaining representatives of Diaixidae, Parkiidae, Tharybidae and Scolecitrichidae typically have 3-4 sensory setae at the maxillary proximal praecoxal endite.

The new genus has uniramous, strongly asymmetrical P5, with the left leg longer than right, similar to phaennids (e.g., *Onchocalanus* SARS, 1905) and the scolecitrichid genus *Scolecitrichopsis* VYSHKVARTZEVA, 2000.

Kirnesius groenlandicus shares a large and thick, oval-rectangular rostrum lacking filaments with the scolecitrichid genus *Racovitzanus* GIESBRECHT, 1902.

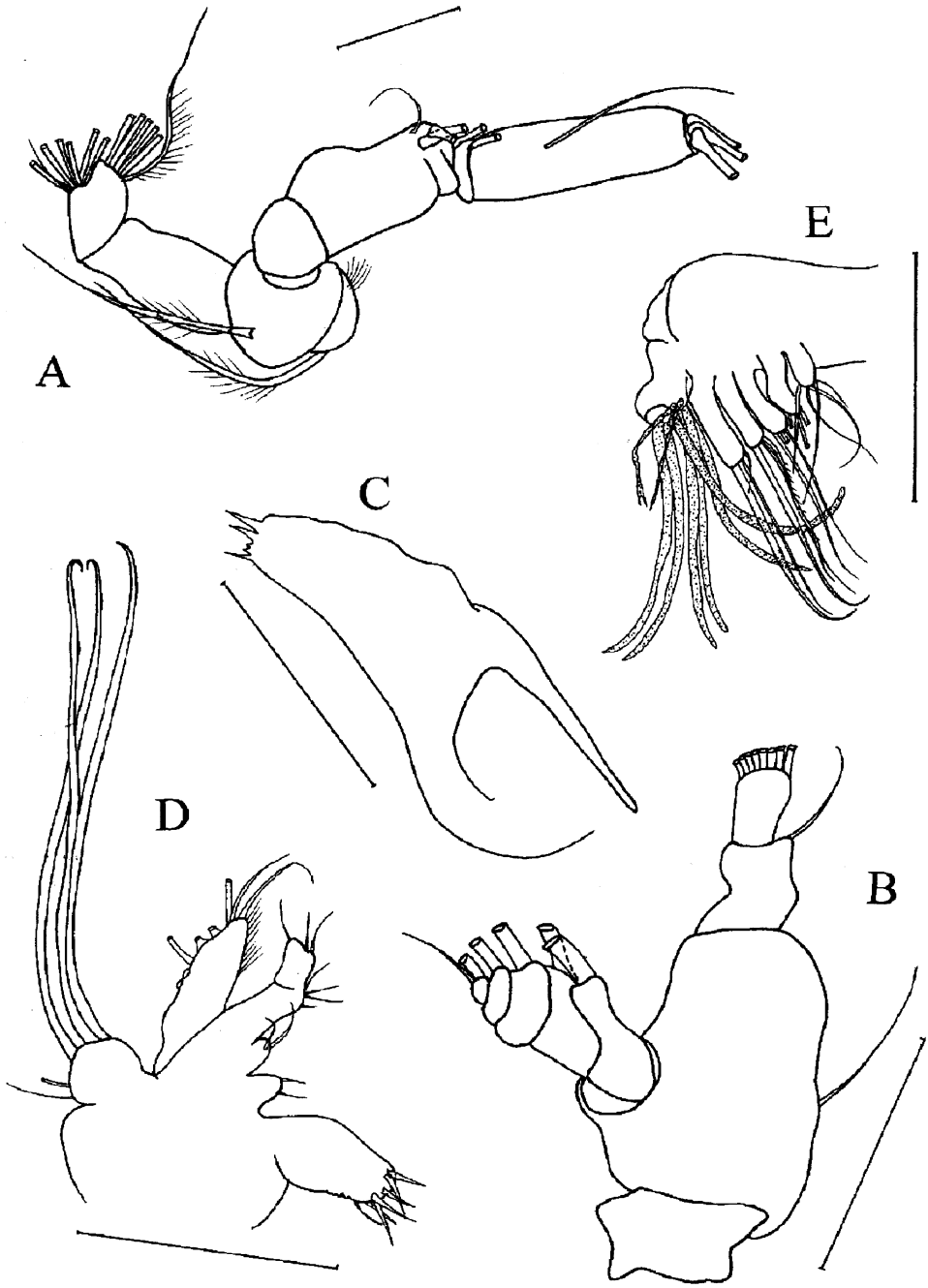

Fig. 5. *Kirnesius groenlandicus* gen. et sp. nov. Male. **A,** antenna; **B**, mandibular palp; **C**, mandibular gnathobase; **D**, maxillule; **E**, maxilla. Scale bars: 0.1 mm.

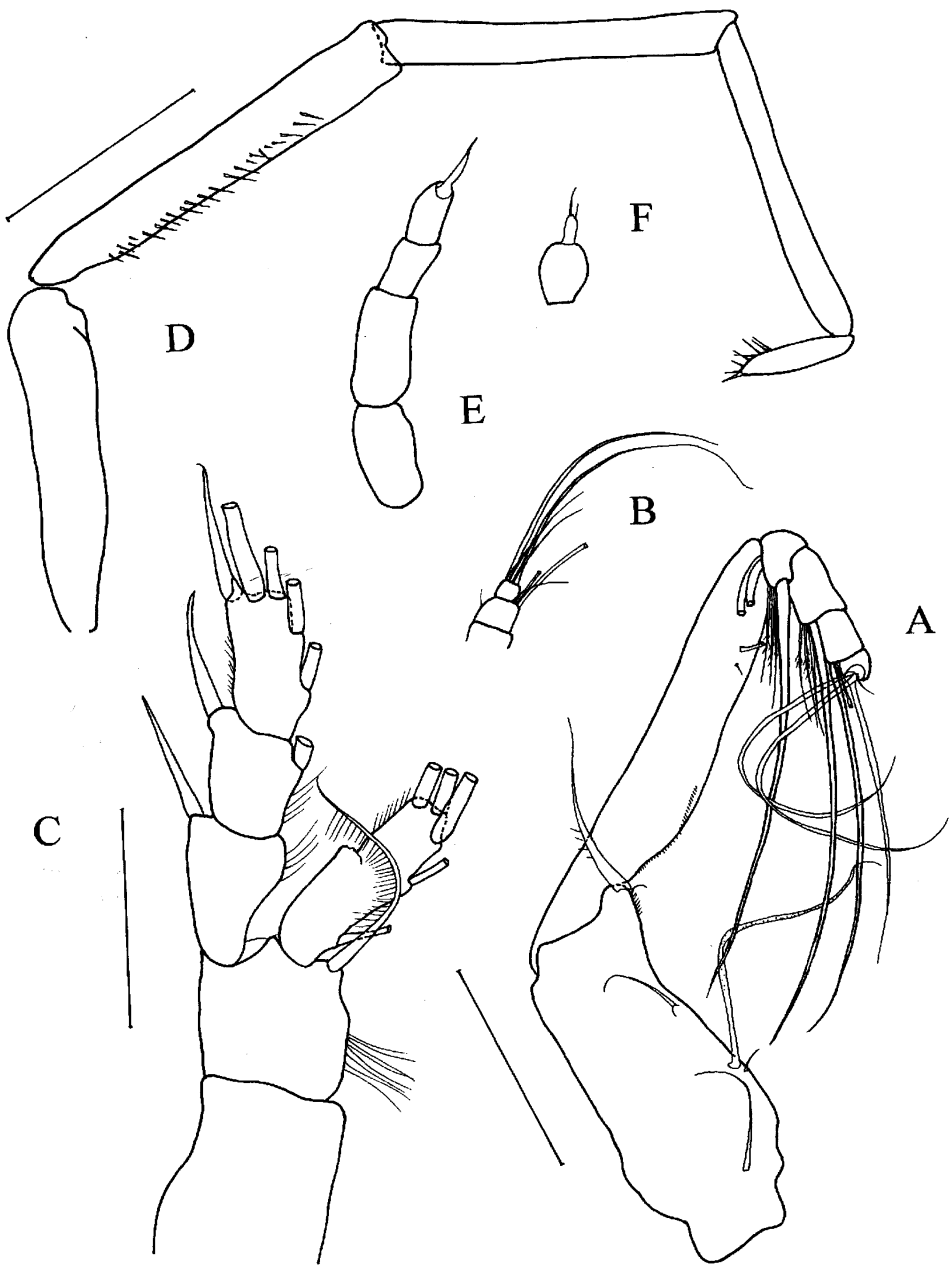

Fig. 6. *Kirnesius groenlandicus* gen. et sp. nov. Male. **A**, maxilliped; **B**, maxilliped, endopod distal segments 4-5; **C**, swimming leg 1; **D**, left leg 5; **E**, right leg 5; **F**, right leg 5, exopod segments 2-3. Scale bars: 0.1 mm.

The syncoxal setal formula of maxilliped is of scolecitrichid type: 1, 2, 1; however, the distal praecoxal seta is not sensory.

The new genus above all is distinguished from all calanoids by a unique apomorphy, two well developed brush-like aesthetascs on the second and fifth articulated segments of antennule.

It differs from phaennid, scolecitrichid, diaixid and tharybid males in the following combination of characters: 1) complete absence of brush-like sensory setae on the maxillary exopod; 2) maxilliped basis with 1 seta plus small sensilla (3 seta usually present in the remaining families); 3) left antennule 22-segmented with articulated segments 18 and 19 (ancestral XXII-XXIII) fused (in males of the above mentioned families only the right antennule demonstrates fusion); 4) poor posterior spinulation of endopod segments of P2-P4 (well developed in phaennids and scolecitrichids).

In conclusion the new genus does not fit the diagnosis of any clausocalanoidean family with sensory setae on maxilla and maxilliped. *Kirnesius groenlandicus* shows resemblance with Phaennidae mostly in P5 structure and possession of 5 setae on the proximal praecoxal endite of maxilla, and thus is tentatively placed in this family.

Discussion

Antennulary aesthetascs with brush-like tips are rare in the subclass Copepoda. Several examples of such aesthetascs are known in the poecilostomatoid males *Pachos punctatum* (CLAUS, 1863) and *P. tuberosum* (GIESBRECHT, 1891) (GIESBRECHT 1892, MORI 1964). Antennulary aesthetascs similar to brush on its tip are also observed in some Cyclopoida males, e.g. *Eucyclops serrulatus* (FISCHER, 1851), *Macrocyclops albidus* (JURINE, 1820) and *Austriocyclops vindobonae* KIEFER, 1964 (KIEFER 1978; POSPISIL & STOCH 1997).

Since GIESBRECHT (1892) the trithek/quadrithek pattern of antennulary armament is considered typical of copepod females and males. The trithek pattern is 2 setae plus 1 aesthetasc; quadrithek: 2 setae plus 2 aesthetascs. It was suggested that the doubled aesthetascs of the quadrithek are an adaptation of calanoid males to search for females in the pelagic environment (FERRARI & BENFORADO 1998).

Kirnesius groenlandicus demonstrates a setation typical of the copepod quadrithek pattern: articulated segment 2 is a complex of fused ancestral segments II-IV and bears 6 setae plus 4 aesthetascs (found also in other males of families possessing sensory setae on maxilla). In the new species, however, one of four aesthetascs is brush-like, with a well defined head supplied with long filaments. Another aesthetasc with brush-like tip is situated on articulated segment 5 (ancestral segment VII) which has a typical quadrithek pattern: 2 setae plus 2 aesthetascs (Figs 2-3).

While sensory setae on maxilla and maxillipedal syncoxa of calanoids are assumed to have originated from sclerotized setae (SARS 1902:43, BRADFORD 1973:136, VYSHKVARTZEVA 1989:35; FERRARI & MARKHASEVA 1996:277, OHTSUKA et al. 1998: 801), the origin of antennulary aesthetascs is not so clearly understood. Moreover, doubling of antennulary aesthetascs which is common in clausocalanoidean males (BOXSHALL & HUYS 1998), complicates their interpretation. BOXSHALL & HUYS (1998:780) state that: "Comparison of antennules from a variety of pelagic copepods has revealed many examples of the

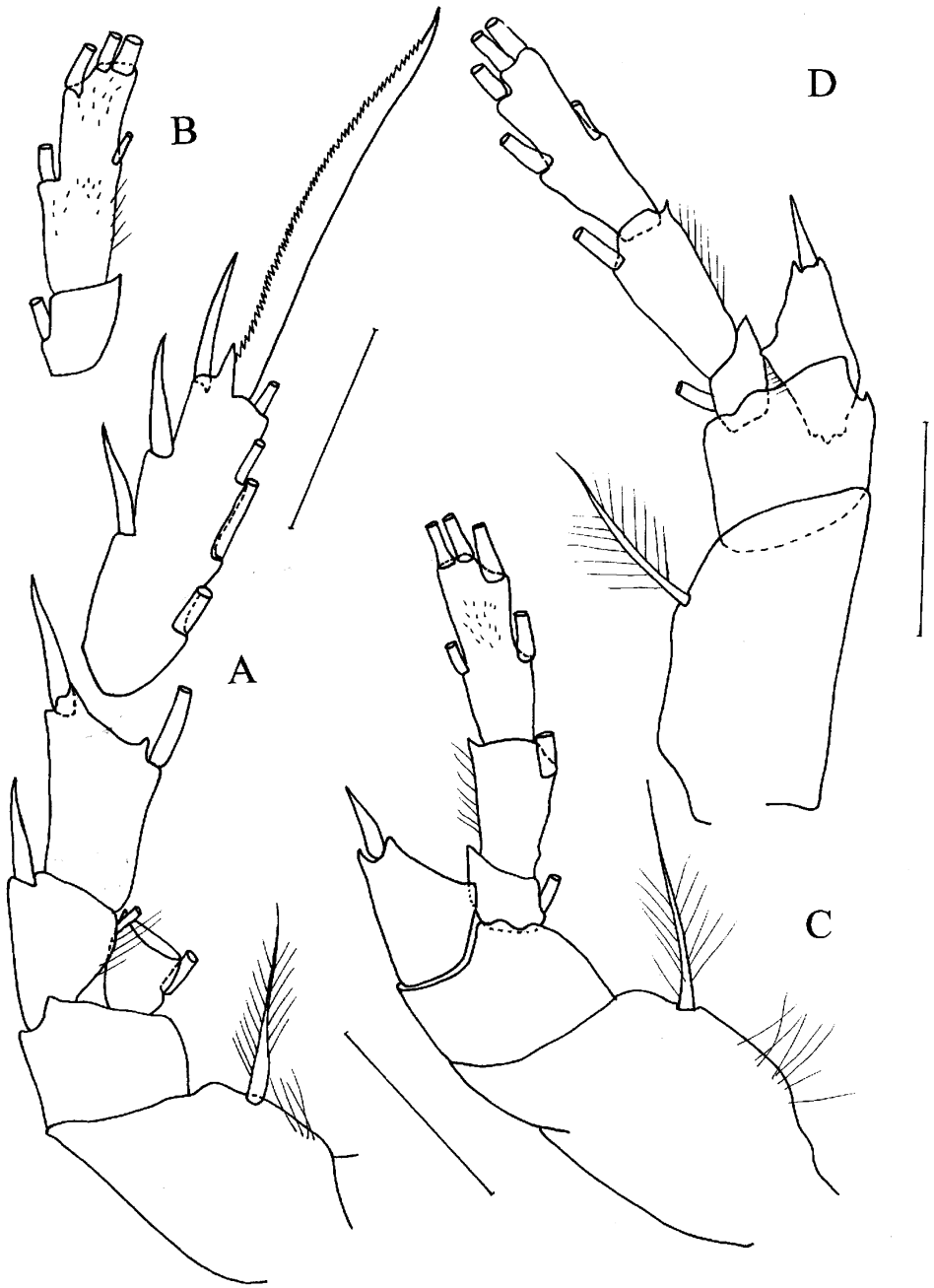

Fig. 7. *Kirnesius groenlandicus* gen. et sp. nov. Male. **A**, swimming leg 2 without endopod segment 2; **B**, swimming leg 2, endopod segments 1-2; **C**, swimming leg 3; **D**, swimming leg 4. Scale bars: 0.1 mm.

apparent transformation of setation elements.... setae have undergone transformation into thin-walled aesthetasc-like elements". As a result, we often cannot distinguish between aesthetascs that have originated from setae and those of other origin.

Sensory setae of the maxilla and maxilliped of calanoids play the role of chemosensors and may be "directly used for capture and manipulation of food particles" (NISHIDA & OHSUKA 1997). Those which are worm-like are considered to have the function of "more general detection", while brush-like aesthetascs are "more specific" in detection of chemicals (NISHIDA & OHSUKA 1997). In male calanoids aesthetascs of the antennule, which until now were known only of worm-like morphology, are considered to serve for the detection of sex pheromones in the mate-locating process (OHTSUKA & HUYS 2001).

It is hypothesized that brush-like aesthetascs on the proximal segments of the male antennule have developed to achieve an improved search for females in conditions of low abundances of hyperbenthic animals (like in *Kirnesius groenlandicus*). However, it is not clear then, why they are also present in other copepod species (fresh-water cyclopids with brush-like aesthetascs), which usually do not show low abundances.

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