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Kliopsyllus schminkei sp. n. (Copepoda, Harpacticoida, Paramesochridae) — a new copepod from the southeast Atlantic deep sea (Angola Basin)*

GRITTA VEIT-KÖHLER[1, #] & JAN DREWES[2]

[1]*Abt. DZMB, Forschungsinstitut Senckenberg, Südstrand 44, D - 26382 Wilhelmshaven, Germany*
[2]*Universität Oldenburg, Institut für Biologie und Umweltwissenschaften, Fakultät 5, D - 26111 Oldenburg, Germany*
[#] *Corresponding author: gveit-koehler@senckenberg.de*

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Abstract

A new species of *Kliopsyllus* (Paramesochridae) has been collected with a multicorer from the abyssal Angola Basin in 2000 (on the DIVA-1 cruise, RV Meteor 48/1). *Kliopsyllus schminkei* sp. n. is the second most abundant *Kliopsyllus*-species in the Angola Basin and raises the number of valid members of the genus to 33. The new species is placed in the genus *Kliopsyllus* because of its typical segmentation and the setation of the swimming legs. *K. schminkei* sp. n. is unique within the genus and can be distinguished from the other species by a large apical pore on the P5 baseoendopodal lobes of the male, a length:width ratio of the furcal rami of 9 to 10:1 in both sexes, and an exceptional ratio of the length of the furcal rami to the whole body size of one fourth in the female and one fifth in the male. The new species is one of the four deep-sea *Kliopsyllus*-species described until now.

Key words: *Kliopsyllus*, species description, abyssal plains, diversity, taxonomy, biogeography

Introduction

There is an increasing number of taxonomic studies on deep-sea copepods (Bröhldick 2005, George 2006, Ivanenko & Defaye 2004, Seifried *et al.* 2007, Seifried & Martínez Arbizu 2008, Vasconcelos *et al.* 2008, Veit-Köhler 2004, 2005, Willen 2005). This is partly due to a program for the study of abyssal plains, the 'Census of the Diversity of Abyssal Marine Life' (CeDAMar) within the framework of the international 'Census of Marine Life' (CoML). The number of deep-sea expeditions dedicated to taxonomy and biogeography purposes has increased recently. It is therefore important to produce reliable descriptions in order to enable the scientific community to carry out large-scale biogeography studies for deep-sea copepods.

The animals presented here were collected during the RV Meteor cruise M 48/1 DIVA-1 in 2000. The new species contributes to the description of the community of Harpacticoida in the Angola Basin and adds a new member to the few known deep-sea Paramesochridae.

The family Paramesochridae Lang, 1944 comprises benthic harpacticoids that are mostly small-sized and have a typical cylindrical body shape. The genera of the subfamily Paramesochrinae Huys, 1987 are among other things, characterized by swimming legs with gradually reduced endopodal segments and decreasing numbers of setae. *Kliopsyllus* Kunz, 1962 is a small sized genus with one-segmented endopods with one apical seta at the swimming legs 2 and 3.

Only a few members of the genus have been described from deep-sea sediments (Veit-Köhler 2004, 2005). Recent investigations show, that the genus *Kliopsyllus* is not only commonly represented with new

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species in deep-sea sediment samples (Vasconcelos *et al.* 2009), but also that it is wide-spread in the abyss (Gheerardyn & Veit-Köhler accepted).

Material and methods

Sediment samples were taken in July 2000 during the DIVA-1 campaign (Meteor 48/1). The samples for meiofaunal analyses were collected at two sites (stn. 325, 5447 to 5505 m depth (between 19°58.2‘S, 002°59.7‘E and 19°58.4‘S, 002°59.8‘E), and stn. 346, 5389 to 5390 m depth (between 16°16.9‘S, 005°27.0‘E and 16°17.0‘S, 005°27.0‘E)) located in the Angola Basin (for a map see Rose *et al.* (2005)). The type material for *Kliopsyllus schminkei* sp. n. stems from three different multicorer hauls at station 346.

Details on sampling strategy and sample treatment are described by Rose *et al.* (2005). Adult Paramesochridae were determined to species level with the aid of a Leica MZ 12.5 stereo microscope and a Leica DMR microscope.

Specimens of *Kliopsyllus schminkei* sp. n. selected for description were drawn from the dorsal and the lateral side before dissection. The dissected parts were mounted using glycerine as mounting medium. Drawings were made using a Leica DMR microscope equipped with a camera lucida and differential interference contrast (DIC) at 1000x magnification. Abbreviations used in the text: exp = exopod, enp = endopod, aes = aesthetasc, benp = baseoendopod, P1–P6 = swimming legs 1–6, "enp1 P2" = the first segment of the endopod of P2.

Taxonomy

Paramesochridae Lang, 1944
Kliopsyllus Kunz, 1962
***Kliopsyllus schminkei* sp. n.**

Type material: The examined specimens are registered and deposited in the collection of the Senckenberg Forschungsinstitut und Naturmuseum Frankfurt, Germany. All specimens of the type material were collected on 07-27-2000 at a depth of 5389 m. Station numbers indicate “station/multicorer deployment number - core number”.

Female holotype: SMF 31436 (13 slides), DIVA-1 station 346/2-7 (16°17.0’S, 05°27.0’E).
Male allotype: SMF 31437 (6 slides), DIVA-1 station 346/2-10 (16°17.0’S, 05°27.0’E).
Female paratype 1: SMF 31438 (10 slides), DIVA-1 station 346/5-7 (16°16.9’S, 05°27.0’E).
Female paratype 2: SMF 31439 (1 slide), DIVA-1 station 346/2-3 (16°17.0’S, 05°27.0’E).
Male paratype 1: SMF 31440 (1 slide), DIVA-1 station 346/1-5 (16°17.0’S, 05°27.0’E).
Male paratype 2: SMF 31441 (1 slide), DIVA-1 station 346/1-4 (16°17.0’S, 05°27.0’E).

Etymology: The species is dedicated to Prof. Dr. Horst Kurt Schminke, our mentor and teacher at the University of Oldenburg, Germany. Among many other merits he promoted the founding of the German Centre for Marine Biodiversity Research (DZMB), a young and successful department of the Senckenberg Research Institute.

Description of female: Total body length measured from anterior tip of rostrum to posterior margin of telson: Holotype 0.23 mm (values of 6 additional females measured: mean 0.22 mm, min. 0.21, max. 0.23 mm); including the caudal rami: Holotype 0.30 mm (values of 6 additional females measured: mean 0.29 mm, min. 0.27, max. 0.31 mm).

Body cylindrical (Figs. 1A, B), slightly depressed dorsoventrally; prosome slightly wider than urosome; with few pores and sensilla distributed dorsally and laterally on cephalothorax, the three free pedigerous

somites of the prosome, the somite bearing P5 and the genital double-somite; first free abdominal somite with sensilla, only. Somitic hyaline frills slightly developed. Posterior margin of urosomites with ventrolateral minute spinules (Figs. 1B, 2A). Penultimate somite with a fine pseudoperculum. Telson with ventrolateral spinules (Figs. 1B, 2A).

Furcal rami of adult female (Fig. 3) cylindrical, ten times as long as wide, with 6 setae and a minute ventrolateral outer pore: Seta I absent; seta II slender, dorsally displaced; seta III short and slender, situated dorsolaterally, near posterior margin; seta IV long and slender, seta V slender, longer than IV, both situated distally; seta VI small; seta VII slender and naked.

Rostrum (Fig. 1B) small, hyaline, fused to cephalothorax.

Antennule (Figs. 4A, B) eight-segmented, segment I with long spinules along inner margin. Armature formula: I (0), II (9), III (4), IV(2+(1+aes), V (2), VI (2), VII (3), VIII (4+(1+aes); 20 setae slender and unarmed, one plumose, 5 setae on elevations, two setae fused at base with aesthetasc.

Antenna (Fig. 4C). Basis without armature. Endopod two-segmented; enp1 with one inner seta; enp2 armed with several spinule rows; three subapical setae and six apical pinnate setae, three of which geniculate. Exp one-segmented, with four setae with transversally cut tips and one slender lateral seta.

Labrum (Fig. 5A) broad and naked as depicted.

Mandible (Figs. 5B–D). Coxa with slender and elongated gnathobasis (Figs. 5B, C); cutting edge with one large and five smaller teeth. Basis with one seta (Fig. 5C). Enp two-segmented; first segment with two slender setae, second segment with five slender and naked apical setae. Exp small, one-segmented, with two slender setae (Fig. 5C).

Maxillule (Fig. 5E). Praecoxal arthrite with two juxtaposed slender setae. Inner margin of arthrite with six strong spines, and one seta. Coxal endite with three setal elements, one of which is strong and serrate. Endite of basis with six slender, naked setae. Enp one-segmented, with five slender setae. Exp small, one-segmented, with two naked setae.

Maxilla (Fig. 5F). Syncoxa with three endites; proximal endite slightly bilobed, with one setal element on proximal lobe and two setal elements on distal lobe; middle endite with two elements, distal endite with three elements. Basis fused to syncoxa with three strong setal elements of different sizes. Enp two-segmented with one naked seta on first segment and four bare setae on second.

Maxilliped (Fig. 5G). Syncoxa with a spinule row and one bare seta. Basis without armature. Enp one-segmented with two long and two small setae.

Swimming legs (Figs. 6A–D, Tab. 1) with highly reduced rami. Outer spines on exps without ornamentation.

TABLE 1. Seta and spine formula of swimming legs of *Kliopsyllus schminkei* sp. n.

	Basis	Exopod	Endopod
P1	1-0	0.022	0.020
P2	0-1	0.0.022	010
P3	0-1	0.0.022	010
P4	0-1	0.0.011	010

P1 (Fig. 6A). Basis with some spinules along inner margin and one inner naked seta. Enp one and a half times as long as exp, both two-segmented and ornamented on outer rim with spinules, those in enp1 longer than in exp. Enp1 without armature, enp2 with one long and one short seta. Exp1 with one outer spine. Exp2 with two outer spines, one apical spine and one apical seta.

P2–P4 (Figs. 6B–D). Basis of P2–P4 bearing one outer seta. No setules visible. Three-segmented exopods slightly longer than endopods with spinules along outer margin. Enps with long setules along outer margin and a row of shorter setules reaching from the posterior side to the apical part of enp.

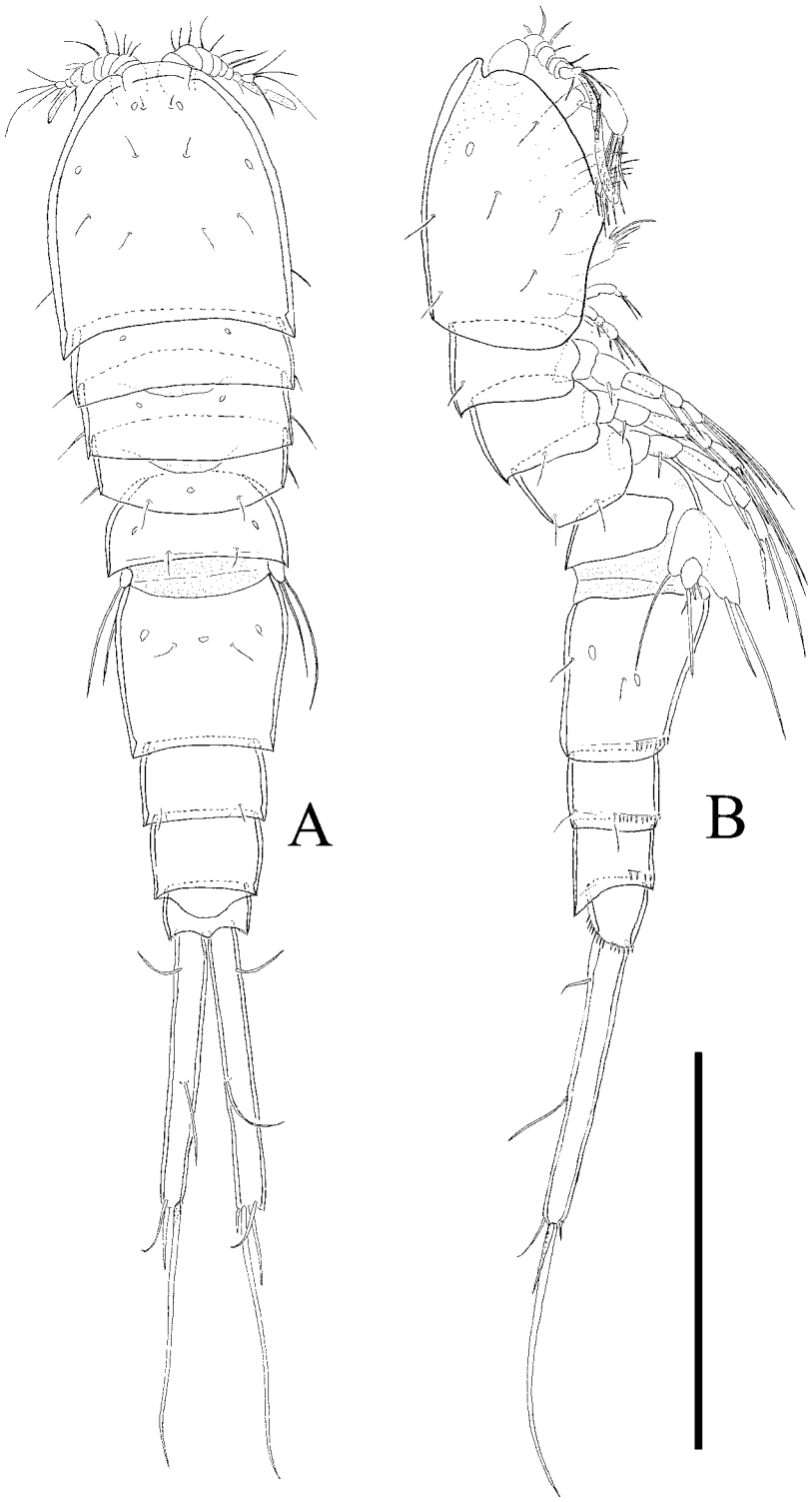

FIGURE 1. *Kliopsyllus schminkei* n. sp. Female holotype: (A) Habitus dorsal; (B) Habitus lateral. Scale bar = 100 µm.

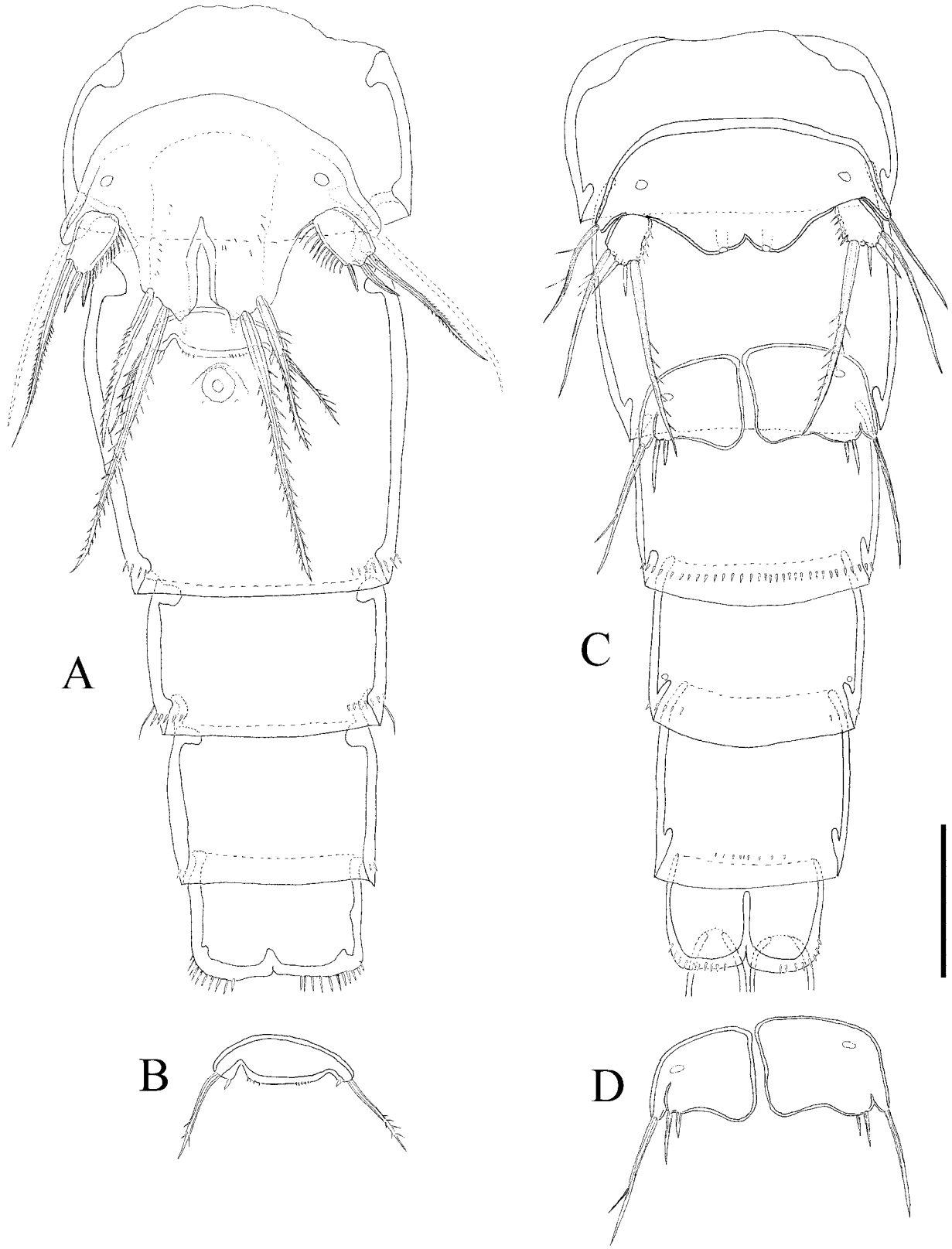

FIGURE 2. *Kliopsyllus schminkei* n. sp. Female holotype: (A) Abdomen ventral with P5, P6; dotted elements added after paratype; (B) P6. Male allotype: (C) Abdomen ventral with P5, P6; (D) P6. Scale bar = 20 µm.

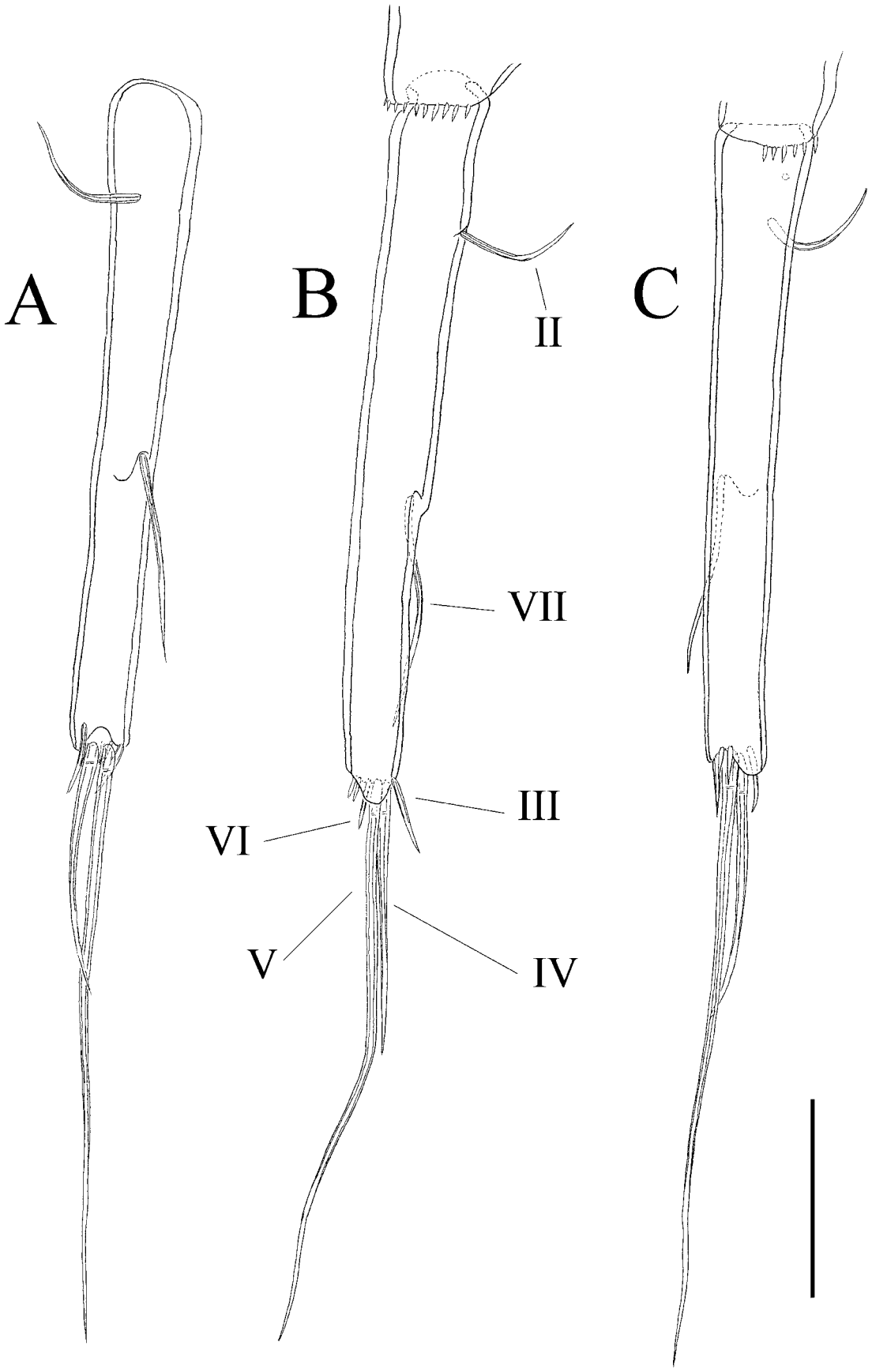

FIGURE 3. *Kliopsyllus schminkei* n. sp. Female holotype: Left furcal branch (A) dorsal; (B) lateral; (C) ventral. Scale bar = 20 µm.

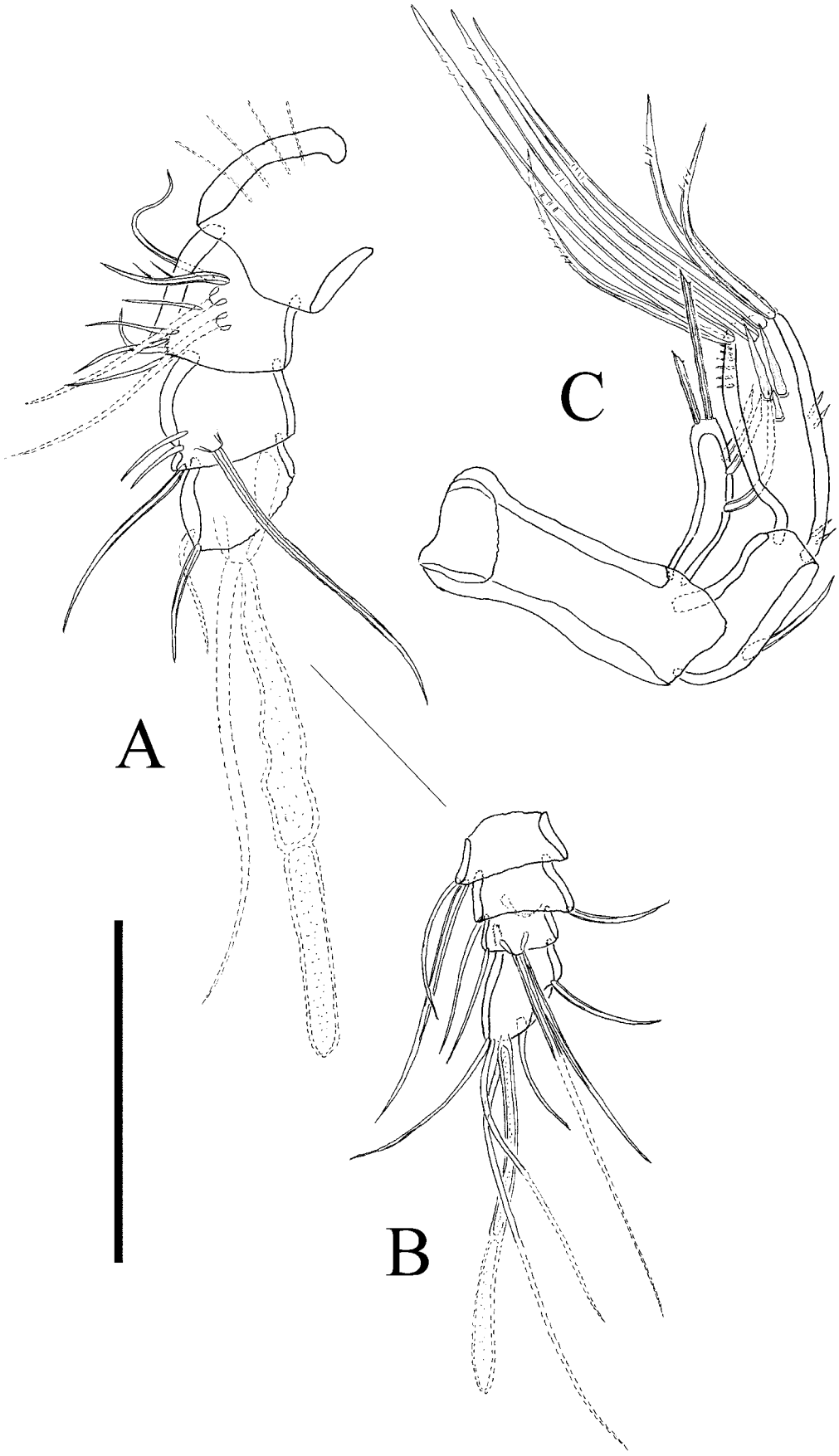

FIGURE 4. *Kliopsyllus schminkei* n. sp. Female holotype: (A) Antennule, segments 1-4 (dotted elements added after paratypes); (B) Antennule, segments 5-8 (dotted elements added after paratypes); (C) Antenna. Scale bar = 20 µm.

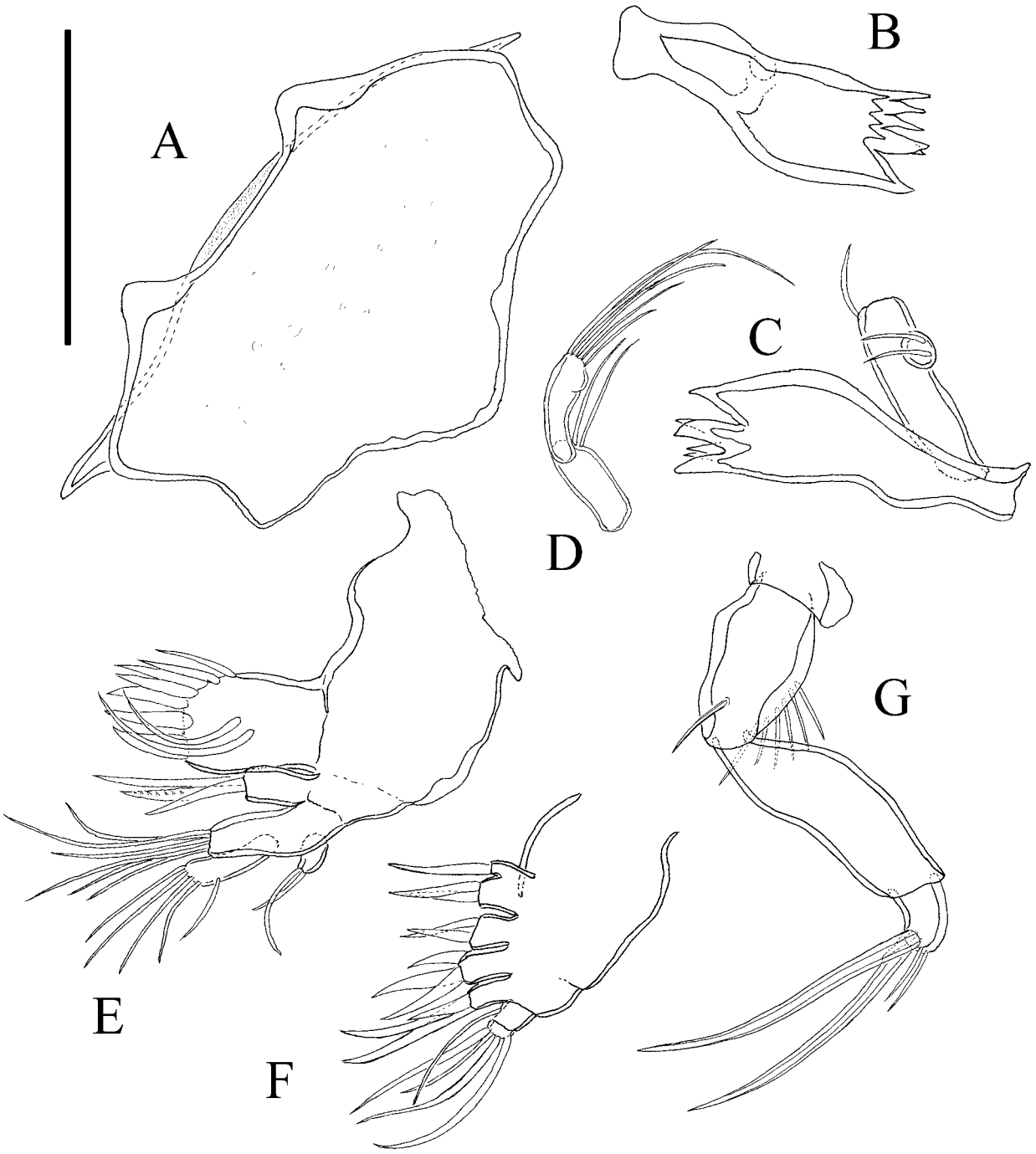

FIGURE 5. *Kliopsyllus schminkei* n. sp. Female holotype: (A) Labrum; (B) Mandible; (C) Mandible, apical part of palp broken off; (D) Mandible, apical part of palp; (E) Maxillule; (F) Maxilla; (G) Maxilliped. Scale bar = 20 µm.

P2 and P3 (Figs. 6B, C). Exp1 and exp2 of P2 and P3 with one stout outer spine. Exp3 with two outer spines of different sizes, one apical spine with several setules on inner side and one apical seta with setules on inner side. Enp with one apical seta with setules on inner side.

P4 (Fig. 6D). Exp1 and exp2 armed with one stout outer spine. Exp3 with one outer spine and one outer terminal spine with inner setules. Enp P4 with strong terminal spine.

P5 (Fig. 2A). Legs fused, small exopod clearly separated from baseoendopod. Benp with outer basal seta and an anterior pore. Endopodal lobe with several spinules and with one large inner and one smaller outer stout pinnate seta. Exp with two inner small elements and one outer long and bipinnate seta; ornamented with inner spinule row.

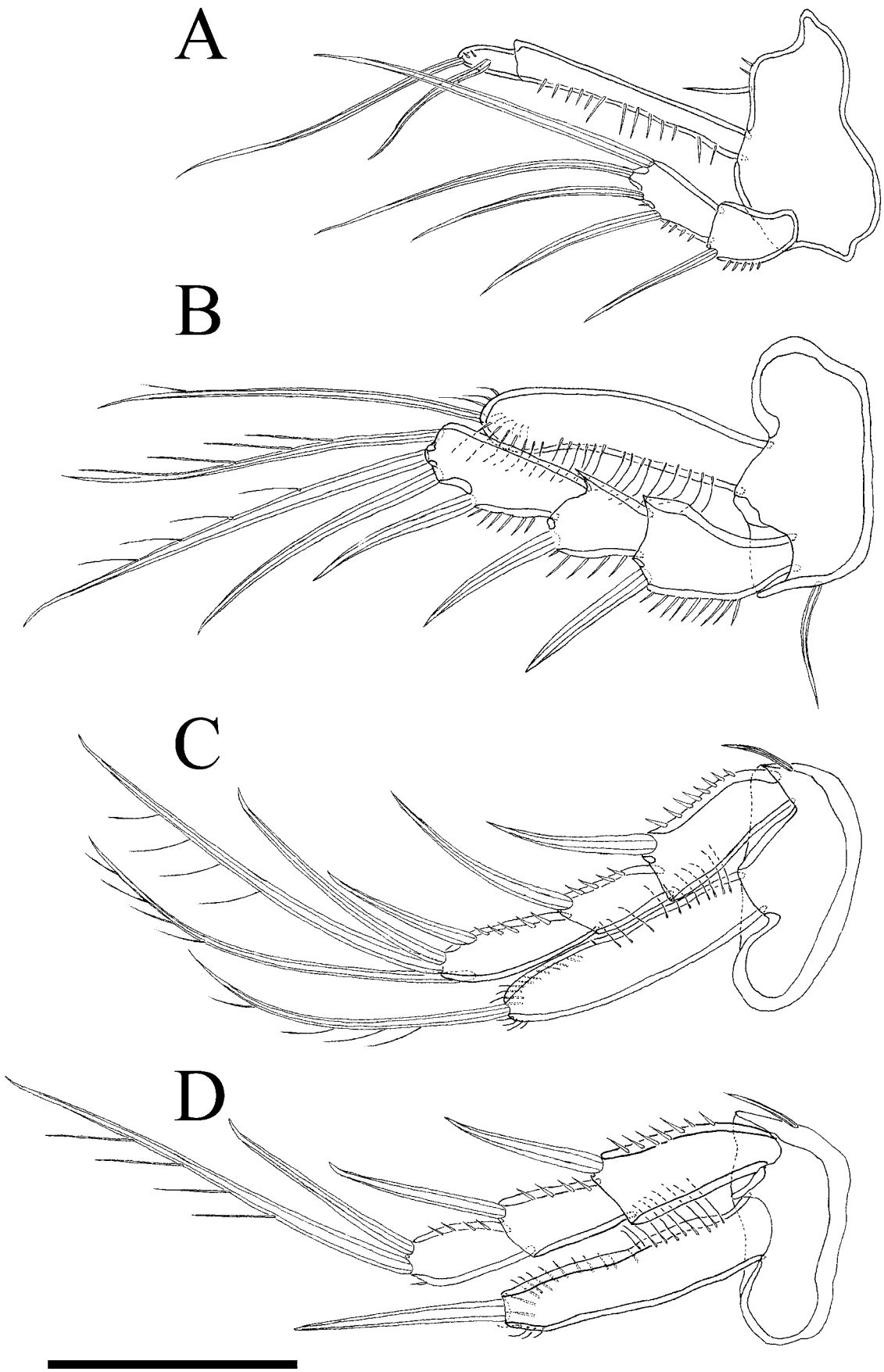

FIGURE 6. *Kliopsyllus schminkei* n. sp. Female: (A) P1 (holotype); (B) P2 (holotype); (C) P3 (paratype); (D) P4 (paratype). Scale bar = 20 µm.

Genital complex and P6 (Figs. 2A, B). Genital field as figured. Sixth pair of legs (Fig. 2B) represented by small fused outgrowths bearing some minute spinules and one small inner thorn, each leg with one bipinnate seta.

Description of male: Habitus (Fig. 7) as in female except for genital-double somite. Total body length measured from anterior tip of rostrum to posterior margin of telson: Allotype 0.24 mm (values of 4 additional males measured: mean 0.22 mm, min. 0.21, max. 0.23 mm); including the caudal rami: Allotype 0.30 mm (values of 4 additional males measured: mean 0.29 mm, min. 0.27, max. 0.30 mm).

Mouthparts and swimming legs as in female. Sexual dimorphisms only in antennule, P5 and P6.

Antennule (Fig. 8) seven-segmented, chirocer. Segment VI rounded and bulbous.

Armature formula: I (0), II (1), III (6), IV (2), V (2), VI (4+(1+aes)), VII (7+aes); 23 slender naked setae, one of which fused at base with aes.

P5 (Fig. 2C). Both legs fused medially. Exopod clearly separated from baseoendopod. Benp bearing an outer slightly pinnate seta, with one anterior pore and one tube pore on the endopodal lobe. Exp with four setae (innermost longest and pinnate, two middle, small, naked setae and one outer element, slightly pinnate) and with inner spinule row.

Each P6 (Figs. 2C, D) represented by a plate with one large outer and two small inner setae; with a proximal pore.

Discussion

Systematics: at present, *Kliopsyllus* contains 33 species (including the one described in this paper and *K. minor* Vasconcelos, Veit-Köhler, Drewes & Santos, 2009) and seven subspecies. The history of the genus *Kliopsyllus* and the unsatisfactory systematic situation within the Paramesochridae has been discussed broadly with the descriptions of *Kliopsyllus diva* Veit-Köhler, 2005 and *Kliopsyllus andeep* Veit-Köhler, 2004 (Veit-Köhler 2004, 2005).

The new species is placed in *Kliopsyllus*. This decision is based on the species' combination of characters which agrees with the short working diagnosis of the genus given by Veit-Köhler (2004): two-segmented exp and enp of P1, 3-segmented exp of P2–P4, only two setae in exp3 P4, one-segmented enps of P2–P4 with one apical seta.

Kliopsyllus schminkei sp. n. is unique within the genus and can be distinguished from the other species by the following features: large apical pore on the P5 baseoendopodal lobes of the male, length:width ratio of furcal rami from 9 to 10:1 in both sexes, the exceptional ratio of the length of the furcal rami to the whole body size of one fourth in the female and one fifth in the male. In addition, the fact that *K. schminkei* sp. n. is one of the four deep-sea *Kliopsyllus*-species described until now is especially emphasized.

All studied males of *K. schminkei* sp. n. show a large apical pore on the P5 baseoendopodal lobes. In most other species like *K. diva* a very long seta is present at the same site. *Kliopsyllus unguiseta* Mielke, 1984 and *K. similis* Mielke, 1984 do not carry this seta at the benp but pores with channels comparable to *K. schminkei* sp. n. have not been described for these species (Mielke 1984b). During a large-scale study of Paramesochridae in the south-east Atlantic (Gheerardyn & Veit-Köhler accepted) all males of *K. schminkei* sp. n. showed this character.

K. schminkei sp. n. has furcal rami that are about nine to ten times as long as wide. Until now *K. diva* had the longest known non-transformed furcal rami, which are about six times as long as wide. Only *K. spiniger ornatus* Kunz, 1981 has length to width ratio comparable to *K. schminkei* sp. n. but it has highly transformed furcal rami and dorsal spines on the last abdominal segment (Kunz 1981).

When the total body length of *K. schminkei* sp. n. is compared with the length of its furcal rami it is obvious, that this species has the (relatively) longest non-transformed furcal rami in the whole genus. In the male furcal rami make up one fifth of the whole body size, in the female it is one fourth.

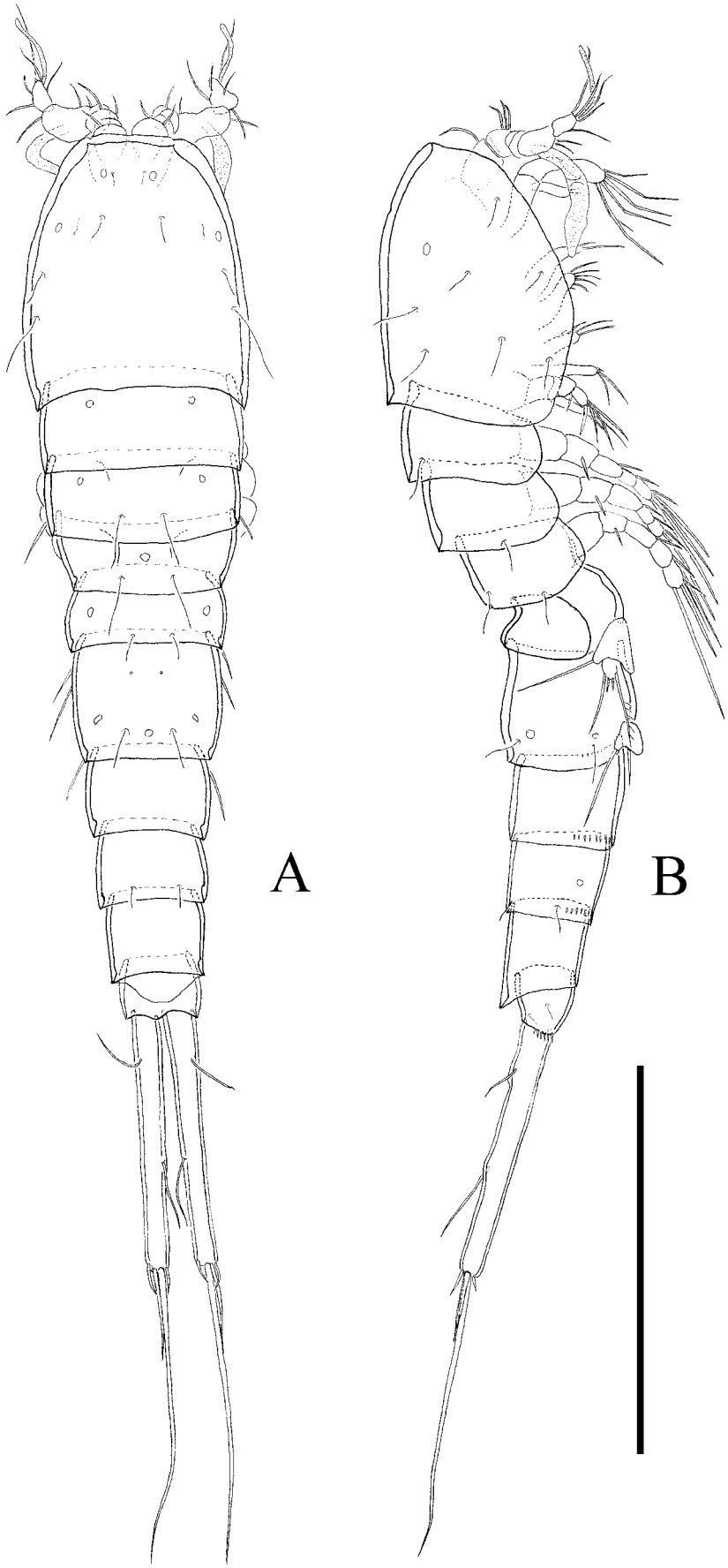

FIGURE 7. *Kliopsyllus schminkei* n. sp. Male allotype: (A) Habitus dorsal; (B) Habitus lateral. Scale bar = 100 µm.

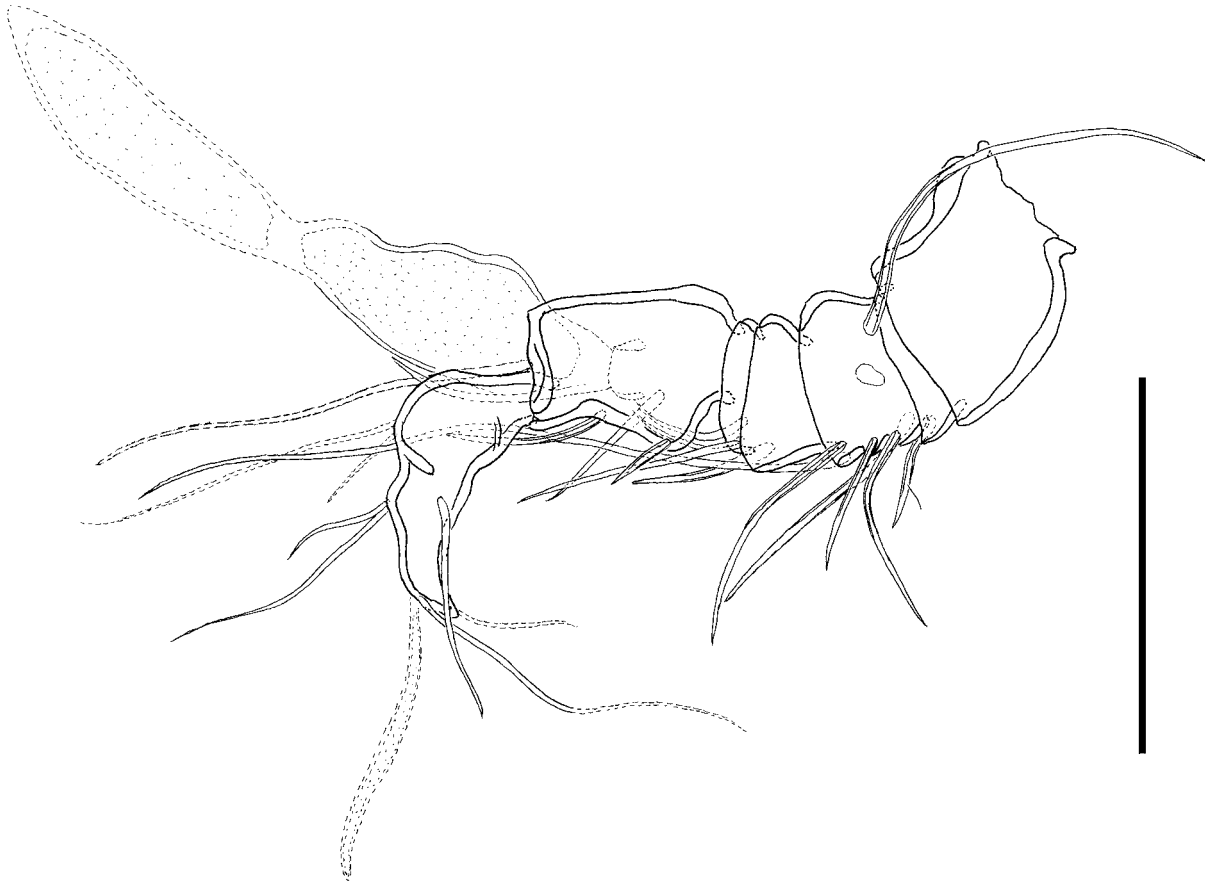

FIGURE 8. *Kliopsyllus schminkei* n. sp. Male allotype: Antennule; dotted elements added after paratype. Scale bar = 20 µm.

K. schminkei sp. n. is one of the smallest *Kliopsyllus*-species ever described. In Figure 9 a size-comparison between the deep-sea *Kliopsyllus*-species described to date is given. Vasconcelos *et al.* (2009) present with *Kliopsyllus minor* Vasconcelos, Veit-Köhler, Drewes & Santos, 2009 the smallest *Kliopsyllus*-species known. *K. schminkei* sp. n. has a comparably small body size. Regarding only the total body size of *K. schminkei* sp. n. is misleading in this case, as the extremely long furcal rami add about one fifth to one fourth to the total size.

Two groups of *Kliopsyllus*-species can be distinguished due to the characteristic shape of the endopods of P2–P4. There are species with more stout and inflated enp like *Kliopsyllus paraholsaticus* Mielke, 1975, *Kliopsyllus panamensis* Mielke, 1984 and *Kliopsyllus similis* (Mielke 1975, 1984a, 1984b). On the other hand there are species like *Kliopsyllus miguelensis* Kunz, 1983 and *K. diva* with rather straight column-like enps in P2–P4 (Kunz 1983, Veit-Köhler 2005). *Kliopsyllus schminkei* sp. n. belongs to the second group. Whether these differences in the shape of the enp have systematic relevance remains to be determined.

Occurrence and abundance: Altogether 2199 adult harpacticoid copepods (7329 individuals including copepodids and copepods of other orders, Seifried, pers. comm.) were sampled at the two stations 325 and 346 during the DIVA-1 campaign. These individuals came from 75 multiple cores from 15 MUC hauls. As already shown by Rose *et al*. (2005), the densities of Paramesochridae as well as the densities of copepods in general differed between the two stations 325 and 346. Paramesochridae were represented with 65 individuals at site 346 (0.224 ind. $10cm^{-2}$), whereas site 325 revealed altogether only 16 individuals (0.063 ind. $10cm^{-2}$). *Kliopsyllus schminkei* sp. n. was represented by 14 individuals: one female from station 325 (0.004 ind. $10cm^{-2}$) and 9 females and 4 males from station 346 (0.044 ind. $10cm^{-2}$). The species constitutes after *K. diva* the second most abundant *Kliopsyllus* in the Angola Basin.

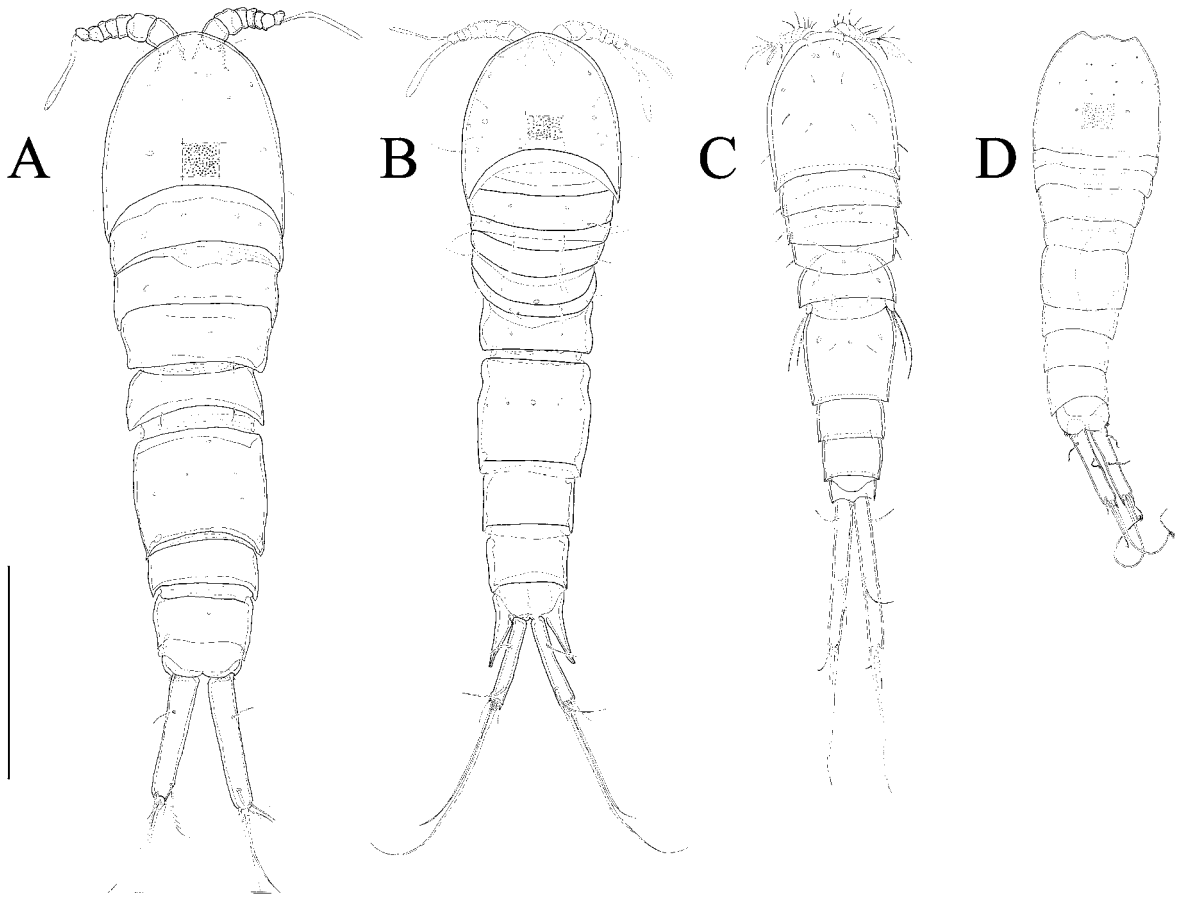

FIGURE 9. The deep-sea species of *Kliopsyllus* described to date. (A) *Kliopsyllus diva* Veit-Köhler, 2005; (B) *Kliopsyllus andeep* Veit-Köhler 2004; (C) *Kliopsyllus schminkei* sp. n.; (D) *Kliopsyllus minor* Vasconcelos, Veit-Köhler, Drewes & Santos, 2009. Scale bar = 100 µm.

Kröncke & Türkay (2003) report a gradient of total organic carbon in the sediment between the low productivity area of site 325 on the one hand and site 346 with its considerably higher food supply on the other. Therefore Rose *et al.* (2005) conclude that the differences in abundance of benthic harpacticoids between station 325 and 346 are due to contrasting food supply. The ratio of 1:13 individuals of *K. schminkei* sp. n. at the two stations follows this general finding.

Comments on biogeography: A study on the large-scale biogeography and species-level diversity of deep-sea Paramesochridae by Gheerardyn & Veit-Köhler (accepted) showed, that *K. schminkei* sp. n. has a much wider distribution range than the Angola Basin. They found individuals of this species across the south-east Atlantic, from the Guinea Basin in the north to the Cape Basin in the south. Comparable findings with an even larger distribution range have recently been reported for the harpacticoid *Bradya kurtschminkei* Seifried & Martínez Arbizu, 2008. This species is present in samples from the Porcupine Abyssal Plain in the north, in the Guinea Basin, the Angola Basin and in the Cape Basin, which seems to be its southernmost limit of occurrence. *Bradya kurtschminkei* is not present in samples from the Antarctic Southern Ocean (Seifried & Martínez Arbizu 2008).

K. schminkei sp. n. can easily be recognised by its typical paramesochrid body shape and the extremely long furcal rami. All other relevant characters such as the setation of the swimming legs can be checked without dissection of the specimens. Therefore *K. schminkei* sp. n. as well as the other species of the genus *Kliopsyllus* are convenient for the study of deep-sea copepod biogeography and diversity (Gheerardyn & Veit-Köhler accepted).

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