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Redescription of two species of *Asterocheres* Boeck, 1860 (Copepoda: Siphonostomatoida), *A. corneliae* Schirl, 1973 and *A. boeckii* (Brady, 1880), and proposal of a new genus for *Asterocheres fastigatus* Kim, 2010

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Abstract

Asterocheres Boeck, 1860 is the largest genus in the family Asterocheridae and includes approximately 96 nominal species. Nevertheless, according to Kim (2010), the current assignment of twelve of these species to *Asterocheres* is debatable, and fifteen species are too incompletely described for reliable comparisons to be made. In this paper, two species, *A. corneliae* Schirl, 1973 and *A. boeckii* (Brady, 1880), are redescribed and compared with their congeners. As a result of the comparison between *A. boeckii* and *A. fastigatus* Kim, 2010, a new genus, *Kimcheres*, is erected to accommodate the only species of *Asterocheres* displaying the armature formula (0-1) on the second endopodal segment of leg 4. The taxonomic position of *A. longisetosus* Nair & Pillai, 1984, considered as *species inquirenda* by Kim (2010), is discussed. Examination of the original description and illustrations, especially the antennules and the mandible, casts doubts on the validity of the species.

Key words: Asterocheridae, *A. longisetosus*, *Kimcheres* **gen. nov.**

Introduction

The Siphonostomatoida is a well-defined order diagnosed by the shape of the mandible and the possession of an oral cone formed by the labrum and the medially fused paragnaths (labium) (Huys & Boxshall 1991). This order includes about 38 families that accommodate predominantly symbiotic copepods, living in association with fish and a variety of invertebrate hosts (Ho 1994). Among them, the Asterocheridae is one of the most speciose families, currently including about 250 species, the great majority of which utilize marine invertebrates as hosts. It is widely accepted that a revision of the various asterocherid genera is long overdue, since for more than a century the family Asterocheridae has served as a repository for genera and species which did not fit in any other siphonostomatoid family (Boxshall & Halsey 2004). This state of affairs has inevitably contributed to the heterogeneity of this family (Nair & Pillai 1984; Boxshall & Halsey 2004; Johnsson & Neves 2004). Currently, the Asterocheridae includes 62 genera and more than 60% of them are monotypic; only nine genera accommodate five or more species. *Asterocheres* Boeck, 1860 is the largest genus in the family, containing nearly 35% of the known species (approximately 96 nominal species). As Kim (2010) pointed out, it is necessary to consider the validity of the nominal species of *Asterocheres* in order to refine the definition of the genus. His attempt to sort the nominal species resulted in the recognition of valid species (69 species currently), incompletely described species that are hardly comparable with other congeners (15 species) and *species inquirendae* whose current position in *Asterocheres* is questionable (12 species). The species belonging to the last two groups need to be re-examined for morphological details before they can be placed in a particular genus and for reliable comparisons to be made. Most of these poorly known species have not been recorded since their original descriptions and future studies are ideally to be based on type material deposited in museums. A partial revision of the genus *Asterocheres*, based on type material deposited in various museums, was recently initiated to clarify the confused systematic and

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phylogenetic relationships of this genus. The present paper deals with the redescription of two species deposited in the Natural History Museum of London, the Natural History Museum of the University of Oslo and the Zoological Museum of the University of Copenhagen. Although this material belonged to the group of valid species recognized by Kim (2010), re-examination of *Asterocheres corneliae* Schirl, 1973 and *A. boeckii* (Brady, 1880) showed some discrepancies with their respective original descriptions and, furthermore, the comparison of the redescribed species with the remaining species of the genus, particularly with *A. fastigatus* Kim, 2010, necessitated the erection of a new genus, *Kimcheres*. In addition, the taxonomic position of *A. longisetosus* Nair & Pillai, 1984, relegated by Kim (2010) to *species inquirendae*, is reassessed in this paper.

Material and methods

Asterocherid material was loaned by various European museums, including specimens from the Natural History Museum of London (NHMUK) (three females belonging to the Norman Collection), seven specimens collected by Sars in Norway in 1915 and deposited in The Natural History Museum of the University of Oslo (ZMO), and two specimens deposited in the Zoological Museum of the University of Copenhagen (ZMUC).

When slide preparations from the different museums were not sufficient for a detailed description of some appendages, a whole specimen was stained with Chlorazol black E (Sigma® C-1144) prior to dissection in lactic acid. The dissected parts were then examined as temporary mounts in lactophenol and subsequently sealed with Entellan to make permanent mounts.

All figures were drawn with the aid of a camera lucida on a Leica DMLB differential interference contrast microscope. All appendage segments and setation elements were named and numbered using the system established by Huys & Boxshall (1991). In the armature formula of the swimming legs 1–4, spines are indicated by Roman numerals and setae by Arabic numerals. Mean body length of the copepod was measured from the anterior margin of the rostrum to the posterior margin of the caudal rami.

Results

Order Siphonostomatida Burmeister, 1835

Family Asterocheridae Giesbrecht, 1899

Asterocheres Boeck, 1860

Asterocheres corneliae Schirl, 1973
(Figs. 1–2)

Asterocheres corneliae Schirl, 1973: 71–77; Figs. 3–4, 5(g–j)

Material examined. Six females (NHMUK reg. no 1986.385), associated with a red sponge collected in a bay situated 2 km north of Banyuls-sur-Mer, France; August 1983.

Description of female. Body cyclopiform, with oval cephalothorax and cylindrical urosome (Fig. 1A). Mean body length 756µm (n = 5; 710–790 µm) and mean maximum width 385 µm (n = 5; 375–404 µm). Prosome comprising cephalothorax (fully incorporating first pedigerous somite) and three free pedigerous somites.

Urosome 4-segmented, comprising leg 5-bearing somite, genital double-somite and two free abdominal somites (Fig. 1B). Except for leg 5-bearing somite, all other urosomites ornamented with epicuticular scales. Genital double-somite (Fig. 1B) slightly wider than long; paired genital apertures bipartite, each comprising lateroventral copulatory pore and dorsolateral gonopore (oviduct opening); lateral margins with long spinules in middle third (posterior to genital apertures). Each genital area provided with one very plumose seta (Fig. 1B).

Caudal rami (Fig. 1B) about as long as wide (measured along outer margin); armed with six setae: seta I absent; setae III–VI all plumose and arranged around posterior margin; insertion sited of setae II and VII slightly displaced onto dorsal surface, both of them smooth.

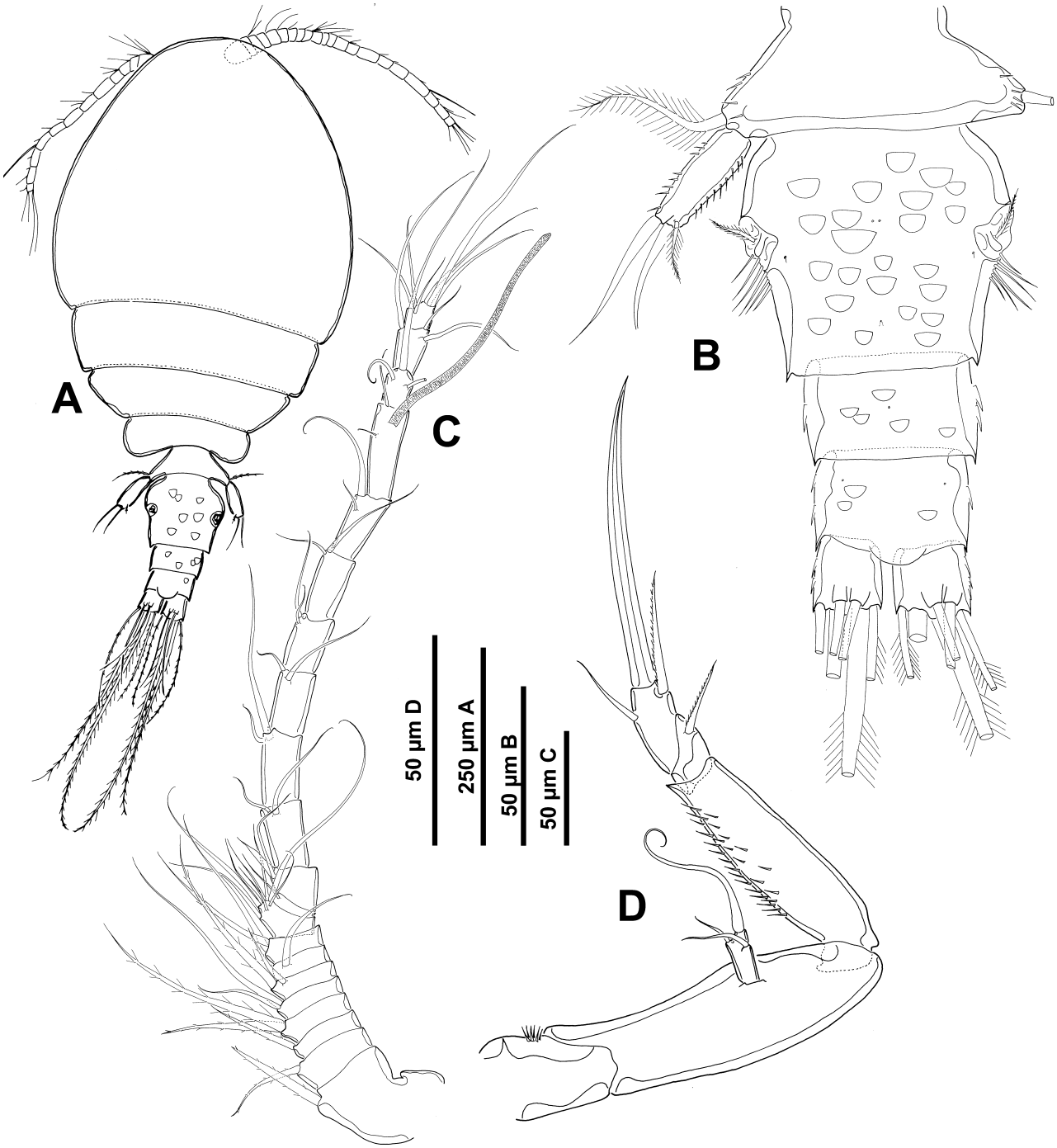

FIGURE 1. *Asterocheres corneliae* Schirl, 1973 (female). A, habitus, dorsal; B, urosome, dorsal; C, antennule; D, antenna.

Antennule (Fig. 1C) 21-segmented, about 375 µm long. Segmental fusion pattern and armature as follows: 1(I)-1, 2(II)-1, 3(III)-1, 4(IV)-2, 5(V)-2, 6(VI)-2, 7(VII)-1, 8(VIII)-2, 9(IX–XII)-8, 10(XIII)-1, 11(XIV)-1 + 1 spine, 12(XV)-2, 13(XVI)-2, 14(XVII)-2, 15(XVIII)-2, 16(XIX)-2, 17(XX)-2, 18(XXI)-2 + 1 aesthetasc, 19(XXII–XXIV)-3, 20(XXV–XXVI)-3 and 21(XXVII–XXVIII)-6. Segment 10(XIII) reduced, forming incomplete sclerite partly overlapped by distal expansion of compound segment 9(IX–XII).

Antenna (Fig. 1D) biramous, about 240 µm long including terminal claw. Coxa small and ornamented with tuft of spinules in distal inner margin. Basis elongate and unarmed. Exopod 1-segmented, about twice longer than wide, armed with one lateral seta, one short subterminal seta and one very long terminal seta, all of them smooth. Endopod 3-segmented; proximal segment elongate and ornamented with rows of spinules along inner margin; middle segment produced distally on medial side but articulating with distal segment proximally on lateral side,

bearing one plumose distal seta which is longer than the entire segment; distal segment armed with two subterminal setae, one of them plumose, and apical claw.

Siphon reaching to between bases of maxillipeds and intercoxal sclerite of leg 1.

Mandible (Fig. 2A) comprising stylet-like gnathobase and slender 1-segmented palp. Stylet with denticulate margin subapically. Palp elongated, with row of spinules at medial side and two barbed terminal setae of unequal length.

Maxillule (Fig. 2B) bilobed; praecoxal gnathobase (inner lobe) 3.5 times longer than palp (outer lobe). Praecoxal endite ornamented with short spinules laterally and tuft of long spinules medially; armed with five terminal setae, one of them very short and naked. Palp bearing two subterminal setae (one of them barbed and very short and the other one long and plumose) and two plumose terminal setae, equal in length.

Maxilla (Fig. 2C) 2-segmented. Coxa with row of spinules along proximal inner margin (not figured). Basis claw-like, longer than coxa, with recurved tip and ornamented with row of spinules in distal half.

Maxilliped (Fig. 2D) 5-segmented, comprising short syncoxa, long basis and 3-segmented endopod. Syncoxa with one short smooth seta along distal inner margin. Basis elongate with few short spinules along outer margin and minute seta halfway along inner margin. First endopodal segment compound, partial suture marking original separation of two ancestral segments, armature formula (2,0); second endopodal segment short, bearing one short naked seta medially; third endopodal segment armed with terminal claw plus additional plumose subterminal seta. Distal two-thirds of claw provided with spinules along medial margin.

Swimming legs 1–4 (Fig. 4A–D) biramous, with 3-segmented rami and intercoxal sclerite present in all legs (legs 1–4 as described and illustrated by Schirl (1973)). Spine and seta formula:

	coxa	basis	exopod	endopod
Leg 1	0-1	1-1	I-1;I-1;III,4	0-1;0-2;1,2,3
Leg 2	0-1	1-0	I-1;I-1;III,I,4	0-1;0-2;1,2,3
Leg 3	0-1	1-0	I-1;I-1;III,I,4	0-1;0-2;1,1+I,3
Leg 4	0-1	1-0	I-1;I-1;III,I,4	0-1;0-2;1,1+I,2

Fifth leg (Fig. 1B) with protopod incorporated into somite; outer basal plumose seta displaced to laterodorsal surface, longer than entire free segment. Exopod elongate, with three terminal setae, the longest two smooth and stout and the short one densely plumose; outer and inner margins with spinules.

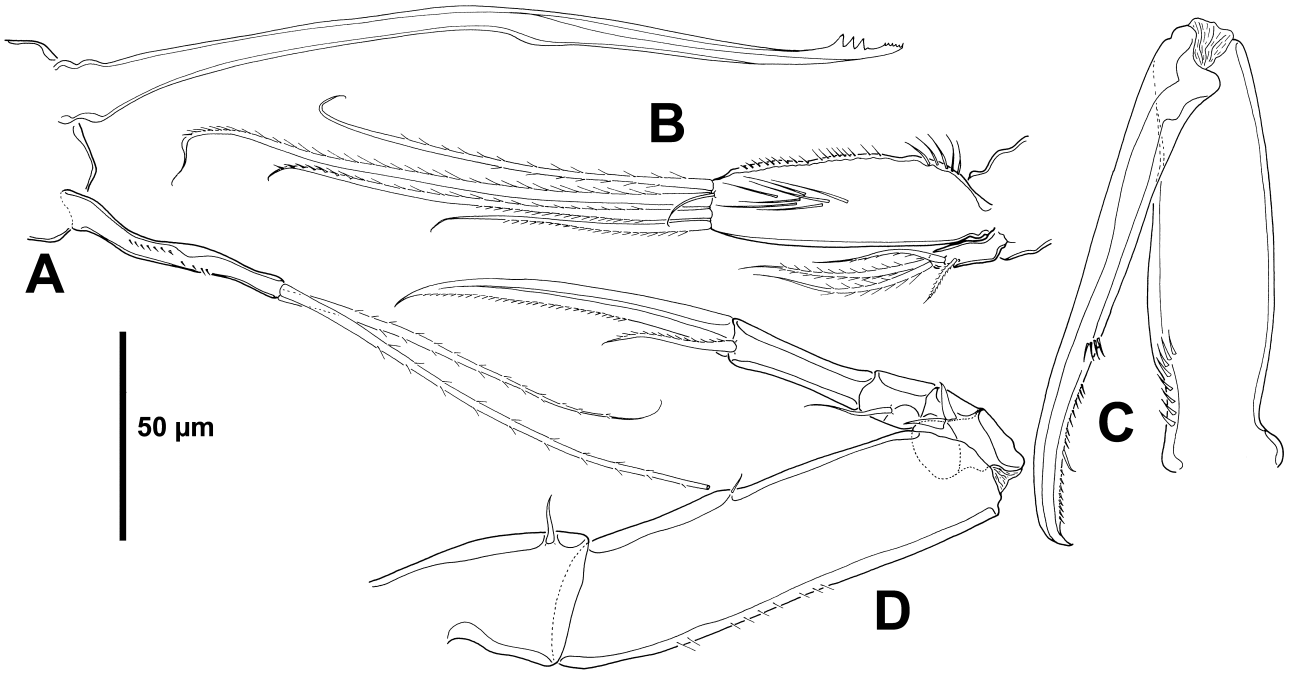

FIGURE 2. *Asterocheres corneliae* Schirl, 1973 (female). A, mandible; B, maxillule; C, maxilla; D, maxilliped.

Sixth leg (Fig. 1B) represented by paired opercular plates closing off gonopores on genital double-somite; armed each with one very plumose seta.

Male. Not examined.

Discussion. Schirl's (1973) description was based on specimens collected from Banyuls in the early 1960s that were found to be associated with three species of calcarean sponges, *i.e. Clathrina clathrus* (Schmidt, 1864), *C. primordialis* (Haeckel, 1872) and *Ascandra contorta* (Bowerbank, 1866). The specimens deposited in the Natural History Museum of London are labelled *Asterocheres cf. corneliae*, and upon re-examination were confirmed to belong to this species. However, some discrepancies with the original description were observed, including: (1) the antennule is 20-segmented in the female in the original description, although the illustration shows a 20-segmented antennule with the last segment indistinctly 2-segmented (with three and three setae each); our re-examination showed that the antennule is 21-segmented, with the last two segments clearly divided (three and six setae each); (2) the antenna bears three setae on the exopod instead of the two setae illustrated by Schirl, and the proximal segment of the endopod is ornamented with rows of spinules along the inner margin; (3) the mandibular palp was described as "probably 2-segmented, but the dividing line is barely visible"; the mandibular palp proved to be clearly 1-segmented and the stylet of the mandible is illustrated here for the first time; (4) the outer lobe of the maxillule is smaller and the terminal setae are shorter than those shown in the original description; the inner lobe is provided with one additional seta; (5) row of spinules along proximal inner margin in the coxa and row of spinules in distal half of basis claw-like are missing in Schirl's illustration of the maxilla; (6) the minute seta halfway along inner margin of basis and one seta on first endopodal segment are missing in Schirl's description of the maxilliped; (7) the leg 5-bearing somite and all other urosomites are ornamented with epicuticular scales which were overlooked in the original illustration.

Despite the discrepancies observed between the specimens examined herein and the original description, the species is easily identifiable as *A. corneliae*. As in other redescriptions of *Asterocheres* species (Bandera & Conradi 2009a, 2009b, 2013, 2014; Kim 2010), such discrepancies are mainly confined to the ornamentation and armature of oral appendages and are relatively common in descriptions published 40 or more years ago.

Asterocheres corneliae belongs to the group of *Asterocheres* species that display a 21-segmented antennule in the female. This group includes 27 species: *A. astroidicola* Conradi, Bandera & López-González, 2006, *A. echinicola* (Norman, 1868), *A. ellisi* Hamond, 1968, *A. eugenioi* Bandera & Conradi, 2014, *A. faroensis* Crescenti, Baviera & Zaccone, 2010, *A. flustrae* Ivanenko & Smurov, 1997, *A. genodon* Stock, 1966, *A. hirsutus* Bandera, Conradi & López-González, 2005, *A. hoi* Bandera & Conradi, 2013, *A. jeanyeatmanae* Yeatman, 1970, *A. kervillei* Canu, 1898, *A. latus* (Brady, 1872), *A. lilljeborgii* Boeck, 1860, *A. madeirensis* Bandera, Conradi & López-González, 2007, *A. minutus* (Claus, 1889), *A. nudicoxus* Kim, 2010, *A. peniculatus* Kim, 2010, *A. reginae* Boxshall & Huys, 1994, *A. sarsi* Bandera & Conradi, 2009b, *A. simulans* (Scott, 1898), *A. siphonatus* Giesbrecht, 1897, *A. suberitis* Giesbrecht, 1897, *A. tarifensis* Conradi & Bandera, 2011, *A. tenerus* (Hansen, 1923), *A. tenuicornis* Brady, 1910, *A. tubiporae* Kim, 2004b, and *A. urabensis* Kim, 2004a.

Only six species of the group listed above are reported to have a 1-segmented mandibular palp as in *A. corneliae*, *i.e. A. echinicola*, *A. faroensis*, *A. madeirensis*, *A. minutus*, *A. nudicoxus* and *A. siphonatus*. The remaining species exhibit a 2-segmented mandibular palp. Although *A. nudicoxus* was described by Kim (2010) as having a 1-segmented mandibular palp, in the description he pointed out that the palp showed a vestigial articulation which was displayed in the illustration (Kim 2010: Fig. 34A). This vestigial articulation and the characteristic shape of the genital double-somite, consisting of a broad anterior part and a very short, narrower posterior part, with the anterior part strongly tapering anteriorly (Kim 2010: Fig. 33B) serve to separate *A. nudicoxus* from *A. corneliae*.

Two species, *A. echinicola* and *A. minutus*, differ from *A. corneliae* by the morphology of the maxillule. In both species the inner and outer lobes are approximately equal in length, and one of the four terminal setae on the inner lobe is four times longer than the remaining three setae (Bandera & Conradi 2009b; Conradi & Bandera 2011). In contrast, *A. corneliae* has an inner lobe which is about 3.5 times longer than the outer and bears four long and one short distal setae.

Asterocheres siphonatus can easily be separated from *A. corneliae* by the length of the siphon. In *A. corneliae* it extends beyond the bases of the maxillipeds but does not reach the intercoxal sclerite of the first leg, whereas in *A. siphonatus* the siphon extends to the posterior margin of the intercoxal sclerite of the fourth leg (Conradi & Bandera 2011).

Detailed comparison between *A. corneliae* and *A. faroensis* reveals a number of significant differences, including the size of the caudal rami (about as long as wide in *A. corneliae* compared to 1.7 times longer than wide in *A. faroensis*) and the more dorso-ventrally flattened prosome in *A. faroensis* (Crescenti *et al.* 2010). The long aesthetasc-like element on the coxal part of maxilla is present in *A. faroensis* but was not discernible in *A. corneliae.*

The most similar species of the group mentioned above is *A. madeirensis* which can be distinguished by the following differences: (1) antennary exopod armed with two setae in *A. madeirensis* and three setae in *A. corneliae*; (2) mandibular stylet pointed in *A. madeirensis* but denticulated in *A. corneliae*; (3) siphon slightly longer in *A. corneliae*; (4) inner lobe of maxillule three times longer than outer lobe in *A. madeirensis* but four times longer in *A. corneliae*; (5) aesthetasc-like element present on coxal part of maxilla in *A. madeirensis* but absent in *A. corneliae*; (6) outer basal seta of protopod of leg 5 longer than the entire free segment in *A. corneliae* but shorter in *A. madeirensis*; and (7) lateral margins of the genital double-somite with long spinules in the middle third in *A. corneliae*, but much more spinous in *A. madeirensis* (Bandera *et al.* 2007).

Asterocheres boeckii (Brady, 1880)

(Figs. 3–5)

Artotrogus Boeckii Brady, 1880: 60–61; Plate XCI, figs. 1–9.

Material examined. (a) seven females (ZMO F21599) from Ranø, collected by G.O. Sars; (b) two females (ZMUC; CRU-4936) from Talsnafiord Island, 1893; (c) three females (NHMUK-1911.11.8.47282–286) from Salcombe, Devon, England, 1875 (Norman collection); (d) seven females, three juveniles (NHMUK-1986.381) from Loch Riddon (Loch Ruel), Argyll and Bute, Scotland.

Description of female. Body cyclopiform, with very broad prosome and cylindrical urosome (Fig. 3A). Mean body length 864µm (n = 4; 791–920 µm) and mean maximum width 497 µm (n = 4; 396–620 µm). Prosome comprising cephalothorax (fully incorporating first pedigerous somite) and three free pedigerous somites. Cephalothorax with posterolateral angles rounded. Somites bearing legs 2–3 very broad; epimeral areas with posterolateral angles rounded. Somite bearing leg 4 much smaller and narrower than preceding ones, largely concealed under pleurotergite of leg 3-bearing somite.

Urosome 4-segmented, comprising leg 5-bearing somite, genital double-somite and two free abdominal somites. Posterior hyaline frills of urosomites with serrate free margins (Fig. 3B). Genital double-somite ornamented with flattened epicuticular scales arranged in irregular pattern dorsally (Fig. 3B); about as long as wide; paired genital apertures bipartite, each comprising lateroventral copulatory pore and dorsolateral gonopore (oviduct opening); lateral margins with setular tufts in distal half (posterior to genital apertures).

Caudal rami (Fig. 3B) slightly wider than long (measured along outer margin); trapezoid with inner margin shorter than outer one; armed with six setae; seta I absent; setae II–VII all arranged around posterior margin with setae II and VII slightly displaced onto dorsal surface.

Antennule (Fig. 3D) 21-segmented, about 370 µm long. Segmental fusion pattern and armature as follows: 1(I)-2, 2(II)-2, 3(III)-2, 4(IV)-2, 5(V)-2, 6(VI)-1, 7(VII)-1, 8(VIII)-2, 9(IX–XII)-7, 10(XIII)-1, 11(XIV)-1 + 1 spine, 12(XV)-2, 13(XVI)-2, 14(XVII)-2, 15(XVIII)-2, 16(XIX)-2, 17(XX)-2, 18(XXI)-2 + 1 aesthetasc, 19(XXII–XXIII)-2 , 20(XXIV–XXV)-3 and 21(XXVI–XXVIII)-6. Segment 10(XIII) reduced, forming incomplete sclerite partly overlapped by distal expansion of compound segment 9(IX–XII).

Antenna (Fig. 3E) biramous, about 350 µm long including terminal claw. Coxa unarmed, with few spinules. Basis unarmed, with fine spinule row as shown in Figure 3E. Exopod 1-segmented, small, about 1.5 times longer than wide; with one short proximal seta and two terminal setae unequal in length, all of them smooth. Endopod 3-segmented; proximal segment elongate, ornamented with lateral and distal rows of fine spinules; middle segment produced distally on medial side but articulating with distal segment proximally on lateral side, bearing one distal smooth seta; distal segment with long terminal claw and two subterminal pinnate setae; inner margin of distal segment and claw with spinules.

Siphon reaching to the intercoxal sclerite of leg 1.

Mandible (Fig. 4B) comprising stylet-like gnathobase and slender 2-segmented palp. Proximal segment of palp

longest (3.9 times longer than distal one), ornamented with rows of spinules; short distal segment, with two plumose unequal apical setae.

Stylet located in oral cone, with denticulate margin subapically as figured.

Coxae ornamented with spinule rows around outer margin; inner coxal seta short and naked in legs 1 and 4, long and plumose in legs 2–3. Outer basal seta long and naked in legs 1–2 and short in legs 3–4 (the last one plumose). Outer spines of exopodal segments in legs 1–4 bilaterally serrate. Lateral margin of exopodal segments with minute serrations or spinular rows; those of endopodal segments with rows of setules.

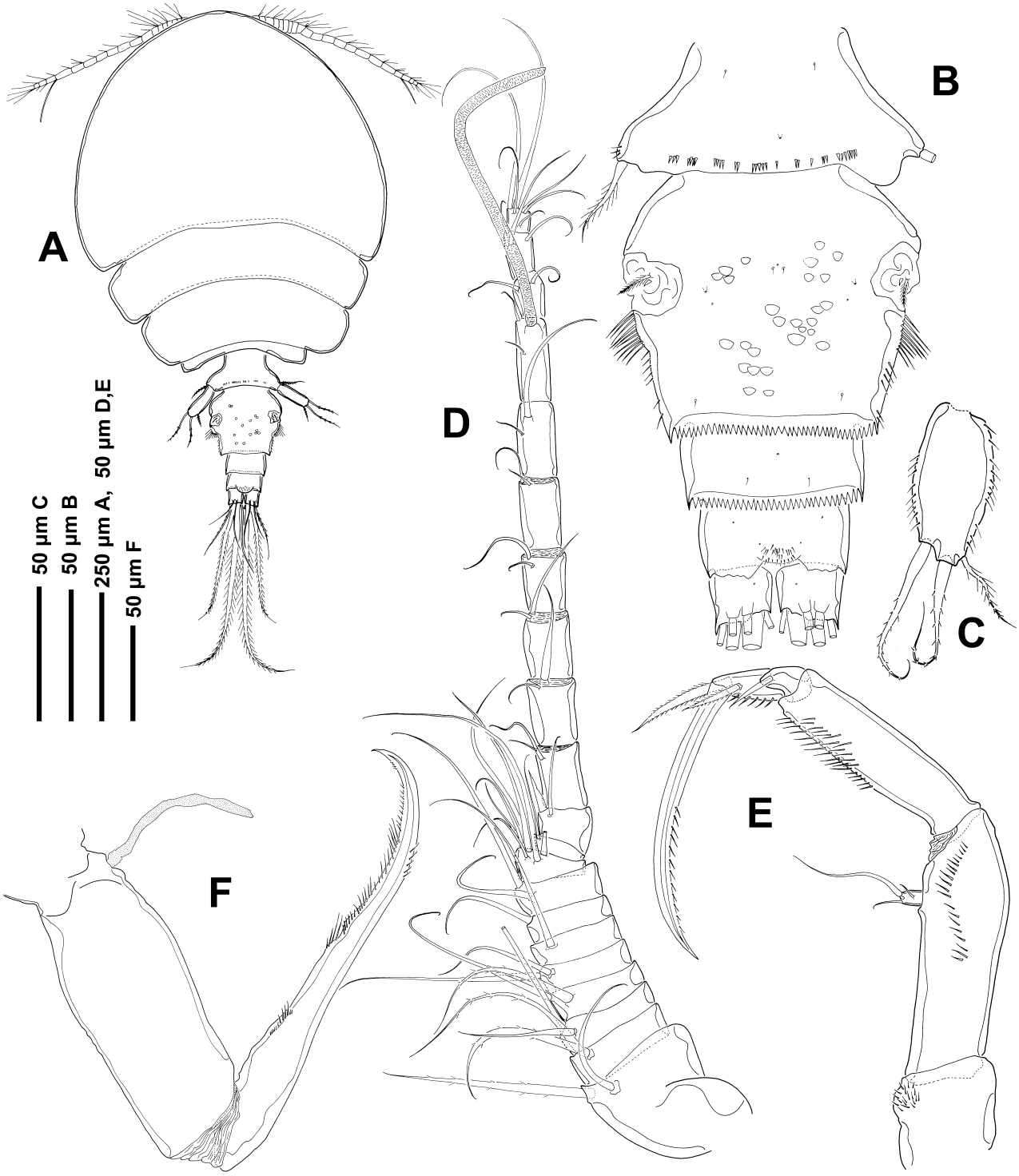

FIGURE 3. *Asterocheres boeckii* (Brady, 1880) (female). A, habitus, dorsal; B, urosome, dorsal; C, exopod of leg 5; D, antennule; E, antenna; F, maxilla.

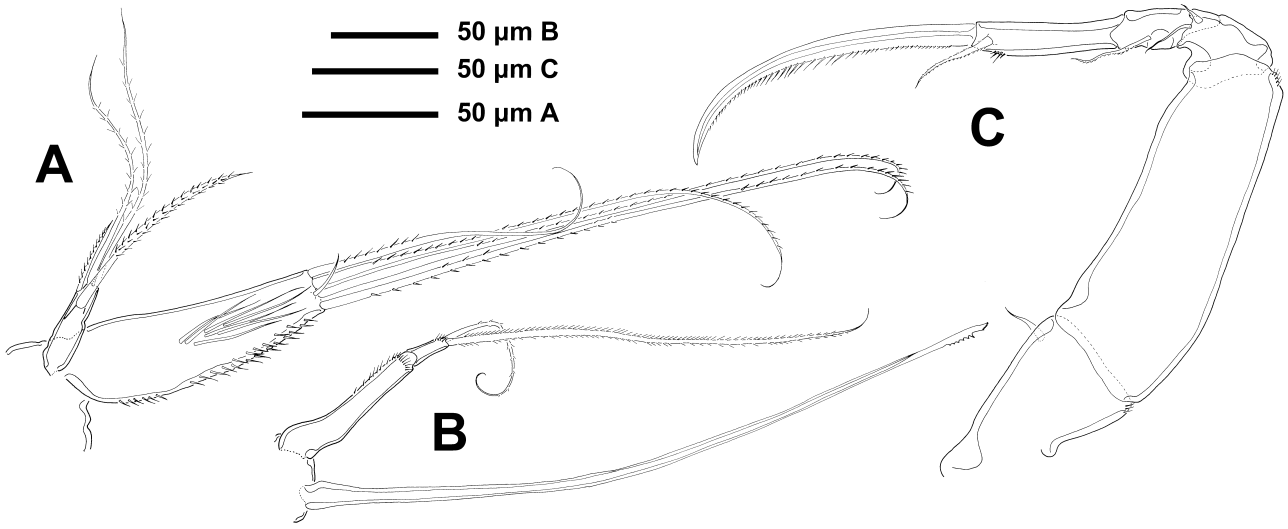

FIGURE 4. *Asterocheres boeckii* (Brady, 1880) (female). A, maxillule; B, mandible; C, maxilliped.

Maxillule (Fig. 4A) bilobed. Inner lobe much larger than outer lobe, about three times longer than wide. Inner lobe ornamented with spinules on lateral margin and tuft of long setules medially; armed with one minute and naked seta and four long but unequal setae, latter setae ornamented with spinules. Outer lobe armed with two long plumose setae, one subterminal spinulose seta and one lateral stout seta densely covered by spinules (Fig. 4A).

Maxilla (Fig. 3F) 2-segmented but with partial transverse surface suture on syncoxa (proximal segment) possibly marking plane of praecoxa-coxa fusion; praecoxal portion bearing flaccid aesthetasc-like element medially, representing tubular extension of external opening of maxillary gland; coxal portion unarmed. Basis claw-like and much longer than coxa, more or less straight but recurved towards the apex; margins provided with rows of spinules as figured.

Maxilliped (Fig. 4C) 5-segmented, comprising short syncoxa, long basis and 3-segmented endopod. Syncoxa with one short seta distally. Basis with few spinules on distal outer margin. First endopodal segment bearing two unequal distal setae; second endopodal segment with one plumose medial seta; third endopodal segment bearing recurved terminal claw and subterminal plumose seta. Distal margin of claw with rows of spinules.

Swimming legs 1–4 (Fig. 5A–D) biramous, with 3-segmented rami; intercoxal sclerite present. Spine and seta formula as follows:

	coxa	basis	exopod	endopod
Leg 1	0-1	1-1	I-1;I-1;III,4	0-1;0-2;1,2,3
Leg 2	0-1	1-0	I-1;I-1;III,I,4	0-1;0-2;1,2,3
Leg 3	0-1	1-0	I-1;I-1;III,I,4	0-1;0-2;1,1+I,3
Leg 4	0-1	1-0	I-1;I-1;III,I,4	0-1;0-2;1,1+I,2

Fifth leg (Fig. 3B–C) with protopod incorporated into somite; outer basal seta displaced to laterodorsal surface. Free segment elongate-oval, with three terminal setae, two of them long and pinnate and one of them shorter and plumose; margins with spinules.

Sixth leg (Fig. 3B) represented by paired opercular plates closing off gonopores on genital double-somite; armed each with one plumose seta and one spiniform element.

Discussion. This species was originally described by Brady (1880) under the name *Artotrogus boeckii* Brady, 1880, based on two or three specimens taken in a surface-net, and amongst weeds, at about 3.6 m depth in Westport Bay (Co. Mayo) and Roundstone Bay (Co. Galway), on the west coast of Ireland. Most workers have subsequently referred to it as *Asterocheres boecki* (*e.g.* Sars 1915; Stock 1966; Hamond 1973; Schirl 1973; Humes 1980; Kim 2014). However, the use of the genitive ending *-i* in a subsequent spelling of a species-group name that is a genitive based upon a personal name in which the correct original spelling ends with *-ii*, is to be treated as an incorrect subsequent spelling, even if the change in spelling is deliberate (ICZN Art. 33.4). The correct spelling of the

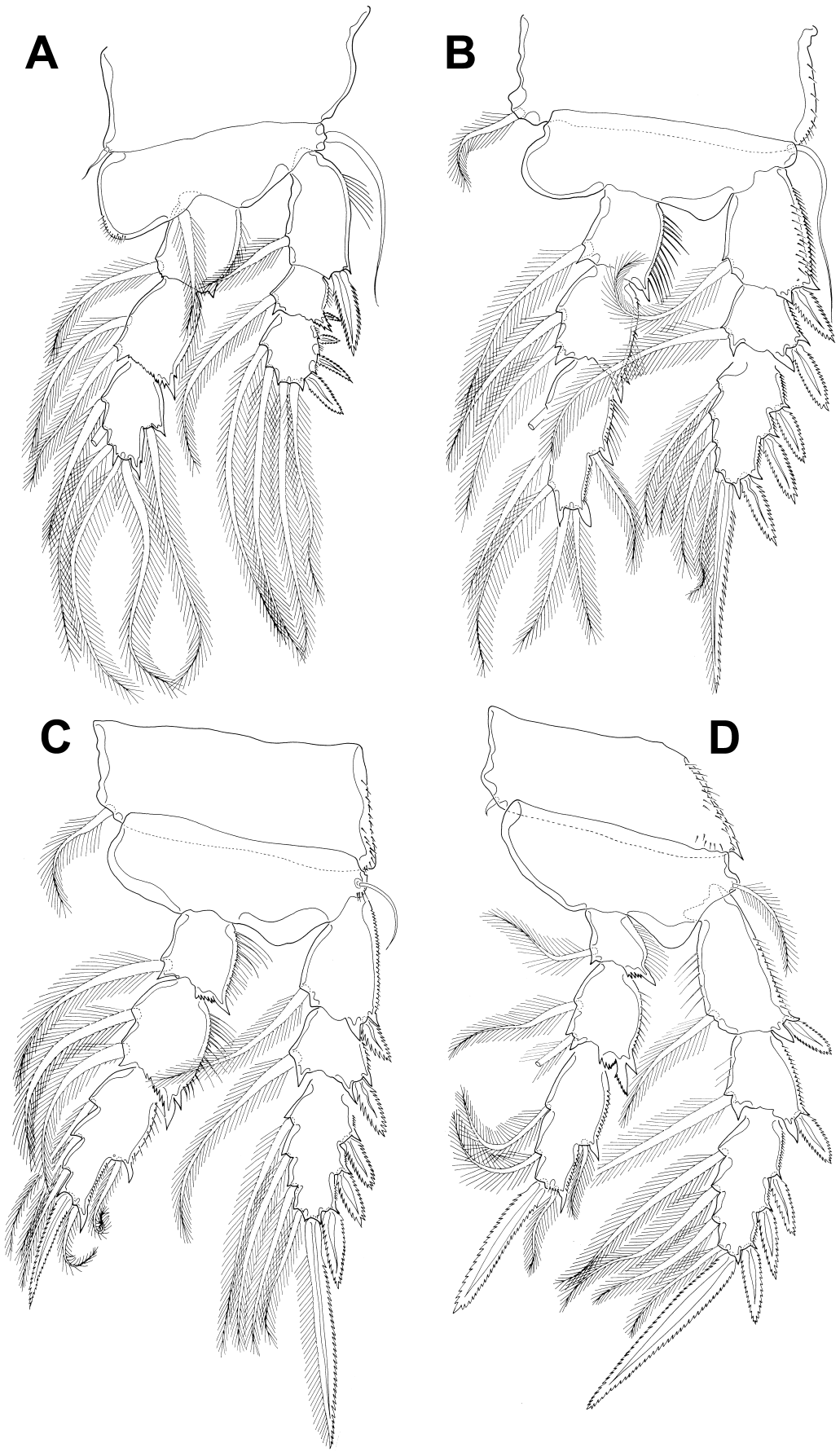

FIGURE 5. *Asterocheres boeckii* (Brady, 1880) (male). A, leg 1; B, leg 2; C, leg 3; D, leg 4.

specific epithet should therefore be *boeckii* and is reinstated here. The same applies to the type species of the genus which is widely cited as *Asterocheres lilljeborgi* but was originally spelled as *A. Liljeborgii* by Boeck (1860). Since the species was named after the Swedish zoologist Wilhelm Lilljeborg, the incorrect original spelling was subsequently corrected to *lilljeborgi* by Brady (1880), Canu (1892), Giesbrecht (1997) and others, but unfortunately, the correct suffix *–ii* was lost in the process. The correct spelling is adopted here as *Asterocheres lilljeborgii* Boeck, 1860. Similarly, the type species of *Ascomyzon* Thorell, 1859 (a synonym of *Asterocheres*), should be cited by its original spelling *Ascomyzon lilljeborgii* Thorell, 1859. Note that *Ascomyzon* (published 14 Sep 1859) takes priority over *Asterocheres* Boeck, 1860 (date of publication to be adopted is 31 December when only the year is specified or demonstrated (ICZN 21.3.2)). A ruling by the International Commission on Zoological Nomenclature will be required to avoid upsetting a long-accepted name in its accustomed meaning. In addition, since *Ascomyzon lilljeborgii* Thorell, 1859 has become the senior secondary homonym of *Asterocheres lilljeborgii* Boeck, 1860, the latter will need to be replaced, in this case by its oldest junior synonym, *Asterocheres asterocheres* (Sars, 1915).

Brady (1880) listed *Ascomyzon lilljeborgii* Thorell, 1859 as a synonym of *A. boeckii*, although in the text he mentioned that Thorell's (1859) specimens were obtained from *Corella* (as *Ascidia*) *parallelogramma* (Müller, 1776) and he himself "… had never seen any examples taken from ascidians". Giesbrecht (1899), in his monograph of asterocherids from the Gulf of Naples, amended the description of *A. boeckii* and illustrated the male and female. However, Sars (1915) pointed out that the specimens used in Giesbrecht's redescription of *A. boeckii* belonged to another species which was later described by Stock (1960) as *Asterocheres complexus* Stock, 1960. In the same paper, Sars also redescribed *A. boeckii*, transferred it to *Ascomyzon* (*Asterocheres* was considered invalid), and stated that *Asc. lilljeborgii* Thorell, 1859 and *Asc. lilljeborgii* (Boeck, 1860) were different species, both being distinct from *Asc. boeckii* (Brady, 1880).

Asterocheres boeckii was poorly described and illustrated by Brady (1880) and the only available redescription and illustrations that are more complete are those by Sars (1915). The specimens of this species deposited in different European museums show some discrepancies with the previous descriptions, *i.e.* (1) the antennule is 21-segmented in female instead of the 20 segments reported by Brady and Sars; (2) the antennary exopod has not two but three elements; Sars missed one lateral seta; (3) although Brady described the mandible in the text as "… produced into a long filiform seta, and destitute of a palp", his illustration shows a 1-segmented palp with two terminal setae (Brady 1880: Plate XCI, Fig. 3); the stylet is here described and illustrated for the first time; (4) the inner lobe of the maxillule possesses five setae instead of the four setae illustrated by Sars; (5) the maxilla has a long aesthetasc-like element medially which was not illustrated or mentioned in previous descriptions; (6) the maxilliped is 5-segmented with the armature formula: (1, 0, 2, 1, 1 + claw), but the majority of these setae or spines are missing in preceding descriptions; (7) according to Sars's illustration, the armature formula for the second endopodal segment of leg 4 is (0-1); however, the second endopodal segment of leg 4 bears two setae as is usual for the genus; and (8) the exopod of leg 5 shows not two but three terminal setae; there is one terminal seta missing in previous descriptions.

This species belongs to the *Asterocheres* species group characterized by 21-segmented antennules in the females, a 2-segmented mandibular palp and a siphon reaching to the intercoxal sclerite of leg 1. This group is composed of nine species: *A. ellisi*, *A. eugenioi*, *A. hirsutus*, *A. hoi*, *A. latus*, *A. peniculatus*, *A. sarsi*, *A. tenuicornis* and *A. urabensis*. Although there is no information about the length of the siphon in *A. tenuicornis*, this species can easily be separated from *A. boeckii* by the length of the caudal rami, being six times longer than wide, the longest within the genus (Eiselt 1965). Caudal ramus length can also be used to separate both *A. latus* and *A. hirsutus* from *A. boeckii* since the caudal rami is 2.6 times longer than wide in *A. latus*, 2.5 times longer than wide in *A. hirsutus* and slightly wider than long in *A. boeckii* (Bandera & Conradi 2009b; Bandera *et al.* 2005).

Asterocheres boeckii can be separated from *A. ellisi*, *A. eugenioi* and *A. sarsi* by differences in body shape. While *A. boeckii* shows a cyclopiform body, with very broad prosome and cylindrical urosome, *A. ellisi* is characterized by a dorsoventrally flattened prosome (Hamond 1968: Fig. 7); *A. eugenioi* and *A. sarsi* have an oval cephalothorax, a cylindrical urosome, and epimeral areas of somites bearing legs 2–3 with pointed posterolateral angles (Bandera & Conradi 2014: Figs. 2A, 6A).

Kim (2010) stated that "… *A. boeckii* differs from *A. peniculatus* having the more expanded prosome, the narrower genital double-somite which is as long as wide, the rostrum with rounded posterior margin, a single inner seta on the second endopodal segment of leg 4, and only two distal setae on the free segment of leg 5, according to the description and figures made by Sars (1915)". After our redescription of *A. boeckii*, it is now confirmed that the

last two differences do not exist and *A. peniculatus* and *A. boeckii* share a similar leg 4 and exopod of leg 5. However the other three differences listed above remain valid to separate these two species.

Two other species are very similar to *A. peniculatus* and *A. boeckii*, *i.e. A. genodon* and *A. astroidicola*. The latter can be distinguished from the first two by the length of the siphon (extending beyond the intercoxal sclerite of leg 2 in *A. astroidicola* but reaching the bases of leg 1 in *A. peniculatus* and *A. boeckii*) (Conradi *et al.* 2006). Furthermore, *A. genodon* shows a feature that separates this species from the other three: the presence of seven caudal setae, including a small, naked ventral seta (Kim 2010: Fig. 39C).

The remaining two species of the group, *A. hoi* and *A. urabensis*, differ from *A. boeckii* in the morphology of the free segment of leg 5, the maxillule and the terminal spine of the third exopodal segment of legs 2–4. The exopod of leg 5 is 2.5 times longer than wide in *A. hoi*, 3.8 times longer than wide in *A. urabensis* but only 1.9 times longer than wide in *A. boeckii*. The length ratio between the inner and outer lobes of the maxillule is about 3 in *A. hoi* and *A. urabensis*, but only 1.8 in *A. boeckii*. The terminal spine of the third exopodal segment of leg 2–4 is much longer than the entire segment in *A. boeckii*; in contrast, this spine is almost equal in length or slightly shorter than the segment in *A. hoi* and *A. urabensis* (Kim 2004a; Bandera & Conradi 2013).

Kimcheres gen. nov.

Diagnosis. Asterocheridae. Body cyclopiform, with large prosome and small urosome. Siphon of medium size, extending beyond bases of maxillipeds. Sexual dimorphism in urosomal segmentation, antennules, maxillipeds, size of leg 5 and leg 6.

Urosome 4-segmented in female and 5-segmented in male. Antennule 17-segmented in female, with large aesthetasc on segment 14; 14-segmented in male, with large aesthetasc on segment 13. Antenna with very long 1-segmented exopod and 3-segmented endopod with terminal claw. Mandibular palp 2-segmented, second segment with two plumose distal setae. Maxillule bilobed. Maxilla 2-segmented, proximal segment with aesthetasc-like element and a claw-like basis, strongly curved distally. Maxilliped 6-segmented, comprising short syncoxa, long basis and 3-segmented endopod; male basis with weak proximal process. Legs 1–4 biramous, with 3-segmented rami. Inner seta on coxa of leg 4 lacking. Armature formula of second endopodal segment of leg 4 (0-1). Leg 5 with protopod incorporated into somite and 1-segmented exopod bearing three setae.

Etymology. The genus is named in honour of Prof. Il-Hoi Kim (Gangneung National University, Korea), who described its type species, in recognition of his contribution to the systematics on symbiotic copepods. The generic name is derived from "Kim" and the suffix *–cheres*, frequently used in the names of asterocherid genera.

Type species. *Asterocheres fastigatus* Kim, 2010 = *Kimcheres fastigatus* (Kim, 2010) **comb. nov.** by original designation (Kim 2010: 64–68; figs. 45A–I, 46A–G, 47A–E).

Discussion. Kim (2010) placed his new species *Asterocheres fastigatus* in *Asterocheres* but expressed some reservations about this generic assignment. He pointed out three characters as the most striking features of this species: (1) armature formula of second endopodal segment of leg 4 (0-1); (2) coxa of leg 1 lacking inner seta, and (3) the elongate antennary exopod. Three other species share the absence of the inner coxal seta of leg 1 with *A. fastigatus*: *A. trisetatus* Kim, 2010, *A. eugenioi* and *A. sarsi*. However, the absence of this coxal seta is the only characteristic shared among these four species.

Although Kim (2010) mentioned that the elongate antennary exopod (longer than half the length of the first endopodal segment) is not present in other species of *Asterocheres*, there is one other species sharing this character. In *A. ellisi* the antennary exopod is six times longer than wide. The most striking differences between *A. fastigatus* and *A. ellisi* are the segmentation of the female antennule (17-segmented vs 21-segmented, respectively) and the body shape which is dorso-ventrally flattened in *A. ellisi* (Hamond 1968; Bandera & Conradi 2009a). The morphology of the antenna is very similar to that displayed by the two species of the genus *Stockmyzon* Bandera & Huys, 2008. Both *Stockmyzon* species had previously been included in *Asterocheres* (Bandera & Huys 2008) but do not share any other characteristics of special relevance. Members of the genus *Orecturus* Humes, 1992 also exhibit a very elongate antennary exopod, but the segmentation of the antennary endopod, the remaining appendages and the general body appearance are completely different (Humes 1992: Fig. 9C).

The striking segmentation pattern of the female antennule was not highlighted in the original description of *A. fastigatus*. The basic number of segments in the female antennule of *Asterocheres* is 21, and the reduction in the number of segments predominantly occurs in the distal part of the antennule (Kim 2010). Typically, species

belonging to *Asterocheres* have a compound segment 9(IX–XII) which usually bears seven or eight setae. Segmental fusions proximal to segment 9 are uncommon within the Asterocheridae and are often diagnostic at genus level (*e.g.*, *Acontiophorus* Brady 1880). *Asterocheres fastigatus* displays three segmental fusions proximal to segment 9, *i.e.*, the second segment with three setae, the third with eight setae and the fifth with six setae. However, this is not the only example in the genus showing antennulary fusions proximal to segment 9. In *A. bahamensis* Kim, 2010 the second segment is also a compound one, bearing four setae, but shows a vestigial articulation on the anterior side (Kim 2010: Fig. 9E). Therefore, *A. fastigatus* is the only species in the genus with three clear and complete fusions proximal to segment 9, showing a total of seven segmental fusions in the female antennule: 1(I)-2, 2(II–III)-3, 3(IV–VII)-8, 4(VIII)-2, 5(IX–XI)-6, 6(XII)-2, 7(XIII)-2, 8(XIV)-2, 9(XV)-2, 10(XVI)-2, 11(XVII)-2, 12(XVIII)-2, 13(XIX)-2, 14(XX–XXI)-2 + aesthetasc, 15(XXII–XXIII)-2, 16(XXIV–XXV)-4 and 17(XXVI–XXVIII)-7.

Another characteristic considered being very relevant and of potential generic significance is the possession of only a single inner seta on the second endopodal segment of leg 4. According to Kim (2010) this characteristic is shared only by *A. boeckii*, as illustrated by Sars (1915), and *A. fastigatus*. Kim considered this similarity as potential evidence for assigning these species to a separate genus but the lack of other similarities between them prevented him from doing so. Our redescription of *A. boeckii* revealed that Sars's (1915) illustration of leg 4 was incorrect and confirmed that the species has two instead of one inner setae on the second endopodal segment as is typical for the genus *Asterocheres*. Therefore, *A. fastigatus* is the only species in the genus which exhibits the 1-seta condition. Although some other characteristics (mandible, maxillule, maxilla, maxilliped, leg 5) resemble those of *Asterocheres* species, the four striking features listed above warrant the proposal of a new genus, *Kimcheres* **gen. nov.** Two other asterocherid genera display the armature formula (0,1) on the second endopodal segment of leg 4, *i.e. Hermacheres* Stock, 1987 and *Gomumucheres* Humes, 1996. However, *Hermacheres*, characterized by several apomorphic reductions in the armature of legs 1 to 4, differs from *Kimcheres* in many others characters, such as (1) the exopodal segment of leg 4, (2) the minute antennary exopod being reduced to a bud, (3) the form of the mandibular stylet, being shortish, rather wide, sinuous and distally widened into a toothed blade, and (4) the barrel-shaped siphon without tubiform distal part (features shown by the type species *Hermacheres diploriae* Stock, 1987). *Gomumucheres* shows the armature formula (0,1) on the second endopodal segment of both leg 3 and leg 4. The formula 2,2,1,1, indicating the number of inner setae on the second endopodal segment of legs 1–4 differentiates the genus from all others in the Asterocheridae (Humes 1996).

Taxonomic position of *Asterocheres longisetosus* Nair & Pillai, 1984

Asterocheres longisetosus was described by Nair & Pillai (1984: 362–365; figs. 20–23) on the basis of five females found associated with *Porites rus* (Forskål, 1775) [as *Porites convexa* Verill, 1864] from Chetlat Island (Lakshadweep archipelago) in the Arabian Sea. Unfortunately, the specimens deposited in the Indian Museum in Kolkata were lost and since the species has not been recorded again, there is no material available to re-examine it. Although *A. longisetosus* was fully described, Kim (2010) remarked that it can hardly be recognized as a member of *Asterocheres.* He based this assessment on the setation of the third endopodal segment of leg 3 which was originally described with the formula (1, 2, 3) rather than (1, 1+I, 3). According to the figures provided by Nair &Pillai, this is not the only feature exhibited by this species which does not conform to the diagnosis of *Asterocheres*. There are five more features which together with that proposed by Kim (2010), serve to separate this species from *Asterocheres*: (1) the long aesthetasc on the apical segment of the female antennule; (2) the mandibular palp bearing three terminal setae; (3) the setation of the third exopodal segment of leg 4 being III, I, 3 instead of III, I, 4; (4) the exopod of the fifth leg with two long setae and two very short spines; (5) the basis of the first leg being produced at the inner distal part into a conspicuous lobe (Nair & Pillai 1984: figs. 22, 24, 28, 30, 32). Female members of the family Asterocheridae typically possess antennules consisting of six to 21 segments and carrying a single large aesthetasc on the segment homologous with ancestral segment XXI. Depending on the fusion patterns in the distal part of the antennule the position of this aesthetasc can either be on the preantepenultimate, antepenultimate, penultimate, or, rarely, the terminal segment (Boxshall & Halsey 2004). Within the family the presence of an aesthetasc on the last antennulary segment is shared only by four genera, *i.e. Onychocheres* Stock & Gooding, 1986, *Asterocheroides* Malt, 1991, *Siphonopontius* Malt, 1991 and *Cephalocheres* Kim, 2010. A common characteristic observed in the antennules of these genera is the elongate

terminal segment (Stock & Gooding 1986: Fig. 11; Malt 1991: Figs. 7K, 9C; Kim 2010: Fig. 110C).In *Asterocheres*, the female antennule typically has short and wide segments 1–10, and long and narrow segments 11–21. Usually, compound segments are longer than free ones, and the aesthetasc present on segment XXI is retained in most species. The antennule illustrated by Stock & Gooding (1986: Fig. 11) in the original description of *Onychocheres* shows the segmental fusion pattern as follows: 1(I)-2, 2(II)-2, 3(III)-2, 4(IV)-2, 5(V)-2, 6(VI)-2, 7(VII)-2, 8(VIII)-2, 9(IX–XII)-7, 10(XIII)-2, 11(XIV)-2, 12(XV)-2, 13(XVI)-2, 14(XVII)-2, 15(XVIII)-2, 16(XIX)-2, 17(XX)-2, 18(XXI–XXVIII)-16 + 1 aesthetasc. The compound segment 18(XXI–XXVIII) retains all the setae belonging to the ancestral segments XXI-2, XXII-1, XXIII-1, XXIV-2, XXV-2, XXVI-2, XXVII-2 and XXVIII-4 and the aesthetasc belonging to ancestral segment XXI. This segment is elongate, long enough to bear all the setae and aesthetasc belonging to the ancestral segments XXI–XXVIII. However, this characteristic has not been observed in the illustration of *A. longisetosus* (note the short last antennulary segment and the similarity of the last four segments with those of typical 21-segmented antennules). Although Nair & Pillai (1984) described and illustrated the antennule of *A. longisetosus*as as 20-segmented, they only provided the armature for 19 segments. This armature is difficult to match with the basic pattern for female copepods as proposed by Huys & Boxshall (1991: Fig. 1.5.1).

The antennule is not the only appendage that is in need of redescription since the setation of the mandibular palp also does not correspond with that given by Kim (2010) in his redefinition of the genus *Asterocheres*. Usually, the mandibular palp of *Asterocheres* species bears two distal setae instead of the three setae present in *A. longisetosus*. According to Huys & Boxshall (1991), the mandibular palp of siphonostomatoids bears a maximum of two setae on its apex, suggesting that the third supernumerary seta in Nair & Pillai's (1984) description is based on an observational error. Members of the genus *Asterocheres* typically have three setae on the exopodal segment of the fifth leg, one of which is usually small or obsolete (Kim 2010). Conversely, *A. longisetosus* displays a free exopodal segment with two long setae and two very short spines. This combination of setae and spines obviously does not fit the *Asterocheres* condition, although it can be found in other members of the Asterocheridae such as some species of *Orecturus* Humes, 1992.

Asterocheres longisetosus resembles other species of *Asterocheres* in many aspects, such as the body shape, the antenna with a 1-segmented exopod and 3-segmented endopod, the segmentation and form of the maxillule, the maxilla and the maxilliped, but the atypical characters mentioned above warrant its removal from this genus. Although its assignment to the Asterocheridae is irrefutable, the unusual characteristics observed in the antennule and mandible prevent inclusion of *A. longisetosus* in any of the existing genera. However, the inconsistencies in Nair & Pillai's (1984) description combined with the loss of the type material, and the unavailability of other specimens have dissuaded us from erecting a new genus.

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