

A Review of *Typhlamphiascus* Lang, 1944 (Copepoda: Harpacticoida: Miraciidae) with a New Species *Typhlamphiascus higginsi* from Phuket Island, Thailand

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Supawadee Chullasorn (2009) A review of *Typhlamphiascus* Lang, 1944 (Copepoda: Harpacticoida: Miraciidae) with a new species *Typhlamphiascus higginsi* from Phuket I., Thailand. *Zoological Studies* 48(4): 493-507. A new species belonging to the Miraciidae Dana, 1846 (Copepoda: Harpacticoida: Miraciidae), is described from a seagrass bed dominated by *Enhalus acoroides* at Banpaklok, Phuket I., Thailand. An amended diagnosis of *Typhlamphiascus* includes: rostrum well-developed, expanded at the base with a small sensillum on each side of the rostrum about 1/5 from the acute tip. The new species, *T. higginsi* sp. nov., is similar to other species of the genus by having 8 segmented antennules, an almost linear body shape, and the baseopod of the 5th legs with fork-tipped setae. Autapomorphies of the new species are provided by the following characters: the inner edge of the basis of male 1st legs with only 3 chitinous lamellae; the dorsal edge of the female 1st abdominal somite ornamented with 1 row of 7 min spinules on each side, the armature of the abdominal somites furnished with rows of triangular spinules along the ventral edge of the 3rd and 4th somites in special patterns above the hyaline frills; the caudal ramus with a conical shape twice as long as broad, and the inner edge with 2 min spinules at the base. <http://zoolestud.sinica.edu.tw/Journals/48.4/493.pdf>

Key words: *Typhlamphiascus higginsi*, New species, *Enhalus acoroides*, Phuket I.

The harpacticoid family Miraciidae (Dana 1986) currently accommodates 53 genera (Boxshall and Halsey 2004). The miraciid genus *Typhlamphiascus* Lang, 1944 comprises 12 species (Boxshall and Halsey 2004), but the present author compiled 18 species from Por (1963), Soyer (1963 1972), Lang (1965), Bodin (1997), and Wells (2007). These species have been reported from different regions of the world: *T. blanchardi* Sars, 1906 is from the northern Atlantic; *T. brevicornis* Thompson and A. Scott, 1903 is from Sri Lanka; *T. bouligandi* Soyer, 1972 is from the Mediterranean Sea; *T. confusus* T. Scott, 1902 is from the northern coasts of Europe, Israel, and the Red and Black Seas; *T. dentipes* Thompson and A. Scott, 1903 is from Sri Lanka; *T. drachi* Soyer, 1964 is from France; *T. gracilicaudatus* Thompson

and A. Scott, 1903 and *T. gracilis* Por, 1963 are from Sri Lanka and the southern Red Sea; *T. lamellifer* Sars, 1911 is from the coast of northern Europe; *T. lamellifer capensis* Kunz 1975 is from southern Africa; *T. latifurca* Por, 1968 is from the Dahlak Archipelago and Red Sea; *T. longifurcatus* Rouch, 1962 and *T. pectinifer* Lang, 1965 are from the USA; *T. lutincola* Soyer, 1963 is from France; *T. ovale* Wells and Rao, 1987 is from India; *T. typhlops* Sars, 1906 is from Europe, the northern Atlantic, and Arctic waters; and *T. typhloides* Sars, 1911 and *T. unisetosus* Lang, 1965 are from the USA.

Boxshall and Halsey (2004) stated that the Miraciidae exhibit a variety of different lifestyles, with different genera preferring different types of sediment. Some genera, such as *Amphiascus*

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Sars, 1905, are essentially epibenthic, while others are interstitial. The miraciids occur in a wide variety of sediments ranging in grain size from flocculent mud to coralline debris and are primarily found in intertidal and shallow subtidal areas of continental shelves. Por (1963) reported that the genus *Typhlamphiascus* could be found on deep, sublittoral muddy bottoms, the littoral zone, algal cover, and surface layers of the sea.

This paper includes a description of a new species of the miraciid genus *Typhlamphiascus* from sediments of a seagrass bed of *Enhalus acoroides* at Banpaklok, Phuket I., Thailand.

MATERIALS AND METHODS

Specimens were collected from sediments of seagrass beds dominated by *Enhalus acoroides* at Banpaklok, Phuket I., Thailand (8°N, 98°20'E) using a hand corer of 3.5 cm in diameter x 10 cm in length. Sediment samples were subsequently sieved through 500 and 63 µm sieves. The meiofauna remaining on the latter sieve was fixed for 24 h in a solution of 10% formalin and rose bengal. Copepods were separated, put in vials, fixed in 6% buffered formalin, and subsequently preserved in ethanol after sorting in the laboratory.

Prior to a light microscopic examination, specimens were cleared in lactic acid. The material was examined using bright-field and differential interference contrast optics. All measurements and dissections were made under a Leica MZ8 dissection microscope (NY, USA). Drawings were prepared using a camera lucida on a Nikon compound microscope (Tokyo, Japan). The description is based on a holotype female and an allotype male. For long-term preservation, the holotype, allotype, and paratypes were mounted on slides in glycerol and sealed with Eukitt (O. Kindler, Washington, USA).

References used for the morphological description of the new species of *Typhlamphiascus* included Huys and Boxshall (1991), Huys et al. (1996), Lang (1948 1965), Por (1963), Soyer (1963 1972), Wells (2007), and Wells and Rao (1987). The terms "seta", "spine", and "spinule" were defined according to Huys and Boxshall (1991) as follows: seta, a tapering, flexible armature element with a hollow central core, which is inserted into a hole passing through the integument; spine, a rigid armature element with a hollow central core, and which is inserted into a hole passing through the integument; and spinule, a small rigid

ornamentation element which is borne in a hollow on the surface of the integument.

Typhlamphiascus Lang, 1944

Although the genus *Typhlamphiascus* Lang, 1944 was characterized morphologically, Wells (2007) stated that the taxonomy is confusing, and the situation of identification is complex, so it is essential to check the characters in KG 1/16/1 and 1/16/2. However, according to Por (1963), the genus can be divided in 2 major groups, depending on whether the last joint of the endopod of the 4th leg bears 1 or 2 setae.

The 1st group includes *T. blanchardi* (Thompson and A. Scott) from the northern Atlantic and *T. dentipes* (Thomson and A. Scott) from Sri Lanka, which are also characterized by a spur-like process on the exopod of the 5th leg, *T. gracilicaudatus* (Thompson and A. Scott) from Sri Lanka and the southern Red Sea, and *T. gracilis* from the Skagerrak (Norwegian coast, North Sea), *T. typhloides* (Sars) belongs here as well, as it has an aberrant inner furcal seta, besides a tendency for reduced armature of the P5 exopod. *Typhlamphiascus typhloides* was found only 1 time by Sars (1911), and the armature of its swimming legs was not mentioned. This group can also be characterized by a genital segment of the female that is divided only laterally, but on neither the dorsal nor ventral side.

The 2nd group is characterized by a single seta on the inner side of the last endopod joint of the 4th leg. The 2 inner spines of the baseoendopod of P5 are bifid (as in all members of the genus). Since this seems to be the only morphological difference between *T. brevicornis* (Thompson and A. Scott) from Sri Lanka and *T. confusus*, *T. brevicornis* is probably not a valid species due to its later description.

Shorter and straight furcal branches are the main character used to differentiate 2 other species: *T. typhlops* (Sars) from the northern Atlantic and Arctic waters and *T. lamellifer* (Sars) which shows a similar distribution. No doubt, specimens of *T. confusus* with straight and shorter furcal branches have been repeatedly considered to belong to *T. typhlops*. Specimens in the Sars collection at the Zoological Museum in Oslo, labeled *T. typhlops*, turned out to be *T. confusus* according to Por (1963).

The principal character utilized to differentiate *T. typhlops* from *T. lamellifer* has been the lack

of an inner seta on the median joint of the P4 endopod in *T. typhlops*. Por (1963) had an opportunity to study 2 samples of *T. typhlops* in Prof. Lang's collection at the Museum of Natural History in Stockholm, one from the Gullmarfjord (Sweden) and the other from Spitzbergen (Norway); the endopods of P4, however, had an inner seta on the median joint. Since *T. typhlops* is the older name, Por (1963) considered the species in Lang's collection as representing *T. typhlops*.

SPECIES DESCRIPTION

Order Harpacticoida Sars, 1903
Family Miraciiidae Dana, 1846
Genus *Typhlamphiascus* Lang, 1944
***Typhlamphiascus higginsi* sp. nov.**
 (Figs. 1-9)

Type locality: Banpaklok, Phuket I., Thailand (8°N, 98°20'E). Environmental data of the seagrass area during low tide were as follows: dissolved oxygen 8.4 mg/l, salinity 35 psu, temperature 32°C, pH 8.36, organic matter 4.95%, and a substrate of muddy sand.

Type specimens: A dissected holotype ♀ (USNM 1120439) and a dissected allotype ♂ (USNM 1120440), plus 1 dissected ♀ in 1 vial, 1 dissected ♂ in 1 vial, and 2 ♀♀ and 2 ♂♂ in 1 vial are deposited in the Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, DC, USA. The type specimens were collected in Apr. 1999 by the author.

Etymology: The specific name honors Dr. Robert P. Higgins, the emeritus curator of the Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, DC, USA.

Adult female (holotype): Habitus (Figs. 1A, B). Body length 0.62 mm measured from anterior outer corner of cephalothorax to posterior margin of caudal ramus. Body slender, almost linear with inconspicuous boundary between prosome and urosome, with scattered sensilla on dorsal and lateral surfaces. Prosome 4 segmented, comprising cephalothorax incorporating 1st pedigerous somite and 3 free pedigerous somites. Urosome 5 segmented, comprising 5th pedigerous somite, genital double-somite, and 3 free abdominal somites.

Rostrum (Fig. 2A) expanded at base with a

sensillum on each side of rostrum about 1/5 from acute tip.

Antennule (Fig. 2A) relatively long, 8 segmented, with 2 aesthetascs on segment 4 and terminal segment. Armature formula: 1-11-6-4+ae-1-3-3-7+ae.

Antenna (Fig. 2B) biramous, coxa comparatively large, bare. Allobasis with small spinules near coxa. Exopod 3 segmented; with 1, 0, and 4 setae, respectively. Endopod 1 segmented; with 6 spines, 3 spinulose setae, and 7 apical setae.

Mandible (Fig. 2C): Coxa well developed, gnathobase with a row of 5 strong teeth superimposed on 2nd row of 5 smaller teeth. Basal endite with 3 setae and 1 row of tiny spinules. Exopod 2 segmented with 2 spinulose setae and 1 smooth seta, respectively. Endopod 1 segmented with 2 lateral and 6 apical setae.

Maxillule (Fig. 2D): Arthrite of praecoxa with 2 setae on anterior surface and 8 spines at distal margin. Coxal endite with 1 pinnate and 1 smooth seta; basal endite with 4 smooth setae. Exopod 1 segmented with 2 pinnate setae. Endopod 1 segmented with 4 pinnate setae.

Maxilla (Fig. 2E): Syncoxa bearing 3 endites with 3, 2, and 2 spinulose setae, respectively. Basis with 1 serrate claw and 4 smooth setae. Endopod 2 segmented; enp-1 with 1 seta, enp-2 with 4 setae.

Maxilliped (Fig. 2F): Basis with 1 row of small spinules and 2 setae. Endopod 2 segmented; enp-1 with rows of spinules and 2 plumose setae; enp-2 with 1 strong claw and 1 small seta.

P1 (Fig. 3A). Coxa ornamented with rows of spinules on anterior surface. Basis relatively small bearing 1 inner distal strong spinulose spine and 1 spinulose spine on proximal outer corner. Exopod 3 segmented; exp-1 with a row of spinules near base of outer pinnate spine; exp-2 with 1 inner seta 1/3 pectinate, and 1 outer smooth spine; exp-3 with 1 lateral smooth seta, 2 medial pinnate setae, and 3 outer spines. Endopod 3 segmented; enp-1 as long as enp-2 plus enp-3, with 1 long spinulose seta at inner distal corner; enp-2 with 1 inner short spinulose seta; enp-3 with 3 setae, 1 inner small smooth seta, and 2 medial spinulose setae.

P2 (Fig. 3B). Coxa ornamented with rows of spinules on anterior surface. Basis bearing 1 outer spinulose spine. Exopod 3 segmented; exp-1 with 1 inner seta 1/3 pectinate, and 1 outer pinnate spine; exp-2 with 1 inner long seta about 1/4 pectinate, and 1 outer smooth spine; exp-3 almost as long as exp-1 plus exp-2, with 1 lateral

spinulose seta, 2 medial spiniforms, and 2 outer smooth spines. Endopod 3 segmented; enp-1 with 1 short plumose seta on inner edge; enp-2 with 2 inner setae, 1 short seta 1/3 pectinate, 1 long seta 1/5 pectinate, and 1 smooth strong spine on outer

distal corner; enp-3 almost as long as enp-1 plus enp-2, with 1 lateral seta 1/8 pectinate, 2 medial spinulose setae, and 1 outer smooth spine.

P3 (Fig. 4A). Coxa ornamented with rows of spinules on anterior surface. Basis bearing 1

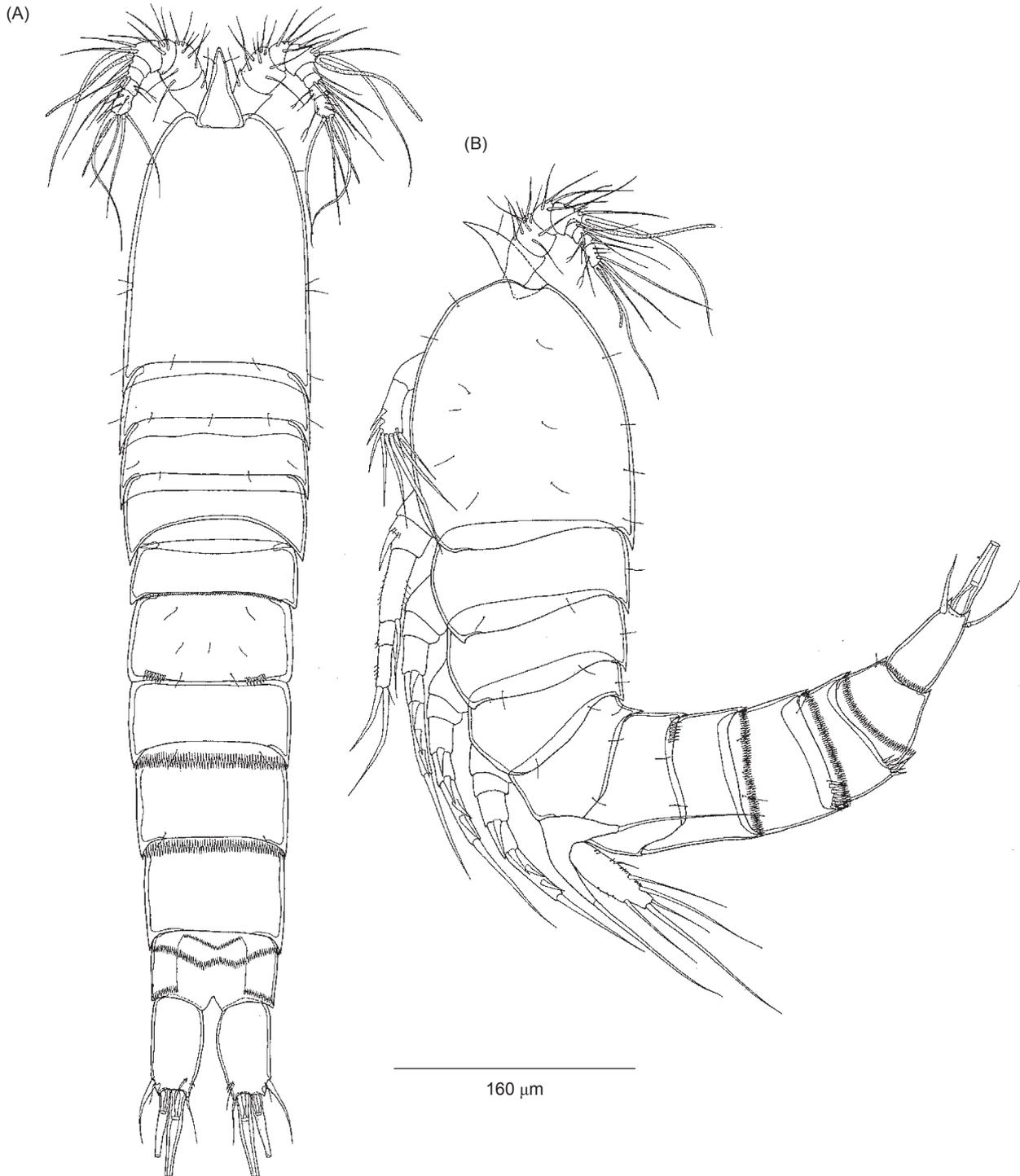


Fig. 1. *Typhlamphiascus higginsi*, sp. nov. female. (A) Habitus, dorsal view; (B) habitus, left lateral view.

outer slender seta. Exopod 3 segmented; exp-1 with 1 inner seta 1/5 pectinate, and 1 outer smooth spine; exp-2 with 1 long inner seta 1/4 pectinate,

and 1 outer smooth spine; exp-3 with 1 lateral long spinulose seta, 2 medial spiniforms, and 2 outer smooth spines. Endopod 3 segmented; enp-1 with



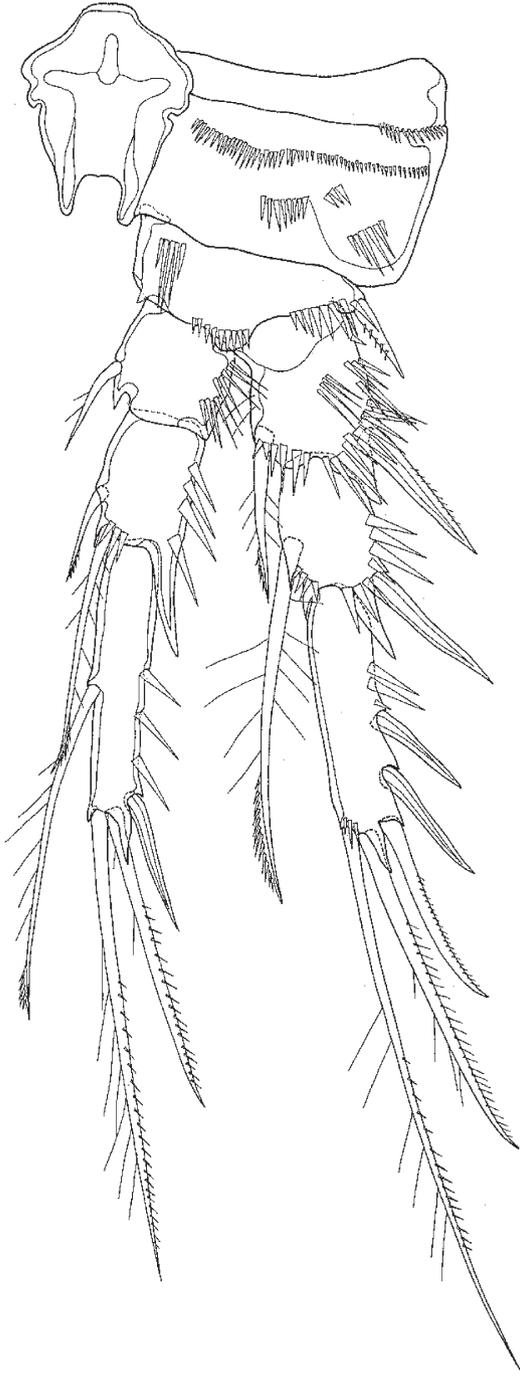
Fig. 2. *Typhlamphiascus higginsi*, sp. nov. female. (A) Antennule, anterior view; (B) antenna; (C) mandible; (D) maxillule; (E) maxilla; (F) maxilliped.

1 inner pinnate seta; enp-2 with 1 inner seta 1/5 pectinate; enp-3 with 1 inner seta 1/6 pectinate, 2 medial spinulose setae, and 1 outer smooth spine.

P4 (Fig. 4B). Coxa ornamented with rows of spinules on anterior surface. Basis bearing 1 outer

slender seta. Exopod 3 segmented; exp-1 with 1 inner seta 1/4 pectinate, and 1 outer smooth spine; exp-2 with 1 inner long seta 1/3 pectinate, and 1 outer smooth spine; exp-3 with 3 inner lateral setae, 1 seta 1/3 pectinate, 1 long and large seta

(A)



(B)



63 μm

Fig. 3. *Typhlamphiascus higginsi*, sp. nov. female. (A) Left P1; (B) left P2.

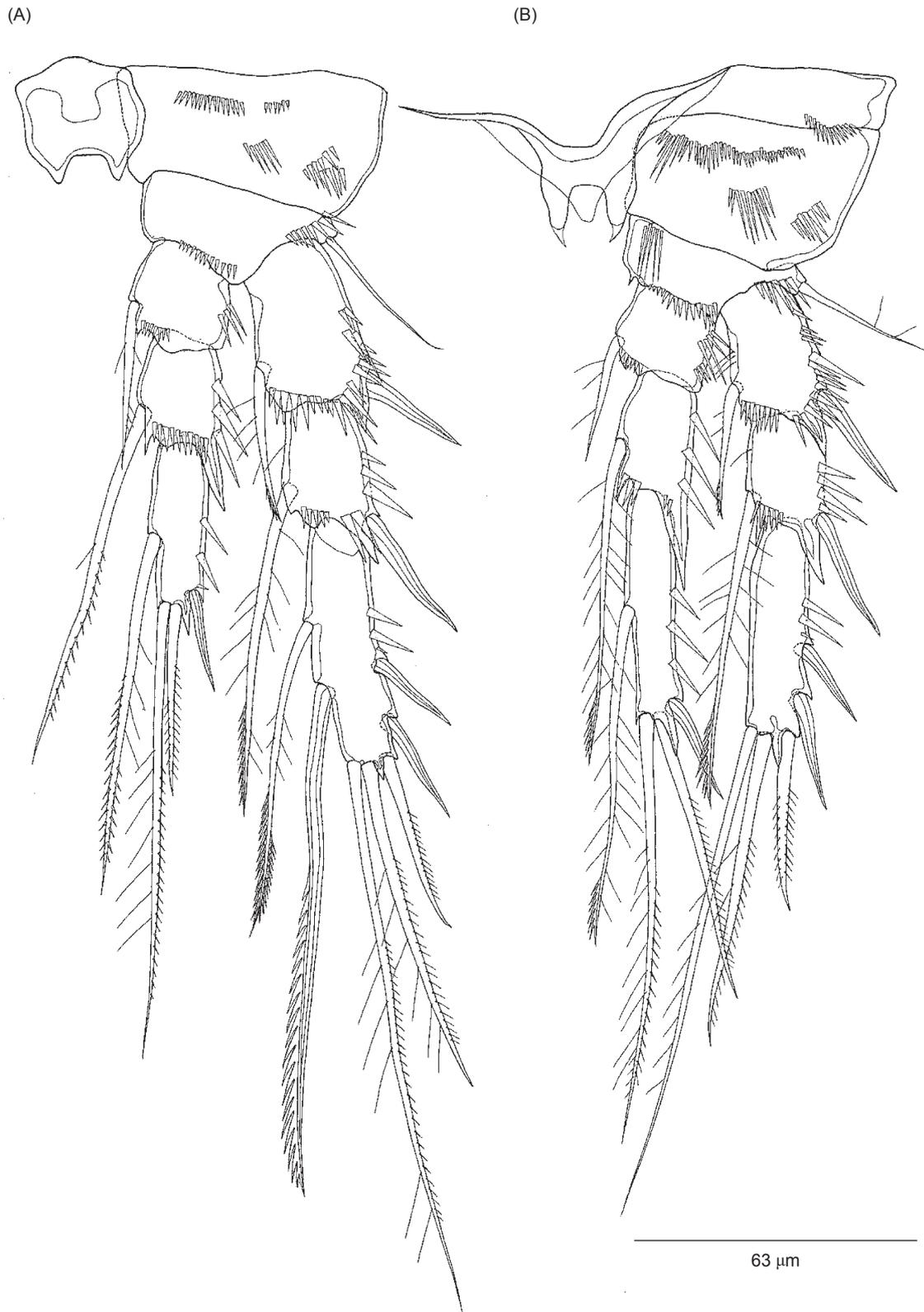


Fig. 4. *Typhlamphiascus higginsi*, sp. nov. female. (A) Left P3; (B) left P4.

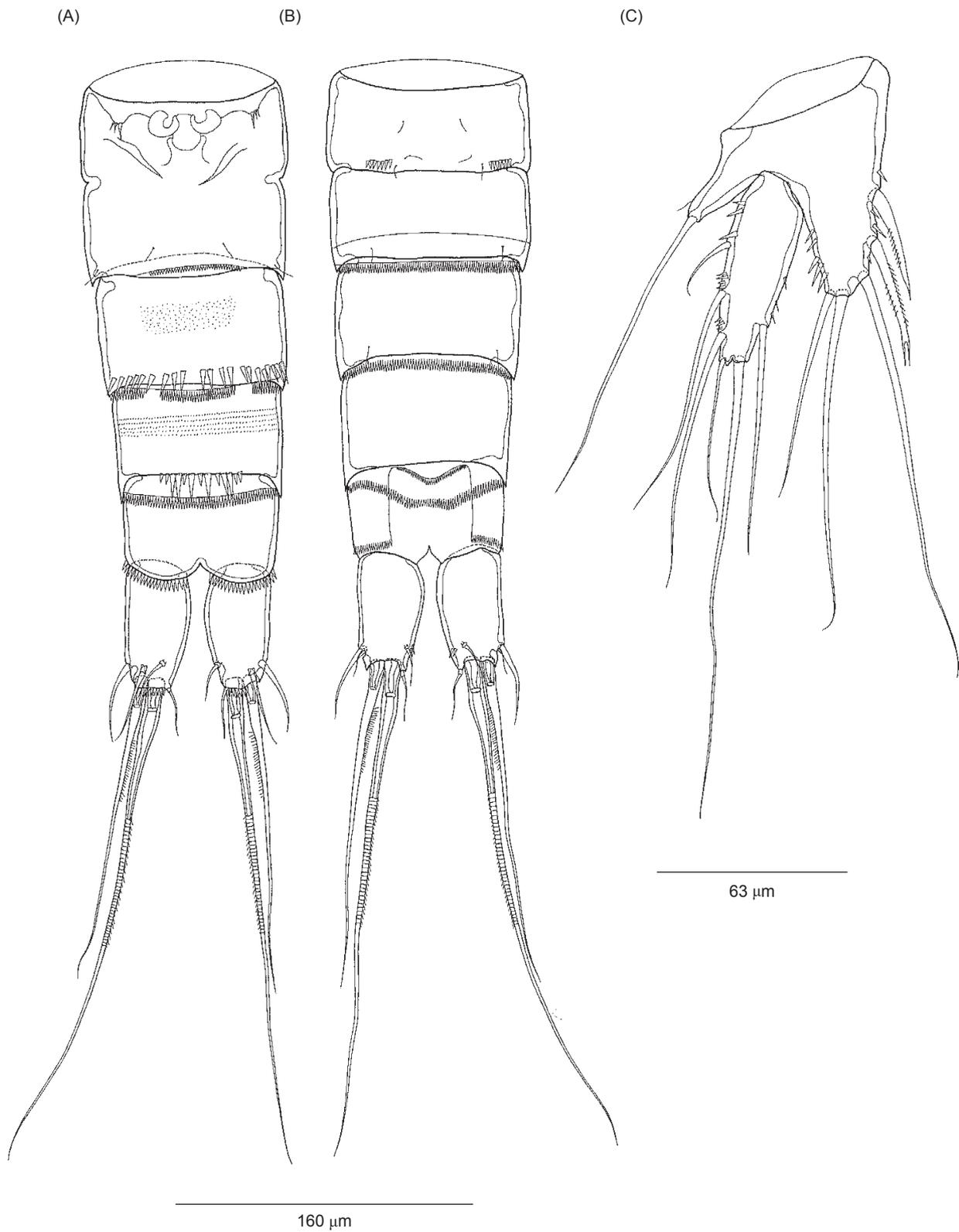


Fig. 5. *Typhlamphiascus higginsi*, sp. nov. female. (A) Urosome, dorsal view; (B) urosome, ventral view; (C) left P5.

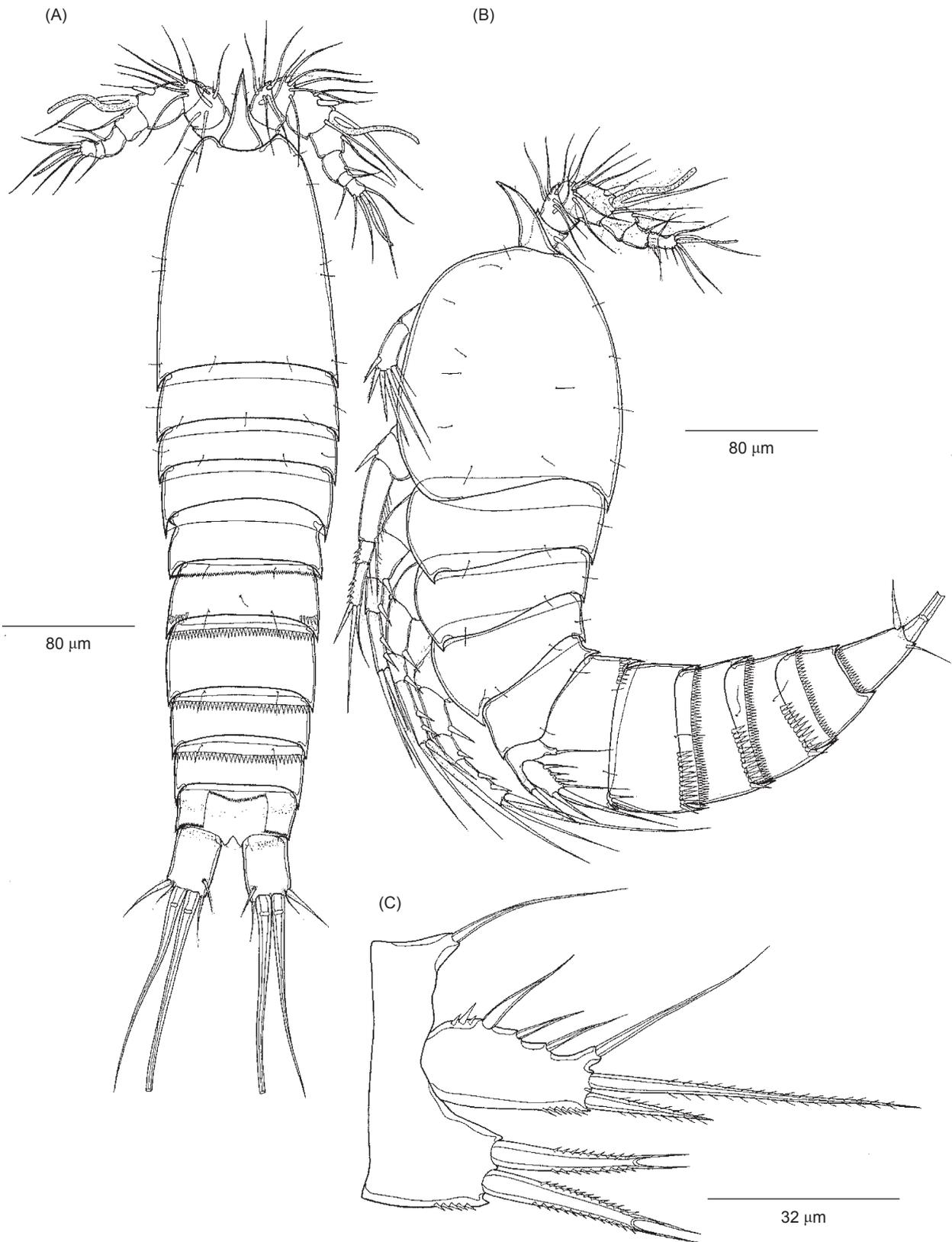


Fig. 6. *Typhlamphiascus higginsi*, sp. nov. male. (A) Habitus, dorsal view; (B) habitus, left lateral view; (C) left P5.



Fig. 7. *Typhlamphiascus higginsi*, sp. nov. male. (A) Antennule, anterior view; (B) antenna; (C) mandible; (D) maxillule; (E) maxilla; (F) maxilliped.

3/5 pectinate, 1 long spinulose seta, 2 medial spiniforms, and 2 outer smooth spines. Endopod 3 segmented; enp-1 with 1 inner spinulose seta; enp-2 with 1 inner long spinulose seta; enp-3 with 1 inner spinulose seta, 2 medial spinulose setae, and 1 outer smooth spine.

P5 (Fig. 5C). Inner expansion of base-oendopod extending to about halfway along exopod; with 2 inner fork-tipped spinulose setae, and 1 median and 2 outer setae. Exopod oval more than twice as long as greatest width, with 6 bare setae unequal in length.

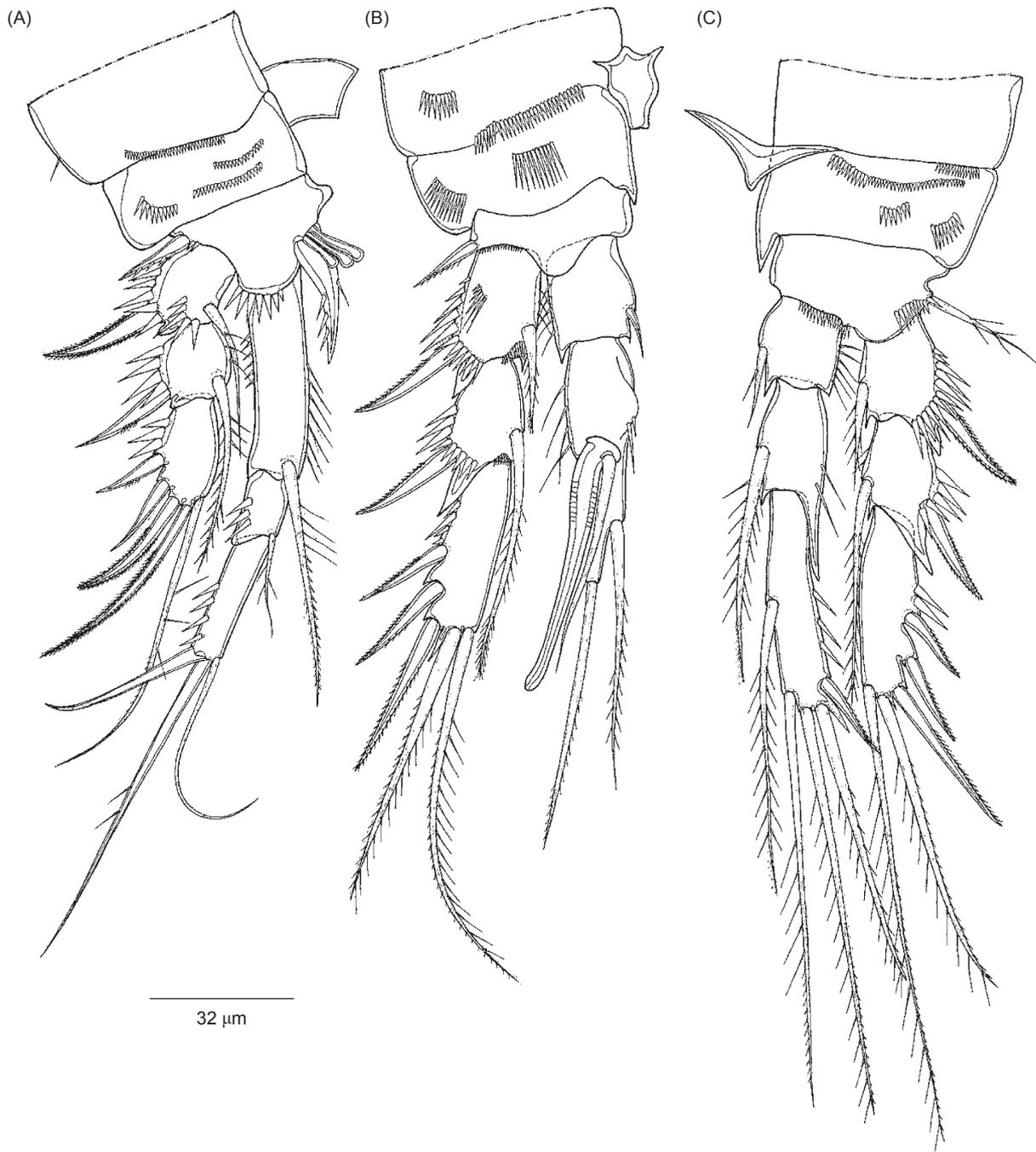


Fig. 8. *Typhlamphiascus higginsi*, sp. nov. male. (A) Right P1; (B) right P2; (C) left P3.

Urosome (Figs. 5A, B): Dorsal edge of 1st abdominal somite ornamented with 1 row of 7 minute spinules on each side, 2nd-5th abdominal

somites furnished with rows of hyaline frills. On ventral side, genital double-somite ornamented with hyaline frills, from 3rd and 4th abdominal

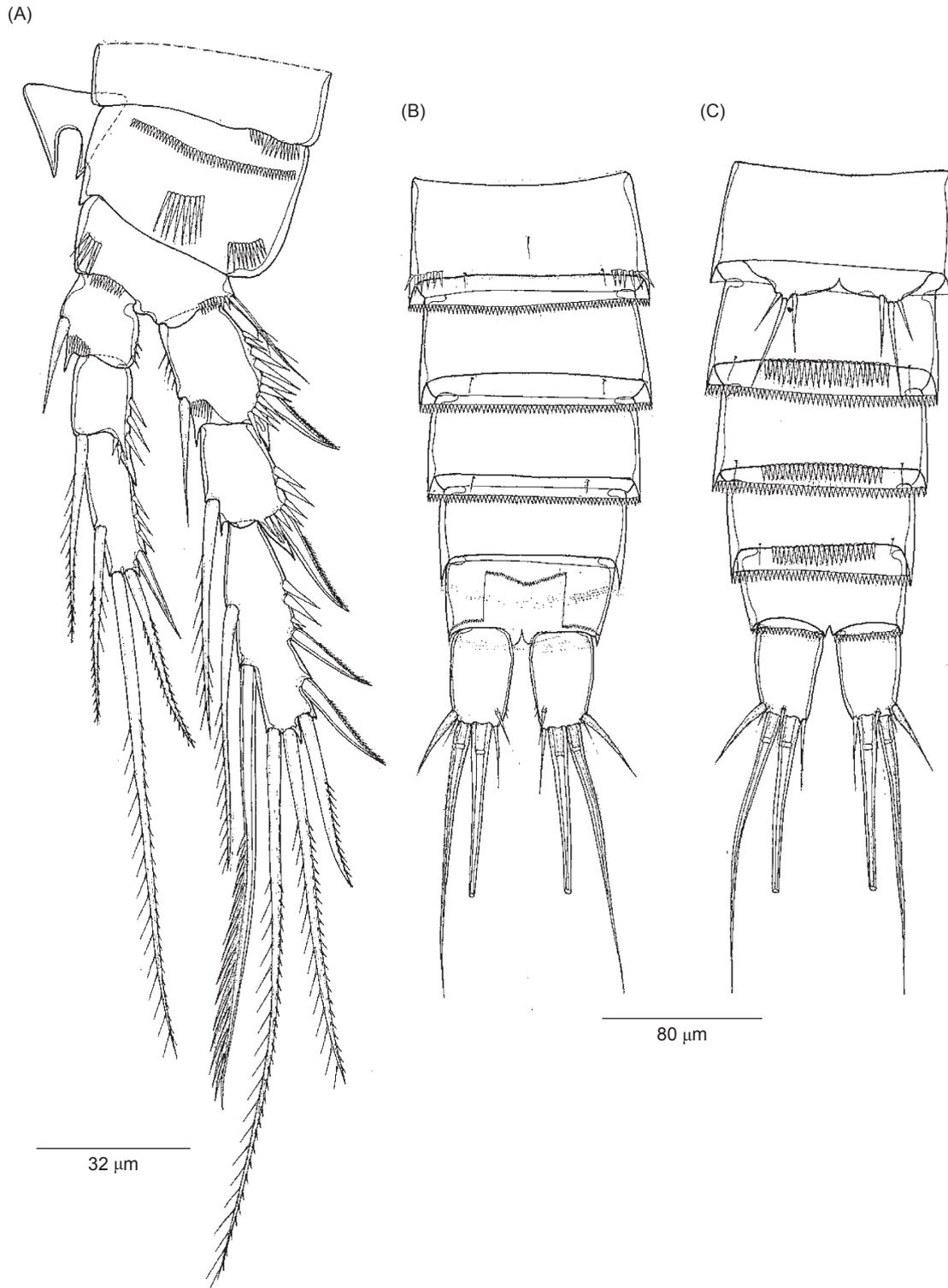


Fig. 9. *Typhlamphiascus higginsi*, sp. nov. male. (A) Left P4; (B) urosome, dorsal view; (C) urosome, ventral view.

somites furnished with rows of triangular spinules in special patterns above hyaline frill. Anal operculum large, ornamented with rows of constant spinules dorsally and ventrally above the furca. Furcal rami conical, twice as long as wide, inner edge ornamented with 2 min spinules at base; each caudal ramus carrying 2 outer setae, 1 inner seta, 1 dorsal seta, 1 ventral seta, and 2 large medial furcal setae, the inner one longer and ornamented with 1 row of spinules at base.

Adult male (allotype): Habitus (Figs. 6A, B) much smaller than female, with body length 0.44 mm measured from anterior outer corner of cephalothorax to posterior margin of caudal ramus.

Antennule (Fig. 7A): Haplocer, 8 segmented. Fourth and terminal segments with 1 large and 1 small aesthetasc, respectively. Armature formula:

Table 1. Armature formulae of legs 1-4 of *Typhlamphiascus higginsii* sp. nov.

	Exopod	Endopod
P1	0 : 1 : 1 2 2	1 : 1 : 1 2 0
P2	1 : 1 : 1 2 2	1 : 2 : 1 2 1
P3	1 : 1 : 1 2 2	1 : 1 : 1 2 1
P4	1 : 1 : 3 2 2	1 : 1 : 1 2 1

1-12-5-6+ae-1-1-4-7+ae.

P1 (Fig. 8A). Praecoxa bare. Coxa ornamented with rows of spinules on anterior surface. Basis bearing 1 outer and 1 inner strong spinulose spine; on the inner edge of basis with 3 chitinous lamellae unequal in length. Exopod and endopod rami as in female, but without pectinated setae.

P2 (Fig. 8B). Distal segment of endopod modified as common in the genus, without pectinated seta.

P3 and P4 (Figs. 8C, 9A). As in female, but without pectinated seta.

P5 (Fig. 6C). Baseoendopod confluent, with 2 bifid spinulose spines. Exopod bearing 6 setae; 3 lateral short setae, 1 outer long smooth seta, 1 medial longest spinulose seta, and 1 inner short spinulose seta.

P6 (Fig. 9C). Each leg with 3 setae unequal in length, the median one longest.

Urosome (Figs. 9B, C): 6 segmented. Abdominal somites ornamented with hyaline frill on dorsal side, from 2nd to 6th abdominal somites. From 3rd to 5th abdominal somites furnished with rows of spinules above hyaline frill on ventral side.

Sexual dimorphism in antennule, P1-P5, and ornamentation of abdominal somites.

Armature formula as given in table 1.

Table 2. Information about species belonging to *Typhlamphiascus* Lang, 1944

Species Synonyms	Locality	Amendments
1. <i>Typhlamphiascus blanchardi</i> (Sars 1906)	Northern Atlantic	
2. <i>Typhlamphiascus brevicornis</i> (Thompson and A. Scott 1903)	Sri Lanka	
3. <i>Typhlamphiascus bouligandi</i> Soyer 1972	Mediterranean Sea	
4. <i>Typhlamphiascus confusus</i> (T. Scott 1902)	North Europe, Israel, Red and Black Seas	Klie 1942, Bodin 1964
5. <i>Typhlamphiascus dentipes</i> (Thompson and A. Scott 1903)	Sri Lanka	
6. <i>Typhlamphiascus drachi</i> Soyer, 1964	France	
7. <i>Typhlamphiascus gracilicaudatus</i> (Thompson and A. Scott 1903)	Sri Lanka, Red Sea	Por 1967
8. <i>Typhlamphiascus gracilis</i> Por, 1963	Sri Lanka, Red Sea	Bodin 1968b
9. <i>Typhlamphiascus lamellifer</i> (Sars 1911)	Sri Lanka, Red Sea	Bodin 1968b
10. <i>Typhlamphiascus lamellifer capensis</i> Kunz, 1975	Southern Africa	
11. <i>Typhlamphiascus latifurca</i> Por, 1968	Dahlak Archipelago, Red Sea	
12. <i>Typhlamphiascus longifurcatus</i> Rouch, 1962	USA	
13. <i>Typhlamphiascus pectinifer</i> Lang, 1965	USA	Pallares 1975b
14. <i>Typhlamphiascus lutincola</i> Soyer, 1963	France	Soyer 1964b
15. <i>Typhlamphiascus ovale</i> Wells and Rao, 1987	India	
16. <i>Typhlamphiascus typhlops</i> (Sars 1906)	Europe	Chislenko 1967
17. <i>Typhlamphiascus typhloides</i> (Sars 1911)	USA	
18. <i>Typhlamphiascus unisetosus</i> Lang, 1965	USA	

DISCUSSION

Typhlamphiascus higginsi sp. nov. shows distinctive characters of the genus by having 2 bifid inner spines of the baseoendopod. The inner edge of the basis of male 1st leg has only 3 chitinous lamellae of unequal length, while *T. bouligandi* lacks any chitinous lamella (Soyer 1972), *T. confusus* and *T. gracilicaudatus* have 3-5 chitinous lamellae (Por 1963), *T. lutincola* has 3 chitinous lamellae (Soyer 1963), *T. pectinifer* and *T. unisetosus* have 4 chitinous lamellae (Lang 1965), *T. typhlops* and *T. gracilis* have 7 or 8 chitinous lamellae (Por 1963), and *T. ovale* has a chitinous complex palmate-like structure (Wells and Rao 1987). Autapomorphies of the new species are provided by the following characters: the inner distal corner of the basis of the male 1st legs with only 3 chitinous lamellae, the number of setae and spines on enp-3 of P3: P4 of 4: 4, exopod of P1 extending to about the end of enp-2, the ratio of the maximum length to the maximum breadth of the caudal ramus of 1: 2, the dorsal edge of the female 1st abdominal somite ornamented with 1 row of 7 min spinules on each side, the armature of the abdominal somites furnished with rows of triangular spinules along the ventral edge of the 3rd and 4th somites in special patterns above the hyaline frills; caudal ramus with a conical shape twice as long as broad, and the inner edge with 2 min spinules at base.

The 3rd leg of the new species, *Typhlamphiascus higginsi* sp. nov., bears only 4 setae on its distal endopodal segment, contrary to all other representatives of the genus. This is in contrast to *T. lutincola*, *T. gracilis*, *T. drachi*, *T. blanchardi*, *T. gracilicaudatus*, *T. bouligandi*, and *T. longifurcatus* which bear 5 setae on the distal endopodal segment. However, *T. higginsi* sp. nov. bears 4 setae as do the remaining species of the genus, *T. confusus*, *T. lamellifer*, *T. pectinifer*, *T. latifurca*, *T. unisetosus*, *T. typhloides*, and *T. accraensis*. *Typhlamphiascus higginsi* sp. nov. bears 5 and 6 setae on the female P5 baseoendopod and exopod, respectively, in contrast to the remaining species of the genus which have different setal arrangements. Concerning the male P5, the setal configuration of *T. higginsi* sp. nov. is as in *T. lutincola*, *T. confusus*, *T. lamellifer*, and *T. pectinifer* with 2 and 6 setae on the baseoendopod and exopod, respectively. According to Bodin (1997) and Wells (2007), the following species are incertae sedis: *T. longifurcatus* Rouch, 1962 was assumed by Lang

(1965) to be a representative of a new genus, close to *Robertgurneya*. Por (1963) thought but was not certain to have found the male of *T. typhlops* (Sars 1906).

Ecological notes. The present study concerns the description of a new species of *Typhlamphiascus* collected from sediments of a seagrass, *Enhalus acoroides*, in mangrove areas of Phuket I., Thailand. It is found year-round there. The habitat of the new species differs from that where other species of *Typhlamphiascus* were found. According to Huys and Boxshall (1991) and Boxshall and Halsey (2004) these marine harpacticoids are adapted to widely variable environments. Suárez-Morales et al. (2006) found *T. pectinifer* in the Caribbean Sea along the Mexican coast. Lang (1965) described *T. pectinifer* from Monterey Bay tidal pools that contain shells, sand, stones, and algae. Representatives of *Typhlamphiascus* occur in a variety of lower intertidal/shallow subtidal habitats in the northern Atlantic and Pacific coast (Por 1963), as shown in table 2. But *Typhlamphiascus higginsi* sp. nov. was found from *Enhalus acoroides* sediments in mangrove areas in Thailand.

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