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A new species of the genus *Rhizothrix* (Copepoda: Harpacticoida: Rhizothricidae) from Korean waters

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Abstract.—A new species, *Rhizothrix sejongi*, is described from a sandy beach at Sangju, south coast of Korea. This species bears a superficial resemblance to *Rhizothrix gracilis* in the fused endopod and exopod of the fifth thoracopod, the four-segmented antennule, and the armature formula of the antennary exopod. The Korean species is unique in its bifid rostrum and short caudal rami, and the armature formula of the endopod of the fifth thoracopod in the female; it is distinguishable from congeners by the broad denticles on the whole body surface. A key to the species of genus *Rhizothrix* is provided.

The genus *Rhizothrix* Brady & Robertson, 1875 has a complex history. Brady & Robertson (1875) created the genus to accommodate *R. curvata* Brady & Robertson, 1875, the type species, but they did not include any description of the species. Later, Brady (1880) offered a detailed description of *R. curvata*. Pennak (1942) created the genus *Adelopoda* Pennak, 1942 and assigned it to the family Canthocamptidae Sars, 1906. Bodin (1997) was of the opinion that *Adelopoda* should have been assigned to the Cletodidae. Božić (1953) considered *Adelopoda* a subgenus of *Rhizothrix*. Wells (1963) considered *Adelopoda* a synonym of *Tryphoema* Monard, 1926 and suggested that *Tryphoema* had to be considered a subgenus of *Rhizothrix*. Lang (1965) considered *Rhizothrix* and *Tryphoema* distinct, and reallocated the genus *Adelopoda* into the genus *Tryphoema*. Por (1986) allocated the genera *Rhizothrix* and *Tryphoema* to the family Rhizothricidae Por, 1986.

Currently, 11 species and subspecies are included within *Rhizothrix* (Bodin 1997). The type species of the genus, *Rhizothrix curvata*, was reported from British coasts. Later, Scott (1903) reported *R. minuta* (T. Scott, 1903) and *R. gracilis* (T. Scott, 1903) from Scotland. Wilson (1932) described *R. tenella* (Wilson, 1932) from the Atlantic coast of North America, and Lang (1936) reported *R. scotti* (Lang, 1936) from the Arctic Ocean. Since Lang's (1948) monograph, six species and subspecies have been added: *R. reducta* Noodt, 1952; *R. reducta noodti* Galhano, 1970; *R. pubescens* Por, 1959; *R. quadriseta* Wells, 1967; *R. spinosa* Coull, 1971; and *R. wilsoni* Bodin, 1979. Most recently, Arlt (1983) reported *R.* cf. *minuta* from the Baltic Sea and discussed the differences observed between his *R.* cf. *minuta* and *R. minuta*.

During a survey of the harpacticoid community along the south coast of Korea, a new species of *Rhizothrix* was collected from a sandy beach at Sangju. Herein, we provide an illustrated description of this new species and discuss its relationships with other members of the genus. A key to the species is also provided.

Materials and Methods

The specimens examined were collected by sieving sand at Sangju Beach

(34°43′22″N, 127°59′30″E) on 29 July 1992 and 18 February 2002. Specimens were fixed with neutral formalin and preserved with 70% ethanol. Specimens were dissected in lactic acid, and the dissected parts were mounted on slides using lactophenol as the mounting medium. Preparations were sealed with transparent nail varnish. All drawings have been prepared using a camera lucida fitted to an Olympus BX51 or a Zeiss Axioskop differential interference contrast microscope.

The descriptive terminology proposed by Huys et al. (1996) was adopted. Abbreviations used in the text and figures: A1, antennule; A2, antenna; ae, aesthetasc; exp, exopod; enp, endopod; P1-P6, first to sixth thoracopod; exp(enp)-1(2, 3) to denote the proximal (middle, distal) segment of a ramus. Type series were deposited in the collections of The Natural History Museum, London (NHM), the Smithsonian Institution, National Museum of Natural History, Washington DC (USNM), and the Laboratory of Biodiversity, Department of Life Science, Hanyang University, Seoul. Scale bars in the figures are indicated in μm.

Systematics

Order Harpacticoida Sars, 1903
Family Rhizothricidae Por, 1986
Genus *Rhizothrix* Brady & Robertson, 1876, in Brady (1880)

Rhizothrix sejongi, new species

Figs. 1–6

Type locality.—Sangju, south coast of Korea (34°43′22″N, 127°59′30″E).

Material examined.—Holotype 1 ♀ (NHM 2003.617) dissected on 10 slides; paratypes 1♂ (NHM 2003.618) dissected on 8 slides, and 3 ♀♀ and 3 ♂♂ (NHM 2003.619–624), and 3 ♀♀ and 3 ♂♂ (USNM 2029683) in 70% ethanol.

Additional material.— 2 ♀♀ and 6 ♂♂ dissected on slides and deposited in the author's collection (WL) in the Laboratory of Biodiversity, Department of Life Science, Hanyang University, Seoul, collected by E.J. Nam, K.H. Lee, H.W. Bang, and S.J. Song on 18 February 2002. 4♀♀ dissected on slides and deposited in the author's collection (WL) in the Laboratory of Biodiversity, Department of Life Science, Hanyang University Seoul, collected by W. Lee on 29 July 1992.

Description of female.—Total body length 624 μ (N = 12, range 513–701 μm, measured from anterior margin of cephalic shield to posterior margin of caudal rami). Body slightly depressed dorsoventrally, tapering posteriorly. Largest width measured at posterior margin of cephalic shield 159 μm. Entire surface covered with tiny broad denticles as illustrated in Fig. 1A, B.

Prosome (Fig. 1A, B) 4-segmented, comprising cephalothorax (bearing first pedigerous somites) and 3 free pedigerous somites. Cephalothorax with serrate posterior margin, pleural areas rounded, well developed, and posterolateral angles minutely crenate, ornamentation consisting of tiny denticles and few sensilla. All prosomites without defined hyaline frills, and hind margin serrulate.

Rostrum small, bifid (Figs. 1A, 2C), completely fused to cephalosome, dorsal surface with broad denticles as in cephalothorax, and with pair of sensilla near anterior margin.

Urosome (Figs. 1A, 1, 2A) 6-segmented, comprising P5-bearing somite and 4 free abdominal somites. All urosomites with surface ornamentation consisting of dense denticles dorsally and ventrally, and with hind margins serrate dorsally and ventrally. Urosome gradually tapering posteriorly (Fig. 1A).

Genital double-somite with original segmentation indicated by transverse, serrate surface ridge dorsally and ventrally. Gonopores not fused medially at ventral surface, and covered on both sides by opercula derived from sixth legs. Location of copulatory pore obscure (Fig. 2A). P6 with small unarmed protuberance.

Somite preceding anal somite (Fig. 2B) with well-developed pseudoperculum with

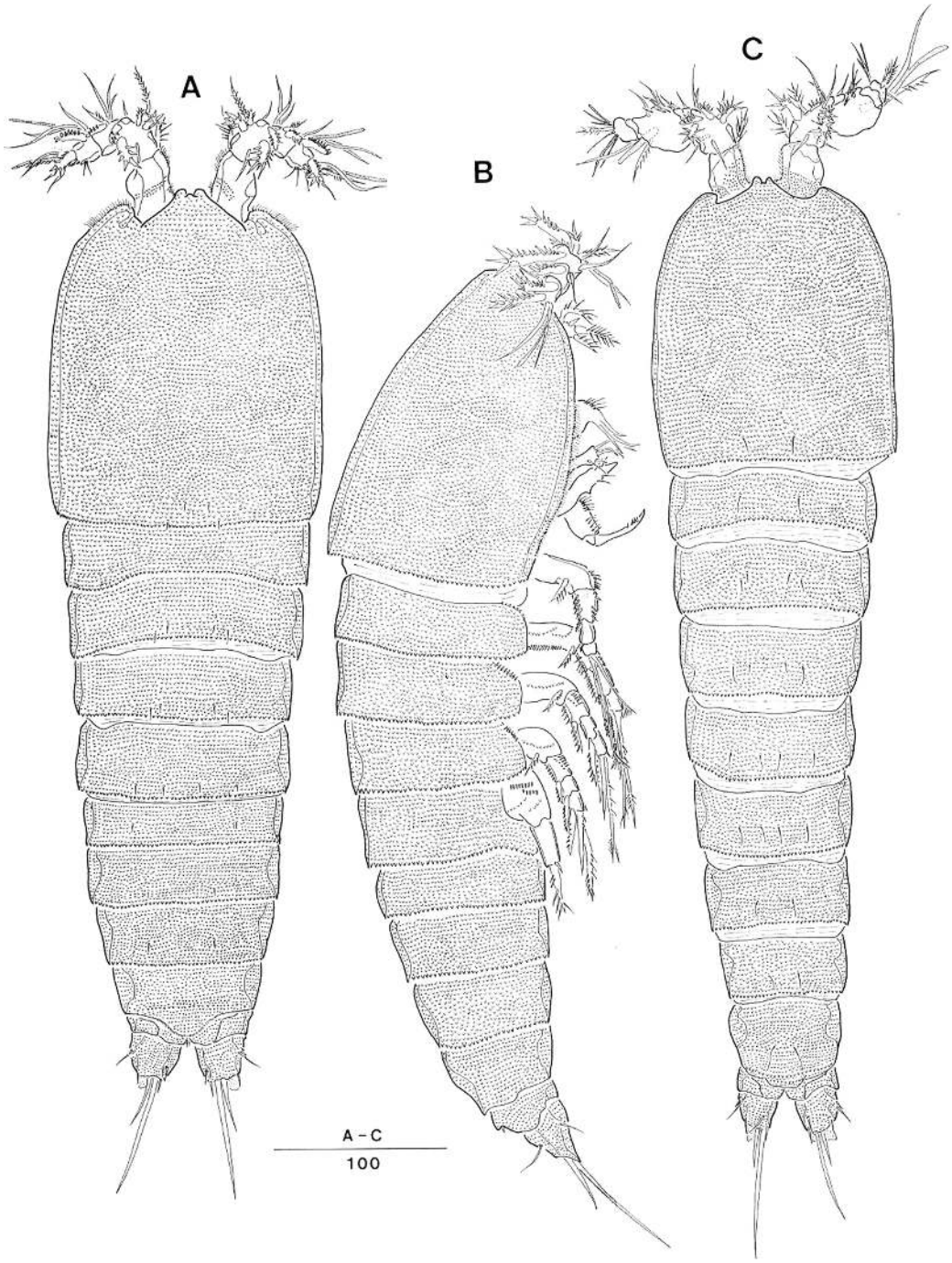

Fig. 1. *Rhizothrix sejongi.* A, female, habitus, dorsal. B, female, habitus, lateral. C, male, habitus, dorsal.

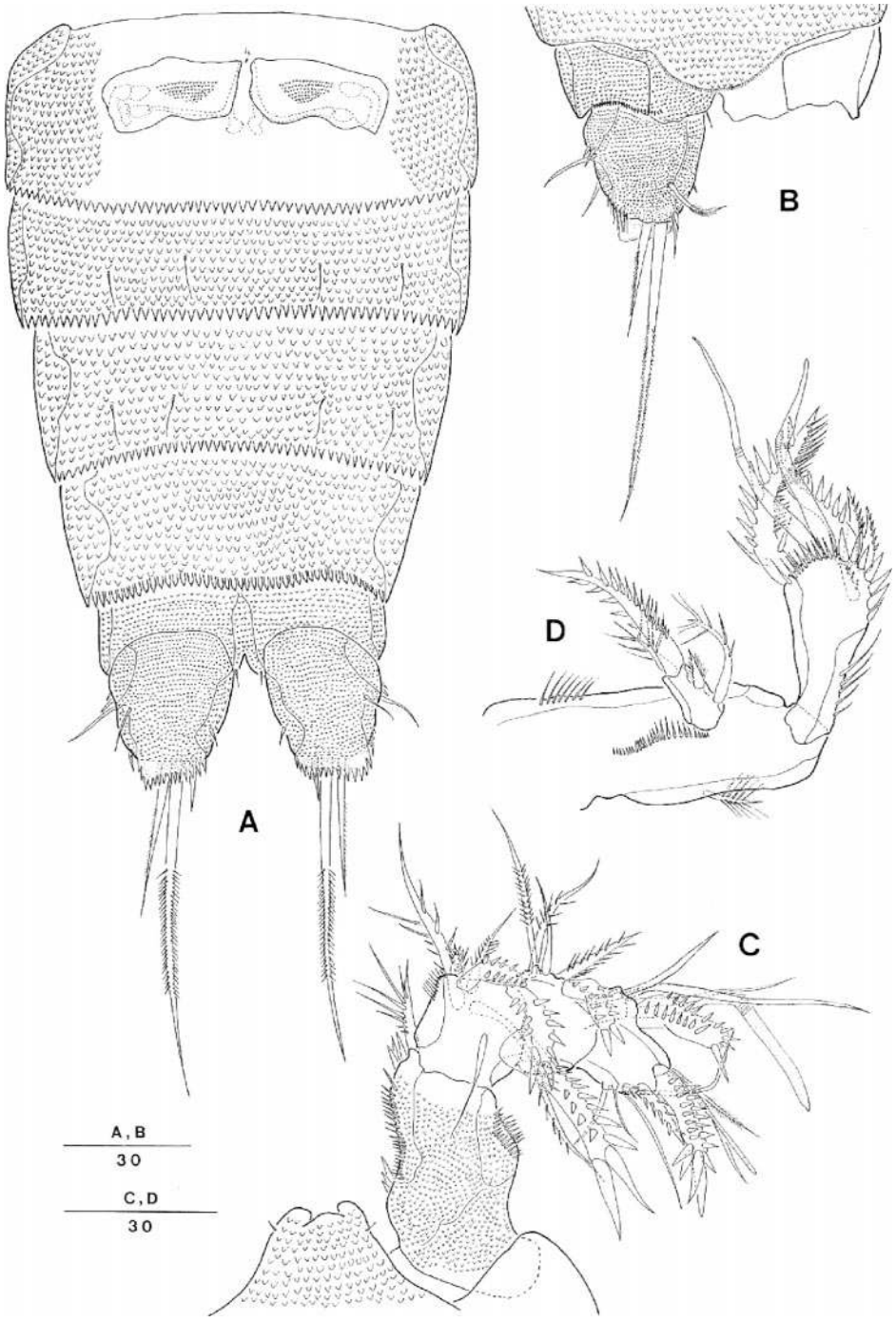

Fig. 2. *Rhizothrix sejongi,* female. A, urosome, ventral. B, anal segment and caudal rami, dorsal. C, rostrum and antennule. D, antenna.

spinulous posterior margin. Anal somite small and presence of pair of sensilla obscure.

Caudal rami (Fig. 2B) 1.2 times as wide as long, with 7 setae each; seta I minute and ventral to seta II, and situated more proximally than the latter; seta II about 4 times long than seta I; seta III nearly as long as seta II and located ventrally; setae IV and V bare proximally and bipinnate distally, the former about ½ total length of the latter; seta VI about ⅓ total length of seta IV and located on distal inner corner; seta VII bipinnate, close to outer margin on distal third and triarticulated.

Antennule (Fig. 2C) 4-segmented, segment 1 longest, surface densely covered with tiny denticles, inner margin ornamented with strong spinules proximally and distally, and with smaller spinules medially, outer margin with small spinules distally. Armature formula: 1-[1 plumose], 2-[1 bare + 3 plumose + 4 large spinulose], 3-[4 plumose + 1 large spinulose + 1 acrothek], 4-[4 bare + 4 large spinulose + 1 acrothek]. Acrothek consiting of well-developed aesthetasc fused basally to slender seta; aesthetasc on segment 3 large and geniculate, fused to long seta; aesthetasc on segment 4 slender.

Antenna (Fig. 2D) 2-segmented, comprising allobasis and free 1-segmented endopod. Allobasis with abexopodal seta arising in distal third, and ornamented with longitudinal spinular rows along outer margin and close to insertion of exopod. The latter 1-segmented, with 4 setae. Free endopodal segment with strong spinules along inner margin and armed with 1 lateral spine and 6 apical setae and spines.

Labrum with spinular ornamentation on anterior surface as in Fig. 3A.

Mandible (Fig. 3B) with large coxa bearing well-developed gnathobase; cutting edge with 5 major blunt teeth overlapping each other; accessory seta bifid. Mandibular palp large. Basis with 2 pinnate setae. Endopod rectangular with 4 long setae apically. Exopod represented by 1 short spinulose spine.

Maxillule (Fig. 3C). Praecoxa with numerous spinules near outer margin; arthrite incorporated and strongly developed, with 2 surface setae and 9 apical setae and spines. Coxa with cylindrical endite bearing 2 setae. Basis with 2 setae. Endopod with 2 outer and 7 apical setae. Exopod absent.

Maxilla (Fig 3D). Syncoxa ornamented with spinules and denticles along inner and outer margin; with 2 endites; proximal praecoxal endite with 3 setae (innermost seta incorporated, middle seta with apical pore opening, and outermost seta pinnate); distal praecoxal endite with 3 setae as in proximal endite except for incorporated innermost seta. Allobasis produced into strong claw, with 2 accompanying setae on posterior surface. Endopod 1-segmented with 2 elements.

Maxilliped (Fig. 3E) comprising syncoxa, basis, 2-segmented endopod. Syncoxa with 1 plumose seta on outer margin, and ornamented with spinules along inner and outer margins and with tiny denticles close to inner margin. Basis with longitudinal row of spinules along outer margin, and with short outer spinular row proximally. First endopodal segment bare. Second endopodal segment produced into strong claw with 2 additional setae.

Swimming legs 1–4 biramous, each leg with 3-segmented exopod and 2-segmented endopod, and each segment covered with dense spinules as figured.

P1(Fig. 4A). Praecoxa fused to coxa. Coxa wider than long and ornamented as in fig. 4A. Basis with 1 strong outer pinnate seta on outer margin and 1 pinnate spine on inner distal surface. Endopod 2-segmented, reaching almost to end of exp-3; enp-2 longer than enp-1, and enp-1 without seta; enp-2 with spinular outer edge and 2 terminal brush-like setae. Exopod 3-segmented; exp-1 largest; exp-3 slightly shorter than exp-2; exp-3 with 1 tiny outer spine, and 2 apical brush-like setae.

P2–P4 (Figs. 4B, 5A, B) with praecoxa,

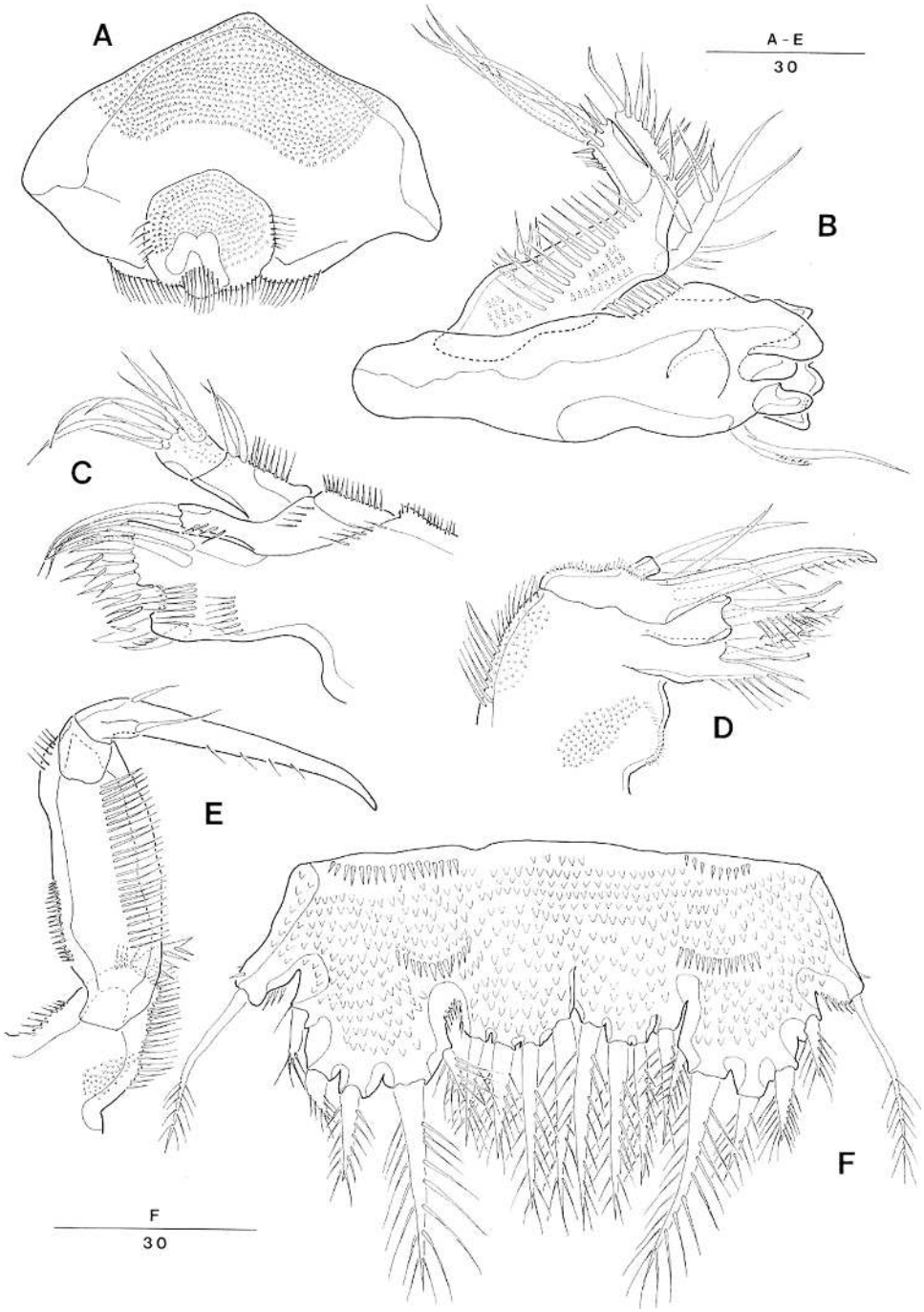

Fig. 3. *Rhizothrix sejongi*, female. A, labrum. B, mandible. C, maxilulle. D, maxilla. E, maxilliped. F, P5, anterior.

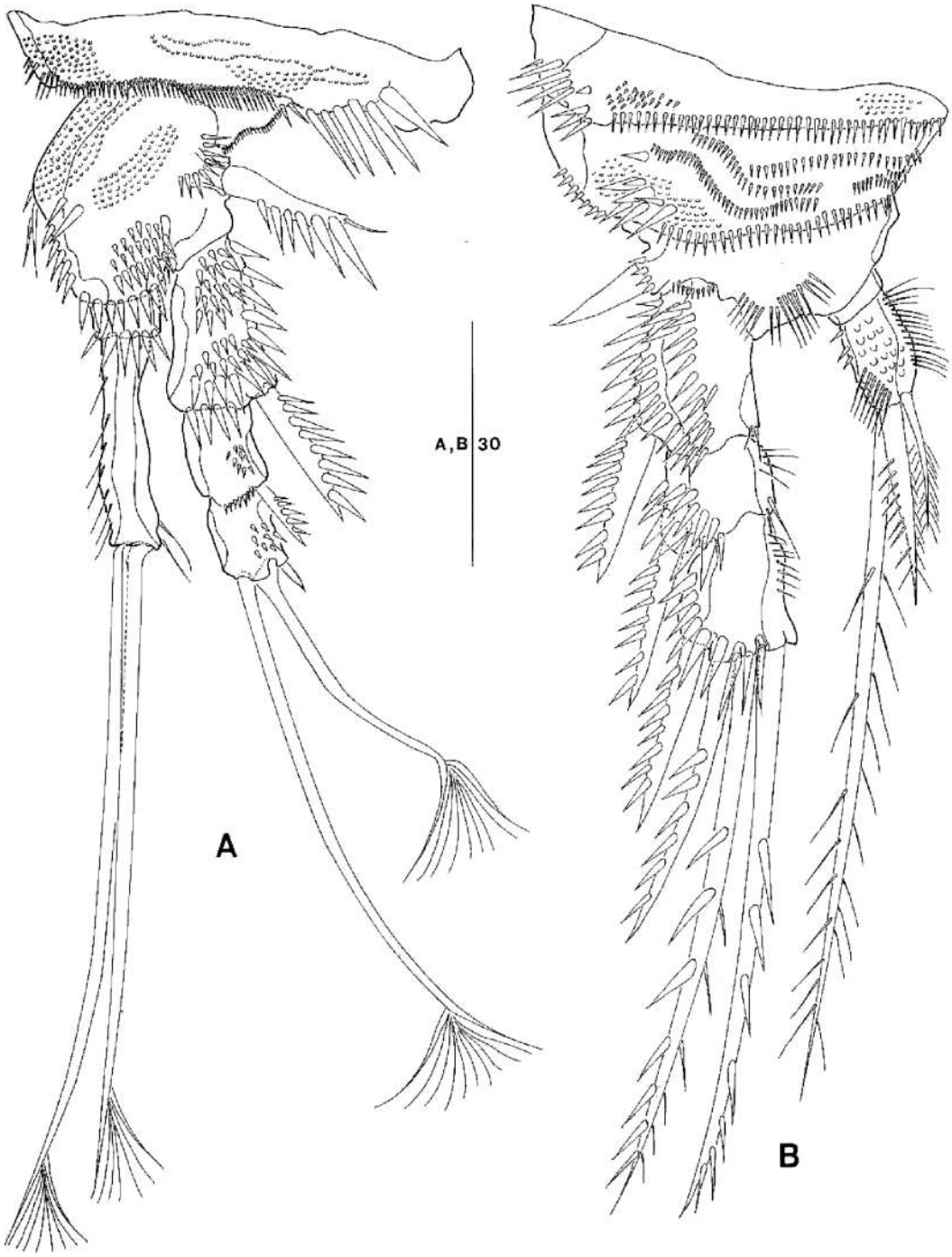

Fig. 4. *Rhizothrix sejongi*, female. A, P1. B, P2.

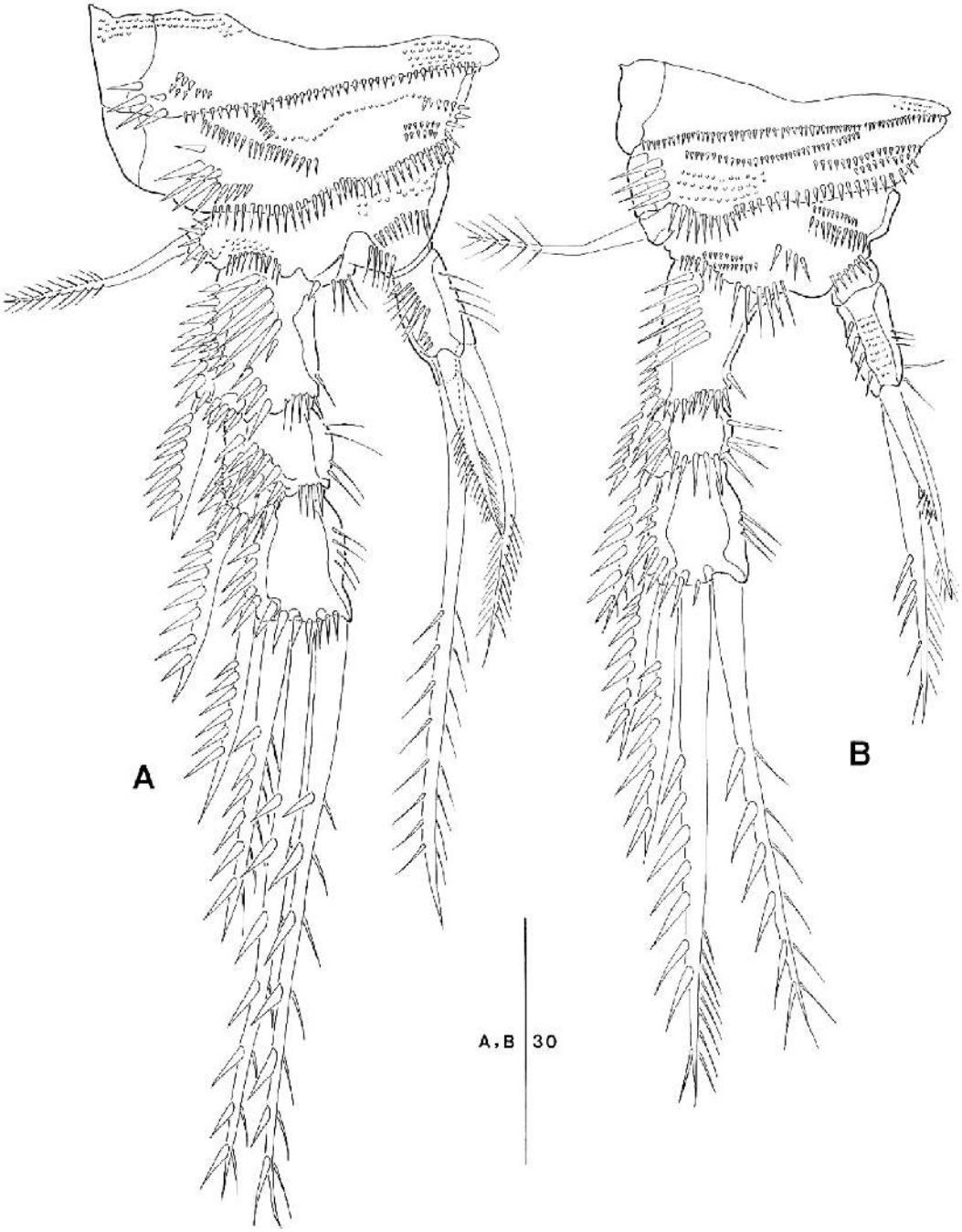

Fig. 5. *Rhizothrix sejongi*, female. A, P3. B, P4.

coxa and basis covered with spinules as figured. Basis with 1 strong outer spinulose spine (P2) or plumose seta (P3—P4). Endopod 2-segmented, reaching distal margin of exp-2; enp-1 small without seta; enp-2 much longer than enp-1, with 3 pinnate setae.

Armature formulae as follows:

	Exopod	Endpod
P2	0.0.022	0.120
P3	0.0.022	0.120
P4	0.0.022	0.120

P5 (Fig. 3F). Both legs fused; exopod and baseoendopod completely fused at both sides. Each lobe distinguished by narrow grooves. Exopod longer than baseoendopod. Exopod with 5 pinnate setae and baseoendopod with 4 pinnate setae. Outer pinnate basal seta set on short setophore. Ornamented as illustrated.

Genital field located rather proximally in the middle of genital double-somite (Fig. 2A). Genital aperture paired, comprising gonophore. Location of copulatory pores not clearly visible, presumably each covered by operculum derived from P6 bearing no seta and only with smooth lobe close to outer distal margin.

Description of male.—Body form more slender than in female (Fig. 1C). Body length 500 μm (N = 13, range 416–555 μm, measured from anterior margin of cephalic shield to posterior margin of caudal rami). Greatest width measured at posterior margin of cephalic shield 141 μ. Sexual dimorphism in A1, P5, and genital field. Entire surface covered with broad denticles as in female.

Prosome (Fig. 1C) 4-segmented, comprising cephalothorax (bearing first pedigerous somite) and 3 free pedigerous somites. Cephalothorax narrower than in female. All prosomites without defined hyaline frills, and hind margin serrulate as in female. Rostrum small, bifid as in female.

Urosome (Figs. 1C, 6A) 6-segmented, comprising P5-bearing somite, genital somite, and 4 free abdominal somites. All urosomites with pattern of surface ornamentation consisting of dense spinules dorsally and ventrally; all hind margins serrulate dorsally and ventrally.

Antennule (Fig. 6B, C) 7-segmented, chirocer with geniculation between segments 6 and 7. Segment 1 largest, with minute spinules along anterior margin, and with 1 seta at anterior distal corner. Segment 4 (Fig. 6C) represented by small sclerite. Segment 5 swollen. Segment 6 forming dorsal spinous process overlying anterior part of segment 7. Segmental homologies: 1-I, 2-(II-VIII), 3-(IX-XII), 4-XIII, 5-(XIV-XX), 6-(XXI-XXIII), 7-(XXIV-XXVIII). Armature formula: 1—[1], 2-[9 pinnate], 3-[7 pinnate], 4-[1 pinnate + 1], 5-[1 pinnate + 8 + (1 + aesthetasc)], 6-[3 small processes], 7-[1 pinnate + 5 + acrothek]. Apical acrothek consisting of minute aesthetasc and 2 naked setae.

Exopod and baseoendopod of P5 fused (Fig. 6D), forming one plate with 3 pinnate spines, inner pinnate spine shortest, and large setophore bearing outer basal seta. Row of long hair-like spinules present along inner distal margin of P5.

Sixth pair of legs (Fig. 6A) asymmetrical, each represented by small plate without setae on both sides (fused to ventral wall of supporting somite along one side, articulating at base and covering gonopore along other side). Each plate of P6 present as narrow membrane.

Etymology.—The name of this new species honors King Sejong the Great, who during his reign (1418–1450) made many cultural and scientific innovations and devised the Korean Hangeul alphabet.

Discussion

The new species is placed in the genus *Rhizothrix* on account of the 4-segmented female antennule, the typical brush seta in P1, the absence of sexual dimorphism in the thoracic legs, and the reduced first endopodal segments of P1–P4.

Rhizothrix gracilis was originally de-

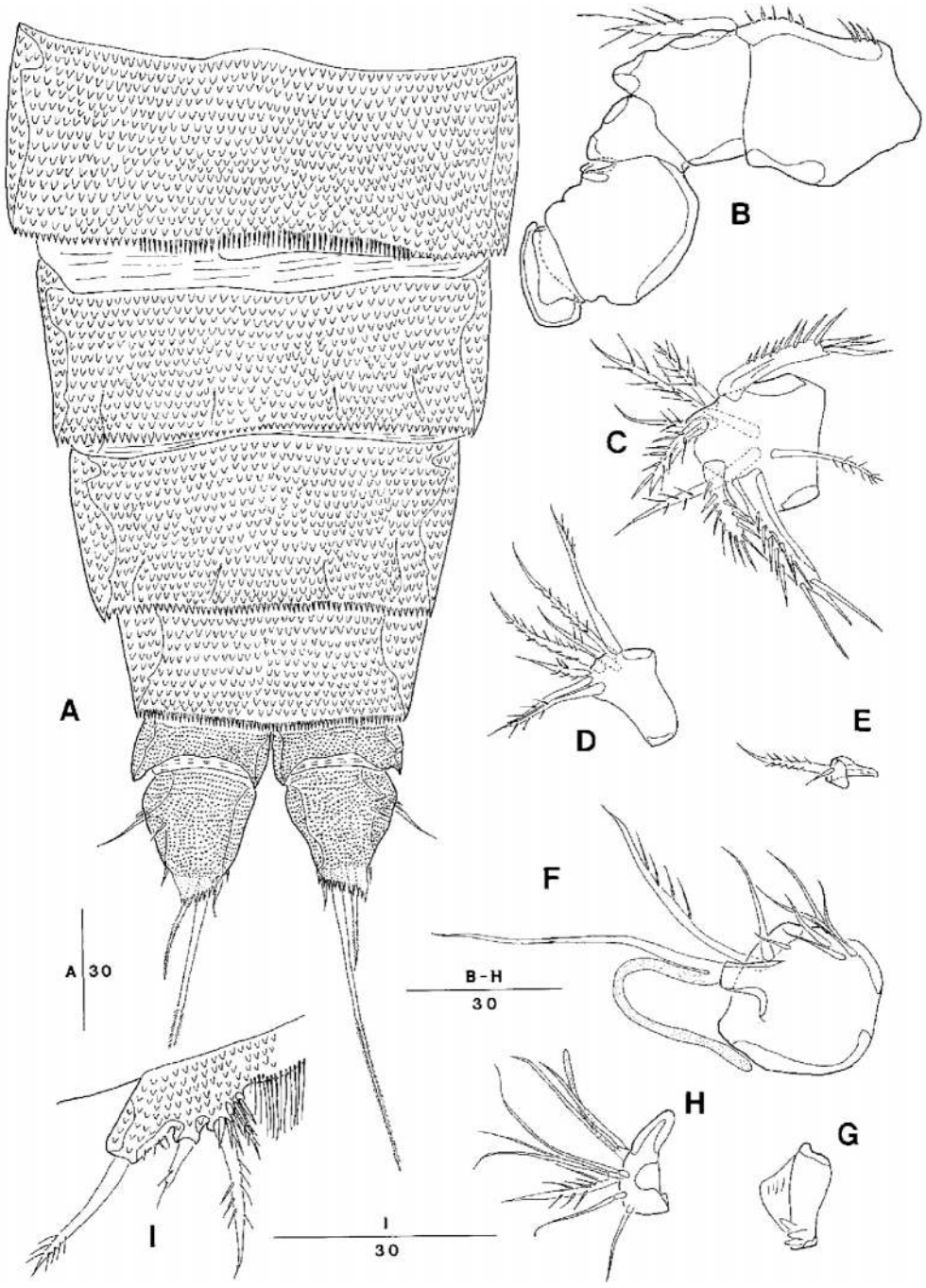

Fig. 6. *Rhizothrix sejongi*, male. A, urosome, ventral. B, antennule (armature omitted from segments 2–7). C, antennular segments 2; D, antennular segment 3; E, antennular segment 4; F, antennular segment 5; G, antennular segment 6; H, antennular segment 7; I, P5, anterior.

scribed by Scott (1903) as *Enhydrosoma gracile,* and seems to be most closely related to *R. sejongi.* Additionally, *Rhizothrix minuta* seems to be closely related to these two species, as indicated by the following shared character states: (1) 4-segmented female antennule, (2) presence of four setae on the antennary exopod, (3) armature formula of P1 and P2, (4) fused exopod and baseoendopod of P5, (5) short ovate caudal rami.

Although the new species resembles *Rhizothrix gracilis* in the above characters, both species can be easily distinguished by the seta formation of the thoracic legs (Table 1). *Rhizothrix sejongi* has three setae on the second endopod segments of P3–P4, whereas *R. gracilis* has 4 setae. The fused P5 of *R. sejongi* has only nine setae in the female and four setae in the male, whereas *R. gracilis* has ten and five setae respectively. Also, the accessory setae on the antennule, antenna, mandible, and maxilliped of *R. gracilis* (Scott 1903: Pl. II, Fig. 17–20) are longer and more slender than in *R. sejongi* (Figs. 2C, D, 3B, E). Similarly, the outer spines on the P1 exopod of *R. gracilis* (Scott 1903: Pl. II, Fig. 21) are much longer and more slender than in *R. sejongi* (Fig. 4 A). Caudal seta V of *R. gracilis* is somewhat bulbous in Scott's original illustration (Scott 1903: Pl. II, Fig. 26), and normal in *R. sejongi* (Fig. 2A, B). In terms of body length, *R. sejongi* (624 μm in ♀) is larger than *R. gracilis* (450 μmm in ♀). However, the reported lengths of *Rhizothrix* species vary widely.

The whole body surface of *R. sejongi* is covered by tiny denticles; it is smooth in *R. gracilis.* Similar ornamentation on the body somites can be found in some other congeners, such as *R. spinosa* (Coull, 1971: Fig. XVI, 137). However, the denticles on the body surface of the new species are coarser than in *R. spinosa. Rhizothrix pubescens* also exhibits spinules on the body surface, but it is different from *R. sejongi* in having a unique pattern of patchiness as shown by Por (1959: Pl. II, Figs. 19–26). This spinular ornamentation on the body surface is quite common in harpacticoid copepods, and seems to have developed independently several times within the genus.

Five species of *Rhizothrix,* including the new species, have the P5 fused in the female. *Rhizothrix sejongi, R. tenella, R. gracilis,* and *R.* cf. *minuta* have a perfectly fused P5 in the female, whereas the female P5 of *R. minuta* is partially divided by a groove indicating original segmentation along the border between the exopod and baseoendopod.

Among the currently known *Rhizothrix* species, five of them, *R. reducta noodti, R. quadriseta, R. spinosa, R. wilsoni,* and *R.* cf. *minuta* have been reported only once.

Since *R.* cf. *minuta* Arlt, 1983 shows clear discrepancies from *R. minuta,* having a separated P5 exopod in the female, and a one-segmented endopod in P2–P4, this taxon could be raised to full species rank. Arlt (1983) expressed the suspicion that his specimen was probably a copepodite of *R. minuta,* based on the segmentations in P3-P4. However, at least one-segmented endopod can be recognized from the *reducta*-lineage (see below). Although examination of the specimen is essential in order to confirm the status of *R.* cf. *minuta,* the specimen is not available.

Mielke (1975) reported *Rhizothrix reducta* Noodt, 1952 from the type locality, Sylt Island, and pointed out some differences between his material and Noodt's (1952) description. Mielke's specimen shows four setae on the antennary exopod (two in *R. reducta*), only two setae on the P2 endopod (three in *R. reducta*), and a one-segmented endopod in P2–P4 (two-segmented in *R. reducta*). In terms of the endopod segmentation of P2–P4, *R. reducta* sensu Mielke seems to be related to *R. reducta noodti,* and should be separated from *R. reducta* Noodt as a valid species.

Brady and Robertson (1875) described *R. curvata,* but they did not give a diagnosis. The diagnosis was presented by Brady (1880) under the name *Enhydrosoma cur-*

Table 1.—Morphological features of the species of *Rhizothrix* Brady & Robertson, 1876.

Name Author Year	*curvata* Brady, 1880	*minuta* T. Scott, 1903	*gracilis* T. Scott, 1903	*scotti* Lang, 1936	*tenella* Wilson 1932	*reducta* Noodt, 1952	*reducta noodti* Galhano, 1970	*reducta* sensu Mielke, 1975	*pubescens* Por, 1959	*quadriseta* Wells, 1967	*spinosa* Coull, 1971	*wilsoni* Bodin, 1979	cf. *minuta* of Arlt, 1983	*sejongi*, new species
♀ Al segments	4	5	4	4	6	4	5	4	4	4	4	4	5	4
[1]A2 exp	2	4	4	2	4	2	3	4	4	4	4	4	4	4
P1 exp-3	021	020	022	022	021	022	022	—	021	022	022	021	020	021
Enp-2	020	020	020	020	012	020	020	—	020	020	020	020	020	020
P2 exp-3	022	022	022	022	022	012	012	021	022	122	022	022	021	022
Enp-2	021	010	021	111	121	012	020*	011*	111	121	021	021	010*	021
P3 exp-3	022	022	022	022	022	012	012	021	022	122	022	022	022	022
Enp-2	021	010	021	111	020	012	020*	021*	111	121	021	111	010*	021
P4 exp 3	022	022	022	022	022	012	012	021	022	122	022	022	022	022
Enp-2	021	010	022	021	020	012	020*	021*	121	121	021	111	010*	021
[2]♀ P5	5:5[3]	5:5 (fused)	5:5 (fused)	5:5	5:5 (fused)	5:5	5:5	5:5	5:5	5:3	5:5	5:5	5:5 (fused)	4:5 (fused)
[2]♂ P5	4 or 5	2:3	5	—	5	5	4	—	5	4	3	4	—	3
Type locality	England	Scotland	Scotland	Arctic Ocean	Woods Hole	Sylt Island	Portugal	Sylt Island	Black Sea	Inhaca Island	North Carolina, U.S.A. Atlantic coast	Martrais Bay, France	Baltic Sea	Sangju, Korea

[1] no. of setae, [2] benp:exp, no. of setae, [3] form of Sars (1909), * 1-segmented.

vatum. There are several unusual features in Brady's (1880) illustrations. The female P5 exopod has either three or four setae, and the male P5 has eight or nine setae (Brady 1880: Pl. 81, fig. 14, Pl. 82 Fig. 19). The female P5 of *R. wilsoni* has a similar shape with the P5 of *R. curvata*, and 5 setae on the exopod (Bodin 1979: p.352, Fig. 20). Brady's (1880) illustration for the male P5 perhaps was based on a female copepodite. Because of the uncertainty regarding Brady's (1880) illustrations, the descriptions of Sars (1909, 1911) for the female P5 of *R. curvata* was used in Table 1.

Rhizothrix reducta and *R. reducta sensu* Mielke are from the same locality, Sylt Island. The sympatric distribution of *Rhizothrix* species at the island points to a possible underestimation of the species diversity within the genus. For instance, a second undescribed species has been collected from a sandy beach 10 km distant from the type locality of *R. sejongi* (H. Y. Soh, pers. comm.).

Key to the species of the genus *Rhizothrix* (amended from Bodin 1979)

1. P1 endopod-2 with 3 setae . . . . . *tenella* Wilson
– P1 endopod-2 with 2 setae 2
2. Distal segment of P2-P4 exopod with 3 setae and spines 3
– Distal segment of P2–P4 exopod with 4 setae and spines 5
Distal segment of P2–P4 exopod with 5 setae and spines . . . . . *quadriseta* Wells
3. Endopod of P2–P4 1-segmented 4
– Endopod of P2–P4 2-segmented . . . . . *reducta* Noodt
4. Endopod of P3–P4 with 2 setae . . . . . cf. *minuta* Arlt
– Endopod of P3–P4 with 2 setae . . . . . *reducta noodti* Galhano
– Endopod of P3–P4 with 3 setae . . . . . *reducta* sensu Mielke
5. A2 exopod with 2 setae 5
– A2 exopod with 4 setae 6
6. Female P5 exopod wider than long . . . . . *scotti* Lang
– Female P5 exopod longer than wide . . . . . *curvata* Brady & Robertson
7. Distal segment of P2–P4 endopod with only 1 seta . . . . . *minuta* (T. Scott)
– Distal segment of P2–P4 endopod with at least 3 setae 8
8. Distal segment of P2–P4 endopod with 4 setae . . . . . *wilsoni* Bodin
– Distal segment of P2–P4 endopod with 3 setae . . . . . *spinosa* Coull
– Distal segment of P2–P3 endopod with 3 setae and of P4 endopod with 4 setae 9
9. female P5 exopod separated from baseoendopod . . . . . *pubescens* Por
– Female P5 exopod & baseoendopod fused 10
10. female P5 exopod & endopod with 10 setae . . . . . *gracilis* (T. Scott)
– female P5 exopod & endopod with 9 setae . . . . . *sejongi*, new species

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