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A new species of *Parategastes* Sars, 1904 from the Thale Noi Lake, southern Thailand (Copepoda, Harpacticoida, Tegastidae)

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Abstract

Parategastes pholpunthini **sp. n.** is described and illustrated based on material collected in the Thale Noi Lake, Phatthalung province, southern Thailand. This species can be distinguished from its congeners by the number segments of female antennule, the lengths of rami and basis of P1, the shape of middle inner seta of P4 exp-3, shape of P5, and relative lengths of spine at apically of baseoendopod of P5. The differences among *Parategastes* species are pointed out and they are compared with the new species. An identification key to species of the genus *Parategastes* are proposed.

Key Words

Crustacea
Meiofauna
Taxonomy
Parategastes pholpunthini

Introduction

The family Tegastidae Sars, 1904 is characterised as being laterally compressed, amphipod-like, strongly chitinous and well sculptured (Huys et al. 1996). To date, this family comprises approximately 60 species in six genera. Each genus can be easily distinguished by the number of segments in P2-P4 and the length of caudal ramus (Gollner et al. 2008). This family is widely distributed, and has been recorded in areas such as the Andaman Islands, India (Fiers 1986); southwestern Australia (Bartsch 1995); the Mid-Atlantic Ridge (Ivanenko and Defaye 2004); Spitsbergen in the Arctic Ocean (Ferrari et al. 2007); a hydrothermal vent site on the East Pacific Rise (Gollner et al. 2008); the Gulf of Mexico (Plum and Arbizu 2009); and a hydrothermal vent in the Okinawa Trough, Japan (Back et al. 2010). One of the six genera, *Parategastes*, was created by Sars (1904) who proposed this genus base on the number segments of female antennule (6-7 segments), maxilliped and shape of P5. In addition, *Parategastes sphaericus* was proposed as a type species of the genus (Sar 1904). Later, Huys et al. (1996) proposed the number of segments in P2-P4 to distinguish genus *Parategastes* from other genus in family Tegastidae. Currently, this genus has so far accommodated six valid species and one species incertae sedis (*Parategastes haphe*) (Wells 2007). Only one species, *P. sphaericus* (Claus, 1863) had been found in many localities such as from the Mediterranean, the North American Atlantic coast, European Atlantic coast (Lang 1948) Naples, Italy (Claus 1863), Chilka Lake, India (Sewell 1924) and Tunis, Tunisia (Monard 1935) whereas other species had been recorded in one locality, *P. chalmersi* (Thompson & Scott, 1903) from Ceylon, Sri Lanka (Thomson and Scott 1903); *P. haphe* Leigh-Sharpe, 1936 was described from Naples (Leigh-Sharpe 1936); *P. herteli* Jakobi, 1953 from Santa Catarina, Brazil (Jakobi 1953); *P. caprinus* Wellershaus, 1970 from Cochin backwater, South India (Wellershaus 1970); *P. coetzeei* Kunz, 1980 from the Wilderness Lakes, South Africa (Kunz 1980); and *P. conexus* Humes, 1984 from Moluccas, Indonesia (Humes 1984). However, this

is the first time record of genus *Parategastes* in Thailand. Thus, this paper will provide detailed description and illustrations of both female and male of the new species collected from Thale Noi Lake, southern Thailand and propose a key to species in genus *Parategastes*.

Material and methods

Samples were collected from Thale Noi Lake, Phatthalung province, southern Thailand, using a 60 µm mesh sized plankton net, every two months from February 2013 to February 2014. Samples were immediately preserved in 70% ethanol. Then specimens were sorted using an Olympus SZ-40 stereo microscope and each specimen was dissected and mounted on a slide in glycerine, and then sealed using nail varnish. The morphological characters were examined using an Olympus CH-2 compound microscope, and drawings were made of both complete and dissected specimens using a *camera lucida* connected to the Olympus CH-2 compound microscope. Descriptive terminology proposed by Huys et al. (1996) was adopted; abbreviations used in the text are: **A1** antennule; **A2** antenna; **P1-P5** swimming legs 1-5; **enp-1** (2, 3), proximal (middle, distal) segment of endopod; and **exp-1** (2, 3), proximal (middle, distal) segment of exopod. Holotypes and paratypes were deposited in the reference collection of the Princess Maha Chakri Sirindhorn National History Museum, Prince of Songkla University, Songkhla, Thailand.

Taxonomy

Order Harpacticoida Sars, 1903
Family Tegastidae Sars, 1904

Genus *Parategastes* Sars, 1904

P. sphaericus (Claus, 1863)
P. chalmersi (Thompson & Scott, 1903)
P. caprinus Wellershaus, 1970
P. coetzeei Kunz, 1980
P. conexus Humes, 1984
P. herteli Jakobi, 1953
P. pholpunthini sp. n.
P. haphe Leigh-Sharpe, 1936 (*incertae sedis*)

Type species. *Parategastes sphaericus* (Claus, 1863).

Generic diagnosis. *Parategastes* Sars, 1904. antennules with 6-7 segments in female and 8 segments in males; exopod of antenna with one segment and with two or three setae; anterior maxilliped with the 2 proximal lateral lobes replaced by simple setae, outermost lobe less broad and provided with only two setae at the tip, terminal joint produced at the tip to a long digitiform process. P2 and P3 with 2-segmented endopod and 3-segmented exopod; and P4 with 3-segmented endopod and exopod, whilst enp-1 was not swollen. P5 in female, baseoendopod very large, with inner expansion to broad and vaulted, exopod somewhat dilated towards the end, with a single short apical seta.

***Parategastes pholpunthini* sp. n.**

http://zoobank.org/1260D5FC-FA5E-4375-9E3F-E08463CAB275

Type material. Holotype: adult female, dissected and mounted on 4 slides, (PSUZC-PK2001-01-PSUZC-PK2001-04); Paratype 1: undissected female, mounted on 1 slide, (PSUZC-PK2001-05); Paratype 2: undissected adult male, mounted on 1 slide, (PSUZC-PK2001-06); Paratype 3: adult female, dissected on 4 slides, (PSUZC-PK2001-07-PSUZC-PK2001-10); Paratype 4: adult male, dissected on 4 slides, (PSUZC-PK2001-11-PSUZC-PK2001-14). All specimens were collected from the type locality on 23 October 2013.

Additional materials. 8 females and 8 males from the type locality are stored in 70% ethanol.

Type locality. Klong Ban Klang canal, Thale Noi Lake, Phatthalung province, southern Thailand (07°46’30.47”N, 100°9’31.68”E). The canal is connected to Songkhla Lake. Water temperature ranged between 28.3 to 28.5 °C, pH of 5.71–6.07, salinity 1.1 ppt, depths between 0.8 m to 1.35 m, transparency of 0.2–1.35 m, and dissolved oxygen levels of 3.06–4.24 mgO_2/L. This area was covered with aquatic plants, such as *Neptunia oleracea* Lour., *Eichhornia crassipes* (C. Mart.) Solms, and *Nympheas* sp.

Description of the adult female. Body laterally compressed with sensilla, surface of whole body pitted (Fig. 1A). Total length, measured from the anterior margin of the cephalic shield to the posterior margin of the caudal rami, 280–340 µm (mean = 310 µm, n = 11). Prosome comprising of cephalothorax and three somites bearing P2 to P4. Urosome 5-segmented (Fig. 1D), first urosomite with P5, genital double somite and three abdominal somites. Caudal rami (Fig. 1C) as wide as long, with seven setae of different lengths. All setae smooth.

Egg sac (Fig. 2G) round, containing four eggs, located ventrally between fifth pair of legs.

Rostrum (Fig. 1B) a rounded prominence.

Antennule (Fig. 2A) 6-segmented, aesthetasc on 4th and 6th segments. Armature formula 1-[1], 2-[8], 3-[8], 4-[3+aesthetasc], 5-[5], 6-[10+acrothek]. Aesthetasc on 4th segment fused basally to one smooth seta. Apical acrothek consists of an aesthetasc fused basally with two slender smooth setae. Only seta on first segment bipinnate, all other setae smooth.

Antenna (Fig. 2B) 4-segmented, comprising coxa, basis and 2-segmented endopod. Coxa and basis without ornamentation, exopod 1-segmented with three setae. Enp-1 with one median seta; enp-2 with eight setae (two laterals and six apical).

Mandible (Fig. 2C) gnathobase with four teeth. Coxa-basis with row of long spinules and with two setae; endopod 1-segment with three setae; exopod represented by one seta.

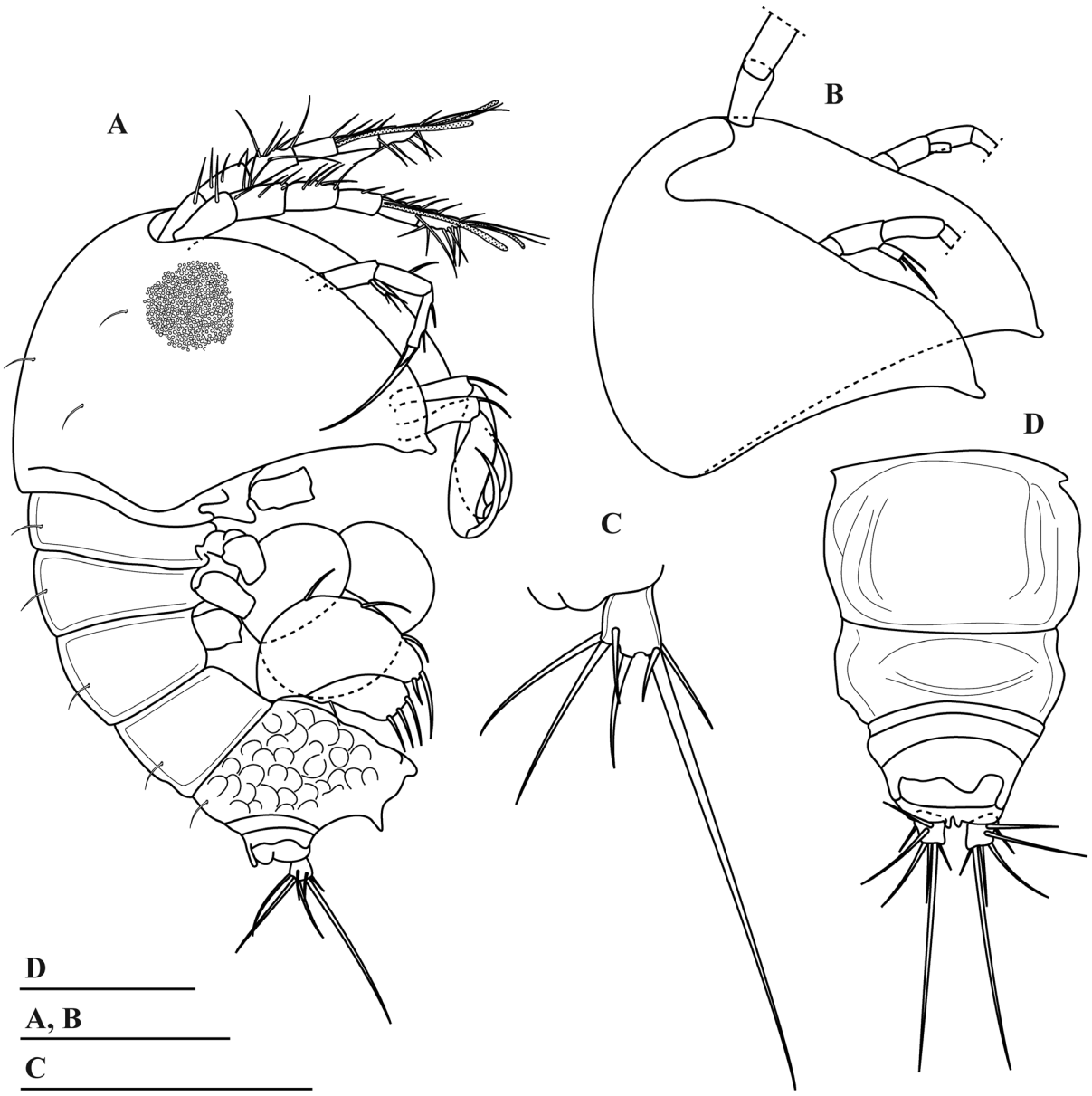

Figure 1. *Parategastes pholpunthini* sp. n., holotype female. **A** habitus, lateral view **B** rostrum **C** caudal ramus, lateral view **D** urosome. Scale bars: **A, B** = 100 μm; **C, D** = 50 μm.

Maxillule (Fig. 2D) precoxal arthrite bearing seven elements. Coxal endite with one seta. Endopod elongated with a row of spinules, five terminal setae, and two setae at outer margin.

Maxilla (Fig. 2E) syncoxa with transverse row of spinules proximo-laterally and with two endites. Precoxal endite with four setae, one seta elongated; coxal endite with three setae. Allobasis with three setae, middle seta forming a strong claw, and three setae at outer margin representing endopod.

Maxilliped (Fig. 2F) subchelate, 2-segmented, comprising syncoxa and basis. Syncoxa with one pinnate seta at the inner distal corner. Basis with row of spinules, one pad-like process ornamented with short spinules on its surface. Endopod 1-segmented, forming a strong claw with one seta proximally.

P1 (Fig. 3A) coxa with a row of setules along inner margin. Basis with a row of spinules along inner margin, one inner seta, and one outer seta. Both rami with 1-segmented endopod wider than exopod. Endopod with a row of setules along outer margin; with one inner proximal biplumose seta, one inner middle modified spine, one inner distal bipinnate spine, two apical bipinnate spines, and one outer bipinnate spine. Exopod with a row of spinules along inner margin; with two apical bipinnate spines, three outer setae, the middle of which being bare, and the others bipinnate.

P2 and P3 (Figs 3B, 4A) coxa with a set of spinules on pronounced disto-lateral corner. Basis elongated with one small outer seta and row of spinules along medial margin. Rami with 3-segmented endopods and 2-segmented exopods; all segments of endopod with a row of setules

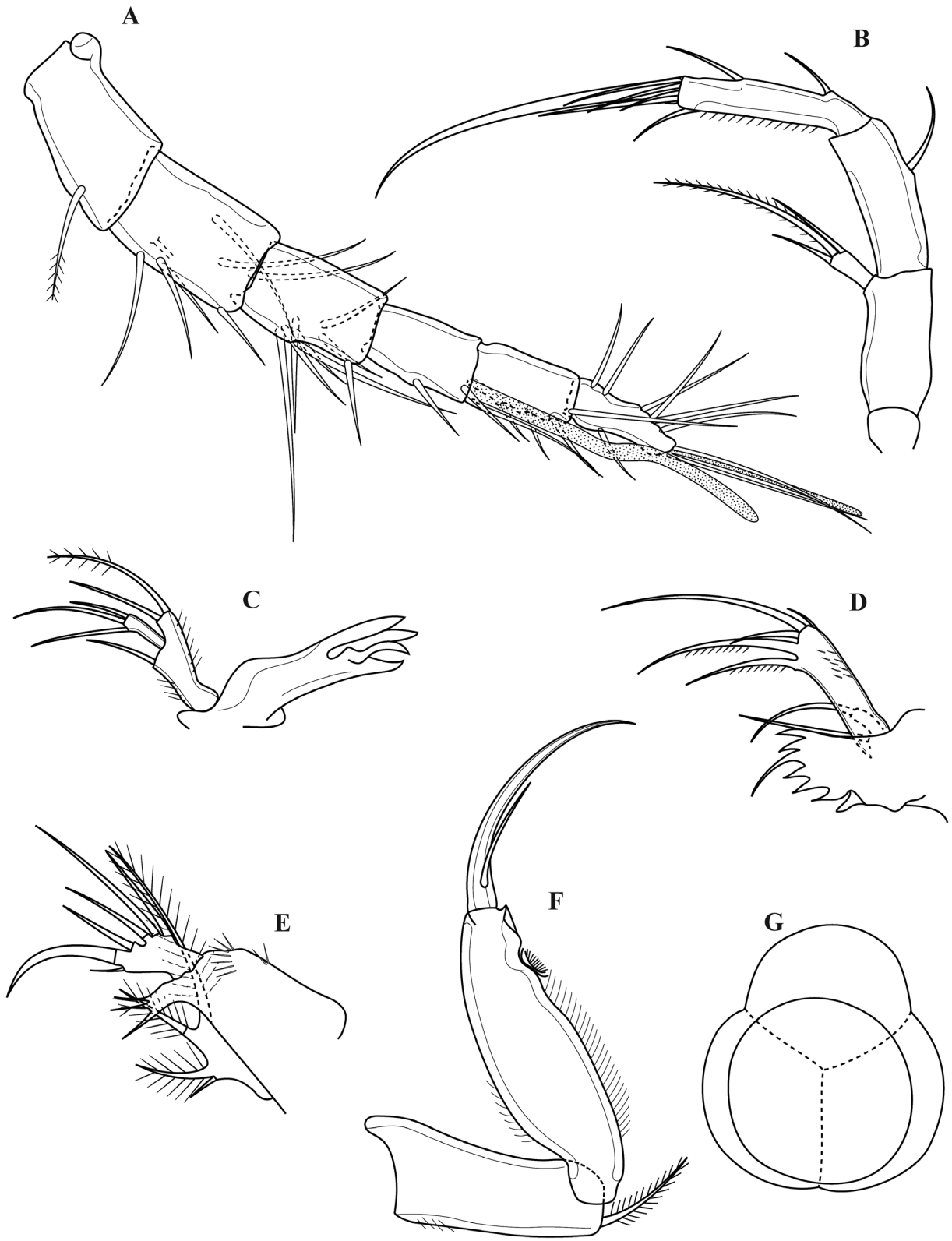

Figure 2. *Parategastes pholpunthini* sp. n., holotype female. **A** antennule **B** antenna **C** mandible **D** maxillule **E** maxilla **F** maxilliped **G** egg. Scale bars: **A–E** = 50 μm; **G** = 100 μm.

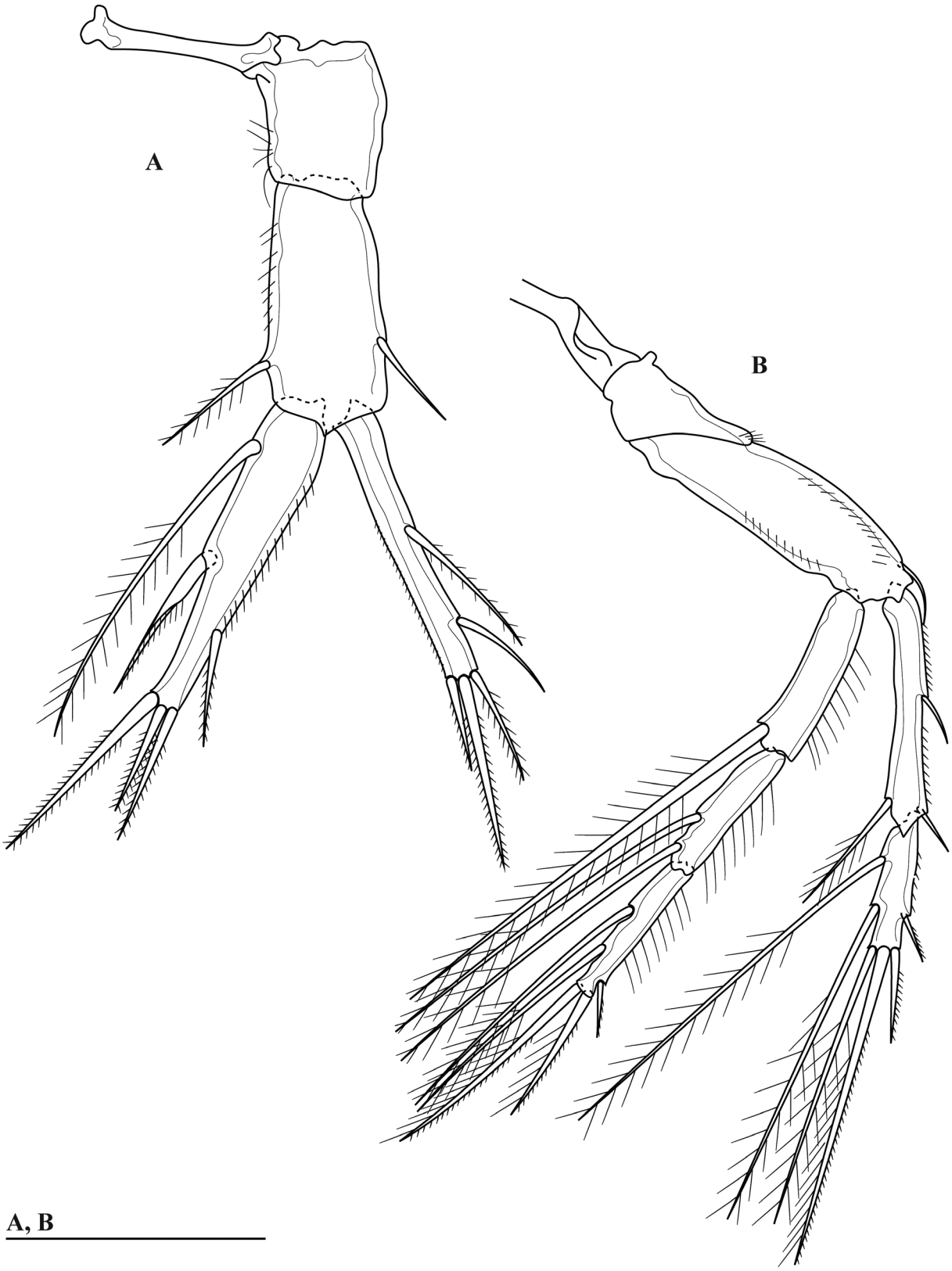

Figure 3. *Parategastes pholpunthini* sp. n., holotype female. **A** P1 **B** P2. Scale bar: **A, B** = 50 μm.

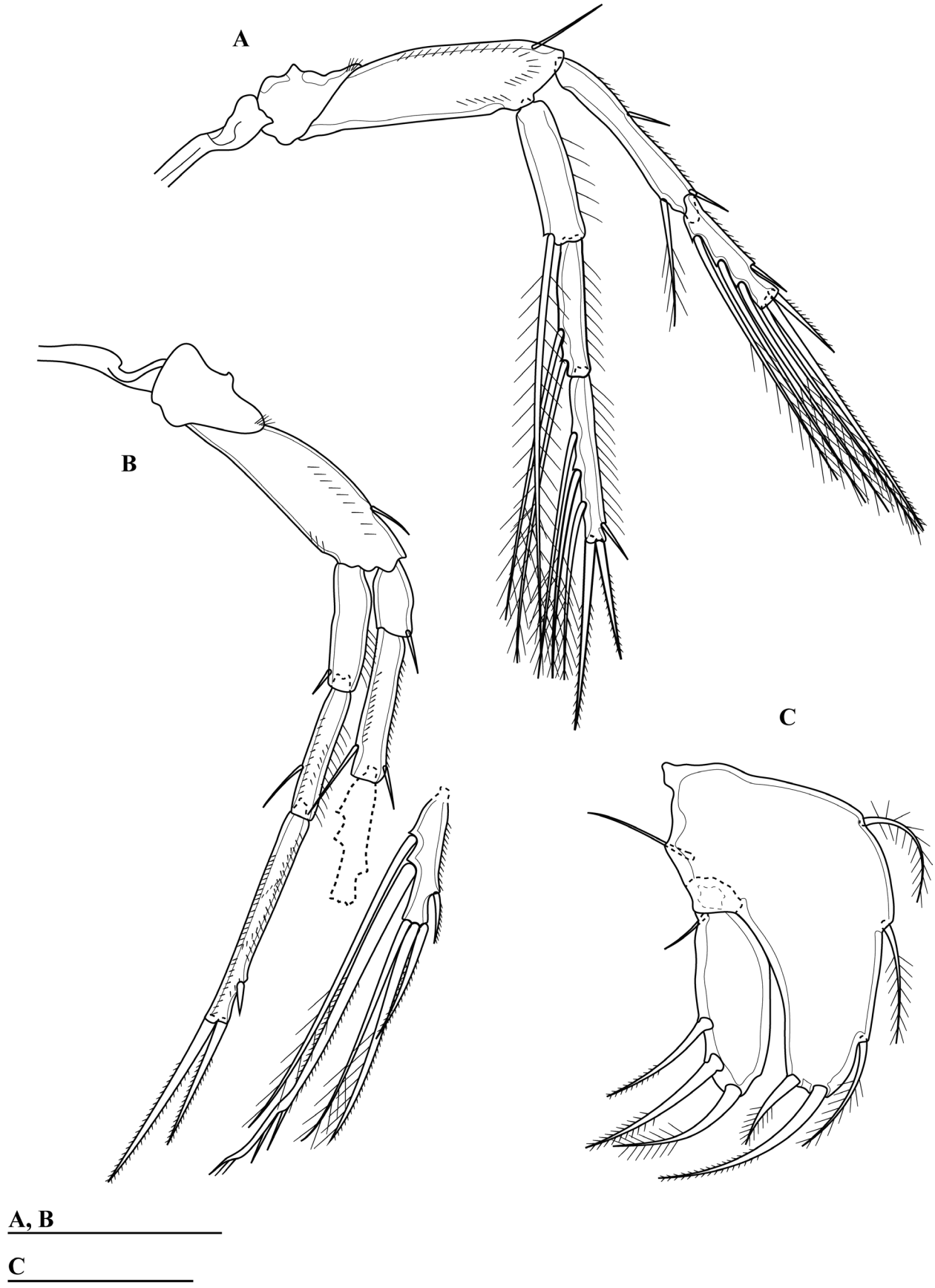

Figure 4. *Parategastes pholpunthini* sp. n., holotype female. **A** P3 **B** P4 **C** P5. Scale bar: **A–C** = 50 μm.

Figure 5. *Parategastes pholpunthini* sp. n., paratype male. **A** habitus, lateral view **B** antennule **C** P5. Scale bars: **A** = 100 μm; **B, C** = 50 μm.

along outer margins, all segments of exopod with a row of spinules along outer margin.

P4 (Fig. 4B) coxa with a set of spinules on pronounced disto-lateral corner. Basis elongated with one small outer seta and a row of spinules on the inner and outer margins. Both rami 3-segmented. Enp-1 and enp-2 equal in length but shorter than enp-3; enp-1 and enp-2 with inner setae and with a row of setules along outer margins; enp-3 with two apical pinnate spines, and one outer seta. Exp-1 small, with one outer spine; exp-2 with one inner seta and one outer spine, and with a row of spinules on the inner and outer margins; exp-3 with a row of spinules on the outer margin, with one inner pinnate seta, middle inner seta enlarged, this enlarged seta has a peculiar shape with two long pinnae at the distal third, with the bending, and with three shorter pinnae distal end, two apical setae, one seta plumose, another seta inner margin plumose and outer margin pinnate, and two outer pinnate spines.

Armature formula of P1-P4 as in Table 1.

P5 (Fig. 4C) with baseoendopod and exopod; baseoendopod with three lateral biplumose setae, and one inner seta along proximolateral, apically with one inner bipinnate seta and one outer biplumose spine. Exopod with one apical biplumose seta and two outer bipinnate setae, one small seta basally.

Description of the adult male. Body laterally compressed (Fig. 5A). Total length, 290–310 µm (mean = 290 µm, n = 10). Spermatophore reservoir produced ventrally in a large, elongated prominence bearing distally asymmetrical genital flaps.

Antennule (Fig. 5B) 8-segmented, aesthetasc on 3rd, 4th and 8th segments. Armature formula 1-[1], 2-[9], 3-[7+aesthetasc], 4-[7+aesthetasc], 5-[1], 6-[2], 7-[1], 8-[10+acrothek]. Aesthetasc on 3rd and 4th segment fused basally to one naked seta. Apical acrothek consists of an aesthetasc fused basally with two slender naked setae. Only seta on first segment bipinnate, all others smooth.

Rostrum, antenna, mandible, maxillule, maxilla, maxilliped, P1-P4 (not shown) as in female.

P5 (Fig. 5C) 2-segmented with baseoendopod and exopod; baseoendopod small with long spinule at lateral margin; exopod elongate with one proximal outer seta, one subterminal outer spine and two apical spines.

Etymology. This species named after Dr. Pornsilp Pholpunthin, who has studied the freshwater copepods in Southern Thailand since last twenty years.

Table 1. Armature formula of P1-P4 of *Parategastes pholpunthini* sp. n.

Swimming legs	Coxa	Basis	Endopod	Exopod
P1	0-0	1-1	1, II, III	2, 1II, 0
P2	0-0	1-0	0-1; 0-2; I, II, 2	[I-0, I-1]; I, II1, 2
P3	0-0	1-0	0-1; 0-2; I, II, 3	[I-0, I-1]; I, II1, 3
P4	0-0	1-0	0-1; 0-1; I, II, 0	I-0; I-1; I, II1, 2

Note: roman numerals representing spines and arabic numerals representing setae

Discussion

Four *Parategastes* species have been recorded in the Oriental region (Sewell 1924, Thompson and Scott 1903, Humes 1984, Wellershaus 1970). They comprises of *Parategastes sphaericus*, *P. chalmersi*, *P. conexus* and *P. caprinus*. However, this is the first record of the genus *Parategastes* in Thailand.

Parategastes pholpunthini sp. n. is clearly distinguished from other *Parategastes* species in the following characters: (1) number of antennule segments of female, 7-segmented in most species of *Parategastes*, except *P. coetzeei* and *P. pholpunthini* sp. n. with 6-segmented; (2) P1, length of rami and basis in this genus can be separated into three groups: the first group, rami shorter than basis, comprises of *P. chalmersi* and *P. conexus*, the second group, rami approximately as long as basis, comprises of *P. herteli* and *P. sphaericus* and the third group, rami longer than basis, comprises of *P. caprinus*, *P. coetzeei* and *P. pholpunthini* sp. n. (Table 2). However, in the latter group, inner middle spine of P1 modified except *P. caprinus*; (3) P4, middle inner seta of exp-3 enlarged in various forms, in *P. sphaericus* and *P. caprinus*, this seta thickened and elongated with serrated margin at the middle to the distal end (see fig. 2 P4, Sewell 1924; plate XLIII, Sars 1903; fig. 54, Wellershaus 1970), *P. chalmersi*, thickened, inner and outer margins not serrated (plate IV, fig. 21, Thompson and Scott 1903), *P. conexus*, inner margin of this seta not serrated and outer seta with three slender teeth at distal end (see fig. 8f, Humes 1984), *P. herteli*, this seta enlarged (see fig.1, Jakobi 1953), *P. pholpunthini* sp. n., this seta has a peculiar shape with two long pinnae at the distal third, with the bending, and with three shorter pinnae distal end, and slender seta in *P. coetzeei* and (4) P5, baseoendopod, only *P. conexus* with sub-triangular shape, other species with sub-oval shape; all species in this genus, apically with inner seta as long as outer spine, except *P. pholpunthini* sp. n. length of inner seta twice of outer spine, and *P. conexus* length of inner seta twice of outer seta.

From the comparisons, it was found that *Parategastes pholpunthini* sp. n. resembles *P. coetzeei*, but differs from the latter in the following characters: (1) P1, proximal inner seta of endopod 1.08 times as long as the endopod in *P. pholpunthini* sp. n. (Fig. 3A) yet equal in length to the endopod in *P. coetzeei* (see Fig. 9, Kunz 1980), (2) P4 of *P. pholpunthini* sp. n. has short setae at the inner edge of enp-1 and outer edge of exp-1 (Fig. 4B); in *P. coetzeei* is without seta at the inner seta of enp-1 and outer seta of exp-1 (see Fig. 13, Kunz 1980), (3) *P. pholpunthini* sp. n. has one seta of enp-2 of P4 (Fig. 4B); in *P. coetzeei* it has two setae (see Fig. 13, Kunz 1980), (4) P5, length of the inner apical seta of baseoendopod is twice of outer apical spine in *P. pholpunthini* sp. n. (Fig. 4C), and length of the medial apical seta is as long as the lateral apical seta *P. coetzeei* (see Fig. 15, Kunz 1980), (5) the exopod of P5 of *P. coetzeei*

Table 2. Comparison of characters of female of *Parategastes* species (modified from Wells 2007).

Species/ characters	A1	Exp of A2 (setae)	P1				P2-P4			P4 exp-3		P5	
			rami/ basis	setae		inner middle spine of enp	inner setae		enp-3	middle inner seta	outer setae	baseoendopod	
				enp	exp		enp-1	enp-2				shape	inner/outer spine (seta)
P. sphaericus	7	2	m	6	5	slender	1:1:1	2:2:1	5:6:3	thickened , with serrated	2	sub-oval	A
P. chalmersi	7	-	s	5	4	slender	1:1:1	2:2:2	5:6:6	thickened, without serrated	3:wd: B	sub-oval	A
P. caprinus	7	3	l	6	5	slender	1:1:1	2:2:2	5:6:3	thickened, with serrated	3:rud	sub-oval	A
P. conexus	7	3	s	6	5	slender	1:1:1	2:2:2	5:6:5	enlarged, 3 teeth at the distal end	3:wd: A	sub-triangular	A
P. herteli	7	3	m	6	5	slender	1:1:1	2:2:2	5:6:3	enlarged	2	sub-oval	A
P. coetzeei	6	3	l	6	5	thickened	1:1:0	2:2:2	5:7:3	slender	2	sub-oval	B*
P. pholpunthini sp. n.	6	3	l	6	5	thickened	1:1:1	2:2:1	5:6:3	enlarged, bending, pinnae at the distal third and distal end	2	sub-oval	B**

Note: not include *P. haphe*. - = no data; P1, lengths of rami relative to lengths of basis; l = exopod or endopod longer than basis; m = exopod or endopod approximately as long as basis; s = exopod or endopod shorter than basis; P4 exp-3, number and type of setae on inner edge; 3:wd:A = 3 setae, distal seta well developed, about as long as both proximal setae; 3:wd:B = 3 setae, distal seta well developed, about as long as the proximal seta but much shorter than the middle seta; 3:rud = 3 setae, distal seta very thin and weak, barely reaching to the end of the segment; 2 = setation of inner edge apparently represented by only the two very long proximal setae; P5, lengths of inner spine(seta) relative to lengths of outer spine(seta); A= inner seta as long as outer seta, B* = inner seta is twice of outer seta, B** = inner seta is twice of outer spine.

(see Fig. 15, Kunz 1980) has a distance between the two terminal setae of the exopod relatively wider than that of *P. pholpunthini* sp. n. (Fig. 4C).

At present, the taxonomic status of members of the genus *Parategastes* is still unclear. Original descriptions and illustrations of type specimens of some species are poor. It seems that this genus is in need molecular data of each species.

Key to species of female of *Parategastes* Sars, 1904 (modified from Kunz 1980)

1 Endopod and exopod of P1 with 5 and 4 setae..... *P. chalmersi* (Thompson & Scott, 1903)
– Endopod and exopod of P1 with 6 and 5 setae..... 2
2 Exopod of antenna with two setae..... *P. sphaericus* (Claus, 1863)
– Exopod of antenna with three setae 3
3 Rami of P1 shorter than basis ..... *P. conexus* Humes, 1984
– Rami of P1 equal or longer than basis 4
4 A1 with 7 segmented, middle inner spine of endopod of P1 is slender..... 5
– A1 with 6 segmented, middle inner spine of endopod of P1 is thickened 6
5 P1, endopod and exopod approximately as long as basis, proximal seta of inner edge of endopod longer than segment. Exp-3 of P4 with 2 outer seta..... *P. herteli* Jakobi, 1953
– P1, endopod and exopod longer than basis, proximal seta of inner edge of endopod shorter than segment. Exp-3 of P4 with 3 outer setae ..... *P. caprinus* Wellershaus, 1970
6 Length of inner apical seta of baseoendopod of P5 as long as outer apical seta. Enp-1 of P4 without inner seta..... ..... *P. coetzeei* Kunz, 1980
– Length of inner apical seta of baseoendopod of P5 is twice of outer apical seta. Enp-1 of P4 with 1 inner seta..... ..... *P. pholpunthini* sp. n.

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