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Review of the genus *Haloschizopera* (Harpacticoida: Miraciidae, Diosaccinae) with description of a new species

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Abstract:

Haloschizopera cheni **sp. n**., was recognized from our latest collections from the East China Sea. The new species is similar to *H. abyssi* Becher, 1974 but differs from it by the following combined features: baseoendopodal lobe of female P5 with five setae, P2 and P3 enp-3 both longer than enp-1-2 combined, and caudal rami longer than broad. Comparison of all the known species of *Haloschizopera* was performed. Species in the genus can be divided into four groups by the setal formulae of P3 and P4. The main diagnostic characters of each species are listed and a key to all known species of *Haloschizopera* is also provided.

Key words: East China Sea, Meiobenthos, Phylogeny, Taxonomy

Introduction

The harpacticoid copepod genus *Haloschizopera* Lang, 1944 belongs to the family Miraciidae Dana,1846, which is a large group of benthic harpacticoids (Boxshall & Halsey 2004) and often dominates the benthic copepod fauna both in diversity and abundance (Garlitska & Azovsky 2016; Chertoprud et al. 2018). The genus *Haloschizopera* was erected by Lang (1944) based on characters of P1 endopodal structure, setal formulae of P2-P4, and number of setae on P5. The genus comprised five species: *H. pygmaea* Norman & Scott, 1905, *H. exigua* Sars, 1906, *H. bulbifer* Sars, 1911, *H. junodi* Monard, 1935a, and *H. mathoi* Monard, 1935b. Subsequently, another 16 species were described worldwide. Currently, the genus *Haloschizopera* contains 21 valid species (Wells 2007) with a wide distribution in the European coasts (*H. pygmaea* Norman & Sccot, 1905), the northern Atlantic (*H. bathyalis* Schriever,1984), and the eastern Pacific (*H. apprisea* Gee & Fleeger, 1990). Species of *Haloschizopera* also inhabit in a wide depth range, from the sublittoral zone (*H. mathoi* Monard, 1935b) to abyssal environments (*H. abyssi* Becher, 1974).

However, members of *Haloschizopera* from the western Pacific weres only referred to in ecological studies (Mu et al. 2001; Mu et al. 2002; Ma & Li 2017a), and has not been properly documented in taxonomic surveys. Until now, only a few records of benthic harpacticoids have been reported from Chinese seas (Gee & Mu 2000; Mu & Gee 2000; Mu & Huys 2002, 2004; Huys & Mu 2008; Ma & Li 2011; Ma & Li 2017b). Therefore, the benthic harpacticoid fauna from this area is yet to be studied.

During an investigation of the biodiversity, composition and community structure of the benthic copepod fauna off the Yangtze River Estuary, specimens of *Haloschizopera* were collected from the sublittoral zone. After taxonomic examination and comparison with its congeners, we recognized a new species, *H. cheni* **sp. nov**., which is described herein. In addition, a table of diagnosis morphological characters of all the valid species of *Haloschizopera* is presented. A key to the species of this genus is also provided.

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Material and methods

Samples were collected in December 2016 offshore of Zhejiang province in the East China Sea by RV "Kexue-III". The types of sediments of the sample sites range from muddy sand to mud, depths ranged from 25 m to 79 m.

All the samples were fixed in 10% formalin and the specimens were extracted from benthic samples by a 31 μm sieve and colloidal silica Ludox HS-40 suspension centrifugation flotation method. Specimens were then preserved in 75% alcohol. For their taxonomic identification, specimens were cleared in lactic acid and observed under a light microscope. Before dissection, the habitus was drawn and the whole-body length (from the basis of rostrum to the end of the anal somite) was measured while being temporarily mounted in lactophenol. Specimens were dissected in lactic acid, mounted on slides in lactophenol, and sealed with neutral balsam. Observations and dissection were performed using a stereomicroscope (Nikon C-DSD230), and drawings were prepared using a Nikon ECLIPSE Ni-U microscope with a drawing tube. The habitus was drawn at 400× magnification; appendages were drawn at 1000× magnification, with an oil immersion lens.

The terminology follows Huys et al.'s (1996) nomenclature. Abbreviations used in the text, figures and tables are: aes, aesthetasc; A1, antennule; A2, antenna; Md, mandible; Maxillule, Mx1; Maxilla, Mx2; Maxilliped, Mxp; L/W, length : width; exp, exopod; exp (enp) -1(-2-3), the first (second, third) segment of exopod (endopod); P1-P6, swimming legs 1-6. Type materials are deposited in the Marine Biological Museum, Chinese Academy of Sciences, Qingdao, China (MBMCAS).

Results

Systematics

Order Harpacticoida Sars, 1903

Family Miraciidae Dana, 1846

Subfamily Diosaccinae Sars M., 1906

Genus *Haloschizopera* Lang, 1946

Haloschizopera cheni sp. nov.

Material examined. Holotype: 1 adult female, dissected on 6 slides (MBM189248), soft mud, depth 52 m, 122.51°E, 28.95°N, 18 December 2016. Paratypes: 2 adult females, dissected on 11 slides (MBM189249-189250); 3 adult males, dissected on 12 slides (MBM189251-189253); 1 adult female and 2 adult males (MBM189254) preserved in alcohol, collecting information as holotype.

Diagnosis. Body subcylindrical, widest at posterior margin of cephalothorax, prosome slightly tapering anteriorly and posteriorly, cephalothorax and three free somites subequal, prosome slightly wider and longer than urosome. Rostrum defined at base, elongate, triangular, semi-hyaline distally, with central reinforcement, extending beyond second antennular segment, pair of small lateral sensilla in distal half length. Somatic ornamentation simple and slight, dorsal and lateral surface without spinules except one dorsal-lateral row of spinules on first abdominal somite in male. Antennule eight-segmented in female, nine-segmented in male; with aesthetascs on fourth and terminal segments. Allobasis of antenna with one seta at inner middle margin; exopod three-segmented, second segment with one plumose seta; endopod with seven terminal elements. Mandibular basis with three plumose setae; exopod two-segmented, with 1:3 setae; endopod one-segmented, with two middle and six terminal setae. Maxillulary coxal endite with one seta; basis with five setae; endopod and exopod one-segmented with four naked setae and two plumose setae, respectively. Maxilla with three coxal endites, with 2:2:3 elements (proximal to posterior); allobasal endite with three elements; endopod with seven naked setae. Maxilliped with three setae on syncoxa; basis with one seta and one small spine; endopod one-segmented, with a terminal claw and one accessory seta. P1 endopod and exopod three-segmented; endopod not prehensile, enp-1 not extending to the middle of exp-2, sexual dimorphism characterized by two hyaline apophyses and reinforcement at inner margin of male basis.

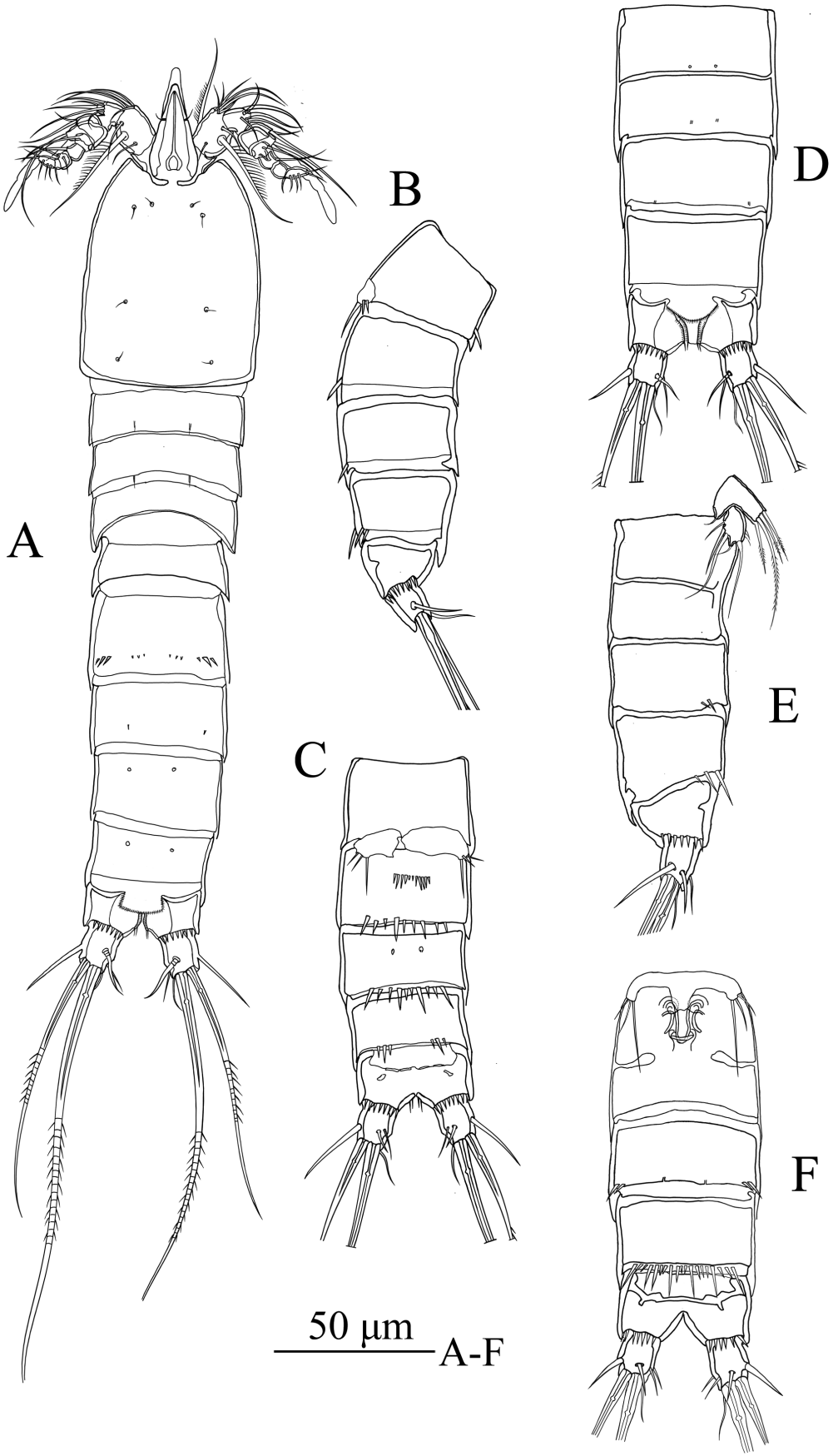

FIGURE 1. *Haloschizopera cheni* **sp. nov**., male (A-C), female (D-F); (A) Habitus, dorsal view; (B) abdomen, lateral view; (C) abdomen, ventral view; (D) abdomen, dorsal view; (E) abdomen, lateral view; (F) abdomen, ventral view.

P2-P4 rami three-segmented, except enp-2 of P2 in male; P2 enp-2 modified in male, with two inner setae, one apical spine and two outer spines, inner one of outer spine with two teeth at tip; exp-3 of P3 without inner seta, P4 with two inner setae. Caudal rami longer than broad, with one dorsal, two ventral, one inner distal, one outer lateral and two terminal setae.

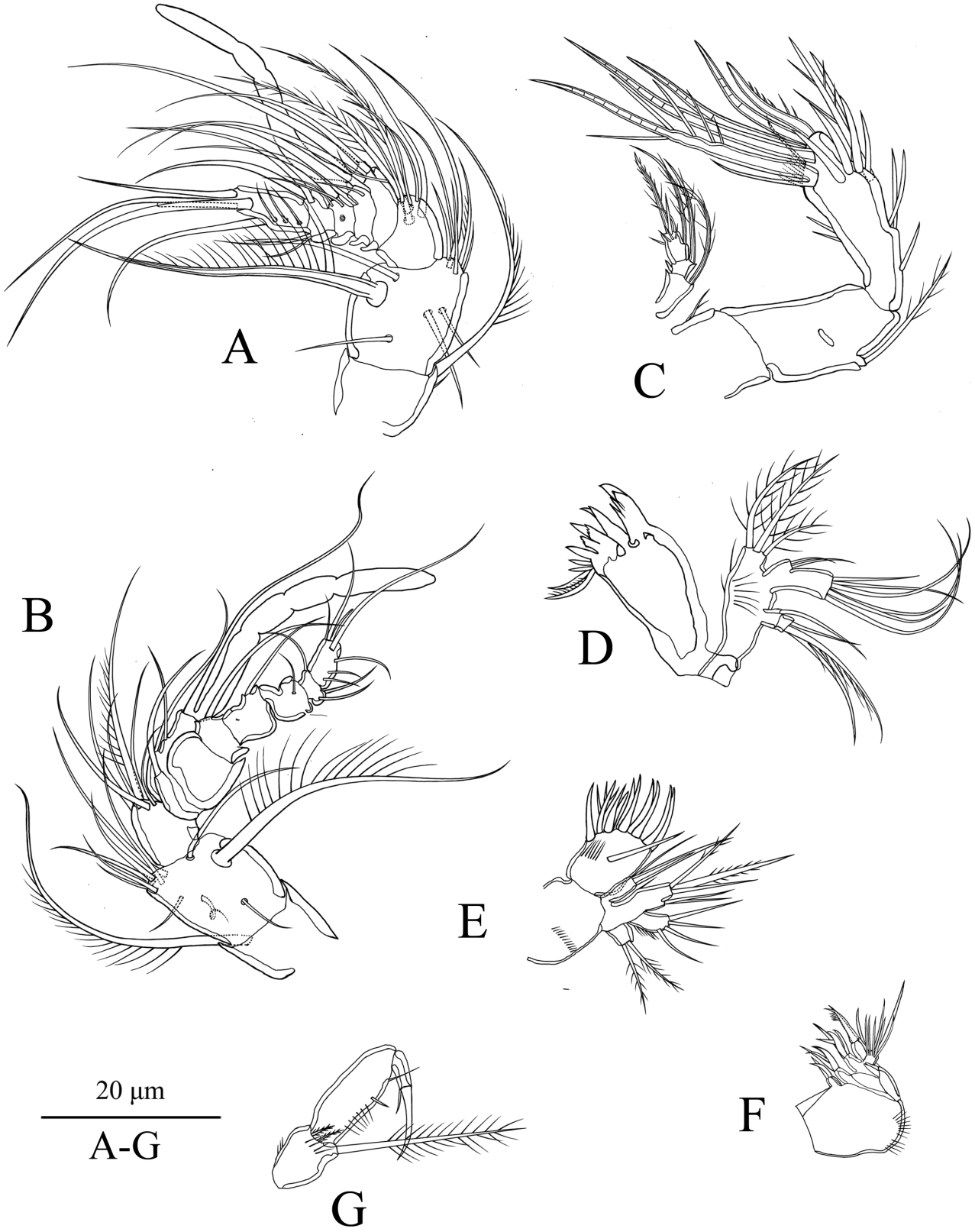

FIGURE 2. *Haloschizopera cheni* **sp. nov.**, (A) antennule of female; (B) antennule of male; (C) antenna; (D) mandible; (E) maxillule; (F) maxilla G maxilliped.

Description of adult female. Body length: 251–296 μm. Body subcylindrical (Fig. 1A), tapering slightly posteriorly, widest at posterior margin of cephalothorax. Rostrum defined at base, elongate, triangular, semi-hyaline distally, extending beyond second antennular segment, with central reinforcement and pair of small lateral sensilla in half length. Cephalothorax tapering anteriorly, with scattered sensilla, metasome with paired sensilla; cephalothorax slightly longer than metasome. Genital double-somite dorsally and laterally subdivided by subcuticular rib; genital area as in Fig. 1E; vestigial sixth swimming leg bearing one long seta and two small smooth setae. Anal somite deeply divided in dorsal view with inner margins bearing complex rows of small spinules; operculum flabellate, near median dorsal anterior border with hyaline frills. Caudal rami (Fig. 1) longer than broad (length/width: 1.3), carrying seven setae: one smooth and three-segmented seta near inner margin of dorsal surface, one strong seta on outer lateral surface, one fine seta on inner distal corner, one short and one fine setae on posterior part of ventral surface and two well developed terminal setae with outer one been smaller and shorter than the inner one.

Somatic ornamentation. (Fig. 1D-F) Body ornamentation simple and slight. Prosome same as in male with sensilla and pores. Dorsal surface of urosome smooth except with several sensilla; ventral surface with one continuous row of spinules on penultimate somite and short ventral-lateral row of spinules on third abdominal somite. Anal somite with lateroventral row of spinules around caudal rami. Posterior margin of cephalothorax and free thoracic somites, hyaline frill of urosomites with inconspicuous incision.

Antennule. (Fig. 2A) Eight-segmented, first segment with setulose seta; second segment with two unipinnate setae, one large on outer margin and one small on distal inner corner; third segment with two plumose setae on distal corner; aesthetascs on fourth and terminal segments; armature formula: 1 [1], 2 [11], 3 [6],4 [4 + aes], 5 [2], 6 [3], 7 [3], 8 [7 + aes].

Antenna. (Fig. 2C) Coxa with spinules at outer subdistal corner. Allobasis with one pinnate seta at proximal half of abexopodal margin. Exopod three-segmented, first segment and second segment both with one plumose seta; second segment short; third segment slender with spinules around subterminal margin, one plumose seta on middle inner margin, and three setae on distal margin, one plumose and two naked. Endopod with rows of spinules along proximal inner margin; subterminal inner corner with two setae, one spinulose, surrounded by one row of strong spinules; outer distal corner with one row of setules on posterior surface; outer margin with several spinules; distal end with seven elements: one pinnate seta, one slender seta, four geniculate setae, posterior one of which strongly spinulose around point of inflexion and sharing base with slender seta, one short fine seta inserted inside terminal edge.

Mandible. (Fig. 2D) Gnathobase armed with one large tricuspid tooth, two bicuspid, four unicuspidal teeth, one smooth and one pinnate setae at outer distal corner. Basis broad, with row of setules on surface and scattered setules along outer margin. Endopod one-segmented, with two lateral and six terminal setae, all smooth. Exopod two-segmented, approximately half length of endopod; proximal segment with one smooth seta on distal corner, terminal segment with one plumose seta and two smooth setae.

Maxillule. (Fig. 2E) Praecoxa with row of short setules on anterior surface; arthrite with one smooth seta and row of setules on anterior surface, distal margin with eight stout, one slender and one spinulose spines. Coxa with two setae on distal margin, one stout, one slender. Basis with two slender subterminal setae, one smooth and two pinnate apical setae. Exopod one-segmented, with two plumose setae. Endopod one-segmented, with four smooth apical setae.

Maxilla. (Fig. 2F) Syncoxa with two rows of spinules at outer proximal edge; inner edge with three endites, proximal endite armed with two spines, middle endite with one spine and one seta, distal endite with three spines (one pinnate). Allobasal endite with two spines (one dentate) and one naked seta fused at base of endite. Endopod one-segmented, with seven unequal smooth setae, longest one stout.

Maxilliped. (Fig. 2G) Syncoxa with rows of spinules on proximal edge and on anterior surface at subdistal margin; two small pinnate setae and one large plumose seta on distal margin. Basis with row of spinules on proximal surface; subdistal distal margin with one slender seta and middle inner margin with one short spine. Endopod one-segmented, with one terminal claw and one accessory seta.

P1. Intercoxal sclerite long, rectangular (Fig. 3A). Coxa with four rows of setules on anterior face. Basis with several stout spinules at distal outer corner; inner spine peculiar, rather strong and stout with long spinules on distal part, basis reinforced and armed with row of spinules; outer spine pinnate. Exopod and endopod three-segmented, all segments with row of stout spinules along outer margin and on the anterior face of exp-1; both exp-1 and -2 with one long pinnate spine at outer distal corner; exp-3 with two pinnate spines at outer distal corner and two apical

plumose setae without geniculation; enp-1 and -2 each with one plumose seta at subdistal inner margin; enp-3 with two apical setae (one large, plumose and another slender, smooth), and one pinnate spine at outer subdistal corner. Exopod shorter than Endopod, first and third segments subequal, slightly longer than middle segment; Endopod not prehensile, enp-1 subequal with enp-2, not extending to the middle of exp-2.

P2-P4. Intercoxal sclerite bulbous, with two conical projections, unornamented (Figs. 3B, 4A-B). Coxa with two rows of setules on anterior surface. Basis with one row of setules at inner distal corner and several long spinules on inner margin. Outer proximal corner of basis in P3 and P4 each with one smooth seta borne on short peduncle. All rami three-segmented, terminal segments longest; P2 and P3 enp-3 longer than enp-1 and enp-2 together; P2-P4 with hyaline plate between exp-1 and exp-2 on posterior face, enp-2 with conspicuous apophysis at outer distal corner; P2 and P3 enp-1 with small apophysis at inner distal corner (Figs. 4D & 5A-B). Endopod slightly longer than exopod in P2 and P3, shorter in P4. Terminal setae of distal segments well-developed, plumose and longer than the whole length of each ramus. Setal formulae of P1-P4 as follows:

	Exopod	Endopod
P1	0:0:022	1:1:021
P2	0:1:123	0:2:121 (0:212)
P3	0:1:123	1:1:121
P4	0:1:223	1:1:121

P5. (Fig. 4D) Baseoendopods not fused medially, separated with exopod. Baseoendopodal lobe extending to the end of exopod. Baseoendopod with one small pinnate inner seta, one subterminal unipinnate seta and three apical pinnate setae (middle one more than two times as long as others); outer margin with few spinules, hyaline area near base of exopod. Exopod slightly oval in shape, approximately 1.3 times as long as broad, with one rows of spinules on distal inner margin, and five setae (one inner, one apical, three outer); inner seta well developed and pinnate, about four times as long as apical seta, apical seta fine, naked, and borne on short peduncle; distal outer seta naked, slightly shorter than inner seta; middle outer seta smooth, about half length of distal outer seta; outermost seta small and naked.

Description of adult male. Similar to female except for following features:

Body. Shorter than females, 240–260 μm long, first two abdominal somites distinct.

Somatic ornamentation. Ornamentation on urosome more complete than female. Dorsal surface with dorsolateral row of spinules and sensilla on first abdominal somite; second and third abdominal somites both with one continuous ventral row of spinules at posterior margin, one ventral row of short spinules on anterior part of second abdominal somite; fourth abdominal somite with discontinuous ventral rows of spinules on posterior margin.

Antennule. (Fig. 2B) Haplocer, nine-segmented, with major articulation between sixth and seventh segments; aesthetascs on fourth segment and terminal segment. Armature formula: 1 [1], 2 [11], 3 [6], 4 [4 + aes], 5 [1], 6 [1], 7 [1], 8[3], 9 [6+aes].

P1. (Fig. 3C) Inner margin of basis reinforced with two chitinous projections at proximal corner and distal inner corner respectively; inner spine well-developed with strong spinules.

P2. (Fig. 3D) Endopod two-segmented. First segment ornamented with row of setules on outer margin. Second segment modified; proximal inner margin with one long plumose seta, arising from small cuticular projection; distal inner seta well-developed, plumose, arising from basis of terminal spine; terminal spine geniculate at distal margin, with long and narrow basis; outer margin with one stout spine, thick at proximal end, and one slender spine, with two teeth at distal end.

P3. (Fig. 4C) Distal segment of exopod with small hyaline tube pore issuing from anterior surface, next to inner margin, nearly parallel with most proximal outer spine.

P5. (Fig. 4E) Endopodal lobe extending beyond end of exopod, with two stout pinnate terminal setae and few spinules along outer margin, hyaline spot at base of exopod. Exopod separate, subcircular, with five setae; inner seta stout and pinnate; apical seta pinnate, longer than half length of inner seta, ornamented with one spinule at base; distal outer seta smooth, about twice as long as apical one; other two outer lateral setae small and naked.

P6. (Fig.1C) Plate with one inner large seta and two small outer setae. One leg larger than another.

Etymology. The species is named after Dr. Qingchao Chen, in recognition of his numerous contributions to marine planktonic copepods of China.

Variation. No obvious variation was noticed among the specimens examined except body length (251–296 μm). Urosome and prosome often bent at an angle, which may lead the shrinking of urosomites and variation in length/width ratio of abdominal somites.

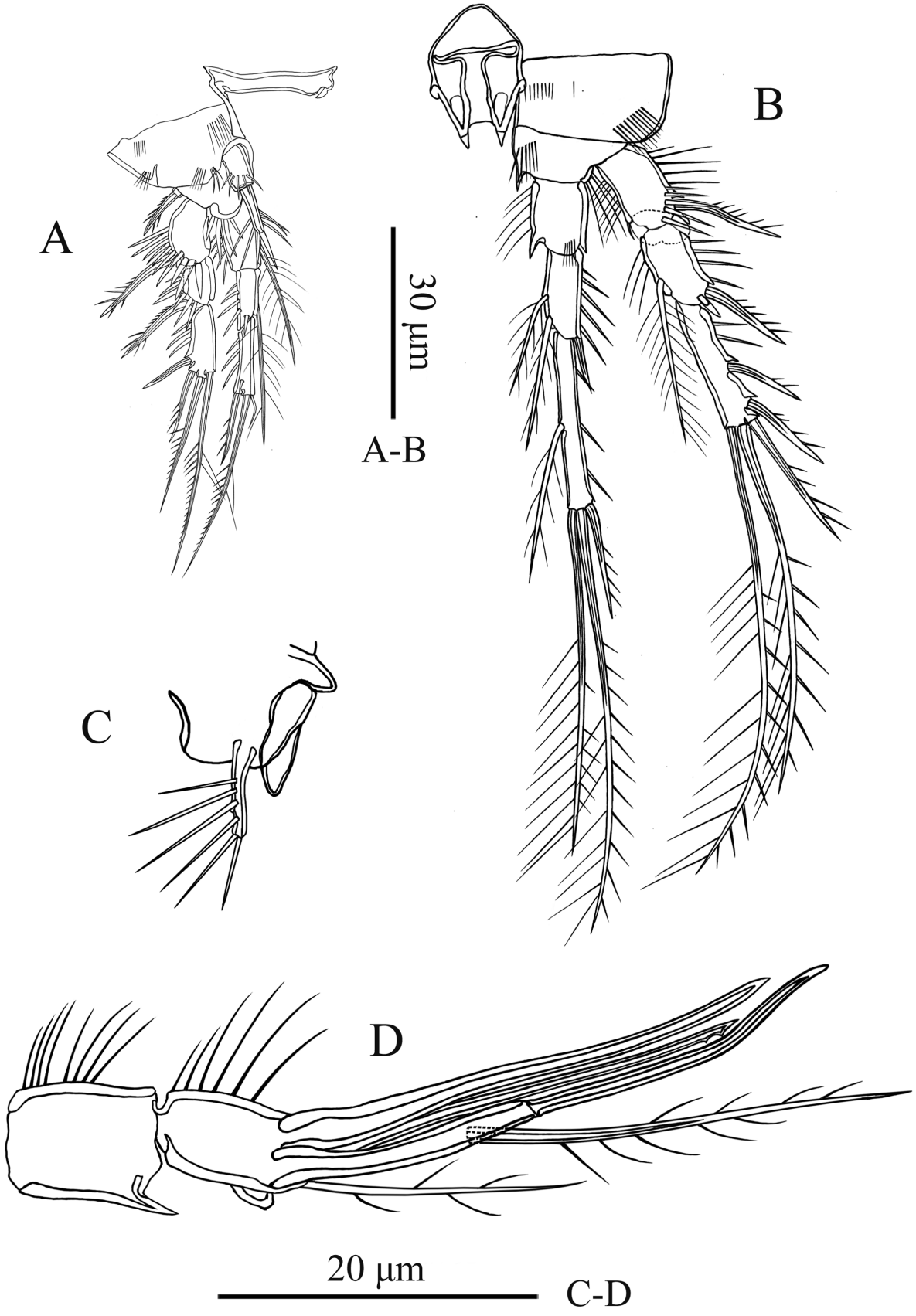

FIGURE 3. *Haloschizopera cheni* **sp. nov.**, (A) P1 female; (B) P2 female; (C) P1 basis of male; (D) endopod of male P2.

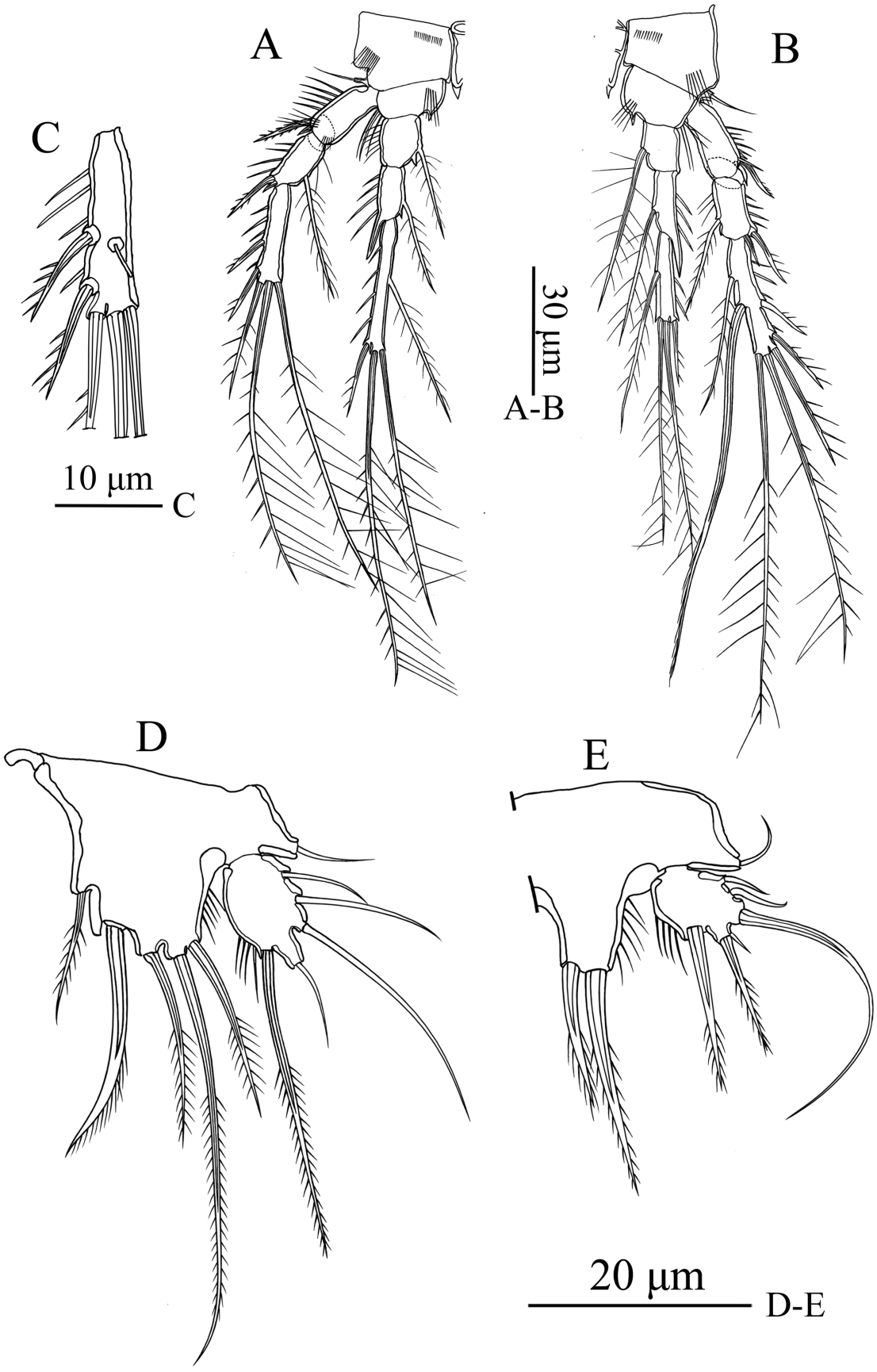

FIGURE 4. *Haloschizopera cheni* **sp. nov.**, (A) P3 female; (B) P4 female; (C) exp-3 of Male P3; (D) female P5; (E) male P5.

Discussion

History and Synonymies. *Haloschizopera pygmaea* (synonym: *Stenhelia pygmaea*), the type species of *Haloschizopera*, was described by Norman & Scott (1905) from samples collected from the English Channel and Firth of Forth. Sars (1906) erected the family Diosaccidae (Diosaccinae) including the genera *Amphiascus* Sars, 1905, *Stenhelia* Boeck, 1864, and several other genera, based on their sharing of paired egg sacs, less prehensile P1 and modified male P2 endopod. Monard (1928) revised the genus *Amphiascus* but didn't refer to *Stenhelia pygmaea*. Subsequently, Monard (1935b) identified the species collected from the Mediterranean area as *A. exiguus* Sars var., (sic), which was similar to *A. exiguus* Sars, 1906. In Lang's monography (1948) of Harpacticoida, he transferred 6 species, *Stenhelia pygmaea* Norman & Scott, 1905, *Amphiascus exiguus* Sars, 1906, *A. bulbifer* Sars, 1911, *A. mathoi* Monard, 1935, *A. exiguus* Sars var. Monard, 1935, *A. junodi* Monard, 1935 to a new genus, *Haloschizopera* placed in the family Diosaccidae (Diosaccinae), according to their common characters: body normal or uniform; genital double-somite subdivided dorsally and laterally; caudal rami shorter than broad; A1 no more than eight segments with aesthetasc on fourth segment; A2 with allobasis carrying one seta, exopod three-segmented, middle segment with one seta; Mx2 with four endites; exopodal segments of P1 subequal, exp-2 without inner seta, exp-3 with 4 armatures, enp-1 as long as first two exopodal segments, enp-2 and -3 long; endopod of P2 and P3 longer than exopod, endopod of P4 shorter than exopod; P5 exopod oval, with 5-6 setae, endopod with 4 setae; setal formulae of P2-P4 as follows:

	P2	P3	P4
Exopod	0:1:023	0:1:0(1)23	0:1:1(2)23
endopod	0(1):2:121	1:1:121	1:1:121

After re-examining Monard's works on *Amphiascus*, Lang (1948) confirmed that Monard was unaware of *Stenhelia pygmaea* when he described *A. exiguus* Sars var. (Monard 1935b). *Amphiascus exiguus* Sars var. is more similar to *S. pygmaea* than *A. exiguus*, based on the Mediterranean material. Since Monard (1935b) did not figure the P5 *A. exiguus* Sars var., Lang doubted about its conspecificity with *S. pygmaea* and treated it as *incertae sedis*. Therefore, five species were included in *Haloschizopera* by Lang: *H. pygmaea*, *H. bulbifer*, *H. mathoi*, *H. junodi* and *H. exigua* (alerted from *exiguus*).

Afterwards, another 19 species of the genus *Haloschizopera* were described. However, due to the inaccuracy of published descriptions, it is hard to make a comprehensive comparison between species within *Haloschizopera* and synonymies might be present among these species.

Por (1964) reviewed the genus *Haloschizopera* with five species added, *H. marmarae* Noodt, 1955, *H. pontarchis* Por, 1959 (synonym of *H. mathoi*), *H. pauciseta* Por, 1959, *H. conspicua* Por, 1964, and *H. minima* Por, 1964. Based on the materials available, he compared all the species and designated the neotype of *H. exigua* basing on the absence of inner seta on P2 enp-1 and 5 setae rather than 6 on P5 exopod. He also divided genus into two groups based on the number of inner setae on distal segment of P3 and P4.

Subsequently, Moore and O'Reilly (1989, 1993) redescribed *H. pygmaea*, *H. mathoi*, and *H. bulbifera*, and added three new species *H. clotensis*, *H. lionensis*, and *H. nuditerga* to this genus, after comparing the new specimen collected from the same sites with the original material. They also confirmed that *H. junodi* Monard, 1935, which had been described around European, was a junior synonym of *H. pygmaea*, while *H. pontarchis* Por, 1959 was synonymous with *H. mathoi*.

Therefore, the genus *Haloschizopera* consist of 21 valid species temporally. Their common characters are shown in Table 1 including the new species described in the paper.

Evolutionary direction of *Haloschizopera*

Within the family Miraciidae, the genus *Haloschizopera* showed special characteristics in the structure of A2, the appearance of P1 endopod and setal formulae.

In the form of A2, *Haloschizopera* belongs to the group that has evolved well-developed allobasis and three-segmented exopod within the subfamily Diosaccinae (Lang, 1948). Species within *Haloschizopera* also have

TABLE 1 List of valid species within *Haloschizopera* with the main morphological characters in identification of the female.

Group	Species	A1		A2	P1		P2		P3		P4	
		no. of seg.	aes. on	exp armature	exp	enp	exp	enp	exp	enp	exp	enp
bulbifer-group	*H. pygmaea*	8	4, 8	1,1,3	0:0:022	1:1:021	0:1:023	0:2:121	0:1:123	1:1:121	0:1:223	1:1:121
	H. mathoi	8	4, 8	1,1,3	0:0:022	1:1:021	0:1:023	0:2:121	0:1:123	1:1:121	0:1:223	1:1:121
	H. marmarae	8	4, 8	1,1,3	0:0:022	1:1:021	0:1:023	0:2:121	0:1:123	1:1:121	0:1:223	1:1:121
	H. bulbifera	7	4, 7	1,1,3	0:0:022	1:1:021	0:1:023	0:2:121	0:1:123	1:1:121	0:1:223	1:1:121
	H. clotensis,	7	4, 7	1,1,3	0:0:022	1:1:011	0:1:023	0:2:121	0:1:123	1:1:121	0:1:223	1:1:121
	H. nuditerga	7	4, 7	1,1,3	0:0:022	1:1:011	0:1:023	0:2:121	0:1:123	1:1:121	0:1:223	1:1:121
	H. lionensis	7	4, 7	1,1,3	0:0:022	1:1:021	0:1:023	0:2:121	0:1:123	1:1:121	0:1:223	1:1:121
	H. latisetifera	8	unknown	1,1,3	0:0:022	1:1:011	0:1:023	0:2:121	0:1:123	1:1:121	0:1:223	1:1:021
	H. ruthorum	8	4	1,1,2(?)	0:0:022	1:1:021	0:1:023	0:2:121	0:1:123	1:1:121	0:1:223	1:1:121
	H. tenuipes	8	un	1,1(0),2(3)	0:0:022	1:1:021	0:1:023	0:2:121	0:1:123	1:1:121	0:1:223	1:1:121
aegyptica -group	*H. noodti* ♂	8	4	1,1,3	0:0:022	1:1:021	0:1:023	unknown	0:1:123	1:1:121	0:1:123	1:1:121
	H. aegyptica	8	un	1,1,3	0:0:022	1:1:021	0:1:123	0:2:121	0:1:123	1:1:121	0:1:123	1:1:121
abyssi -group	*H. abyssi*	8	4	1,1,3	0:0:022	1:1:021	0:1:023	0:2:121	0:1:023	1:1:121	0:1:223	1:1:121
	H. cheni sp. nov.	8	4,8	1,1,4	0:0:022	1:1:021	0:1:023	0:2:121	0:1:023	1:1:121	0:1:223	1:1:121
	H. lima	8	4	1,1,3	0:0:022	11:021	0:1:023	0:2:121	0:1:023	1:1:121	0:1:223	1:1:121
exigua-group	*H. apprisea*	8	4,8	1,1,3	0:0:022	1:1:021	0:1:022	0:2:121	0:1:022	1:1:121	0:1:122	1:1:121
	H. bathyalis	8	4	1,1,1	0:0:022	1:1:021	0:1:023	0:2:121	0:1:023	1:1:121	0:1:123	1:1:121
	H. exigua	8	4	unknown	0:0:022	1:1:021	0:1:023	0:2:121	0:1:023	1:1:121	0:1:123	1:1:121
	H. pauciseta	8	unknown	unknown	0:0:022	0:1:021	0:1:023	0:2:121	0:1:023	1:1:121	0:1:123	1:1:121
	H. phyllura	8	4	1,0,3	0:0:022	1:1:021	0:1:023	0:2:121	0:1:023	1:1:121	0:1:123	1:1:121
	H. minima	8	5	unknown	0:0:022	1:1:021	0:1:023	0:2:121	0:1:023	1:1:121	0:1:123	1:0:121
	H. conspicua	8	5	unknown	0:0:022	0:1:021	0:1:023	0:2:121	0:1:023	1:1:121	0:1:123	1:0:121

TABLE 1 Continued

P5		Abdominal ornamentation																		CR L/W	References
		abd-1			abd-2				abd-3					abd-4				abd-5			
exp	enp	D	D-L	L	D-L	L	V-L	V	D	D-L	L	V-L	V	D-L	L	V-L	V	V-L	V		
5, L/W≈2	4, 130		1		1	1			1		1		1		1					<1	Lang, 1948; Moore & O'Reilly, 1989
5, L/W≈1.7	4, 112		2		1	1	1	1		1	1	1	1		1	1	1		1	<1	Monard, 1935b; Moore & O'Reilly, 1989
5, L/W≈3	4, 121		1		1	1			1		1		1		1					<1	Noodt, 1955; Moore & O'Reilly, 1989
5, L≈W	4, 130		1				1					1	1			1	1			1.1-1.2	Sars, 19111; Moore & O'Reilly, 1993
4, L≈W	4, 130		1		1		1					1	1			1			1	1.3	Moore & O'Reilly, 1993
5, L≈W	4, 220											1	1			1			1	<1	Moore & O'Reilly, 1993
5, L≈W	4, 130		1			1			1		1		1		1	1	1		1	<1	Moore & O'Reilly, 1993
5, L/W≈2.5	4, 220									without										<1	Marinov, 1973
5, L/W≈1.7	4, 220						1				1	1				1				<1	Por, 1967
5, L/W≈2.2	4, 220									without										<1	Noodt, 1964
5, subcircular	un									unknown										<1	Bodin, 1968
5, L/W≈2.2	4, 220			1		1														<1	Noodt, 1964
5, subcircular	4, 220									unknown										1	Becher, 1974
5, subcircular	5, 230											1					1			1.2-1.3	the present study
5, L/W≈1.7	4, 130	1			1					1				1						<1	Becher, 1974
4, L/W≈1.6	4, 220		3		1			1			1		1		1		1			≤1	Gee & Fleeger, 1990
4, L/W≈2	3, 030									unknown										1	Schriever, 1984
5, L/W≈2.2	4, 220												1							≤1	Sars, 1906; Por, 1964
5, L/W≈2.5	4, 130						1						1			1	1			<1	Por, 1959
5, L/W≈3.6	4, 220															1				<1	Noodt, 1964
5, L/W≈2.5	4, 022						1					1				1	1	1		>1	Por, 1964
5, L/W≈2.2	4, 220						1					1	1			1				≤1	Por, 1964

developed three-segmented P1 endopod, while in other subfamilies Stenheliinae and Miraciinae, two-segmented endopod of P1 is commonly seen. Moreover, in the appearance of P1 endopod, most of the species within *Haloschizopera* tend to have a nun-prehensile endopod of P1, with all the segments been subequal and enp-1 extending not beyond the end of exp-2. Only three species, *H. aegyptica*, *H. phyllura* and *H. tenuipes*, found in the Red Sea by Noodt (1964), show prehensile form of P1 endopod.

In terms of setal armature, species within *Haloschizopera* tend to have a more reduced setal formulae: P1-P4 exp-1 without inner seta; P1 exp-2 without inner seta, exp-3 with only two spines; P2 exp-3 and enp-1 without inner seta; P3 exp-3 with only one or without inner seta, enp-3 with only one inner seta; P4 exp-3 with no more than two setae, enp-3 with only one seta; P5 exopod at most with five setae, endopod normally with four setae in female and two in male. The setal formulae suggest a close relationship between *Haloschizopera* and *Schizopera*, within which species shows a further reduction of setal armatures on swimming legs and all distal segment of exopod.

Willen (2000) pointed out that the prehensile form of P1 was a plesiomorphic character of Miraciidae in his revision of Pseudotachidiidae. Mu and Gee (2000) believed that the reduction in setal armature and in the length of P1 enp-1 seem to be the main evolutionary trend within Diosaccinae. Based on those characters showed by *Haloschizopera*, it can be inferred that the genus *Haloschizopera* may be the latest evolutionary group within the family Miraciidae.

Species groups of *Haloschizopera*

According to the number of inner setae on the distal exopodal segment of P3 and P4, we can divide the species within *Haloschizopera* into four groups: 1) the *bulbifera*-group: exp-3 of P3 with one inner seta, P4 with two inner setae; 2) the *exigua*-group: exp-3 of P3 without inner seta, P4 with one inner seta; 3) the *aegyptica*-group: exp-3 of P3 and P4 each with one inner seta; 4) the *abyssi*-group: exp-3 of P3 without inner seta, P4 with two inner setae. Among these four groups, the *exigua*-group shows the most reduced setal formulae on P3 and P4 exp-3, and A2 exopod. Besides, there is further reduction of setal armature on P1 enp-1 in *H. pauciseta* and *H. conspicua*, and P4 enp-2 in *H. apprisea*.

H. cheni **sp. nov.** belongs to the *abyssi*-group and but differs from its congeners by having five setae on P5 baseoendopodal lobe of female, P2 and P3 enp-3 both longer than enp-1-2 together, and caudal rami longer than broad. It is uncommon that species within the genus *Haloschizopera* have their caudal rami longer than broad. Apart from *H. cheni* **sp. nov.** which has a caudal rami about 1.2-1.3 times as long as broad, only *H. minima*, *apprisea* and *bulbifera* have caudal rami longer than or equal with broad. However, what more notable is that within *Haloschizopera*, *H. cheni* **sp. nov.** is the only one species with five setae on female P5 baseoendopodal lobe while other species only has 4 setae. Thus, it makes the taxonomic status of *H. cheni* **sp. nov.** a little doubtful. Nevertheless, we still put it in *Haloschizopera* for their so many sharing characteristics.

In summary, *Haloschizopera* shows reductions of setal armatures of swimming legs, numbers of seta on A2 exopod and length of caudal rami. Moreover, the style of P1 endopod changes from prehensile to normal and all the segments of endopod are subequal. The evolutionary trend of leg reduction of P1 endopod is presented by the *bulbifera*-group, and the evolutionary trend of setal armature reduction is presented by the *exigua*-group. We presume that those morphological characters shown by the species of *Haloschizopera* reflect an adaption to the benthic habitats. Finally, a key to all the species of *Haloschizopera* is given below.

Key to species in *Haloschizopera* (amended from Noodt, 1964; Wells, 2007)

1. P3 exp-3 with one inner seta and P4 exp-3 with two inner setae 2
-- P3 exp-3 without inner seta and P4 exp-3 with two inner setae 10
-- P3 exp-3 with one inner seta and P4 exp-3 with one inner seta 12
-- P3 exp-3 without inner seta and P4 exp-3 with one inner seta 13
2. P1 enp-1 no longer than the end of exp-2 3
-- P1 enp-1 longer than exp-2, no longer than exp-3 ..... *H. ruthorum* Por,1967
-- P1 enp-1 longer than the end of exp-3 ..... *H. tenuipes* Noodt,1964
3. Female A1 eight-segmented 4
-- Female A1 seven-segmented 6
4. First abdominal somite with one dorsal-lateral row of spinules, anal somite without ventral row of spinules 5
-- First abdominal somite with two parallel dorsal-lateral rows of spinules, anal somite with one ventral row of spinules ..... *H. mathoi* Monard, 1935
5. Female P5 exopod about two times as long as broad, endopod lobe extending to the middle point of exopod and with one inner

and three terminal setae··· ..... *H. pygmaea* Norman & Scott T.,1905

-- Female P5 exopod about three times as long as broad, endopod extending not to the middle point of exopod with one inner, one outer and two terminal setae ..... ·*H. marmarae* Noodt, 1955

6. P1 exp-3 with two terminal setae· ..... ··7

-- P1 exp-3 with only one terminal seta 8

7. Abdominal somites without row of spinules on dorsal surface except the first somite, hyaline spot on P5 baseoendopod small ..... *H. bulbifera* Sars, 1911

-- Abdominal somites with dorsal-lateral row of spinules, hyaline spot on P5 baseoendopod relatively large· ..... ·*H. lionensis* Moore & O'Reilly,1994

8. P4 enp-3 with four setae and/or spinules· ..... ·9

-- P4 enp-3 with five setae and/or spinule ..... *H. latisetifera* Marinov, 1973

9. Abdominal somites without row of spinules on dorsal surface, coxa without row of spinules on outer proximal area, P5 exopod with five setae·· ..... *H. nuditerga* Moore & O'Reilly,1994

-- Abdominal somites with row of spinules on dorsal surface, coxa with row of spinules on outer proximal area, P5 exopod with four setae· ..... *H. clotensis* Moore & O'Reilly,1994

10. P5 endopod with four setae 11

-- P5 endopod with five setae· ..... ·*H. cheni* **sp. n.**

11. P5 exopod about 1.7 times as long as broad, endopod with three long setae, furcal rami about 1.5 times as long as broad· ..... ·*H. lima* Becher, 1974

-- P5 exopod subcircular, endopod with two long setae, caudal rami as long as broad·· ..... ·*H. abyssi* Becher, 1974

12. A1 long and simple, P1 enp-1 extending to posterior of exp-3·· ..... *H. aegyptica* Noodt, 1964

-- A1 delicate, P1 endopodal segment subequal, enp-1 extending to the end of exp-2· ..... ·*H. noodti* Bodin 1968

13. P2-4 exp-3 with three outer spines·· ..... ·14

-- P2-4 exp-3 with two outer spines· ..... *H. apprisea* Gee & Fleeger, 1990

14. A2 exp-2 without seta· ..... ·15

-- A2 exp-2 with one seta, female P5 endopod with three setae· ..... ··*H. bathyalis* Schriever,1984

15. P4 enp-2 with one inner seta·· 16

-- P4 enp-2 and P1 enp-1 without inner seta·· ..... · *H. conspicua* Por, 1964

-- P4 enp-2 without inner seta, P1 enp-1 with inner seta ..... *H. minima* Por, 1964

16. P1 enp-1 longer than the exopod· ..... ·*H. phyllura* Noodt, 1964

-- P1 enp-1 no longer than exp-2·· ..... ··*H. pauciseta* Por, 1964

-- P1 enp-1 extending to proximal half of exp-3 ..... *H. exigua* Sars G.O., 1906

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