

A new genus of Cletodidae (Copepoda; Harpacticoida) from the Bohai Sea, China

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Neoacrenhydrosom a zhangi gen. et sp. nov. is described from specimens recovered from muddy sediments in the shallow waters of the Bohai Sea. On the basis of the structure of the mouthparts, P5 of both sexes and the female genital field, it is suggested that the taxon is related to the *Acrenhydrosoma*-complex within the Cletodidae. It differs from other known genera in the structure of the exopod in P2–P4 which is two-segmented as a result of the failure to separate the proximal two segments of a three-segmented ramus; and the P5 in as much as the mucroniform process incorporates the exopod, as well as the endopodal lobe of the baseoendopod.

KEYWORDS: Copepoda, Harpacticoida, Cletodidae, *Neoacrenhydrosoma* gen. nov., Bohai Sea, China.

Introduction

The Bohai Sea, embraced by the Shandong and Laidong peninsulas, is a shallow, usually less than 30 m deep, northern arm of the Yellow Sea which is heavily used for mariculture, particularly of prawns, bivalve molluscs and nudibranchs. In recent years the Bohai Sea has been subject to intensive offshore exploration and production of natural gas and petroleum reserves, general pollution has increased enormously, the fisheries returns heavily depleted and red tides have become a frequent occurrence. In order to assess the impact of energy exploration and increased pollution on mariculture activities, a national and international oceanographic and ecosystem study of the Bohai Sea has been launched which includes annual sampling strategies for the benthos, both macrofauna and meiofauna. As in most other parts of the world, the meiofaunal communities in the shallow sublittoral, muddy sand bottoms, are dominated by nematodes and harpacticoid copepods.

Chen (1986), in his brief review of Chinese marine copepods, states that 27 species

are known from the Bohai Sea but these are almost all planktonic copepods. Only Shen and Bai (1956) have studied the harpacticoid copepods of this region. Within the last decade a number of studies have been made of the harpacticoids from the Korean coast, bordering the Yellow Sea and Sea of Japan, by Chang and Song (1995, 1997), Kim (1991), Kim and Kim (1996, 1997), Kim *et al.* (1993), Song and Chang (1993, 1995) and Yoo and Lee (1993, 1995). Further afield, Chislenko (1971, 1978) has described harpacticoids from the deeper waters of the Sea of Japan, and Shen and Tai (1963, 1965) from estuarine environments in southern China.

In sediment samples taken from the Bohai Sea in 1997, members of the harpacticoid family Cletodidae T. Scott were relatively rare but, so far, seven taxa have been identified, all of which appear to be new to science. In this paper we describe one of these taxa, justify the erection of a new genus to accommodate it, and briefly discuss its phylogenetic relations with other genera of Cletodidae.

Materials and methods

The taxon described here was recovered, in 1997, from three sites: Site 1 in the central part of the Bohai Sea, $38^{\circ}29'98''N 120^{\circ}29'92''E$, with fine sand sediment at a depth of 30 m; Site 3 in Bohai Bay, $38^{\circ}30'N 118^{\circ}30'26''E$, with silt-clay sediment at 19 m depth; Station 4 in the north-east part of the Bohai Sea, $38^{\circ}44'95''N 120^{\circ}29'9''E$, with silt-clay sediments at 27 m depth. Sediment samples were collected in a 0.1 m^2 box core and the harpacticoids extracted, using a 48μ sieve and Ludox flotation, from a standard subsample taken from the box core in three 26 mm diameter plastic tubes inserted to a depth of 5 cm and separated into 0-2 and 2-5 cm sections.

Animals were fixed in 10% formalin and preserved in 4% formalin. Before dissection the habitus was drawn and body length measurements made from whole specimens temporarily mounted in lactophenol. Specimens were dissected in lactophenol and the parts were individually mounted in lactophenol under coverslips subsequently sealed with nail varnish. All drawings were prepared using a camera lucida on a Nikon Optiphot 20 differential interference contrast microscope. The terminology of the body and appendage morphology follows that of Huys and Boxshall (1991). Abbreviations used in the text and figures are P1–P6 for thoracopods 1–6; exp(enp)-1(-2-3) to denote the proximal (middle, distal) segment of a ramus; a for aesthetasc. Body length was measured from the base of the rostrum to the median posterior border of the anal somite. All type material has been deposited in the Natural History Museum, London.

Description

Family CLETODIDAE T. Scott (sensu Por, 1986)

Genus Neoacrenhydrosoma gen. nov.

Diagnosis. Cletodidae. Body with pronounced spinulose socles on urosome; penultimate somite without hyaline, dentate pseudoperculum; anal operculum in posterior half of anal somite. Caudal rami cylindrical, about five times longer than broad, setae I and II implanted at 25%, and setae III and VII at 34%, of ramus length. Rostrum recurved dorsally with slightly bifid tip. Antennule five-segmented in female, seven-segmented and sub-chirocer in male; second segment with flexible penicillate seta; trithek of distal segment with small aesthetasc and two naked setae;

in male swollen fifth segment with a chitinous hump on palmar margin, sixth segment with strong naked spine. Antennal allobasis with one seta proximally on abexopodal margin, exopod one-segmented with two setae; endopod with two spines and a seta sub-distally and, on distal margin, three spines, two geniculate setae, a minute seta fused to base of inner spine and a tube pore. Mandibular palp one-segmented with three setae. Maxillulary coxal endite, partially fused to basis, and bearing two setae; palp one-segmented with six setae. Distal syncoxal endite of maxilla with three naked setae. Maxillipedal syncoxa with large pinnate seta on distal margin. Pl exopod three-segmented, two setae on distal margin of exp-3 without comb tips, outer seta very short; endopod two-segmented, enp-2 with three armature elements without comb tips. P2–P4 rami both two-segmented, exp-1 with two outer spines, enp-2 with only two setae; male P3 endopod as in female. P5 triangular, uniramous, strongly chitinized, projecting laterally from body; peduncle bearing outer basal seta articulating medially on anterior face, distal portion a mucroniform process recurved distally, bearing two setae on outer distal margin and, in female only, a proximal spine on inner margin. Female genital field with spinulose vestigial P6s bearing two setae, common genital slit partially occluded medially; copulatory pore small.

Type species. N. zhangi sp. nov. by monotypy.

Etymology. The prefix *Neo* is from the Greek *neos* meaning new, referring to the presence, in the adult, of juvenile characteristics; the retention of *Acrenhydrosoma* indicates that it is closely related to that genus.

Gender. Feminine.

Neoacrenhydrosom a zhangi sp. nov. (figures 1–6)

Material examined

HOLOTYPE: adult female (dissected on to three slides) from muddy sand at 19 m depth in Bohai Bay, NHM Reg. No. 1999.675. PARATYPES: one male (dissected on to three slides) and two whole and one partial female, spirit preserved, NHM Reg. Nos 1999.676–679.

Description of female

Body (figure 1). Length 0.47-0.51 mm (mean = 0.49 mm, n = 3) semi-cylindrical, tapering posteriorly from posterior border of cephalothorax, without clear distinction between prosome and urosome. Cephalothorax almost square with pattern of subcuticular ribs and sensilla as in figure 1; posterior border smooth with six small sensillum-bearing socles. Free prosomites and urosomites with pattern of subcuticular ribs in anterior region of somite as in figure 1A; presence of tube pores not discerned because of dirt on specimens; dorsal and lateral posterior borders smooth, with four to eight sensillum-bearing socles, four of which particularly prominent and spinulose on each urosomite (figure 2B); dorsal socles on preanal somite with tube pores rather than sensilla. Ventral border of urosomites minutely spinulose (figure 2A) and, on urosomites 3-4, with two strongly spinulose, sensillum-bearing socles (figure 2D). Urosomites 2-3 fused to form genital double-somite, line of fusion marked dorsally and laterally by presence of socles, and ventrally by subcuticular rib. Anal operculum in posterior half of anal somite (figure 2B), semi-circular, minutely dentate, bordered by pair of small sensillum-bearing socles. Caudal rami (figures 1C, 2B) elongate, cylindrical, tapering posteriorly, approximately five times longer than basal width, setae I and II implanted at 25%, setae III and VII at 34%



FIG. 1. Neoacrenhydrosoma zhangi. Female holotype, habitus (A) dorsal view; (B) lateral view; (C) caudal ramus, dorsal view.



FIG. 2. Neoacrenhydrosoma zhangi. Female holotype (A) urosome (excluding P5-bearing somite), ventral view; (B) preanal and anal somite of paratype, dorsal view; (C) rostrum, dorsal view; (D) genital field, ventral view; (E) maxilla, anterior view.

of ramus length, distal seta IV small, fused at base to well-developed, minutely pinnate seta V, seta VI very small; outer margin with two tube pores, one proximal to seta I, the other distal to seta III but variable in position.

Rostrum (figure 2C). Fused to cephalothorax, recurved dorsally, triangular with slightly bifid tip, pair of lateral sensilla and median ventral pore.

Antennule (figure 3A). Short, stout, five-segmented with one to four pinnate or pectinate setae on all segments except segment 4; segment 1 with four rows of spinules; segment 2 with a flexible penicillate seta; segment 3 with aesthetasc fused at base to one seta; segment 4 small, segment 5 with distal trithek of two smooth setae and a small aesthetasc. Setal formula as follows: 1[1], 2[8], 3[6+(1+a)], 4[1]. 5[9+(2+a)].

Antenna (figure 4A). Coxa well developed with three rows of spinules. Allobasis with partial suture on dorsal surface in region of exopod, with a proximal pectinate seta and distal group of strong spinules on abexopodal margin. Exopod one-segmented bearing two large setae, distal seta with small, closely set pinnules, lateral seta with widely spaced, long pinnules. Free endopod with two rows of strong spinules on outer margin, and rows of smaller spinules on distal and inner margin; subdistal armature consisting of two large, strongly spinulose, spines and a small seta; distal margin armed with two pectinate spines, a smooth spine, two geniculate setae and a tube pore and small seta fused to base of inner spine.

Labrum (figure 4B). Fused to form a single plate, with group of long spinules on anterior face and three rows of small spinules on distal margin.

Mandible (figure 4C). Coxa relatively slender, with row of spinules on outer margin. Gnathobase with three bicuspid and one unicuspid teeth and a pinnate seta at dorsal corner. Palp one-segmented with two rows of long spinules and three pinnate setae (one basal and two endopodal).

Maxillule (figure 4D). Praecoxa with row of spinules; arthrite with one subdistal seta, and three spines and two pinnate setae on distal margin. Coxa partially fused to basis, bearing two setae (one naked and one pinnate) on distal margin. Basis and rami completely fused into one-segmented palp with six setae (one pinnate seta exopodal, one seta endopodal, and four setae basal, in origin).

Maxilla (figure 2E). Syncoxa with two rows of spinules and two endites each with three elements, all naked except for pinnate spine on proximal endite. Allobasal endite with fused, slightly dentate spine and two naked setae. Endopod represented by two setae not fused at base.

Maxilliped (figure 4E). Well developed, subchelate. Syncoxa with large pinnate seta on distal margin. Basis oval with row of spinules on palmar margin and two rows on outer margin. Endopod represented by a claw (much longer than basis) and a large accessory seta.

P1 (figure 5A). Intercoxal sclerite narrow, straight and naked. Praecoxa narrow, triangular without setules. Coxa with row of surface spinules near inner, distal and outer margin. Basis with row of spinules on distal margin and at base of inner and outer stout pinnate setae. Exopod three-segmented, each segment with row of spinules on distal margin of exp-3 without comb tips and outer seta very short (only equal in length to distal outer spine). Endopod two-segmented, each with row of spinules on outer and row of setules on inner margins; enp-2 three times longer than enp-1, distal margin with inner naked seta, a large pinnate seta without comb tip, and a large pinnate outer seta.

P2-P4 (figures 5B, 6A). Protopod as for P1 except praecoxa with row of setules, coxa with extra proximal row of spinules, basis without inner seta. Exopod



FIG. 3. Neoacrenhydrosoma zhangi. Female holotype (A) antennule, distarticulated, posterior view. Male paratype (B) antennule, disarticulated, antero-dorsal view; (C) antennule segment 5, posterior view; (D) urosomites 2–3, ventral view.



FIG. 4. *Neoacrenhydrosoma zhangi*. Female holotype (A) antenna, posterior view; (B) labrum, anterior view; (C) mandible, ventral view; (D) maxillule, ventral view. Male paratype (E) maxilliped, ventral view.

two-segmented, each with row of spinules on outer and distal margin and row of setules on inner margin; exp-1 with two outer spines and hyaline frill at inner distal margin. Endopod two-segmented, ornamented as in P1 but enp-2 armed with only



FIG. 5. Neoacrenhydrosoma zhangi. Female holotype, anterior view of (A) P1; (B) P2.

two elements. Setal formula of swimming legs as follows:

Exopod	Endopod
0.0.022	0.021
0.022	0.020
0.122	0.020
0.122	0.020
	Exopod 0.0.022 0.022 0.122 0.122



FIG. 6. *Neoacrenhydrosoma zhangi*. Female holotype, anterior view of (A) P3; (B) P5. Male paratype, anterior view of (C) P5.

P5 (figure 6B). A large, strongly chitinized uniramous structure projecting laterally from the body (as in figure 1A) and triangular in shape. Wide basal portion flattened with a socket-like structure to the inner and outer basal corners, a long penduncle bearing one seta and articulating near the median proximal margin; a row of spinules, a pinnate spine and a tube pore on inner proximal margin. Distal portion long, cylindrical, recurved distally, sparsely covered with small setules but with a row of strong, blunt teeth and two setae on the outer margin, and a tube pore medially on inner margin.

Genital field (figure 2D). Vestigial P6s forming small flaps over gonopores, with two rows of strong spinules on face, two naked setae on distal margin (outer one short), and row of setules on inner margin. Unclear as to whether gonopores open into common genital slit or whether this fused medially. Copulatory pore small, opening at ventral subcuticular rib marking line of fusion of genital double-somite; single copulatory duct leading to paired seminal receptacles.

Description of male

As in female except in urosome, antennule and P5.

Body. Slightly smaller than female, length 0.46 mm. Genital somite (figure 3D) separate, vestigial P6 forming small asymmetrical plate ornamented with row of setules but without armature elements.

Antennule (figure 2B, C). Short, stout, seven-segmented, sub-chirocer with principal articulation between segments 5 and 6. Segment 1 with two rows of spinules; segment 2 with flexible penicillate seta and five pectinate setae; segment 4 minute; segment 5 markedly swollen with row of spinules on anterior face, palmar margin with a dentate spine and a chitinous hump, distal margin with aesthetasc fused at base to one seta; segment 6 small with a spine; segment 7 hook-shaped with distal trithek of two naked setae and a small aesthetasc. Setal formula as follows: 1[1], 2[9], 3[8], 4[2], 5[9 + spine + (1+a)], 6[1+spine], 7[7+(2+a)].

P5 (figure 6C). As in female except row of spinules and spine absent from inner proximal margin (but tube pore probably still present).

Etymology. The specific name is in honour of Professor Zhang Zhi-nan of the Ocean University, Qingdao, whose enthusiasm for meiofauna research initiated this project.

Discussion

In a recent paper, Gee (1999) re-described Acrenhydrosoma perplexa (T. Scott) and erected two new genera, Paracrenhydrosoma Gee (to accommodate species from North America and northern Norway) and Dyacrenhydrosoma Gee (to accommodate a new species from South-East Asia). In general body facies, the structure of the cephalic appendages, and the basic structure of the P5, our specimens from the Bohai Sea belong to this Acrenhydrosoma complex within the Cletodidae. However, they exhibit certain characters not possessed by any other genera in this complex which has necessitated the erection of a new genus Neoacrenhydrosoma. Firstly, the structure of the P5 in both sexes of the known genera is a broadly triangular baseoendopod with the peduncle of the outer seta articulating medially on the anterior face, the endopodal lobe is attenuated into a large, dentate, mucroniform process (with one or two spines on the inner margin) and the small exopod (bearing two or three setae) articulates with, or is partially fused to, the extreme outer margin of the baseoendopod. In our specimens the P5 is the same basic shape but in both

sexes the exopod is absent and the mucroniform process bears two setae distally on the outer margin. It is suggested that these two setae are exopodal in origin and indicate that the exopod has failed to separate from the baseoendopod during ontogeny. Secondly, the exopods of P2–P4 are three-segmented in the known genera in this complex but in our specimens they are two-segmented. The presence of two outer spines and the arrangement of the outer spinule rows on the proximal segment clearly indicates that the two-segmented condition has arisen through the failure to separate during ontogeny of the proximal and middle segments of a three-segmented ramus. Within the Cletodidae, a two-segmented exopod formed by the same process is also found in the genus *Enhydrosomella* Monard but this must be regarded as a case of parallel evolution rather than implying any close relationship between our specimens and *Enhydrosomella*.

Neoacrenhydrosoma also differs from the other genera in the Acrenhydrosoma complex in a number of other characters. In Neoacrenhydrosoma the trithek on the distal margin of the distal segment of the female antennule consists of an aesthetasc fused at the base to two naked setae whereas in all the other genera in this complex one of these setae is strongly pinnate. All the genera of this complex bear one seta on the abexopodal margin of the antennal allobasis. However, in Neoacrenhydrosoma there is a distal group of setules and the seta is situated proximally on the allobasis (indicating that it is basal in origin) whereas in the other genera there is a proximal group of spinules and the seta articulates distally (indicating that it is endopodal in origin). Neoacrenhydrosoma has three smooth setae on the distal syncoxal endite of the maxilla whereas in other genera there is at least one pinnate element on this endite. In Neoacrenhydrosoma the vestigial P6s of the female genital field (and the sensillum-bearing socles on the ventral border of the following two urosomites) are heavily spinulose whereas in other genera they are unornamented. Gee (1999) pointed out that the structure of the female genital field in genera of the Acrenhydrosoma complex (i.e. P6s with two armature elements and gonopores joined by a common genital slit) probably indicated a close relationship with *Enhydrosoma* curticauda Boeck, 1872. Neoacrenhydrosoma has a similarly structured genital field except that it appears the genital slit is partially occluded medially. The armature of the antennule of the male of *Neoacrenhydrosoma* is somewhat different to the other genera in this complex. The palmar margin of the swollen fifth segment in Neoacrenhydrosoma bears 10 smooth setae, one dentate spine and a distinct, convex chitinous hump whereas in the other genera there are 10 smooth setae and three or four dentate or pinnate spines and no distinct chitinous hump. Similarly, segment six in Neoacrenhydrosoma bears a prominent spine and a small seta whereas in the other genera there are two small setae on this segment. Lastly, the male P5 of Neoacrenhydrosoma has no inner spines, whereas in all other genera there is one inner spine on this limb.

Within the Acrenhydrosoma complex, Neoacrenhydrosoma is similar to Paracrenhydrosoma in that the preanal somite lacks a dorsal, dentate, hyaline pseudoperculum; the anal operculum is situated in the posterior half of the anal somite; and the maxillule has two setae on the coxal endite and six setae on the palp of the basis. However, the swimming leg armature of Neoacrenhydrosoma is the same as that of Dyacrenhydrosoma in that the setae on the distal margin of exp-3 of P1 are short, without comb tips; P2–P4 enp-2 has only two armature elements; there is no sexual dimorphism in the male P3 endopod; and the female P5 has only one spine on the inner margin. Gee (1999) has suggested that the lack of sexual dimorphism in *Dyacrenhydrosoma* is probably a neotenic character as the absence of an outer spine on P3 enp-3 in the female in other genera of cletodid does not preclude the presence of sexual dimorphism in the male. This is also the case in *Neoacrenhydrosoma*, a view which is reinforced in this genus by the fusion of the proximal two segments of the P2–P4 exopod and the incorporation of the exopod of the P5 in the mucroniform process. Thus, the retention of the most primitive setation patterns on the oral appendages suggests that *Neoacrenhydrosoma* may have been derived by further neotenic development from a *Paracrenhydrosoma*-like ancestor. However, the setation pattern of the antennal allobasis (in which *Neoacrenhydrosoma* has retained the basal seta, whilst the other genera in this complex have retained the endopodal seta) suggests that the split must have occurred at an early stage as both states are apomorphic alternatives derived from the primitive two-setal condition found in some other cletodid genera.

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