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A new species of *Tharybis* (Crustacea: Copepoda: Calanoida: Tharybidae) from northern Taiwan

YAN-GUO WANG[1, 2] & JIANG-SHIOU HWANG[2, 3, 4,*]

[1] *Third Institute of Oceanography, Ministry of Natural Resources, Xiamen 361005, Fujian*
[2] *Institute of Marine Biology, National Taiwan Ocean University, Keelung 20224, Taiwan*
[3] *Center of Excellence for Ocean Engineering, National Taiwan Ocean University, Keelung 20224, Taiwan*
[4] *Center of Excellence for the Oceans, National Taiwan Ocean University, Keelung 20224, Taiwan*
[*] *Corresponding author: jshwang@mail.ntou.edu.tw; Tel: +886-9-35289642; Fax: +886-2-24629464*

Abstract

A new species *Tharybis kueishanensis* sp. n. (Copepoda: Calanoida: Tharybidae) is described from the inshore surface waters of Kueishan Island off northern Taiwan, which is the first report of *Tharybis* from the China Seas. Its female is distinguished from the other species of *Tharybis* by the total body length (1.89–2.12 mm) larger than the other species, the shape of the genital double-somite, which is slightly asymmetrical with a small notch on the distal margin of the right side, and the length of the inner terminal spine of leg 5, which is about 1.5 times of the terminal spiniform projections. The male is distinguished by the presence of 3 triangular projections at the inner middle margin and the tip of the distal segment of the right leg 5.

Key words: Copepoda, *Tharybis*, new species, northern Taiwan, western Pacific

Introduction

Tharybis Sars, 1902 was established to accommodate *Tharybis macrophthalma* Sars, 1902 which was collected at about 180 m depth in the Christiania Fjord in Norway (Ferrari & Markhaseva, 2005). Andronov (2002) mentioned that species of the genus *Tharybis* mostly live near the bottom in depths from 30 to 4745 m and are rarely found in plankton samples. Since Sars (1902), in total 21 calanoid species were described belonging to *Tharybis* worldwide (Walter, 2021).

In this paper, we describe a new species of *Tharybis* which was collected by plankton sampling from Kueishan Island, northeast of Taiwan.

Material and methods

Horizontal plankton tows were made in the upper 5 m water layer around Kueishan island, northeastern Taiwan of the western Pacific. Samples were collected with a conical plankton net (mouth area, 0.2 m^2; mesh aperture, 333 μm). The organisms taken by the net were preserved in 5% formaldehyde. The new species of a calanoid copepod described below was found in one sample (Station Ex2: 24°50.40′N, 121°58.20′E; depth, 94 m) taken at 18:00 h local time on 18 November 2020. The surface water temperature and salinity was 20.3 ºC and 34.5 PSU, respectively.

Sorted copepods were observed, dissected, and mounted in glycerol and examined with differential interference optics Zeiss Axio Imager M2. Drawings were made with a *camera lucida*. The morphological nomenclature followed that of Huys & Boxshall (1991). Specimens were deposited at the Third Institute of Oceanography, Ministry of Natural Resources, Xiamen, China.

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Taxonomy

Tharybis kueishanensis sp. n.

Holotype: Total body length, measured from anterior margin of rostrum to posterior margin of caudal rami. Dissected female 2.06 mm (KIC 22001), prosome 1.7 mm, urosome 0.36 mm. Paratypes: 5 undissected females 1.89 to 2.12 mm (KIC 22002 to KIC 22006). Allotype: dissected male 1.69 mm (KIC 22007), prosome 1.29 mm, urosome 0.4 mm.

Female. Prosome ovoid in dorsal view (Fig. 1A). Rostrum absent. Cephalosome and first pedigerous somite partly fused. Fourth and fifth pedigerous somites partly fused. Posterior corner of prosome broadly rounded in lateral view, reaching almost first third of genital double-somite (Fig. 1B). Genital double-somite asymmetrical in dorsal view, right side slightly more produced laterally than left; ventral bulge close to distal margin; in ventral view, left side with small notch near distal margin (Fig. 1C). Posterior borders of urosomites unfurnished.

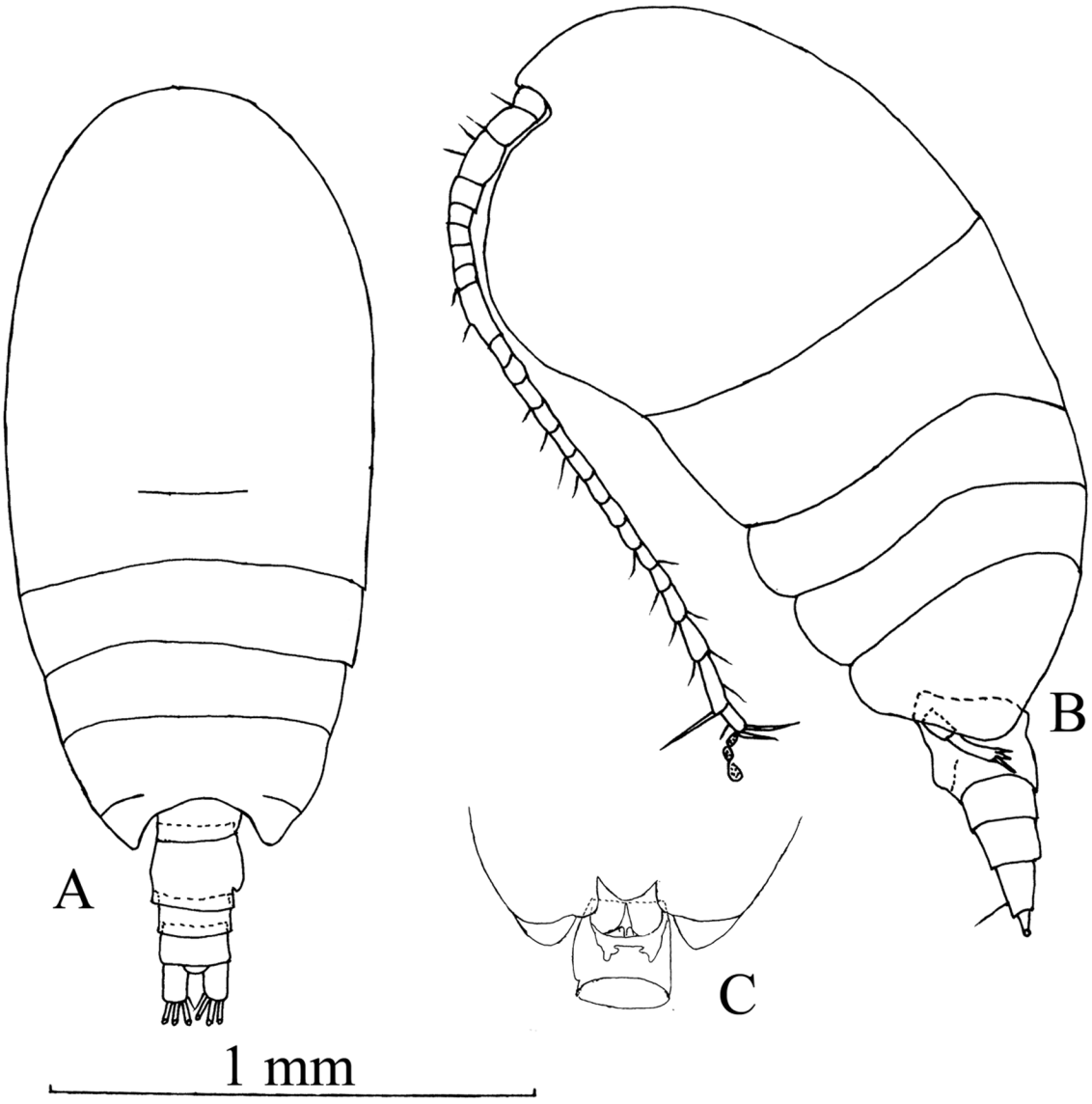

FIG. 1. ***Tharybis kueishanensis*****, new species. Female. A. habitus, dorsal; B. habitus, left lateral; C. posterior corner of prosome and genital complex, ventral.**

Antennule (Fig. 2A): Reaching slightly beyond posterior margin of third pedigerous somite, with 24 free segments, with the following armature: 3, 6+ae (=aesthetasc), 2+ae, 2, 2+ae, 2, 2+ae, 4+ae, 1, 1, 2+ae, 1, 2+ae, 1, 1, 1, 1, 1+ae, 1, 1, 2, 2, 2, 4+ae. Segments 8 and 9 completely separated.

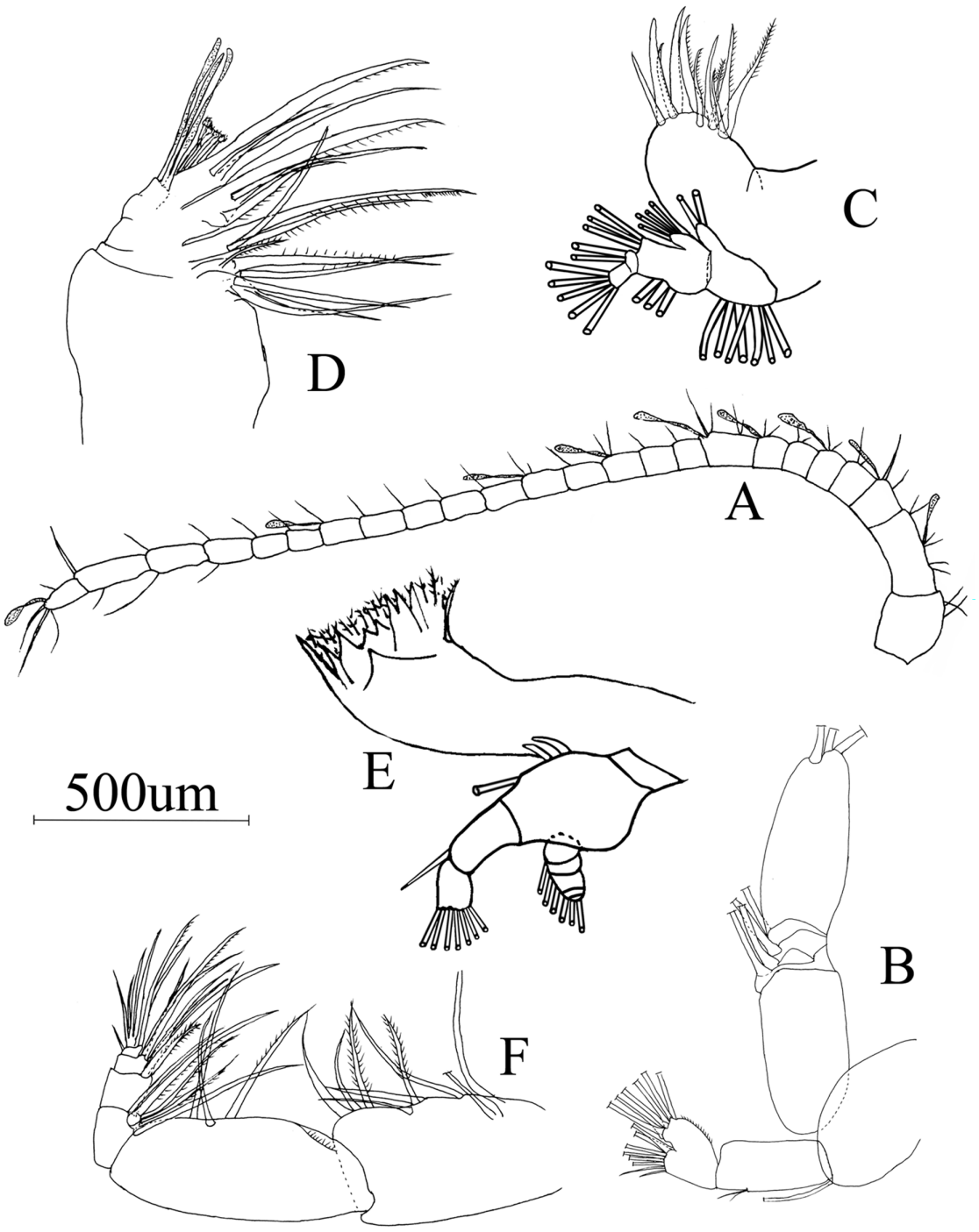

FIG. 2. ***Tharybis kueishanensis*****, new species. Female. A. Antennule; B. Antenna; C. Mandible; D. Maxillule; E. Maxilla; F. Maxilliped.**

Antenna (Fig. 2B): With short endopod; basis with 1 seta; endopod segment 1 with 2 setae, segment 2 with 14 (8+6) setae and outer border lined with small spinules; exopod 6-segmented, segment 1 without seta, segments 2-5 each with 1 seta, segment 6 with 3 terminal setae.

Mandible (**Fig. 2C**): Gnathobase with 8 ventral teeth and strong dorsal seta, anterior and posterior surfaces of cutting edge with rows of spinules; basis with 2 strong short setae and long more distally placed seta; endopod 2-segmented, proximally with 1 seta and distally with 7 setae.

Maxillule (**Fig. 2D**): Praecoxal arthrite very large, with 11 elements; coxal endite and coxal epipodite carrying 2 and 7 setae, respectively; basal endites with 4+3 setae; endopod indistinctly 2-segmented, bearing 2 and 5 setae, respectively. exopod fused to basis, and armed with 3 setae.

Maxilla (**Fig. 2E**): Praccoxa with an outer distal protrusion, endites 1 and 2 with 3 setae each; coxal endites 3 and 4 with 3 setae separately; basal endite bearing 3 setae; endopod with 3 long worm-like and 6 brush-like aesthetascs distally.

Maxilliped (**Fig. 2F**): Syncoxa and basis almost equal length; syncoxa with 2, 1, 3, 3 setae; basis with 3 setae; endopod half-length of basis, segment 1 apparently incorporated into basis with 2 setae, free segments 2-6 with 3, 4, 3, 2 + 1, and 4 setae respectively.

Swimming legs one to four (**Fig. 3A-D**): Segmentation and disposition of spines and setae as follows (Arabic and Roman numerals represent setae and spines, respectively; numbering proceeds from outer to inner edge of each segment):

	Coxa	Basis	Exopod segments	Endopod segments
Leg 1	0-0	0-1	I-0; I-1; I, I, 3	0, 2, 3
Leg 2	0-1	0-0	I-1; I-1; III, I, 4	0-1; 1, 2, 2
Leg 3	0-1	0-0	I-1; I-1; III, I, 4	0-1; 0-1; 1, 2, 2
Leg 4	0-1	0-0	I-1; I-1; III, I, 4	0-1; 0-1; 1, 2, 2

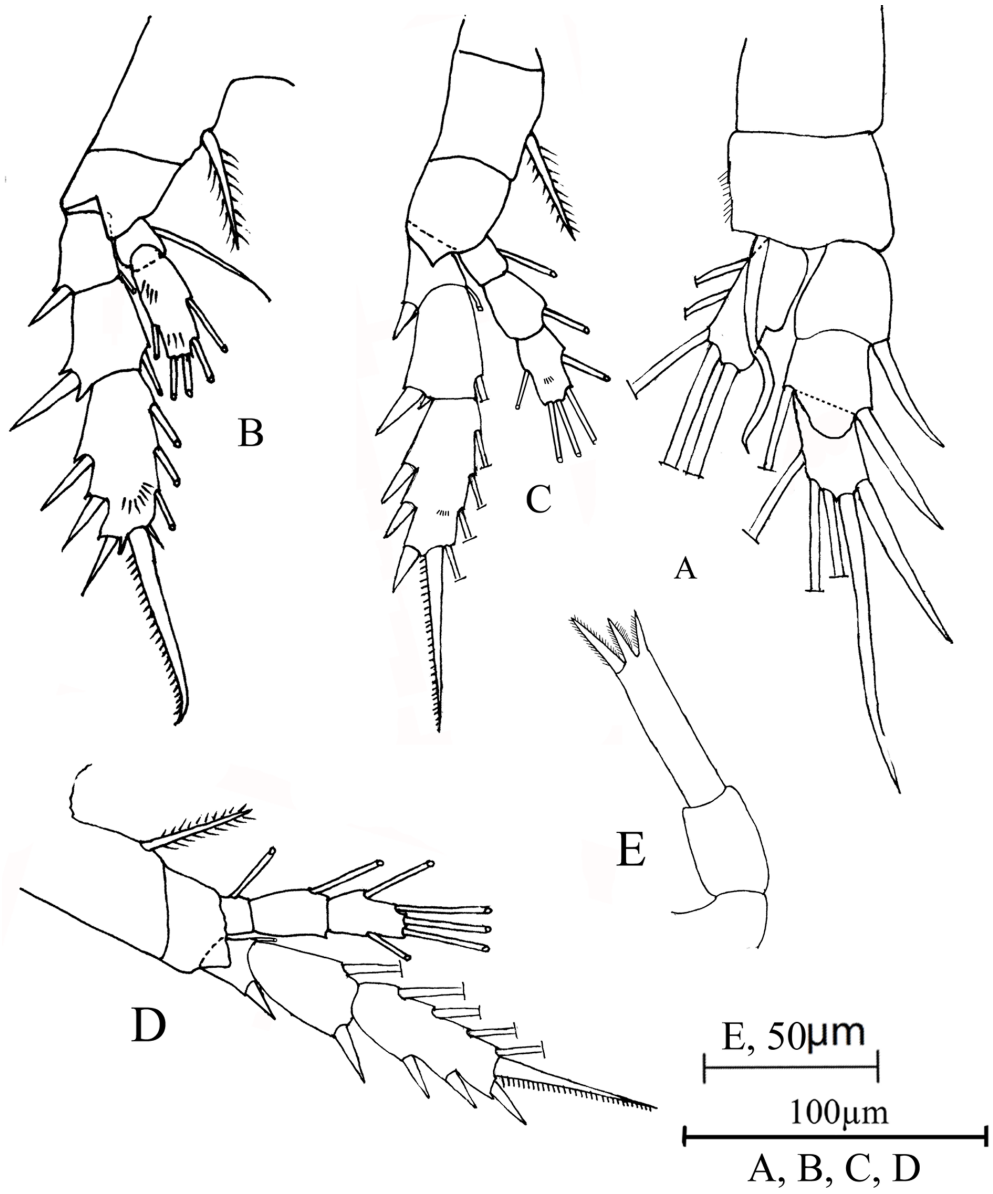

FIG. 3. ***Tharybis kueishanensis*****, new species. Female. A. Leg 1, posterior; B. Leg 2, posterior; C. Leg 3, posterior; D. Leg 4, posterior; E. Leg 5, posterior.**

Leg 1: Basis with curved distomedial seta. Tip of lateral seta on proximal exopod segment reaching midpoint of terminal segment.

Legs 2, 3: Posterior surface of distal segment of endopod and exopod with rows of small denticles.

Leg 5 (**Fig. 3E**): Uniramous, symmetrical and 3-segmented. Distal segment about 4 times longer than wide, with two spiniform projections of equal length distally, distolateral spine about 1.5 times longer than the projections.

Caudal rami (**Fig. 1A-B**): symmetrical and slightly longer than wide, with 4 large, terminal setae and small ventral seta; length about 1.4 times as long as width.

Male. Prosome 3.2 times longer than urosome. Rostrum absent. Cephalosome and first pedigerous somite partially fused laterally. Fourth and fifth pedigerous simites separated laterally. Posterior corners of prosome rounded in lateral view (**Fig. 4B**), asymmetrical in dorsal view with left posterior margin strongly modified as shown in **Fig. 4A**.

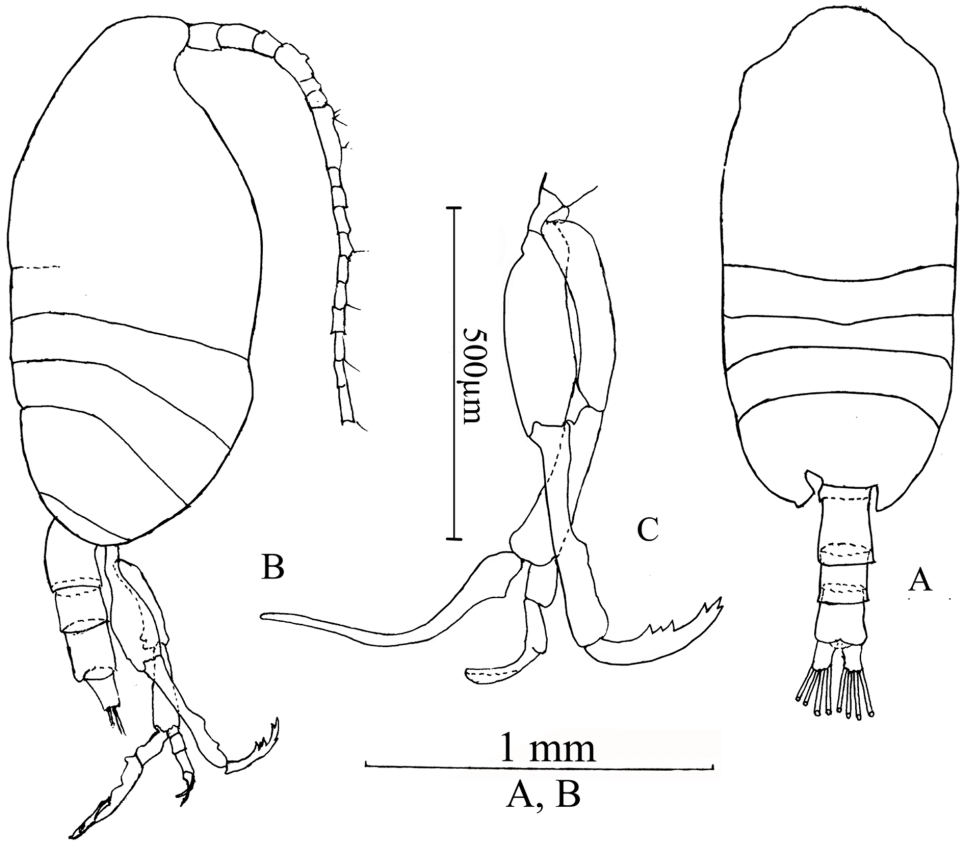

FIG. 4. *Tharybis kueishanensis*, new species. Male. A. habitus, dorsal; B. habitus, right lateral; C. Leg 5, posterior view.

Leg 5 (**Fig. 4C**): right leg uniramous with 4 segments. Distal segment about half length of proximal segment, with 3 triangular projections at inner middle margin and tip. Left leg biramous. Endopod 1-segmented falciform, thin, narrowing distally. Exopod 3-segmented.

Etymology

The species name ***kueishanensis*** refers to Kueishan Island where the species was collected.

Remarks

Females of *Tharybis kueishanensis* n. sp. can easily be distinguished from *Tharybis shuheiella* Ferrari & Markhaseva, 2005; *Tharybis inflata* Andronov, 2002; *Tharybis scaura* Andronov, 2002 and *Tharybis inaequalis* Bradford-Grieve, 2001 by symmetrical or asymmetrical leg 5. Leg 5 of *T. kueishanensis* was symmetrical. Genital complex of *T. kueishanensis* was asymmetrical which was obviously different to *Tharybis juhlae* Ferrari & Markhaseva, 2005; *Tharybis fultoni* Park, 1967; *Tharybis macrophthalma* Sars, 1902; *Tharybis neptuni* (Cleve,

1904); *Tharybis tuberosa* Andronov, 2002; *Tharybis macrophthalmoida* Andronov, 2002; *Tharybis magna* Bradford & Wells, 1983; *Tharybis asymmetrica* Andronov, 1976; *Tharybis angularis* Schulz, 1995; *Tharybis tumidula* Andronov, 2002; *Tharybis megalodactyla* Andronov, 1976 and *Tharybis compacta* (Grice & Hulsemann, 1970). The cephalon and pedigerous somite 1 fused, rostrum with 2 thin filaments in *Tharybis sagamiensis* Tanaka, 1960 and *Tharybis pseudomegalodactyla* Ferrari & Markhaseva, 2005. In *Tharybis lauta* Andronov, 2002, cephalon and pedigerous somite 1 separated and rostrum with 2 thin filaments. However, in *T. kueishanensis*, cephalon and pedigerous somite 1 partly fused and rostrum without filaments. The differences between *Tharybis groenlandicus* (Tupitzky, 1982) and *T. kueishanensis* as follows: pedigerous somites 4 and 5 fused in *T. groenlandicus* (Tupitzky, 1982) but partly fused in *T. kueishanensis*; posterolateral corners of pedigerous somite 5 rounded and covering almost half of genital complex in *T. groenlandicus* (Tupitzky, 1982), the posterolateral border of cephalosome only reaches the first third of the genital complex in *T. kueishanensis*.

Females of *T. kueishanensis* share several features with females of *T. angularis* Schulz, 1995 except the asymmetrical or symmetrical genital complex. *Tharybis angularis* Schulz, 1995 was collected in the south of Iceland, North Atlantic on 28th July 1989 about 20 m above the bottom at a water depth of 2860 m (Schulz & Beckmann, 1995). *T. kueishanensis* is very similar to *T. angularis* in the fifth pair of legs. Both of them have symmetrical fifth legs and distal segment of fifth legs are very long. The length of the distal segment is about 4 times longer than its width and the length of the inner terminal spine is about 1.5 times of the terminal projection. However, the main differences between these two species are as following: firstly, the body length of female *T. angularis* was 1.21 to 1.27 mm, the female body length of *T. kueishanensis* ranges from 1.89 to 2.12 mm which was longer than *T. angularis*; secondly, cephalon and pedigerous somite 1 are almost separate in *T. angularis* and partly separate in *T. kueishanensis*; thirdly, the pedigerous somites 4 and 5 are completely fused in *T. angularis*, however, in *T. kueishanensis* only partly fused dorsally; fourthly, the genital complex of *T. angularis* is symmetrical and somewhat spherical in dorsal view, the genital field is swollen in the middle part in lateral view, but in *T. kueishanensis*, there is a notch at the right side posterior margin in dorsal view and the genital field swelling is close to the posterior margin in lateral view; fifthly, the length to width ratio of the penultimate segment of the fifth swimming leg is about 1.5 in *T. kueishanensis*, whereas the ratio is only about 1 in *T. angularis*.

Female and male specimens have been assigned to the same species based on their co-occurrence and morphological similarity. The body shape of male *T. kueishanensis* is very similar with the female individual. The antennule was not modified as a grasping appendage on both sides in male. The significant character of the male is the 3 triangular projections at the inner middle margin and tip of the right leg 5, which is the main difference to previously described male species.

Discussion

Tharybis macrophthalma was described from fjord waters of Norway by Sars in 1902. According to Sars, the species belongs to a bottom-dwelling form. After Sars, *T. neptuni* was reported as *Scolecithricella neptuni* by Cleve in 1904 (Cleve, 1904). Andronov redescribed *Scolecithricella neptuni* as *Tharybis neptuni* based on samples from northwest Africa at a depth of 275-530 m (Andronov, 2002). Tanaka (1960) described *T. sagamiensis* which was collected from vertical hauls from 1000 m to surface waters in Sagami Bay. *Tharybis fultoni* which was collected from deep waters close to the bottom in the Strait of Georgia in January and March, 1966, was reported by Park in 1967 (Park, 1967). *Tharybis compacta* and male *T. altera*, which were originally collected from the hyperbenthic layer at water depths of 1750 to 1822 m, were reported by Grice & Hulsemann as *Undinella* in 1970 from Woods Hole, Atlantic (Grice & Hulsemann, 1970). In 1976, Andronov described another two species *T. asymmetrica* and *T. megalodactyla* from the South East Atlantic which were collected from the hyperbenthic layer at water depths from 145 to 700 m and 250-780 m, respectively (Andronov, 1976). *Tharybis groenlandica* was reported by Tupitzky in 1982 as *Xanthocalanus groenlandicus*, which was collected from 0-2000 m, 1000-3000 m and 500-1750 m in the Greenland Sea (Tupitzky, 1982). Bradford & Wells (1983) reported *T. magna* from Antarctica and suggested a scavenging mode of feeding as it was attracted to a bait which was set on the sea floor. *Tharybis angularis* was collected from Iceland, Atlantic about 20 m above the bottom at a water depth of 2860 m (Schulz, 1995). *Tharybis inaequalis* was collected from the upper slope on the south-east coast of North Island New Zealand above the bottom 4-6 cm with water depths ranging from 299 to 452 m (Bradford-Grieve, 2001). Andronov (2002) revised

the genus *Tharybis* Sars, 1902 from the original material collected in the Atlantic and some samples from the Indian and Pacific Oceans. In this paper, *T. inflate* and *T. lauta* were collected from Walvis Ridge, south-east Atlantic at a depth of 540 m and in hauls from 1000-1100 m, respectively; *T. macrophthalmoida*, *T. scaurus* and *T. tumidula* were collected from the East-Central Atlantic from hauls taken at 125 m, 500 m depths and silt bottom samples collected by a benthic trawler at water depths of 4745 m, respectively; *T. tuberosa* was collected from the Southern Atlantic in a haul from 700 m; *T. pseudomegalodactyla* and *T. juhlae* were collected from the eastern tropical Pacific Ocean 1-5 m above the bottom at water depths of 1291-3010 m in November 1988. About 10 years later, *T. juhlae* was captured again with *T. shuheiella* from a flexible plastic pipe about 30 m above the bottom at water depths of 600 m in July 1997 (Ferrari & Markhaseva, 2005).

Based on above reviews, an ecological conclusion could be made that species belonging to *Tharybis* may have a worldwide distribution and most of the species are bathypelagic. Some of them could be scavengers such as *Tharybis magna*, *T. juhlae* and *T. shuheiella*. The water depths of species distribution ranged from hundreds to thousands meters, from the continental slope to oceanic ridges. Kueishan Island, the type locality of *T. Kueishanensis*, is renowned for having numerous gaseohydrothermal vents (10-300 m deep) and the most acidic vents (with lowest recorded water pH at the vent) worldwide. The vent fluids float to the sea surface and getting mixed with tidal currents and the adjacent Kuroshio current (Chen *et al.*, 2005; Chen *et al.*, 2005). Average temperatures and salinities were 19.4 °C and 34.5 PSU in the upper 50 m water column at sampling stations with 20.3 ℃ and 34.5 PSU in the upper 5 m surface layer, indicate a well-mixed water column during sampling. Previous research also proved that there was an up-welling all year round in the research area which was generated by the Kuroshio intrusion (Wu, 2017). *T. kueishanensis* sp. n., which probably also belongs to benthopelagic copepods, could have been lifted up from the bottom to the surface layer by upwelling or by ascending hydrothermal fluids.

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