

REDESCRIPTION OF *THERMOCYCLOPS KAWAMURAI* KIKUCHI, 1940 (COPEPODA: CYCLOPOIDA)

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Abstract.— *Thermocyclops kawamurai* Kikuchi, 1940, a poorly-known cyclopoid from northern China is redescribed. Data on variability are given. Proposed synonymy of *T. kawamurai* Kikuchi, 1940 and *Thermocyclops orientalis* Dussart et Fernando, 1985 (Defaye *et al.* 1988) is rejected.



Key words.— Copepoda, Cyclopidae, *Thermocyclops kawamurai*, redescription, China.

INTRODUCTION

Genus *Thermocyclops* Kiefer, 1927 is one of the most important among Cyclopidae. Its representatives inhabit various biotopes of various continental water-bodies, often dominating plankton communities. There are 6 species of the genus *Thermocyclops* known from China: *Thermocyclops crassus* (Fischer, 1853), *T. dybowskii* (Landé, 1890), *T. taihokuensis* Harada, 1931, *T. mongolicus* Kiefer, 1937, *T. vermifer* Lindberg, 1935, *T. kawamurai* Kikuchi, 1940 (Shen *et al.* 1979, Guo 1999). Last species is one of the most poorly studied species of the genus. It was described from Manchuria by Kikuchi (1940) and reported later from most provinces of China (Shen *et al.* 1979; Guo 1999). Type specimens of *T. kawamurai* are apparently lost.

In this article we redescribe *T. kawamurai* using material collected in three northern provinces of China.

MATERIAL AND METHODS

1. Polluted pond in vicinities of Harbin, Heilongjian Prov., China, 01.09.2000, coll. I. M. Mirabdullayev, many females and males.
2. Polluted pond in Mishan, Heilongjian Prov., China, 15.09.2005, coll. I. M. Mirabdullayev, many females and males.

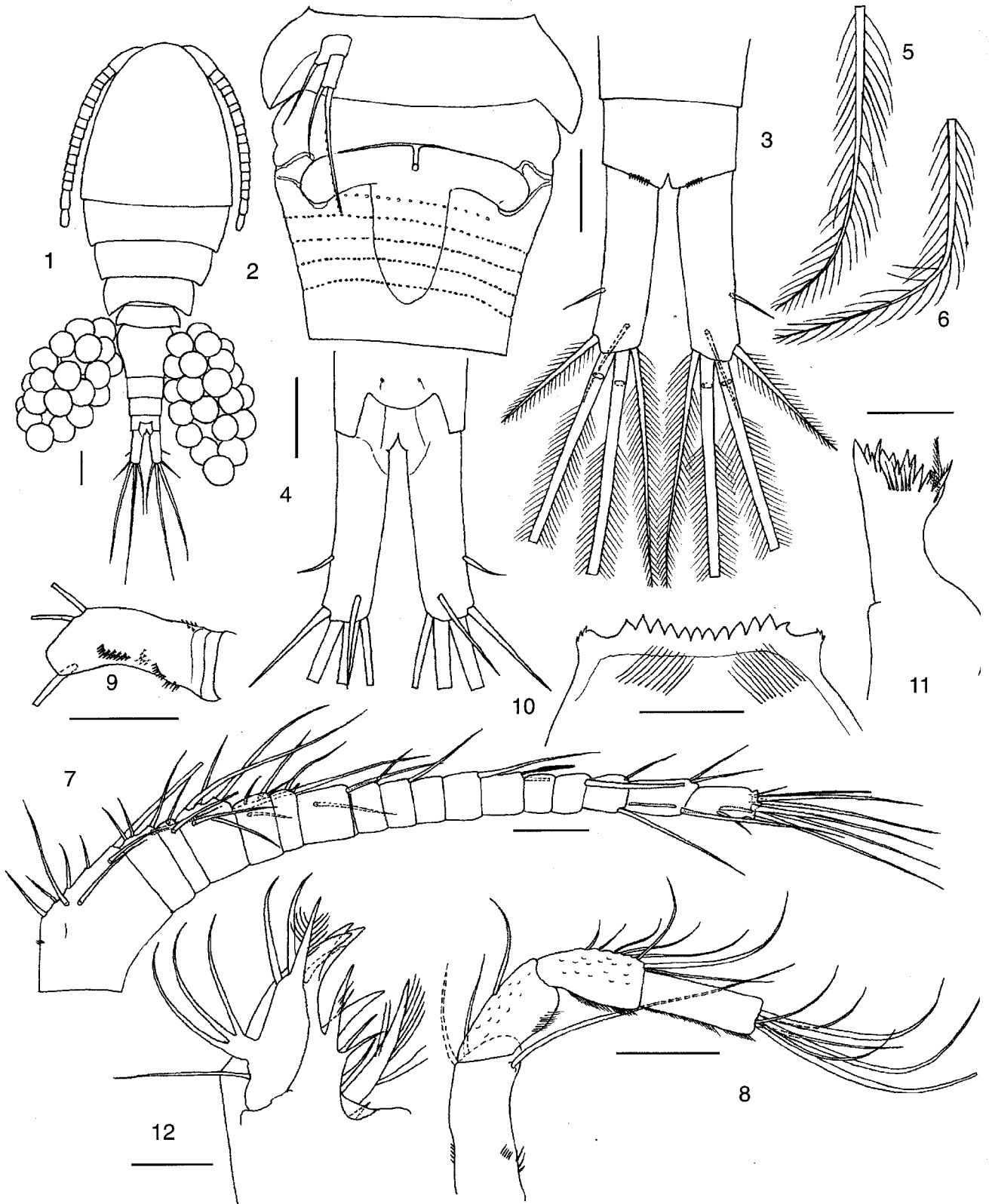
3. Shenyang (Mukden), Liaoning Prov., China, F. Kiefer Copepod Collection in Staatliches Museum für Naturkunde, Karlsruhe, Germany, slides N 4116, N 4725, 6 females, 2 males.
4. Lake Dai Hai, Inner Mongolia Prov., China, 21.06.1997, coll. Xiaoming Guo; many females.
5. L. Honshuihai, Inner Mongolia Prov., China, 13.09.1984, leg. Su Rong, many females.
6. Lake Shingli, Inner Mongolia Prov., China, 01.09.1984, leg. Su Rong, many females.
7. Lake Quiangishuiku, Inner Mongolia Prov., China, August 1987, leg. Su Rong, many females.

All drawings have been made using a drawing tube. Designations of furcal setae are given according to Dussart and Defaye (1995): Me – lateral furcal seta, Ti – innermost apical furcal seta, Tmi – inner medial apical furcal seta, Tme – outer medial apical furcal seta, Te – outer apical furcal seta, Sd – dorsal furcal seta.

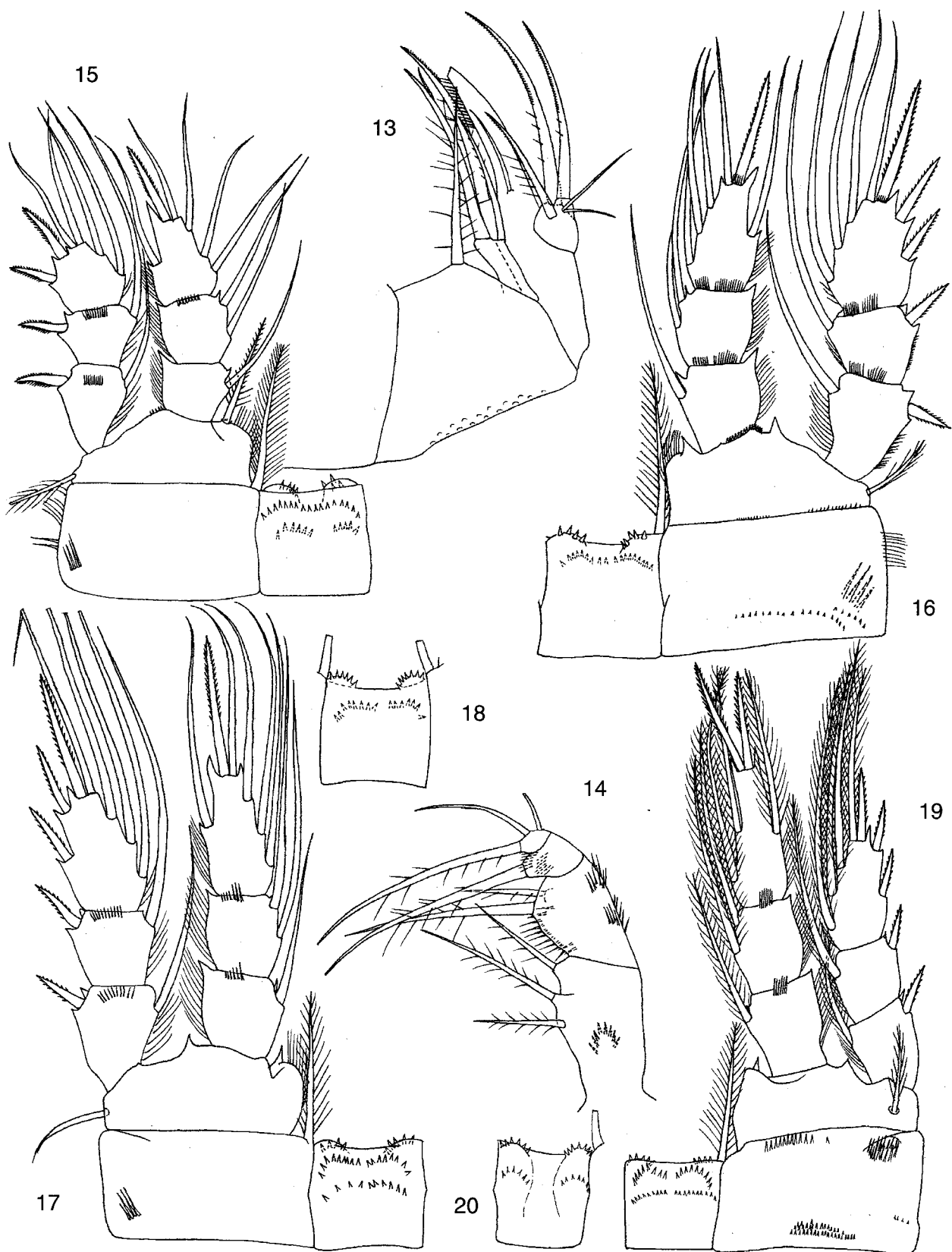
TAXONOMY

Thermocyclops kawamurai (Kikuchi, 1940)

Female. Body length 950–1200 μ m. Body widest at cephalothorax (Fig. 1). Lateral surfaces of fifth pediger without ornamentation.



Figures 1–12. *Thermocyclops kawamurae*, female, Harbin. (1) Habitus; (2) last thoracic and genital somites; (3) furcal ramus ventrally; (4) furcal ramus caudally; (5) tip of Tmi, specimen from Honshuihai; (6) tip of Tmi, specimen from Quinqishuiku; (7) antennule; (8) antenna, frontal side; (9) basipodite of antenna, caudal side; (10) labrum; (11) mandible; (12) maxillulae. Scales: (1) 100 μ m; (2–4, 7) 50 μ m, (8–12) 25 μ m.



Figures 13–20. *Thermocyclops kawamurai*, female, Harbin. (13) Maxilla; (14) maxilliped; (15) P1; (16) P2; (17) P3; (18) intercoxal plate of P3, another specimen; (19) P4, caudal side; (20) intercoxal plate of P4, frontal side. Scales: (14–15) 40 μ m; (16–20) 50 μ m.

Genital somite about as long as wide. Well developed lateral arms of receptaculum seminis slightly curved posteriorly (Fig. 2).

Anal somite with well developed operculum and 2 groups of 5–9 spinules on posterior ventral margin (Figs 3, 4). Furcal rami 3.8–4.2 times as long as wide, with smooth inner surface.

Implantations of Me and Te furcal setae not provided with spinules. Me is situated at 0.66–0.69 of length of furcal rami. Ti 1.1–1.4 times as long as furcal rami, about twice as long as Te and more than twice longer than Sd furcal setae. Tips of Tmi are straight (Fig. 5).

Antennules relatively short, reaching the middle of second pediger, 17-segmented, armored as follows (segment number in Roman numerals, setal number in arabic numerals, sp = spine):

I(8)-II(4)-III(2)-IV(6)-V(4)-VI(1+sp)-VII(2)-VIII(1)-IX(1)-X(0)-XI(1)-XII(1+aesth)-XIII(0)-XIV(1)-XV(2)-XVI(2+aesth)-XII(7+aesth) (Fig. 7).

Last antennular segment about as long as the penultimate segment. Medial seta of the last segment is situated at middle of length of the segment. Aesthetasc on 12th segment protruding beyond middle of 14th segment. Last and penultimate segments bear hyaline membranes.

Basipodite of antenna bearing 3 setae. Its ornamentation as on Figs 8–9. The endopod is 3-segmented. Its first segment is armed with 1 medial seta at midlength and bears a row of spinules at the outer margin. Second endopodite of antenna bearing 8–9 setae and third endopodite bearing 7 setae terminally and row of spinules on outer rim.

Labrum with 12 teeth. Lateral lobes serrated (Fig. 10).

Morphology of mandible and maxillule as on Figs 11–12.

Maxilla with praecoxa, coxa, basis and 2-segmented endopod. Shorter seta of movable endite of coxa is 0.70–0.75 times as long as the longer seta (Fig. 13). Maxilliped with syncoxa, basis, and 2-segmented endopod (Fig. 14). Length ratio between two shortest apical setae 1.3–1.4.

Swimming legs 3-segmented. Spine formula of exopodites P1–P4: 2.3.3.3; seta formula: 4.4.4.4 (Figs 15–17, 19). Inner margin of P1 basipodite with long spine-like seta protruding beyond middle of P1enp2, but not reaching P1enp3. The seta bears setules proximally and spinules distally. Inner margins of P1–P3 basipodites bearing setules, these of P4 are smooth. Intercoxal plate of P1 with broken rows of spinules on caudal as well as on frontal surfaces (Fig. 15). Intercoxal plates of P2 and P3 bearing broken row of spinules on caudal surface (Figs 16–18). Intercoxal plate of P4 with one row of spinules on frontal and two rows spinules on caudal surfaces (Figs 19–20).

Intercoxal plates of P1–P4 bearing low rounded prominences armed with 4–5 spinules. P4enp3 2.4–2.9 times as long as wide. Its inner spine markedly shorter than the segment and 0.9–1.1 times as long as the outer spine.

P5 of morphology typical for the genus *Thermocyclops* (Fig. 2). Inner spine of second segment of P5 1.5–1.8 times as long as outer seta.

Male. Body length 875 mm. Anal somite with well developed operculum bearing many spinules on distal margin. Furcal rami 3.7–4.1 times as long as wide, with smooth inner surface. Ti about of the same length as furcal rami.

Table 1. Data of measurements of females of *Thermocyclops kawamurai* (Kikuchi, 1940) (* number of spinules in each group on ventral side of anal somite, ** number of setae of 3rd segment of antenna).

	Harbin, pond, Heilongjian Prov. n = 5	Mukden Liaoning Prov. n = 6	L. Dai Hai Inner Mongolia Prov. n = 3	L. Honshuihai, Inner Mongolia Prov. n = 3	L. Quinqshuiiku Inner Mongolia Prov. n = 4
Body length, μm	1175–1325	1200–1250	950–1000	1075	950–1050
Anal somite spinules*	7–9	7–9	5–6	6–8	4–9
Furcal ramus L/W	3.85–4.17	4.05–4.40	3.80–4.20	4.10–4.35	4.00–4.40
Ti/furcal ramus L	1.15–1.28	1.14–1.24	1.33–1.40	1.16–1.21	1.09–1.20
Ti/Tmi	0.41–0.46	0.40–0.47	0.40–0.42	0.36–0.39	0.35–0.38
Ti/Tme	0.51–0.55	0.52–0.56	0.49–0.50	0.47–0.50	0.46–0.47
Ti/Te	1.73–2.15	1.76–2.19	1.85–2.13	1.71–1.83	1.68–1.96
Ti/Sd	2.38–2.50	2.30–2.63	2.10–2.65	2.00–2.35	2.03–2.18
A2enp2 setae**	9	8–9	8	9	9
P4enp3 L/W	2.33–2.63	2.19–2.68	2.55–2.75	2.57–2.77	2.52–2.70
P4enp3 inn. sp./L	0.69–0.79	0.73–0.92	0.79–0.82	0.77–0.78	0.77–0.80
P4enp3 inn.sp./out.sp.	1.11–1.25	1.00–1.10	0.85–0.92	1.00–1.10	1.00–1.00
P5 inn.sp./out. set.	1.50–1.80	1.80–1.84	1.30–1.60	1.50–1.75	1.50–1.60

Table 2. Morphological differences between *Thermocyclops kawamurai* (Kikuchi, 1940) and *T. orientalis* Dussart et Fernando, 1985.

Characters	<i>T. kawamurai</i>	<i>T. orientalis</i>
P4enp3 L/W	2.4–2.9	About 1.7
Prominences of the intercoxal plate of P4	Low	Higher
Ti/Te	1.7–2.2	About 1.1
Ti/Sd	2.0–2.6	About 1.4
Tmi/Tme	Tmi markedly longer than Tme	Close in length

Implantations of Te furcal setae provided with spinules (Fig. 21). Tips of Tmi strongly curved ventrally.

Antennules as on Fig. 22. Endopodite 2 of antenna bearing 7 setae (Fig. 23). Connecting plate of P4 bearing rows of spinules on frontal and caudal sides (Fig. 24). Inner spine of P4enp3 markedly shorter than the segment and 1.0–1.1 times longer than outer spine. Inner spine of second segment of P5 longer than outer seta (Fig. 25). Inner spine of P6 1.1–1.2 times shorter than outer seta and about twice as long as inner seta (Fig. 25).

Variability. There is some variability in ornamentation of intercoxal plates of P3. Females from Mukden, and from the Lake Honshuihai have 2 rows of spinules on caudal sides of the plates, whereas females from Lake Dai Hai had 1 row. Populations from Lake Quinqishuiku and from Harbin were represented by specimens with 2 as well as with 1 row of spinules on the plate.

The biometrical data are given in Table 1.

Remarks. Species co-occurring with *T. kawamurai*. *Moina macrocopa* (Straus, 1820) and *Daphnia* cf. *pulex* Leydig, 1860 inhabited the pond in vicinities of Harbin. *Thermocyclops taihokuensis* (Harada, 1931) and *Moina micrura* Kurz, 1874 co-occured with *T. kawamurai* in lakes of Inner Mongolia. *Cyclops vicinus* Uljanin, 1875, *Mesocyclops pehpeiensis* Hu, 1943, *Moina macrocopa* (Straus, 1820), *Daphnia* cf. *similis* Claus, 1976, *Brachionus rubens* Ehrenberg, 1838 co-occured with *T. kawamurai* in pond in Mishan.

DISCUSSION

Morphology of the specimens studied in general readily corresponds to description given by Kikuchi (1940). *Thermocyclops kawamurai* is related to a broad group of species of the genus *Thermocyclops*, like *T. schmeili* (Poppe et Mrazek, 1895), *T. tinctus* Lindberg, 1936, *T. uenoi* Ito, 1952, *T. ouadanei* Van de Velde, 1978, *T. conspicuus* Lindberg, 1950, *T. philippinensis* (Marsh, 1932), *T. orientalis* Dussart et Fernando, 1985, *T. hastatus* Kiefer, 1952 etc., which is characterised by spinular ornamentation of caudal surface of intercoxal plate of P4; short and broad genital

segment; relatively low (< 2.0) ratio between length of apical spines of P4enp3; relatively short innermost apical furcal seta, etc.

Inside this group *T. kawamurai* can be easily distinguished by smooth inner side of the furcal rami (hairy in *T. uenoi*), relatively long Ti (Ti/Te < 1.5 in *T. hastatus* Kiefer, 1952, *T. conspicuus* Lindberg, 1950, *T. philippinensis* (Marsh, 1932), by a few spinules on ventral posterior margin of anal somite (many spinules in *T. schmeili* and *T. hastatus*), by rich ornamentation of intercoxal plates of P1–P4 (Mirabdullayev *et al.*, 2003).

Defaye *et al.* (1987) proposed that *Thermocyclops orientalis* Dussart et Fernando, 1985 is a synonym of *T. kawamurai* (Kikuchi, 1940). However, *T. orientalis* differs from *T. kawamurai* by at least 5 characters (see table 2). We propose that *T. kawamurai* (Kikuchi, 1940) and *Thermocyclops orientalis* Dussart et Fernando, 1985 are separate species.

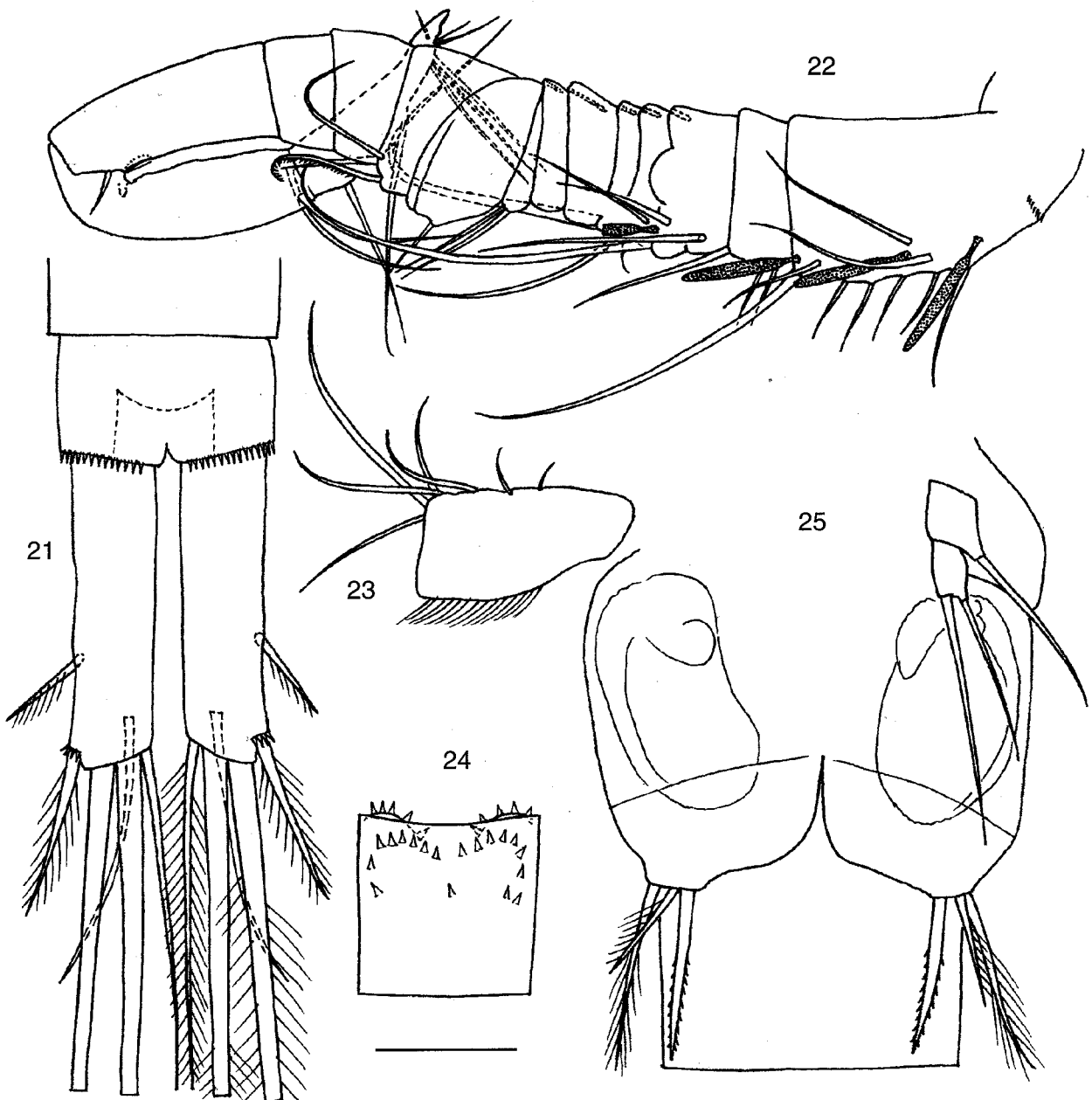
Species morphologically very close to *T. kawamurai* were found recently in southern China (Baribwegure and Mirabdullayev 2003) and Vietnam (Reid and Mirabdullayev unpublished). It shows that *T. kawamurai* may be restricted in distribution to northern China. Records of the species from southern China (Shen *et al.* 1979, Guo 1999) should be revised.

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Figures 21–25. *Thermocyclops kawamurae*, male, Harbin. (21) Furcal ramus, caudal side; (22) antennule; (23) endopodite 2 of antenna; (24) intercoxal plate of P4; (25) genital somite. Scales: (21, 22, 25) 40 μm ; (23, 24) 25 μm .

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