

Redescription of two Iranian cyclopoids: *Thermocyclops tinctus* LINDBERG, 1936 and *Th. hyalinus persicus* LINDBERG, 1936 (Copepoda, Cyclopidae)

by I. M. MIRABDULLAYEV & Frank FIERS

Summary

Two *Thermocyclops* species, *Th. tinctus* LINDBERG, 1936 and *Th. hyalinus persicus* LINDBERG, 1936, both described from Iran, are redescribed in detail after re-examination of the type-series. *Th. tinctus* appears to belong to a group of species which are characterised by the spinular surface of the leg 4 coupler, the compact genital double-somite, and the relative shortness of the apical spines of the leg 4 endopodite. *Th. hyalinus persicus*, considered for long as synonymous with *Th. crassus*, resembles most to *Th. vermifer*. The particular morphology of the principal seta on the caudal rami appears to be typical for the Iranian populations, named *Th. vermifer persicus*.

Key-words Cyclopidae, *Thermocyclops*, *Th. tinctus*, *Th. vermifer persicus* comb. n., redescrptions

Résumé

Deux espèces de *Thermocyclops*, *Th. tinctus* Lindberg, 1936 et *Th. hyalinus persicus* Lindberg, 1936, décrites d'Iran, sont redécrites en détails à la suite de la réexamination du matériel type. *Th. tinctus* semble être attaché à un groupe d'espèces caractérisé par: une ornementation particulière des épines à la surface de la lame précoxale de la patte 4, un segment génital relativement compact, et des épines apicales courtes au niveau de l'endopodite de la patte 4. *Th. hyalinus persicus*, considéré longtemps comme synonyme de *Th. crassus*, se rapproche plus de *Th. vermifer*. Les populations iraniennes, nommées *Th. vermifer persicus*, se caractérisent par une morphologie particulière de la soie principale au niveau des branches furcales.

Mots-clefs Cyclopidae, *Thermocyclops*, *Th. tinctus*, *Th. vermifer persicus* comb. n., redescrptions.

Introduction

A selection of the cyclopid collection made by K. Lindberg during his first voyage to Iran in 1935 has been deposited in the collections of the Royal Belgian Institute of Natural Sciences (GHENNE & FIERS, 2000). The collection essentially contains the type-material of the six cyclopid species which were described by LINDBERG (1936) in his first contribution to the cyclopid fauna of that country.

Among the six species, Lindberg's collection lodges the types of two rare *Thermocyclops* species: *Th. tinctus* LINDBERG, 1936 and *Th. hyalinus persicus* LINDBERG, 1936. The original description of the former has been amended twice by LINDBERG himself based on additional material from Iran (LINDBERG, 1941) and collections from India (LINDBERG, 1942a). *Th. hyalinus persicus*, however, seems to be never reported again, but was sunk in synonymy with *Th. crassus* (FISHER, 1853) (DUSSART & DEFAYE, 1985). In the course of the compilation of a world-wide key to the species of the genus *Thermocyclops* by the first author (I. M. M.) the type-series of the two species were re-examined and are here redescribed in detail.

Material and Method

Preserved specimens are stored in 75% ethylalcohol, dissected specimens were mounted in glycerine with sealed cover glasses. All specimens are deposited in the copepod collection (COP#) of the Royal Belgian Institute of Natural Sciences (Brussels). Observations were made on a Leitz Dialux 20 light microscope and a Leitz Diaplan, both equipped with a drawing tube. Abbreviations used in text and tables are: aesth, aesthetasc; enp, endopodite; P1-P6, legs 1 to 6; caudal rami armature: Me, median lateral seta; Te, apical lateral seta; Tme, outer terminal principal seta; Tmi, inner terminal principal seta; Ti, medial terminal seta; Sd, dorsal seta.

Systematics

Thermocyclops tinctus LINDBERG, 1936

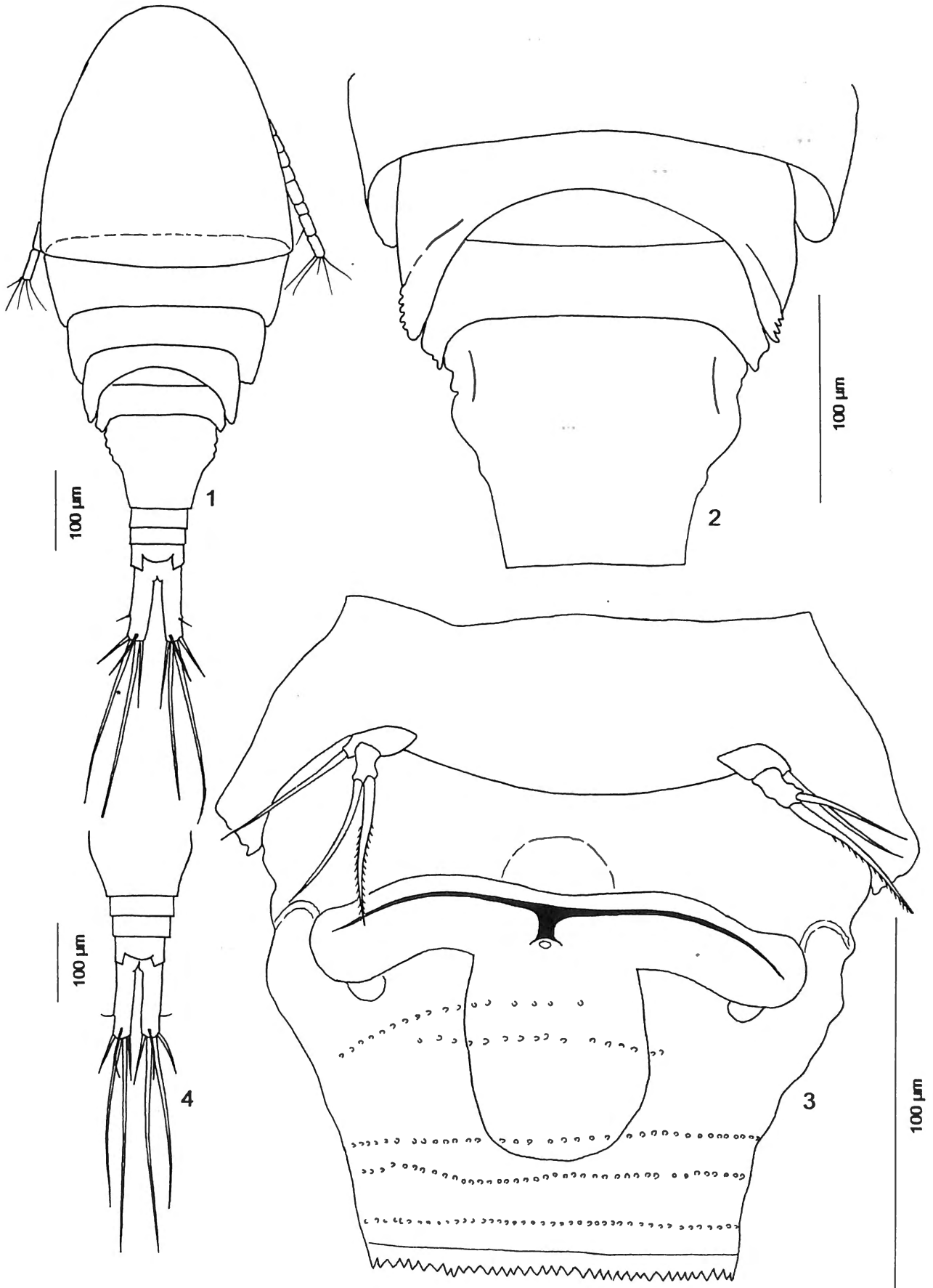
Figs. 1-27

synonymy

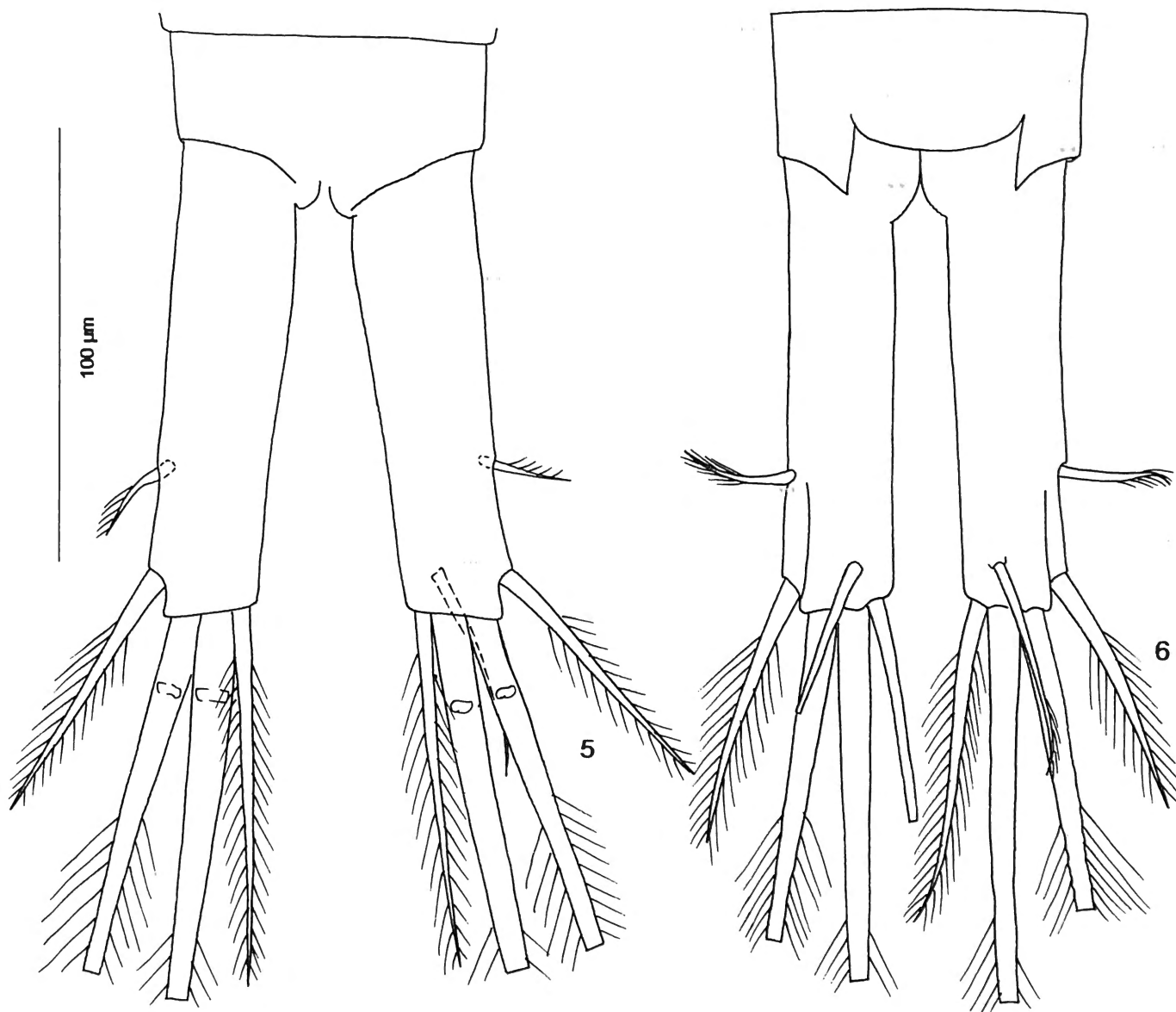
Thermocyclops tinctus, Sp.N. - LINDBERG, 1936: 20-22, Figs. 28-33.

Mesocyclops (Thermocyclops) tinctus LINDBERG - LINDBERG, 1941: 266-262, 264, fig. 2a-h; LINDBERG, 1942a: 21-22, Fig. 4a-e.

Thermocyclops tinctus LINDBERG - LINDBERG, 1942b: 159-167; LÖFFLER, 1961: 393; DUSSART, 1981: 162; DUSSART & DEFAYE, 1985: 131.



Figs. 1-4. *Thermocyclops tinctus* LINDBERG, 1936, female. 1, habitus; 2, fourth and fifth pedigerous somites, and genital double-segment, dorsal view; 3, fifth pediger and genital double-somite, ventral view; 4, Distal somites of urosome and caudal rami of other female specimen, dorsal view.



Figs. 5-6. *Thermocyclops tinctus* LINDBERG, 1936, female. 5, anal somite and caudal rami ventrally; 6, idem, in dorsal view.

MATERIAL

Lectotype: 1 dissected female (COP 4551); paralectotypes: 1 dissected female (COP 4552), 1 dissected male (COP 4553), 1 dissected female copepodid V (COP 4554), 2 males and several copepodids preserved (COP 4556)

TYPE-LOCALITY

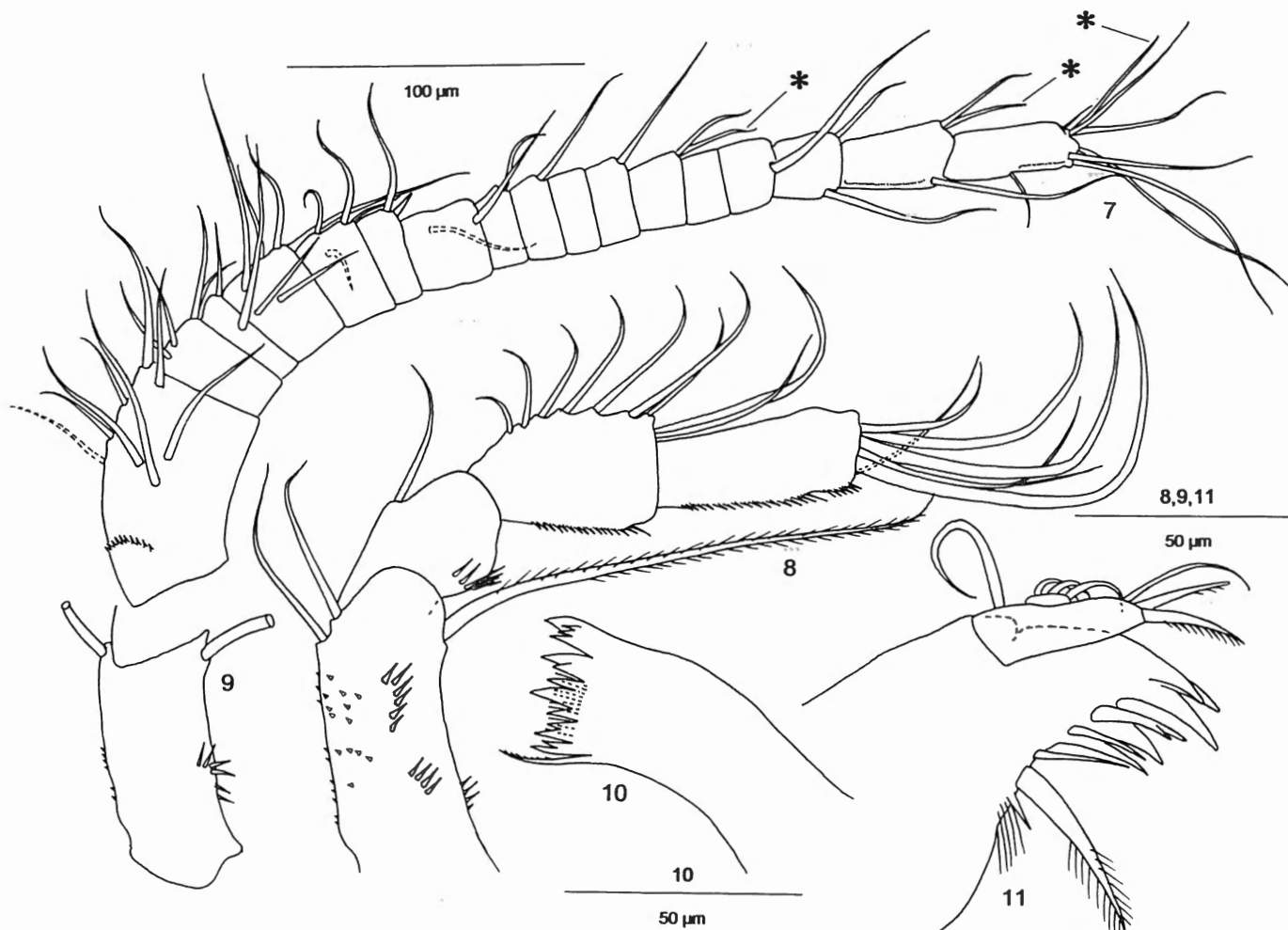
Iran, pool of the local mosque of Saghand (city coordinates approx.: 32°31'N 55°13'E), 100 km northeast of Yazd. Leg. K. Lindberg, October 1935.

FEMALE

Body length, from top of head to end of caudal rami, 810-815 μ m. Posterolateral margins of 4th and 5th pedigerous somites serrated (Figs. 1, 2). Lateral sides of 5th pedigerous somite without ornamentation. Genital double-somite wider than long. Well developed lateral wings of receptaculum seminis, slightly recurved posteriorly. Copulatory pore large, circular. Ventral surface of genital double-somite and

abdominal somites with transverse rows of pits (Fig. 3). Posterior margins of anal somite without the usual spiniform ornamentation (Figs. 5-6). Anal operculum relatively weakly developed with slightly crescentic margin (Fig. 6). Caudal rami 4.10-4.25 times as long as wide, with smooth inner surface (Figs. 4-6). Insertion places of lateral (Me) and outermost apical seta (Te) without spinules. Me arising in posterior half, at 67-68% of total length of ramus. Ti shorter than caudal ramus. Setal ratios: $Ti/Tmi = 0.24$; $Ti/Tme = 0.33-0.38$; $Ti/Te = 1.24-1.31$; $Ti/Sd = 1.35-1.55$. Tips of Tmi straight (Fig. 4).

Antennules relatively short, not reaching posterior margin of second thoracic segment, 17-segmented, complemented 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)-XVII(7+aesth) (Fig. 7). Ventral surface of segments I-III ornamented with rows of pits. Hyaline membrane on segment XVI as long as entire



Figs. 7-11. *Thermocyclops tinctus* LINDBERG, 1936, female. 7, antennule (asterisks indicating aesthetascs); 8, antenna, caudal side; 9, antennal basispodite, frontal side; 10, distal end of mandibular gnathobasis; 11, maxillule.

segment, membrane of segment XVII only present between lateral seta and distal edge.

Antennal basispodite bearing 3 setae, second segment of endopodite with 9 setae (Figs. 8-9). Caudal surface of basispodite with 2 short rows parallel with outer margin and several minute spinules scattered in the abexopodal half. Frontal surface with a group of spinules arising in median half of outer margin. Exopodal seta bipinnate.

Mandible and maxillule (Figs. 10-11) with normal armament and smooth gnathobasis and arthrite, respectively. Mandibular palp distinct with 2 long and 1 short seta. Surface of maxillar syncoxa covered with pits (Fig. 12). Maxilliped with complete armament (Fig. 13). Syncoxa with a horse-shoe-shaped pattern of spinules on frontal surface. Basis with an irregular spinule pattern on caudal surface, and first endopodal segment with spinules on frontal surface.

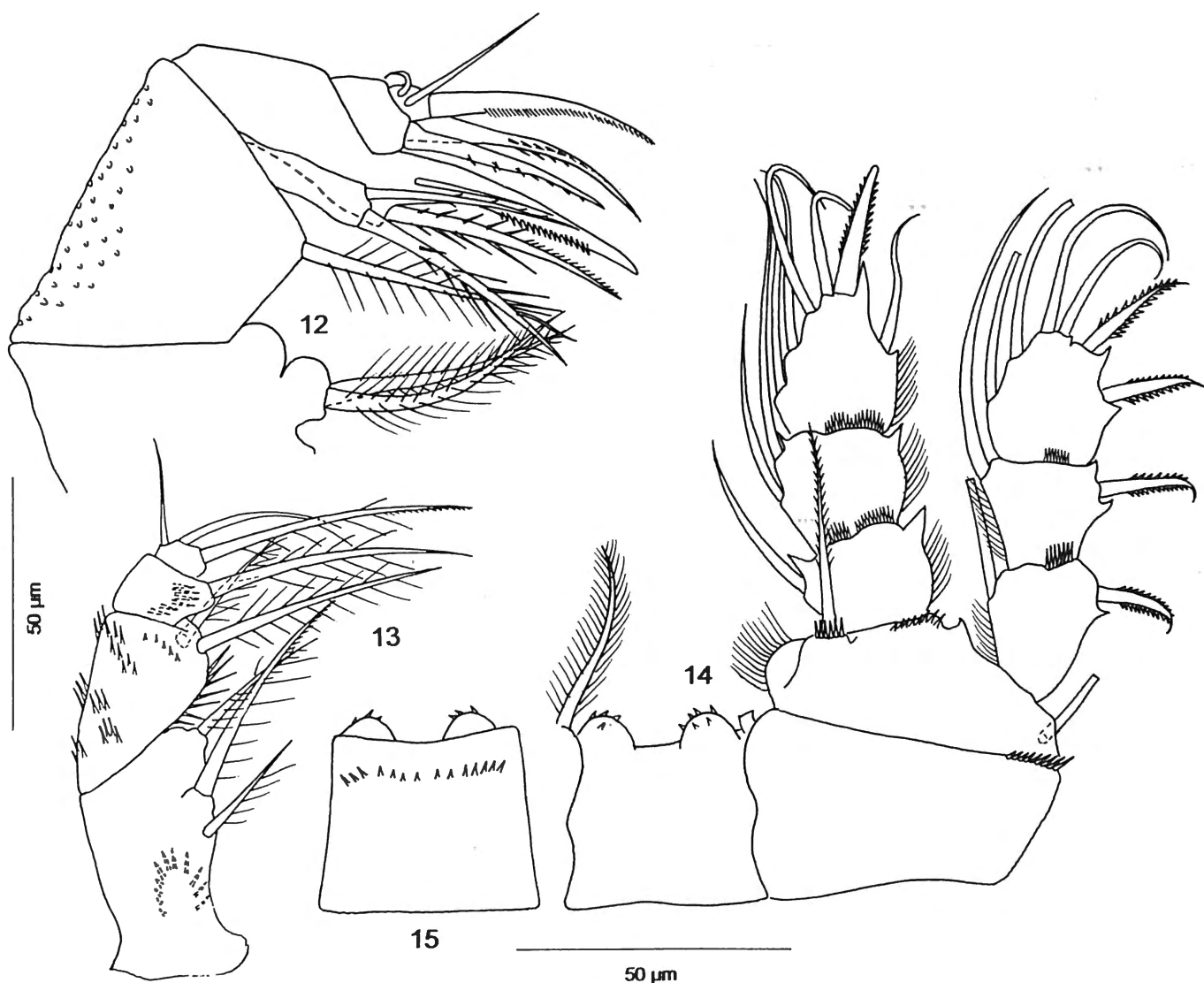
Natatorial legs with 3-segmented rami. Spine formula 2.3.3.3, setae formula 4.4.4.4 (Figs. 14, 16, 19). Medial element on P1 basis reaching slightly beyond distal margin of median endopodal segment. Medial margin of P1 basis with hairs, of P2 and P3 with spinules (Fig. 16), and of P4 smooth (Fig. 19). Free margins of connecting plates of P1-P4 bearing low, broadly rounded prominences armed with small spinules. Caudal surface of connecting plate in P1-P3 with a

single row of spinules (Figs. 15, 17, 18), in P4 with 2 rows (Fig. 21). Frontal surface of connecting plate in P1-P4 smooth (Figs. 14, 16, 22). Caudal surface of P4 coxa with a long mediolateral and short medioproximal spinule row and 2 rows in outer region of surface. P4enp3 relatively short, $L/W = 1.24-1.31$. Inner terminal spine longer than the article and 1.7 times longer than outer spine (Fig. 21).

Second segment of P5 relatively short, nearly square. Inner terminal spine longer than outer seta (Fig. 3).

MALE

Body length 748 μm . Posteroventral margin of anal somite with numerous minute spinules (Fig. 23). Caudal rami 4.05 times as long as wide, with smooth inner surface. Insertion place of outermost apical seta (Te) furnished with spinules. Ti shorter than rami, longer than Te and of equal length as Sd. Antennule 16-segmented, complemented as follows: I(8+aesth)-II(4)-III(2)-IV(2+aesth)-V(2) -VI(2)-VII(2) -VIII(2)-IX(1+aesth+sp) -X(2)-XI(2)-XII(2)-XIII(2+aesth)-XIV(2) -XV(1+aesth)-XVI(12+aesth). First segment with single aesthetasc arising from the distal margin, and with row of spinules. Elements on segments XIV and XV typically transformed in T-shaped plates.



Figs. 12-15. *Thermocyclops tinctus* LINDBERG, 1936, female. 12, maxilla; 13, maxilliped; 14, P1, frontal side; 15, intercoxal sclerite of P1, caudal side.

Second segment of antennal endopodite with 8 setae. Connecting plate of P4 bearing single, medially interrupted, row of spinules on caudal surface (Fig. 24). P4enp3 L/W = 1.6. Inner terminal spine 1.6 times longer than outer one, and 1.44 times longer than segment.

Distal segment of P5 very short, squarish (Fig. 25), with inner terminal spine longer than outer seta. Inner spine of P6 is about twice as long as median one.

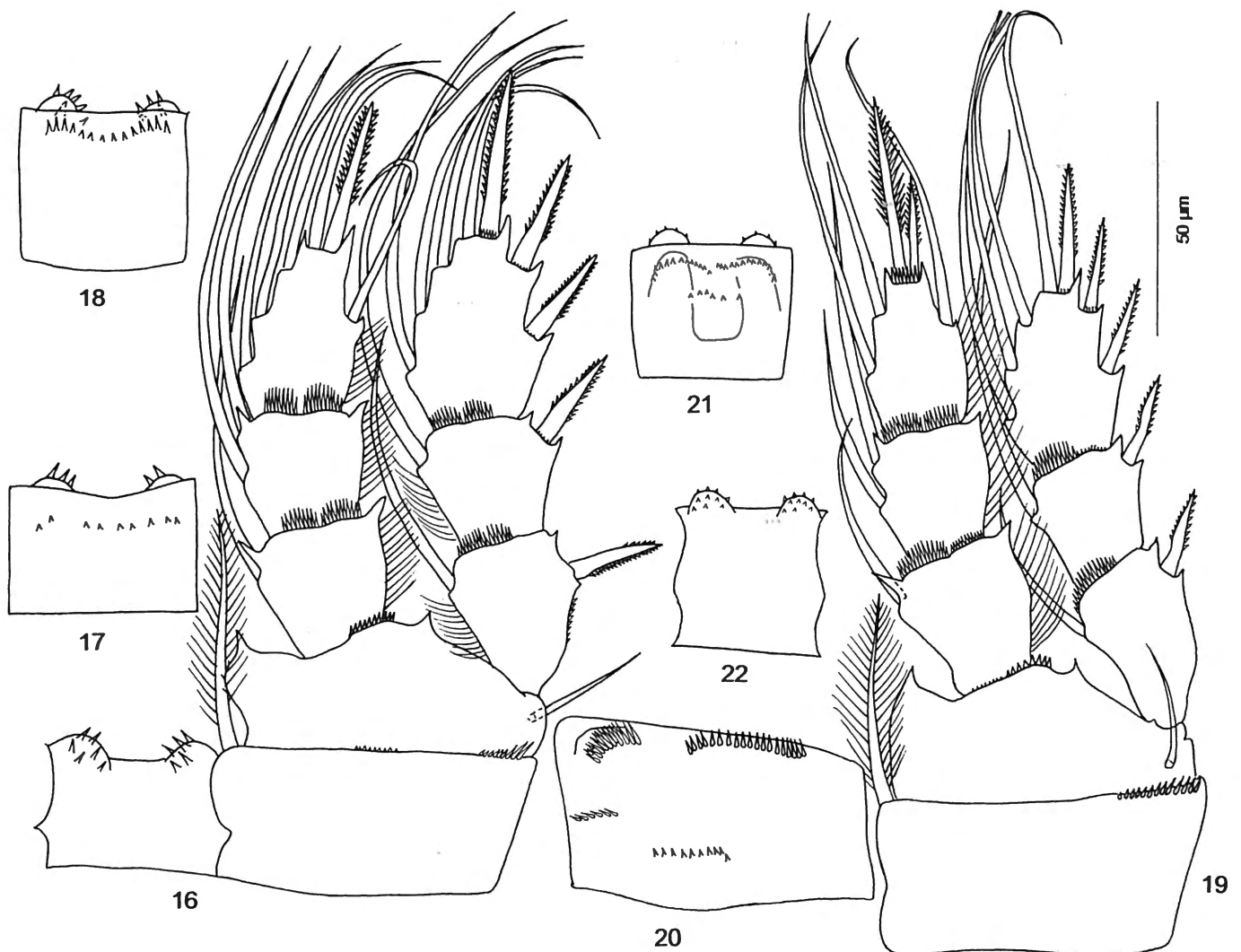
Comments

Lindberg (1936, 1941) reported the presence of spinules along the posteroventral margin of the anal somite of the female, but, in neither one of the two adult females re-examined were spinules observed at this location. In contrast, spinules are present at this location in the male (Fig. 23) and the fifth copepodids (Fig. 27).

Thermocyclops tinctus is related to a broad group of species within the genus which are characterised by the spinular or-

namentation of the caudal surface of connecting plate in P4; the short and broad genital double-somite; the relatively low (< 2.0) ratio between the lengths of the apical spines of the P4enp3, and the relatively short innermost apical furcal seta. This group comprises *Th. schmeili* (POPPE & MRAZEK, 1895), *Th. kawamurai* KIKUCHI, 1940, *Th. uenoi* ITÔ, 1952, *Th. ouadanei* VAN DE VELDE, 1978, *Th. orientalis* DUSSART & FERNANDO, 1985, *Th. hastatus* KIEFER, 1952, *T. operculifer* (KIEFER, 1930), *T. philippinensis* (MARSH, 1932), *T. iantinus* HARADA, 1931, *T. vizarae* FRYER, 1957, *T. dalmaticus* PETKOVSKI, 1956, *T. conspicuus* LINDBERG, 1950, *T. marmagoensis* SEWELL, 1957, and *T. crenulatus* BREHM, 1948.

Within this group *Th. tinctus* can be easily distinguished from its congeners by the very short P4enp3, the serrated margins of 4th and 5th pedigerous somites and probably by the lack of spinules (at least in the female) along the caudal margin of anal somite. The only species known so far possessing a L/W-ratio of the P4enp3 shorter than 2 are *Th. orientalis* (known from Sri Lanka) and *Th. hastatus* (known



Figs. 16-22. *Thermocyclops tinctus* LINDBERG, 1936, female. 16, P2, frontal side; 17, intercoxal sclerite of P2, caudal side; 18, intercoxal sclerite of P3, caudal side; 19, P4, frontal side; 20, P4 coxa, caudal side; 21, intercoxal sclerite of P4, caudal side; 22, intercoxal sclerite of P4, frontal side.

from Lake Kivu). Both species differ from *Th. tinctus* because of their much shorter inner apical spine of P4enp3 (shorter than outer spine).

T. tinctus is apparently a rare species. Besides its type-locality, the species has been reported only from Pakistan (Lindberg, 1941, Lindberg 1942a, Löffler, 1961).

***Thermocyclops vermifer persicus* LINDBERG,**
1936 comb. nov.
Figs. 28-33

Syn. *Thermocyclops hyalinus* var. *persicus* LINDBERG, 1936
Thermocyclops crassus persicus - auctorum

MATERIAL

Lectotype: 1 dissected female (COP 4548); paralectotypes: 3 dissected females (COP 4548-4555), 12 females and 21 copepodids preserved (COP 4555).

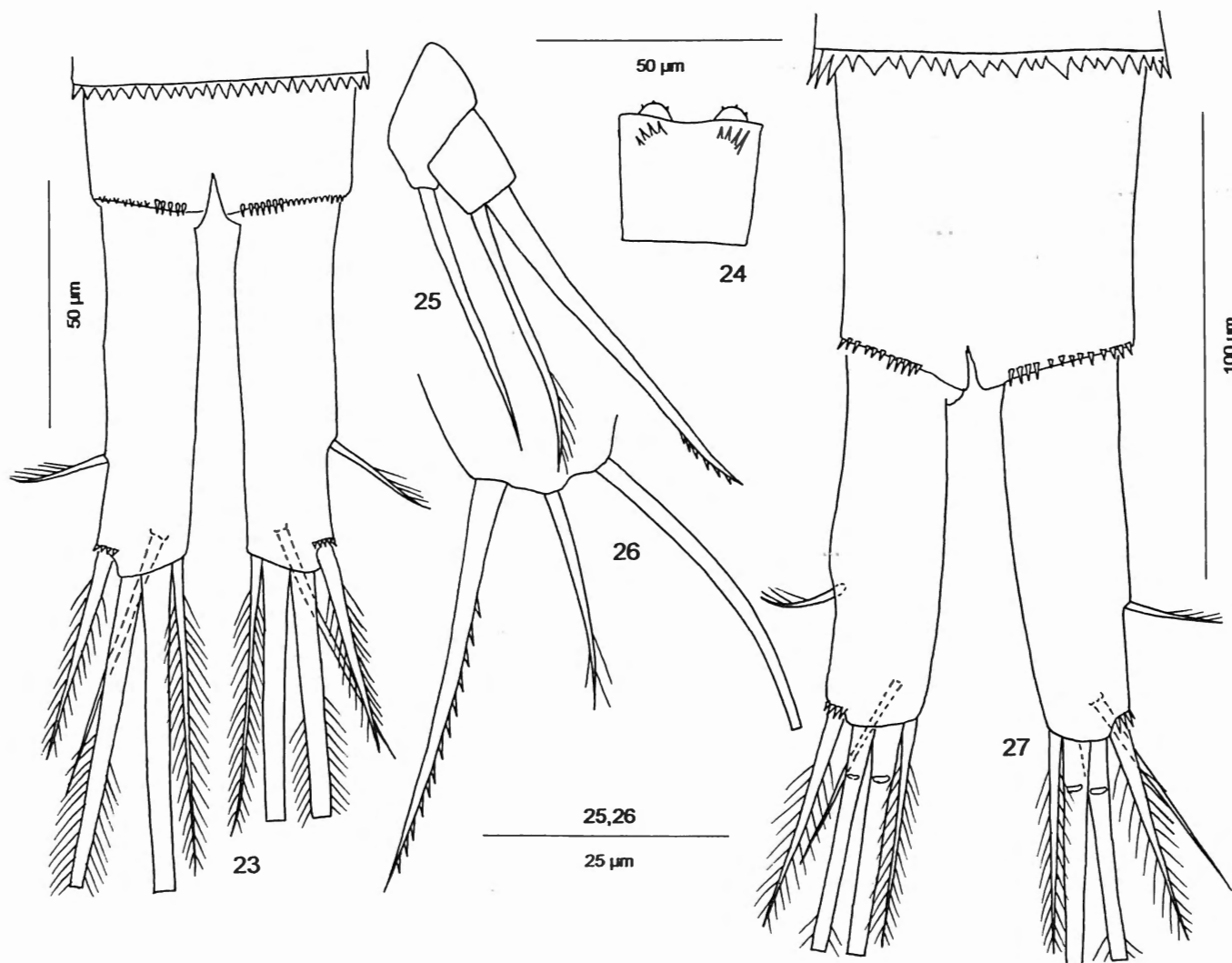
TYPE-LOCALITY

Iran, pool at Meshed (alternatives: Mashhad, Mecched) without more specific indications (city coordinates, approx.: 36°17'N 59°35'E). Leg. K. Lindberg, October 1935.

FEMALE

Body length 800-910 µm. Lateral sides of pediger 5 without ornamentation (Fig. 29). Genital double somite longer than wide. Well developed lateral wings of receptaculum seminis, both slightly recurved posteriorly (Fig. 29). Anal somite bearing 2 groups of 3-6 spinules along the posteroventral margin (Fig. 31), and 2 groups of 4 spinules along the posterodorsal margin (Fig. 30). Anal operculum weakly developed.

Caudal rami 2.7-3.2 times as long as wide, with smooth inner surface. Implantations of Me and Te without spinules. Me situated on 63-64% of length of caudal rami. Ti/length of rami = 2.7-3.0; Ti/Te = 2.5-3.1; Ti/Sd = 1.8-2.3. Tips of Tmi strongly recurved ventrally.



Figs. 23-27. *Thermocyclops tinctus* LINDBERG, 1936. 23, caudal rami of male, ventrally; 24, intercoxal sclerite of male P4, caudal side; 25, P5 of male; 26, P6 of male; 27, caudal rami and anal somite of female 5th copepodite.

Antennule 17-segmented, reaching posterior margin of 2nd pedigerous somite (Fig. 28), complemented as follows: 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)-XVII(7+aesth). Spinule row on segment I present. Hyaline membrane on segment XVI as long as segment, on segment XVII only present between lateral seta and distal edge of segment.

First and third segments of antenna bearing 3 and 9 setae, respectively. Caudal surface of basipodite as in preceding species however, without scattered minute spinules in abexopodal half. Frontal surface with single row (as in preceding species) composed by 8-10 slender spinules. Mandible and maxillule as in preceding species. Maxilla without pitted surface. Maxilliped with complete armament and spinule pattern as in preceding species.

Medial spine on P1 basis long, reaching P1enp3. Connecting plates of P1-P3 without ornamentation. Connecting plate of P4 bears 2 rows of setules on caudal surface (Fig. 32). Well developed rounded prominences of P4 coupler, each with 5-7 spinules. Inner margin of P4 basis naked. Inner margins of P1-P3 basis with setules. P4enp3 L/W = 2.8-3.5. Inner spine

of P4enp3 slightly curved, 1.0-1.1 times as long as segment and 2.5-2.8 times longer than outer spine.

Distal segment of P5 twice as long as wide. Inner spine on distal segment 1.0-1.2 times as long as outer seta (Fig. 33).

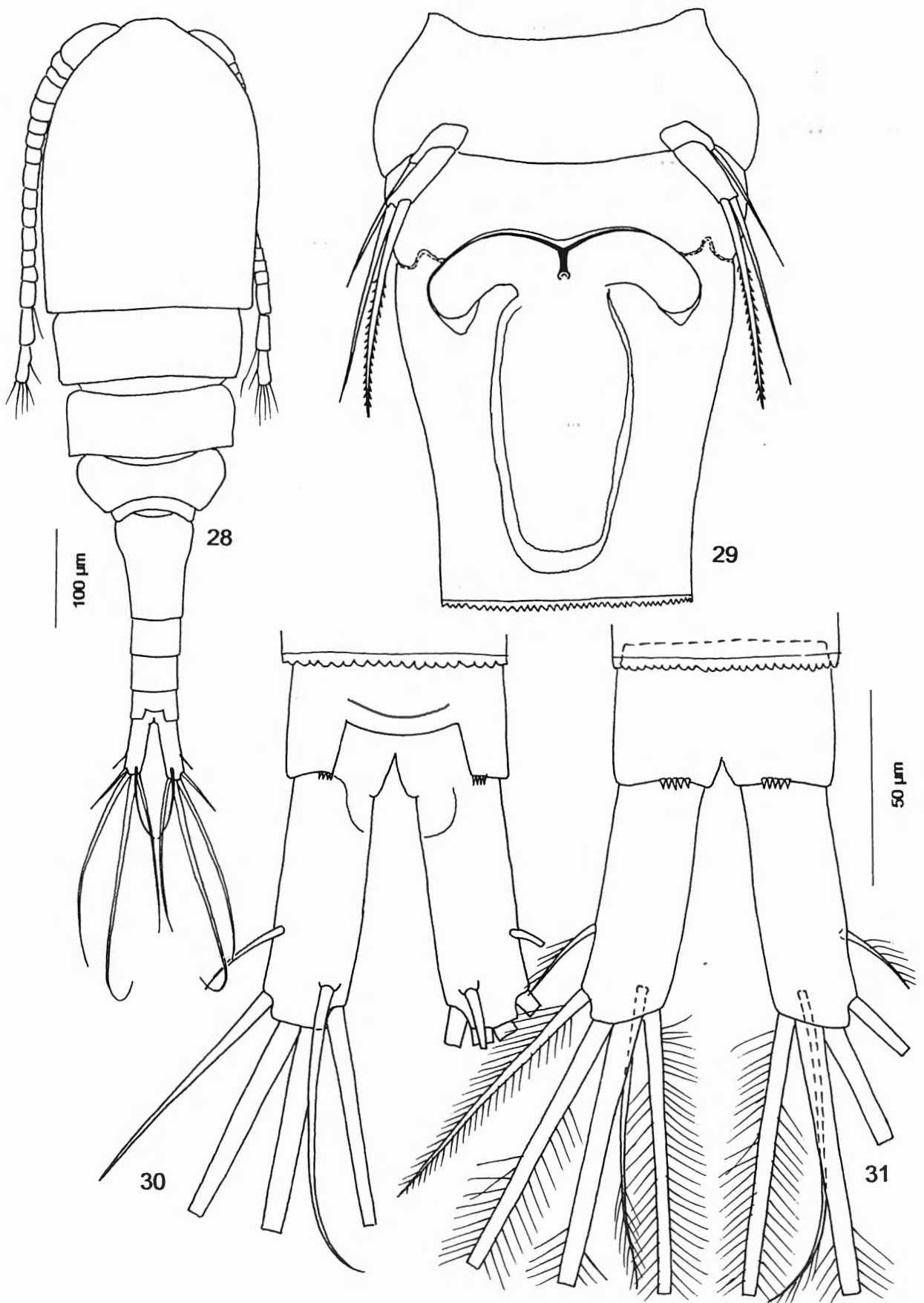
MALE

Unknown.

Comments

LINDBERG (1936) attributed his specimens to *Thermocyclops hyalinus* (REHBERG, 1880) (= *T. crassus* (FISCHER, 1853)), but considered the observed differences sufficiently relevant to treat them as a separate variety, *Th. hyalinus* var. *persicus*. With the common recognition that *Th. hyalinus* has to be considered as a junior synonym of *Th. crassus* (FISCHER, 1853), *Th. hyalinus persicus* has been sunk in synonymy with the latter (MONCHENKO, 1974; DUSSART & DEFAYE, 1985). However, the separate status of the subspecies *persicus* remained questionable (RYLOV, 1948, 1963).

The re-examination of the type-material of *Th. hyalinus*



Figs. 28-33. *Thermocyclops vermifer persicus* LINDBERG, 1936, female. 28, habitus; 29, 5th pedigerous somite and genital double-somite, ventrally; 30, caudal rami, dorsally; 31, caudal rami, ventrally.

persicus provided quite some evidence that the assignation of the Iranian specimens to *Th. crassus*, is doubtful because of the following characteristics:

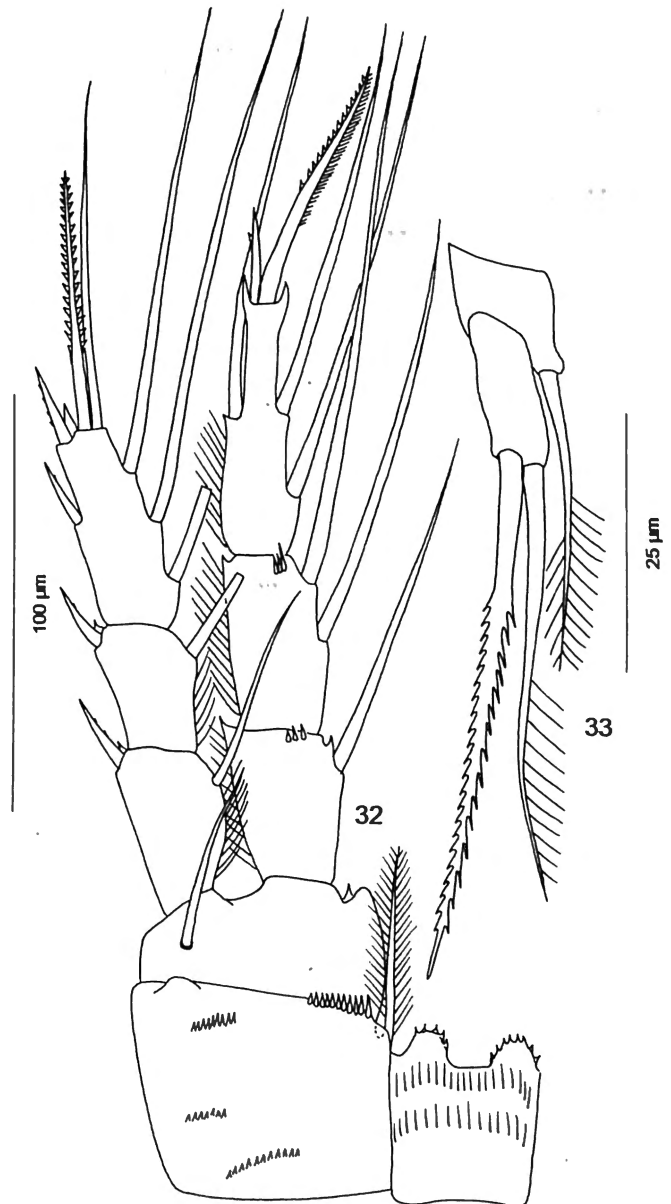
- the longer and more slender lateral wings of the receptacula;
- the smooth lateral sides of fifth pediger;
- the smooth inner margin of the P4 basis (hairy in *Th. crassus*);
- the distinctly longer caudal rami (L/W ratio between 2.7 and 3.2; 2.2 to 2.6 in *Th. crassus*);
- the relative lengths of the apical spines of the P4enp3 (2.8-3.5; 1.9-2.3 in *Th. crassus*).

Taking these features under consideration, the specimens studied herein resemble most *Th. vermifer* (LINDBERG, 1935) described from India, and which was subsequently reported from Afghanistan (LINDBERG, 1948), Uzbekistan (MIRABDULAYEV & KUZMETOV, 1997), southern Kazakhstan and eastern Turkmenistan (MIRABDULAYEV *et al.*, 1999). Obviously the specimens from Iran have to be attributed to *Th. vermifer* instead of be considered as a synonym of *Th. crassus*.

The only difference between the specimens from Iran and those from India and Central Asia is that the tip of the longest terminal seta on the caudal rami (Tmi) is strongly recurved ventrally in the Iranian specimens whereas this seta is invariably straight in the Indian and centralasian specimens. Specimens (labeled as *Thermocyclops* sp.) lodged in the Kiefer copepod collection at Karlsruhe (slide #8622, glycerine preserved specimens #3902, I.M.M., pers. obs.) and which originate from Lake Dez-Stau in Iran clearly showed the same recurved tips of their Tmi. This character appears to be constant and is considered as a taxonomic important feature. Species such as *Th. crassus* (FISCHER, 1853), *Th. dybowskii* (LANDE, 1890), *Th. neglectus* (SARS, 1909) always have the ventrally recurved principal inner seta on their rami. In contrast, other species which are known to occur within the area (*Th. oithonoides* (SARS, 1863), *T. rylovi* (SMIRNOV, 1929), *T. taihokuensis* HARADA, 1931)) display always straight or only insignificantly recurved tips of their Tmi. Thus, where the morphology of the two Iranian populations studied herein coincides largely with *T. vermifer*, they are morphological distinct from the more eastern populations of the latter in the appearance of their Tmi. As such we consider them as a separate subspecies, *Th. v. persicus* LINDBERG, 1936 comb. nov. Within the context of this contribution, it seems worth to mentioned that the record of *Th. vermifer* from Russia (the delta of the River Volga, ALEKSEEV, 1998) is most probably erroneous. The illustrations provided in this paper (ALEKSEEV, 1998, p. 34, figs. 7-9) depict clearly that the specimens should be assigned to *Th. oithonoides* (SARS, 1863) rather than to *Th. vermifer*.

Acknowledgements

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Figs. 32-33. *Thermocyclops vermifer persicus* LINDBERG, 1936, female. 32, P4, caudal view; 33, P5.

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Table I. Comparison between *Thermocyclops vermifer persicus* and *T. vermifer vermifer*.

Species	<i>Th. vermifer persicus</i>				<i>Th. vermifer vermifer</i>	
	Iran, Meshed		Iran, DezStaw		Uzbekistan	
Origin/Collection	Lindberg collection		Kiefer collection		6 populations*	
Number of specimens	n=10		n=9		n=60	
	min-max	\bar{x}	min-max	\bar{x}	min-max	\bar{x}
Length (μm)	870-907	887	800-850	826	750-933	835
Ornamentation						
# spinules ventrally on anal somite	4-6		3-6		3-4	
# spinules on P4 intercoxal sclerite	5-6		5-7		3-7	
Caudal Rami						
L/W	2.67-2.92	2.80	2.83-3.28	2.99	2.69-3.25	2.95
TI/Length CR	2.71-2.94	2.79	2.79-3.00	2.86	2.50-3.17	2.83
TI/Tmi	-		-		0.56-0.71	0.63
Ti/Tme	0.76-0.85	0.81	0.76-0.84	0.80	0.75-0.88	0.81
Ti/Te	2.43-2.78	2.63	2.85-3.10	3.00	2.40-3.22	2.76
TI/Sd	1.96-2.30	2.17	1.75-2.11	1.99	1.63-2.06	1.89
Enp3P4:						
L/W	2.83-3.30	3.05	3.00-3.50	3.17	2.93-3.83	3.22
Inner sp./L	0.97-1.04	1.01	1.05-1.13	1.10	0.92-1.17	1.03
Inner sp./outer sp.	2.45-2.75	2.65	2.45-2.77	2.65	2.40-3.15	2.79

(*data from MIRABDULLAYEV & KUZMETOV, 1997)

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