Plankton Biol. Ecol. 44 (1/2): 41–54, 1997

plankton
biology & ecology

Species composition and description of limnoplanktonic copepods from Okinawa

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Received 6 February 1997; accepted 24 March 1997

Abstract: Planktonic copepods were collected from ponds and reservoirs of dams in Okinawa, Ishigaki and Iriomote Islands, the southernmost area of Japan, and five cyclopoid species, *Eucyclops* cf. *speratus, Mesocyclops ruttneri, M. thermocyclopoides, Thermocyclops crassus* and *T. taihokuensis*, and a calanoid *Sinodiaptomus sarsi* were described. The two species of *Mesocyclops* and probably *S. sarsi* are recorded for the first time from Japan and *T. taihokuensis* for the first time from the Ryukyus. The most abundant copepod was *T. crassus* except for in the reservoirs of dams on Ishigaki Island, where *T. taihokuensis* and *M. thermocyclopoides* were dominant. A comparison with Kiefer's study of more than 50 years ago on a pond in Okinawa Island indicates that the copepod fauna in the pond has apparently changed. Eutrophication and introduction of African cichlid fish are considered as possible causes. The copepod fauna in Okinawa differs from that on the mainland of Japan in that some species which are common in the latter are absent in the former where *S. sarsi* is instead common.

Key words: species composition, taxonomy, Copepoda, limnoplankton, Okinawa

Introduction

The freshwater copepod fauna of the Ryukyus has been studied by Kiefer (1938), Ito (1955, 1962) and Ishida (1990). With regard to limnoplanktonic copepods in Okinawa, the southern half of the Ryukyus (Fig. 1), Kiefer (1938) and Ito (1955) recorded five cyclopid species, *Eucyclops serrulatus* (Fischer, 1851), *Tropocyclops prasinus* (Fischer, 1860), *Microcyclops varicans* (Sars, 1863), *Mesocyclops leuckarti* (Claus, 1857) and *Thermocyclops hyalinus* (Rehberg, 1880) from ponds in Okinawa and Kume Islands; the last species *T. hyalinus* is synonymous with *T. crassus* (Fischer, 1853) (see Defaye et al. 1987). However, it was considered necessary to resurvey limnoplanktonic copepods in Okinawa because of the following reasons. First, the conditions in their habitats have changed over the long time since these studies were done. Second, freshwater copepods have not been studied in the Yaeyama Group, the southernmost group in the Ryukyus, except for those copepods found in streams (Ishida 1990). Thirdly, Kawabata & Defaye (1994) and Ueda et al. (1996) indicated that previous recordings of *E. serrulatus* and *M. leuckarti* in Japan were taxonomically doubtful. We examined plankton samples collected from ponds and reservoirs on Okinawa, Ishigaki and Iriomote Islands, of which the latter two belong to the Yaeyama Group. These ponds and reservoirs

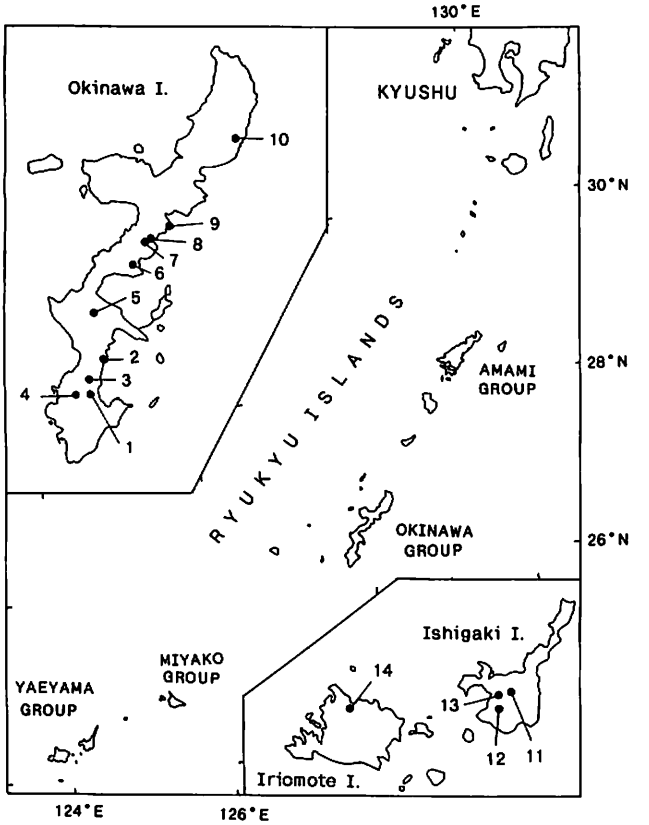

Fig. 1. Map of the Ryukyu Islands with insets showing sampling localities on Okinawa, Ishigaki and Iriomote Islands. The numbers of the localities correscpond to those in the text.

were made after World War II and copepods in these waters have not been studied. We identified five cyclopid species, *E.* cf. *speratus* (Lilljeborg, 1901), *Mesocyclops ruttneri* Kiefer, 1981, *M. thermocyclopoides* Harada, 1931, *T. crassus* (Fischer, 1853) and *T. taihokuensis* Harada, 1931, and a calanoid copepod *Sinodiaptomus sarsi* (Rylov, 1923). Of these species, *M. ruttneri*, *M. thermocyclopoides* and probably *S. sarsi* are recorded for the first time from Japan, and *T. taihokuensis* from the Ryukyus. This paper describes the copepods, especially the newly recorded species, and briefly compares the present fauna with that found in the previous studies done in Okinawa.

Materials and Methods

Sampling localities are shown in Fig. 1 and sampling dates are described below. Samplings at localities 1 and 2 were made by vertical hauls of a plankton net of 0.1-mm mesh from a depth of 3 m and those at the other localities were done by throwing a plankton net of the same mesh-size from the shore and towing it horizontally. All samples were preserved in formaldehyde solution until examination. Dissection and measurements were made in lactophenol and drawings were made with the aid of a camera lucida. For detailed observations of fine hairs and spinules, we used a differential interference microscope (Nikon NT–16) at a magnification of ×500.

Results

Species Composition

Species occurring at each locality are listed according to their abundance as follows. Single or double asterisks in parentheses indicate a species was dominant or that it was overwhelmingly abundant comprising >90% of the total number of copepods, respectively.

Locality 1.—"Haebaru-damu", a farming pond in Ikeda, Haebaru Town, Okinawa I., monthly from 10 Dec. 1984 to 26 Nov. 1985: *Thermocyclops crassus* (**), *Sinodiaptomus sarsi*, *Mesocyclops ruttneri*, *Eucyclops* cf. *speratus* (only 1 female and 2 males on 27 March 1985).

Locality 2.—"Nakagusuku-damu", a farming pond in Nakagusuku Village, Okinawa I., monthly from 1 Nov. 1984 to 13 Dec. 1985 (except Dec. 1984 and June 1985): *Thermocyclops crassus* (* throughout the year, ** from Dec. to May), *Sinodiaptomus sarsi*, *Mesocyclops ruttneri*.

Locality 3.—"Senbaru-ike", an artificial pond at the University of the Ryukyus, Nishihara Town, Okinawa I., 2 Aug. 1991: *Thermocyclops crassus* (*), *Mesocyclops ruttneri*, *Sinodiaptomus sarsi*.

Locality 4.—"Ryûtan-ike", a pond in Shuri, Naha City, Okinawa I., 11 Aug. 1991 and 21 Jan. 1992: *Thermocyclops crassus* (**), *Sinodiaptomus sarsi*, *Mesocyclops ruttneri*.

Locality 5.—Tengan Dam, Ishikawa City, Okinawa I., 19 Aug. 1991: *Thermocyclops crassus* (**), *Mesocyclops thermocyclopoides*.

Locality 6.—Kin Dam, Kin Town, Okinawa I., 19 Aug. 1991: *Mesocyclops* sp. (copepodid) (**), *Thermocyclops crassus*.

Locality 7.—Nabekawa Dam, Ginoza Village, Okinawa I., 19 Aug. 1991: *Thermocyclops crassus* (*), *Mesocyclops* sp. (copepodid).

Locality 8.—Katabaru Dam, Ginoza Village, Okinawa I., 19 Aug. 1991: *Thermocyclops crassus* (*), *Mesocyclops* sp. (copepodid).

Locality 9.—Henoko Dam, Nogo City, Okinawa I., 19 Aug. 1991: *Mesocyclops* sp. (copepodid) (**), *Thermocyclops crassus*.

Locality 10.—Arakawa Dam, Higashi Village, Okinawa I., 30 Aug. 1991: *Thermocyclops crassus* (**), *Mesocyclops* sp. (copepodid).

Locality 11.—Sokohara Dam, Ishigaki I., 27 Aug. 1991: *Thermocyclops taihokuensis* (*), *Mesocyclops thermocyclopoides*, *Sinodiaptomus sarsi*.

Locality 12.—Ishigaki Dam, Ishigaki I. 27 Aug. 1991: *Mesocyclops thermocyclopoides* (**), *Thermocyclops taihokuensis*, *Sinodiaptomus sarsi*.

Locality 13.—artificial farming ponds in Nagura, Ishigaki I., 27 Aug. 1991: *Thermocyclops crassus* (**).

Locality 14.—artificial ponds in Funaura, Iriomote I., 13 March 1991: *Thermocyclops crassus* (**).

Description

Cyclopoida

Eucyclops cf. ***speratus*** (Lilljeborg, 1901) (Fig. 2)

Body length.—Female, 1.00 mm (n=1); male, 0.75 and 0.79 mm (n=2).

Remarks.—This species was described under the same name from ponds in Kyushu by Ueda et al. (1996a) and from a stream in the limestone cave "Akiyoshido", Yamaguchi, by

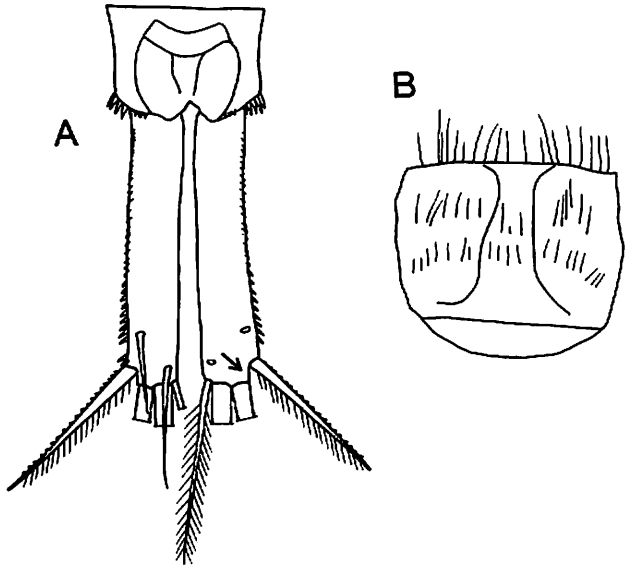

Fig. 2. *Eucyclops* cf. *speratus*. Female from locality 1, 27 March 1985. **A.** Anal somite and caudal rami; dorsal. **B.** Coupler of leg 4; caudal.

Ueda et al. (1996b). It is distinguishable from related species through the following characteristics: convex margin of the anal operculum (Fig. 2A), longer caudal rami with well developed lateral denticles, wide gap distance between the bases of the lateral terminal caudal seta and the next terminal seta (Fig. 2A, arrow), and long hairs on the distal margin of the leg 4 coupler (Fig. 2B). *Eucyclops* cf. *serrulatus* described by Kiefer (1938) from Ryûtan-ike (locality 4), Okinawa Island, is probably the present species because he described long caudal rami and well-developed lateral denticles on the rami. However, it is unknown whether Ito's (1955, 1962) *E. serrulatus* from Okinawa and Okino-erabu Islands is identical to the present species or not, since he made no useful descriptions. We found only 1 female and 3 males in a sample from locality 1, indicating that the species is not a common plankter in the limnetic waters of Okinawa.

Mesocyclops ruttneri Kiefer, 1981 (Fig. 3)

Female.—Body (Fig. 3A) length 1.13–1.28 mm (n=6) from locality 1, 28 Sep. 1985; 1.32 mm (n=1) from locality 4, 11 Aug. 1991. Pediger 5 (Fig. 3B) naked on lateral sides. Posterior margin of proximal part of seminal receptacle acutely V-shaped from copulatory pore. Caudal ramus (Fig. 3C, D) 3.2–3.4 times longer than broad, with spinules at bases of anterolateral seta and lateral terminal seta; dorsal seta 0.8–1.0 times as long as lateral terminal seta. Antennule (Fig. 3E) article 4 with 1 transverse row of spinules. Ornamentation of antennary basis as in Fig. 3F, G. Leg 4 (Fig. 3H) coupler with long, acute spiniform processes on distal margin; medial expansion of basis naked; medial terminal spine of endopod 3 (Fig. 3I) 1.3 times longer than lateral terminal spine. Spine on terminal segment of leg 5 (Fig. 3B) 0.7–0.8 times as long as terminal seta.

Male.—Body (Fig. 3J) length 0.74 mm (n=1) from locality 1, 28 Sep. 1985. Caudal ramus (Fig. 3K, L) 2.9 times longer than broad. Leg 4 coupler (Fig. 3M) and terminal spines of endopod 3 (Fig. 3N) as in female.

Remarks.—*Mesocyclops ruttneri*, originally described by Kiefer (1981) from a greenhouse in Austria, was considered a synonym of *M. pehpeiensis* Hu, 1943 (Dussart & Fernando 1985; Lim & Fernando 1985). However, Reid (1993) redescribed *M. ruttneri* from China, Thailand,

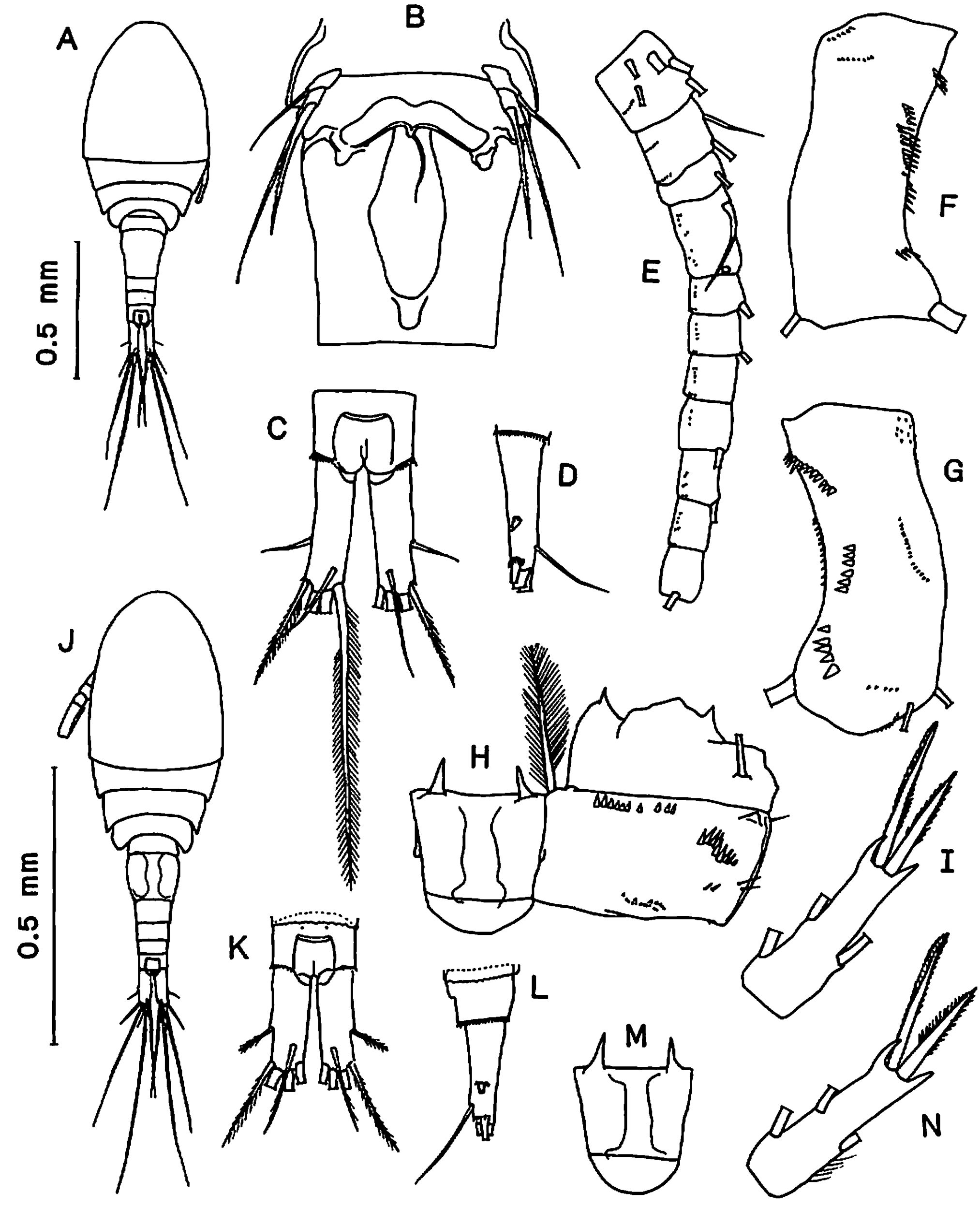

Fig. 3. *Mesocyclops ruttneri*. Female from locality 1, 28 Sep. 1985. **A.** Habitus. **B.** Pediger 5 and genital double somite; ventral. **C.** Anal somite and caudal rami; dorsal. **D.** Left caudal ramus; lateral. **E.** Antennular articles 4–14; ventral. **F.** Antennary basis; frontal. **G.** Antennary basis; caudal. **H.** Leg 4 coupler, coxa and basis; caudal. **I.** Leg 4 endopod 3. Male from locality 1, 28 Sep. 1985. **J.** Habitus. **K.** Anal somite and caudal rami; dorsal. **L.** Right caudal ramus; lateral. **M.** Leg 4 coupler. **N.** Leg 4 endopod 3. Scales apply to A and J.

Viet Nam and the U.S.A. along with Kiefer's (1981) type specimens, because it differs somewhat from all previous descriptions of *M. pehpeiensis*, which also differ among themselves. Although she stated that a comparison of the topotype specimens of *M. pehpeiensis* is essential for final taxonomic determination, we assigned our specimens to *M. ruttneri* on the basis of their shorter caudal ramus (3.6–4.0 times longer than broad in Hu's (1943) original description) and shorter spine on leg 5 (approximately equal to the terminal seta dimensions in Hu's). The shape of the posterior margin of the proximal part of the seminal receptacle and the spinules on the caudal side of the antennary basis and on the caudal rami are the characters that distinguish *M. ruttneri* from the subsequently described *M. pehpeiensis* (see Reid 1993). Kawabata & Defaye's (1994) *M. pehpeiensis* from Lake Kahoku-gata is thought to be *M. ruttneri* based on the lengths of the caudal ramus and the spine of leg 5. This species occurred at localities 1, 2, 3 and 4, suggesting that the species prefers eutrophic, small ponds.

Mesocyclops thermocyclopoides Harada, 1931 (Figs 4, 5)

Female.—Body (Fig. 4A) length 0.88–0.98 mm (n=3) from locality 11. Pediger 5 (Fig. 4B, C) with hairs laterally and dorsally, ventralmost hairs arranged longitudinally and thicker than more dorsal ones. Genital double somite haired dorsally; posterior margins of proximal part of seminal receptacle divergent from copulatory pore at straight angle. Posterior margin of anal somite (Fig. 4D, E) with spinules ventrally, naked dorsally and laterally. Caudal ramus (Fig. 4D) 3.0 times longer than broad, without spinules at bases of anterolateral seta and lateral terminal seta; dorsal seta about 1.5 times longer than lateral terminal seta. Antennule (Fig. 4F) article 4 with 2–3 transverse rows of spinules. Ornamentation of antennary basis as in Fig. 4G–I. Maxillulary palp (Fig. 4J) without spinules. Maxillar (Fig. 4K) coxa with irregular row of minute spinules on frontal side. Leg 4 (Fig. 4L) coupler with blunt triangular processes on distal margin; medial expansion of basis haired densely; medial terminal spine of endopod 3 with no or barely distinguishable spinules on lateral margin, 0.9–1.0 times as long as lateral terminal spine.

Male.—Body (Fig. 5A) length 0.64 and 0.66 mm (n=2) from locality 11. Posterior margin of anal somite (Fig. 5B, C) with spinules not only ventrally but dorsally and laterally. Caudal ramus (Fig. 5B, C) 2.6–3.2 times longer than broad, with spinules at bases of anterolateral seta and lateral terminal seta. Ornamentation of caudal side of antennary basis as in Fig. 5D. Leg 4 (Fig. 5E, F) as in female.

Remarks.—Holynski (1994) redescribed *Mesocyclops thermocyclopoides* in detail using topotype specimens to solve the *M. thermocyclopoides*-complex problem. Our specimens certainly fit the description of *M. thermocyclopoides* s. str. described by her based on the following characters in the female: the maxillar coxa with spinules on the frontal side, which is characteristic to the *thermocyclopoides* species-group (Holynski & Fiers 1994); the antennary basis having a distal group of large spinules on the caudal side (Fig. 4H, arrow), by which *M. thermocyclopoides*, *M. ogunnus* Onabamiro, 1957 and *M. dussarti* Van de Velde, 1984 can be distinguished from other members of the group (Holynski 1994); the maxillulary palp without spinules, which are present in *M. ogunnus*; the caudal ramus lacks spinules at the base of the lateral terminal seta, which are present in *M. ogunnus* and *M. dussarti*. Kawabata (1989) reported *M. thermocyclopoides* from Japan for the first time, but later it was reidentified as a new species, *M. dissimilis*, by Defaye & Kawabata (1993). This species is different from *M. thermocyclopoides* in the shape of the posterior margin of the proximal part of the seminal receptacle, spinules at the base of the lateral caudal setae, and so on. Because *M. leuckarti*, formerly the single representative of the genus in Japan, is considered to be restricted to Europe and West Asia (Kiefer 1981) and Kawabata & Defaye's (1994) *M. pehpeiensis* was thought to be a synonym of *M. ruttneri* as noted above, the species of the genus that can be considered to have been identified correctly in Japan are *M. dissimilis*, *M. ruttneri* and *M. thermocy-*

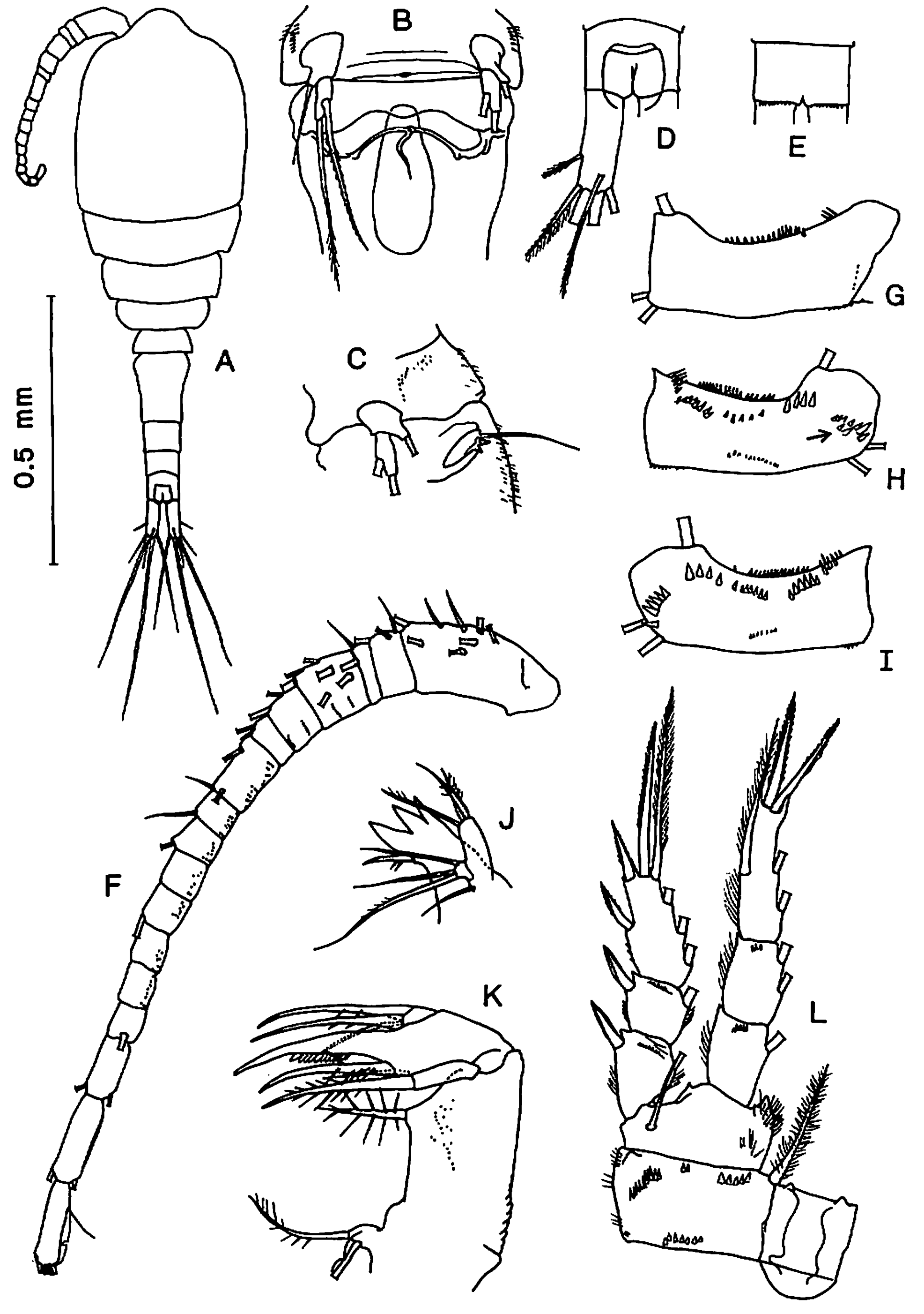

Fig. 4. *Mesocyclops thermocyclopoides*. Female from locality 11. **A.** Habitus. **B, C.** Pediger 5 and genital double somite; ventral and lateral, respectively. **D.** Anal somite and caudal ramus; dorsal. **E.** Anal somite; ventral. **F.** Antennule; ventral. **G.** Antennary basis; frontal. **H, I.** Antennary basis, caudal. **J.** Maxillulary palp. **K.** Maxilla; frontal. **L.** Leg 4. caudal. Scale applies to A.

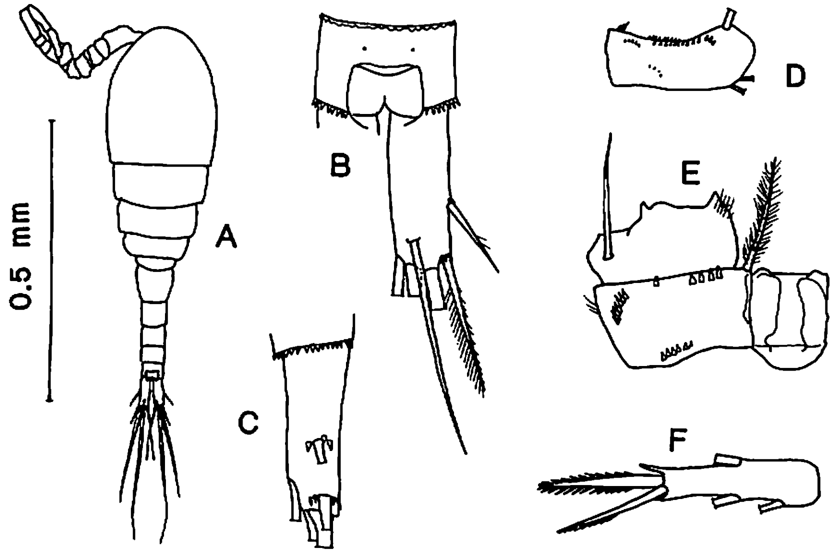

Fig. 5. *Mesocyclops thermocyclopoides.* Male from locality 11. **A.** Habitus. **B, C.** Anal somite and right caudal ramus; dorsal and lateral, respectively. **D.** Antennary basis; caudal. **E.** Leg 4 coupler, coxa and basis; caudal. **F.** Leg 4 endopod 3. Scale applies to A.

clopoides. In Okinawa, *M. thermocyclopoides* occurred only in relatively large reservoirs of dams (localities 5, 11 and 12).

Thermocyclops crassus (Fischer, 1853) (Fig. 6A–G)

Body length.—Female (Fig. 6A) 0.79–0.84 mm (n=5), male (Fig. 6E) 0.62–0.64 mm (n=5) from locality 1, 6 July 1985.

Remarks.—In Japan *Thermocyclops crassus* had been recorded as *T. hyalinus* until Kawabata & Defaye's (1994) description from Lake Kahoku-gata. This species is well defined in having the following characters (Defaye et al. 1987): short caudal rami (Fig. 6C, F); medial median caudal seta curved ventrally at the extremity (Fig. 6A, E); seminal receptacle with short, round lateral arms (Fig. 6B); endopod of leg 4 with a short lateral terminal spine (about 1/2 the length of the medial one) (Fig. 6D, G), and so on. This species is one of the most common freshwater copepods throughout Japan (Mizuno 1984b). In the present study, it occurred at all localities except for in the reservoirs of dams on Ishigaki Island and was usually the most abundant copepod (sometimes comprising >99% of the total number of copepods).

Thermocyclops taihokuensis Harada, 1931 (Fig. 6H–N)

Body length.—Female (Fig. 6H) 0.84–0.94 mm (n=4), male (Fig. 6L) 0.64–0.69 mm (n=3) from locality 11.

Remarks.—*Thermocyclops taihokuensis* can be easily identified based on the following characters: dorsal caudal seta 2–2.5 times longer than lateral terminal seta (Fig. 6J, M); long curved lateral arms of the seminal receptacle (Fig. 6I); endopod of leg 4 with a very short lateral terminal spine (Fig. 6K, N). In Japan this species was recorded from Kyushu through central Honshu (Mizuno 1984b) but not from the Ryukyus though it was originally described from Taiwan. In this study it occurred only in the reservoirs of dams on Ishigaki Island (localities 11 and 12), where *T. crassus* was absent.

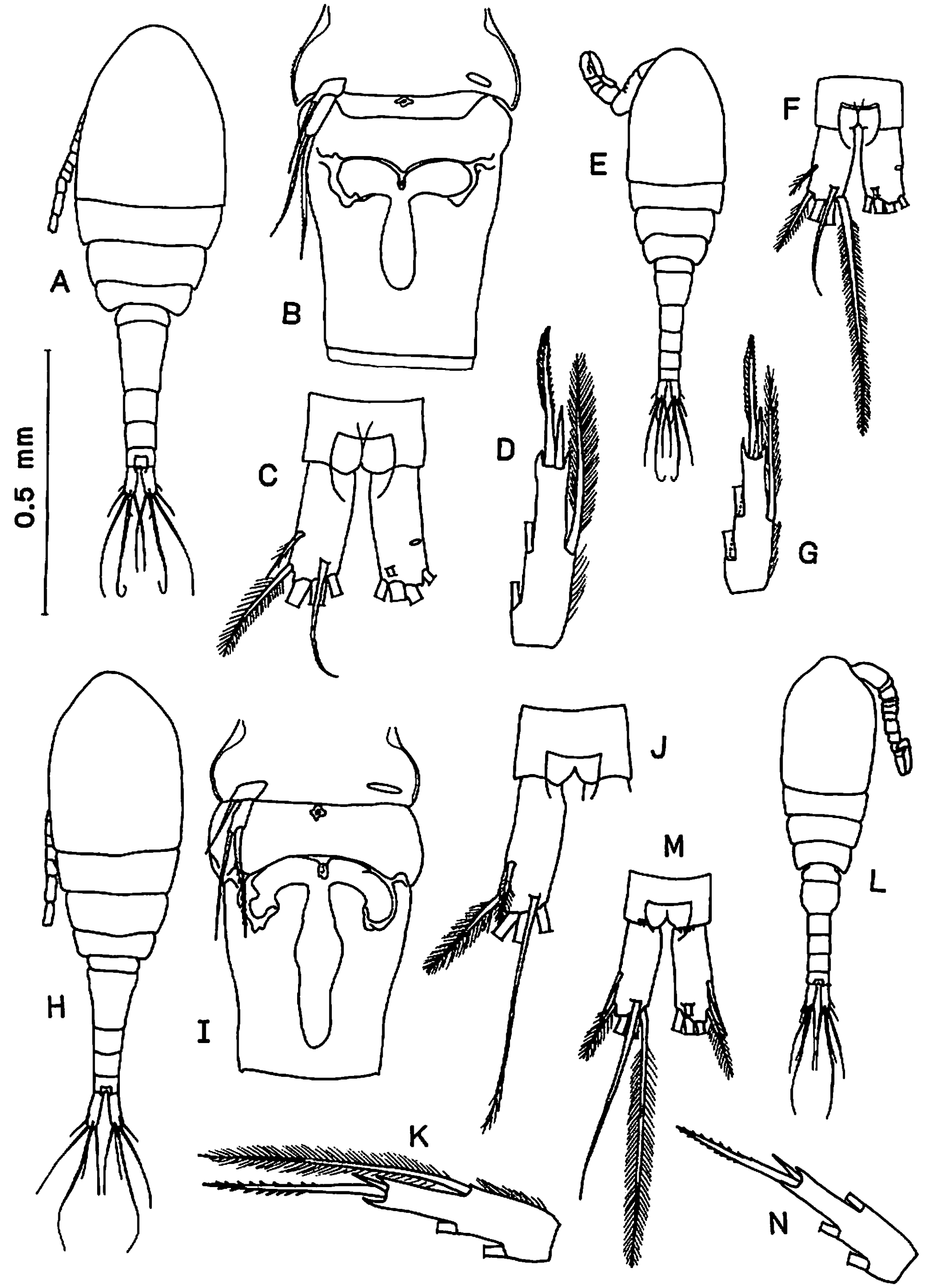

Fig. 6. *Thermocyclops crassus*. Female from locality 1, 6 July 1985. **A.** Habitus. **B.** Pediger 5 and genital double somite; ventral. **C.** Anal somite and caudal rami; dorsal. **D.** Leg 4 endopod 3. Male from locality 1, 6 July 1985. **E.** Habitus. **F.** Anal somite and caudal rami; dorsal. **G.** Leg 4 endopod 3. *Thermocyclops taihokuensis*. Female from locality 11. **H.** Habitus. **I.** Pediger 5 and genital double somite; ventral. **J.** Anal somite and caudal ramus; dorsal. **K.** Leg 4 endopod 3. Male from locality 11. **L.** Habitus. **M.** Anal somite and caudal rami; dorsal. **N.** Leg 4 endopod 3. Scale applies to A, E, H and L.

Calanoida

Sinodiaptomus sarsi (Rylov, 1923) (Fig. 7)

Female.—Body (Fig. 7A) length 2.04–2.12 mm (n=3) from locality 2, 20 Apr. 1985 and 1.62–1.82 mm (n=3) from locality 2, 31 Aug. 1985. Pediger 4 (Fig. 7B–D) fused with pediger 5, with middorsal process directed posterodorsally; lateralmost processes of pediger 5 symmetrical, but medial lateral process of right wing (Fig. 7C, arrow) more developed than left one and directed upwards. Antennule (Fig. 7A) extending almost to caudal setae. Right and left coxae of leg 5 (Fig. 7E) fused; exopod 1 about 2.5 times longer than broad; endopod 2-segmented.

Male.—Body (Fig. 7F) length 1.94–2.06 mm (n=3) from locality 2, 20 Apr. 1985 and 1.49–1.79 mm (n=3) from locality 2, 31 Aug. 1985. Pediger 5 (Fig. 7G) asymmetrical, left wing triangular and right one rounded; each wing with pointed lateral process and small medial spine. Right antennule (Fig. 7H) with spiniform processes on articles 10, 11 and 13–16, of which process on article 15 (Fig. 7H, arrow) longer than that on article 14; antepenultimate article (Fig. 7I) with comb-like process. Basis of right leg 5 (Fig. 7J) with broad, triangular distal process on caudal side; exopod 2 about 1.3 times as long as broad, with lateral spine nearly as long as endopod. Left leg 5 with 3-segmented exopod and 2-segmented (sometimes incompletely segmented) endopod; exopod 2 with curved, hairy spine on frontal surface; thumb-like exopod 3 with transverse membranous folds on medial surface.

Remarks.—Mizuno (1984a, 1991) summarized the studies on *Sinodiaptomus* in Japan as follows. There had been records of *S. sarsi*, *S. valkanovi* Kiefer, 1938 and *S. chaffanjoni* (Richard, 1897) from Japan. Ito (oral presentation in 1953; after Mizuno 1991) reexamined Japanese, Chinese and Mongolian specimens and concluded that all Japanese populations belonged to *S. valkanovi* and the other two species were distributed in China and Mongolia. Notwithstanding, reports of *S. sarsi* and *S. chaffanjoni* were still made in Japan even after Ito's conclusion was presented. Identifications of the species in these records are doubtful because they appeared only in species lists without accompanying morphological descriptions. In conclusion, *S. valkanovi* was formerly held to be the single, undoubted representative of the genus in Japan and this is the first valid description of *S. sarsi* s. str. from Japan.

Sinodiaptomus sarsi is distinguishable from *S. chaffanjoni*, described by Shen & Song (1979), in the following respects: in the female, wings (especially right wing) of pediger 5 are more produced laterally and exopod 1 of leg 5 is more slender; in the male, right leg 5 has a triangular distal process on exopod 1 and a shorter lateral spine on exopod 2. It also differs from *S. valkanovi*, as described by Kiefer (1978), in the following characters in the male: process on article 15 of the right antennule is longer than that on the preceding one, distal process of exopod 1 on right leg 5 is much broader and lateral spine on exopod 2 is nearly as long as the endopod (much shorter in *S. valkanovi*). *Sinodiaptomus valkanovi* was originally described as the subspecies *S. sarsi valkanovi* and reported, as the subspecies, by Dussart & Defaye (1983) and Reddy (1994). In Japan, however, it has been reported as the species though we cannot find the reference which elevated it to the species level. In any case, it had already been listed as an independent species in Ito's (1965) description. Reddy (1994) erroneously cited that Tomikawa (1971) had decided to elevate it to the species level; Tomikawa used the misspelt species name "*S. volkanoni*" for his specimens but did not discuss its status at all. Regarding the status of *S. valkanovi*, Reddy not only opposed its species status but had doubts about the subspecies status because of the wide range of variation in some diaptomid species. We refer to it as a species in the present paper, regardless of Reddy's doubts on its

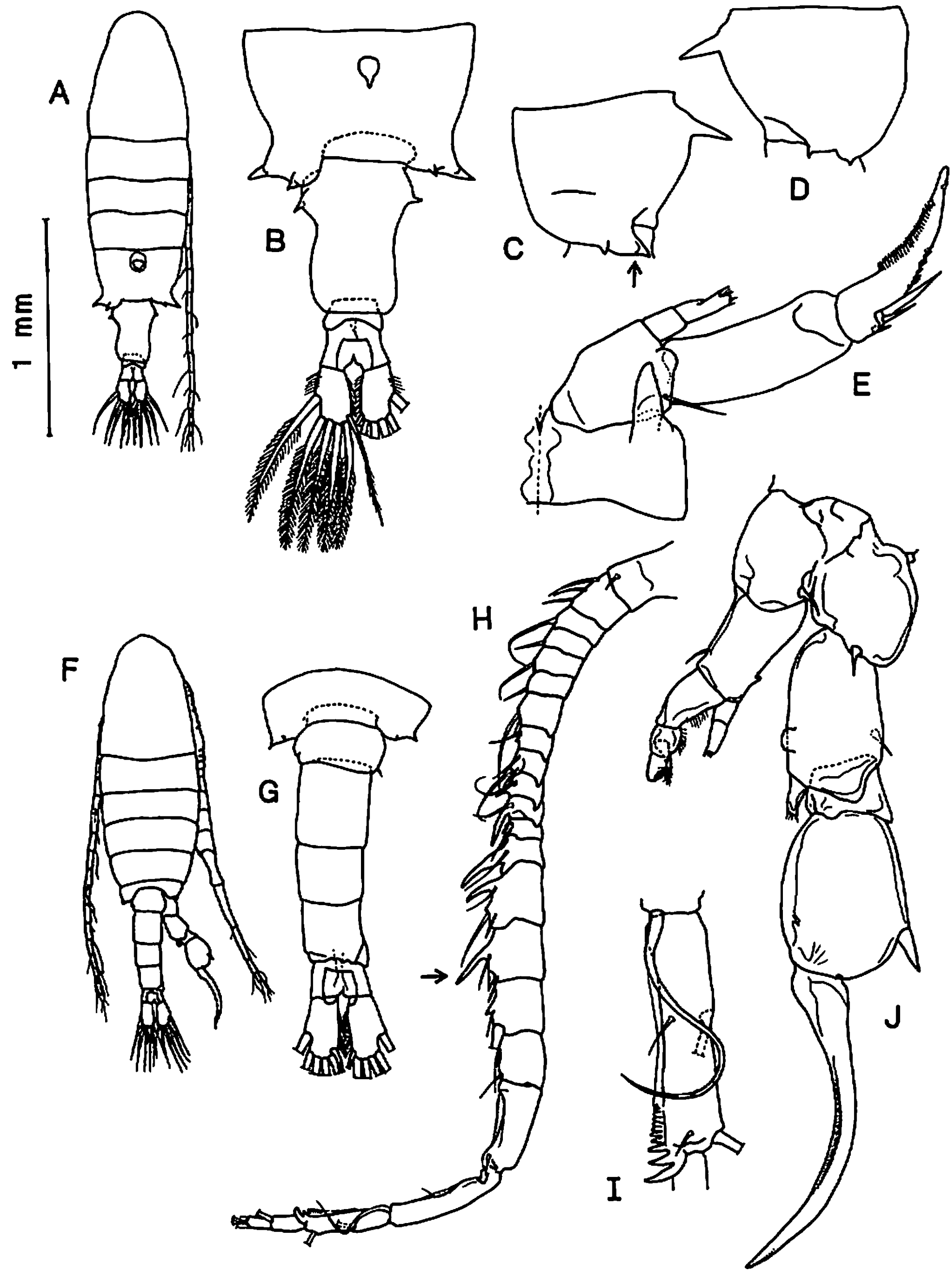

Fig. 7. *Sinodiaptomus sarsi*. Female from locality 2, 31 Aug. 1985. **A.** Habitus. **B.** Pedigers 4, 5 and urosome; dorsal. **C.** Pedigers 4 and 5; left lateral. **D.** Pedigers 4 and 5; right lateral. **E.** Left leg 5; caudal. Male from locality 2, 31 Aug. 1985. **F.** Habitus. **G.** Pediger 5 and urosome; dorsal. **H.** Right antennule; ventral. **I.** Antepenultimate article of right antennule. **J.** Leg 5; caudal. Scale applies to A and E.

status, because the characters in *S. sarsi* that differ from those in *S. valkanovi* noted above show no significant intra- or interpopulation variability. However, examination of morphological variations in *S. valkanovi* and a detailed comparison of *S. sarsi* and *S. valkanovi* are necessary to settle the *S. sarsi-valkanovi* problem conclusively. *Sinodiaptomus sarsi* occurred in both eutrophic small ponds, where it was relatively abundant (e.g., at locality 2 it comprised >10% of the total number of copepods from July to October), and large reservoirs of dams such as locality 11.

Discussion

The present study revealed that *Thermocyclops crassus* is the overwhelmingly dominant (>90%) species in Ryûtan-ike pond (locality 4) in both summer and winter. However, Kiefer (1938) identified *Eucyclops* cf. *serrulatus*, *Microcyclops varicans* and *Mesocyclops leuckarti* in a sample collected from the same pond by Dr. Miyazi on 19 Jan. 1937. Absence of *T. crassus*, which is presently the most abundant species, in his sample indicates that the copepod fauna in the pond has changed since 1937. This change may be partly accounted for by changes in condition of the water, especially eutrophication caused by a decrease in depth due to sedimentation. Because the pond is in Shuri Castle Park in Naha City, it was dredged after our 1992 sampling to help bring back its original depth and clarity. Another possible explanation for the shift in copepod species abundance is that the predatory fauna has changed. It is known that dominant zooplankters in limnetic waters can be replaced by smaller-sized, more evasive species due to the introduction of a size-selective planktivorous fish (e.g., Brooks & Dodson 1965; Drenner et al. 1982). In Okinawa, the African cichlid *Oreochromis* (formerly known as *Tilapia*) was introduced for aquaculture during the 1950s. It has colonized many ponds and is now very abundant in Ryûtan-ike pond. Predation by the fish, especially its fry which are considered to be voracious zooplankton predators, may have eliminated larger copepods such as *Mesocyclops* from the ponds and enhanced the propagation of *T. crassus*, the smallest copepod species found in this study.

According to Mizuno (1984a, b), the most common cyclopoid copepods widely distributed throughout Japanese limnetic waters are *Eucyclops serrulatus*, *Mesocyclops leuckarti*, *Cyclops vicinus* Uljanin, 1875 and *Thermocyclops hyalinus* (=*T. crassus*), and the calanoid species are *Eodiaptomus japonicus* (Burkhardt, 1913) and *Sinodiaptomus valkanovi*. Of these species, *E. serrulatus* and *M. leuckarti* are considered to be complexes of related species as noted above. In contrast, our results show that the most common planktonic copepods in Okinawa are presently *Thermocyclops crassus*, *Mesocyclops ruttneri* and *Sinodiaptomus sarsi* except in the reservoirs of dams on Ishigaki Island, where *T. taihokuensis* and *M. thermocyclopoides* were dominant. Thus, the limnetic copepod fauna of Okinawa is similar to that on the mainland of Japan in the commonness of *T. crassus* but differs in the absence of *Cyclops vicinus* and the two diaptomid species and in the preponderance of *S. sarsi* rather than *S. valkanovi*.

Acknowledgments

We are grateful to Dr. S. Shokita, the University of the Ryukyus, for providing us the samples from localities 1 and 2, and Mr. T. Hoshino for his help in the samplings at the other localities.

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