

Freshwater Cyclopoid Copepods (Cyclopoida, Cyclopidae) of Korea

Kim, Hoon Soo and *Chang, Cheon Young

(Department of Zoology, College of Natural Sciences, Seoul National University, Seoul 151-742; *Department of Biology,
College of Natural Sciences, Taegu University, Kyöngbuk 713-714, Republic of Korea)

한국 담수산 검물벼룩류(키클로프스 목, 검물벼룩 과)

김 훈 수 · *장 천 영

(서울대학교 자연과학대학 동물학과 · *대구대학교 자연과학대학 생물학과)

적 요

1983년 5월부터 1989년 5월까지 남한의 각종 담수역 총 141개 지점에서 채집하여 서울대학교 동물학부에 보관중이던 검물벼룩류의 표본들을 검토한 결과 검물벼룩과에 속하는 2아과 12속 25종 및 아종을 동정하였다. 이중 한국미기록종으로 밝혀진 17종에 대하여는 재기재를 하고 도판을 작성하였다.

Key words: systematics, Copepoda, Cyclopoida, freshwater, Korea.

INTRODUCTION

Family Cyclopidae is the only one that occurs in pure freshwater of 12 families belonging to order Cyclopoida and comprising more than 800 species or subspecies of 40 genera all over the world. In Korea, total twelve species [*Macrocyclops fuscus* (Jurine); *M. albidus* (Jurine); *Eucyclops serrulatus* (Fischer); *Paracyclops fimbriatus* (Fischer); *Cyclops strenuus* Fischer; *C. picinus* Uljanin; *Diacyclops disjunctus* (Thalwitz); *D. languidoides* (Lilljeborg); *Mesocyclops leukarti* (Claus); *Thermocyclops taihokuensis* (Harada); *T. hyalinus* (Rehberg); *T. oithonoides* (Sars)] have been reported in process of researches on limnological conditions (Ueno, 1941; Yamamoto, 1941; Cho, 1965, 1968, 1971, 1974, 1976; Kang and Shin, 1968; Chung, 1968; Cho and Park, 1969; Kang, 1969; Hong *et al.*, 1969; Kim and Park, 1969; Cho and Ra, 1971; Cho and Mizuno, 1977; Kim, 1978; Kim and Lee, 1978; Cho *et al.*, 1978; Mizuno *et al.*, 1980; Chung and Yoo, 1983; Yoo *et al.*, 1987). But those limnological studies have not been accomplished from

This research was supported by the grant from Korea Science and Engineering Foundation during 1986-1987.

taxonomical purposes, and were limited mainly to planktons inhabiting large water bodies like rivers and dams, especially the Han River. Following the paper on calanoid fauna of Korea (Chang and Kim, 1986), the present study aims at clarifying the fauna of cyclopoid copepods occurred in various freshwater habitats in Korea taxonomically.

MATERIALS AND METHODS

The materials on which the present study is based were collected from various freshwater habitats such as rivers, lakes, reservoirs, ponds, swamps, bogs, streamlets, rice fields and springs at 141 localities (Fig. 1) in South Korea during the period from May 1983 to May 1985.

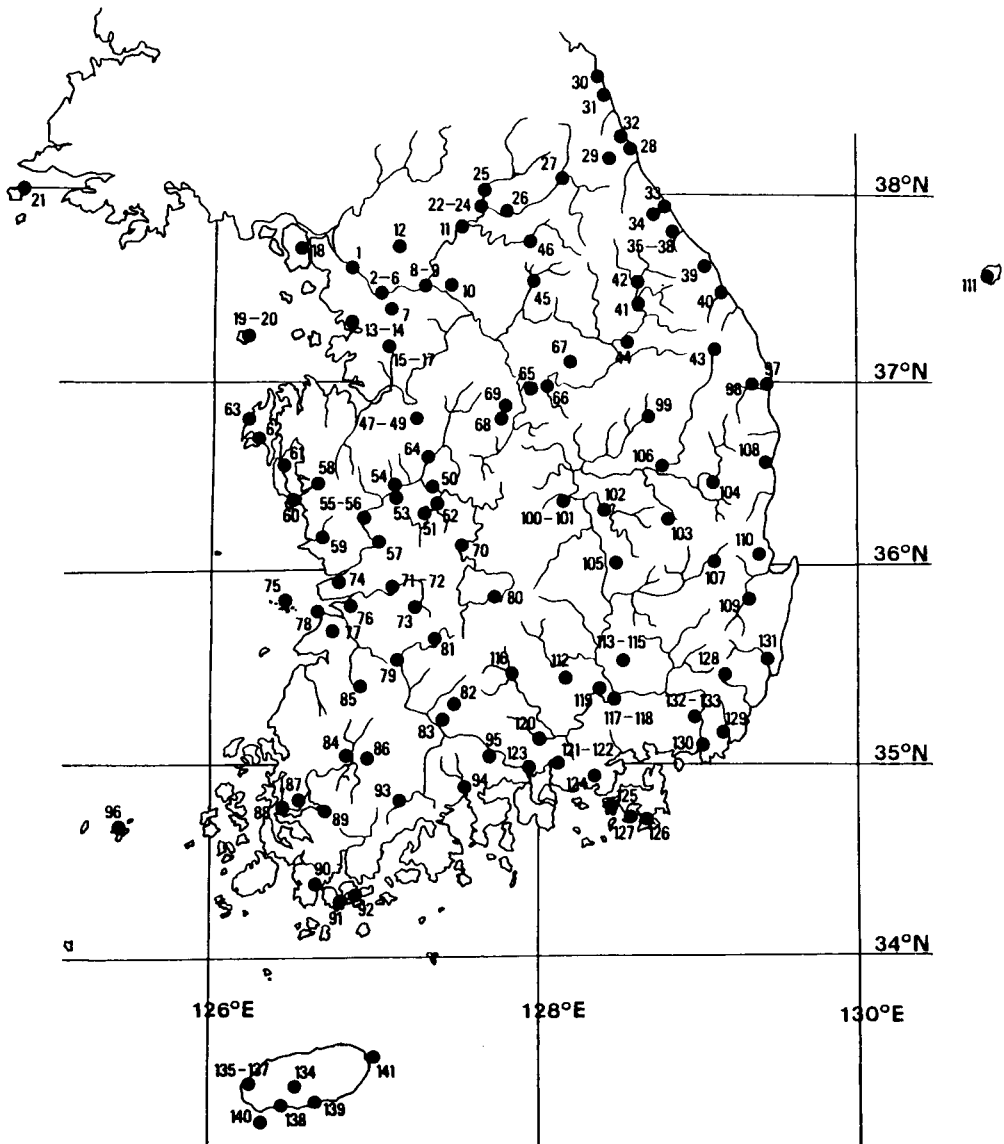


Fig. 1. A map showing the localities.

Materials

The materials from which the collector's name is omitted here are the ones that were collected by the authors themselves.

Seoul and Kyōnggi-do: 1, Haengjunaru(Han R.); 2, Pamsōm I.(Han R.), a, 5 VII 1987; b, 22 V 1987; 3, Sōkchon Pond, 31 V 1984; 4, a pond in Kyōnghee Univ., 26 X 1984; 5, Kwangnaru(Han R.), 22 V 1987; 6, a pond in Seoul Nat'l Univ., a, 10 VIII 1983; b, 12 III 1986; 7, Kwachōn Park Res., 13 XI 1984; 8, Paldang Dam, 3 V 1984; 9, Yangsu-ri(Han R.), 12 VII 1984; 10, Yangpyōng(Han R.), 12 VII 1984; 11, Chōngpyōng(Han R.), 3 V 1984; 12, Wōndobong Mt., Uichōngbu, 1 VII 1987; 13, Hwarang Res., Ansan, a, 10 X 1986; b, 16 X 1986; 14, Kojan Res., Ansan, a, 10 X 1986; b, 16 X 1986; 15, Kwanggyo Res., Suwōn, 2 XI 1983; 16, Ilwōl Res., 2 XI 1983; 17, Shingal Res., 15 X 1983; 18, ricefield at Shinjōng-ri, Kanghwa I., 9 X 1984; 19, Sōpo-ri Res., Tōgjōk I., 22 V 1986; 20, a, a well at Chinmal village, Tōgjōk I., 6 V 1988, M.O. Song; b, Sōpo-ri, 22 V 1986, C.B. Kim; 21, a reservoir at Pugpo, Paekryōng I., 27 VII 1987.

Kangwōn-do: 22, Uiam Dam, 13 X 1984; 23, Kongjichōn, 13 IX 1986, I.H. Kim; 24, a pond in Kangwōn Nat'l Univ., a, 19 II 1988; b, 12 IX 1987; 25, Chunchōn Dam, 25 VII 1984; 26, Soyang Dam, 25 VII 1984; 27, a pool in Inje, 27 VII 1986, I.H. Kim; 28, Yōngrang Lake, Sokcho, 23 VII 1984, M.O. Song and K.S. Min; 29, a pool near Paekdamsa Temple, Sōlak Mt., 19 IX 1984; 30, a swamp near Hwajinp'o Lake, 22 IV 1989, S.M. Yoon; 31, Songji Lake, 21 IV 1989, S.M. Yoon and M.O. Song; 32, Kwanpoho Lake, 3 VI 1986, I.H. Kim; 33, Sachōn Streamlet, 23 III 1987; 34, a small spring at Samsan-ri, Myōngju-kun, 31 V 1987, I.H. Kim; 35, Ojukhōn Res., Kangrūng City, 22 VI 1987, I.H. Kim; 36, ricefields at Ponamdong, Kangrūng 17 III 1982; 37 a pond in Kangrūng College, 18 VII 1981, I.H. Kim; 38, Kyōngpo Lake, 22 IV 1989, S.M. Yoon and K.S. Min; 39, a swamp at Okkye, 2 X 1984; 40, ricefields and ditches at Hujin, 2 X 1984; 41, Chōngsōn Stream, 3 V 1987; 42, springs at Kujōl-ri Valley, 3 V 1987; 43, valley at Nūkku-ri, Tokye, 5 V 1987; 44, a, Changrūng Res., 16 IX 1986, I.H. Kim; b, a swamp, Yōngwōl, 21 VI 1986, I.H. Kim; 45, a bog at Hakkok-ri, Hoengsōng-kun, 20 VII 1986; 46, Hongchōn R., 20 VII 1986, K.W. Lee.

Chungchōngnam-do: 47, Ipchang Res., 2 III 1984; 48, Yangdang Res., Chiksan, 28 III 1984; 49, Ōpsōngdong Res., Chōnan, 29 III 1984; 50, Hoedōk Res., 9 XI 1983; 51, Pangdong Res., 15 III 1984; 52, a pond in Hannam Univ., 14 VI 1986; 53, Kapsa Res., Kyeryong Mt., 5 VII 1987; 54, a spring near Magok Temple, 6 VII 1987; 55, a pool in Puyō city, 11 X 1984; 56, Paekma R. 11 X 1984; 57, Hwangsan Ferry (Kum R.), Kangkyōng, 2 VIII 1986; 58, a small res. at Pyōkche, Kwangchōn, 3 VIII 1986; 59, Paedari Res., Sōchōn, 31 VII 1986; 60, ricefields at Hyoja I., 30 IX 1986; 61, a small res. at Paeksajang, Anmyōn I., 3 VIII 1984, J.H. Park; 62, a res. near Anhūng Harbor, 30 VII 1986; 63, a pond at Chōllipo Arboretum, 7 X 1985, S.M. Yoon.

Chungchōngbuk-do: 64, Osong Res., Chōngwōn-kun, 15 III 1984; 65, Myōnggam Res., Chōngju, a, 14 VI 1986; b, 13 IX 1984; c, 2 V 1987; 66, Chungju Lake, a, 2 V 1987; b, 12 VII 1986; 67, Uirimchi Res., 2 V 1987; 68, Koesan Dam, 4 IX 1984; 69, Chilsōng Res., Chechōn, 14 VII 1986; 70, a swamp and rice fields near Yōngguk Temple, Yangsan, 20 VII 1987.

Chōllabuk-do: 71, Kumma Res., Iksan-kun, 3 V 1988; 72, Chugyo Res., Iksan-kun, 3 V 1988; 73, Paeksōk Res., Chōnju, 3 V 1988; 74, a pond at Ūnjōk Temple, Kunsan, 1 X 1987; 75, Sōnyu I., 6 V 1986, a,

a ricefield; b, a well; 76, rice fields at Kimje, 20 IX 1984, I.H. Kim; 77, ricefields at Puan, 13 VIII 1981, I.H. Kim; 78, ricefields at Kyehwa I., 13 VIII 1981, I.H. Kim; 79, Unam Dam, 22 X 1983; 80, Tökyu Mt., 4 VII 1986, N.K. Paik; 81, a ditch near Imsil Bus Terminal, 2 VI 1988; 82, Namwön Stream near Namwön Station, 2 VI 1988.

Chöllanam-do: 83, Chungdong Res., Kogsöng, 2 VI 1988; 84, Naju (Yöngsan R.), 4 VII 1984, C.S. Lee; 85, Changsöng Dam, 4 XI 1983; 86, Kyori Res., Hwasun, 26 VI 1984, C.S. Lee; 87, Pokryong Res., Muan-kun, 4 VII 1984, C.S. Lee; 88, Yöngsan R. Barrage, 4 VII 1984, C.S. Lee; 89, Wölchul Mt., Yöngam, 26-29 VII 1988; 90, Turyun Mt. Haenam, 7 II 1987; 91, Chungdo Res., Wando, 5 II 1987; 92, a pool at Shinji I., 6 II 1987; 93, Posöng Dam, 14 VIII 1984; 94, a pool in Sunchön City, 6 VII 1986, I.H. Kim; 95, Suöji Res., Kwangyang, 20 I 1987; 96, a, Chinri Res., Taehüksan I., 19 VII 1986; b, a pool at Sohüksan I., 26 VIII 1987, H.S. Kim.

Kyöngsangbuk-do: 97, Yönji Swamp, Uljin; 98, a, a pond in Pulyöng Temple, 6 V 1987; b, a swamp near the Temple, 5 V 1987; 99, ricefields in Yöngju City, 4 VII 1986, I.H. Kim; 100, Konggalmot Res., Sangju, 19 IV 1986, S.M. Yoon; 101, Konggömjü Res., Sangju, 19 IV 1986, S.M. Yoon; 102, Taewön Res., Sönsan, 29 V 1988; 103, Kaüm Res., Uisöng, 26 V 1988; 104, Mapyöng Streamlet, Chöngsong, 29 V 1988; 105, Woikwan (Naktong R.), 10 VIII 1984, S.H. Park; 106, Andong Dam, 1 X 1984; 107, Yöngchön Dam, 27 V 1988; 108, ricefields, Pyönggok, 18 VII 1985, S.M. Yoon; 109, Pomun Res., Kyöngju, 27 V 1988; 110, Yongyönd Res., Yöngil-kun, 27 V 1988; 111, Sadong valley, Ulrüng I., 8 VIII 1985, S.M. Yoon.

Kyöngsangnam-do: 112, a swamp, Chöngyang-dong, Hapchön, 11 V 1988, K.S. Min; 113, Upo Swamp, Changyöng, a, 23 II 1988; b, 16 IV 1988; c, 21 I 1988; 114, Myöngdong Res., Changnyöng, 5 VI 1986, S.M. Yoon; 115, Mago Swamp, Yöngsan, 5 VIII 1986; 116, streamlet, Hamyang, 30 VI 1984, K.S. Min; 117, Oisong Swamp, Haman, a, 20 I 1988; b, 15 IV 1988; 118, Chilnal Swamp, Haman, a, 22 II 1988; b, 15 IV 1988; 119, Nam R., Pöpsu, 17 I 1987; 120, Chinyang Dam, a, 17 I 1987; b, 25 VII 1984; 121, a pond in Kyöngsang Nat'l Univ., 6 VII 1986, I.H. Kim; 122, Duryang Res., Sachön, 14 VIII 1984; 123, Songwön Res., a, 23 VIII 1984; b, 20 I 1987; 124, Taega Res., Kosöng, 21 VIII 1987; 125, Yonghwa Temple Res., Chungmu, 20 VIII 1987, M.O. Song; 126, a Swamp at Chöku-ri, Köje I., 18 VIII 1987; 127, a well at Uihang-ri, Hansan I., 20 VIII 1987; 128, Taeam Dam, Ulju, 30 I 1987, M.K. Shin; 129, Mulgüm (Naktong R.), 8 V 1986; 130, under Sönam Bridge, Kupo (Naktong R.), 28 IV 1987; 131, a pool at Kijang, 26 IV 1983, I.H. Kim; 132, Chunam Res., a, 21 II 1988; b, 14 IV 1988; 133, Tongpangemot (Swamp), 14 IV 1988;

Cheju I.: 134, a swamp, 1100 heights of Halla Mt., 22 II 1987; 135, a pond at Hyöpcha, 24 VIII 1984; 136, ricefield at Ongpo, 9 II 1987; 137, Kosan Res., 9 II 1987; 138, Chonjeyön Fall, 22 IV 1987; 139, Chonjiyön Fall, 11 VII 1981; 140, a well, Kapa I., 10 VII 1981; 141, pools, Udo I., 12 III 1987.

Collections were made with a dipnet or a conical plankton net of No. 10(or No. 25) mesh aperture. All samples were preserved in 95% alcohol. The isolated specimens were dissected and mounted in polyvinyl lactophenol. Drawing and measurings were made with a camera lucida. All specimens reported here are deposited in the Department of Zoology, Seoul National University.

LIST OF SPECIES

- Family Cyclopidae Sars, 1913 검(劍)물벼룩 과
 Subfamily Eucyclopinae Kiefer, 1927 진검(眞劍)물벼룩 아과
 Genus *Macrocyclus* Claus, 1893 장수검물벼룩 속
1. *Macrocyclus fuscus* (Jurine, 1820) 몽당꼬리장수검물벼룩
 - *2. *Macrocyclus distinctus* (Richard, 1887) 긴가시장수검물벼룩
 3. *Macrocyclus albidus* (Jurine, 1820) 맨송꼬리장수검물벼룩
 Genus *Eucyclops* Claus, 1893 톱니꼬리검물벼룩 속
 4. *Eucyclops serrulatus* (Fischer, 1851) 톱니꼬리검물벼룩
 - *5. *Eucyclops macruroides* (Lilljeborg, 1901) 긴톱니꼬리검물벼룩
 - *6. *Eucyclops macruroides denticulatus* (Graeter, 1903) 잔니치레검물벼룩
 Genus *Tropocyclops* Kiefer, 1927 열대검물벼룩 속
 - *7. *Tropocyclops prasinus* (Fischer, 1860) 녹두검물벼룩
 Genus *Paracyclops* Claus, 1893 이형(異型)검물벼룩 속
 8. *Paracyclops fimbriatus* (Fischer, 1853) 이형(異型)검물벼룩
 - *9. *Paracyclops affinis* (Sars, 1863) 근친이형검물벼룩
 Genus *Ectocyclops* Brady, 1904 이방(異邦)검물벼룩 속
 - *10. *Ectocyclops phaleratus* (Koch, 1838) 이방(異邦)검물벼룩
 Subfamily Cyclopinae Dana, 1852 검물벼룩 아과
 Genus *Cyclops* Müller, 1776 검물벼룩 속
 11. *Cyclops vicinus* Uljanin, 1875 참검물벼룩
 Genus *Megacyclops* Kiefer, 1927 거대검물벼룩 속
 - *12. *Megacyclops viridis* (Jurine, 1820) 코끼리검물벼룩
 Genus *Diacyclops* Kiefer, 1927 맵시검물벼룩 속
 - *13. *Diacyclops bicuspidatus* (Claus, 1857) 가시꼬리맵시검물벼룩
 - *14. *Diacyclops thomasi* (Forbes, 1882) 맵시검물벼룩
 - *15. *Diacyclops crassicauda cretensis* (Kiefer, 1928) 열두마디맵시검물벼룩
 Genus *Microcyclus* Claus, 1893 꼬마검물벼룩 속
 - *16. *Microcyclus varicans* (Sars, 1863) 꼬마검물벼룩
 - *17. *Microcyclus varicans rubellus* (Lilljeborg, 1901) 어리꼬마검물벼룩
 - *18. *Microcyclus longiramus* Shen and Sung, 1965 긴꼬리꼬마검물벼룩
 Genus *Cryptocyclops* Sars, 1927 유령검물벼룩 속
 - *19. *Cryptocyclops bicolor* (Sars, 1863) 유령검물벼룩
 - *20. *Cryptocyclops javanus* (Kiefer, 1929) 자바유령검물벼룩
 Genus *Mesocyclops* Sars, 1914 보통검물벼룩 속

21. *Mesocyclops leuckarti* (Claus, 1857) 보통검물벼룩
 *22. *Mesocyclops pehpeiensis* Hu, 1943 갈고리보통검물벼룩
 Genus *Thermocyclops* Kiefer, 1927 온난검물벼룩 속
 23. *Thermocyclops crassus* (Fischer, 1853) 유리온난검물벼룩
 24. *Thermocyclops taihokuensis* (Harada, 1931) 온난검물벼룩
 *25. *Thermocyclops dybowskii* (Lande, 1890) 한철온난검물벼룩

[The species newly reported from Korea are marked with an asterisk(*). All the Korean names are new.]

SYSTEMATIC ACCOUNT

1. *Macrocyclus fuscus* (Jurine, 1820) 몽당꼬리장수검물벼룩

Monoculus quadricornis fuscus Jurine, 1820 (p. 47, pl. 2)

Cyclops coronatus Claus, 1857a (p. 29, pl. 1, fig. 5, pl. 2, figs. 1-11).

Cyclops (Macrocyclus) fuscus: Gurney, 1933 (pp. 67-73, figs. 1292-1313).

Macrocyclus fuscus: Kiefer, 1929b (pp. 27-28, fig. 11); Rylov, 1948 [pp. 130-132, figs. 19(1-50), 20(5)]; Shen & Sung, 1965a (pp. 18-19, figs. 14-17); Dussart, 1969 (pp. 31-33, fig. 7); Reid, 1985 (p. 32, figs. 62-65).

Material examined: 1(ovi.)♀, 44a; 1♀, 42; 1♂, 45; 1♀, 34; 1♀, 1♂, 55; 1♀, 80; 1♀, 90; 2♀, 111; 1♀, 117b; 2♀, 138; 1♀, 134.

Distribution: Europe, North Africa, U.S.S.R., China, Japan, Korea, North America (U.S.A., Canada), South America.

Remarks: The present species had been collected all the year round at the littoral of various water bodies. It is noticeable in Korea that *M. fuscus* was frequently occurred at springs (8-10°C in general) accumulated with fallen leaves and other plant material at the foot of valley. This indicates that *M. fuscus* in most well-adapted to cold water among its relatives (*M. albidus* or *M. distinctus*) though it is basically eurythermal. The materials examined do not show any noticeable variations and agree well with Gurney(1933)'s, Dussart(1969)'s and Shen(1979)'s description on its important characteristics: proximal half of last article of antennule with hyaline membrane conspicuously serrated (bearing about 10 sharp denticles); outer spine on endopod 3 of leg 4 approximately 1.6 times longer than inner one; inner spine of leg 5 about 1.7 times longer than outer spine; inner margins of furcal rami covering with hairs.

2. *Macrocyclus distinctus* (Richard, 1887) 긴가시장수검물벼룩

(Fig. 2)

Cyclops tenuicornis var. *distinctus* Richard, 1887 (p. 162).

Cyclops distinctus: Lilljeborg, 1901 (p. 47, pl. 3, figs. 15-20).

Cyclops (Macrocyclus) distinctus: Gurney, 1933 (pp. 79-86, figs. 1332-1348).

Macrocyclus distinctus: Kiefer, 1929b (p. 28); Rylov, 1948 (pp. 132-134, fig. 20); Dussart, 1969 (pp. 36-38, fig. 9); Shen, 1979 [transl. by Mizuno, 1984 (pp. 354-358, fig. 179)].

Material examined: 2♀, 123; 1♀, 111a.

Description: Female. Body length excluding caudal setae 1.3-1.7mm. Prosoma big and oval. Genital segment a little expanded anteriorly, and nearly as broad as long at the proximal third. Furcal rami subparallel and robust, 2.5-2.8 times longer than wide, with sparse hairs along inner surfaces. Lateral seta very short and inserted rather dorsally near distal end of the ramus. Inner apical seta relatively long, ap-

proximately 1.8 times longer than outer seta. Antennule of articles with the outer margin of hyaline membrane not serrated conspicuously (almost shown smoothly); twelfth to fourteenth articles lack transverse row of denticles on their distal margins. Leg 1-leg 4 with rami of 3 joints, and spine formula 3, 4, 4, 3. Endopod 3 of leg 4 2.8-2.9 times longer than broad; inner apical spine 0.78-0.91 times longer than outer spine and 0.75 times than the ramus. Distal margin of basal lamella little convexed with row of coarse hairs. Leg 5 of 2 joints; distal joint bearing 2 long spines and a medial seta; the outer, relatively long in comparison with that of *M. fuscus*, reaching 0.71-0.77 times longer than inner spine.

Inhabiting the littoral of ponds or swamps. Rarely collected, at times with *M. albidus* or *M. fuscus*.

Distribution: Europe, India, Southeast Asia, U.S.S.R., China, Japan, Korea, New Zealand.

Remarks: The present species is very similar to *M. fuscus* but distinctly discriminated by the following features: smooth hyaline membrane of antennule; relatively short endopod 3 of leg 4 (less than 3 times longer than wide) and long inner spine; relatively long outer spine on distal joint of leg 5; inner margin of furcal ramus with sparse hair, though the lengths of inner apical spine of leg 4 and outer apical spine of leg 5 were somewhat large in variation range in the specimens from Korea.

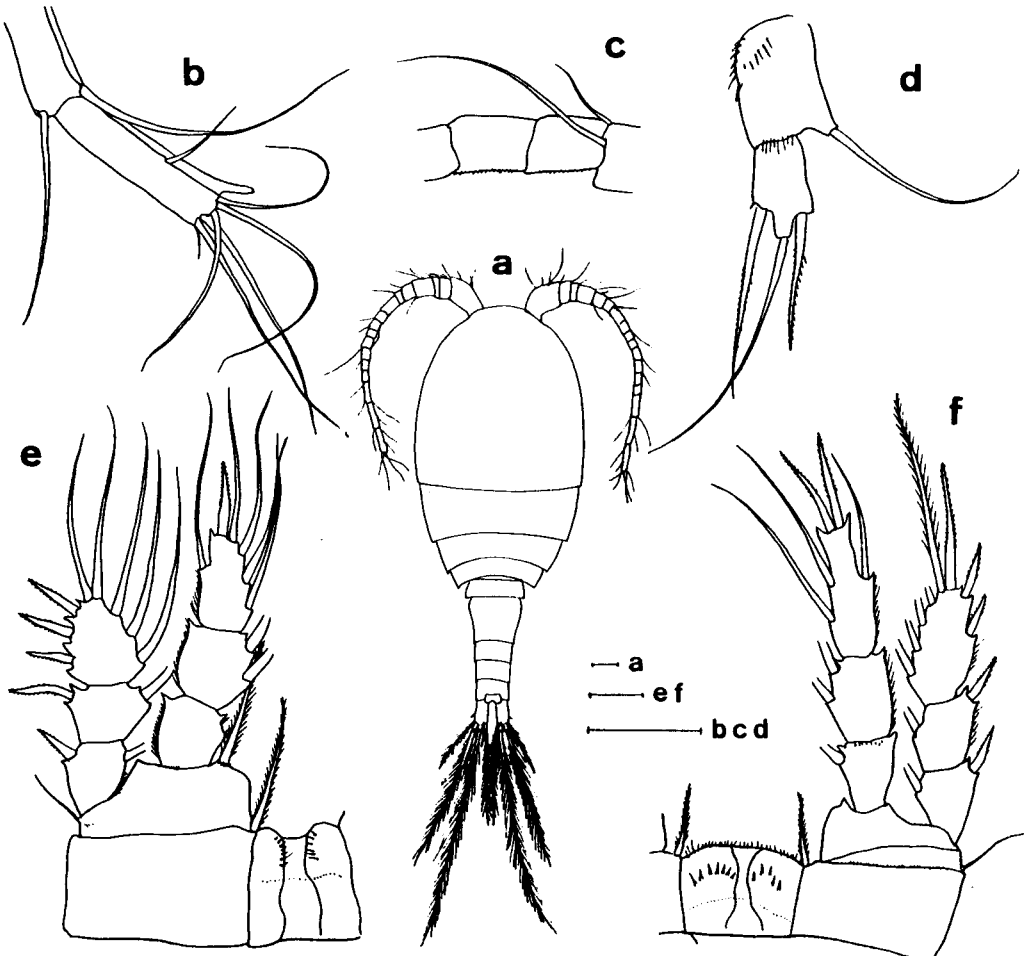


Fig. 2. *Macrocylops distinctus* (Richard), female: a, female (dorsal); b, distal joint of antennule; c, 12th-14th antennular joints; d, leg 5; e, leg 1; f, leg 4. (scale bars: 50 μ)

3. *Macrocyclus albidus* (Jurine, 1820) 맨송꼬리장수검물벼룩

Monoculus quadricornis albidus Jurine, 1820 (p. 44, pl. 2, figs. 10-11).

Cyclops tenuicornis Claus, 1857a (p. 31, tab. 5, figs. 1-11).

Cyclops pennatus: Claus, 1857a (p. 35, tab. 3, figs. 15-17).

Cyclops viridosignatus Byrnes, 1909 (p. 23, pl. 9, figs. 1-8).

Cyclops albidus: Marsh, 1910 (pp. 1087-1090, pl. 76, figs. 1-9).

Cyclops (Macrocyclus) albidus: Gurney, 1933 (pp. 74-79, figs. 1314-1331).

Macrocyclus albidus: Kiefer, 1929b (p. 28); Rylov, 1948 (pp. 134-137, fig. 21). Ito, 1954 (pp. 317-378, figs. 8-12); Shen & Sung, 1962 (p. 42); Shen & Sung, 1965b (p. 169); 1965c (p. 304); 1965d (p. 386); Dussart, 1969 (pp. 356-358, fig. 180); Mizuno & Miura, 1984 (p. 575, figs. 324, 1-7).

Material examined: 5♀, 1♂, 8; 2(ovi.)♀, 10; 1♀, 11; 2♀, 15; 1♀, 63; 2♀, 89; 3(2 ovi.)♀, 104; 3♀, 127; 4(2 ovi.)♀, 132.

Distribution: Cosmopolitan.

Remarks: The present species considerably differs from *M. fuscus* and *M. distinctus* in having smooth inner margin of furcal rami and only one inner seta on endopod 3 of leg 4. *M. albidus* is the most widely distributed species of *Macrocyclus* relatives, and easily collected in the littoral of nearly all the freshwater habitats all the year round in Korea.

4. *Eucyclops serrulatus* (Fischer, 1851) 톱니꼬리검물벼룩

Cyclops serrulatus Fischer, 1851 (p. 423, pl. 10, figs. 22-23, 26-31); Marsh, 1910 (pp. 1094-1097), pl. 78, figs. 5-9, p. 79, fig. 4, fig. 8); Kokubo, 1912 (pp. 97-98, pl. 2, figs. 1-4).

Eucyclops serrulatus: Kiefer, 1929b (pp. 31-32, figs. 12); Kiefer, 1938a (pp. 5-7, Abb. 1-6); Rylov, 1948 (pp. 139-143, figs. 22-23; Mashiko, 1951b (p. 152, fig. 7d); Ito, 1954 (pp. 378-380, figs. 13-16); Shen & Sung, 1965b (p. 169, figs. 1-4); Dussart, 1969 (pp. 40-42, fig. 10).

Material examined: 3♀, 2; 2♀, 6; 3(2 ovi.)♀, 4; 3♀, 8; 4(1 ovi.)♀, 15; 7(5 ovi.)♀, 17; 3(2 ovi.)♀, 18; 3♀, 22; 1♀, 24; 1♀, 31; 3(2 ovi.)♀, 1♂, 28; 1♀, 2♂, 38; 3(ovi.)♀, 2♂, 39; 1♀, 32; 1♀, 1♂, 60; 5(ovi.)♀, 2♂, 55; 3♀, 1♂, 68; 2(ovi.)♀, 2♂, 27; 3(ovi.)♀, 97; 1(ovi.)♀, 1♂, 99; 2(1 ovi.)♀, 74; 2(ovi.), 76; 2♀, 2♂, 75a; 1(ovi.)♀, 75b; 2♀, 73; 2♀, 79; 2♀, 84; 1♀, 81; 2(ovi.)♀, 2♂, 82; 3♀, 89; 1(ovi.)♀, 2♂, 96b; 1♀, 92; 1♀, 94; 3♀, 1♂, 104; 2(ovi.)♀, 131; 1♀, 105; 1♀, 1♂, 113; 3(ovi.)♀, 1♂, 109; 2(ovi.)♀, 2♂, 113; 3(2 ovi.)♀, 1♂, 132; 2(ovi.)♀, 115; 1♀, 121; 3(2 ovi.)♀, 126; 1♀, 116; 1♀, 138; 2♀, 139; 5♀, 141.

Distribution: Cosmopolitan.

Remarks: After examining our specimens in detail, some features showed a considerable variability, especially the length of furcal ramus (3.8-6.3 times as long as broad in females and 3.7-4.3 times in males) and apical spines on endopod 3 of leg 4 (inner spine 1.3-1.5 times longer than outer one). Several specimens' furcal rami of which were much longer and subparallel, were nearly confused with *E. speratus* Lilljeborg. According to Dussart(1969), the inner apical seta on furcal ramus is 0.6 times as long as the ramus itself in female of *E. speratus*, while a little shorter in female of *E. serrulatus*. All our specimens do not show the considerable divergence in length between them (inner seta 0.77-0.80 times longer than furcal ramus). Gurney(1933), Rylov(1948) and Dussart(1969) pointed out the inner seta of male's furca as the decisive character, that is, usually longer or nearly same with ramus itself in *E. serrulatus* while much shorter (more or less 60-80%) in *E. speratus*. All our specimens from Korea agree well with the case of *E. serrulatus*.

We have not yet affirmed the presence of *E. speratus* in Korea.

The present species is the commonest species of all the cyclopoids in Korea, and able to be met with in the littoral of various water bodies including ground waters and estuaries, especially overgrown with macrophytes and other plant material.

5. *Eucyclops macruoides* (Lilljeborg, 1901) 긴톱니꼬리물벼룩 (Fig. 3, a-e)

Cyclops macruoides Lilljeborg, 1901 (p. 85).

Cyclops (Eucyclops) macruoides: Gurney, 1933 (pp. 109-110, figs. 1406-1419).

Eucyclops macruoides: Kiefer, 1929b (p. 25); Rylov, 1948 (pp. 145-146, figs. 25, 4-6); Shen & Sung, 1965c (p. 304); Dussart, 1969 (pp. 46-48, fig. 13).

Material examined: 1♀, 33; 2♀, 100; 1(ovi.)♀, 113a; 2♂, 118a.

Description: Body length excluding caudal setae 1.0-1.25mm. Prosome protruded anteriorly. Anterior portion of genital segment swollen. Furcal rami subparallel and almost 6-8 times longer than wide. Inner apical seta approximately 1.5 times as long as the outer. Dorsal seta shorter than the outer apical seta. Antennule of 12 articles and reaching the middle of first thoracic segment; inner margins of tenth to twelfth articles with narrow, finely serrate hyaline membrane; a row of 16-30 (almost 18-30) denticles on proximal half of last article. Swimming leg 1-4 with rami of 3 articles and spine formula 3, 4, 4, 3. Terminal article of endopod of leg 4 about 3.4 times as long as broad; inner apical spine slender and 1.35 and 1.1 times as long as the outer and the ramus respectively. Leg 5 with very slender and short spine. Found in the littoral of shallow stagnant waters, especially swamps and pools.

Distribution: Holarctic (Europe, North Africa, China, U.S.S.R., Korea, Japan, North America).

6. *Eucyclops macruoides denticulatus* (Graeter, 1903) 잔니치레검물벼룩 (Fig. 3, f-i)

Cyclops serrulatus denticulatus Graeter, 1903 (p. 491).

Eucyclops lilljeborgi: Kiefer, 1929b (p. 35).

Cyclops (Eucyclops) macruoides denticulatus: Gurney, 1933 (p. 111, figs. 1410-1423).

Eucyclops macruoides denticulatus: Rylov, 1948 (p. 148, fig. 25, 1-2); Shen & Sung, 1965b (pp. 169-171, figs. 5-14).

Material examined: 1♀, 13; 1♀, 44b; 1♀, 98b; 1♀, 132.

Description: Female. Body length 1.2-1.4mm. Somewhat larger than the other species of *Eucyclops*. Furcal rami 6-8 times as long as wide, and slightly divergent posteriorly; outer margin often swollen and slightly concave, their armature always consisting of sharp and strong spinules. Inner apical seta a little longer than the outer apical bristle, and shorter than the ramus but much longer than the half of it. Antennules of 12 articles; proximal half of hyaline membrane on the last article with a row of 8-12 denticles. Swimming leg 1-4 with rami of 3 articles and spine formula 3, 4, 4, 3. Two apical spines of endopod 3 of leg 4 conspicuously serrated and thickened; inner one approximately 1.5 times and 1.2 times as long as the outer one and the ramus respectively. Leg 5 being pentagonous with a short and slender inner spine and two outer setae.

Inhabiting the littoral of swamps and reservoirs with a little detritus and vegetation. Eurythermal and found in warm water from spring to fall.

Distribution: Holarctic (Europe, North Africa, China, Korea, Canada).

Remarks: Rylov (1948) proposed the character whether furcal rami are divergent or parallel as a key to the species discriminating *E. macruoides denticulatus* from *E. macruoides*. But it wasn't always effi-

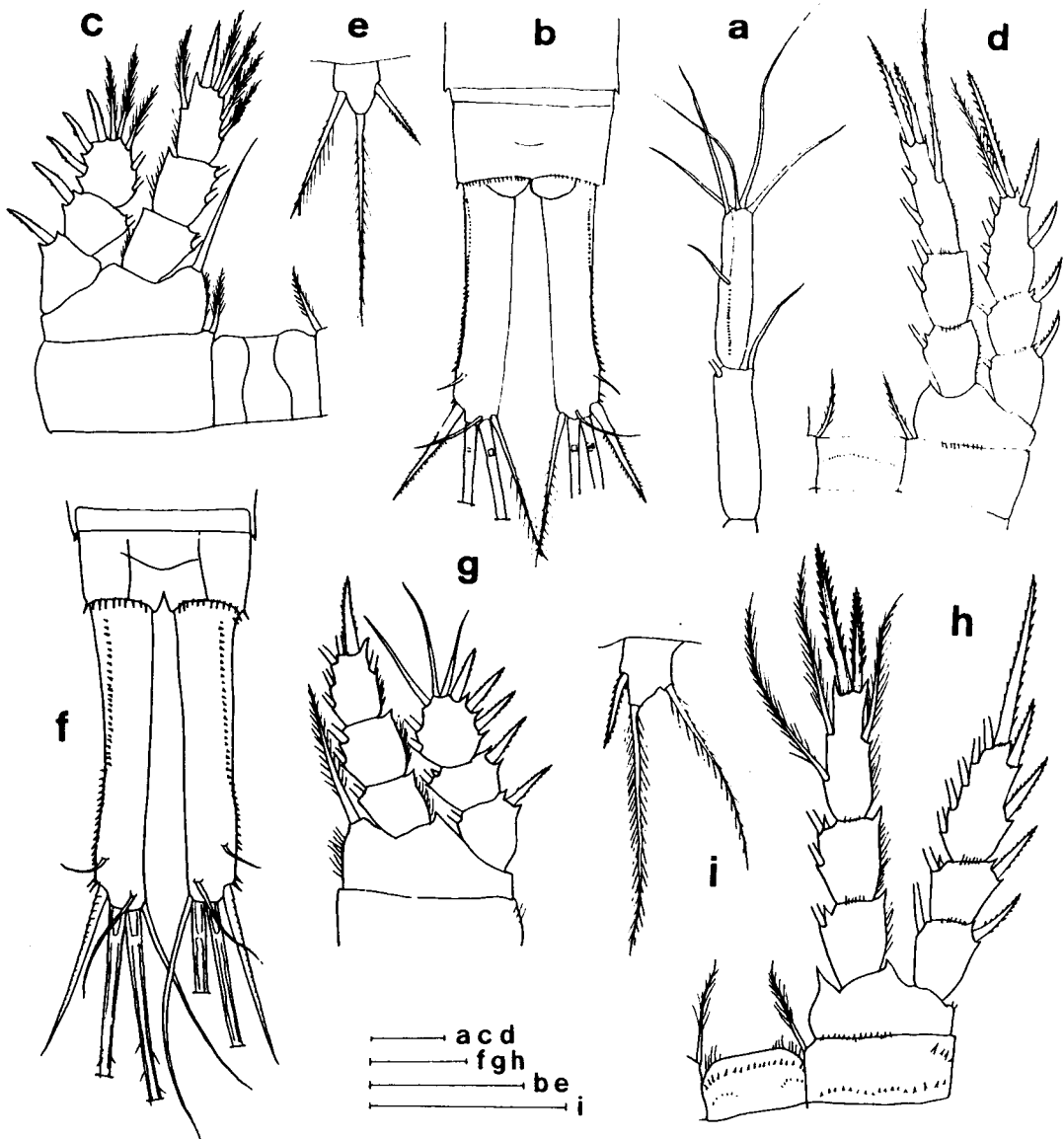


Fig. 3. a-e, *Eucyclops macruroides* (Lilljeborg), female. a, 16th-17th joints of antennule; b, furcal rami; c, leg 1; d, leg 4; e, leg 5. f-i, *Eucyclops macruroides denticulatus* (Graeter), female. f, furcal rami; g, leg 1; h, leg 4; i, leg 5. (scale bars: 50 μ)

cient in our specimens and also different from Shen (1979)'s description. We authors rather want to prefer as diagnostic characters the following features: length of inner apical seta on furcal ramus (a little longer than half of the ramus in *E. macruroides* while relatively long and a little shorter than whole ramus in *E. macruroides denticulatus*); number of denticles on the proximal half of last article of antennule (16-30 denticles in *E. macruroides* while 8-12 denticles in *E. macruroides denticulatus*). In addition, *E. macruroides denticulatus* had a tendency to showing much longer outermost seta of leg 5 (usually more than 2.5 times as long as inner spine, while less than 2 times in *E. macruroides*).

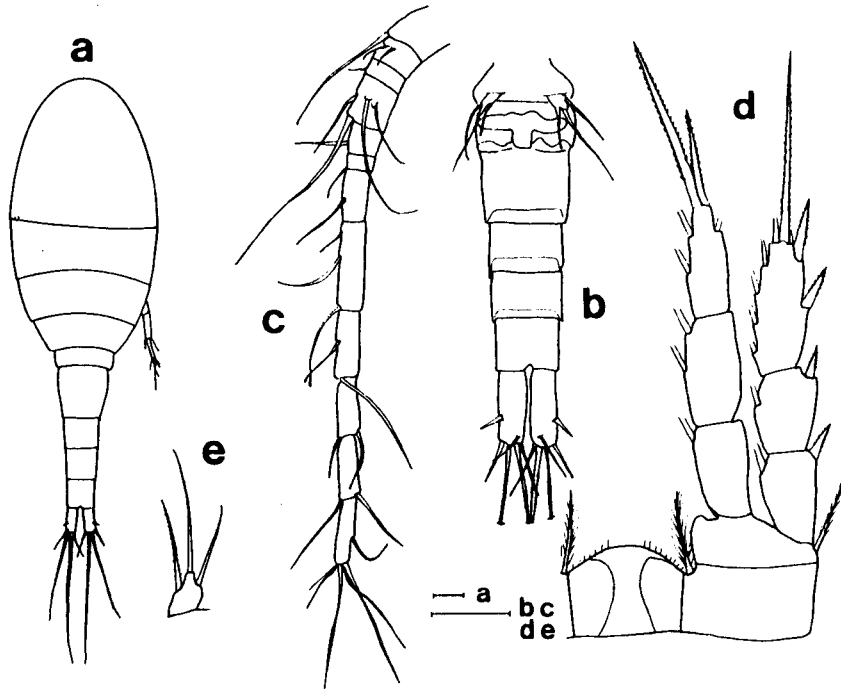


Fig. 4. *Tropocyclops prasinus* (Fischer), female. a, female (dorsal); b, abdomen and furcal rami; c, antennule; d, leg 4; e, leg 5. (scale bars: 50 μ)

7. *Tropocyclops prasinus* (Fischer, 1860) 녹색검물벼룩

(Fig. 4)

Cyclops prasinus Fischer, 1860 (pp. 1097-1099, pl. 79, figs. 1-3, fig. 10).

Cyclops magnoctvus Kokubo, 1912 (p. 98, pl. 2, figs. 8-12).

Eucyclops (Tropocyclops) nigrouiridis Harada, 1931 (pp. 151-153, fig. 4-5).

Eucyclops (Tropocyclops) prasinus: Kiefer, 1929b (p. 39).

Eucyclops (Tropocyclops) prasinus: Gurney, 1933 (pp. 87-97, fig. 1349-1373); Harding & Smith, 1974 (p. 39).

Tropocyclops prasinus: Rylov, 1948 (pp. 151-153, fig. 26); Ito 1954 (p. 383-384, figs. 42-47); Dussart, 1969 (pp. 52-54, fig. 17); Mizuno & Miura, 1984 (pp. 586, 589, fig. 332).

Tropocyclops prasinus prasinus: Shen, 1979 [transl. by Mizuno, 1984 (pp. 371-373, fig. 190)].

Material examined: 5♀, 29; 2(ovi.)♀, 2♂, 70; 2♀, 79; 2♀, 1♂, 98; 2(1 ovi.)♀, 130b; 1♀, 132.

Description: Female. Body length excluding terminal setae within 0.6mm; very small and often tinged with blue-green; prosome oval and protruded anteriorly. Genital segment slightly widened anteriorly. Furcal rami diverging slightly, at most 2.2-2.6 times as long as broad; lateral seta inserted between the middle and the distal third; inner seta 1.2-1.3 times as long as outer seta and almost same with dorsal seta. Antennules of 12 articles, nearly reaching the posterior margin of prosome. Leg 1-4 with rami of 3 articles and spine formula 3, 4, 4, 3. Articles of leg 4 conspicuously slender; endopods 3 about 2.5-2.8 times as long as broad; inner apical spine longer than the article itself and approximately 2.0-2.3 times longer than outer spine; distal margin of basal lamella convexed with a row of short and coarse hairs. Leg 5 in the form of pentagonous plate longer than wide with an inner spine and two seta; inner spine very long and slender.

Male. body length 0.5-0.7mm. Leg 6 with a fine inner spine, slightly shorter than both adjacent setae

with almost equal length.

Usually inhabiting well-warmed shallow waters of pool type; often occurring in the littoral of ponds or reservoirs. Possibly also found in underground water and infrequently in waters containing a little salt. In Korea, occurred during the period from late spring to early fall.

Distribution: Cosmopolitan.

Remarks: *T. prasinus* has presented more than ten subspecies, especially in tropical or subtropical region. Though some of our specimens showed somewhat large variation range in relative rate of spines on endopod 3 of leg 4 (2.0-2.5), all our specimens were ascertained to belong to type species only.

8. *Paracyclops fimbriatus* (Fischer, 1853) 이형검물벼룩

Cyclops fimbriatus Fisher, 1853 (p. 94, pl. 3, figs. 19-23).

Cyclops crassicornis Brady, 1878 (p. 118).

Cyclops (Paracyclops) fimbriatus: Gurney, 1933 (pp. 121-130, fig. 1438-1458).

Paracyclops fimbriatus: Rylov, 1948 (pp. 156-158, fig. 28); Shen & Sung, 1962 (p. 42); Dussart, 1969 (pp. 55-58, fig. 18).

Material examined: 1♀, 1♂, 2; 3♀, 5: 1♀, 19; 2♀, 43; 1♀ 2♂, 45; 1(young)♀, 46; 11♀, 3♂, 89; 2(ovi.)♀, 1♂, 99; 3♀, 111; 1♀, 117; 1♂, 118; 1♀, 124; 3(2 ovi.)♀, 1♂, 126; 1♀, 128; 1♀, 132; 1♀, 2♂, 136.

Distribution: Cosmopolitan.

9. *Paracyclops affinis* (Sars, 1863) 근친이형검물벼룩 (Fig. 5)

Cyclops affinis Sars, 1863 (p. 256); Brady, 1878 (p. 112).

Cyclops (Paracyclops) affinis: Gurney, 1933 (pp. 130-136, figs. 1460-1478).

Paracyclops affinis: Claus, 1893 (p. 83) (cited from Rylov, 1948); Kiefer, 1929b (p. 42); Rylov, 1948 (pp. 161-162, fig. 30); Dussart, 1969 (pp. 60-62, fig. 21); Shen, 1979 [transl. by Mizuno, 1984 (pp. 385-387)].

Material examined: 1♀, 33; 2(ovi.)♀, 35; 1♀, 59; 1♀, 2♂, 111a; 1♀, 116a.

Description: Female. Body length excluding caudal setae 0.6-0.9mm, smaller than *P. fimbriatus*. Body markedly flattened dorsoventrally; Prosoma oval-formed; fifth thoracic segment with lateral groups of small bristles. Abdomen wide, tapering posteriorly. Genital segment wider than long. Furcal rami subparallel, or slightly divergent; furcal ramus 2.2-2.5 times as long as wide; an oblique row of small spinules along the posterior third of dorsal side in front of lateral seta; lateral seta near outer apical seta; inner apical seta approximately 2/3 times as long as the outer one. Antennule of 11 articles; very short, not reaching the posterior margin of cephalothorax. Leg 1 - leg 4 with rami of 3 articles and spine formula 3, 4, 4, 3. Seta on basipod of leg 1 very long, reaching the middle of endopod 3. Endopod 3 of leg 4 1.75 times as long as broad; inner apical spine about 2.3 times longer than outer spine. Leg 5 each consisting of one joint clearly articulated with posterior thoracic segment; armed with inner spine and two setae.

Male. Body length 0.52-0.70mm. Leg 6 with long inner spine and two setae; the outer seta short, and the inner only slightly shorter than the spine.

Benthic and inhabiting the littoral with vegetation, and shallow stagnant waters of small pool-type water bodies like swamps and ponds.

Distribution: Holarctic (Europe, North Africa, Asia, North America).

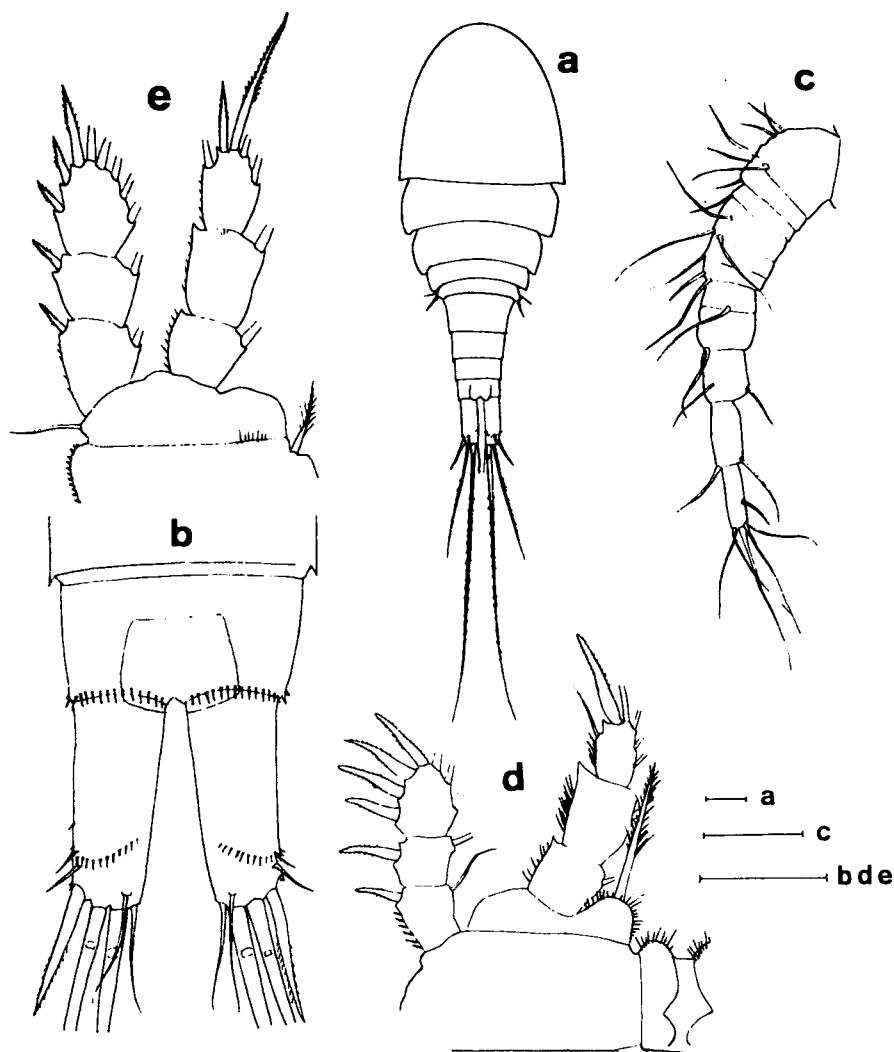


Fig. 5. *Paracyclops affinis* (Sars, 1863), female. a, female (dorsal); b, anal segment and furcal rami; c, antennule; d, leg 1; e, leg 4. (scale bars: 50 μ)

10. *Ectocyclops phaleratus* (Koch, 1838) 이방검물벼룩

(Fig. 6)

Cyclops phaleratus Koch, 1838 (p. 9); Brady, 1878 (p. 116).

Cyclops phaleratus japonicus: Kokubo, 1912 (p.103, pl. 2, figs. 27-29).

Cyclops (Ectocyclops) phaleratus: Daday, 1910 (cited from Dussart & Defaye, 1985); Gurney, 1933 (pp. 137-144, figs. 1479-1501).

Ectocyclops phaleratus: Kiefer, 1929b (p. 43, fig. 15); Rylov, 1948 (pp. 163-166, fig. 31); Fryer, 1955 (pp. 939-942); Dussart, 1969 (pp. 62-65, fig. 22); Shen, 1979 [transl. by Mizuno, 1984 (pp. 389-391, figs. 202-203)].

Material examined: 2♀, 23; 1♀, 1♂, 38; 1(ovi.)♀, 48; 1♀, 63; 1(ovi.)♀, 59; 2(ovi.)♀, 93; 1♀, 113a; 1(ovi.)♀, 113b; 2♀, 1♂, 118a; 1♀, 118b; 1♀, 127.

Description: Female. Body length 0.90-1.00mm, somewhat big and much flattened dorsoventrally.

Middle of thorax is widest, and approximately one third of total length. Abdomen very wide and tapering markedly. Genital segment wider than long. Furcal rami very short and stout, about 1.5-1.9 times as long as broad, tapering posteriorly; each ramus with several rows (often 3 rows) of spinules usually extending obliquely to dorsal and inner side of ramus. Lateral seta very short; several small spinules near its base. Inner spine nearly same in length with outer spine. antennules very short, not reaching the posterior margin of cephalothorax; usually consisting of eleven articles. Basipods of swimming leg 1-4 very wide and outer margins of exopods of swimming legs armed with rows of sharp spinules. Spine formula 3, 4, 4, 3. Endopod 3 of leg 4 small and stubby, about 1.5 times as long as broad; inner spine approximately 2.5 times longer than the outer, and often curved. Fifth pair of legs in the form of short and wide plate fused with lateroposterior margin of thoracic segment 4, and armed with three bristles; innermost bristle a little longer than the others.

Male. Body length 0.64-0.85mm. Leg 6 bearing 3 appendages, long and strong inner spine and two short outer setae.

Body color usually tinged with red-orange or red-brown. Typically benthonic cyclopoid copepods, well adapted to creeping on the substratum and inhabiting the littoral of various types of waters, especially stagnant and detritus-riched ones. Eurythermal but preferring warm waters. Collected nearly all the year round.

Distribution: Cosmopolitan.

Remarks: According to Gurney(1933), Rylov(1948), Fryer(1955) and Dussart(1969), the antennule

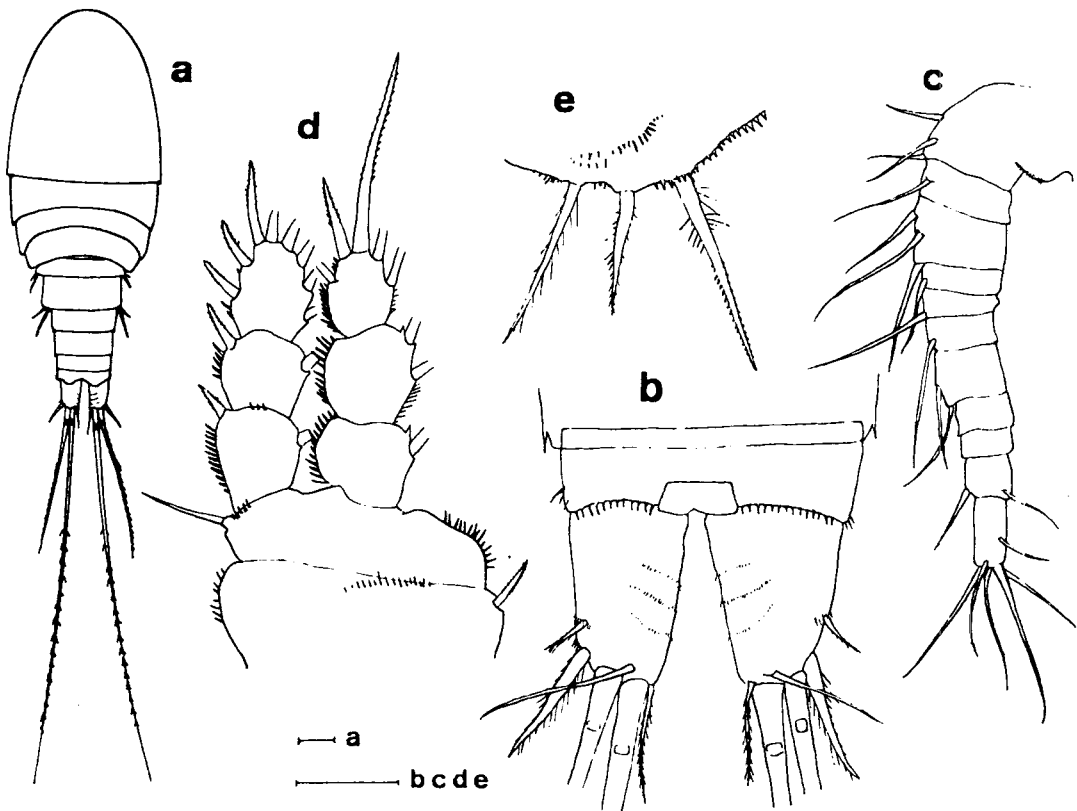


Fig. 6. *Ectocyclops phaleratus* (Koch, 1838). a, male (dorsal). b-e, female. b, anal segment and furcal rami (dorsal); c, antennule; d, leg 4; e, leg 5. (scale bars: 50 μ).

of the present species consists of nine to eleven articles, mostly of ten articles with 6th and 7th articles combined, and the three appendages of leg 5 is almost same in length. But all the specimens the authors examined has eleven-articulated antennules and an innermost bristle of legs is a little longer than the others.

11. *Cyclops vicinus* Uljanin, 1875 참검물벼룩

Cyclops vicinus Uljanin, 1875 (p. 30, pl. 10, figs. 1-7); Lilljeborg, 1901 (p. 26) Sars, 1903 (p. 216, pl. 15, figs. 2, a-k); Brehm, 1909 (pp. 215-216); Kiefer, 1929b (p. 52); Kiefer, 1937 (pp. 295-296); Kikuchi, 1940 (p. 293, fig. 8); Rylov, 1948 (pp. 204-207, fig. 43); Mashiko, 1951b (pp. 152-153); Shen & Sung 1962 (p. 43).

Cyclops (Cyclops) vicinus: Gurney, 1933 (pp. 175-182, figs. 1549-1562).

Cyclops vicinus vicinus: Kiefer, 1938c (pp. 90-91); Rylov, 1948 (p. 204); Dussart, 1969 (pp. 108-111); Shen, 1979 [transl. by Mizuno, 1984 (pp. 398-400, fig. 208)].

Material examined: 2♀, 2; 2♂, 5; 1♀, 6; 3♀, 7a; 1♀, 13; 1♂, 14a; 3♀, 16; 2 (1ovi.)♀, 3♂, 24; 2(ovi.)♀, 47; 2(ovi.)♀, 1♂, 48; 2♀, 49; 2♀, 50; 1♀, 51; 3(ovi.)♀, 55; 1♀, 1♂, 64; 2(ovi.), 2♂, 66; 2♀, 2♂, 67; 3♀, 1♂, 73; 2(ovi.)♀, 1♂, 91; 2♀, 95; 1♀, 3♂, 101; 3(ovi.), 1♂, 113c; 2♀, 2♂, 117c; 2♀, 2♂, 118a; 2♀, 119; 2♀, 120; 3(ovi.)♀, 1♂, 123b; 2♀, 128; 2(ovi.)♀, 1♂, 129; 2♀, 132b; 2♀ (young), 138.

Distribution: Holarctic (Europe, North Africa, Canada, U.S.A., Siberia, Iran, Turkey, China, Japan, Kuril, Islands, Korea).

Remarks: In Korea, *Cyclops vicinus* is very common in reservoirs and rivers in the form of copepodid larva (stage V) (Fig. 7, a-b) in spring (after late April in the south or after mid-May in Central Korea respectively) and late fall. Kim and Park (1969) and Kim and Lee (1978) once confused those larval forms of *C. vicinus* collected from the Han River with *Acanthocyclops morimotoi* Ito, a subterranean species from Japan, male of which is some what similar to the copepodid larva (stage V) of *C. vicinus* morphologically.

12. *Megacyclops viridis* (Jurine, 1820) 코끼리검물벼룩

(Fig. 7, c-h)

Monoculus quadricornis viridis Jurine, 1820 (p. 46, pl. 3, fig. 1).

Cyclops viridis: Fischer, 1951 (p. 412, pl. 9, figs. 1-11); Marsh, 1910 (pp. 1072-1075).

Cyclops brevicornis: Claus, 1857a (p.32, pl. 3, figs. 12-17).

Cyclops (Megacyclops) viridis: Kiefer, 1929b (p. 53, figs. 17, a-b); Kikuchi, 1940 (pp. 293-295, fig. 10).

Cyclops (Acanthocyclops) viridis: Gurney, 1933 (pp. 185-191, figs. 1563-1582).

Acanthocyclops viridis: Rylov, 1948 (pp. 215-219, figs. 45, 1-7).

Megacyclops viridis: Kiefer, 1938a (pp. 9-10, Abb. 11-14); Hsiao, 1950 (pp. 181-184, fig. 20); Ito, 1954 (pp. 387-389, figs. 61-74); Shen & Sung, 1965c (p. 305).

Acanthocyclops (Megacyclops) viridis: Shen, 1979 [transl. by Mizuno, 1984 (pp. 406-407, fig. 212)].

Acanthocyclops (Megacyclops) viridis viridis: Dussart, 1969 (pp. 138-139, fig. 63).

Material examined: 1♀, 1♂, 12; 1♀, 20; 3♀, 36; 2♀, 65; 3♀, 80; 3♀, 75a; 2♀, 75b; 1♀, 89; 1(ovi.)♀, 99; 1♀, 108; 1♀, 121; 1♀, 127; 1♀, 134; 3♀, 140; 1(ovi.)♀, 141.

Description: Female. Body length 1.8-2.00mm. Body huge and thick; often dark brown in color. Genital segment nearly as long as broad and a little swollen anteriorly. A long seta on proximal joint of leg 5 shown under lateroposterior edge of 5th thoracic segment. Furcal rami slightly divergent; about 3.0-4.0 times as long as broad; inner margins scattered with row of long hairs. Lateral bristle short and situated on posterior third of outer margin; outer apical seta very short and 1/3-1/4 times as long as inner one. Antennules of 17 articles, reaching approximately posterior margin of cephalothorax; sum of last 3 articles nearly as long

as sum of next 7 articles. Exopod of antenna whip-formed; endopod of 3 articles with about 9-10 denticles on each inner margin of them. Leg 1 - leg 4 with rami of 3 joints; spine formula 2, 3, 3, 3; seta formula 4, 4, 4, 4. Endopod 3 of leg 4 about 2.5 times as long as broad; inner apical spine slightly longer than outer one, but shorter than the joint. Leg 5 2-jointed; proximal joint very widened and about 4 times as broad as distal joint; a short spinule situated on about middle of inner margin of distal joint.

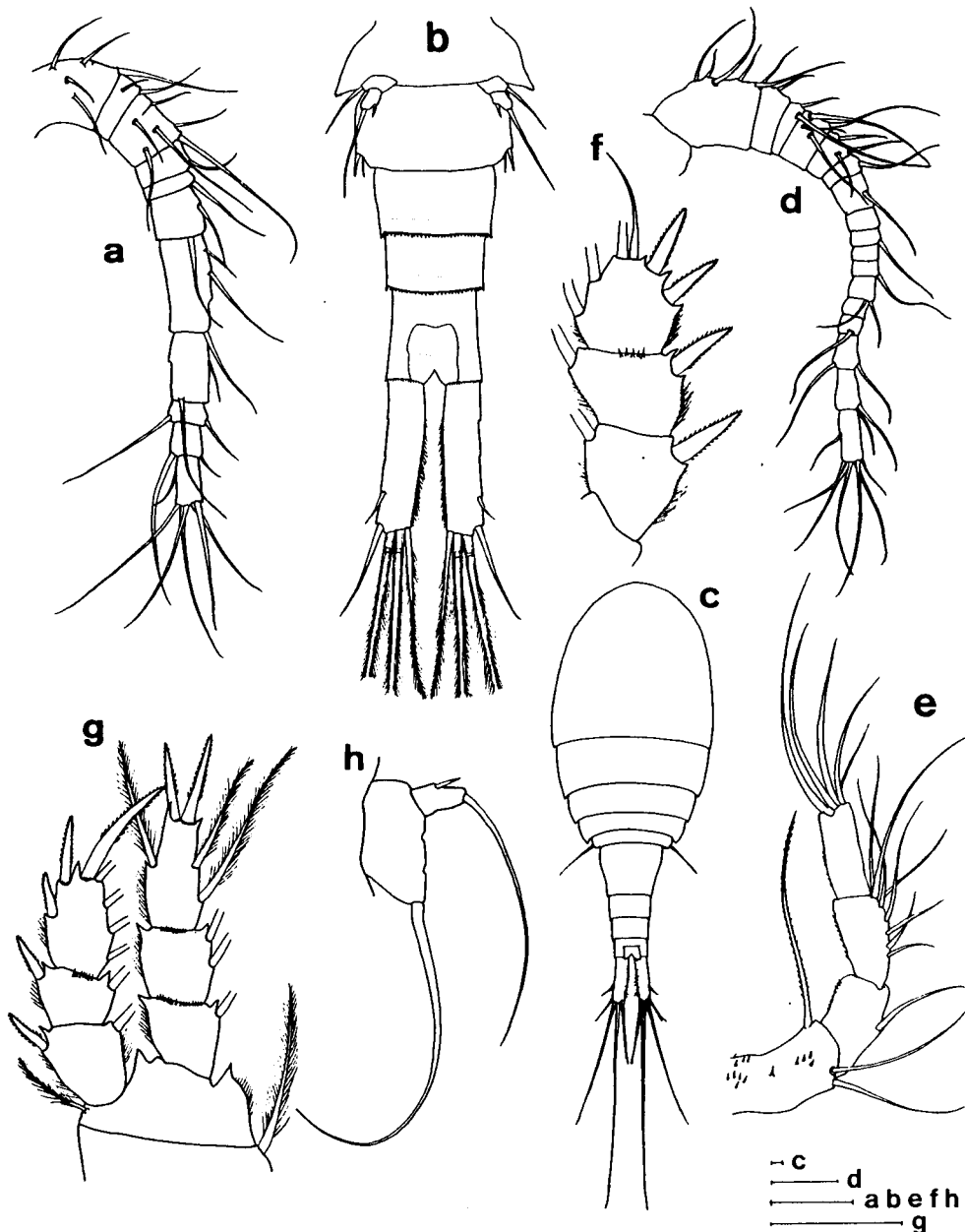


Fig. 7. a-b, *Cyclops vicinus* (Uljanin), female copepodid larva (stage V). a, antennule; b, leg 5 and abdomen. c-h, *Megacyclops viridis* (Jurine), female. c, female (dorsal); d, antennule; e, antenna; f, leg 1; g, leg 4; h, leg 5. (scale bars: 50 μ)

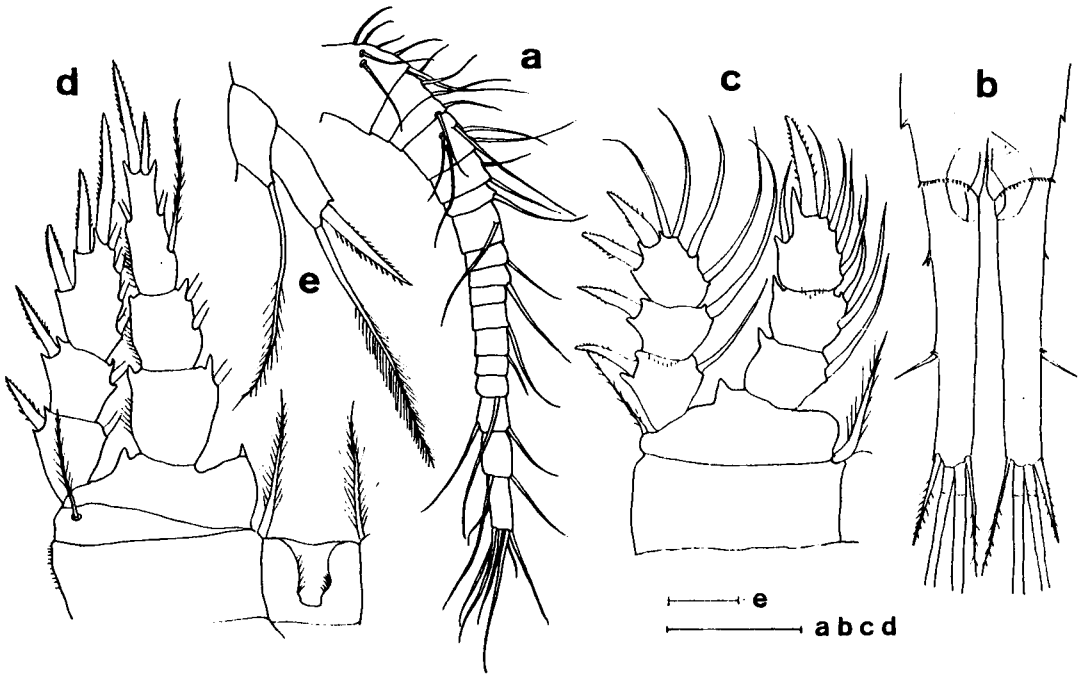


Fig. 8. *Diacyclops bicuspidatus* (Claus), female. a, antennule; b, anal segment and furcal rami; c, leg 1; d, leg 4; e, leg 5. (scale bars: 50 μ)

Male. Body length 1.5-1.7mm. Inner spine of leg 6 a little longer than the outer two setae.

Common in silt bottoms or littoral of all types of waters including alpine swamps and wells, especially rice fields or pools in Korea. Eurythermal and collected all the year round.

Distribution: Europe, Africa, America, Asia (Israel, U.S.S.R., Iran, India, China, Japan, Kuril Islands, Korea).

13. *Diacyclops bicuspidatus* (Claus, 1857) 가시꼬리맵시검물벼룩 (Fig. 8)

Cyclops bicuspidatus Claus, 1857b (p. 209, pl. 11, figs. 6-7); Lilljeborg, 1901 (p. 11).

Cyclops (Diacyclops) bicuspidatus: Kiefer, 1929b (pp. 58-59, fig. 19); Yeatman, 1944 (pp. 49-50, fig. 93, 98-101).

Cyclops (Acanthocyclops) bicuspidatus: Gurney, 1933 (pp. 219-222, figs. 1645-1671)

Acanthocyclops bicuspidatus: Rylov, 1948 (pp. 238-241, fig. 53); Shen & Sung, 1965d (p. 388); Dussart, 1969 (pp. 145-148, fig. 67).

Material examined: 1♀, 2; 2♂, 28.

Description: Female. Body length 1.05mm. Gray-white or yellowish colored. Genital segment much longer than wide. Furcal rami parallel, fairly long and narrow, about 5.3 times as long as broad; long lateral seta inserted between middle and a distal third of ramus, and a small spinule at anterior quarter of outer margin of ramus; inner apical seta about 1.2 times as long as outer one and 0.42 times as the ramus. Antennules slightly beyond the posterior margin of cephalothorax; antennules of 17 articles, and last 2 articles obviously longer than the others. Leg 1 - leg 4 with rami of 3 joints; spine formula 2, 3, 3, 3. Seta on inner edge of coxopod of leg 1 beyond the middle of endopod 2. Endopod 3 of leg 4 approximately 2.7 times as long as broad; outer spine about 1.7 times longer than inner spine and a little shorter than the joint. Leg 5 2-jointed; distal joint elongate, about 2.7 times as long as broad and nearly same in length with inner

spine on it.

Occurred in littoral zone of slowly flowing river and lake.

Distribution: Holarctic (whole of Europe, Asia, North Africa, North America) and New Zealand.

Remarks: The length rate between apical spines on leg 4 is known to be very variable (outer one may be nearly equal or as much as twice the length of inner one even within the same population) (Gurney, 1933; Rylov, 1948; Dussart, 1969). According to Shen(1979), the rate is about 1.4 times, while all our specimen's are nearly 1.7 times or so.

14. *Diacyclops thomasi* (Forbes, 1882) 맵시검물벼룩 (Fig. 9, f-i)

Cyclops thomasi Forbes, 1882 (p. 649, pl. 9, figs. 10-16).

Cyclops (Diacyclops) thomasi: Kiefer, 1929b (p. 59).

Cyclops (Acanthocyclops) bicuspidatus thomasi: Gurney, 1933 (pp. 225-227, figs. 1672-1674).

Cyclops (Diacyclops) bicuspidatus thomasi: Yeatman, 1944 (p. 50, figs. 81-92, 94-97, 99-100, 102-103).

Diacyclops bicuspidatus thomasi: Smith & Fernando, 1978 (p. 48).

Diacyclops thomasi: Shen & Sung, 1965d (pp. 388-389).

Acanthocyclops (Diacyclops) thomasi: Shen, 1979 [transl. by Mizuno, 1984 (pp. 409-411, fig. 215)].

Material examined: 5♀, 3♂, 111a; 1♀, 111b; 2♀, 116a; 1♂ (juv.), 116b; 1♂, 115a; 2♀, 2♂, 115b.

Description: Female. Body length 1.2 - 1.4mm. Body much slender in comparison with *D. bicuspidatus*; lateroposterior margins of 2nd-5th thoracic segments protruding laterally; genital segment much longer than broad and swollen anteriorly. Furcal rami almost parallel and 6.0-8.0 times as long as wide; lateral seta situated near posterior third of outer margin; small spinule on anterior quarter of outer margin; outer apical seta shorter than inner one but longer than dorsal seta. Leg 1 - leg 4 with rami of 3 joints; spine formula 2, 3, 3, 3; endopod 3 of leg 4 about 3 times as long as broad; outer apical spine approximately 2 times longer than inner one and nearly same or a little longer than endopod 3. Leg 5 consisting of 2 joints; distal joint elongated, about 2.7 times as long as wide and 0.71 times as inner apical spine on it.

Male. Body length 0.8-1.1mm. Furcal rami somewhat longer than those of female, about 8 times as long as broad. A thick inner spine, a short medial seta and a longest outer seta on posterior margin of leg 6 respectively.

Mainly found in littoral of swamps or pools. Living in cold water, and becoming copepodid larva from April on in Korea.

Distribution: Holarctic (U.S.A., Canada, Europe, China, Korea).

15. *Diacyclops crassicaudis cretensis* (Kiefer, 1928) 열두마디맵시검물벼룩 (Fig. 9, a-e)

Cyclops crassicaudis cretensis Kiefer, 1928 (p. 245, figs. 1-3) (cited from Kiefer, 1929b).

Cyclops (Diacyclops) crassicaudis cretensis Kiefer, 1929b (p. 61).

Cyclops (Diacyclops) crassicaudis taipehensis Harada, 1931 (p. 158, figs. 17-18).

Acanthocyclops crassicaudis var. *cretensis*: Rylov, 1948 (p. 248).

Acanthocyclops (Diacyclops) crassicaudis cretensis: Shen, 1979 [transl. by Mizuno, 1984 (pp. 412-413, fig. 217)].

Diacyclops crassicaudis cretensis: Dussart & Defaye, 1985 (p. 84).

Material examined: 3♀, 2♂, 28; 1♀, 94; 1(ovi.)♀, 117b.

Description: Female. Body length 0.9-1.15mm. Body slender. Posterior margins of 2nd-5th segment fairly protruding laterally. Genital segment much swollen and wider than long. Furcal rami subparallel and

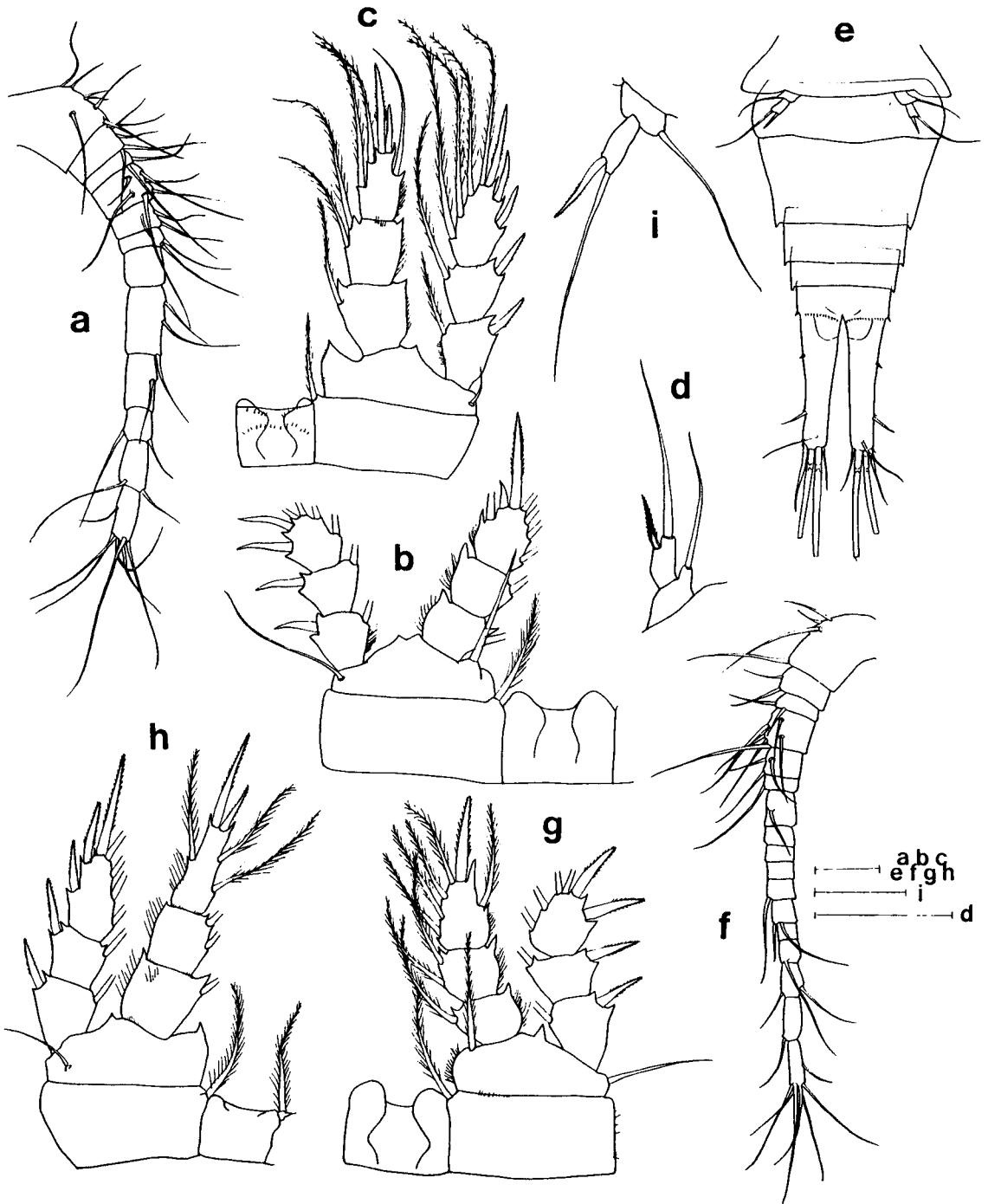


Fig. 9. a-e, *Diacyclops crassicaudis cretensis* (Kiefer). a, antennule; b, leg 1; c, leg 4; d, leg 5; e, abdomen (ventral). f-i, *Diacyclops thomasi* (Forbes). f, antennule; g, leg 1; h, leg 4. (scale bars: 50 μ)

4.0-4.5 times as long as broad; lateral seta located on distal third to quarter; a small spinule on proximal fifth of outer margin of ramus; outer apical seta much shorter than furcal ramus, but somewhat longer than inner one. Antennules of 12 articles and reaching posterior margin of cephalothorax. Leg 1 - leg 4 with rami of 3 joints; spine formula 2, 3, 3, 3. A seta on inner margin of coxopod of leg 1 beyond the posterior margin of endopod 2. Endopod 3 of leg 4 about 1.6 times as long as wide; inner apical spine very long, 1.3 times longer than the joint and nearly 2 times longer than outer one. Leg 5 of 2 joints; inner spine on distal joint slightly longer than the joint itself.

Occurred in temporary pools or swamps that easily dry up in summer and often polluted with sewage.

Distribution: Greece, Turkey, China, Taiwan, Korea.

Remarks: The species previously reported from Japan (Ito, 1957) as *D. crassicaudis* is supposed to be *D. crassicaudis cretensis*. For *D. crassicaudis cretensis* differs from the type species in having much elongated endopod 3 of leg 4 and a long inner spine (approximately 2 times longer than outer one). On the other hand, the species redescribed as *D. crassicaudis cretensis* by Shen(1979) have the possibility in being other different species or subspecies by its conspicuously elongated furcal rami (about 6 times as long as broad) with inner apical seta much longer than outer one. The author (C.Y. Chang) affirmed its considerable differences with the present species (*D. crassicaudis cretensis*) by obtaining two females, which were collected in a swamp at Chŏngyang, Hapchŏn-ŭp, fitting in well with the description and figures of Shen(1979)'s.

16. *Microcyclops varicans* (Sars, 1863) 꼬마검물벼룩 (Fig. 10, a-e)

Cyclops varicans Sars, 1863 (p. 252).

Cyclops (Microcyclops) varicans: Kiefer, 1929b (pp. 66-67, fig. 24, a-b); Gurney, 1933 (pp. 255-260, figs. 1747-1764).

Microcyclops varicans: Kiefer, 1938b (pp. 57-57, Abb. 39-41); Rylov, 1948 (pp. 267-269, figs. 62, 1-7); Dussart, 1969 (pp. 180-182, fig. 89); Mammari & Fernando, 1978 (p. 151, figs. 239-243); Mizuno & Miura, 1984 (pp. 609-611, fig. 345).

Microcyclops (Microcyclops) varicans: Ito, 1954 (pp. 402-403, figs. 154-162); Shen, 1979 [transl. by Mizuno, 1984 (pp. 418-421, figs. 221-222)]

Material examined: 3♀, 9; 1♀, 38; 1(juv.)♀, 46; 3♀, 77; 3♀, 122; 2♀, 119; 2(1 ovi.)♀, 132b.

Description: Female. Body very small, 0.6-0.9mm in length. Prosome oval, and cephalothorax protruding anteriorly. Posterior margins of abdominal segments bearing a row of denticles; ventral side of anal segments with 7 or 8 relatively large denticels. Egg sacs a little divergent posteriorly, containing 10-20 eggs per sac. Furcal rami parallel, about 3.5 times as long as broad; lateral seta situated on distal third of ramus; inner apical seta approximately 1.5 times as long as outer one and nearly same as the ramus. Antennules of 12 articles, not reaching posterior margin of cephalothorax. Leg 1 - leg 4 with rami of 2 joints, and spine formula 3, 4, 4, 3. A long seta on inner margin of basipod of leg 1 beyond the middle of endopod 2. Distal joint of endopod of leg 4 more than 2.5 times as long as broad and about 1.2 times as long as outer apical spine on it; the outer spine about 2 times longer than inner spine. Leg 5 of one joint; proximal joint fused with posterior thoracic segment bearing a long seta; the single joint elongated and with an apical seta and a minute spinule between middle and posterior third of inner margin of the joint.

Typical of shallow water bodies with plant material like littoral of rivers, lakes and reservoirs. Also often encountered in small ponds, rice fields, and temporary pools with macrophyte thickets.

Distribution: Cosmopolitan.

17. *Microcyclops varicans rubellus* (Lilljeborg, 1901) 어리꼬마검물벼룩

(Fig. 10, f-i)

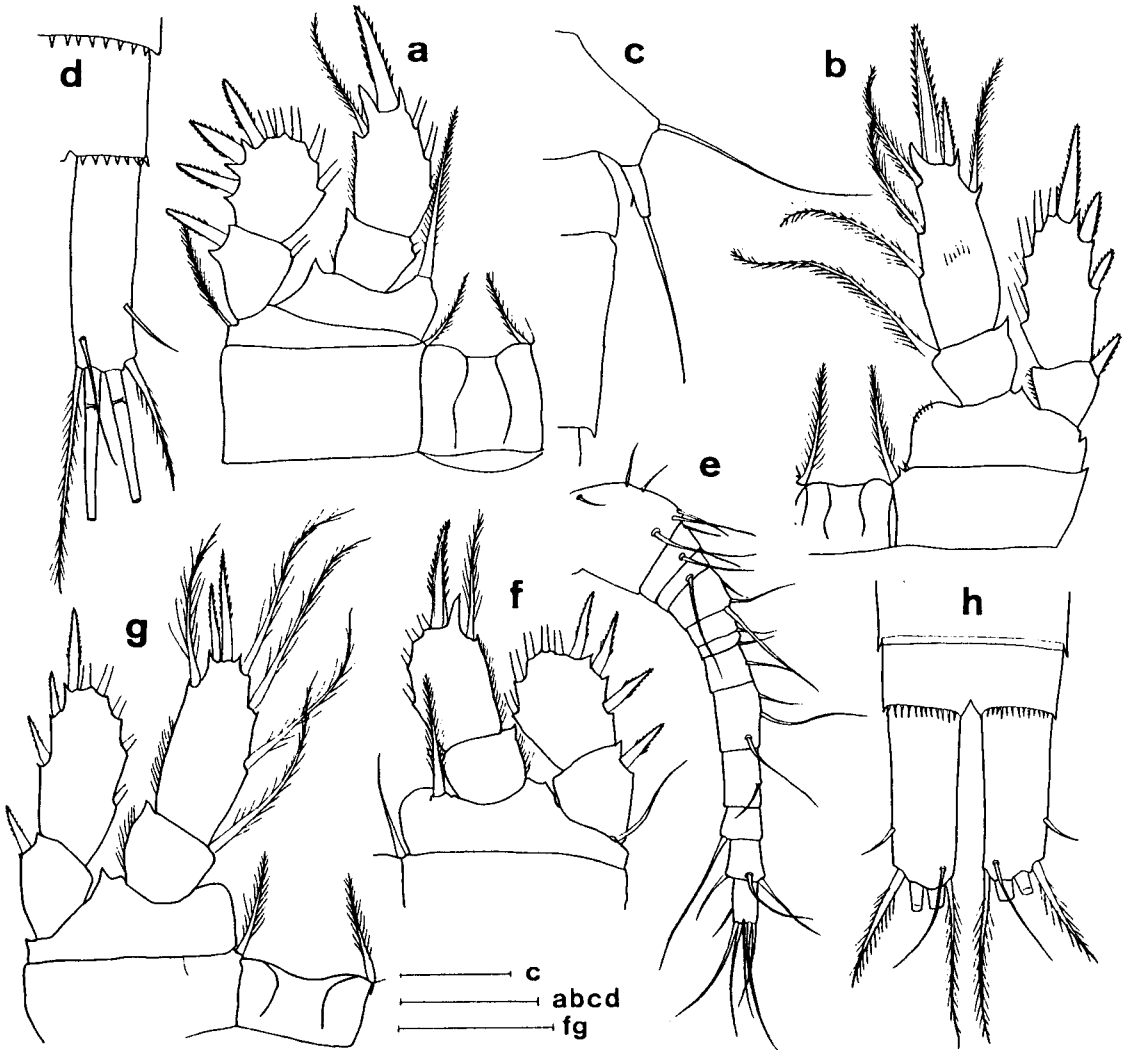
Cyclops rubellus Lilljeborg, 1901 (p. 75, pl. 4, figs. 25-26).*Cyclops (Microcyclops) rubellus*: Kiefer, 1929b (p. 64, fig. 25).*Cyclops (Microcyclops) varicans rubellus*: Gurney, 1933 (p. 260).*Cyclops varicans rubellus*: Yeatman, 1944 (pp. 66-70).*Microcyclops varicans* var. *rubellus*: Rylov, 1948 (p. 269, fig. 63, 3-10).*Microcyclops rubellus*: Dussart, 1969 (pp. 182-183, fig. 90).*Microcyclops (Microcyclops) rubellus*: Shen, 1979 [transl. by Mizuno, 1984 (pp. 421-422, fig. 223)].*Microcyclops varicans rubellus*: Smith & Fernando, 1978 (p. 35, figs. 136-137).

Fig. 10. a-d, *Microcyclops varicans* (Sars). a, leg 1; b, leg 4; c, leg 5; d, furcal ramus (ventral). e-h, *Microcyclops varicans rubellus* (Lilljeborg). e, antennule; f, leg 1; g, leg 4; h, anal segment and furcal rami (ventral). (scale bars: 50 μ)

[transl. by Mizuno, 1984 (pp. 463-466, fig. 254)].

Material examined: 3♂, 37; 2♀, 60; 2♀, 77; 3(1 ovi.)♀, 1♂, 94.

Description: Female. Body length more slender than in *T. crassus* or *T. taihokuensis*. Cephalothorax protruded anteriorly. Lateroposterior margins of thoracic segments a little protruded laterally. Genital segment much longer than wide, and tapering posteriorly. Seminal receptacle "T"-shaped, and each side of it markedly bent posteriorly, and about 2.5-3.0 times as long as broad; lateral seta situated on near posterior third; outer seta about a half as long as inner one, and nearly same in length with dorsal seta. Antennules of 17 articles, not exceeding the posterior margin of cephalothorax; the last two article with thin hyaline membranes on their outer margins. Leg 1-leg 5 with 3-jointed rami; seta formula 4, 4, 4, 4; spine formula 2, 3, 3, 3. Endopod 3 of leg 4 very slender, about 1.7 times longer than outer spine on it; outer spine a little longer (1.1-1.2 times) than inner spine; basal lamella bearing about 5 sharp spinules on each side of posterior margin. Leg 5 consisting of 2 joints; distal joint oblong, just over 2 times longer than wide; inner spine nearly same in length with outer seta, and less than 3 times as long as the distal joint.

Male. Leg 6 armed with three appendages; innermost spine approximately 2 times longer than medial seta.

Inhabiting the littoral of pools or ricefields. Stenothermal, and collected mostly in late spring to early autumn in Korea. Sparse in comparison with *T. crassus* or *T. taihokuensis*.

Distribution: southern part of Palaearctic (Europe, Egypt, Algeria, Pakistan, U.S.S.R., China, Korea).

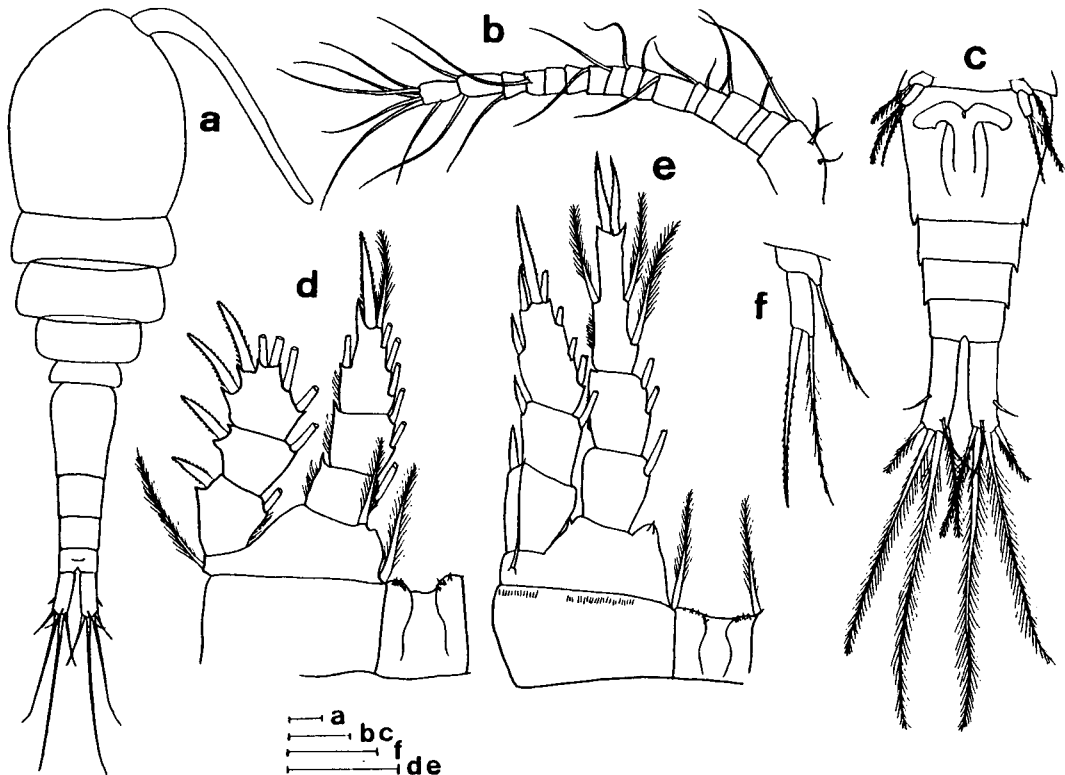


Fig. 15. *Thermocyclops dybowski* (Lande), female. a, female; b, abdomen (ventral); c, antennule; d, leg 1; e, leg 4; f, leg 5. (scale bars: 50 μ)

DISCUSSION

Freshwater cyclopoid copepods, apart from subterranean species, are known to be showing very wide zoogeographical distribution in comparison with calanoid copepods which occur in very limited range of distribution. Korean freshwater cyclopoids confirmed in this study consist of 10 cosmopolitan species (40% of total 25 species), 9 Holarctic species (36%), 2 Palaearctic species (8%) and 4 species of *Microcyclops longiramus*, *Cryptocyclops javanus*, *Mesocyclops pehpeiensis* and *Thermocyclops taihokuensis* (16%) limited only to East Asia (China and its around) respectively. The results above reaffirmed the very high cosmopolitanism and the close relation between Palaearctic and Nearctic Regions [19 species (76%) of total 25 species co-occurring in the two regions]. On the other hand, the fauna of freshwater cyclopoid copepods of Korea has been necessary to study, for it has been poorly known as compared with that of China and Japan [63 species of total 71 species in family Cyclopidae except 8 brackishwater species in China (Shen, 1979); 24 species of total 43 species in family Cyclopidae except 19 brackish or subterranean species in Japan (Mizuno and Miura, 1984)]. After the present study, all the species affirmed in Korea also occur in China, but 6 species (*Diacyclops thomasi*, *Microcyclops varicans rubellus*, *M. longiramus*, *C. javanus*, *M. pehpeiensis* and *Thermocyclops dybowskii*) have not yet been reported from Japan. The rate, 24% of total 25 species is somewhat remarkable considering the wide distribution range of the cyclopoids.

Rylov (1948) divided the inland cyclopoid copepods into two major groups of species: (1) eurythermal species adapted to marked temperature fluctuations, and (2) stenothermal species associated with definite temperature conditions, of which the later group was again divided into cold water and warm water species. But the optimal temperature limits and the number of developmental cycle may vary in some extent according to topography, habitat and particular circumstances, even in the same species. In case of Korean cyclopoids, 4 species (*D. thomasi*, *D. crassicaudis cretensis*, *C. vicinus* and *M. longiramus*) appeared to favor cold water; 4 species (*C. javanus*, *T. dybowskii*, *T. taihokuensis* and *Tropocyclops prasinus*) usually occurred in warm water, of which the latter two species seemed to be getting eurythermal; the other species (17 species, 68% of 25 species occurred nearly all the year round except a freezing season in winter) are eurythermal.

For Cyclopidae is almost littoral and only a few species like *M. leuckarti*, *T. crassus*, *T. taihokuensis* and *C. vicinus* are facultatively planktonic, the greater part of species, especially belonging to *Eucyclops*, *Paracyclops*, *Microcyclops* and *Cryptocyclops* frequently occurred at small pool-type water bodies overgrown with plants like ponds and swamps, or at temporary pools in the peripheries of rivers, lakes and reservoirs. At the natural or artificial reservoirs for irrigation, which are ubiquitous in South Korea, *T. taihokuensis*, with few exceptions, was predominated from early spring to fall often with *M. leuckarti* and *E. serrulatus*, or at times with *T. crassus*, which occurred a little later. In early spring and late fall, *T. taihokuensis* co-existed usually with copepodid larva of *C. vicinus* which increases its population size from late fall to early spring.

ABSTRACT

The cyclopoid specimens collected from various freshwater habitats at 141 locations in South Korea during the period from May 1983 to May 1989 are identified into 25 species

or subspecies of 12 genera in family Cyclopidae, and the seventeen species newly reported from Korea are redescribed and figured.

REFERENCES

- Brady, G. S., 1878. A monograph of the free and semiparasitic Copepoda of the British Islands. Ray. Soc. London, **1**: 1-148.
- Brehm, V., 1909. Über die Mikrofauna chinesischer und sud-asiatischer Süsswasserbecken. Arch. f. Hydrobiol., **4**: 207-224.
- Byrnes, E. F., 1909. The fresh-water *Cyclops* of Long Island (with bibliography). Brooklyn N.Y. Inst. Arts Sci. Cold Spring Herbor Monogr., **7**: 1-43, pls. 1-15.
- Chang, C. Y. and H. S. Kim, 1986. The freshwater Calanoida (Crustacea: Copepoda) of Korea. Kor. J. Syst. Zool., **2**, 1: 49-60.
- Cho, K. S., 1965. A study on limnological condition and plankton of Lake Paro. Chunchon Teachers College Journal, **2**: 45-57. (In Korean)
- Cho, K. S., 1968. A limnological study on three artificial reservoirs in the north Han River system. (1) On the environmental factors and the plankton in Paro Lake, Chunchon Lake and Uiam Lake in spring season. Kor. J. Lim., **1**: 25-32. (In Korean)
- Cho, K. S., 1971. Comparative studies on the limnology of Chunchon, Uiam and Achim reservoirs. (1) The environmental conditions and seasonal variation of plankton. Kor. J. Lim., **4**: 27-42, (In Korean)
- Cho, K. S., 1974. Limnological studies of Soyang multiple-purposed reservoir 1. On the environment factors and plankton succession of the first years of inponded. Kor. J. Lim., **7**: 63-70. (In Korean)
- Cho, K. S., 1976. Limnological studies on the Asan and Namyang Reservoirs to be varying as freshwater. Reports of Science Education, **2**: 67-79. (In Korean)
- Cho, K. S., D. H. Cho and K.M. Yoon, 1978. Biological studies on the effects of sewage disposal of Chunchon city on the physicochemical water quality of the Uiam Reservoir. Kor. J. Lim., **11**, 3-4: 7-24. (In Korean)
- Cho, K. S. and T. Mizuno, 1977. Comparison of limnological conditions and plankton communities in the Uiam Lake consisting of the two different river systems. Kor. J. Lim., **10**: 73-85.
- Cho, K. S. and Y. S. Park, 1969. Limnological studies of the Youngrang Lake. Kor. J. Lim., **2**: 51-66. (In Korean)
- Cho, K. S. and K. H. Ra, 1971. Limnological studies of the polluted water in the Uiam reservoir-On the influence the sewage outflow Chunchon city on plankton and water conditions-. Kor. J. Lim., **4**: 35-47. (In Korean)
- Chung, M. C., 1968. Industrial pollutions and aquatic fauna in Anyang Stream. Kor. J. Lim., **1**, 1: 39-47. (In Korean)
- Chung, J. E. and H. B. Yoo, 1983. The ecological studies on the copepods in the Lake Jangseong. Kor. J. Lim., **16**: 9-21. (In Korean).
- Claus, C., 1857a. Das Genus *Cyclops* und seine einheimische Arten. Arch. Naturgesch., **23**: 1-40.
- Claus, C., 1857b. Weitere Mitteilungen über die einheimischen Cyclopiden. Arch. Naturgesch., **23**: 205-211.
- Dussart, B., 1969. Les Copepodes eaux continentales. II. Cyclopoides et Biologie. Editions N. Boubee et Cie, Paris. 292 pp. 121 figs.
- Dussart, B. et D. Defaye, 1985. Répertoire mondial des Copepodes Cyclopoides. CNRS. Paris. 236 pp.
- Fischer, S., 1851. Beiträge zur Kenntnis der in der Umgegend von St.-Petersb. find. Cyclopiden. Bull. Soc. Imp. Natur. Moscow, **24**: 409-438.
- Fischer, S., 1853. Beiträge zur Kenntnis der in der Umgegend von St. Petersburg sich findenden Cyclopiden (Fortsetzung). Bull. Soc. Imp. Nat. Moscow., **26**, 1: 74-100, 2 pls.

- Fischer, S., 1860. Beitrage zur Kenntnis der Entomostraken. Abh. K. Bayer Ak. Wiss., **8**, 3: 645-682, 3 pls.
- Forbes, S. A., 1882. On some Entomostraca of Lake Michigan adjacent waters. Amer. Natur., **16**: 640-649. pls. 8-9.
- Fryer, G., 1955. A critical review of the genus *Ectocyclops* (Crustacea: Copepoda). Ann. Mag. Nat. hist., **8**, 12: 939-950.
- Graeter, A., 1903. Die Copepoden der Umgebung von Basel. Revue suisse Zool., **11**: 419-541.
- Gurney, R., 1933. British fresh-water Copepoda III. Ray. Soc. London. 384 pp.
- Harada, I., 1931. Studien über die Süßwasserfauna Formosas, IV. Süßwasser-cyclopiden aus Formosa. Annot. Zool. Japan, **13**, 3: 149-163, 32 figs.
- Hong, S. U., K. S. Cho and K. H. Ra, 1969. Studies on the chemical conditions and plankton in the Hwajin-po Lake. Kor. J. Lim., **2**: 35-42. (In Korean)
- Hsiao, S. C., 1950. Copepods from Lake Erh Hai, China. Proc. U.S. Nat. Mus., **100**, 3261: 161-200, 30 figs. 6 tab.
- Hu, Y. T., 1943. Notes on fresh-water copepods from Pehpei. Sinensia, **14**, 1-6: 115-128, figs. A-C.
- Ito, T., 1954. Cyclopoida copepods of Japanese subterranean waters. Rep. Fac. Fish. Prefect. Univ. Mie, **1**, 2: 115-120.
- Ito, T., 1957. Groundwater copepods from South-Western Japan. Hydrobiologia, **11**: 1-28.
- Jurine, L., 1820. Histoire de Monocles qui se trouvent aux environs de Geneve. 260pp. (in part)
- Kang, S. W., 1969. The zooplankters of Uiam Lake. Kor. J. Lim., **2**, 1-2: 39-43. (In Korean)
- Kang, S. W. and Y. M. Shin, 1968. The limnological studies of the rice paddy field during the growing season of the rice plants. Kor. J. Lim., **1**, 1: 3-10. (In Korean)
- Kiefer, F., 1929a. Zur Kenntnis einiger Artengruppen der Süßwasser-Cyclopiden. Z. Wiss. Zool., **138**: 1-56, 61 figs.
- Kiefer, F., 1929b. Crustacea Copepoda. II. Cyclopoda Gnathostoma. Das Tierreich, Berlin und Leipzig, **53**: 1-102, 42 figs.
- Kiefer, F., 1930. Neue Cyclopiden von den Sunda Inseln. Zool. Anz., **36**: 185-189.
- Kiefer, F., 1932. Ein neuer Mesocyclope (Copepoda Cyclopoida) aus der Mandchurei. Zool. Anz., **100**: 234-237, 4 figs.
- Kiefer, F., 1937. Eine kleine Copepodenausbeute aus der Ostlichen Mongolei. Zool. Anz., **119**: 293-298.
- Kiefer, F., 1938a. Zur Kenntnis der Süßwasser cyclopiden (Crustacea Copepoda) Japans. Fauna Musashinensis, no. 2: 1-13.
- Kiefer, F., 1938b. Freilebende Ruderfusskrebse (Crustacea Copepoda) von Formosa. Bull. Biogeogr. Soc. Jap., **8**, 3: 35-73, 38 figs.
- Kiefer, F., 1938c. Freilebende Süßwassercyclopiden von der Nordkurilen. Bull. of the Biogeographical Soc. of Japan, **8**, 4: 75-94.
- Kiefer, F., 1978. Das Zooplankton der Binnengewässer, part 2 Die Binnengewässer, vol. 26. 343pp.
- Kikuchi, K., 1940. Freshwater Copepoda of Manchoukuo. In: Report of the limnological survey of Kwantung and Manchoukuo, pp. 281-300.
- Kim, C. K., 1978. Distribution and seasonal variations of the copepods and branchiopods in the Myeongam Lake. Kor. J. Zool., **21**, 2: 67-75. (In Korean)
- Kim, H. S. and K. S. Lee, 1978. A study on the zooplankton (Copepoda and Branchiopoda) in the Han River. Rep. Inst. Natur. Sci., SNU: 57-69. (In Korean)
- Kim, H. S. and K. B. Park, 1969. A study on the copepods and branchiopods from Han-River, Korea. I. Kwangnaru and Bokwang Dong regions. Zoologica, **8**: 1-17. (In Korean)
- Koch, C. L., 1838. Deutschlands Crustaceen, Myriapoden und Arachniden. Ein Beitrag zur deutschen Fauna, Heft **21**: 9-10. (in part)
- Kokubo, S., 1912. On Japanese fresh-water Cyclopidae, with descriptions of two new species and one new subspecies. Annot. Zool. Jap. Tokyo, **8**: 97-106, pls. 2.
- Lilljeborg, W., 1901. Synopsis specierum hucusque in Suecia observatorum generis *Cyclops*. Kngl. Svenska Vet. Acad.

- Handl., **35**: 1-118.
- Marsh, C. D., 1910. A revision of the North American species of *Cyclops*. *Trans. Wisc. Acad. Sci., Arts Lett.*, **16**: 1067-1136. pls. 73-81.
- Mashiko, K., 1951a. Studies of the fresh-water plankton of Central China I. *Sci. Repts. Kanazawa Univ.*, **1**, 1: 17-31, 3 figs.
- Mashiko, K., 1951b. Studies of the fresh-water plankton of China II. *Sci. Repts. Kanazawa Univ.*, **1**, 2: 1-18, 7 figs.
- Mizuno, T., S. W. Kang and K. S. Cho, 1980. Summary report on Korean freshwater zooplankton. Report of "Oversea Academic Expedition", Ministry of Education, Japan. pp. 63-88.
- Mizuno, T. and Y. Miura (水野壽彦・三浦住文), 1984. 日本の陸水産橈脚類. 日本/中國淡水産橈脚類. たたら書房. pp. 471-620.
- Reid, J.W., 1985. Chave de identificacao e lista de referencias bibliograficas para as especies continentais sulamericanas de vida livre da ordem Cyclopoida (Crustacea, Copepoda) Bolm. *Zool., Univ. S. Paulo*, **9**: 17-143.
- Richard, J., 1887. Liste des cladoceres et copepodes d'eau douce observes en France. *Bull. Soc. Zool. France*, **12**: 156-164.
- Rylov, W. M., 1948. Crustacea, freshwater Cyclopoida. *Fauna Rossii*, n.s., **35**, 3, 3, 318p(en russe). Traduit en anglais, IPST, Jerusalem, 1963.
- Sars, G. O., 1863. Oversigt af de indenlandske Ferskuand-scopepoder, *Forh. Vidensk., Selskab. Christiana (Jahr 1862)*, pp. 212-262.
- Shen, C. J. (chief ed.), 1979. *Fauna Sinica. Freshwater Copepoda*. Science Press, Peking, 650 pp. (translated by Mizuno, 1984. (In Japanese)
- Shen, C. J. and T. H. Sung, 1962. Faunal studies of the plankton crustaceans of the San-men-hsia Reservoir (before and after filling) on the Yellow River, China. *Acta Zool. Sinica*, **14**, Suppl.: 31-52.
- Shen, C. J. and T. H. Sung, 1965a. On three new species and three new records of freshwater copepods from Sinkiang and Heilungkiang, China. *Acta Zootax. Sinica*, **2**, 1: 15-26.
- Shen, C. J. and T. H. Sung, 1965b. The freshwater copepods of the Bai-yang-dien Lake, Hopeh Province. *Acta Zool. Sinica*, **17**, 2: 167-183.
- Shen, C. J. and T. H. Sung, 1965c. Notes on plankton crustaceans from northwestern part of Tibet. *Acta Zool. Sinica*, **17**, 3: 298-308.
- Shen, C. J. and T. H. Sung, 1965d. Notes on freshwater Copepoda of Sinkiang, northwestern China. *Acta Zool. Sinica*, **17**, 4: 383-400.
- Smith, K. and C. H. Fernando, 1978. A Guide to the freshwater calanoid and cyclopoid copepod Crustacea of Ontario. *Univ. of Waterloo. Biol. Ser.*, **18**: 1-83.
- Ueno, M., 1941. Introductory account of the biological survey of inland waters of northern Tyosen (Korea). *Jap. J. Lim.*, **11**, 3: 96-107. (In Japanese)
- Uljanin, V., 1875. Crustaces. *Voyage de Fedchenko au Turkestan*, **2**, 6: 23-41.
- Yamamoto, K., 1941. The plankton of Lake Husenko of northern Korea. *Jap. J. Lim.*, **11**, 3: 103-116. (In Japanese)
- Yeatman, H. C., 1944. American cyclopods of the *viridis-vernalis* group (including a description of *Cyclops carolinianus* n. sp.). *Amer. Midl. Natur.*, **32**, 1: 1-90.
- Yoo, K. I., B. J. Lim and C. I., Choi, 1987. Ecological studies on zooplankton community in Lake Yongsan, Korea. *Kor. J. Lim.*, **20**, 2: 61-72.