

A Taxonomic Study of Genus *Moina* (Branchiopoda, Cladocera, Moinidae) of Korea

Yoon, Seong Myeong and Kim, Won

(Department of Molecular Biology, College of Natural Sciences, Seoul National University, Seoul 151-742, Korea)

한국산 *Moina* 속 (새각 강, 지각 목, 모이나물벼룩 과)
물벼룩류의 분류학적 연구

윤 성 명 · 김 원

(서울대학교 자연과학대학 분자생물학과)

서 론

1983년 7월부터 1991년 7월까지 남한의 각종 담수역 65개 지점에서 채집된 모이나물벼룩류의 표본들을 검토한 결과 한국미기록종 1종을 포함한 3종이 동정되었다. 한국산 *Moina* 속 물벼룩류 4종에 대한 검색표와 함께, 본 연구에서 동정된 3종에 대하여 단위생식하는 암컷 뿐만이 아니라 국내에서 잘 알려져 있지 않았던 수컷 및 휴지란 등을 기재하고 도판을 작성하였다.

Key words: taxonomy, *Moina*, Cladocera, Korea.

INTRODUCTION

Moina is one of the very interesting group of organisms found in temporary pools and saline lakes. Members of the genus have frequently been used as experimental animals in physiological studies as well as in studies of embryology and genetics in many countries. About twenty species of the genus are known in the world.

In Korea, three species (*M. macrocopa*, *M. micrura*, *M. weismanni*) have been recorded in this genus.

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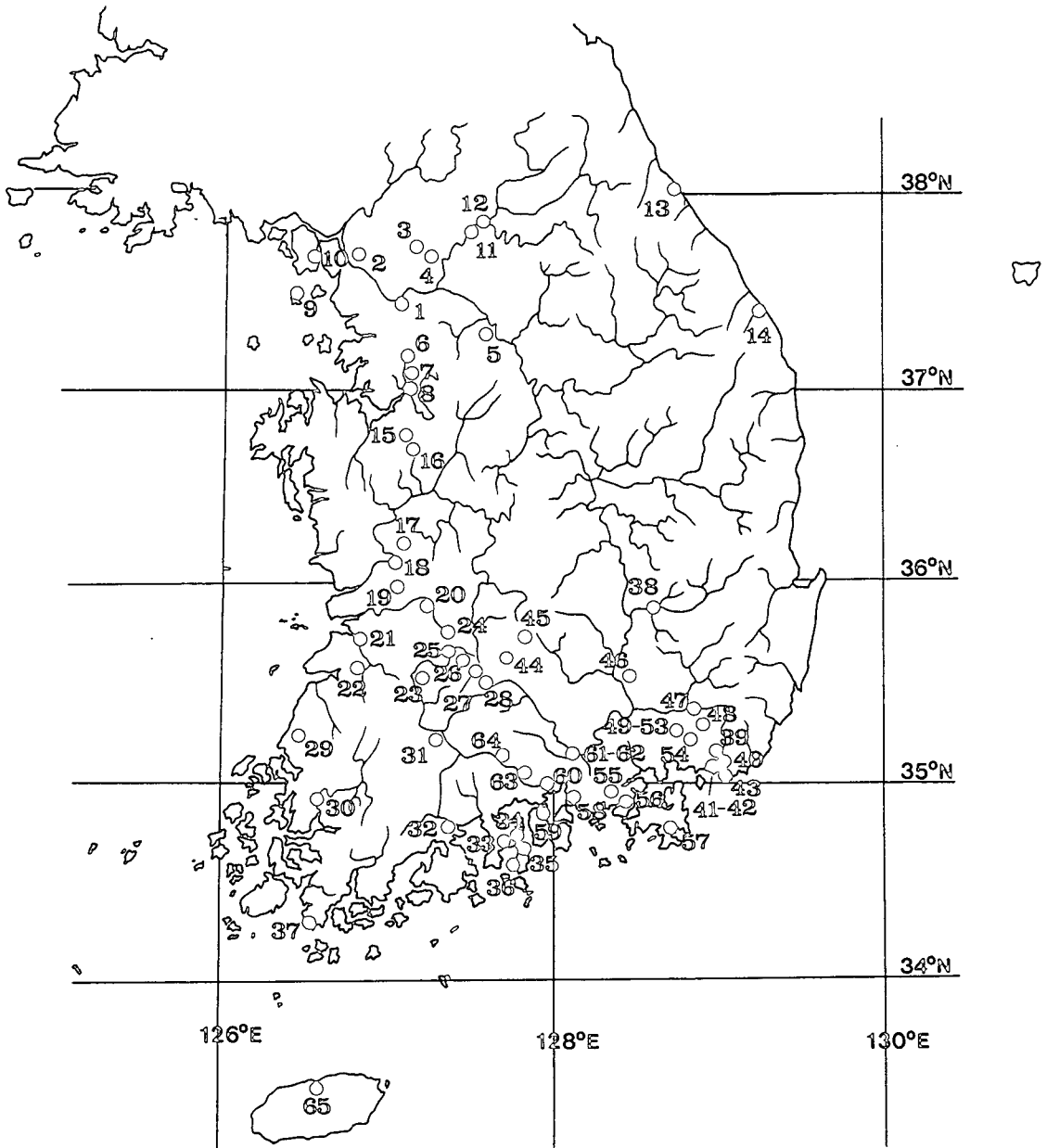


Fig. 1. Localities from which specimens of the present study were collected.

Among them, *M. micrura* was not examined taxonomically but reported only in researches concerning limnological conditions (Cho and Oeh, 1972; Cho and Mizuno, 1977; Kim, 1978; Mizuno *et al.*, 1980). Other two species were examined taxonomically (Yoon and Kim, 1987; Kim, 1988), but those taxonomic studies were based mainly on parthenogenetic female, and consequently studies on male and ephippial female were insufficient.

The present study was carried out to clarify the taxonomic status of the species of the genus *Moina* occurring in various habitats in Korea. As a result of the study three species were identified. Of these, one species, *M. affinis*, was found to be new to Korea. Including this unrecorded species, we presented a key to four species of the genus *Moina* occurring in Korea. We also described and illustrated males and ephippial females known poorly in Korea as well as parthenogenetic females of the three species identified in this study.

MATERIALS AND METHODS

Materials were collected from various freshwater habitats such as ricefields, bogs, streams, swamps, rivers and reservoirs at 65 localities (Figure 1) in South Korea during the period from July 1983 to July 1991.

Collections were made with a dipnet or a conical plankton net of no. 10 (or no. 25) mesh aperture. All samples were preserved in 70% ethanol. Drawing and measuring were made with the aid of a camera lucida. All specimens examined are deposited in the Department of Molecular Biology, Seoul National University.

An abbreviation 'ephi.' in the 'Material examined' section means ephippial female. The classification of family level was based on Bowman and Abele (1982). The appendix includes the station number, its locality and other informations. The collectors were referred when the specimens were not collected by authors.

SYSTEMATIC ACCOUNTS

Key to the species of the genus *Moina* of Korea

1. Head without distinct supraocular depression; anterior seta on penultimate segment of trunk limb I of female with series of teeth on outer surface. *M. macrocopa*
 - Head with distinct supraocular depression; anterior seta on penultimate segment of trunk limb I of female feathered or only with fine setules. 2
2. Long hairs present on head and shell of female. 3
 - Long hairs completely absent on female; setae on posterior margin of shell grouped -- *M. micrura*
3. Setae on posterior margin of shell ungrouped and of equal size. *M. affinis*
 - Setae on posterior margin of shell grouped and of unequal size. *M. weismanni*

Class Branchiopoda Latreille, 1817	새각 강
Subclass Diplostraca Gerstaecker, 1866	양갑 아강
Order Cladocera Latreille, 1829	지각 목

Family Moinidae Goulden, 1968 모이나물벼룩 과
Genus *Moina* Baird, 1850 모이나물벼룩 속

1. *Moina macrocopa* (Straus, 1820) 모이나물벼룩 (Figure 2,3)

Daphnia macrocopus Straus, 1820 [cited from Goulden, 1968 (p. 22)].

Moina macrocopa: Sars, 1903 (p. 178, Pl. 7, fig. 3); 1916 (p. 320, Pl. 35, figs. 1,1a); Keilhack, 1909 (p. 47, figs. 113-115); Ueno, 1927 (p. 283, Pl. 25, figs. 13,13a-13d); 1940 (p. 348, figs. 82,90,91,102); Rylov, 1935 (p. 133, Tab. 18, fig. 191); Cheng and Clemente, 1954 (p. 107, Pl. 3, figs. 7,7a-7d); Sramek-Husek, *et al.*, 1962 (p. 253, Fig. 92); Manuilova, 1964 (p. 159, Fig. 58); Scourfield and Harding, 1966 (p. 25); Flössner, 1972 (p. 204, Fig. 97); Goulden, 1968 (p. 22, Figs. 5-7); Khan *et al.*, 1978 (p. 81, Pl. 5, fig. 29); Mamaril and Fernando, 1978 (p. 136, figs. 123-127); Van de Velde and Dumont, 1978 (p. 359); Chiang and Du, 1979 (p. 153, Fig. 102); Du and Mizuno, 1981 (p. 66, fig. 33); Margaritora, 1983 (p. 81, Figs. 50/A,B, 52/A, 53/B, 54/A, 55/A); Negrea, 1983 (p. 180, Fig. 73); Yoon and Kim, 1987 (p. 190, Fig. 6/c-g); Kim, 1988 (p. 58, figs. 32-34); Michael and Sharma, 1988 (p. 89, Fig. 27/a-d).

Moina macrocopa macrocopa Smirnov, 1976 (p. 215, Figs. 196-199).

Material examined: sta 2, 13 (6 ephi.) ♀♀, 5 ♂♂; sta 3, 11(3 ephi.) ♀♀, 3 ♂♂; sta 4, 2 ♀♀; sta 5, 15 ♀♀; sta 6, 21 ♀♀; sta 7, 11 ♀♀; sta 8, 7 ♀♀; sta 9, 14 ♀♀; sta 10, 11 (5 ephi.) ♀♀, 2 ♂♂; sta 12, 2 ♀♀, 2 ♂♂; sta 13, 1 ♀; sta 14, 9 ♀♀; sta 16, 8 ♀♀; sta 19, 1 ♂; sta 20, 2 ♀♀; sta 22, 8 ♀♀; sta 23, 11 ♀♀; sta 24, 5 ♀♀; sta 28, 8 ♀♀, 2 ♂♂; sta 29, 7 ♀♀, 1 ♂; sta 33, 6 ♀♀; sta 34, 15 ♀♀; sta 35, 17 (6 ephi.) ♀♀; sta 36, 11 ♀♀; sta 37, 14 (6 ephi.) ♀♀, 7 ♂♂; sta 44, 7 ♀♀; sta 45, 11 ♀♀, 3 ♂♂; sta 48, 8 (3 ephi.) ♀♀, 4 ♂♂; sta 52, 12 ♀♀; sta 54, 18 ♀♀, 7 ♂♂; sta 55, 7 ♀♀, 2 ♂♂; sta 56, 8 ♀♀; sta 60, 2 ♀♀; sta 62, 1 ♀; sta 63, 1 ♀.

Female: Body (Figure 2a) 1.0 to 1.3 mm long (excluding abdominal setae), thick, heavy and oblong with head rounded in lateral view; head not distinctly separated from shell; surface of head and shell covered with hairs.

Head broadly rounded, without any distinct supraocular depression. Eye located near tip of head, of moderate size and composed of pigment spot surrounded by small crystalline bodies.

Antennule (Figure 2b) large, robust, and covered with fine setae somewhat longer on posterior medial margin; sensory seta long and originating from lateral margin of midpoint of antennule.

Antenna (Figure 2c) consisting of large basipod, three-segmented endopod and four-segmented exopod. Basipod having one short spine on outer lateral side near distal end and with three sensory setae; two of which originating from posterior margin near base of segment, while other one present on distal end between two rami. First two segments of antennal endopod each having one long swimming seta on their distal end, while distal segment with three long setae and single short spine. Four-segmented exopod having long swimming setae only on two distal segments, while short proximal first segment without setae and second segment with only one short spine; third segment having one long seta and distal-most segment with three long setae and one short spine. All segments of antenna covered with many rows of fine setae; medial rows of setae long.

Shell (Figure 2d) semi-transparent, covered with hairs; hairs denser and longer near anterior half of shell, but shorter and sparser towards posterior margin. Ventral margin of shell having one row of about sixty setae beginning at antero-ventral border, extending along entire ventral margin; setae slightly longer anteriorly, shorter posteriorly. After this row, much shorter ungrouped setae present along posterior margin. Postero-



Fig. 2. *Moina macrocopa* (Straus), female(a-j) and male(k-m): a, female, lateral view; b, antennule; c, antenna; d, left shell; e, labrum; f, mandible; g, maxillule; h, postabdomen, lateral view; i, postabdomen, distal part; j, ephippium; k, male, lateral view; l, antennule; m, trunk limb I. (Scales: a,c,d,j,k= 0.2mm; b,e,f,h,l,m= 0.4mm; g,i= 0.8 mm)

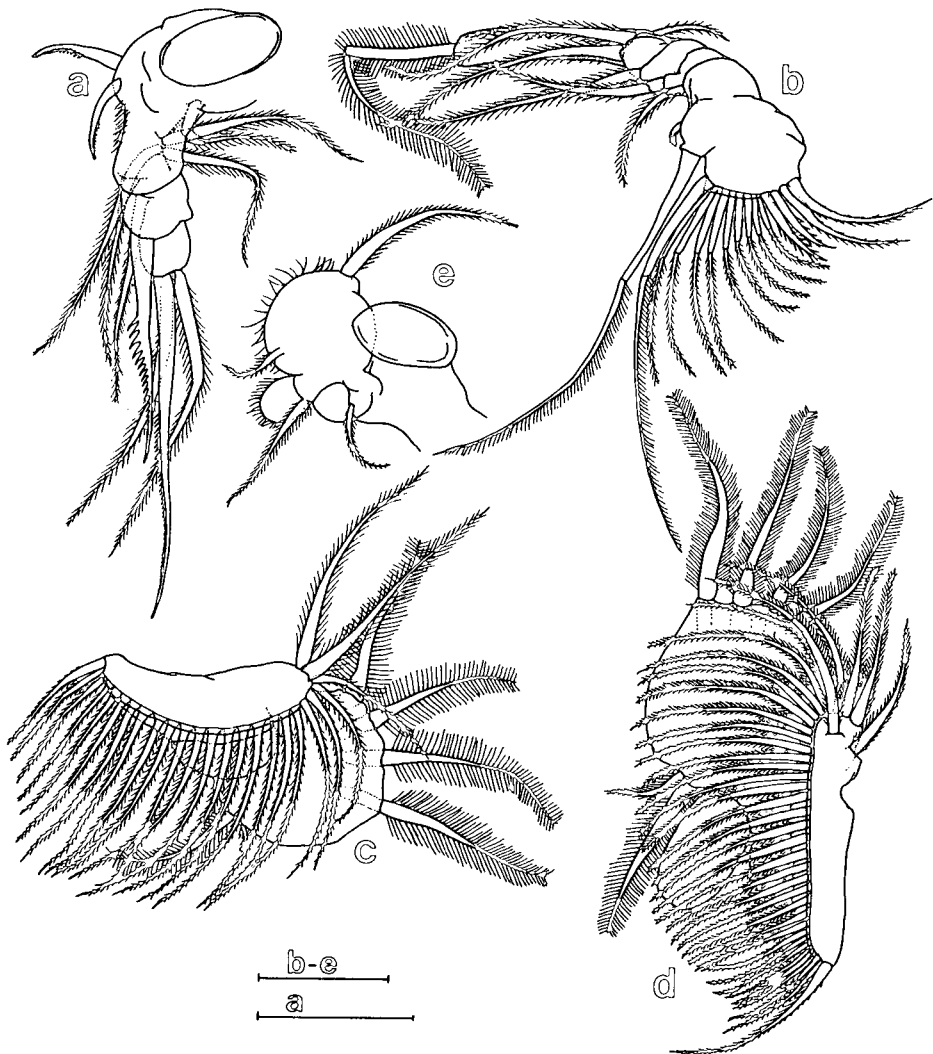


Fig. 3. *Moina macrocopa* (Straus), female: a, trunk limb I; b, trunk limb II; c, trunk limb III; d, trunk limb IV; e, trunk limb V. (Scales: 0.4 mm)

dorsal angle with small hook at near end of row.

Labrum (Figure 2e) tongue-like, with narrow apical setaceous protuberance; fine setae present on protruding areas.

Mandible (Figure 2f) arched and shoe-shaped; bulky masticatory area with about ten transverse rows of teeth.

Maxillule (Figure 2g) small, with four curved setae; outer seta short and its distal half serrated with spinules while other setae long and feather-like.

Trunk limb I (Figure 3a) no longer filtering limb; proximal first and second segments fused; first segment without gnathobase but with epipodite; second segment having five long plumose setae and two short anterior

setae serrated finely; third segment having one plumous posterior seta and one anterior seta with series of teeth on outer surface; distal-most segment with three terminal setae, one of which serrated on outer surface and others plumous.

Trunk limb II (Figure 3b) arched, without filter comb as in limb I. Proximal first segment having one small hooklike seta on middle inner margin and one short plumous seta on basal part of inner margin, and with gnathobase bearing long row of setae on distal part; two inner marginal setae, one of which apart proximally a little from other setae, long, segmented and feathered with long hairs on one side of distal segment; four outer marginal setae stout, unsegmented and serrated with fine spines; other middle setae segmented and feathered on both sides of distal segment. Four long posterior and one short anterior plumous setae present along second to third segment of limb II. Distal-most segment of limb II long, and having one terminal seta segmented and feathered with long hairs on distal segment.

Trunk limb III (Figure 3c) and IV (Figure 3d) very similar in shape each other; each of them with one large filter comb composed of long row of plumous setae on endopod, but comb of limb III a little shorter than that of limb IV; exopods of these two limbs large and flabelliform, with five long and one short setae feathered with long hairs.

Trunk limb V (Figure 3e) considerably reduced in complexity and consisting of endopod and large flabelliform exopod; four to five plumous setae present, and row of hairs present on round margin of endopod and exopod.

Postabdomen (Figure 2h,i) broad and long with conical distal part occupying only one-fourth of total length; dorsal margin with long hairs and rows of fine setae; about nine lateral teeth present, of which distal one bident and others feathered; proximal arm of bident tooth as long as feathered one while distal arm about one and a half times longer.

Claw (Figure 2i) with one to five minute teeth on ventral base; dorsal surface with one row of fine setae of which basal ones larger, and proximal group of these setae similar to pecten but distinct pecten not present; three to five short setae present between base of bident tooth and claw.

Ephippial female smaller than parthenogenetic female, but of same general form. Ephippium (Figure 2j) brown and completely covered with polygonal or rectangular deep cells and with two eggs.

Male: Body (Figure 2k) 0.63 to 0.85 mm long, densely covered with hairs; hairs longer on dorsal part of shell than near ventral part and a few hairs covering head.

Head separated from shell by groove and without supraocular depression, with long antennules originating from area below eye.

Antennule (Figure 2l) with bend near mid-point, with two sensory setae originating at near knee of this bend; one of these setae having thick base on medial margin while another one longer and originating from lateral margin of antennule; distal half of antennule curved inward, with six short hooks forming semicircular shape surrounding group of sensory papillae projected from end of antennule.

Antenna similar to that of female.

Ventral margin of shell with about forty setae and followed by row of short setae as in female; arrangement of these setae identical with that of female. Postero-dorsal angle carrying hook as in female.

Trunk limb I (Figure 2m) with very large, recurved hook originating from penultimate segment; ultimate segment with three setae, one of which longer and hooklike and other setae feathered; penultimate segment covered with many short hairs along medial margin, with one seta arising from this surface opposite to

hook; distal part of exopod segment of limb I with very long seta longer than leg and bent ventrally.

Postabdomen and claw similar in general form to those of female.

Distribution: Cosmopolitan.

Remarks: In most characters, the present specimens are well accorded with the species reported from many other countries. However, the presence of five minute teeth on the ventral base of the claw, shown in most of our specimens, has not been noted yet in *M. macrocopa*. This seems to be a variation of general one-toothed form because many teeth are usually present in other species of the genus.

2. *Moina weismanni* Ishikawa, 1896 시궁모이나물 벼룩 (Figs. 4,5)

Moina weismanni Ishikawa, 1896 [cited from Goulden, 1968 (p. 53, fig. 23)]; Ueno, 1927 (p. 284, Pl. 25, figs. 14,14a,14g, Pl. 26, figs. 14c-14f); Brehm, 1951 (p. 112, figs. 34-36); Goulden, 1968 (p. 53, Figs. 23,25A-B); Smirnov, 1976 (p. 200, Figs. 180-182); Chiang and Du, 1979 (p. 156, Fig. 104); Yoon and Kim, 1987 (p. 190, Fig. 7); Margaritora et al., 1987 (p. 95, Pl. 1/2,4,6,7, Pl.2/1,4,5, Pl. 3/2,4,6,7); Kim, 1988 (p.58, figs. 35-37); Michael and Sharma, 1988 (p. 93, Fig. 27/g-h).

Material examined: sta 1a, 11 ♀♀; sta 1b, 17 (8 ephi.) ♀♀, 4 ♂♂; sta 5, 9 ♀♀; sta 9, 13 ♀♀; sta 17a, 1 ♀; sta 17b, 1 ♀; sta 18, 2 ♀♀; sta 26, 3 ♀♀; sta 27, 2 ♀♀; sta 30, 2 ♀♀; sta 31, 1 ♀; sta 38, 1 ♀; sta 40, 7 ♀♀; sta 41, 15 ♀♀; sta 42, 4 ♀♀; sta 43, 2 ♀♀, 1 ♂; sta 47, 2 ♀♀; sta 49, 21 ♀♀; sta 50, 7 ♀♀; sta 51, 3 ♀♀; sta 61, 1 ♂; sta 63, 6 ♀♀; sta 64, 13 ♀♀; sta 65, 11 ♀♀.

Female: Body (Figure 4a) 0.73 to 1.08 mm long (excluding abdominal setae); surface of head and shell covered sparsely with hairs; head distinctly separated from body by groove behind antennae.

In lateral view, head extending to antero-ventral direction, and large eye located almost contiguous to this margin; ventral and anterior margins of head evenly rounded, but dorsal margin interrupted by well developed supraocular depression.

Antennule (Figure 5a) large and robust, originating from area behind eye, with vertical row of long hairs on posterior medial margin, but without fine setae as those of *M. macrocopa*; sensory seta long and located on about two-thirds distance from head.

Antenna (Figure 4b) similar in general form to that of *M. macrocopa*, but with many rows of setae longer than those in *M. macrocopa* on both rami.

Ventral margin of shell (Figure 4c,d) carrying one row of about fifteen setae beginning at antero-ventral border, extending along frontal half of ventral margin. After this row, row of short, grouped setae present along posterior margin; setae usually increasing in size posteriorly in each group. Number of setae variable in each group; anterior groups usually with three to five setae, middle ones seven to eight and posterior ones about thirteen minute setae. Postero-dorsal angle carrying small hook as in *M. macrocopa*.

Labrum (Figure 4e), mandible (Figure 4f) and maxillule (Figure 4g) identical in general form with those of *M. macrocopa*.

Trunk limb I (Figure 5b) similar to that of *M. macrocopa*, but anterior seta on penultimate segment without series of teeth, feathered only with minute setules. Three terminal setae present on ultimate segment of limb I as in *M. macrocopa*; two of which feathered usually but remaining one not serrated and only feathered with minute setules as in anterior seta.

Trunk limbs II-V (Figure 5c-f) identical in general form with those of *M. macrocopa*.

Postabdomen (Figure 4h,i) slender and long with conical distal part occupying one-fourth of total length;

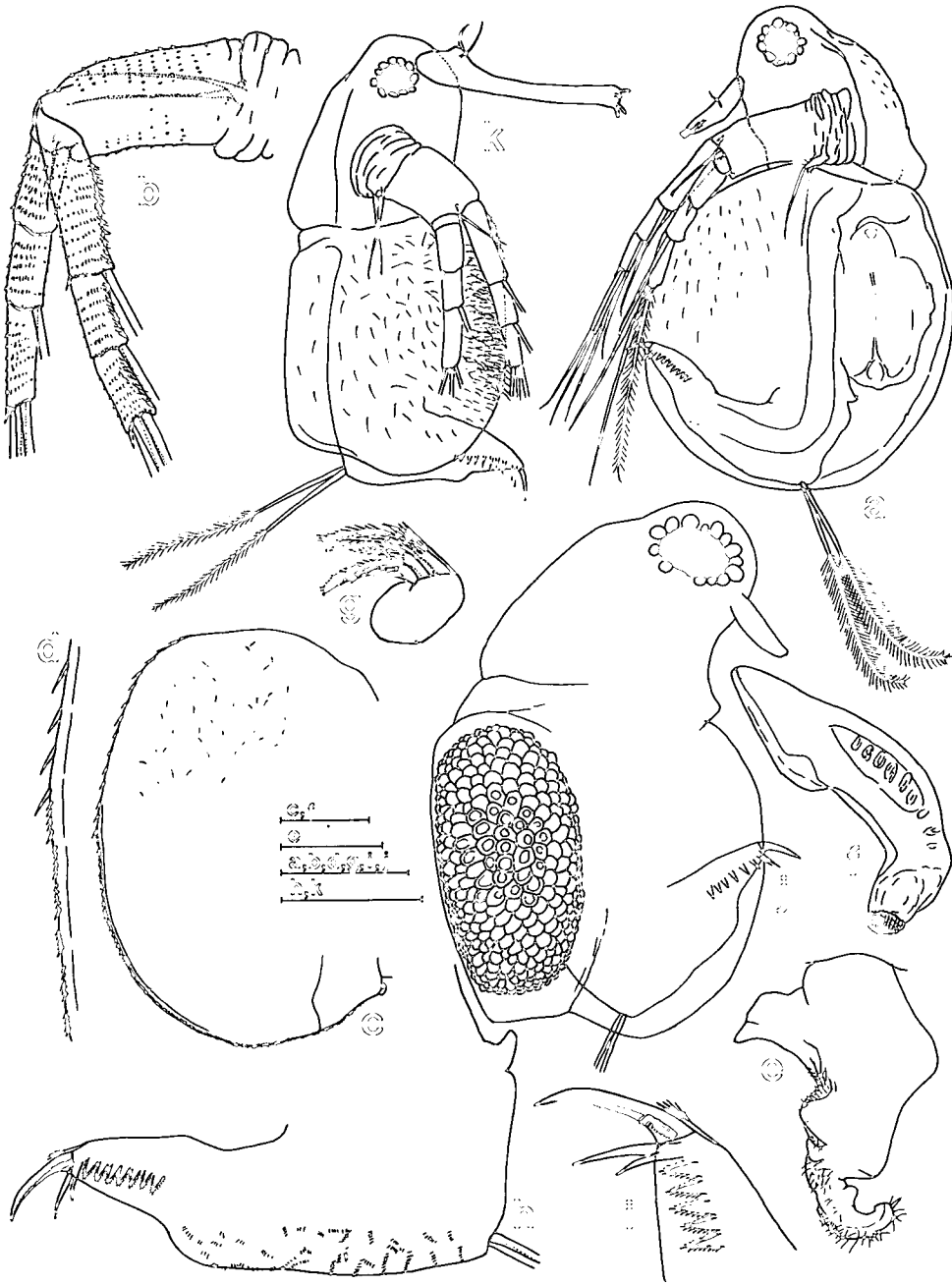


Fig. 4. *Moina weismanni* Ishikawa, female(a-j) and male(k): a, female, lateral view; b, antenna; c, left shell; d, left shell, part of ventral margin; e, labrum; f, mandible; g, maxillule; h, postabdomen, lateral view; i, postabdomen, distal part; j, ephippial female, lateral view; k, male, lateral view. (Scales: a,j,k = 0.2mm; b,c,h = 0.4mm; d-g,i = 0.8 mm)

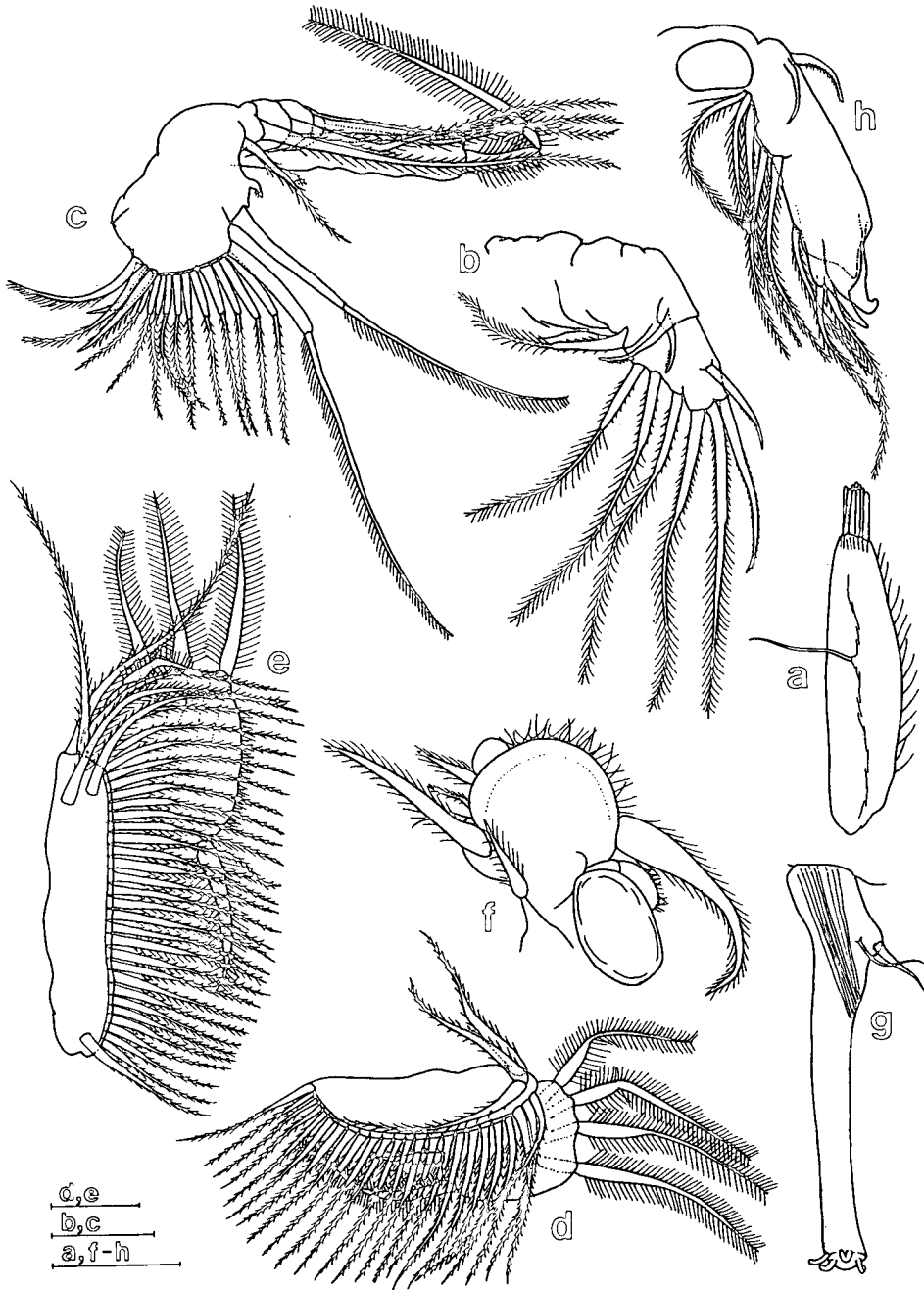


Fig. 5. *Moina weismanni* Ishikawa, female(a-f) and male(g,h): a, antennule; b, trunk limb I; c, trunk limb II; d, trunk limb III; e, trunk limb IV; f, trunk limb V; g, antennule; h, trunk limb I. (Scales: g = 0.4 mm; a-f,h = 0.8 mm)

dorsal margin with rows of fine setae but without long hairs; about seven lateral teeth present on postabdomen, distal one of which long bident while others feathered; proximal arm of bident two times longer than feathered one and distal arm three times longer.

Claw (Figure 4i) with about five minute teeth on ventral base; dorsal surface with pecten consisted of about twelve thin teeth, and remaining part of claw covered with fine setae.

Ephippial female smaller than parthenogenetic female, but of the same general form. Ephippium (Figure 4j) brown and completely covered with polygonal or round cells and with only one sexual egg.

Male: Body (Figure 4k) 0.58 to 0.65 mm long; head separated from shell by groove and with distinct supraocular depression above eye; head without hairs, nor on dorsal margin of shell but antero-ventral area densely covered with hairs.

Antennule (Figure 5g) originating from tip of head and bent at one-fifth from head, with two sensory setae originating from near knee of this bend; one seta of which with thick base on medial margin while another one longer and originating from lateral margin of antennule; four long incurved hooks present on distal end.

Antenna identical in general form with that of female.

Ventral margin of shell with about fifteen long setae and followed by groups of short setae as in female; arrangement of these setae identical with those of female. Postero-dorsal angle carrying hook as in female.

Trunk limb I (Figure 5h) with weakly developed hook on penultimate segment; base of this hook quite broad, but remaining part tapering to point; ultimate segment with three setae, one seta of which forming short hook while other setae feathered; six long feathered setae arising from lateral side opposite to hook.

Postabdomen and claw similar to those of female.

Distribution: Asia (Korea, China, Japan, Cambodia), India, Europe (Italy).

Remarks: The present specimens of this species have a different feature from the species known from other countries. The bident tooth of the postabdomen in our specimens is usually longer (one and a half times) than any other ones reported as *M. weismanni*.

M. weismanni is found often in ricefields, ditches and bogs with other species of the present genus in Korea. But *M. weismanni* seems to be the only species occurring in large reservoirs, rivers and rivermouth in this genus.

3. *Moina affinis* Birge, 1893 털시궁모이나물벼룩 (신칭) (Figs. 6,7)

Moina affinis Birge, 1893 (p. 290, Pl. 10, figs. 1,3,5,7,8,12-14); 1918 (p. 705, figs. 1092B,1093B,1094); Goulden, 1968 (p. 37, Figs. 14-16); Smirnov, 1976 (p. 208, Figs. 189-191); Chiang and Du, 1979 (p. 157, Fig. 105); Margaritora, 1983 (p. 84, Figs. 51/F, 52/D, 54/C, 55/D); Margaritora *et al.*, 1987 (p. 95, Pl. 1/1,3,5, Pl. 2/2,3, Pl. 3/1,3,5,8).

Material examined: sta 11, 1 ♀; sta 15, 1 ♀; sta 21, 4 ♀♀; sta 25, 5 ♀♀; sta 32, 7 ♀♀; sta 34, 6 ♀♀; sta 39, 2 ♀♀; sta 46, 7 ♀♀; sta 52, 17 ♀♀; sta 53, 11 ♀♀; sta 54, 17 (5 ephi.) ♀♀, 7 ♂♂; sta 55, 3 ♀♀; sta 57, 3 ♀♀; sta 58, 12 ♀♀; sta 59, 7 ♀♀.

Female: Body (Figure 6a) 0.82 to 1.15 mm long (excluding abdominal setae); head distinctly separated from body by groove behind antennae; surface of head and shell covered with hairs which dense along ventral and dorsal margins but absent from tip of head. In lateral view, head extending to antero-ventral direction with well developed supraocular depression.

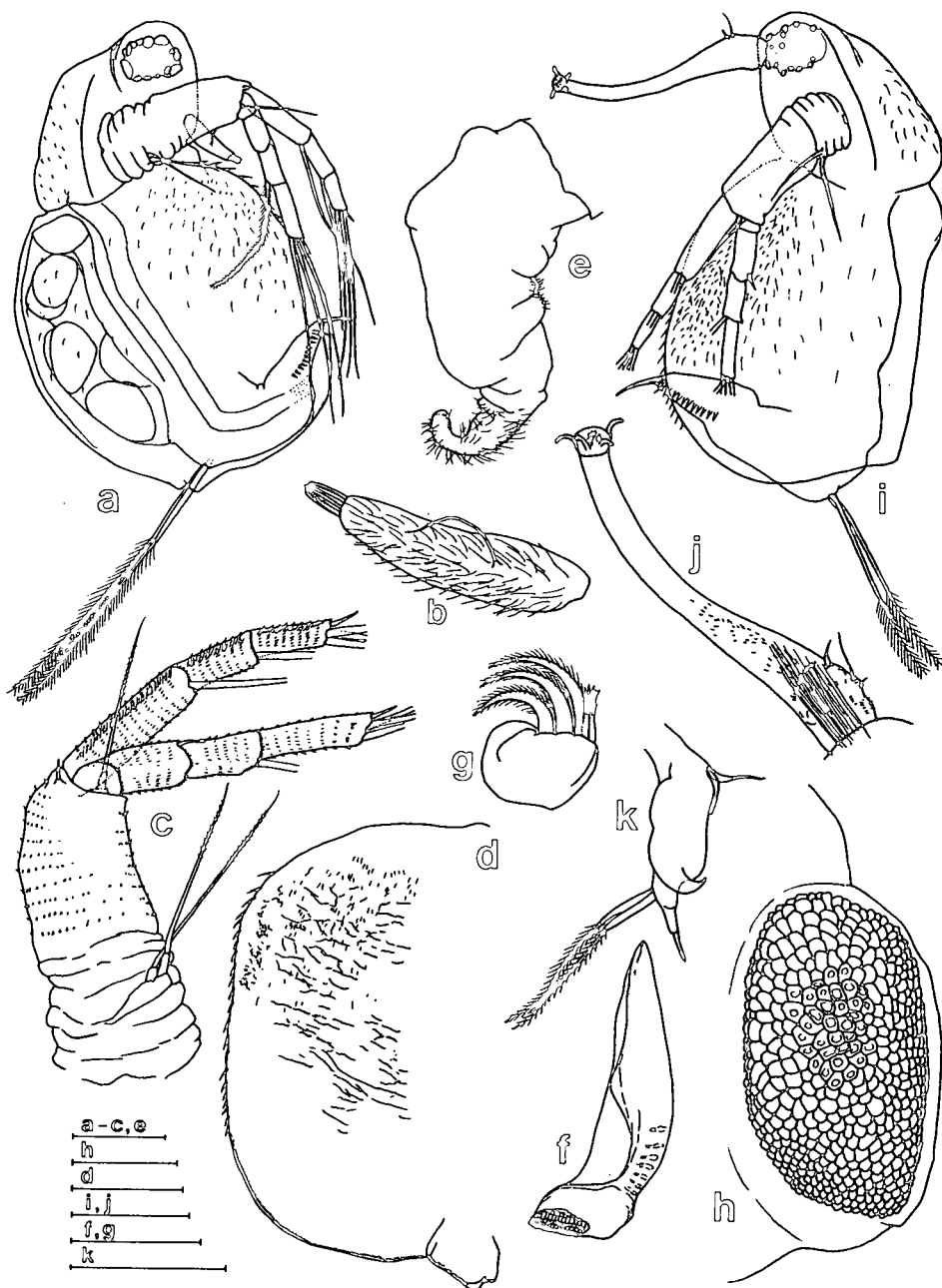


Fig. 6. *Moina affinis* Birge, female (a-h) and male (i-k): a, female, lateral view; b, antennule; c, antenna; d, left shell; e, labrum; f, mandible; g, maxillule; h, ephippium; i, male, lateral view; j, antennule; k, trunk limb I. (Scales: a,d,h,i = 0.2mm; c,f,j,k = 0.4mm; b,e,g = 0.8 mm)

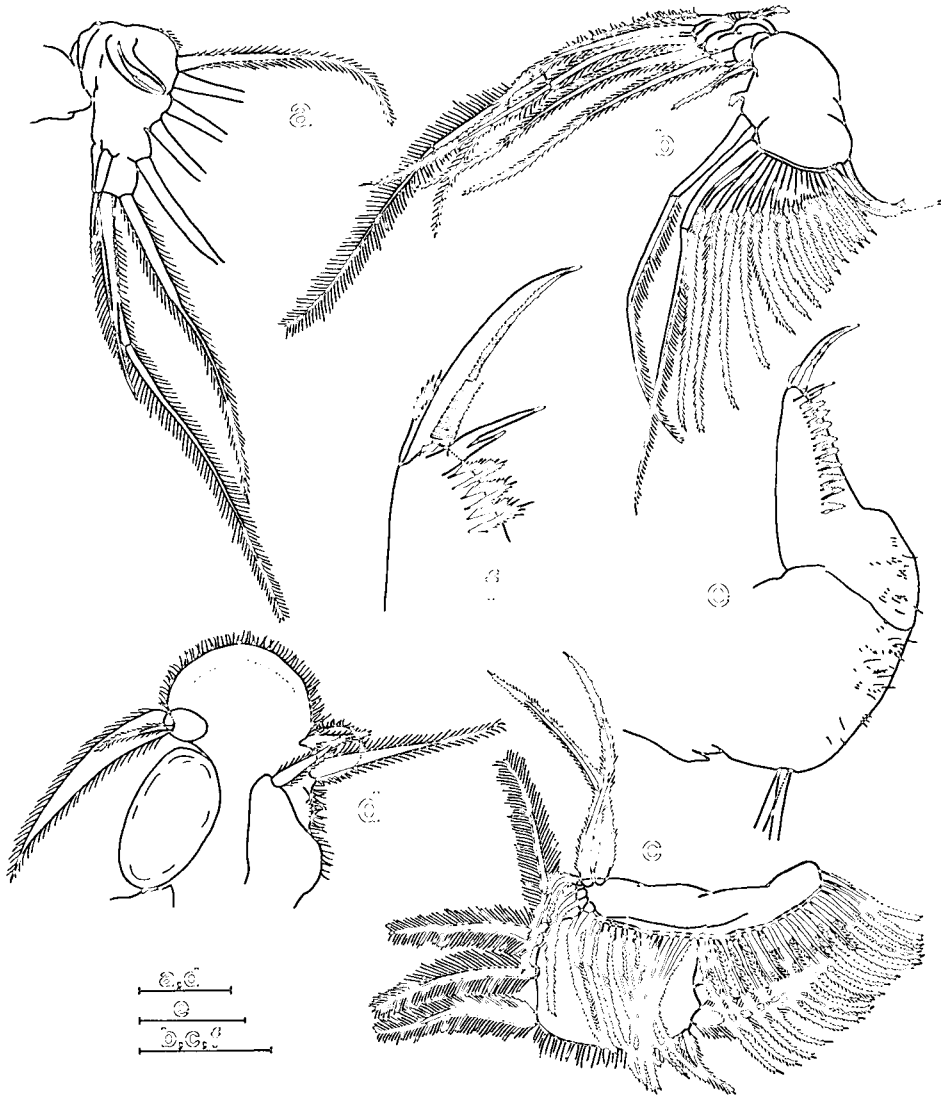


Fig. 7. *Moina affinis* Birge, female: a, trunk limb I; b, trunk limb II; c, trunk limb IV; d, trunk limb V; e, postabdomen, lateral view; f, postabdomen, distal part. (Scales: b,c,e= 0.4mm; a,d,f= 0.8 mm)

Antennules (Figure 6b) short, originating from area behind eye and covered completely with long hairs; sensory seta long and located on medial margin of about one-third distance from head.

Antenna (Figure 6c) similar in general form to that of *M. macrocopa* or *M. weismanni*, but more similar to *M. weismanni* in shape of many rows of setae on exopod and endopod.

Ventral margin of shell (Figure 6d) carrying row of about twenty-two setae beginning at antero-ventral border, extending along frontal two-thirds of ventral margin. After this row, row of much shorter ungrouped setae present along posterior margin. Postero-dorsal angle carrying small hook.

Labrum (Figure 6e), mandible (Figure 6f) and maxillule (Figure 6g) identical in general form with those of *M. macrocopa* and *M. weismanni*.

Trunk limb I (Figure 7a) similar to *M. weismanni*, with anterior seta on penultimate segment feathered with fine setules.

Trunk limbs II - V (Figure 7b-d) identical in general form with those of *M. macrocopa* and *M. weismanni*.

Postabdomen (Figure 7e,f) slender and long with conical distal part occupying one-third of total length; dorsal margin of postabdomen with rows of fine setae and long hairs; about ten lateral teeth present on postabdomen, distal one bident and other ones feathered; proximal arm of bident tooth about one and a half times longer than feathered ones and distal arm two and a half times longer.

Claw (Figure 7f) with about six minute teeth on ventral base; dorsal surface with pecten of about fourteen thin teeth and remaining part of claw with one row of fine setae as in *M. weismanni*.

Ephippial female smaller than parthenogenetic female, but of the same general form. Ephippium (Figure 6h) brown and completely covered with polygonal or round cells and with only one sexual egg.

Male: Body (Figure 6i) 0.68 to 0.86 mm long; head sparsely covered with hairs, but ventral area of shell densely covered with hairs; head separated from shell by groove and with distinct supraocular depression above eye.

Antennule (Figure 6j) originating from near tip of head, curved inward and bent at very near head and with two sensory setae; one seta of which very thin, long and originating from near bend of medial margin while another one very short and thick, and present on medial margin apart from distal extremity; a few small protuberances present along medial part of bend; proximal half of antennule covered with small hairs and distal end with four incurved hooks.

Antenna similar to that of female.

Ventral shell rim with about twenty-two long setae and followed by short setae as in female. Postero-dorsal angle also carrying hook as in female.

Trunk limb I (Figure 6k) with poorly developed hook curved inward on penultimate segment; ultimate segment with three setae, one seta of which reduced to small, knoblike protuberance while other two setae feathered.

Postabdomen and claw similar to those of female.

Distribution: Korea, China, North America, Europe (Italy).

Remarks: The present specimens of this species are well accorded with those reported from other countries in most characters, but have a different characteristic antenna. Our specimens lack a long row of stout teeth on endopod previously noted by other authors (Goulden, 1968; Smirnov, 1976; Chiang and Du, 1979; Margaritora *et al.*, 1987).

ABSTRACT

The specimens belonging to genus *Moina* collected from various freshwater habitats at 65 localities in South Korea during the period from July 1983 to July 1991 were examined. As a result of the present study, three species were identified and one of which was newly reported from Korea. We provided a key to four species of the genus *Moina* occurring in Korea and described and illustrated males and ephippial females poorly known in Korea as well as parthenogenetic females of the three species.

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APPENDIX

Station list

Seoul, Inch'on and Kyonggi-do: sta 1, a pond in Seoul National Univ., a, 6 VII 1983, C.Y. Chang; b, 24 VI 1991; sta 2, ricefields at Madu-ri, Ilsan-ŭp, Koyang-gun, 28 V 1989, G.S. Min; sta 3, ricefields at Changhyŏn-ri, Chinjŏp-myŏn, Namyangju-gun, 20 V 1991; sta 4, ricefields at the approach to Ch'ŏnmasan, 6 VI 1989, C.B. Kim; sta 5, ricefields at Pŏndo-ri, Nŭngsŏ-myŏn, Yŏju-gun, 14 IV 1991; sta 6, a bog and ricefields at Such'ŏng-dong, Osan-shi, 21 IV 1991; sta 7, ricefields at Sŏjŏng-dong, Songt'an-shi, 3 IX 1989 G.S. Min; sta 8, ricefields at Shindae-dong, Pyŏngt'aek-shi, 3 IX 1989 G.S. Min; sta 9, ricefields at Ŭlwang-ri, Yongyudo, Inch'on, 12 VI 1991; sta 10, ricefields at Yongjin, Kanghwado, 24 IV 1991. M.K. Shin and H.B. Kong.

Kangwŏn-do: sta 11, ricefields at Kangch'on-ri, Nam-myŏn, Ch'unsŏng-gun, 16 VIII 1990; sta 12, Kong-jich'ŏn, Ch'unchi'ŏn-shi, 16 VIII 1990; sta 13, ricefields at Ŏsŏngjŏn-ri, Hyonbuk-myŏn, Yangyang-gun, 8 V 1987; sta 14, ricefields at Kyo-dong(Kwangjin), Samch'ŏk-shi, 2 V 1991.

Ch'ungch'ŏngnam-do: sta 15, ricefields at Undang-ri, Chŏnŭi-myŏn, Yŏngi-gun, 21 IV 1991; sta 16, a bog at Sŏkkok-ri, Chŏndong-myŏn, Ch'ŏnwŏn-gun, 21 IV 1991; sta 17, Nosŏngch'ŏn, Kŭmdai-ri, Nosŏng-myŏn, Nonsan-gun, a, 16 VII 1990, C.Y. Chang; b, 30 VII 1990, C.Y. Chang; sta 18, Hwangsansannaru (Kŭmgang), Kanggyŏng, 2 VIII 1986, C.Y. Chang.

Chŏllabuk-do: sta 19, Chugyo Res., Onsu, Iksan-gun, 3 V 1988, C.Y. Chang; sta 20, ricefields at Sŏngdŏk-dong, Chŏnju-shi, 19 VII, 1990; sta 21, ricefields at Tongjin-myŏn, Puan-gun(border on Kimje-gun), 19 VII 1990;

sta 22, ricefields at Chigyŏng-ri, Chŏngŭp-myŏn, Chŏngup-gun, 20 IV 1991; sta 23, Tongsanri Res., Pokhŭng-myŏn, Sunch'ang-gun, 20 IV 1991; sta 24, ricefields at Shinhŭng-ri, Sanggwang-myŏn, Imshil-gun, 18 VII 1990; sta 25, a stream at Imshil-ŭp, Imshil-gun, 2 VI 1988, C.Y. Chang; sta 26, Osuch'ŏn, Tunnam-myŏn, Inshil-gun, 2 VI 1988, C.Y. Chang; sta 27, a ditch near Namwŏn Station, 2 VI 1988, C.Y. Chang; sta 28, ricefields at Chech'ŏn-ri, Chusaeng-myŏn, Namwŏn-gun, 18 VII 1990.

Chollanam-do: sta 29, ditches and ricefields at Yŏnggwang-ŭp, Yŏnggwang-gun, 19 VII 1990; sta 30, Yŏngsan-gang Barrage, 4 VII 1984, C.S. Lee; sta 31, ditches and ricefields at Koksŏng-ŭp, Koksŏng-gun, 18 VII 1990; sta 32, ricefields at Pŏlgyo-ŭp, Posŏng-gun, 18 IX 1989, G.S. Min; sta 33, ricefields at Chusam-dong, Yŏch'ŏn-shi, 25 IV 1990; sta 34, ricefields at Tundŏk-dong, Yŏsu-shi, 25 IV 1990; sta 35, ricefields at Seguji, Tolsan-ŭp, Yŏch'ŏn-gun, 26 IV 1990; sta 36, ricefields at Kŭmch'ŏn-ri, Tolsan-ŭp, Yŏch'ŏn-gun, 25 IV 1990; sta 37, ricefields at Songho-ri, Songji-myŏn, Haenam-gun, 2 V 1990.

Kyŏngsangbuk-do: sta 38, a swamp at P'algongsan, Wach'on-myŏn, Kyŏngsan-gun, 7 IX 1990.

Pusan and Kyŏngsangnam-do: sta 39, under Sŏnam Bridge(Naktonggang), Pusan, 12 IX 1987, D.H. Kwon; sta 40, Myŏngji-dong(Naktonggang), Pusan, 10 VIII 1987, M.O. Song; sta 41, Noksan(Naktonggang), Pusan, 10 VIII 1987, M.O. Song; sta 42, Maektogang, 7 VIII 1986; sta 43, Hadan-dong(Naktonggang), Pusan, 6 VIII 1986; sta 44, ricefields at Hwasan-ri, Sudong-myŏn, Hamyang-gun, 30 VI 1984, G.S. Min; sta 45, ricefields at Kimch'ŏn-ri, Kŏch'ang-ŭp, Kŏch'ang-gun, 14 V 1989, G.S. Min; sta 46, Mago Swamp, Changma-myŏn, Ch'angnyŏng-gun, 22 VII 1987; sta 47, Samrangjin (Naktonggang), Milyang-gun, 7 VIII 1987; sta 48, ricefields at Mangch'ŏn-ri, Hanrim-myŏn, Kimhae-gun, 29 V 1991; sta 49, Chunam Res., Changwŏn-gun, 22 VII 1987, M.O. Song; sta 50, Tongp'ange Res., Changwŏn-gun, 22 VII 1987, M.O. Song; sta 51, a pond near Ugok Res., Changwon-gun, 22 VII 1987, M.O. Song; sta 52, ricefields at Shinbang-ri, Tong-myŏn, Changwŏn-gun, 29 V 1991; sta 53, ricefields at Hwayang-ri, Tong-myŏn, Changwŏn-gun, 29 V 1991; sta 54, ricefields at Kogŭm-ri, Chinyŏng-ŭp, Changwŏn-gun, 29 V 1991; sta 55, ricefields at Tapch'ŏn-ri, Ilbansŏng-myŏn, Chinyang-gun, 25 VI 1984, G.S. Min; sta 56, ricefields at Songhak-dong, Kosŏng-ŭp, Kosong-gun; sta 57, ricefields at Mangch'i-ri, Ilun-myŏn, Kŏje-gun, 5 V 1989; sta 58, ricefields at Hyangch'on-dong, Samch'ŏnp'o-shi, 28 V 1991; sta 59, ditches and ricefields at Och'ŏn-ri, Sŏlch'ŏn-myŏn, Namhae-gun, 20 VII 1990; sta 60, ricefields at Songjŏng-ri, Konyang-myŏn, Sach'ŏn-gun, 3 VII 1984, G.S. Min; sta 61, Namgang, Chinju-shi, 24 VI 1984, G.S. Min; sta 62, Kajwach'ŏn, Kajwa-dong, Chinju-shi, 28 VI 1984, G.S. Min; sta 63, ricefields at Chŏkryang-myŏn, Hadong-gun, 18 VII 1990; sta 64, ricefields at Shingi-ri, Hwagae-myŏn, Hadong-gun, 18 VII 1990.

Chŏnju-do: sta 65, Pyŏldoch'ŏn, Hwabuk-dong, Chejushi, 25 VIII 1984, J.K. Ham.