

## ***Alona quadrangularis* (O.F. Müller, 1785) (Branchiopoda, Anomopoda, Chydoridae) in Korea**

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### **ABSTRACT**

A freshwater chydorid cladoceran, *Alona quadrangularis* (O.F. Müller, 1785), collected from a streamlet on Paektam Valley in Mt. Sorak is described.

Key words: Redescription. *Alona quadrangularis*. Korea

### **INTRODUCTION**

*Lynceus quadrangularis* O.F. Müller, 1785, the type species of genus *Alona* Baird, 1843, was described based on the specimens from Denmark and Norway (Lilljeborg, 1901). Since then it has been frequently reported from many countries in Europe (Baird, 1850; P.E. Müller, 1867; Kurz, 1875; Lilljeborg, 1901; Keilhack, 1909; Sramek-husek *et al.*, 1962; Manuilova, 1964; Smirnov, 1971; Flössner, 1972; Margaritora, 1983; Negrea, 1983; Alonso, 1991), in Asia (Ueno, 1927; Brehm, 1953; Chiang and Du, 1979; Michael and Sharma, 1988), in North America (Birge, 1893, 1918; Pennak, 1978), and in Australia (Smirnov, 1971; Van de Velde and Dumont, 1978; Smirnov and Timms, 1983), *etc.* So far *Alona quadrangularis* (O.F. Müller) is one of the chydorid species occurring on all zoogeographical regions of the temperate and subtropical (see Smirnov, 1971 for world distribution).

In recent time, however, the idea of non-cosmopolitanism becomes generally accepted among cladocerologist, and many of the chydorids claimed to be cosmopolitan are regarded as the complexes of closely related but different species (Frey, 1978, 1987a, 1987b; Michael and Frey,

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1983, 1984; Rajapaksa and Fernando, 1986, 1987a, 1987b, 1987c; Alonso and Pretus, 1989). *Alona quadrangularis* could be one of them, but any intensive study has not been performed yet. So, for increasing our knowledge of so-called *A. quadrangularis* it is needed to revise the previous works or records for its validity and to study in detail the materials from various parts of the world.

*Alona quadrangularis* is very poorly known in East Asia, though it is more than 60 years since it was recorded from Japan (Ueno, 1927). Previous taxonomic studies of this species are scarce (Ueno, 1927; Shen and Sung, 1962; Chiang and Du, 1979), and the descriptions in those are so short that could not show the whole aspects of the species. In Korea *A. quadrangularis* was first reported from the Han River, Seoul by Sato (1940), and subsequently reported from a swamp in the high mountain of Kaemagowŏn, North Korea by Ueno (1941). But both of these reports were the preliminary studies of limnological survey, so the taxonomic details of Korean materials could not be revealed. Since then any record of *A. quadrangularis* has not been in Korea.

While the first author surveyed the freshwater invertebrate fauna of Paektam Valley in Mt. Sorak, middle eastern Korea in 1994, a population of *A. quadrangularis* were found from a streamlet. In this paper, *A. quadrangularis* from Korea is described and the morphological peculiarities are discussed. The present study will increase our knowledge of so-called *A. quadrangularis* which needs cautious and detailed study under non-cosmopolitanism.

## MATERIALS AND METHODS

A population of *Alona quadrangularis* were collected from a streamlet on Paektam Valley in Mt. Sorak (128°22'E, 38°10'N) by the first author and S.H. Kim on 26 August, 1994. The water temperature was 21.0°C, and the air temperature 24.5°C. The place had a good aquatic vegetation with water nearly standing still. Collections were made with a dipnet of 155  $\mu$ m in mesh size and 15 cm in diameter. Samples were fixed with 10% formalin and preserved in 4% formalin.

The samples were inventoried to determine the presence and the reproductive state of the species under an WILD M8 stereomicroscope. All specimens as encountered were removed to a drop of glycerol in a reversed slide for subsequent study. Temporary mounts of whole specimens in glycerol were used for length measurements and for drawings of intact animals and some of their parts. Whole animals were dissected with tungsten needles for investigating headshields, antennules, antennae, trunk limbs, postabdomens, postabdominal claws, and other components. Drawing and measuring were made with a Nikon compound microscope and attached drawing tube system. All specimens examined are retained in the first author's collection.

The synonymy includes selective references to the materials from Europe and Asia, because those from different continents are questioned in conspecificity (see Frey, 1987a). Morphological variation discussed in this paper were made by comparing the materials of the present study with those of other countries on the literatures.

## RESULTS

Family Chydoridae Stebbing, 1902 씨물벼룩과

Subfamily Aloninae Frey, 1965 큰씨물벼룩아과

Genus *Alona* Baird, 1843 큰씨물벼룩속

***Alona quadrangularis* (O.F. Müller, 1785) 사각배큰씨물벼룩 (Figs. 1-3)**

*Lynceus quadrangularis* O.F. Müller, 1785 (cited from Lilljeborg, 1901, p. 448); Lilljeborg, 1901, p. 448, pl. 66, figs. 8-17.

*Alona quadrangularis*: Baird, 1850, p. 131, pl. 16, figs. 4, 4a-b; P.E. Müller, 1867, p. 176, pl. 3, figs. 20, 21; Kurz, 1875, p. 50; Keilhack, 1909, p. 82, figs. 193-195; Brehm, 1953, p. 336, fig. 102; Frey, 1959, p. 36, figs. 34, 35; Sramek-Husek *et al.*, 1962, p. 343, Fig. 127; Manuilova, 1964, p. 247, Fig. 131; Smirnov, 1971, p. 340, Figs. 382-386; Flössner, 1972, p. 316, Fig. 150; Margaritora, 1983, p. 141, Figs. 91A, 92E, 92F, 96C, 98A; Negrea, 1983, p. 282, Fig. 115; Michael and Sharma, 1988, p. 170, Fig. 56.

*Alona sanguinea* P.E. Müller, 1867, p. 177.

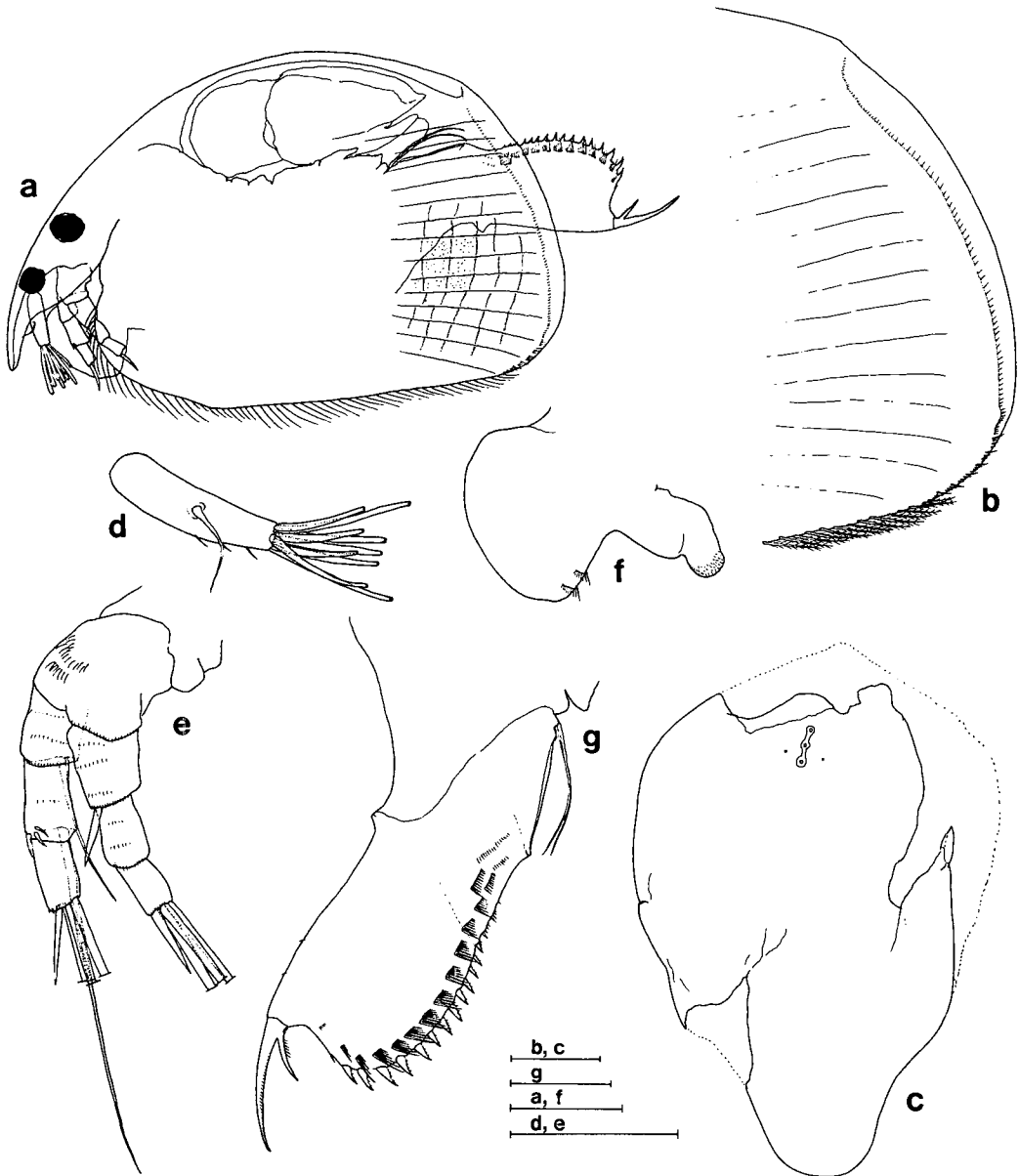
*Alona acanthocercoides* (non Fischer): Sars, 1993, p. 133, pl. 96, fig. 4, pl. 97, figs. 6-8.

**Material examined.** 6 specimens (5 parthenogenetic females and 1 ephippial female), collected from a streamlet of Paektam Valley, Kangwŏn-do, Inje-gun, Puk-myŏn, Yongdae-ri, 26 August 1994, leg. S.M. Yoon and S.H. Kim.

**Parthenogenetic female.** *General shape* (Figs. 1a, 3d). Body subrectangular. Maximum height slightly behind middle. Length about 1.6 times maximum height. Dorsal margin uniformly curved from posterodorsal corner to tip of rostrum; downward curvature of dorsum quite less in posterior half. Posterior margin slightly convex. Posterodorsal corner high and broadly rounded, distinctly farther forward than posteroventral corner. Ventral margin with distinct bulge in anterior part. Anteroventral and posteroventral corners broadly rounded. Color yellowish hyaline.

*Carapace* (Figs. 1a-b, 3d). With subparallel and longitudinal striae, especially distinct in posterior part; longitudinal striae connected by faint transverse lines, forming reticulation; reticulum bearing fine dots. Entire ventral margin from anterior end of carapace flap to posterior corner provided with marginal feathered setae; anteriormost group comprising about 15 setae increasing in length ventrally; setae of ventral bulge very short, followed by group of setae decreasing in length gradually toward posterior end. Posteroventral corner rounded and provided with 5-6 submarginal groups of setules; in each group setules increasing in length dorsally. Following last submarginal group of setules, submarginal row of minute setules gradually becoming shorter dorsally, turning inward and continuing dorsally parallel to posterior margin to posterodorsal corner (Fig. 1b).

*Head* (Figs. 1a, 1c, 3d). In lateral view, rostrum short and slender, rounded at tip, and not reaching level of ventral margin of animal (Figs. 1a, 3d). Ocellus slightly smaller than eye, usually closer to eye than to tip of rostrum. In plane view, head shield longer than broad (Fig. 1c); rostrum broadly rounded and short. Three median headpores connected by channel with nearly equal interpore distance; 2 lateral minor headpores located on each side between middle and posterior median headpores with distance slightly greater than interpore distance of median headpores.



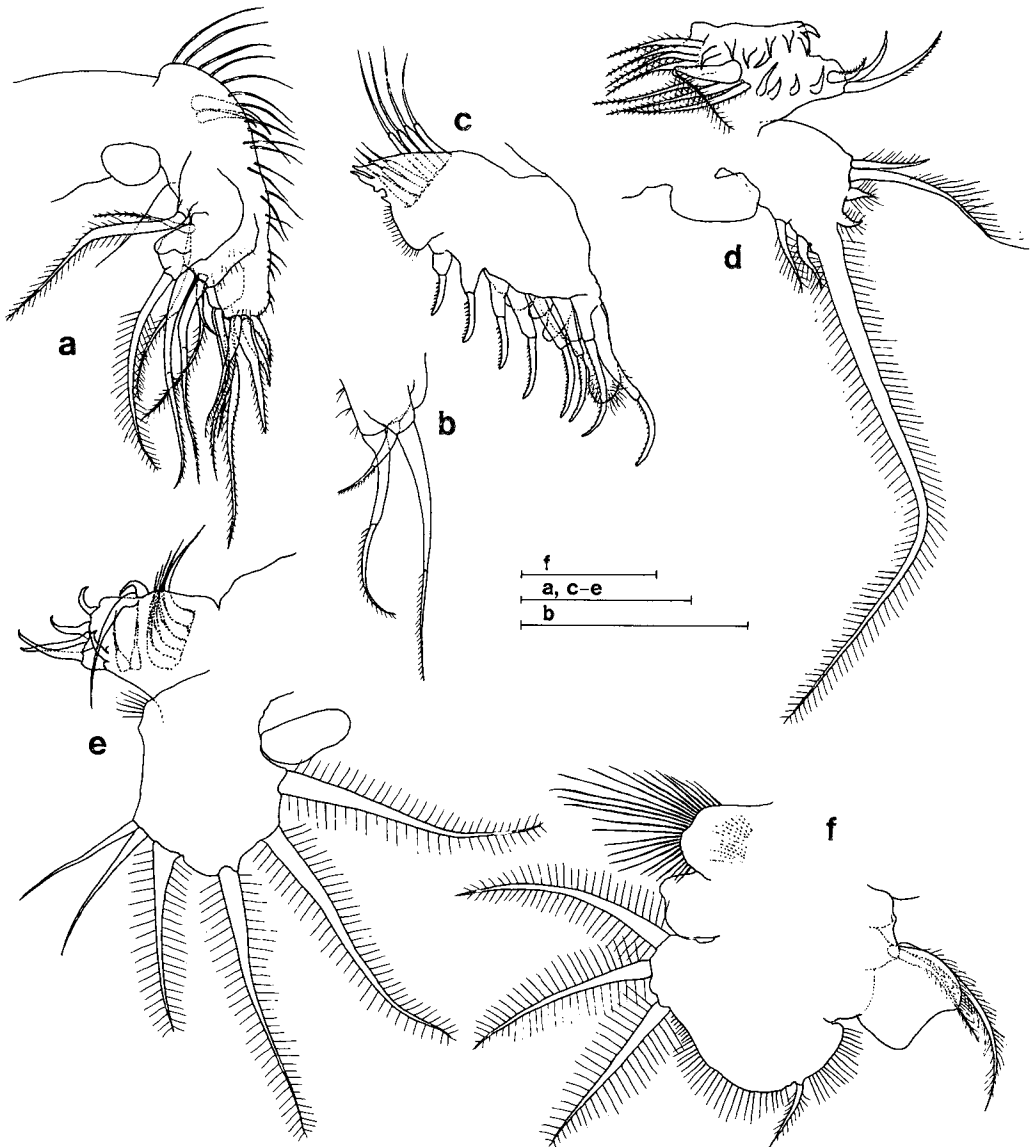
**Fig. 1.** *Alona quadrangularis* (O.F. Müller), parthenogenetic female: a, habitus, lateral view; b, posterior part of carapace; c, head shield, plane view; d, left antennule, lateral view; e, left antenna, lateral view; f, labrum, lateral view; g, postabdomen, lateral view. (Scales: b-g = 0.05 mm; a = 0.1 mm).

**Antennule** (Figs. 1a, 1d, 3d). Elongate and slender in lateral view, not reaching tip of rostrum (Fig. 1a, 3d). Antennular seta about half as long as antennule, arising from indistinct tubercle located on middle between tip and base of antennule. Anterior surface with 3 minute setules on distal half. Nine apical aesthetascs unequal in length; longest aesthetasc slightly shorter than antennule; almost all aesthetascs projecting beyond tip of antennule.

**Antenna** (Fig. 1e). Antennal formula 0(1)-0(0)-3(1)/1(0)-1(0)-3(1); seta arising from basal segment

of endopodite very thin and short, extending only to tip of distal segment; seta arising from middle segment of endopodite about 1.5 times as long as endopodite; spine arising from basal segment of exopodite as long as middle segment; in each ramous, terminal spine slightly longer than distal segment. Surface of each antennal segment provided with rows of fine setules or spinules; anterior surface of middle segment of endopodite with 3 small spiniform setae distally. Coxa with clusters of setules on anterior side.

*Labrum* (Fig. 1f). Anterodorsal and anteroventral corners distinct but broadly rounded. Dorsal and ventral margins converging basally each other; dorsal margin distinctly shorter than ventral. Anterior



**Fig. 2.** *Alona quadrangularis* (O.F. Müller), trunk limbs of parthenogenetic female: a, right limb I, outer view; b, inner distal lobe of right limb I, inner view; c, right limb II, outer view; d, left limb III, inner view; e, left limb IV, outer view; f, right limb V, outer view. (Scales: 0.05 mm for all).

margin smoothly convex. Ventral surface provided with 2 groups of setules distally.

*Trunk limb I* (Figs. 2a, 2b). ODL (outer distal lobe) with 1 seta and distinct protuberance on distal end. IDL (inner distal lobe) with 3 setae, two of which subequal in length and remaining one more than 3 times shorter; all setae provided with setules in distal part (Fig. 2b). Corm with 3 groups of spines; ventral group composed of 3 spines unequal in length, one closest to distal lobes being longest and stoutest, with well-developed accessory seta; middle group comprising 3 long setiform spines, middle spine of which longest; dorsal group composed of only 2 long setiform spines, subequal in length. Dorsal margin provided with well-developed setulose seta and accessory seta directed toward base of corm. Ventral surface with long setules along almost whole margin.

*Trunk limb II* (Fig. 2c). Gnathobase provided with 4 setae, two of which extremely rudimentary; gnathobase filter comb with 7 setae, proximal four of which long while distal three short; 8 scraping spines, proximal three of which spinulated and remaining five finely setulated, increasing in length distally.

*Trunk limbs III-V* (Figs. 2d-f). Showing complex 3-dimensional structure. Gnathobase filter combs of limbs III, IV, and V with 7, 5, and 0 setae, respectively; gnathobase of limb V vestigial (Fig. 2f). Exopodite of limb III with 7 setae; first and second setae setulated while remaining 5 setae plumose; fifth seta very long and other plumose seta short (Fig. 2d). Exopodites of limbs IV and V with 6 and 4 setae, respectively (Figs. 2d-f).

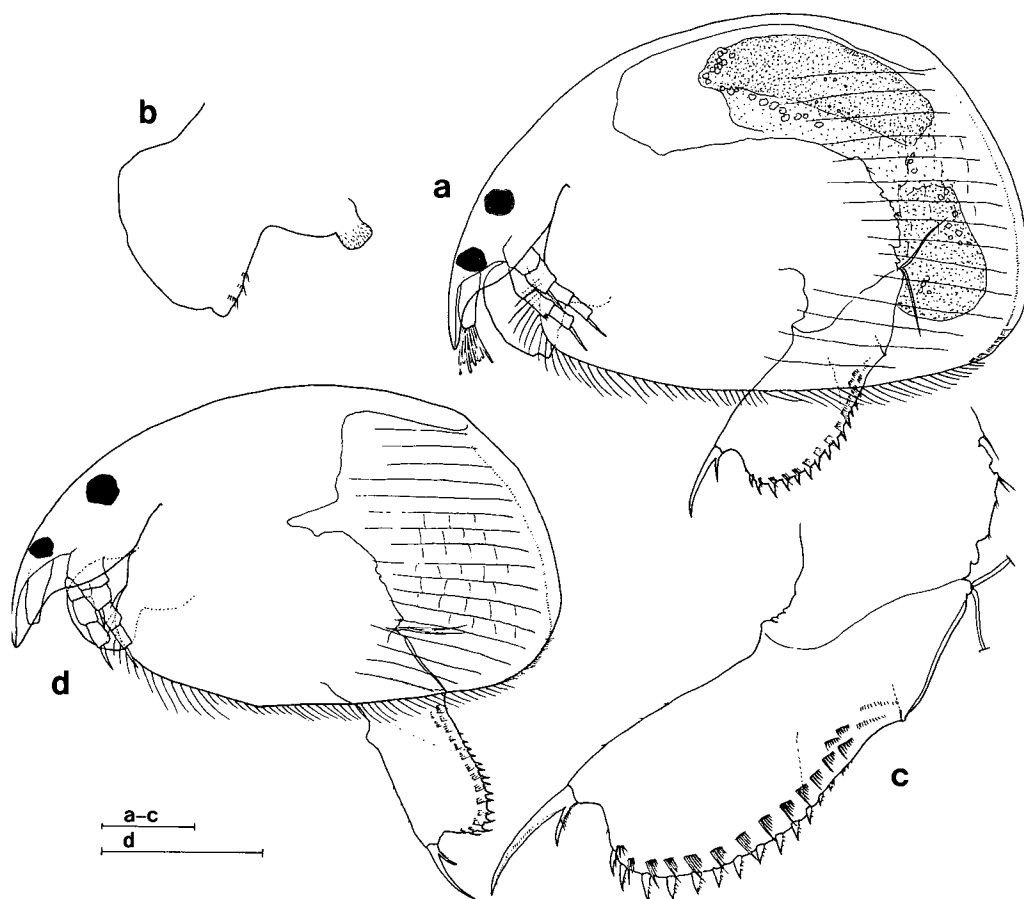
*Postabdomen* (Fig. 1g). About 2.5 times as long as high, somewhat expanded distally; maximum height at about distal fifth. Ventral margin slightly convex, with 2 clusters of fine setules. Distal margin broadly rounded, with shallow notch dorsally near base of postabdominal claw. Dorsodistal corner rounded. Dorsal margin sinuated; preanal angle prominent but postanal angle indistinct; postanal portion about 1.7 times length of anal groove and similar to preanal portion in length. Postanal margin convex, provided with 10-12 marginal spinulate denticles increasing in length distally; marginal denticles followed by single, much smaller denticle on distal margin near dorsodistal corner; distal half of anal margin provided in addition with 3-4 small denticles, each of which accompanied by 1-3 minute accessory denticles; total number of denticles including anal denticles 13-16. Lateral surface provided with 12-13 broad fascicles arranged in row parallel to dorsal margin, and with 1-2 additional fascicle near proximalmost fascicle ventrally; distalmost member in each fascicle longest and stoutest; longer setae of postanal fascicles projecting beyond postabdominal margin; fascicles followed proximally by 3-4 rows of very fine setules along proximal half of anal groove at some distance of margin. Abdominal setae approximately as long as preanal margin.

*Postabdominal claw* (Fig. 1g). Long and slender, about two thirds of postanal portion of postabdomen in length; maximum curvature near tip. Concave surface finely setulated along almost entire length, with 3-5 very minute setules near base of basal spine. Basal spine slender with tip curving away from claw, about two fifths of claw in length; concave surface with row of fine setules along proximal half; setules decreasing in length proximally.

**Ehippial female.** Except for having partial differences on carapace, labrum, and postabdomen, indistinguishable from parthenogenetic female in general form (Figs. 3a-c).

Body (Fig. 3a) somewhat higher relative to length than that in parthenogenetic female; maximum height quite behind middle. Ventral bulge of carapace low and indistinct.

Anterior margin of labrum weakly wavy, with distinct notch near posteroventral corner. Ventral



**Fig. 3.** *Alona quadrangularis* (O.F. Müller), ephippial female (a-c) and instar parthenogenetic female (d): a, habitus, lateral view; b, labrum, lateral view; c, postabdomen, lateral view; d, habitus, lateral view. (Scales: 0.1 mm for all).

surface of labrum with 3 groups of setules on distal half (Fig. 3b).

Dorsal margin of postabdomen evenly convex in distal half, and maximum height of postabdomen near distal third (Fig. 3c).

**Male.** Not found from present study.

**Size.** Length range (from anteriormost part of dorsal margin of head to posteriormost part of posterior margin of carapace) of Korean population 0.35-0.58 mm (n=6). Two parthenogenetic females carrying eggs measuring 0.51 and 0.55 mm; 3 instar females, 0.35, 0.35, and 0.36 mm. Only ephippial female found, 0.58 mm.

## DISCUSSION

*Alona quadrangularis* was confused with several species of the genus in early time (P.E. Müller, 1867; Sars, 1993). Since the time of serious study was opened, most investigators have easily been

able to distinguish this species from other congeners except *Alona affinis* (Leydig, 1860). Diagnostic characteristics of *A. quadrangularis* have traditionally been known as follows: (1) posterodorsal corner of carapace is very high, so the maximum height of body is located behind the middle, (2) carapace has longitudinal striae connected by transverse lines forming reticulation, (3) median headpores are three in number and connected by channel, (4) postabdomen is somewhat expanded distally, and possesses distinct lateral fascicles on lateral surface. However, some authors neglected these characteristics in the recognition of the species (Ueno, 1927; Ching and Du, 1979).

Many authors have regarded the absence of setulation on postabdominal claw as one of the useful and important characteristic features that differentiate *A. quadrangularis* from *A. affinis* (Sramek-Husek *et al.*, 1962; Manuilova, 1964; Smirnov, 1971; Flössner, 1972; Chiang and Du, 1979; Margaritora, 1983). However, this has not been fully consented to all authors (Negrea, 1983; Michael and Sharma, 1988). The separation of *A. quadrangularis* and *A. affinis* is still among the difficult problems in the taxonomy of chydorid cladocerans (Frey, 1987a).

General shape of Korean materials are well accorded with those of European materials shown in the literatures (Lilljeborg, 1901; Sramek-Husek *et al.*, 1962; Manuilova, 1964; Smirnov, 1971; Flössner, 1972; Margaritora, 1983; Negrea, 1983). Especially trunk limbs of the present materials are well fitted with the typical form of the genus. But, Korean specimens have some noticeable features that has not been well noted by other authors as follows: (1) maximum height of body is not located near posterior end of body but located behind middle at short distance though the distances are somewhat different with body shapes from each other depending on the developmental stages of species (Figs. 1a, 3a, 3d), (2) posteroventral corner of carapace is provided with 5-6 submarginal groups of setules (Fig. 1b), (3) labrum possesses 2-3 groups of setules on ventral surface (Figs. 1f, 3b), (4) postabdomen has 12-13 well-developed, broad lateral fascicles, of which postanal fascicles are projecting beyond postabdominal margin (Figs. 1g, 3c), (5) anal denticles are spinulated (Fig. 1g), (6) basal spine of postabdominal claw bears a distinct row of fine setules along its proximal half. Among these the presence of submarginal groups of setules on the carapace near posteroventral corner (Michael and Sharma, 1988), the spinulation of anal denticles (Margaritora, 1983; Negrea, 1983) and the setulation of basal spine of postabdominal claw (Negrea, 1983) were partially observed by several authors, while the others have never been reported in *A. quadrangularis*. Though these features have never been recorded in the most previous works, it can not be declared that these are the peculiarities of Korean materials because other authors may have overlooked them.

Some authors believe that there are several groups or species in so-called *A. quadrangularis* (Frey, 1987a). According to this, there are high possibility that the Korean specimens belongs to another subgroup of *A. quadrangularis* which has not been known. However, it has not been confirmed yet, and the actual state of the species (or species complex) is not revealed. So further comparative study with the specimens from various parts of the world are necessary to determine the valid taxonomic position of the Korean materials. The morphological features discussed above may be useful in the further study, because the application of another characters with new analytical methods are needed in such a study to separate the subgroups within the species or species complex as so-called *A. quadrangularis*.



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## 한국산 사각배큰씨물벼룩(새각강, 이지목, 씨물벼룩과)

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## 요 약

설악산 백담계곡의 소계류에서 채집된 사각배큰씨물벼룩(*Alona quadrangularis* (O.F. Müller, 1785))을 기재한다.