

Taxonomic Review on East Asian Lynceid Conchostracans (Crustacea, Branchiopoda, Laevicaudata), with Redescription of *Lynceus biformis* of Korea

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Lynceid conchostracans of the order Laevicaudata in East Asia are reviewed. Validity of the three older species, *Lynceus mandsuricus* Daday, *Lynceus biformis* (Ishikawa), and *Lynceus dauricus* Thiele, is examined and discussed. Two species among them were acknowledged but *L. dauricus* was synonymized to *L. biformis* and redescribed and illustrated in the present paper, based on the materials collected from the rice-fields at 15 localities in Korea.

The family Lynceidae Stebbing, 1902 is a group of recent conchostracans that have a smooth carapace lacking growth lines and a greatly reduced telson without furca or dorsal abdominal spines (Martin and Belk, 1988). Its members occur mostly in ephemeral pools, especially during spring and early summer.

Lynceidae is a sole family of the order Laevicaudata Linder, 1945 and is comprised of three genera. Species of this family are among the most poorly known of extant branchiopods. Many previous studies were not carefully carried out and reported erroneous information. It was recently proved that many species had been incorrectly described under different names and different species erroneously recorded under the same name in many regions. As a result, most of the previous records needed to be revised, and only about 30 species in the world were regarded as valid (see Mattox, 1957; Martin and Belk, 1988).

The species Lynceidae are poorly known, especially in East Asia. There is no report on this group in Korea, and only three species so far are recorded throughout the whole East Asia (Ishikawa, 1895; Daday, 1927; Ueno, 1927; Brtek et al., 1984; Hu, 1989): *Lynceus biformis* (Ishikawa, 1895), *L. dauricus* Thiele, 1907, and *L. mandsuricus* Daday, 1927. All previous investigations in this region reported incomplete descriptions and illustrations.

Studying the branchiopod fauna, the senior author of the present study found that *L. biformis* was widely distributed in southern Korea. He also suspected that

L. dauricus, originally recorded from Transbaikalia in southeastern Russia, was probably a junior synonym of *L. biformis*. In the present paper, *L. biformis* of Korea is redescribed, and the previous records of lynceid species in East Asia are discussed.

Materials and Methods

The lynceid conchostracan specimens were collected from rice-fields at 15 localities in Korea during the period from June 1984 to May 1997 (Fig. 1). Collections were made with a sieve and a dipnet (1 mm and 155 μ m in mesh sizes, respectively). Specimens were fixed with 10% formalin and preserved in 4% formalin.

The materials were inventoried to determine sex and reproductive state under a Nikon stereomicroscope. Each specimen was transferred to a drop of glycerol on a hole slide for subsequent taxonomic study. Temporary mounts of whole specimens in glycerol were used for the measurements and drawings of intact animals and their parts. Whole bodies were dissected with tungsten needles to examine antennules, antennae, thoracopods, anal somite, and other parts. Drawings and measurements were made with a Nikon compound microscope and a Nikon stereomicroscope, both attached by the drawing tube system. All specimens examined were deposited in the Department of Biology Education, Chosun University.

'Materials examined' section includes its locality, date of collection and other information. Collectors were not referred when the specimens were collected by the authors themselves.

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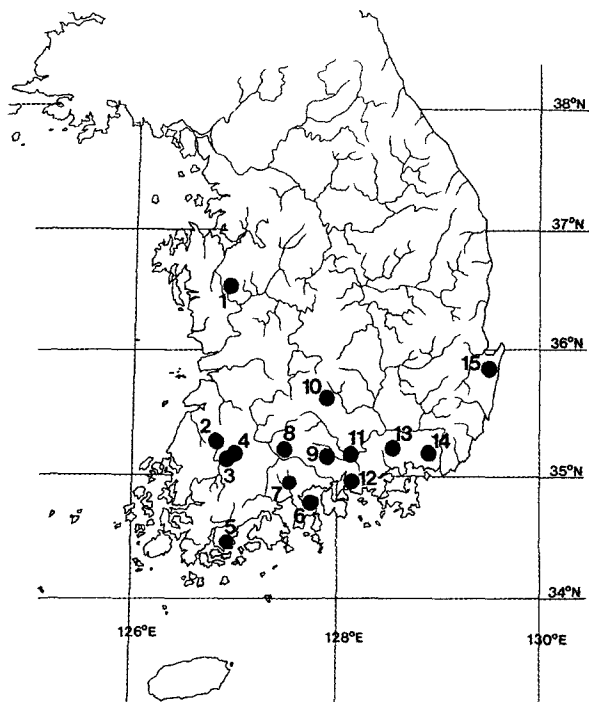


Fig. 1. Localities from which the specimens were collected. 1, Bomulri, Kongju. 2, Bunhyanri, Jangsoung. 3, Chunghyodong, Kwangju. 4, Choungokdong, Kwangju. 5, Sangbalri, Jangheung. 6, Manheungdong, Yosu. 7, Daeanri, Suncheon. 8, Kapsanri, Kurye. 9, Choryangri, Sachon. 10, Kimchonri, Kouchang. 11, Pyunggeodong, Chinju. 12, Hyangchondong, Sachon. 13, Dongjeongdong, Changwon. 14, Mangchonri, Kimhae. 15, Yangpo, Youngil.

Results and Discussion

Redescription of species

Lynceus biformis (Ishikawa, 1895)
(Figs. 2-4)

Limnetis biformis Ishikawa, 1895, p. 8, Pl. 4.

Lynceus biformis: Daday, 1927, p. 37, fig. 153; Ueno, 1927, p. 271.

Lynceus dauricus Thiele, 1907 p. 296, tab. 1, figs. 5, 7, 8, tab. 2, fig. 5; Daday, 1927, p. 57, fig. 158; Brtek et al., 1984, p. 96, figs. 26-37.

Materials Examined: More than 20 specimens, comprising male and female in every sample collected from rice-fields at 15 localities in Fig. 1.

Male: *Carapace* (Fig. 2A). Ovate to round in lateral view, dorsally somewhat flattened and slightly depressed medially toward hinge-line. Umbo lacking. Outer surface completely smooth, lacking growth lines or puncta. Circular area of attachment of adductor muscle surrounded by irregular concentric ovals.

Head (Figs. 2B-E). Large, with distinct occipital notch on slightly indented demarcation between head and thorax. Rostrum truncate distally, with distinct lateral extensions developing anteriorly; disto-lateral angle ap-

proximately 90° to distal margin in frontal view (Fig. 2D). In lateral view rostral carina high in middle, extending nearly to the tip of rostrum and extending posteriorly in smooth curve without indication of post-orbital cleft; carina sloping gradually to lateral borders, abutting posteriorly with fusion of lateral borders and orbital region forming setose sensory field on either side of the rostrum (Fig. 2C). Lateral rostral borders curved proximally, folding slightly over adjacent edge of the rostrum; lateral margins smoothly curved medially at the level of antennae, then sharply curved near the antennal base (Figs. 2B, 2C). Postero-ventral side of the rostrum strongly protruding distally; distal border somewhat subrectangular with arched posterior margin, covered with minute setae (Figs. 2C, 2E).

Antennule (Figs. 2F, 2G). Small, reduced to only 2 segments; proximal segment short and cylindrical; distal segment about twice as long as the proximal and bearing numerous olfactory papillae, each with apical pore and cylindrical base.

Antenna (Figs. 2H-J). Biramous, large and well developed. Basal peduncle composed of poorly demarcated cylindrical segments; basal segment with few plumose setae disto-laterally, distal segment with a few scattered simple setae proximally and group of simple setae distally on dorsal surface. Biramous flagella variable in number of segments from 19 to 24; each segment of both anterior and posterior flagella bearing shorter simple setae along anterior edge and much longer lightly plumose setae along posterior edge; distal segment of anterior flagella with 2 plumose setae and 1 naked spine while that of posterior flagella with only spinulose seta (Figs. 2I, 2J).

Thoracopods. Ten thoracopods of general form of genus, all similar in shape to each other except for, first among all, the decreases in size posteriorly (detailed figures not given); structures identical with those of female (Fig. 4F).

First Thoracopod (Figs. 3A, 3B). Modified as crasping appendage; fourth endite enlarged as claw-like process, covered with minute denticles; second endite reduced, with numerous smooth sensory setae and several heavy cuspidate spines (Fig. 3B); remaining portions of thoracopod unmodified.

Anal somite (Figs. 3C, 3D). Wide, cylindrical, with terminal anus, consisting of 2 lobes in lateral view; surface covered with fine setules distally. Dorsal margin of proximal lobe slightly depressed, with a pair of long hair-like telsonal filaments arising from a small protuberance. Distal lobe with small outgrowth of cuticle on distal margin dorsally (Fig. 3C). Opercular lamellae fused, extending posteriorly from penultimate somite, covering ventrum of terminal somite; distal margin slightly sinuate; surface covered with fine setules distally (Fig. 3D).

Female: Except for differences of head, first thoracopods, and dorsal lamellae owing to carrying eggs, female nearly identical with male in general form (Figs. 4A, 4B).

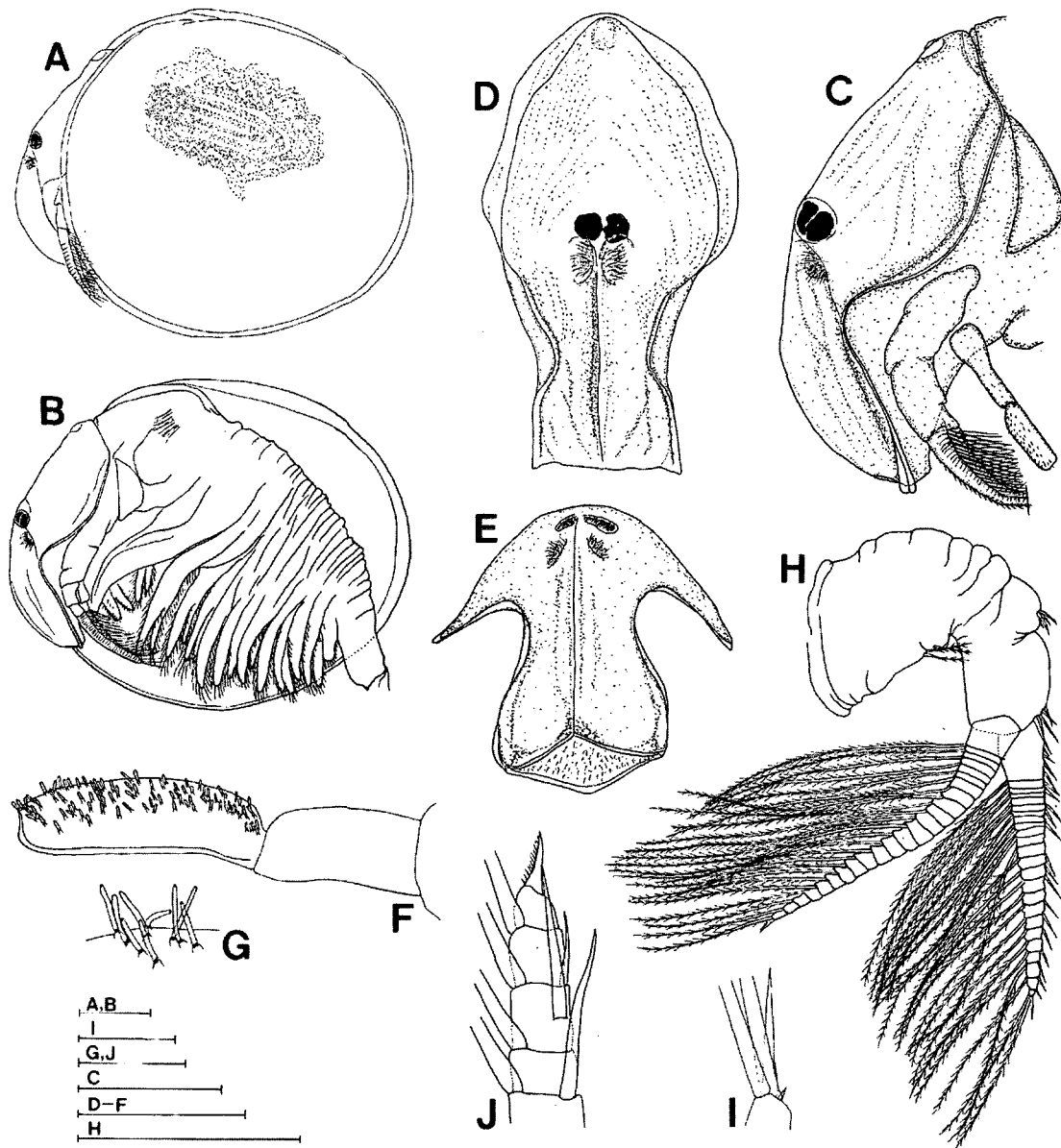


Fig. 2. *Lynceus biformis*, male. A, Habitus, outer view. B, Habitus, inner view. C, Head, lateral view. D, Head, frontal view. E, Head, antero-ventral view. F, Antennule. G, Olfactory papillae of antennule. H, Antenna. I, Distal tip of anterior flagella of antenna. J, Distal part of posterior flagella of antenna. Scale bars=0.1 mm (G, I, J), 1 mm (A-F, H).

Head (Figs. 4B-E). Showing differences from male in rostrum. In lateral view rostrum not truncate, sharply terminating to point; postero-ventral side of rostrum not protruding distally (Fig. 4C). In frontal view, rostrum somewhat similar to that of male except in having slightly extended distal margin (Fig. 4D), but showing a prominent difference on distal border of rostrum denticulate along margin in antero-ventral view (Fig. 4E). Lateral extensions of rostrum comparably wide and well-developed.

Thoracopods. Ten thoracopods of general form of genus as in male; all similar in shape with each other,

decreasing in size posteriorly (detailed figures not given except first thoracopod).

First Thoracopod (Fig. 4F). Somewhat flabelliform, not modified as crasping appendage, composed of 6 endites of endopod, exopod and epipod; epipod naked, but exopod and all endites of endopod ornamented with various types of setae along margins.

Dorsal lamella (Figs. 4G, 4H). Shape variable, oval to palm-like, with 6-8 outgrowths. Outgrowths diverse in size and shape; basal outgrowths broad and short, triangular, others relatively large and long, somewhat ovaly rounded towards inner side; some rudimentary in

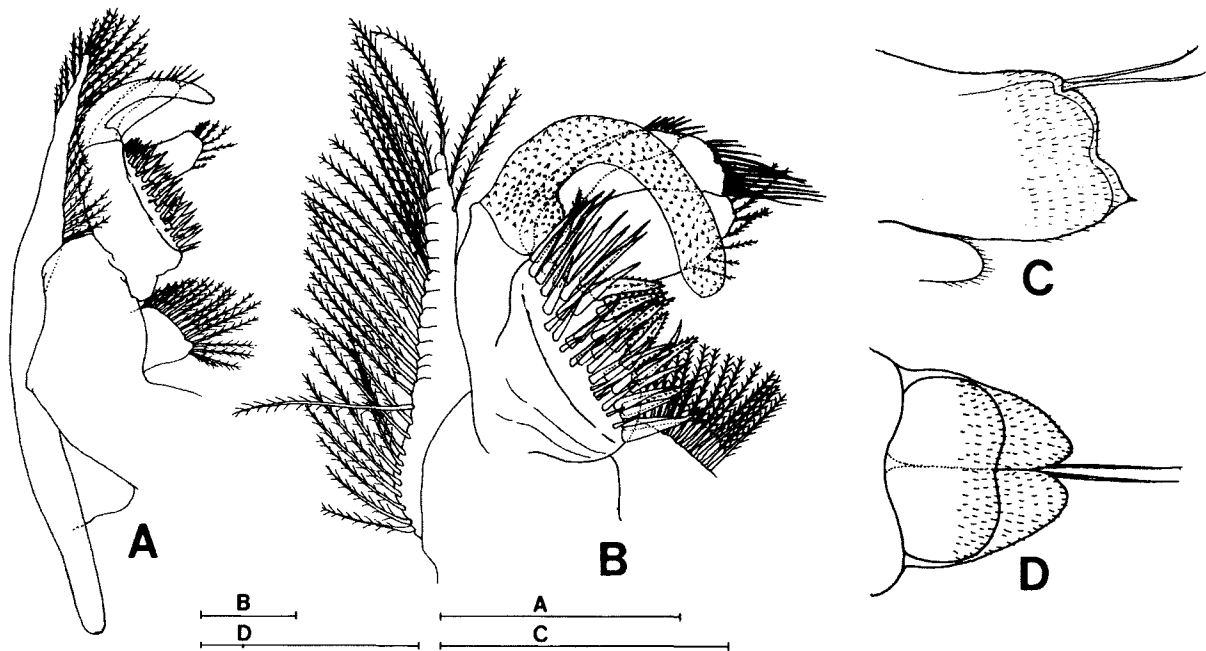


Fig. 3. *Lynceus biformis*, male. A, Left first thoracopod, outer view. B, Clasper of left first thoracopods, outer view. C, Anal somite, lateral view. D, Anal somite, ventral view. Scale bars=0.1 mm (B), 1 mm (A, C, D).

immature individuals (Fig. 4H), and some layed below other outgrowth in mature individuals (Fig. 4G).

Egg (Fig. 4I). Spherical, with large depression; depth of depression about 1/3 of diameter. Whole surface lumpy, with dense indentations of minute wells.

Anal somite (Figs. 4J, 4K). Relatively broad, similar to that of male in lateral view (Fig. 4J). In ventral view, opercular lamellae fused, but forming distinctly 2 lobes, extending posteriorly from penultimate somite, covering ventrum of terminal somite; surface covered with fine setules distally (Fig. 4K).

Size: Length range (from antermost part to postero-most part of carapace) of males and females 2.8-4.0 mm and 2.8-3.8 mm, respectively. Smallest mature female carrying eggs measuring 3.4 mm.

Remarks: This species was first described from Tokyo, Japan by Ishikawa (1895), and later redescribed by Daday (1927) with the specimens from Japan. Though the previous descriptions and illustrations are incomplete, they show the characteristic features of the species such as the particular rostral morphology in both sexes. The specimens from Korea are generally accorded with those of Japan, but show a difference in the female dorsal lamella compared with the description by Daday (1927). That is, the dorsal lamellae of Korean materials are variable in shape, and have larger number of outgrowths than those of Japan. This difference between the two materials seems to due to variability or callousness of the previous author as noticed by Martin and Belk (1988).

Lynceus dauricus Thiele, 1907 was originally described from Transbaikalia, Russia (Daday, 1927), and redescribed by Daday (1927) with the type materials. According to Daday (1927), *L. dauricus* has the closest resemblance to *L. biformis* among lynceid species, especially in the rostral morphology, while small but distinct differences between the two exist. In practice, however, the two species were hardly distinguishable by the descriptions and illustrations provided by Daday (1927). The rostral morphological differences shown from his monograph might be due to observation of different species at different angles. Another difference on the female dorsal lamella between *L. dauricus* and *L. biformis* noticed by Daday (1927) seems to be due to variability within populations, as judging by the recent report of *L. dauricus* from Mongolia (Brtek et al., 1984) and the present result with Korean *L. biformis*. Brtek et al. (1984) also illustrated that the female rostrum has a dentiform distal margin in the Mongolian *L. dauricus*. This is a characteristic feature of *L. biformis*. These strongly support that no valid information exist which discriminate *L. dauricus* from *L. biformis* and that *L. dauricus* is a junior synonym of *L. biformis*.

Distribution: Asia (Korea, Japan, eastern Mongolia, southeastern Russia).

Taxonomic review of the lynceid conchostracans in East Asia

Taxonomy of the lynceid conchostracans is still very poor in the world. Since Daday reported a monograph

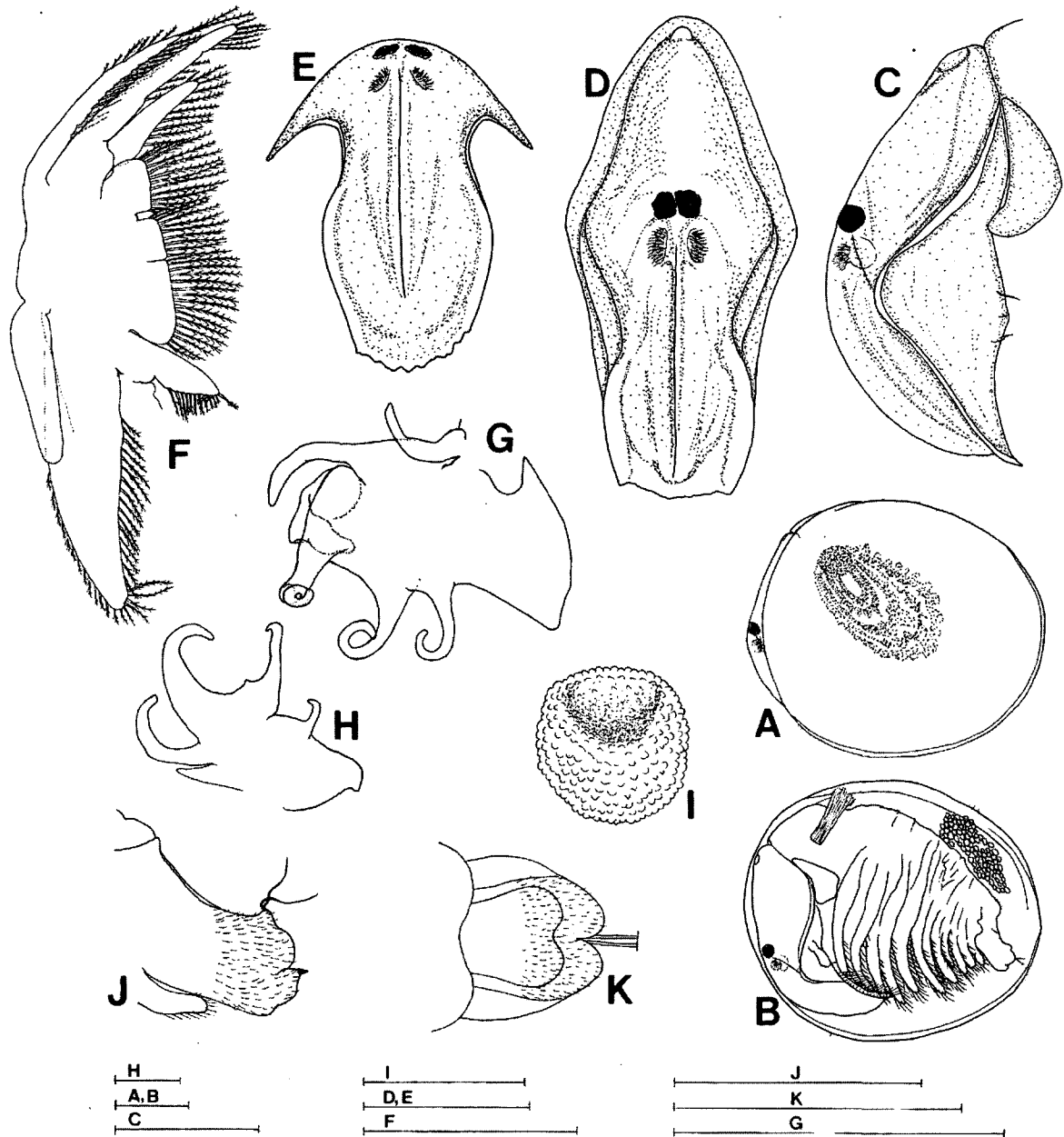


Fig. 4. *Lyncæus biformis*, female. A, Habitus, outer view. B, Habitus, inner view. C, Head, lateral view. D, Head, frontal view. E, Head, antero-ventral view. F, Left first thoracopod, outer view. G, Left dorsal lamella of mature female, outer view. H, Left dorsal lamella of immature female, outer view. I, Egg. J, Anal somite, lateral view. K, Anal somite, ventral view. Scale bars=0.1 mm (H, I), 1 mm (A-G, J, K).

on lynceid conchostracans (Daday, 1927), only a few investigations have been performed in this field. The problems included in Daday's paper were recently revoked by the works from North America (Mattox, 1957; Martin et al., 1986; Martin and Belk, 1988). Many of the characters employed by Daday (1927) appear to be variable, and the descriptions and illustrations were not careful and often inconsistent (Martin and Belk, 1988).

The useful characters in recognizing the lynceid species are presently known as follows (Martin et al.,

1986; Martin and Belk, 1988): (1) rostral morphology in both sexes, (2) modification of the second male thoracopod, and (3) morphology of male clasper in the first thoracopod. Among these, the rostral morphology is relatively consistent within a species and species-specific. The peculiarity of rostrum has been frequently used as one of the most useful key characteristics to distinguish certain species from other related ones.

Among three species recorded from East Asia, *L. mandsuricus* is easily distinguishable from the other two by the bifurcated rostral carina of male (Daday,

1927). It was first described by Daday (1927), based on the male specimens collected from the Manchuria, China. After the original description, no reliable reports of *L. mandsuricus* have been made. Presently the species are very poorly known and furthermore, no information is available on female. The species seems to be a very rare one. While Hu (1989) recently reported *L. mandsuricus* from eastern China, the reality of it is doubtful. He provided illustrations of both sexes without description (Hu, 1989). However, illustrations are not detailed, and therefore provide no characteristic features of the species. He also omitted illustrations of the frontal view of rostral morphology in both sexes. They can be relevant to all species known from East Asia.

Lynceus biformis was first described under the name of *Limnetis biformis* by Ishikawa, based on the materials collected from Tokyo, Japan (Ishikawa, 1895). The species was characterized by the truncate male rostrum in the original description. Thereafter, Daday (1927) redescribed the species with the specimens from Japan in his monograph, and Ueno (1927) confirmed the occurrence of the species in Japan. No further reports had been added, and therefore the species had been regarded to be endemic to Japan. *L. biformis* has remarkable characteristic features in its rostral morphology in both sexes. The male rostrum is truncate with postero-ventral side prominently protruding. The lateral extensions are well-developed in both sides, and their disto-lateral angles are approximately 90° to the distal margin in frontal view. The female rostrum is not truncate, and sharply terminates to a point in lateral view. The postero-ventral side of the female rostrum does not protrude distally, and the distal border is dentiform along the margin in antero-ventral view. *L. biformis* is easily distinguishable from most of the known species by the rostral morphology alone.

The Korean materials of *L. biformis* are well accorded with the Japanese, but show a minor difference in the shape of female dorsal lamella, compared with the description by Daday (1927). The dorsal lamellae of the Korean materials are variable in the shape, and always have larger number (from six to eight) of outgrowths than those of Japan (three). However, this difference seems to be due to variability or callousness of the previous author as noticed by Martin and Belk (1988).

Lynceus dauricus Thiele, 1907 was originally described from Transbaikalia, Russia (Daday, 1927), and redescribed by Daday (1927) with the type materials. Recently Brtek et al. (1984) reported the occurrence in east Mongolia with a short description. According to Daday (1927), *L. dauricus* has the closest resemblance to *L. biformis*, especially in that both have the common characteristic feature of the truncate male rostrum with developing lateral extensions. He stated that the former is differentiated from the latter by the structure

of head including rostrum and by the shape of opercular lamella in both sexes. In practice, however, the two species is hardly distinguishable from each other on the basis of any parts of the descriptions and illustrations provided by himself (Daday, 1927). The suggested differences between the two might have come from observation of different species at different visual angles. Especially in the rostral morphology, it is possible that the illustrations of *L. dauricus* are from a more dorsal angle than those of *L. biformis*, accentuating the nearly straight distal margin in both sexes. According to Daday (1927), another different feature between the two species is also found on the dorsal lamella in female. That is, both species have the palm-like lamellae, and the lamella of *L. biformis* has three outgrowths, while that of *L. dauricus* has five outgrowths. However, it is strongly possible that this is an intraspecific variation as exemplified in *L. dauricus* from Mongolia recorded by Brtek et al. (1984). The lamella is not palm-like but oval, with six outgrowths in the Mongolian materials. At the same time they illustrated a dentiform distal margin of female rostrum as shown in *L. biformis* (Brtek et al., 1984). The Korean materials of *L. biformis* also show the variability according to populations and age in the shape and outgrowth number of dorsal lamella as mentioned previously. These indicate that the morphology of dorsal lamella may not be a significant characteristic feature in the taxonomy of lynceid conchostracans.

Taken together, our observations strongly support that there is no valid information that differentiates *L. dauricus* from *L. biformis*. Therefore, it is suggested that *L. dauricus* is a junior synonym of *L. biformis*. The taxonomic stability of this species can be confirmed by further studies examining materials from other countries, including type materials.

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