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Redescription of Two Chydorid Species of Genus *Leydigia* Kurz, 1875 (Branchiopoda, Anomopoda, Chydoridae) from Korea

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The freshwater cladocerans collected from the riverside of Han-gang and from the ricefields at Kŏjedo were identified as *Leydigia leydigi* (Schoedler, 1863) and *L. ciliata* Gauthier, 1939. These two species are redescribed with illustrations. This is the first report of the chydorid species belonging to the genus *Leydigia* from Korea.

KEY WORDS: Redescription, *Leydigia*, Chydoridae, Anomopoda, Branchiopoda, Korea

Leydigia is one of the poorly known chydorid cladoceran groups in the taxonomy of branchiopod crustaceans. Most members of the genus are rarely found on the littoral or sublittoral regions of freshwater habitats. About 12 species of the genus are known in the world (Smirnov, 1971; Chiang and Du, 1979). In the East Asia four species, *Leydigia acanthocercoides* (Fischer, 1854), *L. leydigi* (Schoedler, 1863), *L. ciliata* Gauthier, 1939 and *L. propinqua* Sars, 1903, were reported. Among them, all four species were recorded from China (Chiang and Du, 1979), three from Japan (Tanaka, 1989), but none from Korea.

Recently many investigators have questioned the cosmopolitanism of chydorid cladocerans, and re-examined the previous works by examining new characters including those on trunk limbs. However, such investigations on the genus *Leydigia* have not been performed yet. In recognition of the species of *Leydigia*, several characters have usually been used. These characters are (1) carapace (presence of striae or rows of granules), (2) relative size of ocellus compared to eye, (3) labrum (shape of anterior margin, armature) (4) postabdomen (shapes of dorsal and ventral margins, arrangements and compositions of lateral groups of spines and setae), (5) basal spine of claw (presence and size). However, the characters on the trunk limbs have been overlooked by most previous workers and were merely noted in a few species (Lilljeborg, 1901; Smirnov, 1971). In these circumstances, it is necessary to redescribe the species of *Leydigia* with more detailed characters from entire body region.

During the studies of Korean branchiopod fauna, the authors could find two species of *Leydigia* from materials collected from two localities in South Korea. In the present paper we redescribed the two species, *L. leydigi* and *L. ciliata*, and discussed the taxonomic status of our specimens with several problems in recognizing the species of *Leydigia*.

The specimens were collected from the riverside of Han-gang at Yangsu-ri, Yangsŏ-myŏn, Namyangju-gun on September 17, 1988 by G.S. Min and on August 11, 1991 by the authors, and

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from the ricefields at Mangch'i-ri, Ilun-myŏn, Kŏje-gun on May 5, 1989 by the authors. The collections were made with a dipnet and a conical plankton net of no. 25 mesh aperture. The samples were preserved in 70% ethanol. Drawing and measuring were made with the aids of a camera lucida and a drawing tube. All specimens examined are deposited in the Department of Molecular Biology, Seoul National University. The classification of ordinal level was based on Fryer (1987). The terminology is after Smirnov (1971) and McLaughlin (1980). This is the first report of the chydorid species belonging to the genus *Leydigia* from Korea.

Systematic Accounts

Class Branchiopoda Latreille, 1817 새각(鰓脚) 강

Order Anomopoda Sars, 1865 이지(異肢)목 (신칭)

Family Chydoridae Stebbing, 1902 씨물벼룩 과

Subfamily Aloninae Frey, 1965 큰씨물벼룩아과

Genus *Leydigia* Kurz, 1875 넓은배물벼룩속 (신칭)

Key to the species of the genus *Leydigia* of Korea according to female

1. Carapace without striae or longitudinal rows of granules; claw with distinct basal spine; exopod of trunk limb III with 5 setae; trunk limb IV with both endopod and exopod ·····*L. leydigi*

   Carapace with longitudinal rows of granules; claw with very small basal spine; exopod of trunk limb III with only 2 distal setae; trunk limb IV with exopod only ·····*L. ciliata*

1. *Leydigia leydigi* (Schoedler, 1863) 넓은배물벼룩 (신칭) **(Figs. 1, 2)**

Lynceus qudrangularis Leydig, 1860 [cited from Lilljeborg, 1901 (p. 494)].

Alona leydigi Schoedler, 1863 [cited from Lilljeborg, 1901 (p. 494)]; P.E. Müller, 1867 (p. 174).

Leydigia quadrangularis: Kurz, 1875 (p. 58, Tab. 2, fig. 2); Lilljeborg, 1901 (p. 494, Tab. 70, figs. 6-17, Tab. 71, figs. 1-3); Flössner, 1972 (p. 325, Fig. 153); Birge, 1918 (p. 721); Pennak, 1978 (p. 379, Fig. 266B-C).

Leydigia leydigi: Keilhack, 1909 (p. 90, figs. 169-170); Frey, 1959 (p. 37, figs. 15-18); Šrámek-Hušek *et al.*, 1962 (p. 355, Fig. 132); Manuilova, 1964 (p. 220, Fig. 107); Scourfield and Harding, 1966 (p. 22, fig. 35); Smirnov, 1971 (p. 450, Figs. 554, 559); Chiang and Du, 1979 (p. 210, Fig. 141); Negrea, 1983 (p. 320, Fig. 131); Margaritora, 1983 (p. 129, Fig. 83D-H, 84C); Smirnov and Timms, 1983 (p. 54).

Material Examined: Both three parthenogenetic females and nine parthenogenetic females were collected among the waterweeds on the riverside of Han-gang at Yangsu-ri, Yangsŏ-myŏn, Namyangju-gun on September 17, 1988 by G.S. Min and on August 11, 1991 by the authors, respectively.

Female: Body (Fig. 1a) 0.65-0.77 mm long (from anteriormost part of dorsal margin of head to posteriormost part of posterior margin of carapace), oval in lateral view.

Carapace (Figs. 1a, b) without striae or longitudinal rows of granules; posteroventral corner round, with row of fine setules on inner side; ventral margin slightly convex, armed with long plumose setae on outer margin.

Head pores situated posteriorly on median line of head shield (Fig. 1c); main head pores 3 in number, connected each other; 2 lateral small pores located near middle main pore. Ocellus nearly as large as eye. Rostrum short and blunt. Plate of labrum (Fig. 1d) fringed with setules on anterior margin; anterior margin weakly undulated; lateral surface without setules.

Antennule (Fig. 1e) slender, not reaching to apex of rostrum (Fig. 1a); anterior surface with 3 groups of setules; posterior surface with 1 seta; distal end with 9 olfactory setae, one of which longer and remaining setae of nearly equal size.

Antenna (Fig. 1f) small; both rami 3-segmented; antennal formula 0(1)-0(0)-3(1)/1(0)-1(0)-3(1); tip of distal spine on proximal segment of exopod overreaching middle of distal segment; setae on anterior surfaces of proximal and second segments of endopod short and spiniform. Anterior surfaces

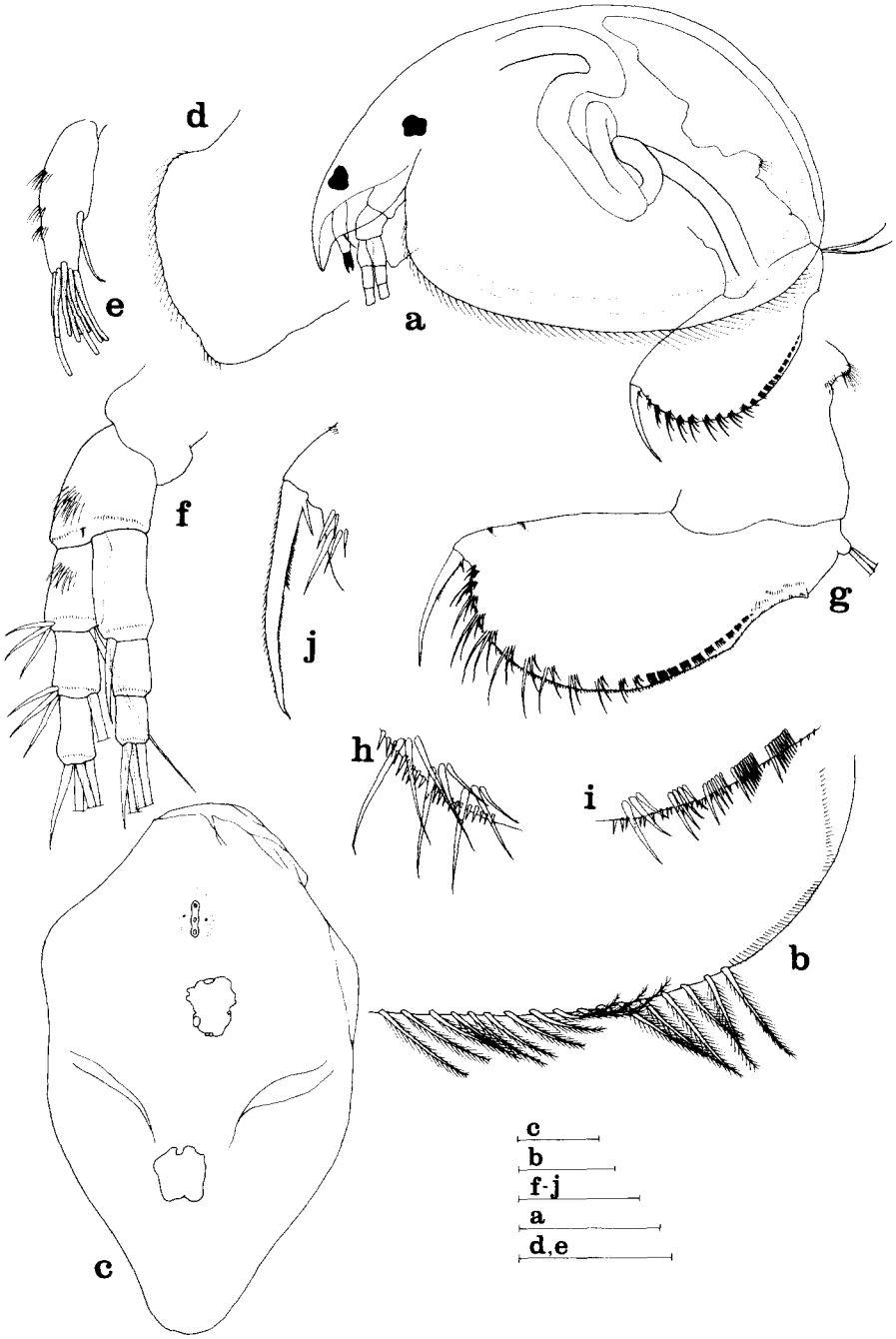

Fig. 1. *Leydigia leydigi* (Schodler, 1863), female: a, habitus, lateral view; b, posteroventral corner of right carapace; c, head shield; d, labrum, lateral view; e, left antennule, lateral view; f, left antenna, lateral view; g, postabdomen, lateral view; h, middle groups of lateral setae; i, proximal groups of lateral setae; j, claw, lateral view. (Scales: b-f, h-i = 0.05 mm; g = 0.1 mm; a = 0.2 mm).

of basipodal segment and proximal segment of endopod with groups of setules. Distal end of basipod with small spinule between both rami.

Postabdomen (Fig. 1g) wide, with evenly round dorsal margin and nearly straight ventral margin. Anal spines very small, arranged along almost whole dorsal margin. Lateral groups of setae well developed, about 20 in number, decreasing in size proximally, and followed proximally by groups of fine setules on anal region; distal seta largest in each group; each distal and middle groups usually consisting of 3-4 long setae while each proximal 5-6 groups near anal region comprising 4-10 small setae (Figs. 1g, h, i).

Claw (Fig. 1j) with 1 distinct basal spine; length of basal spine nearly equal to basal width of claw; proximal half of concave dorsal margin with row of setules decreasing in size proximally, and remaining distal half with row of shorter setules; ventral margin with row of very minute setules.

Five pairs of trunk limbs present. Limb I (Fig. 2a) modified. Outer distal lobe with 1 long segmented seta; distal segment of this seta feathered with setules. Inner distal lobe with 2 spinulose setae of equal size, and with 1 shorter spiniform seta. Anterior lobe with 4 setae, 3 of these setae stout and coarsely setulated, and remaining 1 seta slender and spiniform; anterior surface with group of long setules distally. Posterior lobe with 3 feathered setae on distal end. Inner lateral surface with rows of fine setules. Inner proximal surface with 2 plumose setae near base of posterior lobe. Outer surface with 7 transverse rows of long setules; 2 setulated ejector hooks of unequal size, arising near base of limb.

Limb II (Fig. 2b) with gnathobase. Gnathobase armed with 3 naked setae, seta close to first scraping spine largest. Gnathobase filter plate with 7 setae. Scraping spines on endite 7 in number, increasing in size distally; distal 2 spines long and setiform, with fine setules while remaining 5 spines short, with thicker setules. Exopod with 1 large segmented seta; distal segment of this seta feathered with setules.

Limb III (Fig. 2c) consisting of 2 lobes of exopod and endopod; endopod with endite and gnathobase. Gnathobase filter plate with 7 setae. Endite with 7 setae; distal 3 setae with thick setules, and remaining 5 setae coarsely setulated. Exopod with 5 setae; 2 setae arising from distal end, 1 of these setae feathered with long hairs and another seta much longer, with thick setules on distal part; 3 plumose setae arising from lateral exopodite.

Limb IV (Fig. 2d) with flabelliform exopod. Gnathobase filter plate with 4 setae. Endite with 9 setae; distal 2 setae stout, with thick setules, and remaining lateral 7 setae slender and coarsely setulated. Exopod with 6 setae, 4 of these setae large and feathered with long hairs, and remaining 2 setae slender and not feathered.

Limb V (Fig. 2e) of flabelliform; endopod simple, with extremely reduced gnathobase. Endite with 4 plumose setae. Exopod with 4 large setae feathered with long hairs.

Male: Not known from Korea.

Distribution: East Asia (Korea, China, Japan), Europe, North America, Australia.

Remarks: In most characters the present specimens are well accorded with the redescriptions of European specimens by Lilljeborg (1901) and Smirnov (1971). One noticeable feature observed in our specimens is that the claw bears a row of very minute setules on convex ventral margin. This feature has not yet been noted from *L. leydigi* in most previous works except for Negrea's (1983) illustration. Negrea (1983) illustrated the similar feature in the descriptions of *L. leydigi* and *L. acantho-cercoides* (Fischer, 1854) with Roumania materials. Such claw with setulose ventral margin is also observed in Korean materials of *L. ciliata* Gauthier, 1939. Judging from these observations, this feature seems to be common to the species of *Leydigia*, and many previous invastigators might have overlooked it.

The present species has been recognized as the most common species in *Leydigia*, showing cosmopolitan distribution (see Smirnov, 1971). However, the taxonomic status of this species recorded from many countries is doubtful and the re-examination of this species is needed because of short and unclear descriptions and illustrations of previous reports. Therefore the exact grographical range of *L. leydigi* might to be more restricted within each continent when the

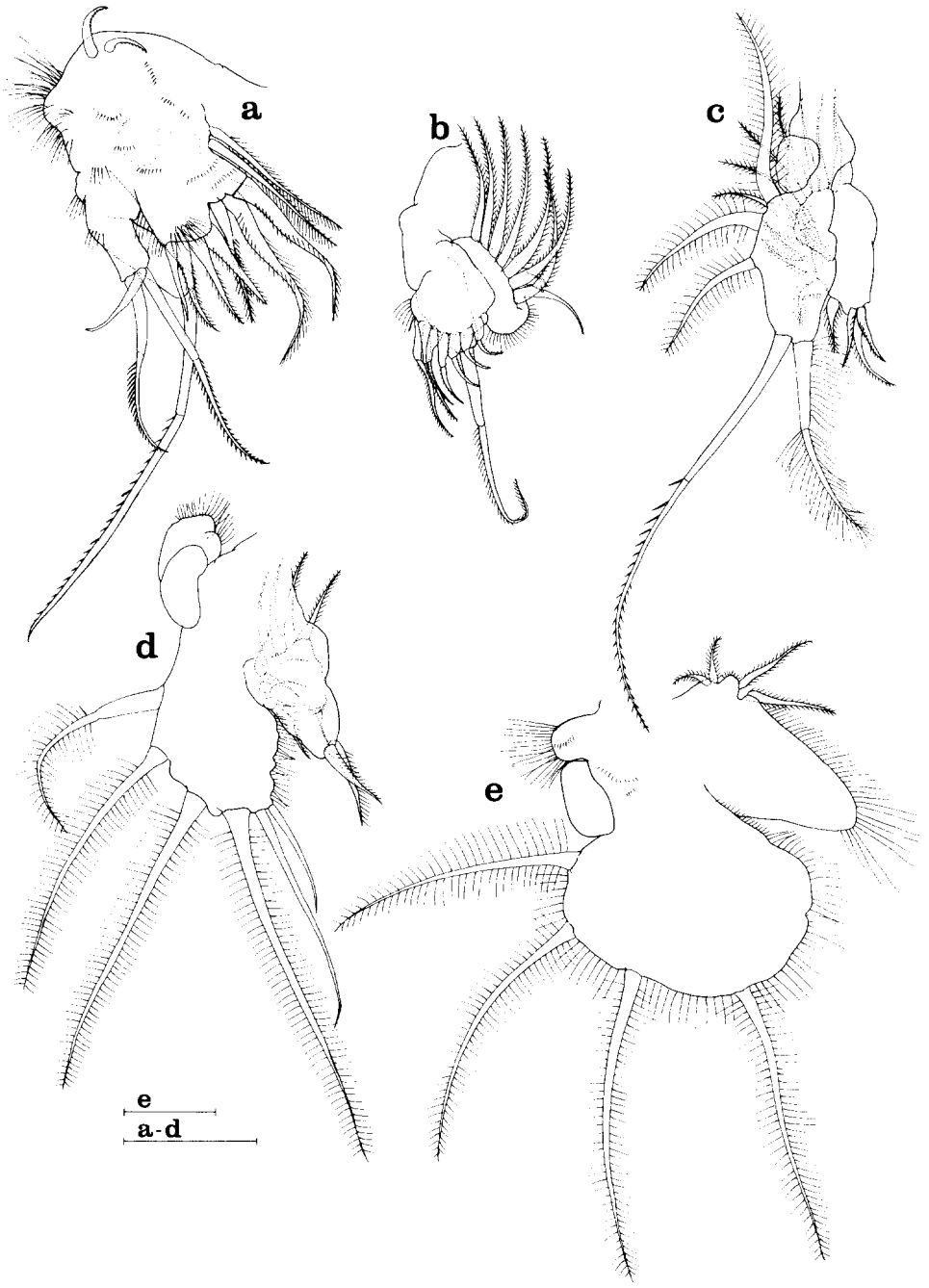

Fig. 2. *Leydigia leydigi* (Schodler, 1863), right trunk limbs of female: a, limb I, inner view; b, limb II, inner view; c, limb III, outer view; d, limb IV, outer view; e, limb V, outer view. (Scales: 0.05 mm).

taxonomic status of this species is revealed as shown in many other chydorid species (Frey, 1987; Michael and Frey, 1983, 1984; Rajapaksa and Fernando, 1986, 1987a, 1987b, 1987c).

2. *Leydigia ciliata* Gauthier, 1939 좁쌀줄무늬넓은배물벼룩 (신칭) **(Figs. 3, 4)**

Leydigia propinqua var. *ciliata* Gauthier, 1939 (p. 168, Fig. 9).

Leydigia ciliata: Smirnov, 1971 (p. 454, Figs. 562-566); Chiang and Du, 1979 (p. 211, Fig. 142); Smirnov and Timms, 1983 (p. 54); Tanaka, 1989 (p. 4, Fig. 1-11,12).

Material Examined: Four parthenogenetic females collected from the ricefields filled with water before rice-planting at Mangch'i-ri, Ilun-myŏn, Kŏje-gun on May 5, 1989 by the authors.

Female: Body (Fig. 3a) 0.63-0.98 mm long (from anteriormost part of dorsal margin of head to posteriormost part of posterior margin of carapace), oval in lateral view.

Carapace (Figs. 3a, b, c) with longitudinal rows of granules; posteroventral corner round, with row of fine setules on inner side; ventral margin slightly convex, armed with long plumose setae on outer margin.

Head pores located on median line near posterior quartile point of head shield between eye and posterior margin (Fig. 3d); main head pores 3 in number, connected each other; 2 lateral small pores located near middle main pore (Fig. 3e). Ocellus slightly smaller than eye. Rostrum short and blunt. Plate of labrum (Fig. 3f) fringed with setules on anterior margin; anterior margin weakly undulated; lateral surface with group of setules.

Antennule (Fig. 3g) slender, not reaching to apex of rostrum; posterior surface with 3 groups of setules; anterior surface with 1 seta; distal end with 9 olfactory setae of nearly equal size.

Antenna (Fig. 3h) small; both rami 3-segmented; antennal formula 0(1)-0(0)-3(1)/1(0)-1(0)-3(1); tip of distal spine on proximal segment of exopod reaching to middle of distal segment; setae on anterior surfaces of proximal and second segments of endopod short and spiniform. Anterior surfaces of basipodal segment and proximal segments of both rami with groups of setules. Distal end of basipod with small spiniform protuberance between both rami.

Postabdomen (Fig. 3i) wide, with evenly round dorsal margin and slightly convex ventral margin. Anal spines very small, grouped in 3-4 spines, arranged along almost whole dorsal margin. Lateral groups of setae well developed, about 25 in number, decreasing in size proximally, and followed proximally by groups of fine setules on anal region; distal seta largest in each group; each distal 12-13 groups consisting of 3-5 long setae while each proximal 12-13 groups near anal region comprising 4 small setae (Figs. 3i, j, k).

Claw (Fig. 3l) with 1 extremely reduced basal spine; proximal half of concave dorsal margin with row of setules decreasing in size proximally, and remaining distal half with row of shorter setules; ventral margin with row of very minute setules.

Five pairs of trunk limbs present. Limb I (Fig. 4a) much similar to that of *L. leydigi* in general form. Outer distal lobe with 1 long segmented seta; distal segment of this seta feathered with setules. Inner distal lobe with 4 setae, 1 of these setae much shorter than others. Anterior lobe with 4 stout setae, 3 of these setae coarsely setulated, and remaining 1 seta feebly spinulated; anterior surface with group of long setules distally. Posterior lobe with 3 setae on distal end, and with 2 transverse rows of spinules on posterior surface distally; 2 of these setae large, of equal size, with long setules on proximal halves and with spinules on distal halves, respectively, while remaining 1 seta short, weakly spinulated. Inner proximal surface with long hairs interiorly, and with 2 plumose setae near base of posterior lobe; maxillary process finely setulated. Outer surface with 9 transverse rows of long setules; 2 setulated ejector hooks arising near base of limb, of unequal size.

Limb II (Fig. 4b) nearly identical in general form to that of *L. leydigi* except for gnathobase; gnathobase armature with 3 setae as in *L. leydigi*, but largest seta close to first scraping spine feathered while remaining 2 setae naked (in *L. leydigi*, all 3 setae naked).

Limb III (Fig. 4c) consisting of 2 lobes of exopod and endopod as in *L. leydigi*. Endopod with endite and gnathobase. Gnathobase armed with 5 setae of equal size interiorly; filter plate with 7

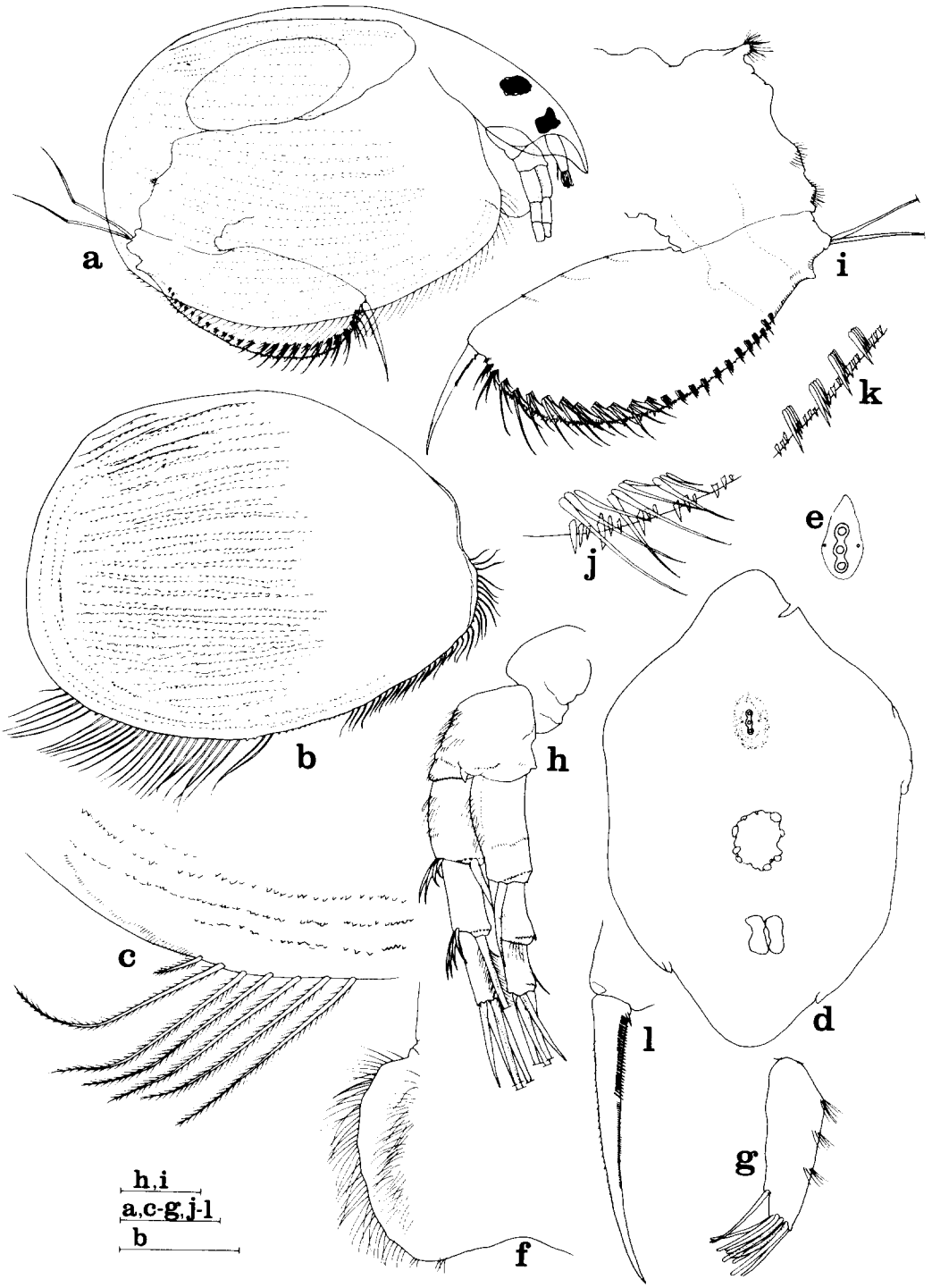

Fig. 3. *Leydigia ciliata* Gauthier, 1939, female: a, habitus, lateral view; b, right carapace, outer view; c, posteroventral corner of right carapace; d, head shield; e, head pores; f, labrum, lateral view; g, right antennule, lateral view; h, left antenna, lateral view; i, postabdomen, lateral view; j, middle groups of lateral setae; k, proximal groups of lateral setae; l, claw, lateral view. (Scales: c, e-h, j-l = 0.05 mm; d, i = 0.1 mm; a, b = 0.2 mm).

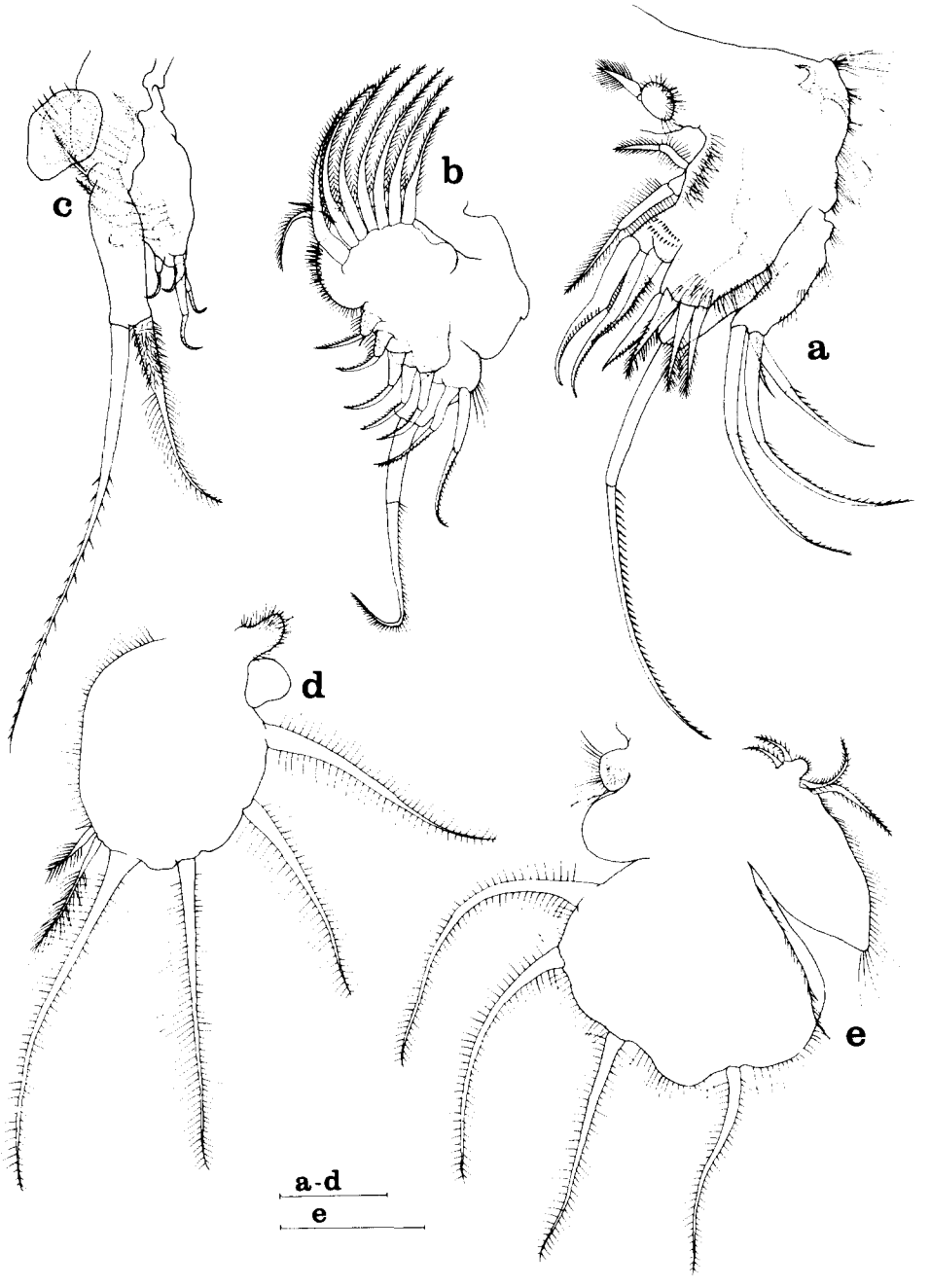

Fig. 4. *Leydigia ciliata* Gauthier, 1939, trunk limbs of female: a, left limb I, inner view; b, left limb II, inner view; c, right limb III, outer view; d, left limb IV, outer view; e, left limb V, inner view. (Scales: a-d = 0.05 mm; e = 0.1 mm).

setae. Endite with 7 scraping setae. Exopod without exopodite; 2 setae arising from distal end, 1 of these setae coarsely feathered with hairs and another seta much longer, with thick setules on distal part.

Limb IV (Fig. 4d) comprising exopod only, without endopod. Exopod flabelliform, with 6 setae; 4 of these setae large and feathered with long hairs, and remaining 2 setae small and coarsely setulated.

Limb V (Fig. 4e) identical to that of *L. leydigi* in general form. Endopod simple and flabelliform, with extremely reduced gnathobase; endite with 4 plumose setae. Exopod large and flabelliform, with 4 large setae feathered with long hairs.

Male: Not known from Korea.

Distribution: East Asia (Korea, China, Japan), Central Africa (Tchad), Central Asia (Kazakhstan), South America (Argentina), Australia (Queensland, New South Wales).

Remarks: *L. ciliata* was first recorded from central Africa (Tchad) by Gauthier (1939) and subsequently reported from other regions of the world by several investigators. However, there have been much confusions in distinguishing the present species from other relative species [see Smirnov (1971); Chiang and Du (1979)]. Most previous works were done without detailed descriptions and illustrations, and many of them seem to be based on a few specimens (Smirnov, 1971). This situation may be explaned in part by the rare occurrence of this species.

The present species is easily distinguishable from other species of the genus by the presence of the rows of granules on the carapace. This characteristic feature, however, may be variable or transiently unnoticeable when the life histories of the individuals such as the age or the habitat *etc.* are different (in Korean materals, the rows of granules are indistinct in two immature specimens). And the relative size of ocellus compared to eye, one of the characters frequently used in recognizing the species of *Leydigia*, also seems to be more or less variable.

The present specimens are well accorded with the original description of Gauthier(1939) in most characters, but they show some characteristic features that have not yet been noted in *L. ciliata*. In Korean materials, the plate of labrum bears additional group of long setules on the lateral surface as well as common row of setules on the anterior margin. This seems to be a variation because the similar feature was noticed in the description of *L. acanthocercoides* (Fischer, 1854) with the Roumania materials by Negrea (1983). Another different characteristic between the present specimens and original description is found on the claw. As previously mentioned in the preceding species, the convex ventral margin of claw bears a row of fine setules in Korean materials. In addition to these, each of the present specimens has a basal spine on the claw, which is very small but distinct. According to Gauthier's (1939) original description the absence of the basal spine on the claw is one of the useful characteristic features in recognizing the species. In this point Korean materials may belong to another group (speceis or subspecies) different from *L. ciliata* described originally based on African materials. However, the assignment of the present materials to another group is reserved because the same feature that the small basal spines exist on claws was noticed before by several investigators (Smirnov, 1971; Chiang and Du, 1979) in *L. ciliata,* though they did not obviously illustrate it. However, we should not exclude the possiblity that there might exist more than one groups in the species previously reported as *L. ciliata* from different regions. Therefore, there is need to re-examine the materials of previous works with respect to the above characteristics. The taxonomic status of the present specimens will be confirmed by further detailed studies with large materials, including the specimens of previous works if possible, from extensive regions of the world.

The features on the trunk limbs have been described in three species, *L. leydigi* (Schoedler, 1863), *L. ciliata* and *L. australis* Sars, 1886, within the genus (Lilljeborg, 1901; Smirnov, 1971). In the trunk limbs, the present specimens are well accorded with Smirnov's (1971) description and illustration based on Australian materials. While examining the Korean specimens, the characters on the trunk limbs are proved to be useful for distinguishing the present species from

other species. Among above three species, *L. ciliata* has some characteristic features on trunk limbs, especially on limb III and IV as follows: (1) limb III of *L. ciliata* has no exopodite on the exopod while that in *L. leydigi* and *L. australis* has it, and consequently the exopod of limb III of *L. ciliata* bears two setae on the distal end while the exopod in other two species has five (Fig. 4c), (2) limb IV of *L. ciliata* is composed of the exopod alone while that in other species comprises both the exopod and the endopod (Fig. 4d). The more useful characters on trunk limbs may be revealed in further studies with the many species of the genus.

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한국산 넓은배물벼룩속 씨물벼룩류 2종의 재기재

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한강변과 거제도의 논에서 채집된 담수산 물벼룩류의 표본들에서 넓은배물벼룩 *Leydigia leydigi* (Schoedler, 1863)과 좁쌀줄무늬넓은배물벼룩 *Leydigia ciliata* Gauthier, 1939의 2종이 동정되었다. 본 연구에서는 2종을 재기재하였으며 도판을 작성하였다. 이것은 넓은배물벼룩속의 종들에 대한 한국 최초의 기록이다.