

# Daphnia of Hokkaidô and their Habitat-lakes

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(With nine text-figures)

More than thirty-six years have elapsed since the writer's works on the Cladocera of Hokkaidô were published (Uéno 1933, 1934). Since that time no detailed study of the genus *Daphnia* in Hokkaidô has appeared, whereas the difficult taxonomy of that genus has been much revised, as the result of a number of works, especially the comprehensive monograph by Brooks (1957). His study, however, is concerned with the North American *Daphnia* alone; nevertheless, it contains very important comments on the general matters regarding the systematics of the genus. As Axelson (1961) indicated the difficulty of its general application in Europe, Brooks' work cannot be employed to the utmost extent in Japan, either, where *Daphnia* are represented by the species distributed mainly in Eurasia rather than in North America. Necessity of the emendation of such early works has led the writer to study again the *Daphnia* of Hokkaidô, because Hokkaidô is an attractive region in regard to the occurrence of the greatest number of species of that genus throughout the Japanese Islands.

In Hokkaidô there are a large number of lakes various in nature, among which more than seven large and deep volcanic lakes, mostly oligotrophic, support or have supported the populations of *Daphnia* species there. Large but shallow lakes that lie in the coastal districts facing the Sea of Okhotsk have no *Daphnia* populations. A small lake, Lake Riya-ushi-ko, near Abashiri is the only exception in having the population of *Daphnia galeata*. The writer's investigations have not extended to any small and shallow bodies of water, in which there may occur one or more particular species of *Daphnia* different

from the species inhabiting the large and deep lakes. When he undertook to research into the plankton materials collected from some small lakes on the Shiretoko Peninsula (Uéno 1966), the writer, at the same time, had it in his mind to revise the taxonomy of *Daphnia* found in Hokkaido and to obtain knowledge of the nature of their habitat-lakes as well. For the accomplishment of this purpose, the writer has since examined, as much as possible, a number of materials collected from these lakes in recent years, and has also re-examined the materials which he formerly used for his early studies and has preserved in the Ôtsu Hydrobiological Station of Kyôto University.

In the present paper, the following five species are given as occurring in the lakes of Hokkaidô: *Daphnia rosea* G. O. Sars, *D. ezoensis* sp. n., *D. hyalina* Leydig, *D. galeata* G. O. Sars, and *D. longispina* (O. F. Müller). No material has been available in regard to *Daphnia cucullata* G. O. Sars reported by the writer from Lakes Akan-ko and Tôro-ko.

## I. The genus *Daphnia* of Hokkaidô and their Habitat-lakes

### *Daphnia rosea* G. O. Sars

This species has long been known as a variety or a form of *Daphnia longispina*. Sars' original description (1862) and Richard's re-description (1896) are referred to in the work by Brooks (1957), who also gives Richard's unpublished drawings of Sars' type material of *D. rosea*. In Hokkaidô *D. rosea* is distributed in some shallow bodies of peaty water in the northern half of the island, particularly in the districts facing the Seas of Japan and Okhotsk. The writer's material came from three different localities, i.e., some small bodies of water on the Shiretoko Peninsula, a peaty swamp at Toyotomi south of Wakkanai, the northernmost part of Hokkaidô (collected by S. Inoué of Hokkaidô University), and a pond on the island of Rijiri off Wakkanai.

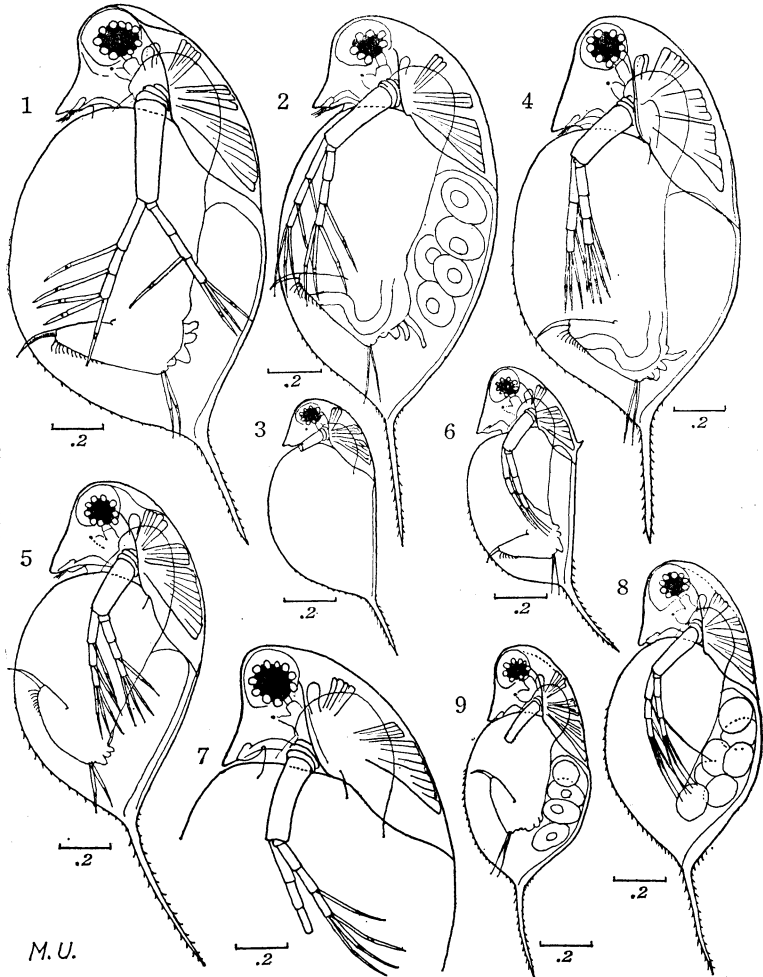


Fig. 1. *Daphnia rosea* G. O. Sars

1-3, ♀ from a small lake on the island of Rijiri, 3: a young individual of the form shown in 2; 4-6, ♀ from the small lake No. 3 on the Shiretoko Peninsula, 6, a young of the form shown in 4; 7, ♀ from the lake No. 1 in the same district with No. 3, head and the anterior half of valve; 8-9, ♀ from Toyotomi south of Wakkanai, the northernmost part of Hokkaidō.

Brooks (1957) indicates that *D. rosea* is the only moderate-sized North American species, the head and the valves usually measuring about 2mm long, as shown in the re-description by Richard (1896). Mature females from Hokkaidō do not exceed 2mm, being mostly 1.5-1.8mm long. Specimens from a lake on the Shiretoko Peninsula and a pond on the Rijiri Island agree with Brooks' figure (Plate 38D, on p. 113) in general appearance. Specimens from the other localities are somewhat different in the shape of the head.

The head is more deep than long, and twice as deep as it is long in some Rijiri specimens. The greatest length of the head is nearly or a little longer than one-third the valve length. Some large adult specimens have a slight crest over the optic vesicle, extending to the attaching portion of the second antennal muscle. The antero-dorsal margin of the head is broadly rounded and the ventral margin nearly straight or concave. The specimens having the head with nearly straight ventral margin closely resemble that of *Daphnia schoedleri* Sars. In such a form, the rostrum is long and acute; the posterior margin of the head is nearly straight or slightly concave; the sense hairs of the antennules do not extend beyond the apex of the rostrum. The fornix reaches the dorsal edge of the optic vesicle. The eye is large, the optic vesicle touching the antero-ventral margin of the head; the ocellus of moderate size is placed nearer to the eye than to the posterior margin of the head.

The antennae are much shorter than the valves. The swimming setae are considerably short in the Shiretoko specimens, while they are moderately long in the Rijiri specimens. The antennal distal joint is a little shorter than the proximal joint, while it is slightly longer than the latter in the North American forms. Brooks indicates that they are sometimes much shorter and stouter. In the Shiretoko material the distal joints are markedly shorter than the proximal ones and are faintly brownish. The post-abdominal claws, some distal anal teeth, the ventral and dorsal edges of the valves and the shell-spine are also brownish, as Brooks has observed from his North American



Fig. 2. *Daphnia rosea* G. O. Sars

1, rostrum of Fig. 1-1; 2 (3), abreptor of Fig. 1 (2); 4, rostrum of Fig. 1 (4); 5-6, abreptor of Fig. 1 (4); 7, post-abdominal claw of Fig. 1 (7); 8, rostrum of Fig. 1 (8); 9-10, abreptor and post-abdominal claw of Fig. 1 (8).

material. As one of the diagnostic characters of *D. rosea*, Keilhack (1909, p. 25, as *D. longispina* var. *longispina* s. str. forma *rosea*) gives the presence of a small spot near the base of the distal joint of each swimming seta. Specimens from Hokkaidô, likewise, have a small round and black spot occupying the same position. It seems, however, that it is not useful for a diagnostic character, because such a spot is

also seen in some other species, though not distinctly black.

The valves are obovate and faintly brownish, the ventral margin not being broadly rounded posteriorly, the dorsal margin a little convex; both margins brown. The spinules on the ventral margin of the valves are confined to the posterior half or a short posterior portion. They are 10-12 in number, very minute and widely spaced. In the specimens from the lake No. 3 on the Shiretoko Peninsula these spinules are as many as 36, while those of the form from Lake Hirazawa-ko in the same district are quite destitute of such spinules. The spinulation on the dorsal edge of the valves is confined to a short strip at the base of the shell-spine or sometimes quite absent. The shell-spine arises dorsal to the mid-line of the body and is a little shorter than half the valve length, sometimes one-fourth, or exceeding beyond half the valve length and directed dorso-posteriorly.

Four abdominal processes; the fourth usually very small, the first and the second subequal to each other, the third subequal to both the first and the second or somewhat longer and broader than the latter two. The number of the anal teeth is 11-13 (Richard's re-description gives 11-14). The post-abdominal claws are long and slender, with three pectens of minute teeth. In *D. schoedleri* the middle pecten is much shorter than the other two.

Brooks (1957) indicates that the presence of toothed crest on the dorsal margin of the head in immature females is one of the diagnostic characters of *D. rosea*. None of immature females with such a crest on the head was found in the materials collected in Hokkaidō during the summer months. Richard's drawings (photo-reproduced by Brooks, 1957, p. 1. II) of Sars' type material of *D. rosea* show the head with concave ventral margin. Among the materials from Hokkaidō some have a head with nearly straight or slightly concave ventral margin, as Kiser's *rosea* (*Daphnia longispina* subsp. *longispina* forma *rosea* Sars, designated by Kiser, 1950, p. 24, p. 1. V, fig. 5). Kiser's *rosea* bears 10-12 anal teeth on the abreptor. His specimens are a little smaller, 1.5-1.6mm long.

*Distribution and Habitats:*

*Daphnia rosea* Sars is widely distributed in the northern part of Eurasia as well as in the western part of North America. Some Kurile forms assigned to *D. longispina* s. str. are actually *D. rosea* (Uéno 1938, Brooks 1957). The present material has its occurrence in Hokkaidô without doubt. It has also been recorded from a small bog-lake at an elevation of 1,000 m as far in the south as in Yamagata Prefecture of the Tôhoku district (Uéno *et al.* 1959).

*Daphnia rosea* is known to be an inhabitant of shallow bodies of water. Its habitats in Hokkaidô are also shallow and usually brown peaty waters, in which it always occurs together with a red-colored calanoid, *Acanthodiaptomus pacificus* Burckhardt. In the plankton collected in 1957 from a small and shallow pond of brown water (called Menunshoro-numa) on the island of Rijiri, Mizuno (1960) has assigned the *Daphnia* among those samples to *D. longispina hyalina*. Examination of the same material given through Dr Mizuno's kindness has revealed that it was actually *D. rosea*.

*Daphnia ezoensis* sp. n.<sup>1)</sup>

*Daphnia longispina* s. str., Uéno, 1933, Pl. XI, figs. 18-27.

*Daphnia longispina* s. str., Uéno, 1934, Pl. XI, figs. 4 & 5.

*Daphnia longispina primitiva*, Uéno, 1937, p. 54-55, fig. 40.

*Type-specimens*:—the population of the species in Lake Shikaribetsuko, NNW of the city of Obihiro in the province of Tokachi, taken on September 25, 1966, by T. Tokui.

*Female*:—Medium-sized *Daphnia*. Head and valves 1.1–1.6 mm long excluding shell-spine. Head short and small, never developing crest, one-fourth to one-fifth the valve length; greatest length of head about half its greatest depth which is a little more than half the valve length; anterior margin round, ventral margin slightly or distinctly concave. Rostrum long, aquiliform and pointed. Sense hairs

1) *ezo* is the old name of Hokkaidô.

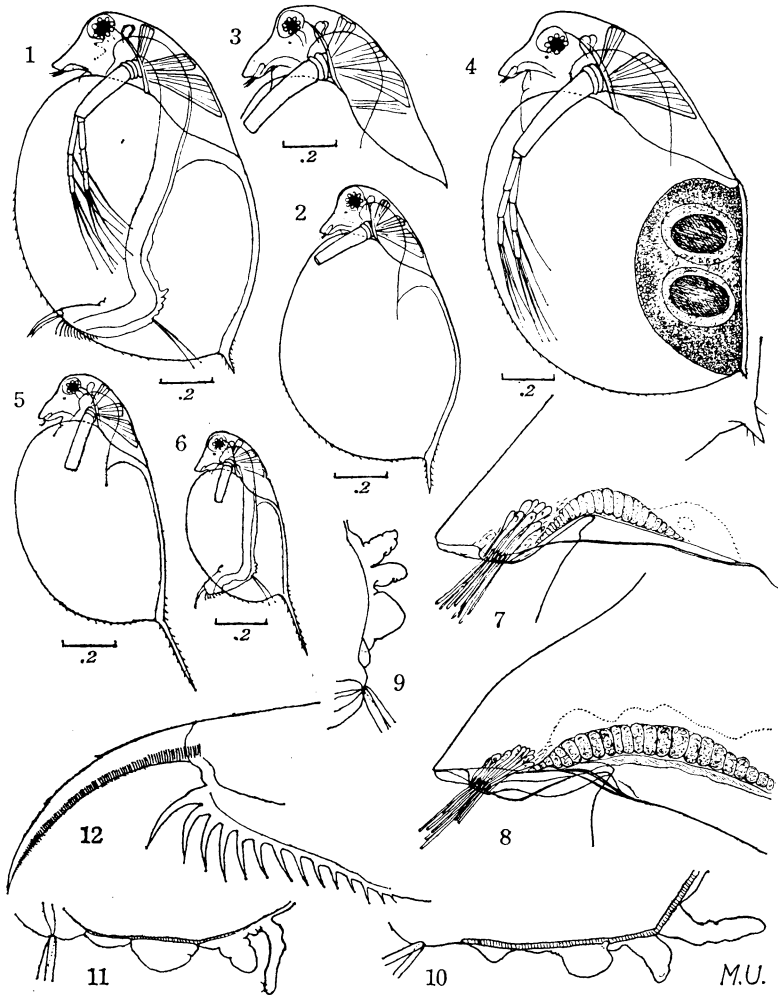


Fig. 3. *Daphnia ezoensis* sp. n., ♀, from Lake Shikaribetsu-ko  
 1, adult ♀; 2, adult ♀, another form; 3, head of an autumnal ♀; 4, ephippial ♀; 5, primipara; 6, neonata; 7, rostrum of 1; 8, rostrum of 4; 9-11, abdominal processes: 9, of 2; 10, of 1; 11, of 4; 12, distal part of abreptor and post-abdominal claw of 1.



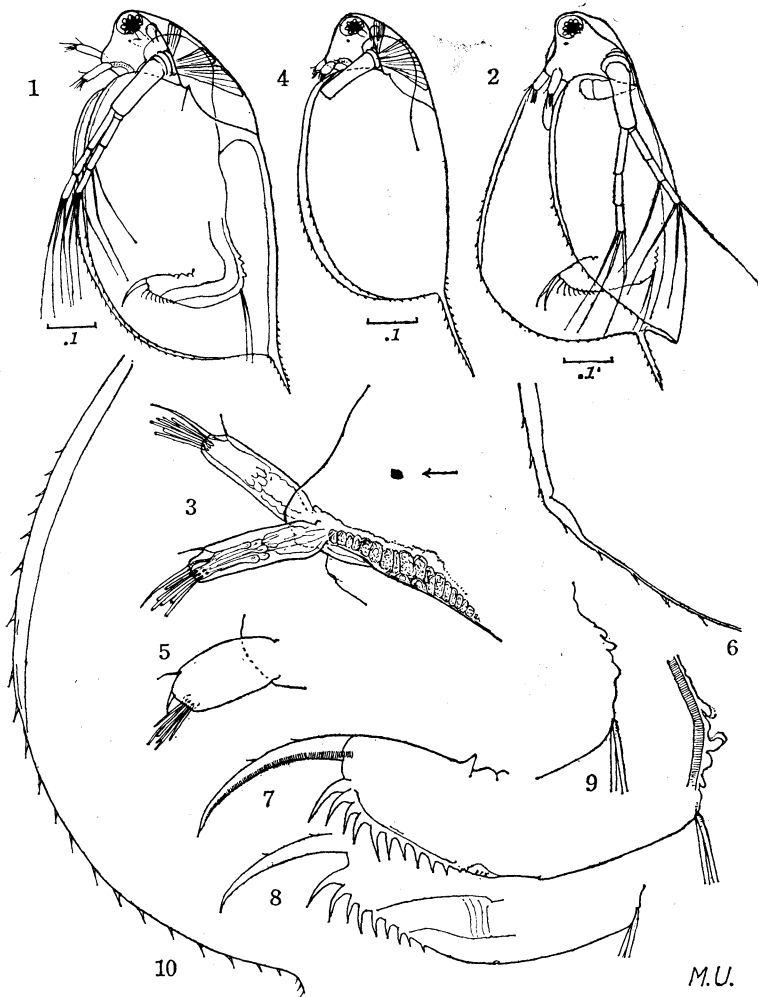


Fig. 4. *Daphnia ezoensis* sp. n. from Lake Shikaribetsu-ko  
 1-2, adult ♂; 3, rostrum and antennules of ♂ (1); 4, young ♂; 5, antennules  
 of the same; 6, middle part of the ventral margin of valve of ♂ (2); 7,  
 abreptor and abdominal processes of ♂ (1); 8, abreptor of ♂ (4); 9, abdominal  
 processes of ♂ (4); 10, ventral margin of valve of ♀.

of antennules slightly extending beyond apex of rostrum. Posterior surface of head slightly or moderately concave; median carina extending beyond tips of antennular mounds; posterior edge of side continues onto or sometimes beyond antennular mounds. Fornix extends towards dorsal edge of optic vesicle. Eye of moderate size placed near vertex, optic vesicle reaching antero-ventral margin of head; ocellus of moderate size. Intestinal coecae small and slender, not markedly curved backwards. Antennae nearly half the valve length, but with comparatively long swimming setae.

Valves oval or nearly circular in lateral view, much deeper than head, narrowed anteriorly and broadly rounded posteriorly; spinulation on ventral margin extending anteriorly about three-fourths of the edge; spinules widely spaced and so minute that they are difficult to discern, especially in anterior part. Spinules on dorsal edge of valves restricted to near base of shell-spine. Shell-spine usually short, one-third to one-fourth as long as valve, and sometimes rudimentary or entirely lacking. It is usually directed dorso-posteriorly, and rarely parallel to the median axis of body or directed ventro-posteriorly.

Four short and small abdominal processes. First the longest, and twice the length of second in large specimens, but it is nearly as large as second in many specimens. Third broadest and shorter than the preceding two, fourth smallest and low. Posterior margin of abreptor nearly straight or slightly curved in lateral view, with 9-14, usually 9-11 anal teeth, which are found to decrease sharply in size proximally. Post-abdominal claws long and slender, with three pectens of fine teeth, of which the most proximal is the largest.

*Male*:—Much smaller than female, 1.5mm in head and valves. Head brachycephalic as in female, with vertex rounded and without crest; ventral margin slightly concave due to the development of rostral region. Rostrum directed ventrally, with apex rounded. Compound eye located near vertex in mid-line of head. Antennules four times as long as broad, a lateral sense hair found subapically and near base of flagellum; flagellum comparatively short, slightly longer than apical

sense hairs.

Valves oblong, a little shorter than twice the breadth, dorsal margin slightly convex; anterior border of ventral margin forming thickened rim, bearing no spines or hairs unlike males of most species of *Daphnia*. Posterior half of ventral margin with about 22 wide-spaced spinules. Dorsal edge without spinulation. Shell-spine one-sixth or less of valve length in mature specimens. Four abdominal processes rudimentary, second the longest. 9-10 anal teeth.

*Differential diagnosis:*

*Daphnia ezoensis* resembles both *D. longispina* and *D. hyalina*, but is a species quite different from the two and is endemic to the lakes of Hokkaidô. It is characterized by its broadly oval valves as well as by its short and small head, the vertex of which is round and never develops a crest in summer. The rostrum is prolonged, aquiliform, and the antennular sense hairs slightly extend beyond the rostral end. The male is also distinctive for the prolonged rostral region and, unlike the males of most species of the genus *Daphnia*, for having no hairs on the inner border of the anterior ventral margin of the valves.

Scourfield(1942) points out that the shape of the head, the length and the position of the shell-spine are unreliable as specific characters, because those features have been found to be extremely variable. In the present species, however, the head is distinctive for its shortness and for the prolongation of the rostral region. The head is the longest over the optic vesicle placed in, or just on the ventral side of, the mid-line; the postero-ventral slope from the vertex in lateral view forms a larger angle to the body axis than the postero-dorsal slope does, the former being 50°-60° and the latter 40°-43°. The ventral margin of the head, therefore, appears to be oblique in profile due to less growth in the greatest length of the head and to the prolongation of the rostral region. The rostrum is long and moderately acute. Spinulation on the ventral margin of the valve is very minute and is confined to its posterior three-fourths. The shell-spine is usually

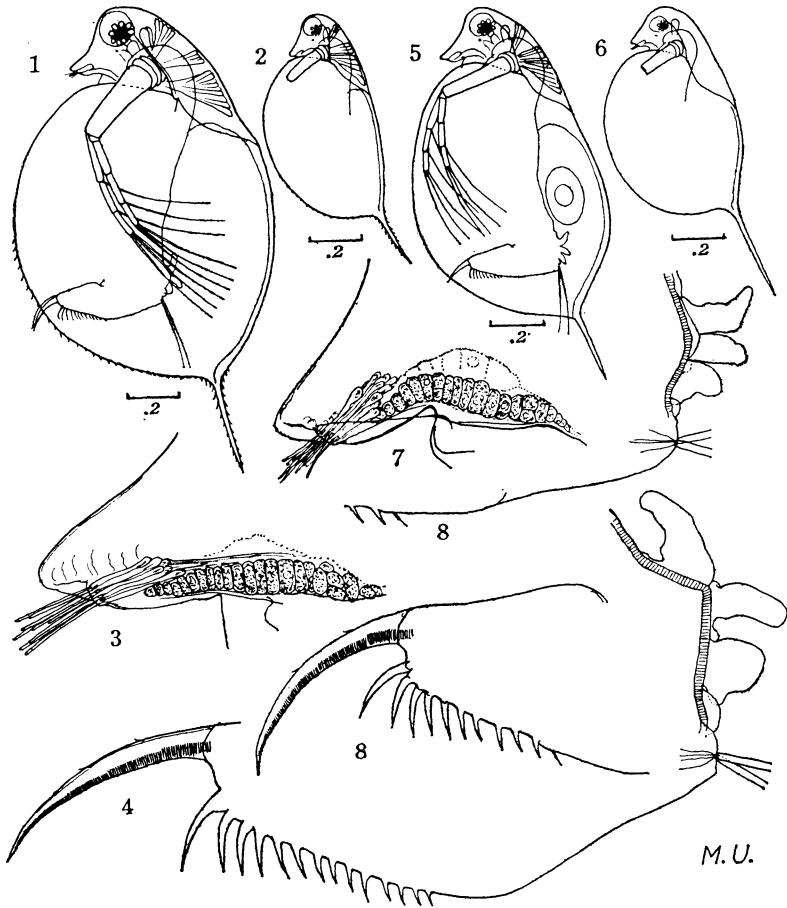


Fig. 5. *Daphnia ezoensis* sp. n. from various lakes of Hokkaidō. 1-4, ♀ from Lake Kutcharo-ko, July 26, 1931, -1, adult ♀; 2, young ♀; 3, rostrum of 1; 4, adreptor and abdominal processes of 1; 5-8, ♀ from Lake Panké-ko NE of Lake Akan-ko, - 5, adult ♀; 6, young ♀; 7, rostrum of 5; 8, adreptor and abdominal processes of 5.

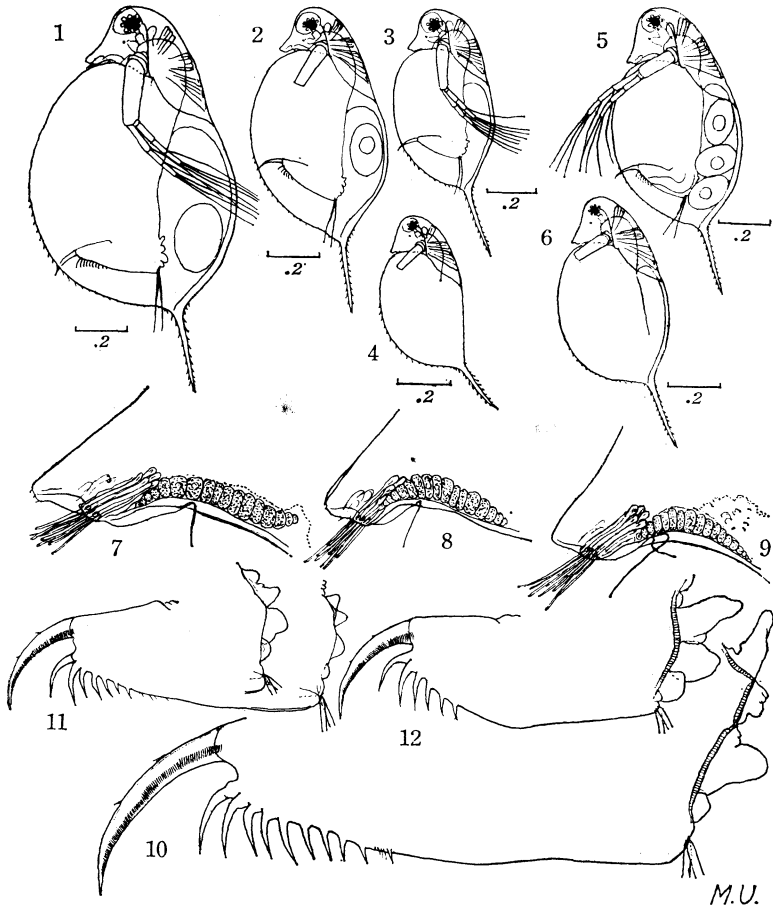


Fig. 6. *Daphnia ezoensis* sp. n. from Lake Akan-ko

1-2, adult ♀♀ taken in 1935; 3-4, ♀♀ taken in 1957, - 4, young ♀; 5-6, ♀♀ taken in 1966, -6, younger specimen; 7-9, orstrum, - 7, of ♀ (1) taken in 1935; 8, of ♀ (3) taken in 1957; 9, of ♀ (5) taken in 1966; 10-12, abreptor and abdominal processes, - 10, of (1) taken in 1935; 11, of (3) taken in 1957, and 12, (5) of taken in 1966.

very short and sometimes entirely lacking. The first and the second abdominal processes are subequal to each other in most specimens. The abreptor bears 9-11 anal teeth (rarely 14), by which feature it differs from *D. longispina* and *D. hyalina*, the former having usually 12-20 and the latter 10-15 anal teeth.

*Local variations:*

In his early papers (Uéno 1933, 1934), the writer recorded *D. ezoensis* under the name of *Daphnia longispina* s. str. from the five lakes in Hokkaidō, namely, Lakes Shikaribetsu-ko, Kutcharo-ko, Akan-ko, Panké-ko and Mashū-ko, all of which are distributed in the eastern part of the island. The populations of *D. ezoensis* which formerly lived or live in these lakes differ from each other in some details, as will be discussed below.

(1) *Shikaribetsu-ko*. This volcanic dammed lake, the type-locality of this species, has 3.5km<sup>2</sup> in its surface area and a maximum depth of 99m. It has kept its conditions almost similar to those seen more than thirty years ago, when the writer's limnological survey was conducted in August 1937 (Uéno 1938a). The materials obtained in 1964 and 1966 show that the lake yet supports the population of *D. ezoensis* well. No marked differences are noticed in this connection in the past thirty years. As described above, the specimens from this lake are remarkable for their very short head and considerably short shell-spine.

The populations of the other four lakes mentioned below, on the contrary, differ from the population of Shikaribetsu-ko in some details. It is suggested that they do not belong to *D. ezoensis* as a pure species but have some characters intermediate between *D. ezoensis* and some other species, probably *D. rosea* or *D. hyalina*.

(2) *Kutcharo-ko*. As will be discussed later, the population of *Daphnia* has entirely disappeared from this large caldera lake during the past thirty years. As early as in July 1931, when Dr Miyadi's survey was conducted, the population of *Daphnia ezoensis* inhabited this lake. It consisted of large individuals as long as 1.5mm in the

head and valves. The shape of the head in profile was similar to that of specimens from Lake Shikaribetsu-ko, but the valves were nearly circular in lateral view with the shell-spine of nearly one-third the valve length. The anal teeth were usually 10 and sometimes as many as 14, preceded by 4-5 spinule groups.

(3) *Akan-ko*. *Daphnia ezoensis* of this lake has come to be replaced by a form of the other species, *D. hyalina*, probably due to a marked eutrophication in recent years. The specimens taken in 1935 measured more than 1.4mm long in the head and valves and closely resemble the form collected from Lake Kutcharo-ko. The shell-spine was one-third or more of the valve length. Anal teeth 9. The change of the populations of *Daphnia* in this lake from year to year will be discussed in more detail in Section II.

(4) *Panké-ko*. This lake that lies northeast of Lake Akan-ko has an area of 2.8km<sup>2</sup> and a maximum depth of 48.8m. The population of *D. ezoensis* in this lake resembles that of Lake Shikaribetsu-ko much more than that of Lake Akan-ko. The shell-spine is markedly directed dorso-posteriorly. Anal teeth 11.

(5) *Mashû-ko*. The material newly obtained from this deep caldera lake (212m in depth) has long been unavailable to the writer, but the population of *D. ezoensis* found in this lake (Uéno 1933) may still have existed.

The populations of *D. ezoensis* in the five lakes mentioned above have common features in the peculiar profile of the head and in fewer numbers of anal teeth. The scarcity and minuteness of spines on the ventral margin of the valve and the absence of hairs on the anterior border of the valve in the male are also noticed. The general shape of *D. ezoensis*, particularly in the population of Lake Shikaribetsu-ko, resembles *D. hyalina* subsp. *lacustris* Sars of Storsjön in Jemtland, Sweden, taken on August 10 (Lilljeborg 1900, Taf. XVI, fig. 7). It has a short head and a large eye placed near the vertex, the antennules being shorter than the apex of the rostrum. Its anal teeth are 8-9. It is 1.84mm long and quite destitute of the shell-spine.

Lilljeborg (l. c., p. 113) writes "Sie schien sehr selten zu sein".

*Distribution and ecology:*

*Daphnia ezoensis* lives in deep volcanic lakes in Hokkaidō and has not been found in the lakes in the western half of the island, where it is replaced by the other species. Outside of Hokkaidō it has been known as occurring in two deep volcanic lakes. One is Lake Urumobetsu-ko on the island of Etorofu (Iturup) of the South Kuriles (Uéno 1933a). The other is Lake Numazawa-numa far down south in Fukushima Prefecture (Uéno 1934). The Numazawa population, however, appears to be a probable hybrid between *D. ezoensis* and another species like *D. rosea*.

None of such a type of *Daphnia* as *D. ezoensis* has ever been reported from the neighbouring regions of Hokkaidō, such as the North Kuriles, Sakhalin and the continental Far East (Uéno 1939a), and also from the Pacific Northwest of North America (Brooks 1957). It may have originated from one of the species among the *D. longispina* group and has become differentiated into a peculiar form as *D. ezoensis* after its migration into the volcanic lakes of post-glacial origin in Hokkaidō. The populations of this species other than that of Lake Shikaribetsu-ko do not appear to belong to a typical ("pure") *ezoensis*, but have some indication of introgression by a supposed species like *D. hyalina* or *D. rosea*. The populations of *Daphnia* intermediate between two species have almost certainly been relatively common in the northeastern part of Hokkaidō and in the Kurile Islands. The occurrence of such presumably hybrid populations of *Daphnia* has been indicated by Brooks (1957) and the present writer (Uéno 1971) to inhabit the districts of the Pacific Northwest of North America.

*Daphnia ezoensis* is never found in small and shallow bodies of water. Its habitats are restricted to the lakes of clear oligotrophic water in which no enormous phytoplankton occurs in summer. The temperature of the surface water of those lakes is 22° or less in mid-summer. The oxygen dissolved in the water does not markedly decrease in the hypolimnion during the summer months. *D. ezoensis*



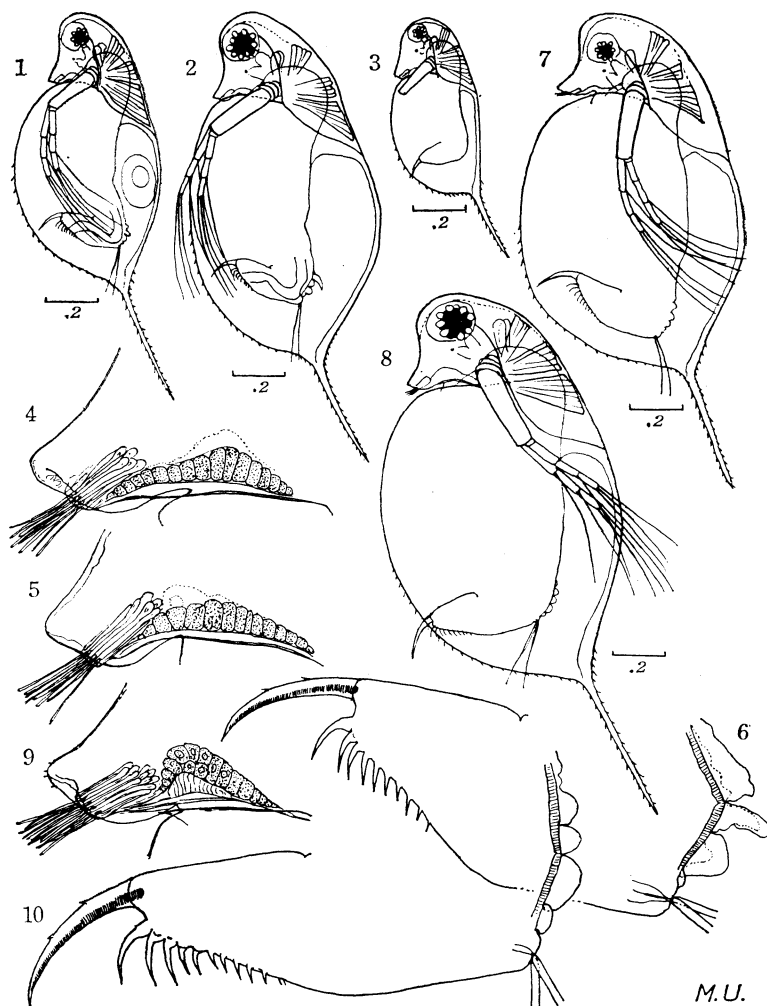


Fig. 7. *Daphnia hyalina* Leydig

1-6, specimens collected from Lake Tōya-ko: - 1, adult ♀ taken in 1931; 2, adult ♀ taken in 1961; 3, neonata in 1961; 4-5, rostrum, 4, of adult ♀ in 1931, 5, of adult ♀ in 1961; 6, abdominal processes of 1; 7-10, specimens from Lake Shikotsu-ko: 7, adult ♀ taken in 1930; 8, adult ♀ in 1966; 9, rostrum of 8; 10, abreptor and abdominal processes of 8.

M.U.

is always found together with *Acanthodiptomus pacificus* and *Bosmina coregoni*, and rarely also with *Polyphemus pediculus*. In Shikaribetsu-ko 99m deep it lives most abundantly above the thermocline in summer.

*Daphnia hyalina* Leydig

The populations of *Daphnia* inhabiting Lakes Shikotsu-ko, Tōya-ko and Akan-ko belong to this species. Among these, the population of Akan-ko has recently replaced *D. ezoensis* (see below). The population of Lake Tōya-ko seems, according to Motoda *et al.* (1967), to have become extinct in recent years, probably since about 1960, due to the rapid acidification of the waters by the inflow of strongly acid water from the neighbouring iron-ore mine.

The egg-carrying females of this species taken in Lake Tōya-ko on July 31, 1931, when *Daphnia* was one of the main components of the plankton of this lake, are smaller than 1.0mm in the head and valves. The shell-spine is slender, a little longer than half the valve length and directed dorso-posteriorly. The head is about one-third the valve length, its greatest length being two-thirds the greatest depth, with a slight crest over the optic vesicle. The ventral margin of the head is slightly concave, with the acute rostrum, the sense hairs of the antennules slightly extending beyond the apex of the rostrum. The posterior margin of the head is slightly convex. The compound eye is of moderate size; the ocellus distinct. The valves are oblong, the dorsal edge slightly convex; spinulation extends towards the middle of the ventral margin; the spinules on the dorsal edge are confined to the base of the shell-spine. Four abdominal processes are present, the second being longer than the first, the third the broadest, and the fourth very small. The posterior margin of the abreptor is a little curved, bearing 10-11 anal teeth; the post-abdominal claws long and slender, with a series of fine teeth.

Specimens from Lake Shikotsu-ko are somewhat larger in size than those from Lake Tōya-ko. They are more than 1.2mm long in the head and valves, and have a somewhat longer shell-spine. The

material taken in 1966 consists of individuals which have a elongate head, a short and blunt rostrum, and a considerably large eye. 10 anal teeth.

The specimens collected from Lake Akan-ko in 1957 do not exceed 0.9mm long in mature females. It seems that they do not belong to a true *hyalina*, but probably to a hybrid introgressed with one of the other species like *D. ezoensis*. The shell-spine is a little longer than half the valve length and sometimes it is directed parallel to the body axis. The anal teeth in these small individuals are always only 7 in number, preceded by two sets of spinules. This arrangement of the teeth corresponds to that of the specimens with 9 anal teeth. The reduction of the anal teeth in the specimens taken in 1957 seems to be accompanied with a considerable decrease of body size.

The distinction between *Daphnia longispina* and *D. hyalina* has long been discussed by many authors but it still remains a troublesome matter. Most authors indicate the presence of a crest on the head in *D. hyalina* and the absence of it in *D. longispina* (Lilljeborg 1900, Keilhack 1909, Wagler 1927, Ponyi 1965, &c). In regard to the diagnostic characters of *D. hyalina*, Leydig's original description (Leydig 1860, p. 151-153) is obscure, having no comment on the presence of a crest on the head. According to his description, the rostrum is elongate and the antennules are short and quite hidden below the rostrum („fast ganz unter dem Schnabel versteckt“), the valves being narrow, with the long shell-spine directed dorsally, and with 8-9 anal teeth. Leydig (l. c.) writes that the postabdominal claw is almost smooth (“fast glatt”). This author probably failed to determine the presence of fine teeth on the claws. *Daphnia hyalina* has been described by many authors as a subspecies or a variety of *D. longispina*, but in recent years it is separated again from *D. longispina* as a distinct species as Leydig did before (cf. Brooks 1957, Ponyi 1965).

In Hokkaidô *Daphnia hyalina* is found in the lakes in its western half. The population of Lake Shikotsu-ko closely resembles the population found as far in the south as in Lake Biwa-ko, though

there are seen minute variations between the two populations. The population which formerly lived in Lake Tôya-ko agrees closely with that which is extant in Lake Kizaki-ko in Central Japan. It is notable that the *hyalina* in the latter lake tends to form a crest to a slight degree and that its living zone is limited to the hypolimnion in summer.

*Daphnia galeata* G. O. Sars

This species rarely occurs in Hokkaidô, being known only to inhabit two shallow lakes, Tôro-ko and Riya-ushi-ko. Short notes on the limnological features of these lakes will be given later.

It has been well-known that the head shape of *Daphnia galeata* is very variabel season by season. The writer has been able to examine the summer materials of it from both lakes, which seem to have a fully developed helmet. In Lake Tôro-ko the winter specimens of it were also available.

The summer form of the Tôro-ko population is 8-11mm long in the head and valves. The helmet of it in profile is shorter, as compared with the Riya-ushi-ko population. Its pointed apex in mature females lies in about the mid-line of the body. The ventral margin of the head is slightly sinuate before and behind the optic vesicle. The length of the head is nearly half to two-thirds the valve length. The rostrum is shorter in comparison with the Riya-ushi-ko specimens. The sense hairs of the antennules extend beyond the rostral end. Spinulation on the ventral margin of the valve is confined to the posterior two-thirds. The shell-spine is three-fourths to two-thirds of the length of the valve and is directed dorso-posteriorly. Four abdominal processes are present, the first being the longest, the second and the third subequal in length, the latter broad and rounded, and the fourth rudimentary. 8-9 anal teeth.

The winter form of the same population is characterized by the presence of a slight crest with a distinct occipital angle, and by the convex ventral margin before the optic vesicle. Such features are also seen in the ehippial females which measure 10-11mm long

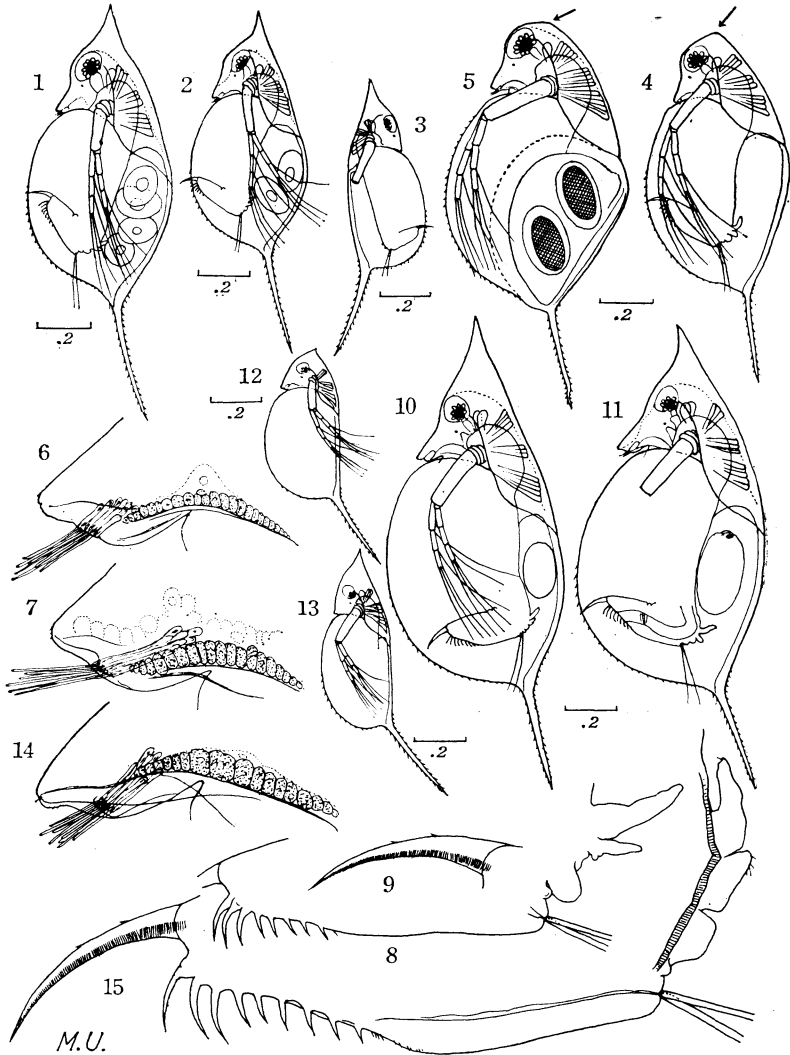


Fig. 8. *Daphnia galeata* G. O. Sars

1-9, ♀♀ from Lake Tôro-ko north of the city of Kushiro. 1-3, summer form (September 1960), 3, neonata; 4-5, winter form (December), 5, ephippial ♀; 6-7, rostrum, 6, of 1, 7, of 5; 8, abreptor and abdominal processes; 9, post-abdominal claw. 10-15, ♀♀ from Lake Riya-ushi-ko west of Abashiri. 10-11, two different forms of adult ♀; 12-13, two different forms of neonatae; 14, rostrum of 10; 15, abreptor and abdominal processes of 10.

with the valves deeper than in the summer form.

The Riya-ushi-ko specimens, when compared with the European ones of the same species, have a helmet different in some details. The helmet of the former in profile is elongate triangular with the narrow and sharply pointed apex that lies in about the mid-line of the body. Its dorsal margin forms a rather smoothly convex curve and its ventral margin is slightly sinuate before and behind the optic vesicle. The head, in its greatest length, exceeds half the valve length, and is smaller, in its greatest depth, than the greatest depth of the valve. In such features, the Riya-ushi-ko specimens closely resemble the Swedish form of *galeata* illustrated by Lilljeborg (1900, Tf. VII, figs. 6 & 8). The ventral margin of the head in larger females is slightly convex over the optic vesicle and concave behind it, but does not curve so much as in the typical European form. In some larger specimens, however, the ventral margin of the head is remarkably convex over the optic vesicle and concave behind it. The pointed apex of the helmet in such females is curved antero-ventrally forming a conspicuous concavity before the optic vesicle. The rostrum is short and obtuse; the sense hairs of the antennules do not extend the apex of the rostrum.

Spinulation on the ventral margin of the valve is confined to the posterior two-thirds or the posterior half. The shell-spine is about half the length of the valve. There are three distinct abdominal processes, the first being the longest and the fourth rudimentary. The distal half of the dorsal margin of the abreptor is slightly sinuate, with 9 anal teeth, preceded by spinules. In the number of the anal teeth, this species is allied to the North American *D. galeata mendotae* Birge (its description given in Brooks 1957, p. 132 ff) rather than to the typical European *D. galeata galeata*, the anal teeth of which are from 10 to 16 in number (Lilljeborg 1900, Richard 1896). The post-abdominal claws have fine teeth arranged in three pectens.

In the material collected from Lake Riya-ushi-ko in the latter part of August, no males and ephippial females were found. Among

the neonatae 0.5-0.7mm long, the helmet was found in two different shapes, one being long and narrow with a pointed apex as in the adult and the other short and pointed at the occipital angle as in the adult of the winter form of Lake Tôro-ko. The ventral margin of the head is smoothly convex in both forms.

*Habitat-lakes :*

The habitats of *D. galeata* in Hokkaidô, so far as we know, are restricted to two shallow lakes, both of which are similarly of chthonio-eutrophy in their conditions designated by Järnefelt (1956) in the lakes of Finland.

(1) *Lake Tôro-ko.* Lake Tôro-ko lies on the eastern margin of the vast peaty plain along the drainage basin of the Kushiro River in the eastern part of Hokkaidô facing the Pacific. In spite of having 6.53km<sup>2</sup> as its superficies, the basin of this lake is considerably shallow and do not exceed 7m in its maximum depth. At the time of the writer's latest visit to this lake on August 24, 1957, the lake water was brown with a yellowish green tint. The colour of water, when comparatively measured with a methylorange color scale, showed 15 in the surface water and 17 in the water of 5m deep. The surface of the lake was covered with a bloom of blue-green algae consisting chiefly of *Aphanizomenon flos-aquae*. The Secchi-disc transparency was as small as 0.8m. The quantities of organic matters dissolved in the lake water were 28.5-31.3mg/l in terms of permanganate consumption. This is probably due to the presence of abundant humic substances in the water, which is derived from the vast peaty area extending along the inflowing river in the southeastern surroundings of the lake. The amount of oxygen dissolved in the lake water was observed to show a sharp decrease below the depth of 4m and with it, a typical eutrophic curve in its vertical distribution. In the bottom water at 5.4m oxygen content was as small in quantity as 1.19mg/l, the deficit for its saturation quantity being 5.57 mg/l. The vertical distribution of pH closely resembles that of the dissolved oxygen. Its values inclined toward weak acid below the depth of 4m, at which

layer pH was 7.8. The surface water was markedly alkaline, the pH value being as high as 8.5. The eutrophic conditions of this lake are also indicated by the quantities of nitrogenous compounds which measured 0.08–0.53mg/l of  $\text{NO}_3\text{-N} + \text{NH}_4\text{-N}$  from the surface to the bottom. *Daphnia galeata* in this lake occurred in comparatively small numbers, together with *Bosmina coregoni*.

(2) *Lake Riya-ushi-ko*. This small lake is interesting as a habitat of *Daphnia galeata* in Hokkaidō, with its limnological features not fully known. On August 26, 1957, a fine day, when the writer visited this lake, the water was greenish brown and the surface was covered with an enormous bloom consisting chiefly of *Aphanizomenon flos-aquae*. Apart from this blue-green alga which made up more than 92% of the phytoplankton composition at that time, Dr Negoro determined four more species, viz., *Microcystis aeruginosa*, *Coelosphaerium Naegelianum*, *Ceratium hirundinella* and *Melosira solida*. These four species together made up the remaining 8% of the composition of the bloom. As the zooplankters, besides *Daphnia galeata*, a large-sized *Bosmina coregoni* occurred in small numbers, together with *Chaoborus* larva which probably came up from the bottom mud. In a mud sample taken by the writer from the bottom 4m deep, Dr Negoro found as many as 44 species of diatoms, among which *Melosira granulata* was the most abundant (75% of the composition).

Lake Riya-ushi-ko lies close to the north of Lake Abashiri-ko and is surrounded by low hills 20–30m high above the sea. The lake basin is elliptical in outline, having its maximum length of 1.1km and the depth of 4.5m. There is a deciduous forest close to the lake shore, leaving the peaty area connected to the northern shore. The littoral region of the lake is represented by a narrow zone of *Phragmites* and *Equisetum*. The lake water was brown in colour of allochthonous origin, the methylorange color scale indicating 30. The humic substances in the water were expressed as 49.8mg/l in terms of permanganate consumption. The transparency was 1.2m. Owing to the occurrence of an enormous bloom, the surface water was markedly



alkaline in its reaction, the pH value showing as high as 8.4. The chlorine ion, which was richer than 20mg/l in the surface water, was probably brought in by a sea breeze from the Sea of Okhotsk 10km distant from the lake.

Kitagawa *et al.* (1953), who made limnological surveys in this lake on August 22-25, 1950, showed that the pH values in the surface water were as high as 8.8-9.0 on the fine, and 7.4 on the cloudy, afternoon, whereas the pH values in the deep water remained 6.6-6.4. These authors noticed a great decrease of the oxygen dissolved in the deep water above the bottom. The late Dr Yoshimura's unpublished data obtained on August 31, 1936 (the data kept by the present writer at hand; cf. also, Uéno 1937a) showed [that the oxygen deficit was only 0.83ml/l at the bottom of 4.5m. This is much smaller than the deficits 3.79-5.85 ml/l obtained by Kitagawa *et al.* (l. c.) in 1950, fourteen years after the Yoshimura's visit. The pH 7.0 obtained by Yoshimura at that time is also lower than those in 1950. These results suggest the progress of eutrophication of this small lake in the past years.

As stated above, the two habitat-lakes of *Daphnia galeata* in Hokkaidô are similarly of brown water and of progressed eutrophy. In Lake Biwa-ko, the only habitat of the same species outside of Hokkaidô, it occurs only in the shallow and eutrophic part of the lake basin.

*Distribution:*

*Daphnia galeata* is distributed in South Sakhalin north of Hokkaidô (Uéno 1935). It is one of the rare species in Hokkaidô as well as in the districts south of the province. So far as it has been known to the writer, the only habitat of it is found as far in the south as in Lake Biwa-ko in Central Japan, in which it occurs during the colder months from the fall to early spring. It entirely disappears from the lake after April. In some details, the helmet of it differs in shape from the one seen in the Tôro-ko and Riya-ushi-ko forms, so that it may belong to a different geographical subspecies which is probably

endemic to Lake Biwa-ko. It is named as *Daphnia galeata biwensis*, the description of which will be given in a separate paper.

*Daphnia longispina* (O. F. Müller)

This species occurs in Lake Nukabira-ko that lies ca. 50km north of the city of Obihiro. The limnological features of this lake will be given below.

Medium-sized *Daphnia*, its length more than 1.5mm in the head and valves. The ventral margin of the head is moderately concave behind the optic vesicle, the dorsal margin evenly rounded from the prominent vertex; the rostrum directed ventro-posteriorly. The posterior margin of the head is evenly curved forward, reaching the apex of the rostrum beyond the antennular mounds. The sense hairs of the antennules slightly extend beyond the apex of the rostrum. The fornix reaches the anterior margin of the optic vesicle. The valves are broadly oval in lateral view, spinulation on the ventral margin being confined to the posterior half, with the spinules relatively small in number (about 15). Four abdominal processes are present but not well developed, the first being the longest. The abreptor bears 11-12 anal teeth. The post-abdominal claws bear three pectens of fine teeth.

Ehippial females attain more than 1.7 mm in the head and valves. The ventral margin of the head is more concave in profile in them than in normal females. The shell-spine is very short or almost reduced.

Males are much smaller than females, more or less 1.0mm in the head and valves. The shell-spine is about one-sixth the body length. The antennules are about one-fourth as broad as long, with a sensory seta near the apex and also with a flagellum slightly longer than the sense hairs. Four abdominal processes short and small. Only 9 anal teeth, preceded by a group of 3 spinules. The post-abdominal claws have three pectens of fine teeth as in females.

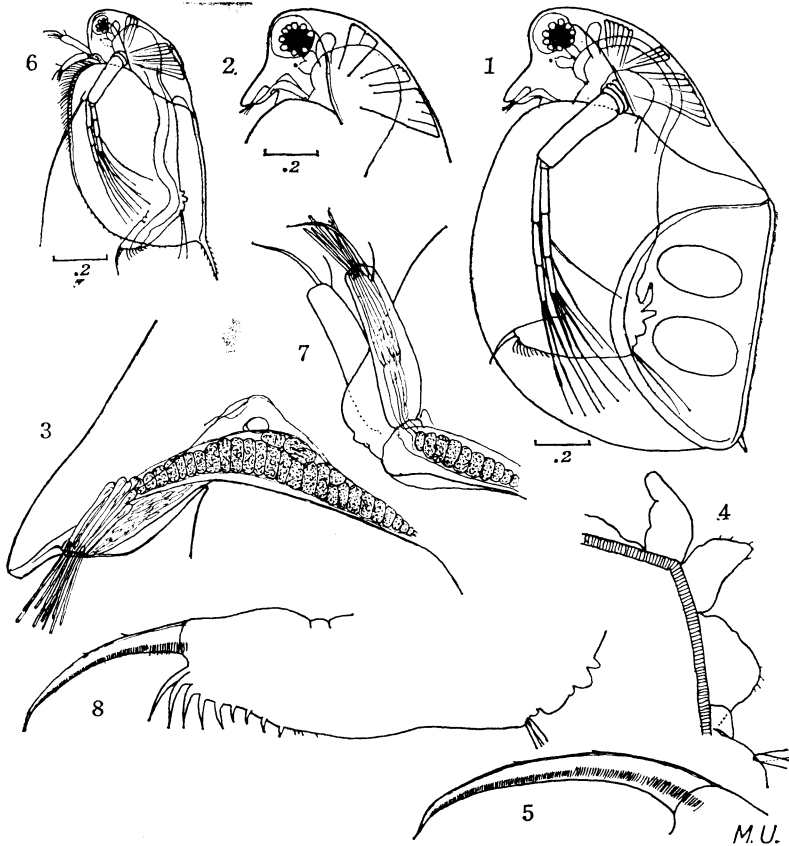


Fig. 9. *Daphnia longispina* (O. F. Müller) from Lake Nukabira-ko, east of Lake Shikaribetsu-ko

1, ephippial ♀; 2, head of a summer form (parthenogenic ♀); 3, rostrum of 2; 4, abdominal processes of 2; 5, post-abdominal claw of 2; 6, ♂; 7, antennules of ♂ (6); 8, abreptor of ♂ (6).

*Habitat :*

Lake Nukabira-ko, the habitat of this species, is an artificial reservoir that lies at an elevation of ca. 530m, with its superficies of 8.1km<sup>2</sup> behind the dam 75m high. It was constructed for the

generation of hydroelectric power. About nine months after the storage of water had been completed, a limnological survey was conducted by the members of the staff of the Hokkaidô Salmon Hatchery. At that time the lake water appeared yellowish brown due to the presence of abundant suspended matters, but chemical analyses proved that the lake water was of oligotrophic, and not of peaty, nature, the pH values showing 5.9-6.9. In the plankton samples obtained on June 10, 1956, when the above stated survey was made, Kurohagi (1959) determined six species of zooplankters, among which he failed to find any *Daphnia*. On November 15-17 of the same year, Kawamura and Anraku (1957) of Hokkaidô University recorded for the first time the occurrence of *Daphnia longispina*, together with *Bosmina coregoni* in this lake. Kawamura (1960), who investigated the plankton succession in this lake during the period from 1956 to October 1960, indicated that *Daphnia longispina* predominated in 1957 (October 25) and 1959 (November 11), with an abundant occurrence of a diatom, *Asterionella formosa*. The samples taken on November 15, 1959, and obtained through Dr Kawamura's kindness for the present study, contained a large number of ephippial females of *Daphnia* accompanied with a number of males.

## II. The Change of the Species of *Daphnia* in some Lakes of Hokkaidô in the Past Half Century

As already stated, the change of the species of *Daphnia* is noticed in some lakes of Hokkaidô in the past forty years. It seems that the *Daphnia* populations have become extinct in Lakes Kutcharo-ko and Tôya-ko, and that they were replaced by a new inhabitant in Lake Akan-ko. Such changes may be due to two kinds of processes. One is the acidification by strong acids throughout the water mass, and the other is a rapid eutrophication of the lake which has progressed in the past half century. The changes of the *Daphnia* populations in the five volcanic lakes are summarized in Table 1.

Table 1. Changes of *Daphnia* species in the lakes of Hokkaidô with some other features

Name of lake	pH of water <sup>1)</sup>		<i>Daphnia</i> <sup>2)</sup>		<i>Bosmina</i> <sup>3)</sup>		Phyto- planton After 1966
	Before 1940	After 1950	Before 1940	1966	Before 1940	1966	
Tôya-ko	7.1-7.2 (1928)	6.8 (1957) 5.2-5.4 (1966)	<i>D. h.</i> +	<i>nil</i>	<i>B. l.</i> +	<i>B. l.</i> +	almost <i>nil</i>
Shikotsu-ko	7.4-7.7 (1928)	7.0-8.0 (1960-63)	<i>D. h.</i> +	<i>D. h.</i> +	<i>B. l.</i> +	<i>B. l.</i> +	scarce
Shikaribetsu-ko	7.0 (1930)	7.3 (1966)	<i>D. e.</i> +	<i>D. e.</i> +	<i>B. c.</i> +	<i>B. c.</i> +	scarce
Kutcharo-ko	4.3-5.5 (1929)	3.6-4.0 (1957)	<i>D. e.</i> +	<i>nil</i>	<i>B. c.</i> +	?	<i>nil</i>
Akan-ko	7.0-7.5 (1927)	7.2 (1955)	<i>D. e.</i> +	<i>D. h.</i> +	<i>B. c.</i> +	<i>B. c.</i> +	bloom
Mashû-ko	7.3 (1931)	7.0 (1954)	<i>D. e.</i> +	<i>D. e.</i> +	<i>B. c.</i> +	<i>B. c.</i> +	scarce

1) Compiled from various source materials, mostly of the surface water.

2) *D. h.* - *Daphnia hyalina*; *D. e.* - *Daphnia ezoensis*.

3) *B. c.* - *Bosmina coregoni*; *B. l.* - *Bosmina longirostris*.

## 1. Acidification by mineral acids

### a) Lake Tôya-ko

According to Motoda *et al.* (1967), *Daphnia longispina* (actually *D. hyalina* in the present work) had been the dominant component of the plankton in this lake before 1960, since when it seems to have become extinct. The present writer was unable to collect any *Daphnia* in this lake in August 1957. Since 1960 *Bosmina longirostris* has rapidly increased as the dominant zooplankter in taking the place of *Daphnia hyalina* (cited by Motoda *et al.*, as *D. longispina*). A marked change of the Cladocera fauna is probably due to the rapid acidification of this lake water in the past decade by the inflow of strongly acid water from an iron-ore mine located to the southeast of the lake. Owing to its oligotrophic conditions and to its water of poor buffering

power, Lake Tôya-ko has rapidly come to be acidified in a short period of time throughout its water mass of  $8.19\text{km}^3$  in volume and 179m in depth. On October 17, 1932, the lake water was still approximately neutral in reaction, the pH values being 7.4 in the surface layer and 6.9 in the depth of 100m (Kanno 1934). The pH values of the surface water have decreased from 7.1-7.2 in 1928 to 5.2-5.4 in 1966. No *Daphnia* was determined in any layer at the latter time.

b) Lake Kutcharo-ko

It has been well-known that this large caldera lake is strongly acid throughout the bottom, in spite of its volume being as large as  $2.2\text{km}^3$  under its superficies of  $77.5\text{km}^2$ . The acidity of the lake water varies according to each different part of the lake. The zone off the mouth of an inflowing river, Sesekpets, is the most acid, fluctuating from 4.3 to 5.5 in the pH values from year to year and sometimes more than 6.0. This river, the main source of acids, receives waste water from the Kawayu hot-spring that lies 2km east of the lake, and is rich in sulphate of aluminium and iron. Its pH values were as low as 2.2(in 1929) to 2.0(in 1938) in its lower course, so that, as might be expected, appreciable quantities of aluminium could be certified to have been dissolved in the river water of the pH value less than 4.5.

A plankton material taken by Dr Miyadi in 1931 proved the presence of *Daphnia* in this lake. On his visit to this lake on August 25, 1957, twenty-five years after that time, the writer failed to collect any specimen of *Daphnia*. The lake water at that time was blue with whitish tint and very clear, the transparency by a Secchi-disc measuring 9.0m. The pH of the surface water was 3.6 at a station off the mouth of the Sesekpets River. *Daphnia* did not appear to be extant in this lake at that time.

Using a persistent culture of a pond species *Daphnia magna*, Naumann (1934) has determined that its existence may be possible in the range of pH from about  $\geq 5.0$  to  $\leq 13.0$ . A typical planktonic species like *D. ezoensis* is probably unable to survive in such mineralized water as that of Lake Kutcharo-ko having less than pH 5.5

values. Aluminium tolerance of *Daphnia* has not been established as in the case of magnesium tolerance of Daphniidae which was studied by Hutchinson(1932) on an experimental basis. It is not clearly understood, however, why *Daphnia* (cf. *ezoensis*) was able to live thirty years ago in tolerance to high ionic concentration. A sudden increase of ionic concentration, which happened at one time in the past, may possibly have had fatal effect upon the population of *D. ezoensis* in this lake.

## 2. Rapid cultural eutrophication

Takayasu *et al.* (1930) noticed in Lake Akan-ko that there was an eutrophic indication already in 1927, when the phytoplankton began to increase quantitatively to a certain extent. The number of algal species was 8-10 against 7-8 of zooplankton species, among which *Daphnia longispina hyalina* (actually *D. ezoensis* in the present work) and *Acanthodiptomus pacificus* were particularly abundant. Both species were important foods for the land-locked kokanee salmon (taken up later). The other subdominant Cladocera were *Bosmina coregoni* and *Polyphemus pediculus*. In the latter part of September 1933, when the writer's limnological survey was conducted (Uéno 1936), the plankton of this lake yet consisted chiefly of crustaceans, particularly *D. ezoensis* and *Acanthodiptomus pacificus* together with *Bosmina coregoni*. The phytoplankton developed only in a state adding an organic color to the lake water. After that time eutrophication seemed to have progressed rapidly, probably due to the result of the rapid exploitation of the surrounding area of the lake as a tourist resort. After having analysed the plankton samples obtained on October 10-16, 1941, Kurohagi and Mihara (1961) indicated that there occurred 10 species of zooplankters and as many as 50 species of phytoplankters. In a sample obtained by a vertical haul from the depth of 38m to the surface at that time, they found that *Daphnia longispina hyalina*(=*D. ezoensis*)made up 11.5% of individual numbers of the total zooplankters, followed by 7.5% of *Bosmina coregoni*. *Acanthodiptomus pacificus* markedly decreased, forming only 0.3% of the composition of the zooplankton. Among the algae, *Melosira granulata* var. *angustis-*

*sima* was the most abundant, making up more than 77% of the composition of the phytoplankton.

In August 1945 an immense population of *Anabaena flos-aquae* occurred (Hirano 1956). During the years from 1955 to 1957, Kurohagi and Osanai (1957) found in this lake 15 species of zooplankters and about 60 of minute algae. *Daphnia longispina hyalina* yet occurred together with *Bosmina coregoni*, and they were abundant particularly in early summer. The plankton material taken by Mizuno on August 22, 1957 contained only a few crustaceans and showed that *Daphnia ezoensis* had disappeared and *D. hyalina* had newly joined the plankton of Lake Akan-ko.

Owing to the rapid eutrophication, the Secchi-disc transparency that had been 9.0m on August 7, 1917, about fifty-five years ago, became decreased to 6.0-8.7 on September 5, 1935 (Uéno 1936). It was as small as 5.5m on October 22, 1955 (Kurohagi & Osanai 1957). Using the plankton samples obtained by Mr. Tokui on September 23, 1966, Dr Hirano determined only seven species, viz., *Ceratium hirundinella*, *Melosira varians*, *Asterionella formosa*, *Volvox aureus*, *Eudorina elegans*, *Staurastrum dorsidentiferum* var. *ornatum*, and a species of *Dinobryon*, among which the first-named two species were the chief components. A bloom of blue-green algae in summer had already disappeared.

The population of *Daphnia* found before 1935 is identical with *D. ezoensis*, but in 1957 there occurred two different populations together in this lake, a dwarf form of *D. ezoensis* as well as a probable hybrid between that and *D. hyalina*, the latter of which has come to replace the typical *ezoensis* since about 1966. As already stated, *D. ezoensis* is a species with a preference for clear oligotrophic lakes of neutral water, like Lake Shikaribetsu-ko, the conditions of which have remained almost unchanged for the past thirty years. In 1966 the lake yet supported the population of *D. ezoensis* which avoids an algal bloom. In Lake Akan-ko, however, the occurrence of an enormous scum of minute algae appears to have made the habitation of this species impossible. *D. hyalina* can dwell better in such a lake with



progressive eutrophication, though very few in individual numbers. The present inhabitant of Lake Akan-ko is a probable hybrid between *D. ezoensis* and *D. hyalina*. *D. longispina kyalina*, which appeared in literature as occurring in this lake, is actually *D. ezoensis*. *Daphnia longispina hyalina* forma *rectifrons* Stingelin (1895, Pl. V) which was identified by Mashiko (1935) on the basis of the 1934 material from this lake, is also *D. ezoensis* (Mashiko's *vectifrons* is probably a misprint). Similarly, *Bosmina coregoni* of Lake Akan-ko has also been replaced by *B. longirostris* to a great extent, but both species still live together in 1966, contrary to the disappearance of *D. ezoensis*.

Lake Akan-ko is well-known as the native place of a land-locked race of the kokanee salmon (*Oncorhynchus nerka*), with which more than sixty Japanese lakes in and outside of Hokkaidô have hitherto been stocked. The original Akan-ko population of this fish appears to have become extinct, and the re-stocking from some other lakes into which the Akan-ko race was formerly introduced has not been successful. On the contrary, the pond smelt (*Hypomesus olidus*) introduced into Akan-ko has become so abundant that smelt-fishing in this lake is now made possible on a commercial basis. With rapid cultural eutrophication (so-called "rasante Seeneutrophierung", Ohle 1955), Lake Akan-ko with an area 11.8km<sup>2</sup> and 36.6m deep has thus changed from a kokanee salmon lake to a pond smelt lake, due to the great decrease of zooplankters, particularly *Daphnia* and *Acanthodiaptomus*, the important foods for the kokanee.

### Summary

The following five species of *Daphnia* are given as occurring in the lakes of Hokkaidô: *D. rosea* G. O. Sars, *D. ezoensis* sp. n., *D. hyalina* Leydig, *D. galeata* G. O. Sars and *D. longispina* (O. F. Müller). The re-descriptions of these species are made in regard to their populations in Hokkaidô together with the nature of their habitat-lakes. In some of those lakes, the change of the species of *Daphnia* is noticed in the past forty years. Such changes may be due to two

kinds of processes, one being the acidification by strong acids throughout the water mass of the lakes under consideration and the other being a rapid cultural eutrophication of Lake Akan-ko.

### **Acknowledgements**

The writer is grateful to the following colleagues and friends for providing him with the plankton material collected by them from the lakes of Hokkaidô: Dr S. Inoué and Dr Teruyoshi Kawamura, both of Hokkaidô University; Dr T. Kawai of Nara Women's University; Messrs. H. Kurohagi and T. Tokui of the Hokkaidô Salmon Hatchery in Sapporo; Dr T. Mizuno of Osaka Educational University. The writer's cordial thanks are due to Mr. Tokui in particular who kindly collected the plankton at the writer's request from Lakes Shikaribetsu-ko, Akan-ko and Shikotsu-ko in Hokkaidô, as well as from Lake Numazawa-numa in Fukushima Prefecture. He also supplied the writer with much useful information. The writer's thanks are tendered likewise to Dr S. Mori, director of the Ôtsu Hydrobiological Station, for permitting the writer to examine the plankton collection deposited in that Station. Mention must be made of Dr Kawai and Mr. Y. Tetsukawa who kindly provided the writer with the plankton samples taken by them in Lake Kizaki-ko in Nagano Prefecture. For the identification of the plankton algae obtained, the writer is greatly indebted to Drs. M. Hirano and K. Negoro of Kyôto University.

## Appendix

Table 2. Morphometric data of the lakes of Hokkaidô referred to in the present work. (Compiled from Horie 1962)

Name of lake	Latitude N	Longitude E	Altitude (m)	Length (km)	Area (km <sup>2</sup> )	Maximum depth (m)	Mean depth (m)	Volume (km <sup>3</sup> )
Tôya-ko	42°36'	140°51'	83	11.0	70.0	179.2	117.0	8.19
Shikotsu-ko	42°45'	141°20'	248 (241)	12.2	76.2	363.0 (356.0)	255.9 (249.3)	19.5 (19.0)
Shikaribetsu-ko	43°17'	143°07'	797	4.5	3.5	99.0	57.1	0.2
Akan-ko	43°27'	144°06'	419	7.0	11.8	36.6	17.8	0.21
Panké-ko (Akan)	43°29'	144°11'	461	4.0	2.8	48.8	23.9	0.067
Kutcharo-ko	43°37'	144°20'	121	18.0	77.5	120.0	28.4	2.2
Mashû-ko	43°35'	144°33'	351	6.8	20.0	212.0	137.5	2.75
Tôro-ko (Kushiro)	43°09'	144°33'	8	8.0	6.53	7.0	3.1	0.02
Riya-ushi-ko	44°00'	144°11'	5	1.1	0.38	4.5	2.6	0.001

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