APPENDIX I.

THE FOSSIL SPECIES OF BOSMINA.

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IN an effort to determine the species of *Bosmina* found in Doctor Deevey's L-10 profile, and to gain some knowledge concerning the qualitative change at the 32-foot level, a study of both the microfossil and modern form was made. It was necessary to make the study of the taxonomy and ecological distribution of the modern species in order to understand more fully these ancient forms. The material available included over 100 samples, 52 of which were from Connecticut. Other localities included Wisconsin, Minnesota, New York, New Hampshire, India and Africa. The writer is grateful to both Prof. G. E. Hutchinson and Dr. E. S. Deevey for their generous help and criticism. Also, thanks are due to Prof. G. E. Hutchinson, Dr. E. S. Deevey, Dr. S. Eddy and Mr. W. T. Edmondson for permission to examine their plankton samples.

Since the first description of the genus by Baird in 1776, there have been numerous revisions of the taxonomy of the family Bosminidae (Sars). The latest account available, and the one which was followed in describing the Connecticut forms, is by Rylov (1935). On the basis of his European material, he has divided the genus, in part following Aurich (1934), into two species, *Bosmina longirostris* and *Bosmina coregoni.*

Bosmina longirostris (O. F. Muller), Rylov

B. longirostris Birge

(Plate II, Figs. 26-33.)

The small sensory hair is usually nearer to the center of the space between the eye and the base of the antenna than to the base of the latter. The mucro (ventral posterior extension of the valves) short, with a small bristle inserted at the ventral basal border. Eye mostly large.

The post-abdomen is characterized by two sets of spines on each claw. In the basal set, the three (or four) distal spines are very large, decreasing in length proximally, followed by 2-6 small spines or bristles. Each claw generally showing two flexions, one at the distal border of the large spines and one at the distal margin of the small spines.

Bosmina coregoni Baird, Rylov

incl. *B. obtusirostris* auct., Birge, and *B. longispina* auct., Birge

(Plate II, Figs. 34-38.)

The sensory hair usually near the base of the antenna. Body form very variable, dorsal margin of the carapace usually marked by a hump. The mucro of the adults much longer than in *B. longirostris*, ventrally denticulate in the early instars. Eyes medium to small.

Each post-abdominal claw with 5-6 large spines, decreasing in length proximally. The spines in the apical set are long and hair-like in contrast to the short heavy spines in *longirostris*. Generally two rows of 4-8 spinules on the body of the post-abdomen, morphologically ventral to the anus. A characteristic of the American, if not of other forms, is the depression or pit on the posterior half of the terminal claw, designated as A on Plate II, Figs. 36 and 37. This pit is clearly visible on all specimens, and it is here that the claw usually bends.

Bosmina coregoni is divided by Rylov into two groups (Reihe) of races, the *coregoni* group and the *longispina* group. These two groups have different distributions, *coregoni* not occurring in the New World. They are therefore conveniently distinguished as subspecies. Rylov's numerous trinomially

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EXPLANATION OF PLATE II.

Fig. 26. *Bosmina longirostris* (O. F. Muller), from Linsley Pond, July 10, 1941.

Fig. 27 and 28. Mucrones from *B. longirostris*, Beseck Lake, August 16, 1938. Showing extreme variations in length and shape of mucrones.

Fig. 29. Mucro from *B. longirostris*, Alton Lake, Minnesota, August 11, 1935. HCO_3—15.5 p.p.m.

Fig. 30. Mucro from *B. longirostris*, Gilstad Lake, Minnesota, August 22, 1936. HCO_3—166 p.p.m.

Fig. 31. *B. longirostris*, Pykara Dam, Nilghiri Hills, North India. November 16, 1932. Note the six large basal spines.

Fig. 32. *B. longirostris*, Beseck Lake, August 16, 1938, showing flexion of claw (a and b).

Fig. 33. B. *longirostris*, Linsley Pond, July 10, 1940.

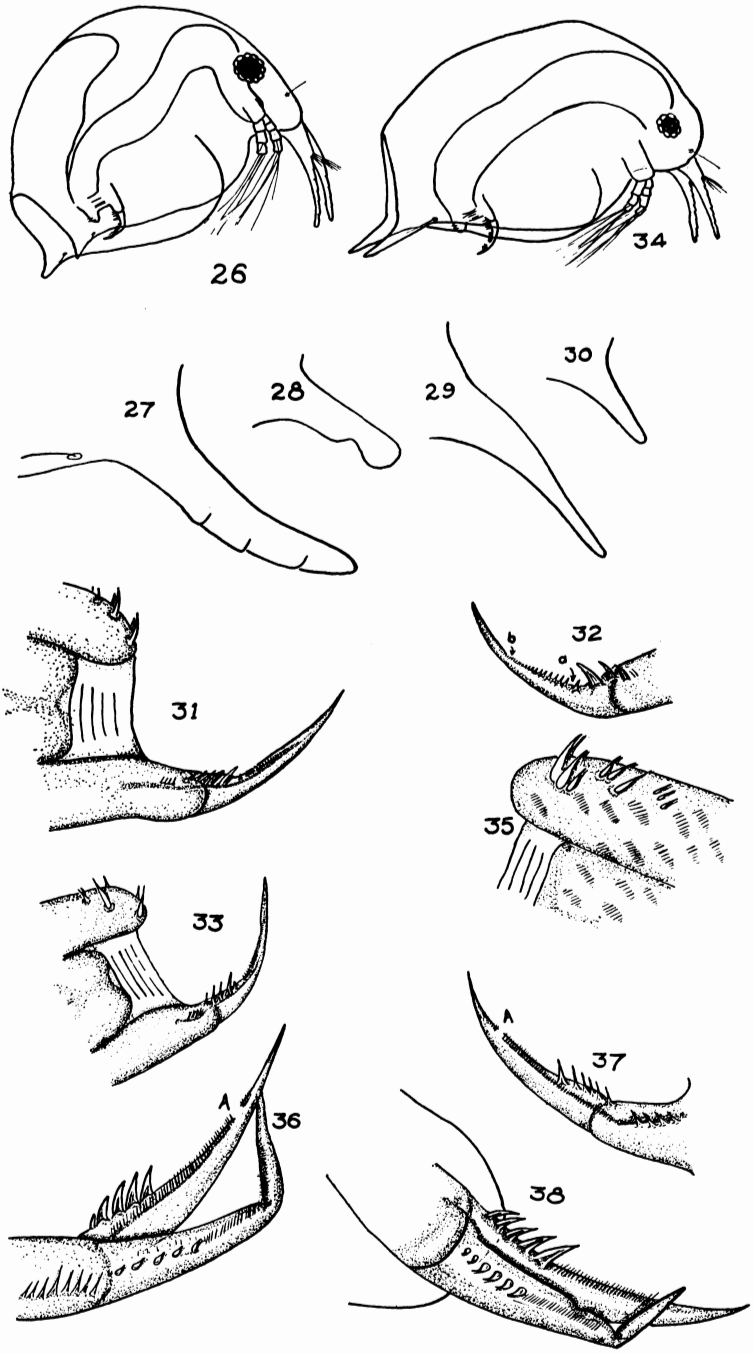
Fig. 34. *Bosmina coregoni longispina* Leydig, Lost Canoe Lake, Wisconsin.

Fig. 35. *B. coregoni longispina*, Lost Canoe Lake, Wisconsin. Dorsal part of post abdomen.

Fig. 36. *B. coregoni longispina*, Shenipsit Lake, July 20, 1939, ventral portion of post abdomen. Note pit or break at A.

Fig. 37. *B. coregoni longispina*, Lake Quassapaug, June 31, 1940.

Fig. 38. *B. coregoni longispina*, 36 feet, L-10 profile, Linsley Pond. Compare with post abdomen from modern *coregoni* form (Fig. 36).


26
34
27
28
29
30
31
32
b
a
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1
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A
37
38

separated categories are here considered *races*; some of these are known in more than one *form*. The American specimens under discussion, with a long mucro and little if any cyclomorphosis, are thus to be designated as *B. c. longispina* Leydig.

Aurich (1934), in his paper on the Bosmina of the Wallacea Expedition, describes two groups of races as belonging to *Bosmina hagmanni* Stringelin. The only reason for his separation of *hagmanni* from *coregoni* appears to be that, in young specimens, denticulation occurs on the dorsal or inner-lateral surface of the mucro of the former species, while in *coregoni* such denticulation is always ventral. Only ventral denticulation has been observed on any of the material examined in preparing this paper, and such a dichotomy appears to the author as unsatisfactory. One group of races, *B. hagmanni americana*, was collected from various localities in Wisconsin; the other, *B. hagmanni hawaiiensis*, from the Hawaiian Islands. Aurich separated the North American races from the typical Brazilian forms by their remarkably short rostrum, the insertion of the sensory hair approximately half way between the eye and the base of the first antennae, and the shape and spreading of the first antennae in the adult. The two subspecies, *B. h. americana*, and *B. h. hawaiiensis*, differ from each other only in the form of the antennae and the rostrum.

In neither Aurich's description of *hagmanni*, nor in any European account of *coregoni*, is mention made of a break or pit such as that observed in the claws of our specimens. When the claw is observed from the side, it appears as though a portion of the inner margin had been removed, and it seems remarkable that it has not been found in previous studies. It is possible, although unlikely, that the character is actually lacking in old world forms and that the American races should be referred to a separate species, to which the name *hagmanni* might be found applicable.

Determination of species from the half-carapaces found in the profile is difficult. This difficulty is further increased when one considers the variation in form represented by the microfossils. The deposition of the carapaces is such that it is impossible to separate the successive instars, and very difficult to separate the seasonal forms. It was fortunate, therefore, that at the 36-foot level in the L-10 profile well below the organic maximum and change of species, a post-abdomen was found within a carapace.

A comparison of the ancient post-abdomen with that of the modern *coregoni longispina* (Plate II, Figs. 36 and 38) illustrates the striking similarity between the two. Although the carapace is smaller in recent specimens, the general proportions of the microfossil agree with those of the modern form.

On the basis of the comparisons of the microfossils with modern specimens, the species found below the 30-foot level in the L-10 profile is therefore referable to *Bosmina coregoni longispina.* Determination of its racial position is more difficult. The somewhat swollen anterior region of the head suggests race *obtusirostris*, possibly the full designation should be *B. c. longispina* race *obtusirostris f. lacustris* (cf. Rylov Fig. 205).

Identification of the "modern" form, found above the level of maximum organic (32 feet in L-10, 18 feet in L-9), was based on the short mucro and the location of the bristle scar relatively close to the base of the first antennae (cf. Deevey Plate I, Figs. 15-17). Both of these characters compare favorably with the modern present-day Linsley form (Plate II, Fig. 26).

In his profiles for Linsley Pond, Doctor Deevey has pointed out the similarity between the curves for organic matter and the number of half-carapaces. His results show that the change in species began just before the organic maximum and reached completion at the maximum. This seems to indicate a correlation between species present and the productivity of the lake. Since the less productive lakes in general contain less bicarbonate and have a lower pH than the more productive, these variables must also be considered. When the Connecticut chlorophyll and alkalinity data, Table I, are compared with the two species found in the state, it can readily be seen that there is a closer correlation with phytoplankton than with bicarbonate, though hydrogen ion concentration may play a part.

However, such correlations do not hold with data derived from samples obtained from Minnesota through the courtesy of Doctor Eddy. The alkalinity of the Superior region of that state varies from 12 p.p.m. to 24 p.p.m., while that of the Chippewa region ranges from 112 to 162 p.p.m. As to productivity, the Chippewa region is much higher than that of the Superior. This latter region is characterized by deep,

TABLE I.

(Data from Deevey, 1940)

Lake	*Chlorophyll* mgrs. per m^3	HCO_3 mgrs. per l.	*pH*
Bosmina longirostris			
Wood Creek	8.70	42.5	..
Beseck	11.92	33.2	7.3
Linsley	12.90	62.5	7.3
Beardsley Park	6.20	21.7	7.4
Samp Mortar	11.50	20.6	6.8
Trumbull	5.90	26.6	7.6
Quonnipaug	8.92	33.1	7.6
Housatonic	5.30	148.2	..
Buena Vista	12.80	28.0	6.9
Bosmina coregoni longispina			
Bashan	2.08	16.0	5.8
Candlewood	3.87	38.6	6.9
Hall	3.49	19.3	6.3
Quassapaug	4.80	11.4	..
Shenipsit	1.10	16.0	6.3

cold, rock-basined oligotrophic lakes. The same species of *Bosmina* is found in all lakes examined from these regions. This species, *B. longirostris* (*B. longispina* of Reif 1940), was as abundant in the soft-water lakes with low productivity as in the harder, more productive Chippewa lakes. One striking difference was observed. The mucrones on the specimens from the Superior region (Plate II, Fig. 29) were much longer than those from the Chippewa (Plate II, Fig. 30). In the former, the mucro was denticulate in both mature and immature specimens. Furthermore, *longirostris* was the commonest form in N. E. Wisconsin, though the productivity is probably comparable to the Connecticut central lowlands.

Rylov, in discussing the distribution of *B. longirostris*, states, "In eutrophen Gewassern besonders stark entwickelt," while *B. c. obtusirostris f. lacustris* and *B. c. obtusirostris f. cisterciensis* are found in oligotrophic waters. His summary of the distribution of the European forms seems to be followed by those of Connecticut.

Thus, while productivity may play a part in the determination of the species present, there are many other factors whose influences are of importance.

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