A BIOLOGICAL RECONNOISSANCE OF SOME ELEVATED LAKES IN THE SIERRAS AND THE ROCKIES

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WITH REPORTS ON THE COPEPODA BY C. DWIGHT MARSH, AND ON THE CLADOCERA BY E. A. BIRGE

13

WITH TWELVE PLATES

During the early summer of 1903, I had the privilege of spending a brief time at Glen Alpine Springs, California, and directly after leaving that point of making a short stay also in the Pike's Peak region, Colorado. Both locations afforded the opportunity of making observations on groups of elevated lakes which, though brief, disclosed certain features of interest. The period of study extended from June 25 to July 15, so that one could speak with some definiteness regarding comparative conditions in the two places at the same time of year.

The work aroused generous interest on the part of some enthusiastic students of nature whom I had the good fortune to meet, and it is their cooperation both before, during and after the time I spent in the field, that has made this report possible.

So far as the Sierra lakes are concerned, I am particularly indebted to Mr. R. S. Gray for his untiring efforts in many directions, especially in the endeavor to secure for me references to all publications bearing upon the Lake Tahoe region, and for his generosity in placing at my disposal collections made in the Glen Alpine lakes in September, 1902. Mr. W. W. Price and Miss Gilmore also afforded me valuable assistance in tracing out literature on this region. For the work on the lakes of the Pike's Peak region, Dr. F. E. Clements proved an indispensable guide and assistant; the fine illustrations of these lakes are made from his photographs, which were freely placed at my disposal. Professors E. A. Birge and C. Dwight

Marsh were kind enough to take up the exact determination of the Cladocera and Copepoda; and to Dr. R. H. Wolcott I am also indebted for many favors in connection with this study.

The fragmentary character of this work, which was carried out under serious limitations as to time, apparatus, and supplies, is apparent to all. My only excuse in presenting it lies in the desire that it may be an incentive to others to take up under more favorable circumstances the study of these elevated lakes so interesting in themselves, and so important in the problems associated with them. This examination of these lakes was simply a reconnoissance; this report of it is at most an outline of the work which is to be done.

Apart from the fragmentary notes jotted down in my field book at the time, the results of my examination of the lakes are contained in a series of thirty Birge net collections, made in the Sierra lakes about July 1, 1903, and in the Pike's Peak lakes about July 13, 1903. These collections were made with great care to secure representative material from the different bodies of water. They certainly do not represent the entire limnofauna of the lakes. But they probably give a fair general idea of the fauna at that time of year. Some reasons for expecting a change later in the summer are detailed elsewhere in this paper.

To the above was added a series of forty-five vials of material collected by Mr. R. S. Gray in September, 1902. This represents to some extent the autumnal life of the waters, although the collections were not made with the purpose of securing all types of life in the lakes.

No effort was made to examine the geology of the two regions; but of both it is well known and admirably represented in the Pyramid Peak and Pike's Peak folios of the U. S. Geological Survey, which include fully the regions studied. It was also impossible in the lack of time and suitable apparatus to make any observations on the physical characters of the lakes. Even the temperature had to be estimated rather than precisely measured. Although many plant organisms were collected from the lakes in both regions, no accurate work has been done in studying them, and only general statements can be made concerning the limnoflora.

The first point to be considered is the character of the lakes studied. Between the lakes in the Sierras and those near Pike's Peak there are not inconsiderable differences which may be made clear by a description and discussion of the chief features in each group. The Sierra lakes will be considered first.

Muir (1900: 122) speaks of the "marvellous abundance of glacier lakes hidden in the fastnesses of California mountains. . . . They nestle in rocky nooks and hollows about all the high peaks and in the larger cañons, reflecting their stern and rugged beauty and giving charming animation to the bleakest and most forbidding landscapes. From the summit of Red Mountain, a day's journey to the east of Yosemite Valley, 42 may be seen within a radius of eight or ten miles. The whole number in the Sierra can hardly be less than 1,500, exclusive of the smaller gems which are innumerable. Perhaps two-thirds of them lie on the west flank of the range, and all are restricted to the alpine and subalpine regions, those which once brightened the lower regions having long since vanished by the filling in of their basins. Lake Tahoe is king of them all, not only in size, but in the surpassing beauty of its shores and waters. . . . With these comparatively unimportant exceptions, the lake itself and all its grandly sculptured, ice-scored, and moraine-streaked basins exist today in just about the condition they presented when first they came to light toward the close of the Glacial Period."

In a later publication (Muir, 1903: 98) the same author adds the following: "Though the eastern flank of the range is excessively steep, we find lakes pretty regularly distributed throughout even the most precipitous portions. They are mostly found in the upper branches of the cañons and in the glacial amphitheatres around the peaks."

The group of Sierra lakes which I studied lies on this precipitous eastern flank of the range at the southwestern corner of Lake Tahoe into which all of them ultimately drain (Plate XIX) through the medium of a smaller body of water, known as Fallen Leaf Lake. The latter is separated from Lake Tahoe by a low plain which was apparently an ancient moraine, and which is not quite two miles in width. While the lower northern end of Fallen Leaf Lake lies in the plain, the upper end is encompassed by mountains, especially on the west, where the steep flank of Mt. Tallac rises directly from the water's edge. The valley in which Glen Alpine Springs is located trends westward from this end. It is narrow, with cragged sides and little vegetation beyond that which is crowded together near the stream. The floor ascends so rapidly that the channel of the brook is little more than a succession of rapids and falls, in some cases of considerable height, with occasional pockets of a swampy nature bearing an abundant plant growth. The lakes occur as a series of larger pockets, in some of which the filling in has progressed so far as to produce a shallow, marsh-edged basin with a distinct rapidly-flowing stream through the center. Others present themselves as deep basins with rocky, often precipitous shores, and little current apart from the immediate region of inlet and outlet. The shallower lakes are also the lower in the series. I have been unable to ascertain the exact altitude of these lakes, but this factor can be calculated sufficiently exactly from the topographic charts of the U. S. Geological Survey, from which I obtained the following list of elevations above sea level: Lily Lake, 2010 m.; Grass Lake, 2194 m.; Susie Lake, 2347 m.; Heather Lake, 2377 m.; Half Moon Lake, 2500 m.; Lake Aloha, 2470 m.; Gilmore Lake, 2530 m. The figures given are probably 5 to 15 m. below the true altitude.

Inflow and outflow are large in proportion to the volume of the lakes, especially in the spring and early summer, while the snow accumulated during the winter is melting rapidly. Later in the season the volume of the streams is said to decrease markedly. The fluctuations in the level of the lakes due to this factor are, however, inconsiderable, since the outflowing streams possess very little depth. At the time of my visit the upper lakes were fed directly from melted snow (Plate XXII), and at many points on sheltered slopes great masses of snow reached into the water, while miniature icebergs floated on the surface. The temperature was accordingly low and conditions were typically glacial.

By the time the water had reached the lower levels, however, it had become much warmer and all snow and ice had disappeared from the immediate environment of the basins. The color of the stream had also acquired a distinct brown tone leached out from the forest mould through which it had filtered. It was everywhere clear and transparent, carrying a very insignificant amount of debris of all kinds whatsoever.

Lily Lake, the lowest of the series, had been filled in considerably and was surrounded by swampy areas covered with plant growth and shallow flats on which at the time of my visit the first traces of a sub-aqueous vegetation were beginning to show themselves. It was the smallest and clearly also the most decadent of all these water basins. Grass Lake was larger, much more open and of greater average depth. The upper end was apparently closed by a thicket of partly submerged alders, through which the water found its way without any proper channel that was visible. There were also banks of eel grass that covered parts of the bottom beyond the alders; but except at the upper end there was no approach to a swampy condition.

In the higher lakes the shallows, swampy areas, and water vegetation were either minimal or absent. The lakes were apparently much deeper on the average, and also larger. Furthermore, instead of possessing a single inlet, water was pouring down every rocky defile from the snow banks above and had worn only shallow channels in the debris of the mountain side, while the debouchment of these rivulets had often no trace of the formation of a delta. These lakes are young and the process of destruction had not yet begun.

The group of lakes in the Rocky Mountains which were made the object of my study, lie in the valley of Beaver Creek, about 7.5 km. (4.5 miles) south-southeast of the summit of Pike's Peak (Plate XXIII). They are known collectively as Seven Lakes and lie at an elevation of about 3,300 to 3,310 m. above sea level. The individual lakes are near together and all empty into Middle Beaver Creek. About 2 km. distant lies a small water basin near the saddle of a divide; it is without visible inlet and outlet and is called Dead Lake. Its altitude is approximately 3,340 m. above sea level. It is of small size and insignificant depth.

Among the Seven Lakes some are very shallow and surrounded by an extensive swamp margin, while others are of considerable depth. At the time of my visit the snow had entirely disappeared from the proximity of these lakes, and even from Mt. Garfield, which towers above them. The surface water was not noticeably cool to the hand and in the shallow lakes even apparently warm. Though much higher than the lakes of the Sierras, these water basins present nothing of the typical glacial conditions already described for the others.

In Dead Lake July 13, 1900, the surface temperature was 14°.4 C., the bottom 13° C. At Ribbon Lake the temperature was 14.°2 C. alike at surface and bottom. The temperature of the air varied during the day from 13°.6 to 18° C.

The amount of inflow and outflow was small comparatively and the normal fluctuations in level slight. One can see that within comparatively recent times several of these lakes have had a greater extent than at present. Within a year, however, they have been connected with the city water supply of Colorado Springs and the level in one of the largest, Mirror Lake, has been reduced so much as to lay bare the entire lake shelf. This result appears clearly in a comparison of the two illustrations (Plates XXVII and XXVIII). The changes contemplated are certain to effect notable alterations in these lakes and also in their fauna.

Viewed as a whole these lakes are old, and some of them are just about to disappear, if natural conditions persist. Very little, if any, of the rocky sides of the mountain enter into their boundaries; the shore is made of broken fragments and detritus, which have also filled the basins in great part. The lakes lie exposed to the sun and wind, not shut in by high banks, nor protected immediately by heavy forest growth. The surrounding territory has a large amount of soil and supports a vigorous growth of mountain vegetation. In most respects then these lakes stand in sharp contrast to those in the Sierras already described.

Zschokke gives (1900: 40) as the picture of a typical alpine lake the following: Water basins of more than 1,500 m. (5,000 ft.) altitude, of variable, but mostly insignificant area and very different depth. The bottom and shore show in their character manifold local differences, and the general external features vary equally. Drought and avalanches may threaten the existence of the basin. The Characeae, algae, and mosses play the chief part in the flora and the littoral plant world generally disappears rapidly with increase in altitude. The inflow is poor in nutriment, and often carries cold water exclusively or in predominant amounts, while periodic increase or decrease of the inflow often produces very important oscillations in the niveau of the lake. The inflow or outflow is often subterranean. The quiet of the surface is almost undisturbed. The water temperature, even in midsummer, is low, wintry. Little difference exists between surface and deep temperatures, between summer maxima and winter minima. The ice covering lasts long. The chemical composition of the water is very variable. In Alpine lakes the most important and most constant conditions which present themselves to the fauna are northerly, glacial. Low temperature of the medium inhabited, long continued winter with heavy covering of ice, sparse development of the flora. Copious inflow of snow water or cold water, poor in food and often unsated with oxygen, and with large amount of mineral matter in suspension. Other conditions are as in water basins of the plain. Glacial conditions control the composition of the fauna of alpine lakes and the animals of elevated lakes are still in the midst of the glacial epoch.

The general limit assumed by Zschokke (1900: 2) which confines his work to lakes having an altitude of more than 1,500 m. is recognized as more or less arbitrary, and yet it corresponds well in the region he studied to the other limitations of strictly alpine lakes. This is not only the case in Switzerland where Zschokke worked, but also in the Tátra lakes, according to Wierzejski and von Daday, in the elevated lakes of the Pyrenees, according to de Guerne and Richard, and in the French Alps and the Pyrenees, according to Delebecques.

The same conditions do not obtain on this continent. There are lakes in Colorado above the 1,500 m. line (about 5,000 ft.) which, located on elevated plateaus, have all the characteristics of flat land lakes. One must usually go higher than this limit to find water basins to which the term "alpine" may properly be applied. Apparently no such limit, even of an approximate character, can be used in this country since conditions at the same elevation evidently vary in different regions. That the limit of alpine lakes does vary my own observations in the White Mountains (New Hampshire) the Rockies (Colorado) and the Sierras (California) show me unmistakably; what may be the extent of this variation and what the approximate altitude of characteristic alpine lakes in different regions can only be determined by much more extensive observations than I have made as yet.

That latitude as well as altitude is an important factor in the comparison of elevated lakes has been recognized by Forbes. In contrasting the two largest lakes in the regions he studied he says (1893: 236): "Flathead Lake is over 200 miles [320 km.] farther northward than Yellowstone, but the latter is 4,775 feet [= 1,455m.] the higher above the level of the sea." Among others, "These differences tend largely to neutralize each other."

The Sierra Lakes visited were much more clearly glacial in their environment than those near Pike's Peak and yet they lie about 1,000

m. lower than the latter, while in latitude they are almost identical, as the line marking 38°50′ N. Lat. crosses both regions (Plates XIX and XXIII). It is clear, however, that conditions are not so constant as in the Alps and questionable whether the same relative conditions persist between the lakes of the Sierras and Rockies throughout the year. In the course of the summer the snow in the Sierras disappears (Plate XXIII), the inflow becomes scantier in amount and probably somewhat higher in temperature, while the lakes themselves, no longer under the influx of a large amount of cold water, must rise in temperature noticeably towards late summer. In the Pike's Peak region these conditions had already come, and the change towards fall would bring even higher temperature. In the Alps the persistent snow masses and ice fields keep down the temperature of the inflow.

Another noteworthy difference between the elevated lakes of this country and of Europe is found in the greater area of our own. Lake Tahoe, lying at an elevation of nearly 2,000 m. (6,225 ft.) has an area of over 50,000 ha. (193 sq. mi.), Shoshone Lake, studied by Forbes (1893) has an elevation of 2,360 m. (7,740 ft.) and an area of about 3,100 ha. (12 sq. mi.), Lewis Lake and Heart Lake, of nearly the same altitude, have from 780 to 1,300 ha. (3 to 5 sq. mi.) of area (Forbes, 1893), while Yellowstone Lake, also at an altitude of about 2,360 m. (7,740 ft.), measures 36,260 ha. (140 sq. mi.). These are by no means isolated cases, as a glance at the contour map of the U. S. Geological Survey will show. The 1,500 m. (5,000 ft.) contour line encloses many water basins of considerable area; some of these are saline, a few, as Mono and Owens lakes, California, excessively so, but others contains water of extreme freshness and purity. Mingled with these large lakes are myriads of smaller. As Russell says (1895 : 63) : "These lakes are of all sizes, from mere tarns across which one might spring with the aid of an alpenstock, to broad plains of blue, many square miles in area, and worthy of comparison with the most beautiful mountain lakes of other lands." The Sierras are peculiarly rich in such water basins. With Lake Tahoe,[1] "the gem of the Sierras," at one extreme of size, and with the tiny rock pool, or swamp-filled basin at the other, the series embraces every variety of contour and environment. Among the

[1] For a splendid description of this incomparably beautiful sheet see Russell (1895 : 63).

Rockies, however, such lakes are far less numerous, and like the Pike's Peak group already described, are for the most part well on the way to final disappearance.

The lakes in the Sierras are about of the same altitude as those studied by Zschokke in Switzerland, and at the time of this study presented the same typically glacial features. In other respects also they are in general agreement with his descriptions, save, as already noted, that the disappearance from the mountains of the snow and ice in late summer is undoubtedly accompanied by a rise in temperature and a consequent greater thermal range than is found in the lakes of the Alps.

The lakes in the Pike's Peak region of the Rockies are 800 m. higher than any in the Sierra group studied; the conditions are, however, much less distinctly glacial. In Dead Lake, the shallow water had already attained a moderate temperature (14°.2 C.) and after two months of summer sunshine would be decidedly higher in spite of the cool nights and cold rains of that elevation. Such lakes will furnish, accordingly, only transiently glacial or northern conditions during the spring and fall. And these periods will be interrupted by an interval in which the temperature conditions are nearer those of the lakes in the flat land. The summer interval will be especially marked in those water basins which are very shallow like Dead Lake, which is also dependent upon seepage for inflow and outflow, and least so in the deeper ones such as Mirror Lake. Locally the latter is said to be "bottomless"; it is certainly more than 10 to 15 m. deep at the maximum. Ribbon Lake measures about 8 m. at the deepest point, while none of the others much exceed one meter in depth and over the greater part of their area the water has a depth of only one-third that figure.

In one further particular both series of lakes studied differ notably from the lakes of the Alps; they all lie below timber line, as an examination of the plates will show distinctly. Two results of this position affect the biological character of the lakes: A considerable amount of plant debris is washed into the waters, which by its presence and gradual disintegration influences the food supply. In the second place, the living trees, as well as the dead fragments, attract additional members to the terrestrial fauna which sooner or later, and in one form or another, add to the water fauna or furnish food for the latter. The forms concerned are chiefly insects, of which a very considerable number depend upon the timber for their presence in the region. The relative importance of insect larvae in the water fauna is discussed elsewhere in this paper.

The fauna of elevated lakes has been subjected to a careful study by Zschokke, whose results have appeared in a series of papers on special regions extending through a number of years and culminating in the splendid crowned memoir of the Swiss Naturalists' Society (Zschokke, 1900). The characteristics of elevated lakes are precisely stated therein in terms which also apply, as already noted, to the lakes of the Sierras and the Rockies that were the seat of my observations. Zschokke sums up these features as follows: (1900: 377) "The truly characteristic external conditions of the alpine lakes are glacial: a low mean temperature, inflow from melting snow and ice, long continued ice covering, poverty in plant growth and fluctuations in level. The elevated water basins still stand in regard to physical and chemical relations in the midst of the glacial epoch. Hence their fauna bears a distinct glacial stamp in composition, origin, distribution, manner of life, and structure of its representatives." The description of the physical features applies to the lakes under discussion, as the description and views reproduced here will show; it remains accordingly to examine the character of the fauna.

At other places in Europe investigations have been made on the fauna of elevated lakes; they are, however, less intensive than the work of Zschokke just noted and need no special mention here. Data concerning them may be found in the full bibliography given by Zschokke (1900: 382).

The earliest study of the fauna of elevated lakes in this country was that of Forbes (1893). There are to be sure, earlier references to the fauna of our mountain lakes, but casual observations made in connection with various expeditions and surveys, or the description of a single species collected by some traveller cannot be considered a study of the lakes themselves. Isolated observations of this type are referred to both in the paper of Forbes (1893) and in those by Beardsley (1902, 1902a). Forbes investigated the lakes of the Yellowstone National Park in Wyoming and of the Flathead region of Montana, spending two seasons, 1890 and 1891, in the field. The lakes examined were many of considerably size and depth; the highest elevation from which material was collected was Mary

Lake at about 2,500 m. (8,200 ft.). The extensive collections included a number of new forms apparently characteristic of elevated lakes. Unfortunately these collections have never been described in detail. This paper contains many points of great interest and will be referred to in detail under later paragraphs.

While the records of Forbes (1893) concern the Rocky Mountain chain, they were made much further to the north than those from the Pike's Peak region. Recorded studies on forms from Colorado are rare and I have traced out but a single recent author. Beardsley (1902, 1902a) has recorded a considerable number of species from Colorado, both of Entomostraca and of Protozoa. Doubtless some of these came from lakes which are strictly alpine. All of them were taken above 1,200 m. and yet very few are in any way characteristic of elevated regions. The significance of this will be pointed out later. He also gives complete references to previous papers on these forms which contain records of their occurrence in Colorado.

So far as the group of Sierra Lakes is concerned almost the only data on the natural history of this region are given by Price (1902), in a pamphlet which embodies the results of several years personal studies by the author, and his students, on the higher animals and plants found in this territory. The birds and mammals are well treated in concise form, the fish and reptiles somewhat more briefly, and the discussion of the plants is confined to trees and shrubs. While the pamphlet does not include any immediate reference to the aquatic plants or animals, it contains much of great interest in the consideration of the general environment of the lakes.

In a brief paper (Ward, 1903) I have related some of the observations made in the series of lakes near Glen Alpine, and have pointed out the relation in which these observations stand to the planting of trout in these waters.

Some collections of Entomatraca, made in the lakes of the Sierras, by G. Eisen, were studied by Lilljeborg and reported by de Guerne and Richard (1889). The localities are given in general terms, except for *Epischura nevadensis,* which was collected in Lake Tahoe and Echo Lake; these water basins lie very near the lakes under consideration (see Plate XIX).

The fauna of the Sierra lakes was noticeably scanty in amount in all regions; neither in shore nor in open water was one able to find either plant or animal forms in considerable numbers of individuals or in variety of species. Only once in a very shallow pool by the side of the trail did I find a moderately populous water basin and even here conditions were far behind what would have been met with under similar conditions at a lower level.

The same scantiness of animal and plant life was observed in the deeper lakes in the Pike's Peak region. In the shallow water basins here, however, the fauna was distinctly richer both in species and in individuals. From bottom hauls came a rich flora of unicellular algae and a more numerous fauna than was elsewhere obtained.

The records from the lakes of the Pike's Peak region represent the greatest altitude from which the limnofauna has been reported in this country, and they also surpass any from European countries. As already pointed out mere altitude cannot be considered as determinative in comparing two elevated lakes. The most important factor here, as in the distribution of marine life, is temperature, and this is related in part to altitude, but also to other factors, the most general of which is latitude. A striking instance of this is drawn from my collection. *Holopedium gibberum* was found in the Sierras at Susie Lake, at an elevation of about 2350 m. above sea level. The greatest altitude at which it had been collected previously was Lewis Lake (Forbes, 1893), at almost exactly the same level, but in the Rocky Mountains. The same species occurs in Gotthard Lake, Switzerland (Zschokke, 1900), at 2,100 m. altitude, and in lakes of the Hohe Tátra, Bohemia, up to 1,795 m. It also occurs in mountain lakes of Norway at altitudes of less than 1,000 m., in Iceland in a shallow pond on an elevated plateau, which in any event is not very high above sea level, and finally in lakes at sea level in Greenland. More accurate and detailed consideration of the various points of occurrence from among which these instances have been taken would probably show them to be uniform in temperature conditions. The species is one which evidently prefers clear, cool water, finding this at different altitudes (or times of year?) in different latitudes.

It is not easy to find examples so distinct in their indications as the one just cited. Usually the evidence is partial; but it may be found in one form or other in the observations of many investigators of mountain lakes. I shall refer only to two instances taken from the same source. Zschokke furnishes many points illustrating this feature. One of the most striking is his statement (1900: 349) that the lakes of the Bohemian forest, investigated by Frič and Vávra, contain a typical alpine fauna, although they lie at an altitude of scarcely 1,000 m. above sea level. Zschokke also gives (1900: 350) an extensive table of the maximum altitude reached by some sixty species in the lake of the Rhätikon, St. Gotthard, St. Bernard, and Upper Engadine regions of the Alps. This furnishes unmistakable evidence of the presence of a species at greater altitudes in the region of more favorable temperature conditions. Zschokke emphasizes the important feature that the fauna varies greatly from point to point both quantitatively and qualitatively by virtue of the general variation in external conditions. But all in all when both European and American lakes are compared, latitude and temperature, which go hand in hand, constitute that factor, the effect of which is most evident.

Certain notes regarding particular groups or individual species of the lake fauna call for special record here. The material could not be examined on the spot; consequently little definite information was obtained regarding the Protozoa and Rotifera which were present.

The paucity of records concerning Branchipoda from alpine lakes has been commented upon by Zschokke (1900: 188) who could find in all hardly half a dozen notices of their occurrence in such water basins of all lands. Their presence and relative abundance in the waters of Colorado are already well known through the work of Packard (1883). Beardsley (1902) has added five species to the faunal list of the state. The largest organism I found in Dead Lake was a branchipod which was present in considerable numbers. This form was *Branchinecta coloradensis* Packard which was originally collected at about 3,800 m. altitude near Grays Peak, Colorado. It is closely related to *B. paludosa* (Müller) which occurs in northern Scandinavia and Greenland. Packard (1883: 339), says of this form, " They thus live under almost exactly the same meteorological conditions as *B. paludosa* in northern Labrador and Greenland, the temperature near the snow line on Colorado in August being about the same as that of northern Laborador and Greenland in August." Dead Lake is the lowest point in Colorado at which the species has been taken.

The twenty species of Cladocera I obtained extend the range of the species into a territory from which the group has not been reported hitherto. The vertical distribution of these forms has also been greatly increased. This is of course true of the American species heretofore known only from the flat land of the eastern or central states, but is equally the case with the cosmopolitan species like *Chydorus sphaericus,* collected in the Rockies about 700 m. above any previous record. European species of an alpine character, such as *Daphnia longispina* occurred here at an altitude equally greater than heretofore recorded. Such occurrences conform to the differences in the character of the American and European regions, which have been discussed in full in the earlier part of the paper. More striking is the presence of some forms, *Bosmina longirostris, Eurycercus lamellatus, Polyphemus pediculus,* in the Sierras at altitudes from 500 to 700 m. higher than Zschokke (1900: 156) has found them in the Alps, although conditions in the two regions, as already noted, are closely similar.

In the distribution of species in the two groups of lakes it was noteworthy that the new form described by Professor Birge, *Macrothrix montana,* occurred both in the Sierras and in the Rockies, and that *Diaphanosoma leuchtenbergianum,* heretofore known only from a single elevated lake, Lewis Lake in the Yellowstone region of the Rockies (Forbes, 1893), was collected from an almost identical altitude in the Sierras. This form has not been reported in Europe from any elevated water basin.

The Copepoda were present in almost every collection I made, although the number of species is small in comparison with the Cladocera. *Diaptomus signicauda* is a small form, viewed as one of the most peculiar of American species and reported hitherto only once from collections made in the Sierra Nevada mountains, California, at an elevation of 2,400 to 3,000 m. (8,000 to 10,000 ft.) above sea level. Its occurrence in the Sierra collections is natural, although the localities represented here lie on the eastern flank of the range, while it was probably collected before on the western slope. It was taken here at a slightly lower elevation than previously reported. Exceedingly interesting is the closely allied new species described by Professor Marsh (p. 147) which occurred only in the Rocky Mountain lakes.

Diaptomus shoshone "has never been found outside of Yellowstone Park" (Forbes, E. B.). The abundant occurrence of this conspicuous species in the lakes of the Pike's Peak region extends its range considerably along the chain of the Rockies; and also its vertical distribution which now includes 2,300 m. (Yellowstone

Park) to 3,300 m. (Pike's Peak region). Extended observations are necessary to determine how much of this may be due to the factor of latitude discussed above. This form may be regarded as a characteristic alpine species in the Rocky Mountains.

Epischura lacustris, a common species in the deeper, clearer lakes of the northern United States, was noted by Forbes specifically as wanting in collections from Yellowstone Park, while in the Flathead River system, Montana, it was apparently replaced by another number of the same genus, *E. nevadensis.* Forbes was inclined to attribute the absence of the common *E. lacustris* to the altitude; and yet the observations made in the Sierras show that this can hardly be the correct view, for this species occurred in collections made in September, 1902, from at least four of the lakes. Furthermore, these included Lake Gilmore, the most elevated of the entire series (2,530 m.). This record extends notably the vertical range of this species, and also of the entire genus. Regarding the latter point, Forbes says (1893: 254), "The absence of all representatives of this genus from the lakes of Yellowstone Park evidently adapted to them, hints strongly at a limit of altitude to their distribution. The highest locality from which any species has been reported is Lake Tahoe, said to be 6,250 feet above the sea; while the lowest lake of suitable size in Yellowstone Park from which our collections were made, was 1,200 feet higher than this." This topographical difference does not measure the biological difference, however, as the lower location is also more than five degrees south of the Yellowstone lakes. As the elevation of Lake Gilmore, the highest record of this species, made in this study, is nearly two hundred meters above the Yellowstone lakes, it is evident that the question of altitude merely is not decisive. The query raised in Forbes' concluding sentence falls under the problem of the influence of latitude upon the vertical distribution of the fauna, and serves to emphasize still further points already discussed in this paper.

The absence of *Epischura nevadensis* from these collections is especially noteworthy, since it was originally collected from Lake Tahoe and Echo Lake in the immediate vicinity and connected with the same water system as the lakes examined.

Among the Cyclopidae collected, *C. serrulatus* and *C. albidus* should be regarded, according to Forbes, as very common mountain forms, and are the only species reported from Crater Lake, Oregon (Forbes, E. B., 1897: 62); this lake is 1,902 m. above the sea.

One peculiar feature which was recorded several times in my field notes, seems to be definitely related to altitude. Says Zschokke (1900: 130), "an extremely striking characteristic of the diaptomids of alpine lakes lies in their brilliant red coloring." This brilliancy of coloring does occur among the diaptomids of lower elevations, and varies much in the same species from point to point; yet it is far more general and more striking among the alpine forms. The red color occurs in other groups, of which Zschokke names hydra, the Cyclopidae, many Turbellaria, some Annelida, and at least one rotifer. Apparently the color is transmitted secondarily to the other forms along with the Copepoda used as food. This view is supported by the fact that hydrae when starved bleach out. Low temperature clearly favors the development of this coloring matter.

Forbes (1893) published the first records on the abundant occurrence in elevated lakes of several red species: *Diaptomus shoshone,* of which the adults of both sexes are blood red throughout except the egg sac of the female which was purple; *Diaptomus lintoni,* and a brick red hydra (p. 222). All of these finds were in the Snake river system, at an altitude of approximately 2,277 m. above sea level.

Such a red color has also been noted in alpine lake forms by Elrod and Ricker (1902). Hydra taken in Echo Lake, Montana, was conspicuous by reason of the bright coral red coloring and a reddish *Daphnia* is abundant in the same water. The authors fed such red hydrae five weeks on colorless entomostraca but in contrast with the results obtained by Zschokke, observed no noticeable dimming of the color. One of the most striking features noted in the Sierra collecting was the presence of similarly colored Entomostraca. The extreme case occurred in Gilmore Lake when apparently the entire haul was made up of a copepod[1] so deeply colored red as to stand out with great distinctness in the water. The latter was at the time ice cold and although the surface was free from ice, the snow banks lay near the margin on all sides. Lake Gilmore is the most elevated of all those visited, being about 2,530 m. above the sea.

In an earlier paper Elrod (1901: 76–78) reported *Diaptomus ashlandi* in McDonald Lake as "conspicuous on account of its red

[1] This form does not appear in the list by Professor Marsh. It was recorded in my field notes as a large brilliant red copepod and I recall its appearance distinctly, but the vial of specimens has disappeared.

color." *Daphnia pulex* from Daphnia Pond (elevation 914 m.) was " so abundant that the water appeared of a dirty red color."

The majority of my collections from both regions contained Ostracoda, but the species were not determined. Zschokke did not find the members of this group in water basins higher than 2,500 m.; in the Pike Peak region they are present 840 m. higher than that level. In algae from the Seven Lakes *Macrobiotus* sp. was also found.

The worms were poorly represented in the collections. A few Oligochaeta were taken both in the Sierras from a temporary pool near Susie Lake, and from Lake of the Rocks and Dead Lake in the Rockies. Numbers of an immature *Planaria* were also present in a bottom haul from the latter place.

The number of hydrachnids collected was not large but rather widely distributed. One form of *Notaspis* was collected from a small pond near Susie Lake at Glen Alpine and from Lake of Rocks near Pike's Peak. From the former young of *Atax crassipes* were also taken and from the latter an *Acercus; Limnesia* and *Curvipes* occur in the September, 1902, collections from the lakes of the Sierras, and one specimen of *Lebertia* was found in the collection I made from Dead Lake at Pike's Peak. The records of these forms from lakes in the Rockies conform to the records of the other groups in being the highest (3,300 m.) yet made for these species, and probably represent the greatest altitude at which water-mites have ever been collected. Undoubtedly more extensive collecting would have added to this element of the fauna.

Thysanura and *Thrips* were observed in both localities, though no more precise determination of the forms was attempted.

Among mollusks *Pleurocera* and *Pisidium* were observed in the Pike's Peak lakes, while *Sphaerium* was obtained in Susie Lake, Glen Alpine Springs.

Insect larvae were relatively abundant in all the collections and in fact appeared to form the predominating element in the fauna. There were larvae of several Hemiptera, Diptera (*Culex, Simulium?*) and Coleoptera, in the collections from the shallower of the Seven Lakes and also from the temporary pools in the Sierra region. From the deeper lakes in the Sierras I collected only Chironomid larvae which were present in nine hauls out of ten, being the most conspicuous organism taken. These were also present in about half the hauls made in the Rockies.

Not only were insect larvae abundant in the pools of the Sierra region, but adult forms were seen in the air and on the vegetation about the water. The air was relatively much warmer than the water so that terrestrial and aerial forms had developed in advance of the limnofauna. It seemed as if the mature insects had pushed their way up from lower altitudes into this region by the aerial route and were taking advantage of the first appearance of suitable water basins which afforded a place to deposit their eggs. Thus the insect fauna was developing in advance of the other elements. Of the larger aquatic forms we saw nothing beyond the insect larvae save that in a single haul were two large Amphipoda.

Two observations contributed evidence in favor of the view just stated. I had the opportunity of examining the stomach contents of a female mallard duck which was shot on one of the lakes, and preserved for the U. S. National Museum. The duck was well nourished and the stomach well filled with food; but there were none of the various small crustacea which usually constitute a very large part of the food of these birds. Not a single part was found which even doubtfully could be referred to such forms; almost the entire mass of stomach contents was composed of mature insects, among which were a few insect larvae. Substantially the same was true of the stomach contents of the trout which were caught during the same time.

I was unable to ascertain what was the original condition of these lakes in the Sierras as to fish fauna. The precipitous character of the outlets, and the limited volume of the outflow, together with the landlocked character of the system which does not reach the ocean, but terminates in saline lakes on the desert, all make it probable that they were entirely without fish in the early days. The impassable character of these outlets in some instances at least may be judged from the photograph of Grass Lake (Plate XXI) where in the midbackground appears the outlet of one of the higher lakes spreading like a film of gauze over the face of a precipitous cliff.

Within recent years, however, numerous plants of trout fry have been made in the lakes with varying degrees of success. The trout caught in different lakes varied much in robustness; from some they were plump and well nourished, from others they were evidently starved, presenting a gaunt, cadaverous appearance, which the fishermen described as "all head and tail." Evidently such had obtained scant nourishment through the winter and had had no opportunity to improve their condition as yet since they came from the highest lakes which were indeed only partly free of their ice covering. The fish which came from the lower lakes were taking the fly eagerly and were voracious after larvae and mature insects, as evinced by the contents of the stomach. If their winter fare had been as limited as that of the others, they had recouped their fortunes on a spring diet of insects which, commensurate with the earlier opening of their basins, came much in advanced of the disappearance of ice from the higher lakes.

In view of these facts one may ask whether the normal winter fauna of these lakes is not scanty for the support of fish life, so poor in fact as to set a distinct limit to the number of fish which may be planted under present circumstances. The limitation will be more apparent in the higher lakes, both on account of the poorer fauna and of the longer closed period, than in the lower basins.

It is also suggested from the foregoing data that the question of food supply for the trout in this region is largely an entomological one, at least at the period in which these observations were made. Of course more extended study is necessary before these conclusions are finally accepted, but the uniform testimony of all data obtained cannot but be suggestive. There has certainly been some modification of the aquatic fauna due to the introduction of the trout, and it may yet be possible to determine this in a broad way by the examination of virgin waters in the vicinity. Such exist and their study would yield data of great value on the question connected with the future of the fish. But these problems as well as those which concern the adaptation of the trout to a new environment that compels some modification of the usual habits of the species, lie really beyond the scope of this paper and must be passed by here.

The biological problems which suggest themselves in the Rockies are of a very different type. Trout have been seen in Mirror Lake and salamanders occur in both Mirror and Ribbon lakes. But on the whole the lakes are unfitted to support a fish population. Their relation to the city water system of Colorado Springs indicates not only irregular changes in level which may be extreme at certain times, but also modifications of shore and immediate environment which will have a pronounced effect on the water fauna. Frič and Vávra (1897) have called attention to the entire destruction of one element in the fauna of a mountain lake by a considerable change in level alone.

The immediate surroundings are sure to be modified also. Within recent years the quality of the water supply has suffered greatly from the caterpillars on the aspen trees along the banks of the mountain streams. These larvae became at times so abundant and dropped into the water in such numbers that the destruction of the aspen trees near the bank was ordered and has been carried out in great part. In connection with the use of the basins for water storage the shores will be cleaned up, and the shore fauna largely annihilated. The bottom will also be freed of all debris and ultimately the process will leave only that part of the original fauna which was not dependent upon either shore or bottom, namely, the true limnetic forms.

Report on the Copepoda by C. Dwight Marsh

Species of Copepoda Found

Diaptomus signicauda Lilljeborg.
Diaptomus shoshone Forbes.
Diaptomus nudus sp. nov.
Epischura lacustris Forbes.
Cyclops viridis var. *americanus* Marsh.
Cyclops albidus Jurine.
Cyclops serrulatus Fischer.

In regard to the occurrence of the species of *Cyclops* there is nothing of any especial interest. The species are of world-wide distribution, and would be found anywhere under similar circumstances. I have listed *Cyclops americanus* as a variety of *viridis* This is not yet proven but I think it is a fact which the recent paper of Miss Lehmann (Lehmann, '03) goes far to prove. The variety *americanus* seems to be the common form in these collections rather than *brevispinosus*.

Epischura lacustris was found in four of the lakes, *viz.*, Lake of the Woods, Strawberry Lake, Grass Lake, and Gilmore Lake.

Diaptomus signicauda occurred in four of the localities, Lake of the Woods, Susie Lake, and in a pond in Glen Alpine.

Diaptomus shoshone and *D. nudus* occurred only in the lakes on Pike's Peak. *D. nudus* appeared in Lake of Rocks, Mirror

Lake, Dead Lake, and Lake Michigan. *D. shoshone* was in the same list with the exception of Lake Michigan.

D. nudus is closely allied to *D. signicauda* which was first reported from California, and probably is widely distributed over the mountain regions of the western part of the United States.

DIAPTOMUS SHOSHONE Forbes. (Plate XXX, fig. 3; Plate XXXI, figs. 1–3.)

This beautiful species is very striking because of its size and color. It is the largest described American species except *D. stagnalis* Forbes. It is highly colored in blues and reds. The cephalothorax is of a deep blue while the antennae, maxillipeds, and abdomen are red. The species was described by Forbes from material found in Shoshone Lake, and it also occurred in other lakes and ponds in the vicinity of Yellowstone Park. In the Ward collection it appeared in the material from Dead Lake, Mirror Lake, and Lake of Rocks, all being in the Pike's Peak region.

As this species was figured only in connection with Forbes's original description and the later description of Schacht from Forbes's material, it has seemed wise to add diagnostic figures to this report. The description of Forbes was very complete and it seems necessary here only to add some things of minor importance. I did not find the female abdomen asymmetrical, and in this my observations agree with those of Schacht. The branches of the furca are setose on both the inner and outer margins and the furcal setae are unusually long. In my specimens the endopodite of the female fifth foot is indistinctly divided into two segments. I also find the endopodite of the left fifth foot of the male two-segmented. In size the specimens agree very closely with the figures given by Forbes.

DIAPTOMUS NUDUS sp. nov. (Plate XXIX, Figs. 1, 2, 4 and 5.)

This species is of moderate size. The first cephalothoracic segment is nearly equal in length to the rest of the cephalothorax. The last cephalothoracic segment is armed laterally with two minute spines. The first abdominal segment of the female is somewhat longer than the rest of the abdomen. It is dilated laterally and armed upon each side with a sharp spine. These spines are at about the termination of the first third of the segment. The distal margin of the segment is extended on the right side in a conical process which extends beyond the second segment. The second segment is very short, and is nearly covered by the first. The third segment is about one-third the length of the first, and somewhat shorter than the furca.

The antennae reach slightly beyond the end of the furca. The right antennae of the male is swollen anterior to the geniculating joint. The antepenultimate segment bears upon its distal extremity a hook-like process which is rather less than half the length of the penultimate segment. In the female fifth foot, the spine of the first basal segment is very pronounced. The second basal segment is armed with the customary delicate hair. The first segment of the exopodite is stout. The second segment is of the usual form, and with the usual armature of the inner margin. The third segment is not distinct, and is represented by two short spines. The endopodite equals in length the first segment of the exopodite, and is armed at the tip with two spines and with short hairs.

In the male fifth foot, the spines of the first basal segment are very pronounced. The second basal segment of the exopodite is trapezoidal in form, and its length exceeds its average width by about one-half. The lateral hair is at about one-fourth its length from the distal end. The first segment of the exopodite is about as broad as long, and has its distal external angle somewhat produced. The second segment of the exopodite is elongate, being more than three times the length of the first. The lateral spine is situated at about one-third the distance from the proximal end, is hook-shaped, and is inserted at an angle with the plane of the segment, that is, it does not lie in the same plane with the flat surface of the segment. The terminal hook is elongate, falciform, with a regular curvature. The endopodite is short, rather shorter than the first segment of the exopodite, and is somewhat triangular in from. The second basal segment of the left foot is similar in form to the corresponding segment of the right foot and is about one-half as long. The lateral hair is situated well towards the distal end. The first segment of the exopodite about equals the basal segment in length, but is more slender. The second segment is short, armed with a terminal pad, a pad on its inner face, and with two blunt spines near its distal end. The pads are armed with short stiff hairs. The endopodite is very slender and very nearly equals in length the two segments of the exopodite.

Average length of the male, 1.115 mm. Average length of the female, 1.132 mm. Locality, Dead Lake, Pike's Peak, associated with *D. magnus;* also Lake Michigan, Lake of Rocks, and Mirror

Lake. It was especially abundant in the collections from Lake Michigan.

This species resembles *D. signicauda* in the process on the posterior border of the first abdominal segment of the female. It differs in so many points, however, that there seems to be no question of its specific difference. The fifth foot of the female and the antennal appendage of the male are as in *signicauda.* The proportions of the female abdomen are quite different. The second abdominal segment in *nudus* is nearly covered while in *signicauda* it is nearly as long as broad. The general proportions of the fifth foot of the male are the same in both species. The first segment of the right exopodite in *signicauda* bears a prominent hyaline lamella on its inner margin, which is entirely lacking in *nudus.* It is on account of this peculiarity that the name is proposed. The lateral spine of the second segment of the right exopodite is nearer the distal end in *signicauda,* while in *nudus* it is nearer the proximal end, is very strongly curved, and does not lie in the same plane with the segment.

Report on the Cladocera by E. A. Birge

The Cladocera in this collection are comparatively few in number and almost all of the species are the common widespread forms, such as would be expected if any representatives of the group were secured. Not only are the species few in number but ordinarily there are but few individuals of each species. *Daphnia, Eurycercus,* and *Chydorus* are ordinarily abundant when present at all, but there are only scanty representatives of the other species. I have, therefore, given a list of the species only, together with the description of one form of *Macrothrix,* which apparently represents a new species.

Diaphanosoma leuchtenbergianum S. Fischer.

In the name of this species I follow Lilljeborg, Cladocera Sueciae.

Glen Alpine, pond near Susie Lake.

Holopedium gibberum Zaddach.

Glen Alpine, Susie Lake.

Daphnia pulex (De Geer).

A large semi-transparent form of this species was found, in numbers, from Dead Lake, Pike's Peak.

Daphnia longispina O. F. Müller.

Some specimens of this species resembled the variety *cavifrons;* others were typical.

Glen Alpine, Lily Lake (male and female), pond near Susie Lake (July 1), Susie Lake (July 1); Pike's Peak, Ribbon Lake, Mirror Lake.

Scapholeberis mucronata (O. F. Müller).

Glen Alpine, Lily Lake.

Simocephalus serrulatus (Koch).

Glen Alpine, Lily Lake; Pike's Peak, Lake of Rocks.

Ceriodaphnia reticulata (Jurine).

Glen Alpine, Grass Lake, Lake of the Woods.

Ceriodaphnia pulchella G. O. Sars.

Glen Alpine, Susie Lake; Pike's Peak, Lake Michigan.

Bosmina longirostris (O. F. Müller) P. E. Müller.

A very few specimens were somewhat doubtfully referred to this species.

Pond near Grass Lake.

Macrothrix montana, sp. nov.

Length 0.45–0.55 mm.; height 0.23–0.27 mm. The general form is oval or round (Pl. XXV, fig. 2). The shell is thin and transparent. Its ventral edge and the post-abdomen are often much overgrown by algae and *Vorticella*. The dorsum of the head is evenly rounded to the junction of head and body, where there is a deep indentation. The shell of the head projects backward and overlies this depression in two or three collar-like folds. No trace of spine or tooth has been found on this ridge; thus differing from *M. odontocephala* Daday. No fornix was seen, but as all the specimens are somewhat swollen by the preservative, such a structure may be present. The carapace is nearly round. The arched dorsal margin meets the ventral edge in a shorply marked posterior angle. The usual spines are found on the ventral margin. The antero-ventral angle is produced into a rounded lobe. The surface of the carapace is marked by very faint hexagonal meshes.

The macula nigra is about one-half the diameter of the eye. It is situated near the point of the restrum and is nearly quadrangular in outline. The eye is of moderate size, not very deeply pigmented. The antennule is large and stout, with a sense hair near the base and about six rows of hairs on the anterior face and three posterior rows. The terminal sense hairs are of the regular *Macrothrix* type; two of them being much longer than the others. The antennule in this species, unlike that of *M. odontocephala,* shows no trace of being twojointed. The antenna shows no marked peculiarities or departure from the ordinary type. The stoutest seta has a length of over 0.3 mm.

The post-abdomen is bilobed (Pl. XXV, fig. 3). The terminal lobe bears several teeth of small size and scattered hairs. The terminal claws are very small, not much larger than the other spines in this part of the post-abdomen. The larger anterior lobe is semi-elliptical in outline and bears 15 to 18 rows of fine hairs. The setae are about 0.35 mm. long, sparsely plumose. Very few specimens afford a good view of the structure of the post-abdomen, as it is usually much overgrown with algae, etc.

This species belongs to the group represented by the forms described by Daday as *M. odontocephala* and *M. bicornis;* being nearer to the former species. From this it differs in the absence of the spine, which gives the name to the species, in the shape of the ventral margin of the head, and in the minute size of the terminal claws.

Susie Lake; Lake Michigan, and Lake of Rocks.

Eurycercus lamellatus (O. F. Müller).

Glen Alpine, Grass Lake, Susie Lake, Small Lake (July 1).

Camptocercus rectirostris.

Grass Lake.

Acroperus harpae Baird.

Grass Lake, Lake of the Woods, Strawberry Lake.

Alona affinis Leydig.

Glen Alpine, Grass Lake, pond near Susie Lake (July 1); Pike's Peak, Lake Michigan, Mirror Lake.

Alona guttata (G. O. Sars).

Glen Alpine, Grass Lake, pond near Susie Lake.

Graptoleberis testudinaria (S. Fischer).

Grass Lake.

Alonella excisa (Fischer).

Lake of the Woods, Strawberry Lake.

Pleuroxus procurvatus Birge.

Pike's Peak, Lake Michigan.

Chydorus sphaericus (O. F. Müller).

Glen Alpine, Grass Lake, pond near Grass Lake, Lily Lake, Susie Lake, pond near Susie Lake (July 1), Small Lake (July 1), pond near Half Moon Lake (cast shells), Lake of the Woods, Strawberry Lake.

Polyphemus pediculus (Linné).

Glen Alpine, Susie Lake, pond near Susie Lake (July 1).

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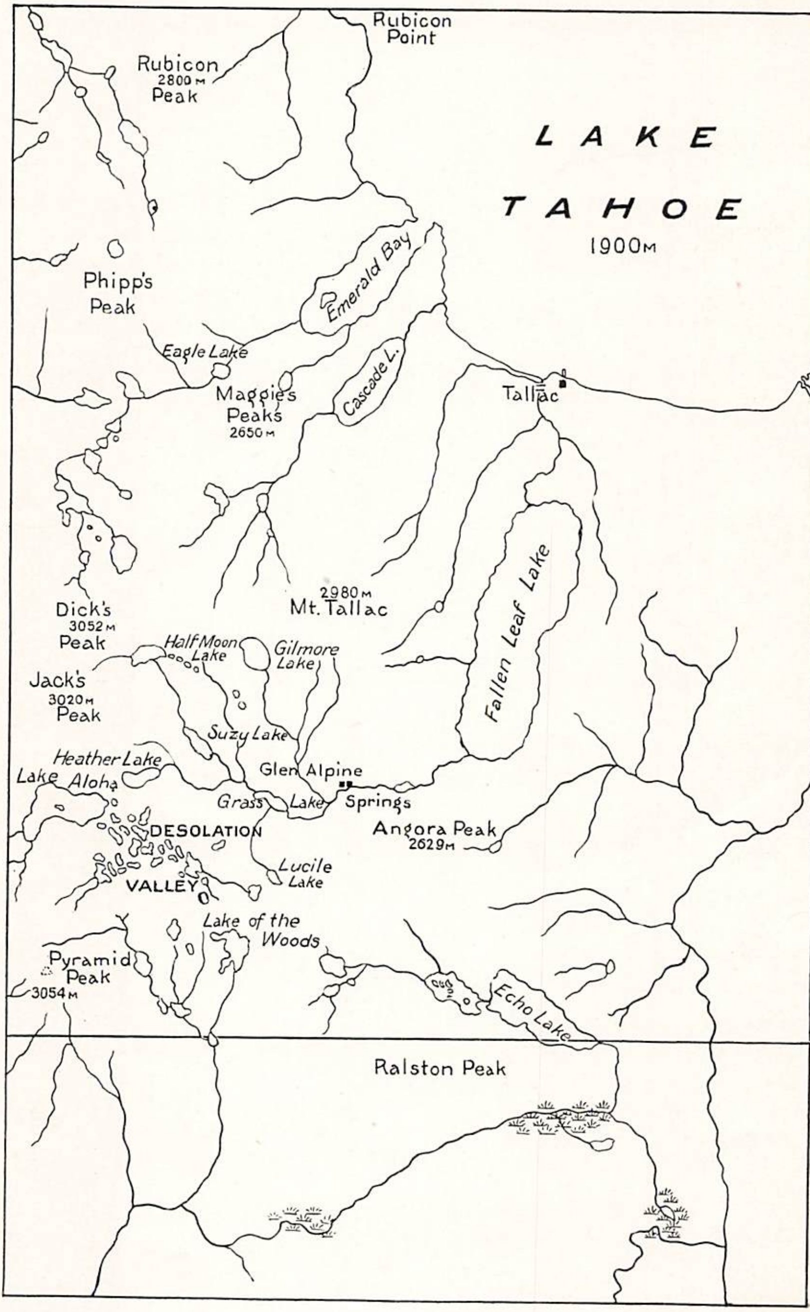
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Rubicon 2800M Peak
LAKE TAHOE
1900M
Emerald Bay
Phipp's Peak
Eagle Lake
Maggie's Peaks 2650M
Cascade L.
Tallac
Fallen Leaf Lake
2980M Mt. Tallac
Dick's 3052M Peak
Half Moon Lake
Gilmore Lake
Jack's 3020M Peak
Suzy Lake
Heather Lake
Lake Aloha
Glen Alpine Springs
Grass Lake
DESOLATION VALLEY
Angora Peak 2629M
Lucile Lake
Lake of the Woods
Pyramid Peak 3054M
Echo Lake
Ralston Peak

PLATE XX

PLATE XXI

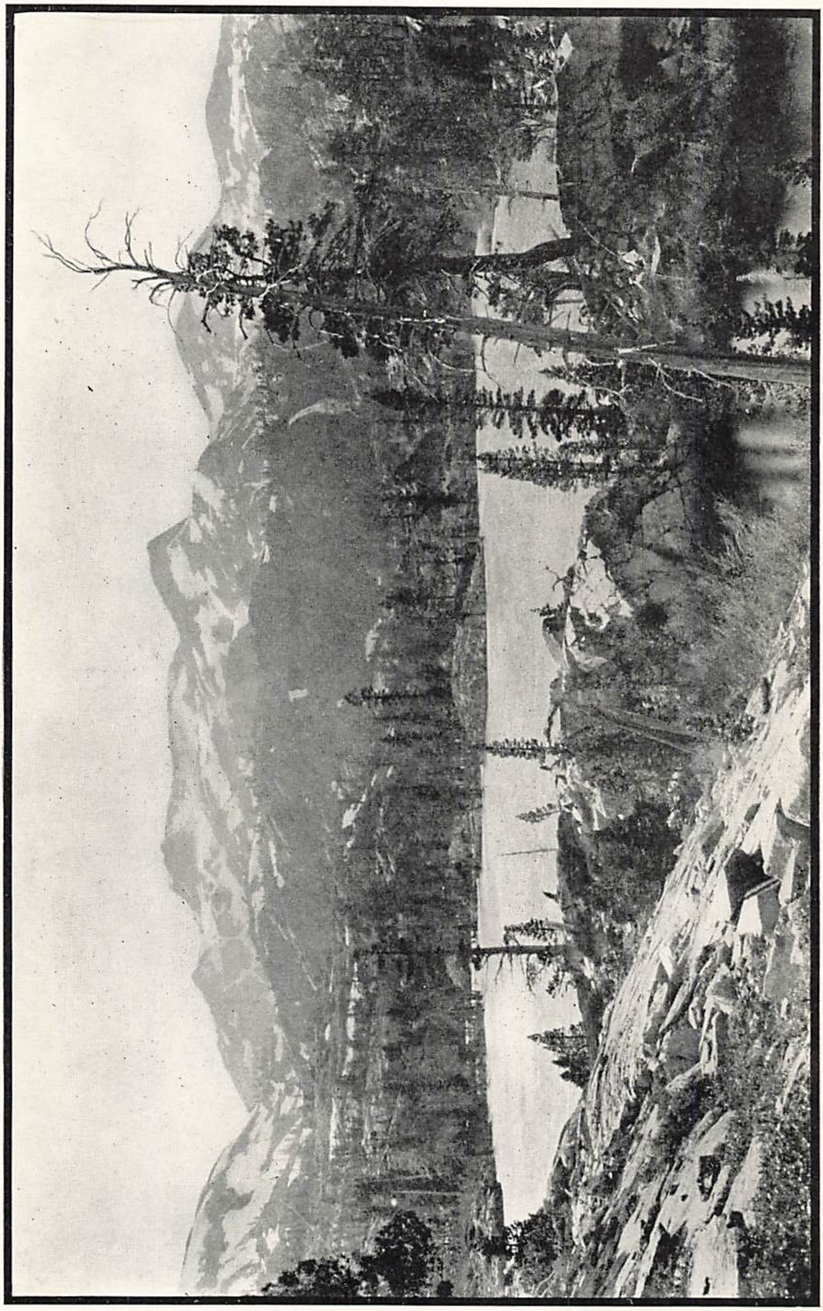

PLATE XXII

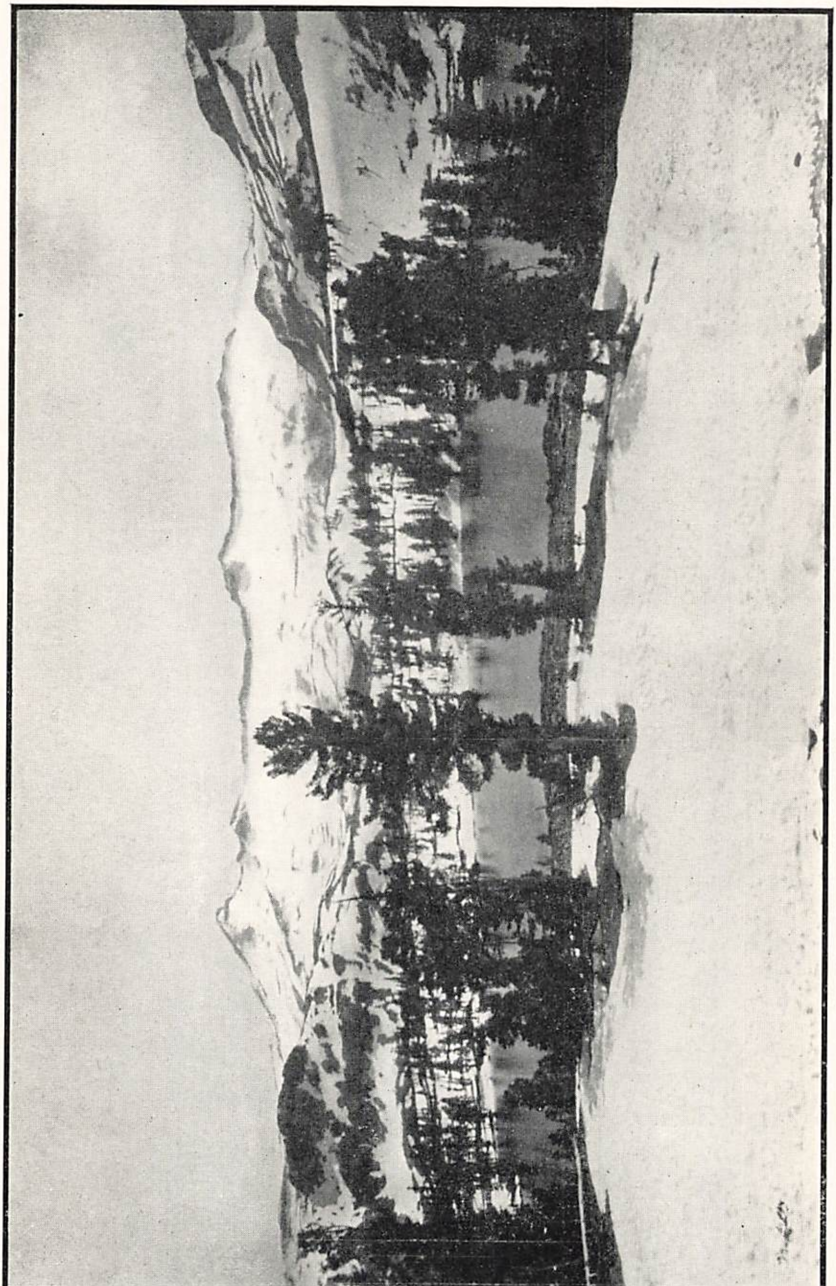

PLATE XXIII

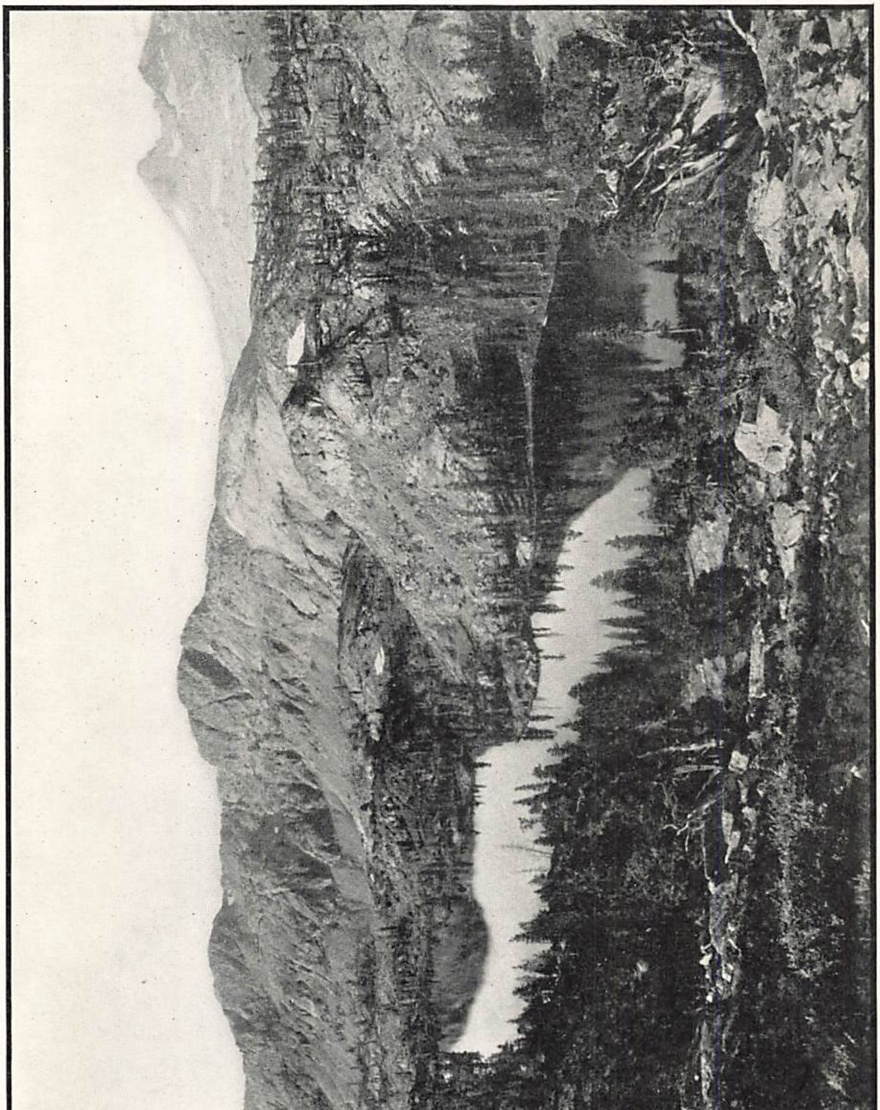

PLATE XXIV.

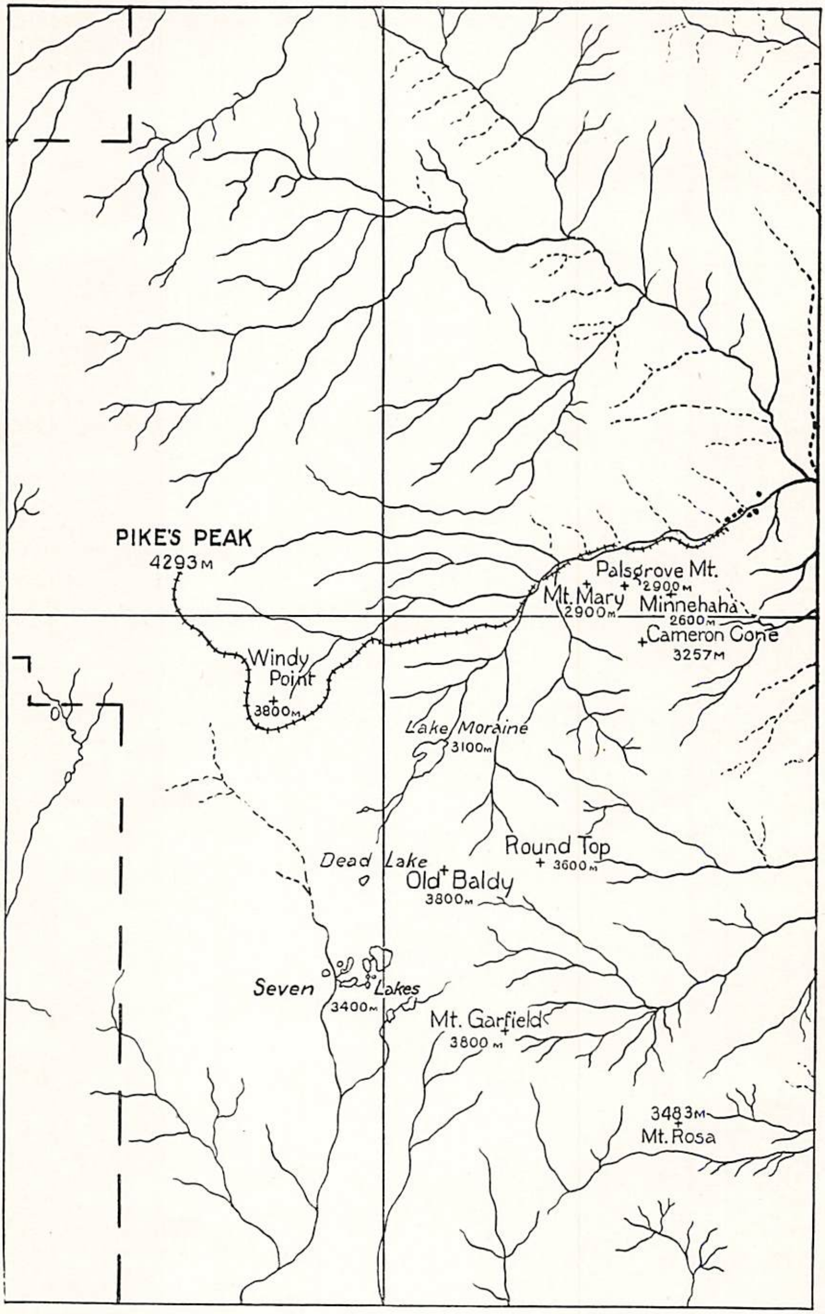
PIKE'S PEAK
4293M
Windy
Point
3800M
Palsgrove Mt.
2900M
Mt. Mary
2900M
Minnehaha
2600M
Cameron Cone
3257M
Lake Moraine
3100M
Round Top
3600M
Dead Lake
Old Baldy
3800M
Seven Lakes
3400M
Mt. Garfield
3800M
3483M
Mt. Rosa

PLATE XXV

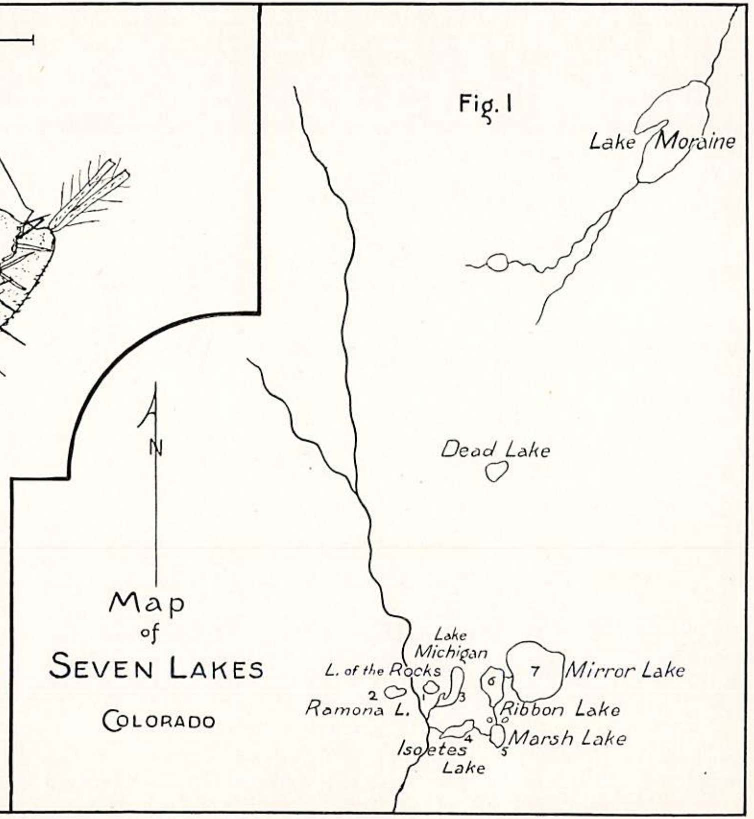

Fig. 1

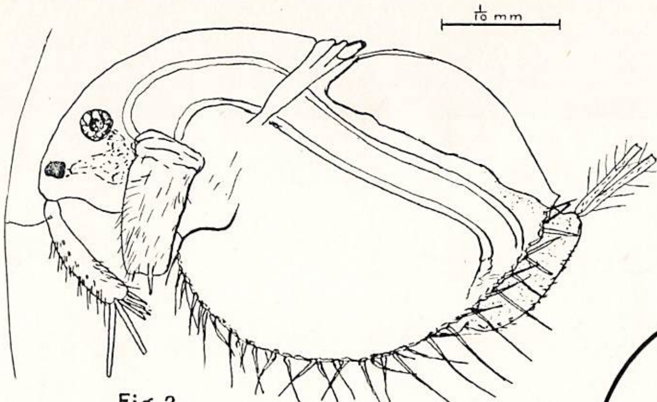

Fig. 2

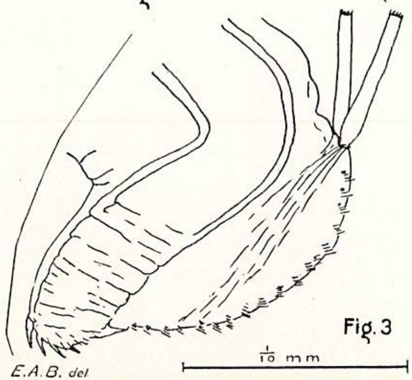

Fig. 3

E.A.B. del.

EXPLANATION OF PLATES

Plate XIX

Sketch map of lakes near Glen Alpine Springs, California, after topographic map of the U. S. Geological Survey, Pyramid Peak sheet, with minor alterations after Mr. W. W. Price. The upper northeast corner of the map is exactly 39° N. Lat. and 120° W. Long. The map is just 10′ of longitude wide, while the line crossing it near the bottom marks 38° 50′ N. L.

Plate XX

The upper view is Eagle Lake, the lower Cascade Lake. Both show the forest growth of the region, the precipitous lake shores and the well protected surface.

Plate XXI

Grass Lake and surroundings. The rocky shore, scanty soil and vegetation, and lack of beach appear at various points.

Plate XXII

Gilmore Lake in early summer. The snow was only a little less extensive on my visit to this lake July 1, 1903.

Plate XXIII

Susie Lake, in late summer. The snow on the mountains has almost disappeared.

Plate XXIV

Sketch map of Pike's Peak region, Colorado, after topographic maps of the U. S. Geological Survey, Pike's Peak and Colorado Springs sheets, with minor alterations after Dr. F. E. Clements. The lines which cross near the center of the map mark 105° W. Long. and 38° 50′ N. Lat.

Plate XXV

Fig. 1. Enlarged plat of territory immediately around Seven Lakes (*Cf.* Plate XXIII).

Fig. 2. *Macrothrix montana* n. sp. See page 150.

Fig. 3. *Macrothrix montana* n. sp., postabdomen.

Plate XXVI

Valley of Seven Lakes from Mt. Garfield. The view is NNW with Pike's Peak at extreme right. 1, Lake of Rocks; 2, Ramona Lake; 3, Lake Michigan; 4, Isoetes Lake; 5, Marsh Lake; 6, Ribbon Lake; 7, Mirror Lake. Photographed by Dr. F. E. Clements in 1899.

Plate XXVII

Ribbon and Mirror lakes from the north. Mt. Garfield in the background. Photographed by Dr. F. E. Clements in 1899.

Plate XXVIII

West shore of Mirror Lake with Garfield range in background, showing reduction in water level in a single year. Compare Plate XXVI. Photographed in 1903 by Dr. F. E. Clements.

Plate XXIX

Dead Lake from the north with Old Baldy in background. Photographed in 1899 by Dr. F. E. Clements.

Plate XXX

Fig. 1. *Diaptomus nudus*—abdomen of female × 165.

Fig. 2. *Diaptomus nudus*—fifth feet of male × 165.

Fig. 3. *Diaptomus shoshone*—terminal segments of right antenna of male × 165.

Fig. 4. *Diaptomus nudus*—penultimate and antepenultimate segments of right antenna of male × 290.

Fig. 5. *Diaptomus nudus*—fifth foot of female × 290.

Plate XXXI

Fig. 1. *Diaptomus shoshone*—abdomen of female × 76.

Fig. 2. *Diaptomus shoshone*—fifth foot of female × 165.

Fig. 3. *Diaptomus shoshone*—fifth foot of male × 76.

PLATE XXVI

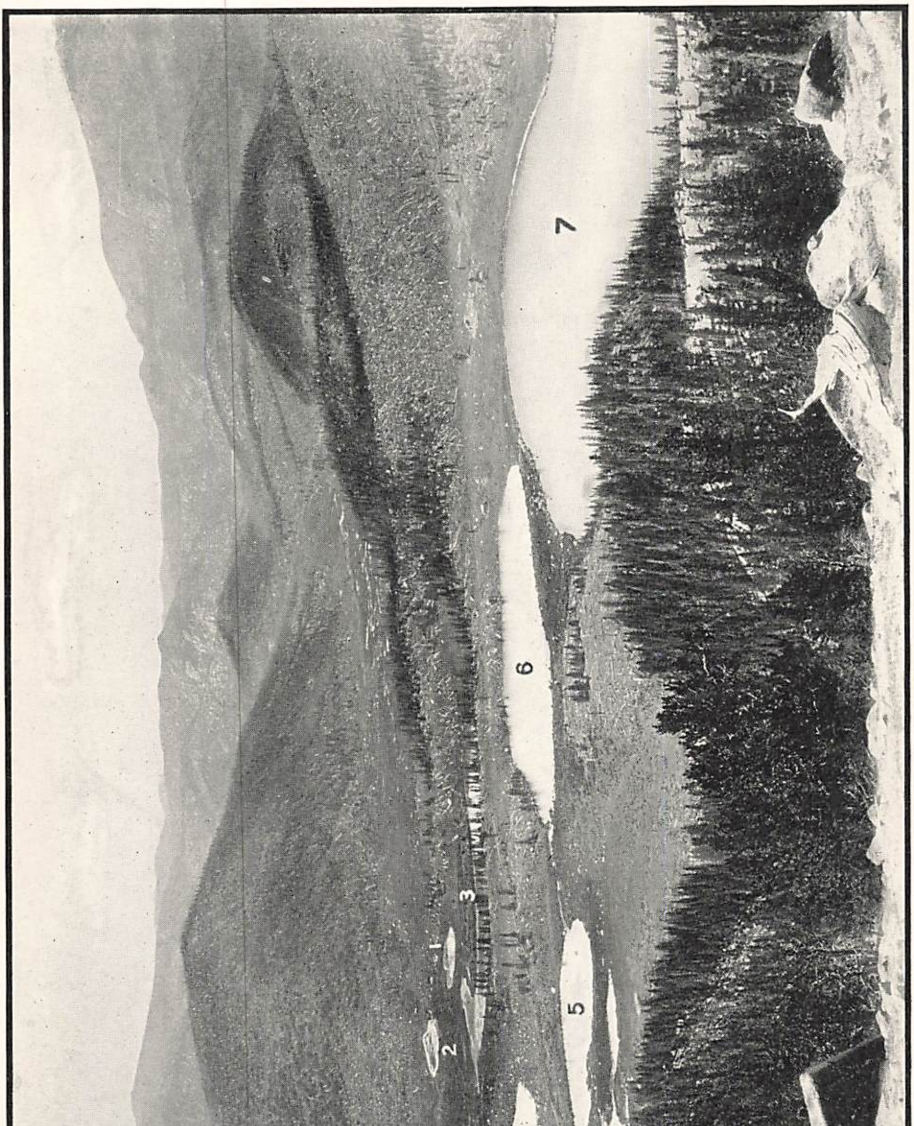

PLATE XXVII

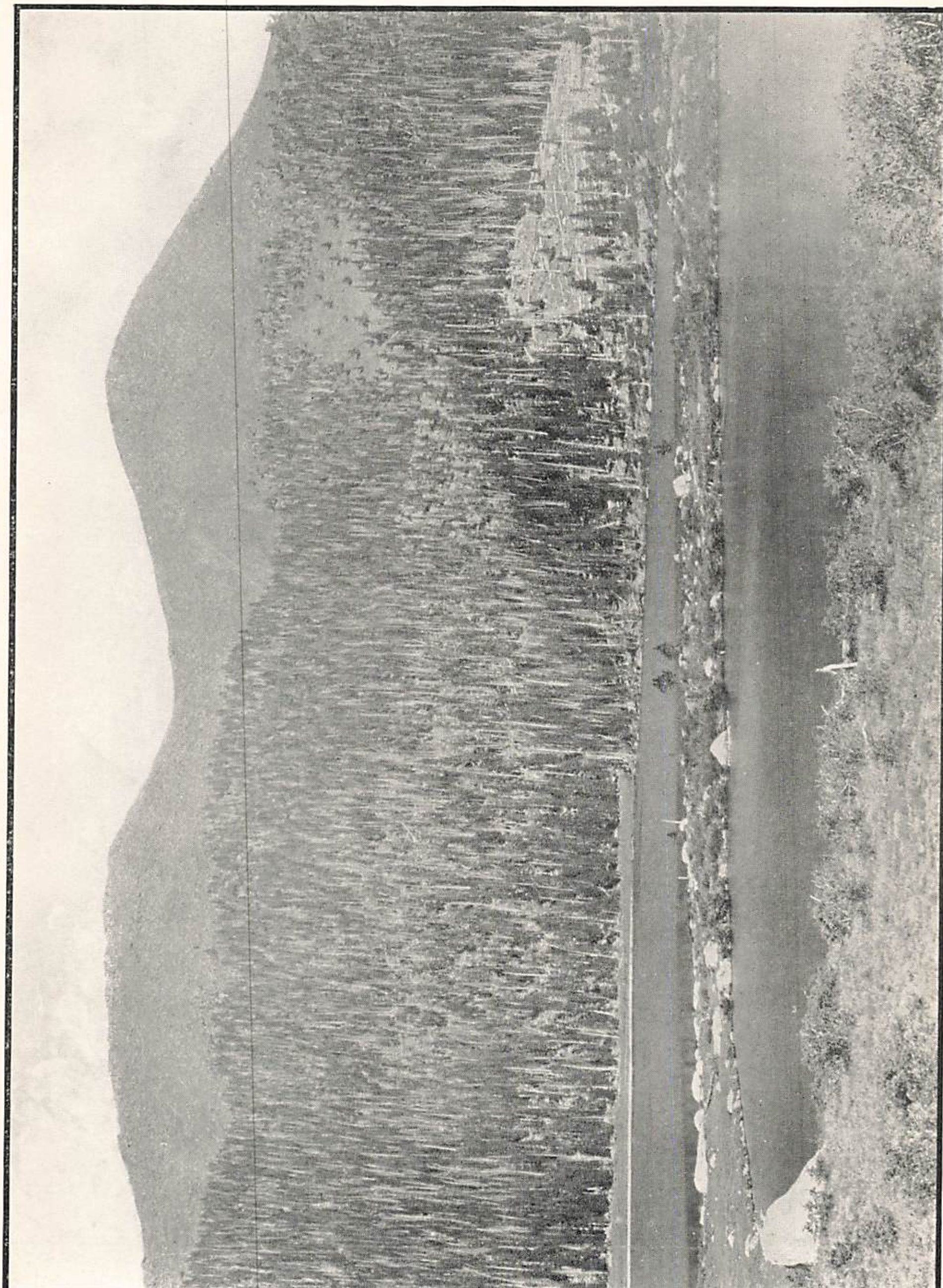

PLATE XXVIII

PLATE XXIX

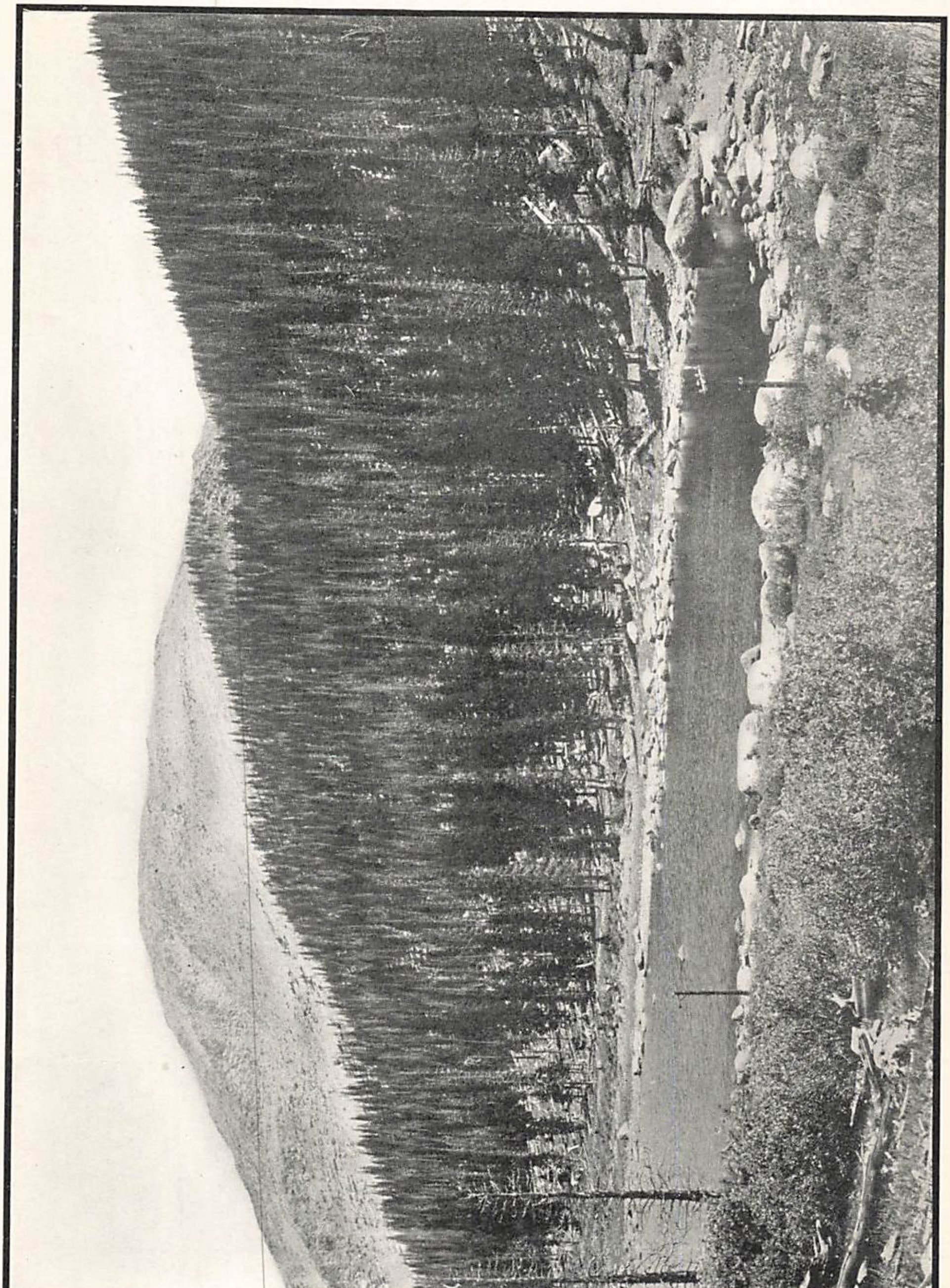

PLATE XXX

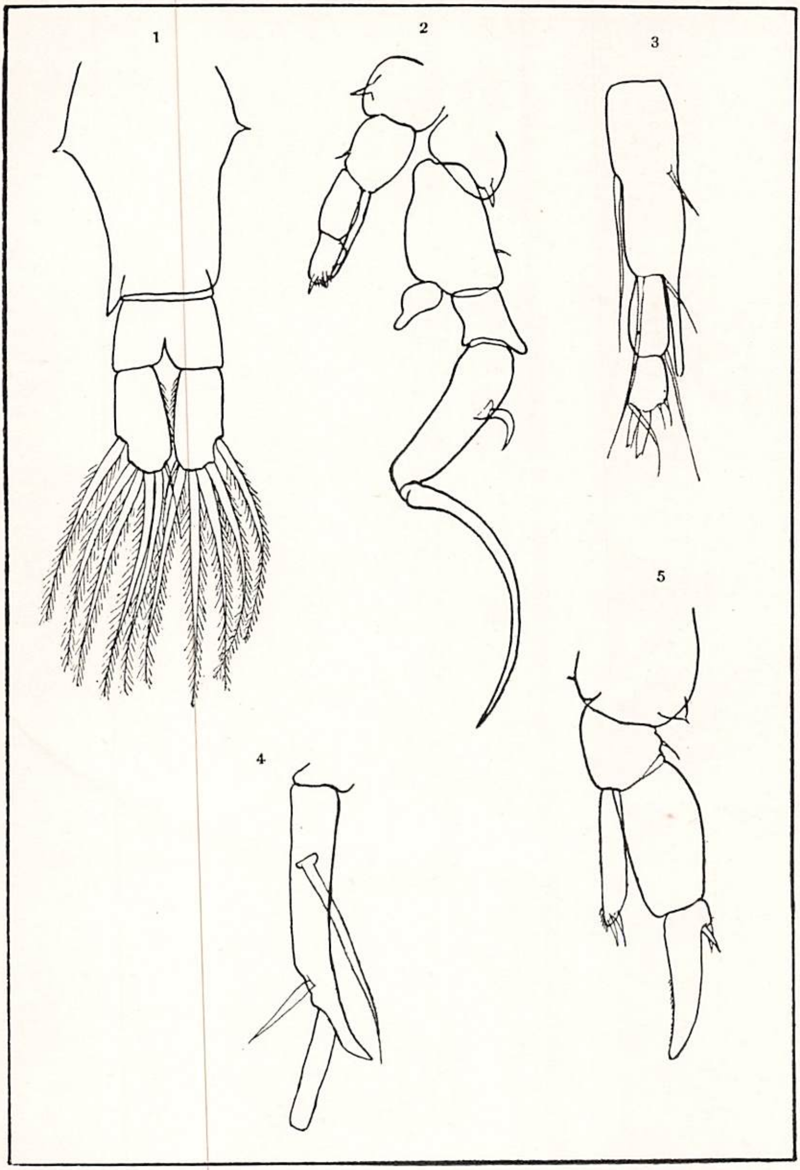

PLATE XXXI