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Hydrobiological Outline of the Mongolian Lakes[1]

Abstract

The waters of Mongolia can be classified according to their catchment areas into three hydrogeographic regions: basin of the Arctic Ocean, basin of the Pacific Ocean, Central Asian basin without outlet. After a short historical survey of the exploration of the lakes of the Mongolian People's Republic, the formation and the classification of the lake system is briefly dealt with. Recent hydrobiological findings are presented in addition to hydrological data. As far as possible, statements are made on the size and the depth of the waters, the growth of macrophytes and the trophic level of the lakes. A distinction is made between ultraoligotrophic, oligotrophic, mesotrophic, eutrophic and dystrophic waters. They are characterized by data on the biomass of the plankton and the ichthyofauna. In the zooplankton of the Central Asian basin, 17 copepod, 29 cladoceran and 58 rotatorian species, and in the waters belonging to the drainage basin of the Pacific Ocean 16 copepod, 40 cladoceran and 37 rotatorian species have already been identified.

The results represent the basis for an intensification of fishery in the Mongolian People's Republic.

Contents

[1] This version of the paper was prepared in close cooperation with Dr. MICHAEL STUBBE, ROSWITHA GOLLING and ECKHARDT GRIMM, Sektion Biowissenschaften, Martin-Luther-Universität Halle, within the treaty of amity between the Martin-Luther-Universität and the State University Ulan-Bator.

1. Introduction

This preliminary work summarizes the research carried out to evaluate the most important lakes of the Mongolian People's Republic in terms of their hydrobiological resources. The author made a special effort to review numerous reports on these lakes, published both by Mongolian and by foreign hydrobiologists, ichthyologists, limnologists and geographers through the first half of this century.

The chief results of this study are the elucidation of the biological structure in the lakes, an evaluation of its regularity throughout the territory of Mongolia, and the classification of the lakes into various types based on a complex of factors. Such information is indispensible as the scientific basis for the development of the aquatic resources to provide drinking and domestic water and for the most economical management of the fishery.

2. Historical Outline of the Studies on the Lakes in the M.P.R.

Investigations of the Mongolian lakes fall into three periods. The first includes the end of the 19th and beginning of the 20th century.

The lake fauna was studied chiefly by Russian scientists on research expeditions. The second significant event was the establishment of the Mongolian Commission of the U.S.S.R. in 1925. To this group the task was assigned of organizing and carrying out research expeditions in the M.P.R., and extending professional help to the Committee of Sciences in the M.P.R.

The third period of research on Mongolian Lakes began in the 1960s, when the focus of the research changed to local investigations and experimental projects. In 1959–60, a joint expedition of the M.P.R. National University and the University of Irkutsk started its work on Lake Hövsgöl, one of the deepest lakes in the country. This expedition provided the very first estimate of the lake's potential for fishery and reported the first quantitative information about its plankton (Kožov *et al.*, 1965).

The investigation of the waters in the Darhatsk Basin, also under the leadership of Prof. M. M. Kožov, brought the research on the Mongolian lakes into a new stage (Dulma 1964, 1967).

The range of scientific research on the Mongolian lakes was greatly increased by the founding of the Institute for Geography and Earth Science in 1962 and the Institute for Biology of the Mongolian Academy of Sciences in 1965. Since 1961, the expeditions of the Mongolian Academy of Sciences have been so organized, that the most important Mongolian lakes were investigated several times. The studies touched on questions of lake classification, the structure and quantity of phyto- and zooplankton, and to some extent the benthic community.

Some of the limnological findings were reported in the monograph "Lakes of Mongolia" by ZERENSODNOM (1970).

The ecology and biology of useful fishes in Lakes Buyr, Terhiyn Tsagaan, Ugiy (ZEND-AJUSH 1967, 1969) and the lakes of the Darhatsk Basin (DULMA, 1967; DULMA & BASANŽAV, 1972) were investigated. Changes in the fishery laws of the M.P.R. have been proposed to provide for reasonable regulation of fishing activities. A specialized study on the biology of the West Mongolian fish species, *Thymallus brevirostris*, from the Dzavhan River in Western Mongolia by TUGARINA & DASHDORŽ (1972) is available.

The parasites of Mongolian fishes were studied by the author in collaboration with the parasitological Institute of the Czechoslovakian Academy of Sciences. In recent years, PRONIN (1972) has been involved in research on the fishes of Lake Hövsgöl.

A steady flow of communication among scientists of Mongolia and several other Socialist countries has developed as a result of many joint comprehensive scientific investigations. An example of this is the outcome of the M.P.R.-GDR Expeditions carried out since 1962. Numerous papers were published containing important reports about the insect and vertebrate fauna of the Mongolian waters, for example PIECHOCKI (1967; 1968), PIECHOCKI & BOLOD (1972), STUBBE & CHOTOLCHU (1968), STUBBE & BOLOD (1971), PIECHOCKI, STUBBE, UHLENHAUT & DAWAA (1977), among others.

3. Natural Conditions in the Mongolian People's Republic and their Influence on the Hydrobiological Characteristics of the Lakes

The Mongolian People's Republic, located in the center of the Asian Continent, occupies a land area of over 1.5 million square kilometers. The entire region in which Mongolia is located is mountainous and is geographically a transition area from the Siberian taiga to the dry steppes and deserts of Central Asia. The average elevation of Mongolia is 1580 m MSL (above mean sea level), while individual peaks reach to between 4000 and 6000 m MSL. The lowest valley is 532 m MSL. These condition produce a specific series of landscapes. The arrangement of the taiga, steppe, and desert zones produce unique topographical characteristics and influence Mongolia's water system.

For the most part, Mongolia's terrestrial fauna is composed of elements from two Palaearctic sub-regions, the Northern and the Asian Mountain Palaearctic. In the Western Territory of the M.P.R., there are relatively few Chinese faunal elements. Several Mediterranean elements penetrate into this conglomeration of Arctic, European-Siberian, Tibetan, and endemic Mongolian fauna.

The birds, represented by 376 species, and the mammals, by 133, are especially numerous, but relatively few amphibians (8) and reptiles (19) are included in the fauna, showing the diversity of the faunal elements to be related to the geophysical conditions such as the elevation levels (ZEVEGMID, STUBBE & DAVAA, 1974). The dryness and continental climate are the chief causes for the low number of amphibian and reptile species.

The climate of the M.P.R. is continental and dry, with a considerable water deficit. In comparison to that of neighboring lands at the same latitude, the climate of Mongolia shows several peculiarities.

The special topographic features and climate of Mongolia exercise a large and multifaceted influence on its lake resource characteristics. The warming of the water commences rapidly after the thaw, and the temperature reaches 19–27 °C between late July and early August, with temperatures in lakes of the Gobi reaching as high as 30 °C. Between the end of October and mid-November, the lake water temperatures fall to 0 °C. In the warm periods, most lakes in the Mongolian region are characterized by both horizontal and vertical variations of considerable magnitude. Temperature differences for shallow lakes are 0.5 to 4 °C. Most lakes freeze at the beginning of November, but the lakes of the Gobi remain unfrozen until the end of December. The ice thickness in the high mountain lakes reaches 2.5 m, at the middle elevations 1.2 to 1.8 m, and in the Gobi lakes 50 to 80 cm. In the high mountain lakes the water transparency is 5 to 24 m, while in the Gobi lakes it is only 1 to 2.5 m. In winter, the oxygen concentration is between 90% and 100% saturation. Periods of low oxygen content were almost never observed. The total mineral content of the water fluctuates from 125 mg/l to 7.63 g/l, and even as high as 19 g/l. The great variability of these factors substantially influences the hydrobiological parameters and special characteristics of the fauna.

4. Origin and Classification of the Mongolian Lake Systems

4.1. The History of the Lake Systems and their Fauna

Extensive palaeontological and geological investigations carried out during recent years in Central Asia, especially in Mongolia, have made it possible to review the fundamental palaeogeography of the Mongolian lakes and their fauna.

The territory of the M.P.R. passed through a protracted cycle of continental development and terrain uplift, which took place mainly in the Mesozoic Era. During this period, several rearrangements of the surface topography, a change in climate, the conversion of the water bodies from flowing to standing waters, took place.

In the second half of the Mesozoic, a humid climate spread over the Mongolian territory. A moderately warm climate developed, as evidenced by the richness and character of the vegetation and the animal life. At this time the foundations of the Mongolian lakes, particularly those in the east and southeast, were laid down. The results of the U.S.S.R. Academy of Sciences palaeontological expedition confirmed that in the upper Cretaceous Period, large water systems with long sandy beaches existed, on the shores of which lived gigantic reptiles, dinosaurs, primitive mammals and invertebrates (MALEYEV, 1955; MARTINSON, 1968). Numerous fossils of molluscs with feathery gills were found in the deeper layers of the lower Cretaceous deposits in the Gobi valleys, in lakes of northwestern and southwestern China, in Central Asia, in isolated spots on the Japanese Islands and the central part of Laos. These give evidence of a giant contiguous water system, that extended from the Pacific Ocean across Manchuria, into the part of Mongolia bordering the Gobi, and on into Central Asia.

The lake system of the lower Cretaceous, which covered an especially great area in Mongolia, widened to the north as a continuous belt. One of these lake systems stretched from the districts of Northwestern Mongolia across the Gusino Udinsk Basin in the area of the recent Yeravnensk Lakes (SPIRKIN, 1970; KOŽOV, 1972). Another system, that still exists today, spread across the Tunginsk and Tarbagataisk Valleys of the western Transbaikal area and on into the Kishinsk Valley and beyond, as far as the Vitimsk Lake area. The lake area of Southeastern Mongolia stretched to the Transbaikal area bordered by the Ingodi, Kuengi and Shilki Rivers.

These shallow waters had a direct hydrogarphic connection with the neighboring Altai and Hangayn Basins. They were fed by numerous rivers and formed inner basins of the type found at the recent Aral and Caspian Seas.

At the end of the Cretaceous, the great basin of Central Asia broke up, as MARTINSON (1955) and other authors reported. Less extensive and more isolated water bodies formed.

Mountain building at the end of the Pliocene and beginning of the Pleistocene shaped the modern topography. The mighty Altai, Hentiyn and Hangayn Mountain Ranges folded and shaped, modifying the hydrographical network to a major degree, changing the climate, and acting as the chief determining factor for the present landscape of the lake regions.

The manifestations of the alterations in the hydrographic network include the rearrangement of the drainage area boundaries, the displacement of lakes, and the increase in their depths. During this period, rivers lost contact with the lakes into which they had once emptied. Many rivers of western and eastern Mongolia changed their courses and took up new directions. The Dzavhan is today a great river of the Hangayn Mountain region, which feeds the water bodies of the Valley of the Great Lakes together with other rivers, including the Baydrag, the Tuyn Gol, and the Tatsain Gol. These rivers drain the southern slope of the Hangayn Range. It is apparent that the Dzavhan once flowed south into the Gobi Lake Basin (SINITZIN, 1962; 1965). The change in course brought about the sinking of the water level in one of the deepest Gobi lakes, the Böön Tsagaan (ZEGMID, 1955). Several lakes, such as Hüngüyn Har, Telmen, Oygon, Sangiyn Dalay, and Ulagshni Har, are today among the mountain lakes of the Hangayn Range, but in the past they were apparently connected by the River Tes directly with the lakes in the Valley of the Great Lakes, explaining the similarity of the fish fauna in these two areas. Comparatively recently, the river, Halhin Gol, began to empty into Lake Buyr in Eastern Mongolia. Earlier it had flowed through the Tamsagbulag Valley and contributed some of its water directly to Lake Dalai (Dalai Nor or Hu-lun Ch'ih, P. R. China), then bypassed Lake Buyr, the water level of which sank so low that a wide sandy beach was uncovered.

The Altai, Hangayn, and Hentiyn Mountain Ranges, against which humid air masses are forced to rise, cause an accentuation of the Continental features of Mongolia's climate. Tectonic manifestations are especially prominent in the region of Lake Baikal and to its east, where the border of the mountain folds are found. Apparently the enormous Baikal System, to which the valley around Lake Hövsgöl and possibly the Darhatsk Basin in Mongolia belong, was formed all at once or in a rapid series of events (FLORENSOV, 1960). This is evidenced by the fact that endemic faunal elements of Lake Baikal, e. g. several mollusc species, such as *Kobbeltocochlea michnoi*, *Choanomphalus mongolicus*, are still found in Lake Hövsgöl.

At this time, the renewed upheaval of the Valley of the Great Lakes and its division into large independent water systems took place. We are convinced that an endemic Central Asian fish fauna exists in the now isolated water bodies within the Gobi Lake Basin. These include Lakes Örög, Böön Tsagaan, Tatsain Tsagaan and Adgiyn Tsagaan.

At the end of the Tertiary Era, numerous species of large molluscs (*Unio* and *Planorbis*) disappeared, along with many fishes and a number of other animals that prefer warm climates and had settled earlier in the waters of Mongolia. The deep freezing of the lakes in winter and the harsh conditions during the summer make colonization of the shallow Mongolian lakes by warm water species impossible. Only a few elements of the Tertiary warm water fauna survived and were able to resettle the lakes of Mongolia when favorable conditions returned. The modern aquatic fauna of Mongolia is qualitatively much poorer than that of the Amur and of Eastern Siberia.

4.2. The Zoogeographical Situation and the Classification of the Lakes Based on the Formation of their Basins

Because our work is chiefly concerned with the hydrobiology of the lakes, we have divided the M.P.R. into limnological regions based on considerations of geography and peculiarities of the lacustrine flora and fauna.

The M.P.R. possesses a relatively large number of lakes, covering an area of over 1.5 million hectares. The total length of all the water courses in the nation is more than 50,000 km. The greatest lake system (36.5% of the total lake surface area) is in the Gobi Region. The region characterized by the fewest lakes is the Altai (0.62%).

Earlier, the territory of the M.P.R. had been divided into four drainage systems: the Arctic Ocean Drainage, the Pacific Ocean Drainage, the Central Asian System without external drainage, and the Western Mongolian Basin. By examining the plankton and fish populations to find similarities in biological structure, the membership of the hydrographically isolated water systems of Western Mongolia and the Central Asian Basin in a single zoogeographical region was established.

The Central Asian Basin can be subdivided as follows:
a) The Valley of the Great Lakes, which includes the northwestern part of the M.P.R. and is joined on the north and west to the Sayan and Altai,
b) The Gobi Valley of the Lakes, which encompasses a vast territory in Southern Mongolia.

The Valley of the Great Lakes in Western Mongolia can be subdivided as follows:

1) The Basin of the Great Lakes, including Lakes Hyargas, Ayrag, Har, Dorgon and Har Us. Lakes Har and Har Us with their outlets, the freshwater Lake Ayrag and the remaining salty lakes without outlets are the final members of one entire hydrographical net. The elevation of the lake levels ranges from 1132 to 1157 m MSL.

2) The Altai Mountain lakes, including Lakes Örög, Achit, Tolbo, Hoton, Horgon, Dayan and others are in the western border region of Mongolia and are situated in the highest mountain system of the Gobi and Altai. They are freshwater lakes with flow-through, with the exception of the salty Lakes Örög and Uvs, which lack outlets. The water levels range from 759 to 2232 m in elevation. The outlet streams connect these lakes with the Great Lakes, with which they share a common fauna.

3) The lake system of the Hangayn Plateau: Lakes Hungüyn Har, (Bayan), Ulagshni Har, Hoh, Oygon, Telmen, and Sangiyn Dalay. The first two of these are deep and contain fresh water, presumably having originated through karst formation. The remaining lakes contain salty water and either have no outlets at all or empty only periodically into the Valley of the Great Lakes. The water levels in these lakes are between 1491 and 1888 m in elevation.

In spite of the topographical distortions and rearrangement of the hydrographical network within the Central Asian Basin, the zoogeographical uniformity of its fauna remains intact.

The long period of time that the isolated Mongolian Basin has existed, made it possible for a native fauna to develop in its oldest centers. This isolation has brought about specific evolutionary modifications of many aquatic continental faunal elements. Formerly itwas believed that the group of lakes on the Hangayn Plateau, which lack outlets, inlcuding Sangiyn Dalay, Telmen, Oygon, Ulagshni Har and Hungüyn Har, belonged to the Arctic Drainage Area (DASHDORŽ, 1962). Because of the endemic fish fauna, however, these lakes must be assigned to the Central Asian Drainage Area. The Bulgan River in the Altai, which possesses no endemic Central Asian species and has an aquatic fauna indistinguishable from that of the waters in the Arctic Drainage, belongs to that drainage system, even though it empties into Lake Ulungur, which has no outlet. It is apparent that the river formerly flowed into the Arctic Basin. In summary, the distribution of the Arctic fauna demonstrates that the modern hydrographic network in the M.P.R. belongs to three fundamental drainage systems (Fig. 1). All Mongolian lakes fall into one of the following groups based on the method of formation by which their basins were shaped:

1) Lakes with beds formed by tectonic processes. Such lakes are deep and have steeply sloping banks. Generally, they are elongated along the fault line or depression. Among these lakes are Hövsgöl, Hyargas, Örög, Achit, Uvs and Sangiyn Dalay. To this group also belong the water-filled craters left behind after periods of volcanic activity, such as Lakes Terhiyn Tsagaan and Sharga. They are characterized by great depth, although their surface areas are not very extensive.

2) Lakes originating from glacial activity. To this type belong lakes located in the deepest parts of glacial valleys and bordered on the edges by high steep mountainsides. They have various shapes and are significantly shallower than tectonic lakes. The relief

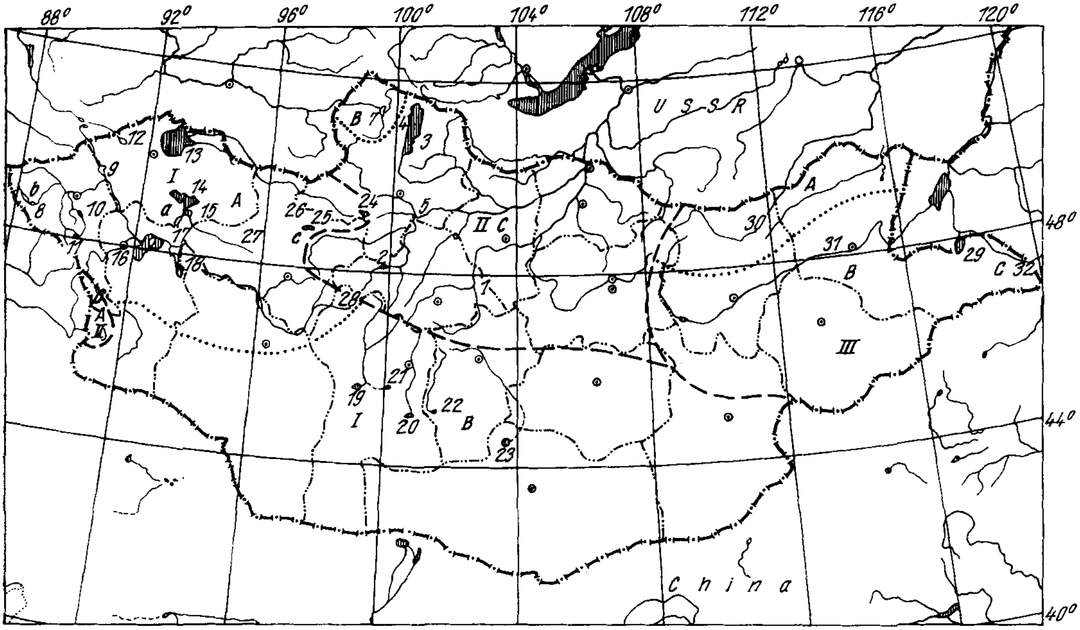

Fig. 1. The zoogeographic classification of the drainage systems in the Mongolian People's Republic

I The Central Asian region with the interior water systems (*8–28*)
- *A* Valley of the Great Lakes
  - *a* Valley of the Great Lakes
  - *b* mountain lakes of the Altai
  - *c* lakes of the Hangayn plateau
- *B* Gobi Valley of the Lakes

II The Arctic Ocean drainage system (*1–7*)
- *A* water system of the Bulgan river
- *B* water system of the Shishhid river (Darhatsk basin)
- *C* water system of the Selenga river

III The Pacific Ocean drainage system (*29–32*)
- *A* water system of the Onon river
- *B* water system of the Kerulen river
- *C* water system of the Halhin river and Numrugiyn rivers

1 Ugiy-nur, *2* Terhiyn Tsagaan, *3* Hövsgöl, *4* Prihövsgöl lakes, *5* Valley of the Many Rivers, *6* Bulgan-gol, *7* Darhatsk basin, *8* Kobdossk lakes, *9* Achit-nur, *10* Tolbo-nur, *11* Hongor-ulen-nur, *12* Örög-nur, *13* Uvs-nur, *14* Hyargas-nur, *15* Ayrag-nur, *16* Har-us-nur, *17* Har-nur, *18* Dorgon-nur, *19* Böön Tsagaan-nur, *20* Oreg-nur, *21* Tatsain Tsagaan-nur, *22* Adgiyn Tsagaan-nur, *23* Ulan-nur, *24* Sangiyn-Dalay-nur, *25* Telmen-nur, *26* Oygon-nur, *27* Hungüyn-Har-nur, *28* Hoh-nur, *29* Buyr-nur, *30* Onon, *31* Kerulen, *32* Halhin-gol

of the lake beds is uneven, and the deposition of moraine material on the bottom is different in each lake depression. Such lakes are usually arranged in short chains, in which the uppermost lake is also the largest and deepest (up to 80 m). As examples, Lakes Paina, Semse and Hulagt in the Prihövsgöl can be taken, as well as the Altai Lakes Hoton, Horgon and Dayan and the Hentiyn Lakes Hungüyn Har, Hoh and others.

3) Lakes originating from the thawing and sinking of the upper soil layers in regions

of permafrost. These are especially widespread in the northern parts of the country. The Darhatsk Basin (Lakes Shargayn, Hushirt and Arsayn) and Eastern Mongolia (Lakes Tsagaan, Sumiyn, etc.) are rich in such lakes.

4) Karst lakes are water bodies originating from the activity of ground water. These are not large but are comparatively deep, having originated from the erosion of limestone. They posses simple rounded contours. Examples are Lakes Hungüyn Har and Ulagshni Har.

5) Valley and subterranean lakes, which originated from the dislocation or at the point of disappearance of rivers. In most cases they are elongated in shape. Examples include Lake Ugiy in the Orhon Valley, Lake Erhel in the former valley of the Egiyn Gol, as well as the lakes of the Tamsagbulag Steppes of Eastern Mongolia, in the Kerulen Valley.

6) Deflation lakes which originated from wind activity on sand basins of the plains. Such lakes are confined to the Gobi Region. Their excess water drains into the sandy ground.

5. The Lakes of the Arctic Ocean Drainage System

The Mongolian part of the Arctic Basin is characterized by the development of a thickly branching hydrogeographical network.

The area of this drainage system in Mongolia is 323,000 km^2, that is, 20.6% of the republic. This system includes the lakes and rivers of the Darhatsk Basin, the Selenga River System and the Bulgan Gol of Southwestern Mongolia. The Selenga River collects water from the northern slope of the Hangayn Mountains through such tributaries as the Hanuy and Orhon, is joined by other tributaries including the Delger Mörön and Egiyn Rivers from the north, and drains the region of the Hentiyn Range. It empties into Lake Baikal. The area of its valley is over 280,000 km^2, 20,000 km^2 of which is the surface of water bodies. The drainage system of the Selenga River comprises 87.3% of the Arctic Basin within Mongolia. Within the Selenga river system are found Lakes Ugiy, Terhiyn Tsagaan and Hövsgöl.

5.1. Lake Ugiy

This shallow mesotrophic lake, covering an area of 25.1 km^2, is fed by the Orhon River. Its greatest depth is 16 m, and its water transparency reaches 3 m. In summer the maximum temperature does not exceed 25 °C. The shallow water zone, up to 3 m deep, includes 40% of the total area. The benthic vegetation is well developed, with up to 50% of the bottom supporting macrophytic growth. The benthic fauna is diverse. The lake's biomass reached a value of 14 g/m^2 among the vegetation along the shore, and varied from 8 to 10 g/m^2 on the muddy bottom. The phytoplankton is composed chiefly of diatoms. The most important zooplankton components are copepods and cladocerans. The average biomass of the zooplankton is about 2.8 g/m^3 in summer and 0.35 g/m^3 in winter.

The lake is the site of an intensive fishery. The annual yield is 50 to 80 tons. The lake is ichthyologically a roach-pike type. A list of its useful fish species is provided in Table 3.

5.2. *Lake Terhiyn Tsagaan*

This lake is in the central Hangayn Region at an elevation of 2060 m MSL. It is an impoundment of the Suman River Valley with a volcanic origin, and it has an outlet through that valley. Its surface area covers 61.1 km^2, and its maximum depth is 19.5 m. Its transparency amounts to 5.5 m, and the summer water temperature reaches a maximum of 13 to 15 °C. The lake is oligotrophic. Its shallow zone, to a depth of about 2 m, includes about 40% of the area. Macrophytes grow beneath 20% of the lake surface. The benthos is comparatively poor. In summer, the blue-green algae dominate the phytoplankton, while in the zooplankton, the copepods and cladocerans are predominant. The mean biomass of the zooplankton is 2.4 g/m^3 in summer and between 0.1 and 1.0 g/m^3 in winter. The lake is of the pike-roach type. Its fishery yield amounts to 50–100 tons per year.

5.3. *Lake Hövsgöl*

Lake Hövsgöl forms the southern member of the tectonic depression of the Baikal region (Kožov, 1972). It is higher than the mean elevation of Mongolia, with its surface at an elevation of 1645 m above sea level, or 455 m higher than Lake Baikal.

The lake extends in a north-south direction to a length of 134 km. Its width varies, with a maximum of 37 km opposite the mouth of the Turag River. The greatest depth measured during an expedition in 1972–73 was 262 m in the central part, southwest of the Dalayn Kuy Island.

In Lake Hövsgöl the vertical zonation of the flora and fauna is pronounced. A littoral, sub-littoral and profundal zone exist, with the last of these divided into an upper and lower part (Tomilov, Erbayeva and Komlev, 1972). The littoral and sub-littoral zones, from the surface to 50 m, comprise 15% of the total lake surface, that is, as much as 40,000 ha (Tomilov and Dashdorž, 1965). The littoral zone is narrow, although it is the richest zone biologically. The vacant shore is bordered by a narrow strip of stones or sand mixed with stones. In several places, the shore region supports growths of *Ulothrix* (Sagorenko, 1972). The profundal zone, over 100 m deep, is found beneath 69% of the lake surface.

More than 96 rivers and streams empty water, either steadily or intermittently, into the lake. Lake Hövsgöl itself empties water into only one, the Egiyn Gol. The total ion content, is 200 to 250 mg/l, twice as much as that of Lake Baikal (Samarina *et al.*, 1965). The temperature curve of the lake corresponds to a temperate climate (Sherkasov *et al.*, 1972). The average daily water temperature of the open pelagic zone was found to be 8.7 °C in July, 9.8 °C in August, 6.1 °C in September and 5.4 °C in October. The seasonal temperature variations were noted to a depth of over 50 m. Corresponding to this, the annual heat reserve in the Hövsgöl water is significantly lower than that in Lake Baikal. The concentration of dissolved oxygen in the surface layer under the ice is 9.98 to 11.0 mg/l or 85 to 95% saturation (Speiser *et al.*, 1972). In summer, there is no oxygen deficit. At the end of June, the macrophytes begin to develop, mainly in the bays. Research on the plankton and benthos characterizes Lake Hövsgöl as ultra-oligotrophic. The phytoplankton biomass in the water layer from the surface to 50 m was found to average 135 mg/m^3 for the entire lake, while the corresponding average for the zooplankton was 110 to 230 mg/m^3. The first results for primary production determinations show a value in the range occurring in similar oligotrophic lakes, such as Lake Baikal. A general average of 300,000 bacteria per ml was found. The phytoplankton biomass is apparently not sufficient to support an intensive development of zooplankton elements that are nourished by bacteria.

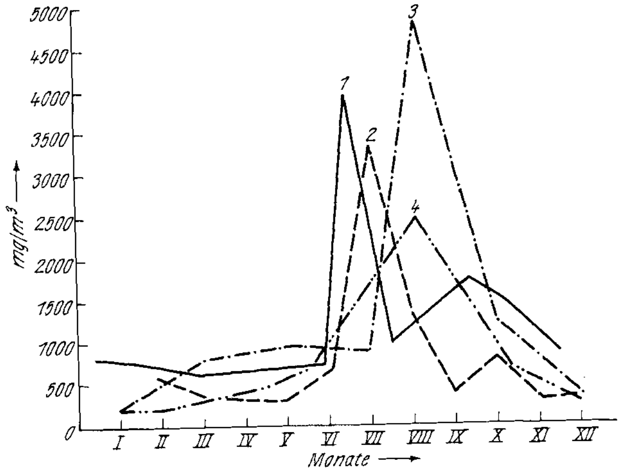

Fig. 2. Seasonal changes in the biomass of the zooplankton of the Mongolian lakes
1 Dod Tsagaan (Darhatsk basin), *2* Buyr (eastern Mongolia), *3* Terhiyn Tsagaan (Selenga river system), *4* Hungüyn Har (Hangayn Plateau)

Gammarids, chironomids, ostracods and oligochaetes represented the benthic fauna. The distribution of animals shows a clear zonation. In the zone from 0 to 50 m, the highest diversity was found in the deeper parts. The biomass in this zone varied from 1.5 to 14.4 g/m^2. The host-parasite relationships, which in the case of endoparasites involve complicated life cycles, are very unusual and show characteristic modifications. In Lake Hövsgöl, there is a high infection rate among valuable fishes.

The fish community developed in the late Quarternary Era. Its dominant species are from the European-Sibirian zoogeographical complex, but it includes an insignificant number of Siberian species from the Baikal and Amur areas. The fish community is composed chiefly of species belonging to the families Salmonidae and Thymallidae. Of the nine species, seven are of economic importance. Recently, the introduction of the Baikal omul, *Coregonus autumnalis migratorius*, has generated great interest, from both scientific and economic viewpoints. The Baikal omul acclimatized itself well to the conditions in Lake Hövsgöl.

The spawning migrations of the omul into the rivers start at the beginning of September at a water temperature between 7 and 10 °C. The mass migration and spawning itself takes place at a temperature of 3 C° and lower and lasts until the water freezes over. Under the conditions in Lake Hövsgöl, the omul is sexually mature in its seventh year of life. On the average, a female produces 39,400 eggs. At the spawning sites, individuals from the eleventh year are represented. The ratio of males to females is 1 : 1. The mean rates of weight and length increase for the omul in Lake Hövsgöl do not vary significantly from those of similar developmental stages of the omuls found in Lake Baikal. At seven to eight years their average lenght is 37 cm, and they range from 34 to 42 cm long. The omul in Lake Hövsgöl is chiefly a bottom feeder. Its nourishment coefficient averages 1.5. The omul population could be increased by environmental modifications to provide more spawning sites.

5.4. The Small Lakes of the Prihövsgöl Region

The many shallow, flat bottomed lakes of the Prihövsgöl Region are rich in nutrients and heavily populated by fishes, many of which are suitable for exploitation. In some of them however, Lakes Erhel and Achmak for example, there is little chance for fishery development, because of the scarcity of zooplankton and a high salinity.

5.5. *The "Valley of the Many Rivers"*

The source of the Selenga River at the confluence of the Chuluut, Ideriyn, and Delger Mörön is located in the "Valley of Many Rivers," Olon Golin Bilcher. It is a location of great economic importance. It is apparent to the ichthyologist that the stock of most fish species found there (*Coregonus lavaretus pidschian* n. *delger muren*, *Hucho taimen*, *Brachymystax lenok*, *Thymallus arcticus*, *Lota lota*, *Perca fluviatilis*) is still underexploited.

5.6. *The Bulgan Gol*

The Bulgan River in Southwestern Mongolia, which flows from the southern slope of the Altai into the Dsungaria, presents a special case. It flows about 250 km through Mongolian territory. In its waters live relatively large populations of six fish species: *Leuciscus leuciscus baicalensis*, *Carassius auratus gibelio*, *Perca fluviatilis*, *Gobio gobio*, *Tinca tinca*, and *Noemacheilus barbatulus toni*. The first three of these have economic importance. The presence of Siberian species among the aquatic fauna of the Bulgan River demonstrates its separation from the Arctic Basin during the uplift of the Mongolian Altai, which divided the Central Asian Basin into two sections.

From 1973 to 1975 the Bulgan Gol was investigated during the Mongolian – DDR Expeditions, which provided a large amount of data about the macrofauna of this river system, as well as of other water bodies (UHLENHAUT, STUBBE, PIECHOCKI and DAWAA, 1977; DAWAA, STUBBE and DORŽRAA, 1977; PIECHOCKI, 1967).

5.7. *The Lakes of the Darhatsk Basin*

The Darhatsk Basin is located in the drainage area of the Shishhid River, a tributary of the upper Yenisey. The elevation of the valley is 1560 m MSL. We investigated about 30 lakes of different sizes and types. Their trophic levels vary from oligotrophic to mesotrophic. Most contain fresh water and have average depths between 5 and 8 m, but a maximum depth of up to 17 m was found in several lakes.

The species composition of the lake zooplankton in the Darhatsk Basin is relatively constant from lake to lake. The great majority of the species are widely distributed in Eastern Siberia, except for Lake Baikal. Ignoring cosmopolitan species, the qualitative composition of the zooplankton in these lakes shows no similarity with that of the lake zooplankton in Eastern Mongolia (Lakes Buyr and Hoh), or in the lakes of the Gobi Valleys, where halophilic forms are predominant. As far as is known, the zooplankton species of the Darhatsk lakes are similar to those of Lake Ugiy, Lake Terhiyn Tsagaan and the Altai lakes.

In all lakes investigated, the maximum plankton development, 0.95 to 5 g/m^3 in June and July, occurs at the maximum temperatures, 19 to 28 °C. The average zooplankton density varies from 0.5 to 3.2 g/m^3 in summer and between 0.13 and 0.93 g/m^3 in winter.

Numerous diatoms, blue-green algae and dinoflagellates develop in the phytoplankton of the lakes.

In all lakes investigated, the qualitative composition of the higher aquatic vegetation resembles that prominent elsewhere. The amount of vegetation coverage varies from 10% or less in Lakes Hushirt, Dod Tsagaan and Tseutson to 90% in Lakes Targan, Tögrög, Sayrt and Duren. The lakes investigated all fall into one of the following types: *Nuphar* type, *Potamogeton natans* – *Nuphar* type, *Myriophyllum* – *Potamoge-*

ton type, *Sparganium – Equisetum* type, *Scirpus – Potamogeton* type, and the mixed group type.

The benthic fauna includes a great number of species. In the oligotrophic lakes, the density of benthic animals varied from 10 to 30 individuals per m^2 (data from Lake Dod Tsagaan). In mesotrophic water bodies, it ranged from 125 to 3670 individuals per m^2 (data from the shallow parts of Lake Dod-Tsagaan and Lake Togrog).

The lakes of the Darhatsk Basin are ichthyologically *Coregonus* types. It is important to mention the presence of *Coregonus lavaretus pidschian* (Gmelin). In the waters of the Darhatsk Basin are found two forms of this species, the lake-river form, which entered the Darhatsk Basin through the Yenisey Region, and the pure lake form, which evolved from the former. The central part of the lake form's range is in the large and small lakes of the Shishhid area, while the usual habitat of the lake-river form is the tributaries of the lower Shishhid and the Tengis Rivers.

These waters are also inhabited by a dwarf *Coregonus*, the females of which become sexually mature in their third year, while the males mature in their second. The houting that live in flowing water at times have a different spawning time from those that live only in standing water. Their spawning sites are different as well. The lake form spawns at a temperature of 10 to 12 °C, while the lake-river form prefers a temperature of 4 °C or lower. The spawning periods begin in the second half of August and last until the end of October. The females produce from 8000 to 35,000 eggs. The year classes of the houting are from 4 to 15 years. The largest specimen collected was a 13 year-old female, 53 cm long and weighing 1.9 kg. The total fish productivity of these lakes is from 150 to 200 tons per year.

6. The Lakes of the Central Asian Basin

The Central Asian Region is the inner water reservoir of Mongolia, and it collects the water from the southern slope of the Tannu Ola, from the southwestern part of the Hangayn Mountain Range and from the southeastern slope of the Mongolian and Gobi Altai. This region is sub-divided on the basis of its geographical situation and its hydrological connections into the Altai Lakes, the Valley of the Great Lakes, the lake valleys of the Gobi Basin and the Hangayn Lake Plateau. The Central Asian Drainage Region is large. It is approximately equal to the Arctic and Pacific Drainages in Mongolia. Here such great rivers as the Hovd, the Dzavhan, the Tes and the Baydrag arise. The total length of these is approximately 4000 km.

6.1. Hydrobiological Characteristics of the Altai Lakes

The majority of the mountain lakes in the Altai are of tectonic origin. Some of them, such as the lower and upper Kobdossk Hoton Lakes and Lake Horgon, are among the deepest lakes in the Altai. Among those of glacial origin are the kettle and moraine lakes, such as Hongor Ulen and Tolbo. High in the Altai Mountains there are many impounded moraine lakes, which are directly fed by water from the glaciers, e. g. Lake Horomdog.

6.1.1. The Kobdossk Lakes

These are the largest high mountain lakes, found 2073 to 2232 m above sea level, within the sub-alpine zone. They are fed by glaciers. This lake region extends as a narrow band to a total length of between 50 and 60 km at the foot of the Tavan Bogdo in the Altai Mountains.

Lake Hoton is situated uppermost in the Kobdossk Lake System. It is a fairly large water body with shallow sloping shores bordered by forests of gymnosperms and broadleaf trees, and in some places by shrubs. Its area is 50.1 km², its length 21.5 km, and its width 4 km. The average depth is 26.6 m, and a maximum depth of up to 58 m occurs. The shallow water up to 5 m deep includes about 20% of the lake area. The water is markedly stratified. The summer temperature ranges between 6.2 and 14.1 °C at the surface and up to 6.9 °C at the bottom. The maximum transparency is only 2 m in summer and 4.8 m in winter. The total mineral content in the water in summer ranges from 0.09 to 0.1 g/l, but in winter it is about 0.4 g/l. The ice cover attains a thickness of 70 to 120 cm.

Macrophytes cover up to 20% of the total area of the Kobdossk Lakes. There are no plants with floating leaves. The reed bank consists of sedges (*Carex*) and rushes (*Scirpus*).

The benthic fauna is rather diverse, the samples, however, are quantitatively poor. The chief components of the zooplankton are rotifers and copepods. Copepods are observed throughout the year, with *Eudiaptomus graciloides* LILL. and *Cyclops vicinus* ULJANIN especially common. In the summer, the total zooplankton biomass is 0.26 to 0.31 g/m³ in Lake Hoton, 0.28 to 0.41 g/m³ in Lake Horgon, and up to 1.38 g/m³ in Lake Dayan. During the period of ice cover, a total zooplankton biomass of 1.08 g/m³ was found in the central part of Lake Horgon, somewhat more than during the summer periods.

Lake Horgon in its hydrobiological structure is similar to Lake Hoton and to the other lakes of the Kobdossk System.

The trophic level of these lakes ranges from ultra-oligotrophic, e. g. Lakes Hoton and Horgon, to oligotrophic, e. g. Lake Dayan. The lakes may be classified ichthyologically as grayling-osman types. The total fish productivity amounts to 80–150 tons annually

6.1.2. Lake Achit (Fig. 3)

This lake is located 60 to 65 km southwest of Lake Örög. Its elevation is 1435 m above sea level. Its greatest length is 24 km and its maximum width is 18 km, giving it a total surface area of 297 km². Its deepest point, measured in the southern part, is 5 m, and its average depth is 2 m. The northern bank is steep and has rock outcroppings. At the feet of these formations are pebbles. At its northwestern end, the Hatugiyn Gol, the Buh Mörön and the Ulyastayn Gol empty their water into the lake. In the south, the water flows out into the Usan Holoy, a tributary of the Hovd (Kobdo).

The lake water is fresh with a total mineral content of 0.16 g/l. In June and July, the surface water warms to between 15.2 to 23.3 °C. The water transparency does not exceed 2 m in summer, and in winter it is about 4 m. About 50% of the lake contains macrophyte vegetation, especially concentrated in the southwestern and eastern parts. There is a diverse benthic fauna especially in the southeastern part of the lake. In the course of the summer, rotifers and copepods dominate the zooplankton. The biomass varies from 0.87 to 2.0 g/m³.

6.1.3. Lake Tolbo

This lake is located in the middle of the hilly western section of the Altai Plateau. It is a long lake, extending in a northwest–southeast direction. Its greatest length is 21.5 km and its maximum width 7 km. It covers an area of 84.0 km². The maximum depth of 12 m was found in the central part of the lake. In the eastern part, the depth does not exceed 6 m. The shallow zone, down to 3 m, includes about 30% of the area. The lake is of tectonic origin, with scarcely any streams emptying into it. The Turgen

Fig. 3. Western shore of Lake Achit (phot. M. STUBBE)

Gol arises from an outlet at the southern end of the lake, and it empties into the Kobdo River. Lake Tolbo freezes at the end of October and thaws again at the beginning of June. The ice cover is up to 1.5 m thick. The color of the water is blue-greenish. The transparency does not exceed 3 m in summer; in winter it is 7 m. In summer there is scarcely any stratification in the water. In July, the surface temperature was found to be 15.2 °C. The total mineral content reaches 0.8 g/l in summer and is reduced to 0.6 g/l in winter.

About 20% of Lake Tolbo's area supports macrophyte populations. The southern part of the lake and the western bay are the most thoroughly overgrown.

Diatoms were observed in the summer phytoplankton, and in the winter season, *Ceratium hirundinella* was present. The zooplankton composition is similar to that of Lake Dayan. The summer zooplankton is relatively sparce, with a biomass of 0.58 g/m^3. In the winter the value is 0.40 g/m^3. In the lake are found the fish species *Oreoleuciscus pewzowi*, *O. potanini* and *Thymallus brevirostris*. They are well nourished.

6.1.4. Lake Hongor Ulen

Lake Hongor Ulen is located 50 km from Lake Tolbo, in the middle of the hilly western landscape, where sandy and loamy soils predominate. It has an elongated oval shape and a strongly differentiated littoral zone. About 60% of the lake is a shallow zone up to 2 m deep. It has an area of 20 ha, with a length of approximately 2 km. The depth is about 16 m at maximum and averages 5 m. The lake has no outlet, but the Hongor Ulengiyn Gol empties into it. The water has a transparency of 3 m in summer. Wind brings about a strong circulation in summer. At the surface and bottom, the temperature is about 14 °C. The water is fresh, with a total mineral content of 0.26 g/l.

Much macrophyte vegetation is present in the lake. Over 50% of its area is settled by these plants. Among the vegetation are populations of benthic fauna, including trichopteran and chironomid larvae, which are rather dense. During the period of observation, the phytoplankton was composed chiefly of diatoms and green algae. The structure of the zooplankton is similar to that in Lake Tolbo. The dominant aggregation in the summer zooplankton is one of copepods and rotifers. At this time, the biomass is as high as 0.83 g/m^3.

The most important fish species are *Oreoleuciscus pewzowi*, *O. patanini* and *Thymallus brevirostris*. The last of these species is of economic importance and is also interesting for its biological peculiarities. The West Mongolian grayling (*Thymallus brevirostris* KESSLER) is a Tertiary relict of the Northeastern Mongolian fauna. Its distribution includes the Kobdo River System, the Dzavhan, and Lakes Achit, Tolbo, Hongor Ulen, Har Us, Har, Dorgon and other lakes, as well as the rivers that empty into them. The water bodies in which this grayling occurs are the remnants of a mighty Tertiary ocean that was characterized by an impoverished fish fauna.

Peculiarities of the West Mongolian grayling are the length of the upper jaw, the large head, the small eyes, the long paired fins and its short tail fin with few rays. The differences observed among graylings from various water bodies indicate the presence of local populations. The age distribution of the species in the Kobdossk lakes includes year classes from 3 to 16, as determined by net catches. Lake Hoh, in the Valley of the Lakes, contains age classes from 3 to 8 years. The greatest age of *Thymallus brevirostris* is apparently 17 years. The numerical ratio of the sexes in all the age groups is practically the same. The maximum size attained is 69 cm in length and 3 kg in weight. The average annual growth rates do not exceed 4.0 cm in Lake Horomdog, 3.7 cm in Lake Hoton, 4.7 cm in Lake Horgon and 4.2 cm in Lake Dayan. TUGARINA (1972) reported that this fish has an average annual growth rate of 3.9 cm in the Bogdin Gol (River).

The West Mongolian grayling lays its eggs between mid-May and the end of June, when the water temperature is 6 to 10 °C. The fishes mature sexually after their fourth or fifth year. Their mean absolute fertility is between 5600 and 17,800 eggs. In summer, the fish's diet is rather diverse. It can be classified as euryphag. The index of stomach fullness varies within a range of 15.8 to 31.9% for both sexes. During the short summer periods, the grayling fattens itself intensively. The nutrient coefficient ranges from 0.81 to 1.4. In the Altai lakes, the potential catch was calculated to be 80 to 100 tons.

6.1.5. Lake Örög

This lake is located on a high plateau of the Altai Range, surrounded by mountains of the Tsagaan Shuvut in Turgen Ul, at an elevation of 1425 m above sea level. The lake is roundish, its area covers 237.6 km^2. The maximum depth is 42 m in the central part, and the average depth is about 15 m. The shallow water zone to a depth of 4 m takes in about 20% of the lake's area. It has no outlet. Some water flows in through streams which enter only at the northwest section. The shore of the lake is stony, and to a significant degree swampy. In the middle of the lake is a fairly large island. The water mass is thermally stratified. The surface water warms to between 12.1 and 18.0 °C by the beginning of July. The water transparency in summer is 7 to 8 m. The taste of the water is salty. The total mineral content varies within a range of 2.88 to 5.1 g/l, with sulfate and sodium being the most abundant ions.

The macrofauna grows under about 20% of the lake surface, mainly concentrated in the shallow swampy northwestern part. Reeds generally dominate the flora, but significant communities of sedges (*Carex*) and horsetails (*Equisetum*) are also present. Benthic fauna is scarce in the littoral zone. It consists of isolated individual molluscs and gammarids. Rotifers and copepods are the chief components of the summer zooplankton, the biomass of which was found to be 0.34 g/m^3. A significant number of *Oreoleuciscus pewzowi* and *O. patanini* are present in the lake. The average length of the fishes is up to 50 cm, with a corresponding weight of 3.8 kg.

6.1.6. Lake Uvs

One of the lowest-lying lakes in the country, Lake Uvs, is only 759 m above sea level. It collects the water from a large drainage area. The lake itself covers 3350 km^2, its length being 84 km and its width 79 km. The shores are stratified with layers of sand from glacial lakes. The lake is without an outlet, but it receives water from the east through the rivers Baruntura, Nariyn Gol and Tes, which flow through a valley of sand dunes extending to the eastern shore of the lake. The Harhira, Sangil, and other rivers flow into the lake from the west. In the summer the temperature exhibits a gradient from 25 °C at the surface to 19 °C at the bottom, which is 6 m deep. The water is very salty, with a transparency of 6 m. The total mineral content is 18.78 g/l, with sulfate and sodium ions being the chief components. The zooplankton biomass is 0.11 g/m^3. Many *Oreoleuciscus pewzowi* and *O. potanini* are found in the lake.

6.2. The Valley of the Great Lakes

Numerous large lakes, including Hyargas, Ayrag, Har, Döröö, and Har Us, are found in the northwestern part of the M.P.R. The lakes are fed by rivers that drain the Mongolian Altai, the Hangayn and the Saylugem. The largest of these rivers are the Kobdo (Hovd Gol), the Buyant, the Dzavhan, and the Hüngüyn. The smaller rivers, in most cases, disappear into the sandy, pebbly alluvium and do not reach the lakes. Their water, however, appears again in the form of springs along the edge of the lakes. All West Mongolian lakes are considered remnants of an old expansive freshwater basin. Evidence for this includes the numerous marks left by breakers, the presence of eroded terraced steps and index fossils characteristic of lake biota.

6.2.1. Lake Hyargas (Fig. 4)

The lake contains salty water. It is located in the lowest depression of the Valley of the Great Lakes' central part at an elevation of 1029 m above sea level. It is 75 km long, 31 km wide, covers an area of 1407 km^2, and has a maximum depth of 80 m. In Lake Hyargas, also called Hirgis Nur, salinity is an important factor that determines the difference in biotic character between this lake and the others in the Valley of the Great Lakes. A unique structure of both the phytoplankton and zooplankton is found. The zooplankton composition is monotonously uniform in all areas, with copepods predominant in summer. The total summer biomass amounts to 0.31 g/m^3. When there is ice cover, rotifers are the most numerous components, and the biomass ranges from 0.22 to 0.31 g/m^3. The dominant phytoplankton species are *Ceratium hirundinella* and *Pediastrum* sp.

6.2.2. Lake Ayrag, Lake Har Us, Lake Har and Lake Döröö

Lake Ayrag contains fresh water. It has a length of 16 km, a width of 13 km, an area of 143.3 km^2, and a maximum depth of 10 m. Its environment is semi-desert. A fairly deep branch of the Ayrag Nurin Holoy connects it with Lake Hyargas, with which it shares almost the same set of characteristics. Like the other lakes in the valley, Ayrag freezes over in October or November and thaws in May or June. The ice cover is 110 to 160 cm thick. The temperature under the ice is 0.1 to 2.5 °C. During the summer, the water warms to between 23 and 25 °C and the transparency reaches a value of up to 4 m. The chief zooplankton components are rotifers and copepods. Their population densities are not high, and samples from various parts of the lake provided

Fig. 4. View above Lake Hyargas, one of the large salt lakes in western Mongolia (phot. M. STUBBE)

approximately equal quantitative results. The summer biomass ranges from 0.73 to 0.98 g/m^3, while during the period of ice cover it was found to be 0.13 g/m^3. An alga that blooms in vast numbers is *Aphanizomenon flos-aquae*, which gives the water a green color. The structure of the fish populations in Lakes Hyargas and Airag show similarities, including the presence of such species as the two osman, *Oreoleuciscus pewzowi* and *O. patanini*.

Representatives of another species, *Oreoleuciscus humilis*, are fairly widely distributed in the waters of the Central Asian Basin.

The territory of the osman is surrounded on practically all sides by mountain ranges. The northeastern border is Lake Sangiyn Dalay, which is situated alongside the Selenga River System. Lake Uvs is located in the extreme northern part of the range. It is limited on the south and southwest by the Mongolian Altai and Gobi-Altai Ranges and borders on the mountainous drainage system of the upper Irtysh. These geographic barriers almost completely confine the range of *Oreoleuciscus* to the northwestern section of the Central Asian Highlands, which rise to between 1000 and 2238 m above sea level. Outside the borders of the M.P.R., the osman is known only from the upper course of the Ob River. The close proximity of the marshes in the Ob watershed to the confluences of the Mongolian rivers apparently permitted the migration of the osman from one water system to the other. According to BERG (1948), three species of Altai osman, *Oreoleuciscus pewzowi, O. potanini* and *O. humilis,* live in the waters of the Central Asian Basin.

Statistical comparisons using the average difference method show that these three osman species possess real distinctions. Distinctions are also observed in their adaptability to the ecological conditions and their presence in local groups confined within characteristic areas. They are lake fishes that can tolerate rivers with slow current flow, but not the rapid current of mountain streams. The osman lives in waters with various oxygen concentrations and mineral contents, including standing freshwater bodies. At spawning time, they leave the salty lakes for the freshwater rivers. The physical characteristics of the species can be described as follows:

The large-mouth osman of the Altai is *Oreoleuciscus pewzowi* (HERZENSTEIN). It is characterized by long lower jaws, a large head, the triangular shape of the operculum, and the spindle-shaped body. The populations of *O. pewzowi* are represented by more than 40 age classes from 1 to 47 years. The greatest age attained is 45 years. The fish is fairly large, with a maximum length of 90 cm and a weight of 8 kg. The rates of weight and length increase, however, are very slow. The annual growth does not exceed 1 cm in length and 20 g in weight. The osman is slow to mature, reaching sexual maturity in its seventh or eighth year. The females produce from 51,000 to 137,000 eggs. *O. pewzowi* is euryphagous and has a fairly large food supply in Mongolian waters.

Oreoleuciscus potanini (KESSLER) is of medium size with a terminally placed mouth. The head is comparatively small, the operculum rectangular, and the body elongated. Netted catches contained representatives of classes from 4 to 25 years, but they were chiefly composed of eight and nine-year-old individuals. The rates of length and weight increase are slow. Sexual maturity comes during the seventh or eighth year of life. The females produce from 109,000 to 183,000 eggs. The diet consists of phytoplankton and detritus. *Oreoleuciscus potanini* occurs together with *O. pewzowi* and *O. humilis*, and the possibility of interbreeding cannot be ruled out.

The dwarf osman of the Altai is *O. humilis* WARPACHOWSKI. It is a relatively small fish with an elongated body, appearing almost naked with its small scales. The head is narrow and conical, and the operculum is triangular. The length of the adults averages 13.5 cm, and ranges from 9.0 to 15.2 cm. The population is composed of 10 year classes from 5 to 14, and a possible maximum age of 20 years is reached. The annual growth does not exceed 1 cm in length or 2 g in weight. Sexual maturity is attained in the fifth or sixth year, at a length of 4,3 to 16.3 cm and a weight of 4,0 to 23,9 g. Females produce 1500 to 4800 eggs. Observations indicate that the fish feeds on plankton. No economic importance has been attached to this species as yet, but it could be used in the production of food for fur animals etc.

Besides those described, the Valley of the Great Lakes contains Lakes Har Us, Har, and Döröö. The freshwater lake, Har Us Nur, with a maximum depth of 4.5 m, is connected through the Conoharayh Gol to Lake Har. Har Nur (Lake) has a maximum depth of 7 m. The small Homin Holoy River arises in this lake and empties into the salty Lake Döröö, the maximum depth of which is 27 m. Lake Har is connected with the Dzavhan River through the Tathen Tel. Biologically, these lakes have the same general characteristics as the other lakes in the valley, including, for example, the presence of the rotifer association, *Hexarthra fennica — Filinia longiseta*, the eurythermal *Eudiaptomus graciloides*, and the euryhaline *Arctodiaptomus salinus* in their pelagic zones. In the phytoplankton, diatoms and chrysophytes predominate. Typical is the heavy growth of macrophytes covering as much as 40 to 80% of the lake area, with associations of *Potamogeton* and *Nymphaea* predominant. In these water bodies, large numbers of *Oreoleuciscus pewzowi, O. potanini, O. humilis, Thymallus brevirostris* and *Noemacheilus strauchi* (KESSLER) are encountered. These lakes are not only promising from the viewpoint of the fishing industry, but also for the introduction of fur bearing

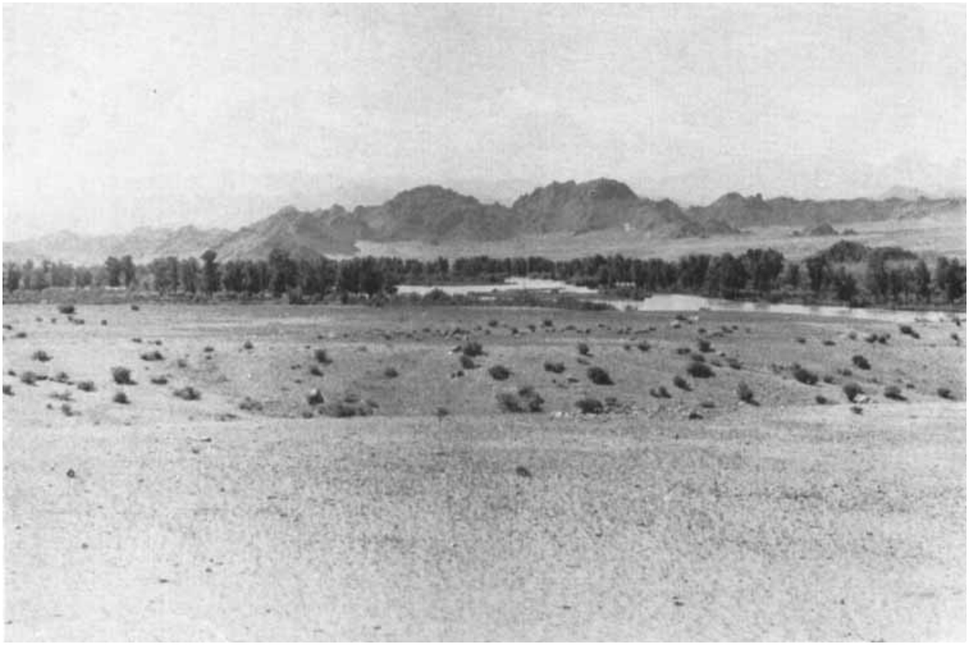

Fig. 5. Middle course of river Hovd (phot. M. STUBBE)

Fig. 6. Lower course of river Hovd, a few kilometers above its outfall into Lake Har Us (phot. M. STUBBE)

mammals. An example is the muskrat, which has adapted to the environment of the Har Us Nur since its introduction in 1967. An annual yield of 5000 individuals is now realized.

6.3. The Lakes of the Gobi Valley

In the northwestern part of the Gobi Region, an extensive hydrographic net exists, but numerous river beds are only filled with water during periods of heavy rain. All large rivers originate from the Hangayn Highlands and empty their water into the Central Asian Plains at the foot of the Gobi Altai, which have no outlets. The northern slopes of the Gobi Altai Mountain Range do not have one river that empties into the Valley of the Lakes. The largest rivers that feed the valley are the Ongiyn Gol, the Tuin Gol and the Baydrag, which have rich fish populations comprised of *Oreoleuciscus pewzowi*, *O. potanini*, *O. humilis*, and *Thymallus brevirostris*. Related to the salinity of the soil, the region of the valley has a poorly developed vegetation and the appearance of a semi-desert. There are not more than 20 lakes covering only a small area. Some of them are temporary and usually dry. The largest permanent lakes between the Hangayn and Gobi Altai Ranges are Lakes Böön Tsagaan, Oreg, Tatsain Tsagaan, Adgiyn Tsagaan and Ulan.

The majority of the lakes are salty, with zooplankton rich in rotifers. In July and August, a massive development of the zooplankton takes place, the biomass of which averages 2.1 g/m^3 in Lake Böön Tsagaan, 3.1 g/m^3 in Tatsain Tsagaan, and 1.3 g/m^3 in Lake Oreg. Larval stoneflies (Plecoptera), *Phasganophora brevipennis* NAV. and *Diura nanseni* KNY, dragonflies (Anisoptera), *Aeschna affinis* LIND. and *Sympetrum flaveolum* L., and caddis flies (Trichoptera), *Limnophilus abstrusus* McL. and *Oecetis ochracea* CURT. dominate the benthic fauna. The water bodies of the valley are oligotrophic. Shallow lakes, such as Tatsain Tsagaan (maximum depth 3 m; area 16.8 km^2) and Adgiyn Tsagaan (depth 2 m; area 22 km^2) show great potential for the fishing industry. The fish yield from the lakes in the Gobi Valley is 80 to 100 tons per year. The hydrobiological conditions that prevail in the lakes (shallow water, rapid warming, and the growth of macrophytes) permit the introduction of the Amur Carp, in order to increase the fishery yield.

6.4. The Lakes of the Hangayn Plateau

An area of 15,000 km^2 in the northwestern part of the Hangayn Plateau is the location of a group of lakes without outlets, at elevations between 1700 and 2000 m. The plateau is covered with many dry riverbeds. The largest of these lakes are Hungüyn Har, Ulagchni Har, Telmen, Sangiyn Dalay and Oygon. The lowest point on the Plateau is the site of the relatively large Lake Hungüyn Har, the elevation of which is 1491 m above sea level. To the northwest of it is Lake Holbo at an elevation of 2020 m MSL. To its east is Lake Sangiyn Dalay at an elevation of 1889 m MSL, and to the south is Lake Telmen, 1789 m above sea level. Lake Oygon's elevation is 1668 m. The lakes have irregular shapes and rugged shores. The banks are steep, salted, and swampy in places. The lakes are fed by both surface and ground water.

6.4.1. Lake Sangiyn Dalay

This large lake has an irregular shape with large bays. In the western part is an island, rising 100 to 150 m above the water level. The lake covers an area of 165.3 km^2, has a maximum depth in a western depression of 30 m, and is up to 12 m deep in the eastern part. Several streams feed the lake, entering only on the northern side. The greater part of the shore is gradually sloping. In several spots, rocky mountains drop off steeply into the lake. The lake water is salty, with a mineral content reaching 2.9 g/l. The water mass is stratified. The surface layer warms to 6.9–12.0 °C in June and July, and reaches 18.5–20.0 °C in August. At a depth of 20 m, the temperature reaches 10.2 °C. The transparency is 2.1 to 3.8 m in summer and 6 m in winter.

Macrophyte vegetation develops only in the southern bays, and is very sparce in the lake. The lake contains little plankton. Its biomass ranges from 0.2 to 0.7 g/m^3. There is a spreading of hydrogen sulfide in the deep zones of the lake. It is an oligotrophic water body. The fish fauna includes species of *Oreoleuciscus.*

6.4.2. Lake Telmen

The lake is situated in a wide valley of steppe between mountain chains on the Hangayn Plateau. The Holoyn Gol is the only river emptying into the lake after having flowed through a valley that is an immediate extension of the Valley of the Lakes. There is no outlet. The area of the lake, including three islands, is 194 km^2. Its greatest length is 26 km, the greatest width, 16 km, and the average width, 12 km. The average depth is 13 m. In the southwest part, a maximum depth of up to 27 m was found. The shallow zone to a depth of 4 m accounts for 40% of the lake area. The water is colored yellow-brown. In summer, the transparency ranges from 3.5 to 4.8 m. The surface temperature reaches 13.9 to 17 °C, and at the bottom it is 8 to 10 °C. The water is salty and unsuitable as drinking water. There are almost no macrophytes in the lake. Only in spots near the shore of the southern section were *Hippuris* and *Chara* encountered. The zoobenthos is scarce. The species diversity of the plankton is low. Copepods are dominant comprising 91%, of the biomass while rotifers are numerically predominant, accounting for 55% of the zooplankton. The total zooplankton biomass averages 0.22 g/m^3. The lake is oligotrophic, and ichthyologically an *Oreoleuciscus* lake.

6.4.3. Lake Hungüyn Har

This lake covers an area of 64 km^2. Its maximum depth is 50 m, and average depth, 21.7 m. Isobathic zones 20 m, 30 m, and 40 m deep comprise 50%, 30% and 8% of the lake area, respectively. The greatest dimensions are 14 km for length and 7.5 km for width. The Muhar Hungüyn Gol empties into the lake. There is no outlet. The water is fresh, with a mineral content of 0.46 g/l. The lake freezes at the end of November and thaws again at the beginning of May. The ice cover is 115 to 150 cm thick. In the winter, the transparency is 7 m. In summer (July and August), the surface water warms to 17–25 °C, while at a depth of 20 to 25 m, the temperature amounts to 8 to 10 °C.

The predominant associations in the zooplankton during the course of the year consists of rotifers and copepods. In July and August, there is a massive development the average biomass of which reaches 2.1 g/m^3. In the course of the seasonal growth period of the phytoplankton, massive blooms of the diatom, *Cyclotella comta* Ehrb., the chrysophyte, *Dinobryon sociale* Ehrb., and the blue-green alga, *Microcystis aeruginosa* Kütz. are observed. The diatoms dominate the winter phytoplankton. The aquatic macrophytes include chiefly communities of *Potamogeton*, *Myriophyllum*, *Polygonum amphibium*, *Ceratophyllum*, and *Hippuris*. *Chara* is found only in scattered locations. Populations of *Potamogeton* and *Polygonum* are distributed over as much as 20% of the lake.

Benthic fauna is richly represented. Hungüyn Har is meso-oligotrophic, and ichthyologically an *Oreoleuciscus* lake.

6.4.4. Lake Hoh

The location of this lake is in the Dzavhan River Drainage System along the southern slope of the Hangayn Mountains. It is 12 km long and has a width varying from 0.5 to 1.5 km. In prehistoric times, a glacial moraine impounded a narrow valley, forming the lake. The moderate size of the lake is about 17,2 km^2. Its depth is 37 m at maximum, and it averages 10 m. The shallow zone, to a depth of 4 m, takes in about 25% of the lake area. The transparency was 4.4 m, and the mineral content is 68 to 88 mg/l. Macrophyte vegetation grows beneath as much as 50% of the lake surface. It is predominantly *Potamogeton* and *Ceratophyllum*. Most of the zooplankton can be assigned to a small number of species. Copepods play a leading role in all quantitative determinations and comprise more than half the total biomass of the autumnal zooplankton. Most of the benthic macrofauna is concentrated in the narrow littoral zone, where the biomass between luxurient stands of *Ceratophyllum* and *Hippuris* exceeds 10 g/m^3. The high biomass values are due chiefly to the populations of larval mayflies (Ephemerida), caddis flies (Trichoptera) and dobsonflies (Megaloptera), and occasionally dragonflies and other aquatic insects. The West Mongolian grayling and the osman live in the lake.

7. The Lakes of the Pacific Ocean Drainage System

The Eastern Mongolian mountain rivers, well filled with water, belong to this system. They include the rivers Onon, Uldza, Kerulen and Halhin, along with their tributaries. The oligotrophic and mesotrophic Lakes Buyr and Höh are also included. Eastern Mongolia possesses many lakes of economic importance. The largest of them is Lake Buyr, with an area of 615 km^2, and a depth of up to 10 m. Höh Nur covers an area of 94.9 km^2, and is at maximum 14 m deep. The zooplankton of these lakes consists of copepods and cladocerans. The phytoplankton includes blue-green algae. The zooplankton biomass in summer reaches 2.6 to 3.4 g/m^3. Macrophyte flora consists of *Phragmites* and *Potamogeton*. The annual fish catch from the lakes in which there is a fishery amounts to 100 to 200 tons. Carp and *Parasilurus* live in these waters.

8. Discussion

The peculiarities of the topographical and climatic conditions in Mongolia have a multifaceted influence on the special distribution patterns of the aquatic biota.

In the Arctic Ocean Drainage System, the Pacific Ocean Drainage System, and the Central Asian Region within the borders of the M.P.R., 187 zooplankton species have been identified, including 37 copepods, 61 cladocerans and 89 rotifers. In the phytoplankton, 107 species or subspecies have been found. BORUTZKI (1959) provides the following zoogeographical classification system for the zooplankton elements: Eurasian-Boreal, Mediterranean, Tibetan, Chinese-Indian, and endemic.

In Mongolia, eurytherm-eurytopic and warm water stenothermal ecological elements are widely distributed. In the lakes of the Central Asian Region, there are 104 species of planktonic fauna, including 17 copepods, 29 cladocerans and 58 rotifers.

Among the group of dominant species belong *Arctodiaptomus salinus* SARS, *Cyclops lacustris* SARS, *Macrothrix laticornis* (JUR.), *Asplanchna brightwelli* GOSSE, *A. sieboldi* LEYDIG, *Colurella colurus* (EHRB.), *Lindia janickii* W., and *Rotaria neptunia* EHRB.

In the waters of the Pacific Drainage Area are 93 planktonic animal species, including 16 copepods, 40 cladocerans and 37 rotifers. The dominant species are *Arctodiaptomus dachuricus* BORUTZ., *Oxyurella tenuicaudis* SARS, *Daphnia* sp., and *Boeckella orientalis* SARS. In the Onon River System, the characteristic regional forms, *Arctodiaptomus yamanacensis* BRE. and *Dunhevedia crassa* KING were found for the first time.

In the lakes of the Arctic Drainage Area are 122 zooplankton species, including 27 copepods, 44 cladocerans and 51 rotifers. In the Darhatsk Basin, the zooplankton species that are often predominant include *Arctodiaptomus anudarini* BORUTZ, *A. wierzejskii* (RICH.), *A. tibetanus* DADAY and in Lake Terhiyn Tsagaan, *Drepanomacrothrix stschalkanowzewi* WER.

The numbers and biomasses of the zooplankters in Mongolian lakes showed different degrees of variation and periods of maximum development. The seasonally dependent periodicity of the numbers and biomass is related to the developmental cycles of the dominant and characteristic species. In several lakes, two maxima in zooplankton during the warm season were recorded. In comparatively deep waters, there is an autumn–winter maximum related to the water bodies' thermal properties and the reproductive behavior of the organisms involved (Fig. 2).

We are presenting a system of classification to be used in future studies and which reflects aspects that are important for the local economy. This system takes into consideration the peculiarities of landscape, morphology, and hydrobiological factors, as well as the fish fauna present. On a trophic basis, the following types of waters are recognized: ultra-oligotrophic, oligotrophic, mesotrophic, eutrophic, and dystrophic.

Table 1. Classification of the investigated lakes according to trophic types

Types of lakes	Arctic Drainage Area		Pacific Drainage Area		Central Asian Region	
	Number	%	Number	%	Number	%
ultra-oligotrophic	3	7	–	–	2	8
oligotrophic	17	39	2	11	6	22
mesotrophic	14	32	6	33	11	40
eutrophic	6	15	5	28	4	15
dystrophic	3	7	5	28	4	15
total	43	100	18	100	27	100

Ultraoligotrophic lakes: These are deep lakes in tectonic depressions with depths from 80 to 246 m, and possessing outlets. They are sparcely settled by aquatic plants. They are distributed in the valleys of the Selenga, Shishhid, and Kobdo Rivers. To this class belong Lakes Hoton, Horgon, Hyargas, Semsa and Hövsgöl. The average biomass of the zooplankton ranges from 0.31 to 0.81 g/m^3, with an average for all lakes of 0.3 g/m^3. The structure includes 45% copepods, 40% rotifers and 15% cladocera. The benthic biomass in such lakes amounts to between 1 and 5 kg/ha, and averages about 4 kg/ha. The most important benthic elements by weight are the chironomids, with molluscs in second place. Ichthyologically, the lakes belong to the *Thymallus – Oreoleuciscus* or *Thymallus – Brachymystax* type. The maximum fish production amounts to 10 or 15 kg/ha.

Oligotrophic lakes: Characterized by moderate depths, these lakes are of volcanic or karst origin. Their waters are cold. The development of aquatic biota is somewhat greater than in the former type. Lakes of this type are located in the Selenga, Kobdo, and Dzavhan River Valleys. They include Lakes Terhiyn Tsagaan, Dod Tsagaan, and Ayrag. Characteristic values for zooplankton biomass are 0.5 to 1.0 g/m^3, but the average overall is only 0.5 g/m^3. Planktonic fauna consists of 60% copepods, 30% cladocera, and 10% rotifers. The benthic biomass amounts to 4–16 kg/ha, and averages 10 kg/ha. Chironomids, oligochaetes, and molluscs of the genera *Pisidium* and *Sphaerium*, are predominant on the benthos in weight determinations. The amphipods are very richly represented. The most widely distributed fishes are *Brachymystax lenok*, *Thymallus brevirostris*, and species of *Coregonus* and *Oreoleuciscus*. The fish productivity averages about 15 to 25 kg/ha.

Table 2. The biomass of the zooplankton and zoobenthos in the types of lakes investigated

Type	Zooplankton g/m^3	Zooplankton mean g/m^3	Zoobenthos kg/ha	Zoobenthos mean kg/ha
ultraoligotrophic	0.31–0.81	0.30	1– 5	4
oligotrophic	0.50–1.00	0.50	4– 16	10
mesotrophic	1.00–2.50	1.50	17– 23	20
eutrophic	2.50–5.00	3.00	30–150	125
dystrophic	0.20–0.60	0.30	1– 10	5

Mesotrophic lakes: These originate from glacial activity or river erosion, possess an outlet, and have a depth between 5 and 10 m. These are among the most widely distributed lake types in wide areas of Central and Eastern Mongolia and in the Valley of the Great Lakes. They are rich in aquatic life, including a well developed shore vegetation. "Blooms" of individual species are not infrequent, and involve mostly blue-green algae or diatoms. Examples of this type are Lakes Buyr, Hoh, and Ugiy. The zooplankton biomass is between 0.5 and 2.5 g/m^3, and averages 1.5 g/m^3. It consists of 50% cladocera, 40% copepoda, and 10% rotifers. The benthic fauna is relatively diverse. Its biomass amounts to 17–23 kg/ha, and averages 20 kg/ha. Crustaceans predominate. Carp, crucian carp, perch and roach are present. The fish production of these lakes ranges between 20 and 30 kg/ha.

Eutrophic lakes: Shallow lakes with depths under 5 m, these have various origins, including glacial activity, river erosion and karst formation. The water is warmed from top to bottom in summer. The mud sediment is dark. This type of lake is widely distributed in the Darhatsk Basin and the Onon River Valley. Examples of this type include Lakes Tsoytson, Dsetsegd, Sumiyn and Tatsain Tsagaan. Zooplankton is frequently found in considerable quantities. Its biomass ranges from 2.5 to 5 g/m^3, and occasionally reaches 10 to 16 g/m^3 in particularly fertile spots. It averages 3.0 g/m^3 and consists of 45% cladocerans, 51% copepods, and 4% rotifers. Thickets of macrophytes are well developed, and green and blue-green algae predominate. Values of 30 to 150 kg/ha are characteristic for the benthic biomass. Molluscs, ostracods, water mites, and chironomids comprise significant proportions of the benthic aggregations. Silurid catfishes *(Silurus)*, burbot and houting live in these lakes.

Dystrophic lakes: These lakes are distributed chiefly in Eastern Mongolia. Their depths range from 1 to 5 m. The water has a yellow brown color. Vegetation is poorly developed. In the deeper regions of the muddy zone, benthic fauna is almost completely absent, with only occasional isolated diptera larvae (Tabanidae) present. The average biomass is about 5 kg/ha. The zooplankton is meagre. Its biomass averages 0.3 g/m^3 and ranges between 0.2 and 0.6 g/m^3. It is dominated by cladocerans, chiefly *Daphnia magna* STRAUS. Cyclopods, such as *Mesocyclops leuckarti* (CLAUS) and *Acanthocyclops viridis* (ZUR.) were also encountered. The lakes are poor in fishes, having populations composed mainly of *Parasilurus* and species of *Oreoleuciscus*.

The quantitative characteristics of the planktonic and benthic biota in the different lakes show that essentially distinctive qualities characterize each water body in regard to both total biomass and the individual groups of organisms present. In general, most of the lake systems mentioned in this work proved to be sufficiently rich in nutrient sources to support valuable fish fauna, and therefore, they have a comparatively high potential for fish production.

The Mongolian fish fauna followed a complicated path of evolution, related to the complete geolcgical rearrangement of the landscape, which caused the alteration of the connections between the individual river valleys, lakes and lake systems, as well as changing the climatic and hydrobiological conditions. Not infrequently, one species is widely distributed in warm, cold, fresh and salty water bodies, carrying out its activities and reproducing in rivers as well as lakes. The adaptation to different ecological conditions resulted in significant differentiation within single species. The houting has lake, lake-river, and river forms. Within the genus, *Thymallus*, four species evolved, while the Altai osman developed into three. The introduced Baikal omul has already begun to show morphological changes in its new environment, Lake Hövsgöl. The greatest species diversity (43 spp.) of the fishes is found in the waters of Eastern Mongolia, and a large number (22 spp.) are also found in the Selenga Valley. The waters of the Central Asian Basin have a less diverse fish fauna consisting of only 8 species. A total of 71 forms, species or subspecies, belonging to 11 families are found in Mongolia. They are listed as follows:

Petromyzontidae	(1)	Cobitidae	(7)
Acipenseridae	(2)	Siluridae	(2)
Salmonidae	(6)	Cottidae	(4)
Thymallidae	(5)	Gadidae	(1)
Esocidae	(2)	Percidae	(1)
Cyprinidae	(41)		

The zoogeographical review by BERG (1948) divided Mongolia's waters between the Circumpolar and the Mountainous Asian Sub-Regions. The Valleys of the Selenga, Shishhid and Bulgan Rivers belong to the Circumpolar Sub-Region. The Mountainous Asian Sub-Region includes the inner enclosed Central Asian Basin, with the Valley of the Great Lakes and the Valley of the Lakes. Eastern Mongolia, belongs to the Amur District.

The zoogeographical divisions here mentioned correspond to the fundamental distribution pattern of the fish fauna within the Mongolian territory, although the exactness of the boundaries is distorted by the penetration of individual species from one area into another.

The ichthyofauna in Mongolian waters is classified in the following faunistic complexes: Arctic freshwater, Boreal foothill, Boreal flatland, Chinese flatland and upper Tertiary freshwater. The Arctic freshwater complex includes members of the families Salmonidae and Gadidae (*Lota lota*). The Boreal flatland complex has the most species, dominated by members of the families Cyprinidae, Esocidae, Percidae, Cobitidae and Cottidae. The Boreal foothill complex is characterized by the family Thymallidae, a series of salmonid species (Lenok and Taimen), and the Altai osman, which lives in this complex while in the downstream portion of its range. The ancient upper Tertiary fauna complex consists of representatives of the ichthyofauna that remained from the preglacial period, such as *Gobio gobio*, *Pseudaspius leptocephalus*, *Rhodeus sericeus*, *Cyprinus carpio haematopterus*, *Misgurnus anguillicaudatus* and *Parasilurus asotus*.

Species especially characteristic of the Chinese lowland fauna are *Saurogobio amu-*

Table 3. Fishes of economic importance in Mongolian lakes

Species of fish	Lakes Ugiy and Terhiyn Tsagaan	Valley of the Many Rivers	Lake Hövsgöl	Darhatsk Basin	Valley of the Great Lakes	Valley of the Lakes	The Onon River Basin	Lake Buyr
Acipenseridae								
Acipenser baeri BRANDT	–	+	–	–	–	–	–	–
Salmonidae								
Hucho taimen PALLAS	+	+	–	+	–	–	+	+
Brachymystax lenok PALLAS	+	+	+	+	–	–	+	+
Coregonus lavaretus pidschian GMELIN	–	–	–	+	–	–	–	–
Coregonus lavaretus pidschian n. delger muren	–	+	–	–	–	–	–	–
Coregonus chadary DYBOWSKI	–	–	–	–	–	–	+	–
Coregonus autumnalis migratorius GEORGI	–	–	+	–	–	–	–	–
Thymallidae								
Thymallus arcticus PALLAS	+	+	+	+	–	–	–	–
Thymallus arcticus grubei DYBOWSKI	–	–	–	–	–	–	+	–
Thymallus nigrescens DOROGOSTAJSKI	–	–	+	–	–	–	–	–
Thymallus brevirostris KESSLER	–	–	–	–	+	+	–	–
Esccidae								
Esox lucius LINNÉ	+	+	–	–	–	–	–	–
Esox reicherti DYBOWSKI	–	–	–	–	–	–	+	+
Cyprinidae								
Rutilus rutilus lacustris PALLAS	+	+	+	+	–	–	–	–
Oreoleuciscus pewzowi HERZENSTEIN	–	–	–	–	+	+	–	–
Oreoleuciscus potanini KESSLER	–	–	–	–	+	+	–	–
Oreoleuciscus humilis WARPACHOWSKI	–	–	–	–	+	+	–	–
Leuciscus idus LINNÉ	+	+	–	–	–	–	–	–
Leuciscus leuciscus baicalensis LINNÉ	–	+	–	–	–	–	–	–
Ctenopharyngodon idella VALENCIENNES	–	–	–	–	–	–	–	+
Pseudaspius leptocephalus PALLAS	–	–	–	–	–	–	+	+
Hemibarbus labeo PALLAS	–	–	–	–	–	–	+	+
Hemibarbus maculatus BLEEKER	–	–	–	–	–	–	–	+
Erythroculter erythropterus BASILEWSKY	–	–	–	–	–	–	–	+
Erythroculter mongolicus BASILEWSKY	–	–	–	–	–	–	–	+
Culter alburnus BASILEWSKY	–	–	–	–	–	–	+	+

Cyprinus carpio haematopterus TEMM. et SCHL.	+[1]	+	–	–	–	–	+	+
Carassius auratus gibelio BLOCH	+	+	–	–	–	–	+	+
Hypophthalmichthys molitrix VALENCIENNES	–	–	–	–	–	–	–	+
Siluridae								
Parasilurus asotus LINNÉ	+	–	–	–	–	–	+	+
Gadidae								
Lota lota LINNÉ	+	+	+	+	–	–	–	–
Percidae								
Perca fluviatilis LINNÉ	+	+	+	–	–	–	–	–

\+ observed
– not observed
[1] Since a few years common in Lake Ugiy, immigrated through the Orchon river; economic use

rensis, *Erythroculter mongolicus*, *Hemicultur leucisculus warpachowskii* and *Hemibarbus maculatus*. The species of the last two complexes are the most notable for their variety of species and form the foundation of the Eastern Mongolian fish fauna. The zoogeographical complex of ichthyofauna in Eastern Mongolia is related to that of the upper Amur River. In its valley, there are two endemic genera, each with one species (*Mesocottus haetej* and *Pseudaspius leptocephalus*), as well as four other endemic species (*Esox reicherti*, *Acipenser schrenki*, *Coregonus chadary* and *Hemiculter leuciscūlus warpachowskii*).

The significant similarity of the fish fauna in the valleys of the Darhatsk Basin, the Selenga River and Eastern Siberia was caused by the former hydrographic connections and climatic conditions, which facilitated mutual exchanges among these waters. The presence of familiar species of the genera, *Oreoleuciscus* and *Thymallus*, in the Kobdo River Valley and in the upper course of the Ob, evidences an exchange of fauna in earlier times.

In Mongolia, there is a water network over 50,000 km long in areas which are more or less inaccessible for fishery. Approximately a thousand lakes have a total surface area of about 1,564,000 hectares. These waters have a great economic importance to the local population at this time. In addition, a great number of ducks and valuable fur-bearing mammals, such as muskrat, beaver, and otter live along the rivers, but are not economically exploited. Thus, the value of the products that can be obtained thanks to the biological wealth of Mongolia's waters, amounts to millions of tugrik.

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