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[Review article]

Contributions of Russian Scientists to the Research of Aquatic Ecosystems in Mongolia

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Abstract

The article gives the overview of the studies of the aquatic fauna and flora of Mongolia by the Russian (and Soviet) scientists for the period of more than a century. This history is divided into three periods: the first period covers the end of the 19th and the beginning of the 20th centuries, the second one – the middle of the 20th century and the third one – the last one third of the 20th and the beginning of the 21th centuries. The first period is connected with the research of Hubsugul Lake and Selenge River basin completely, the second period – with the works of Mongolian Commission and Science Committee of the Mongolian People's Republic. The third period started in 1970's with simultaneous organization of two important expeditions: the Joint Hubsugul Lake Expedition by the Irkutsk and Mongolian State Universities, and Joint Soviet-Mongolian Complex Biological Expedition by the Academy of Sciences of the USSR and the Mongolian Academy of Sciences. The latter expedition celebrates 40th anniversary of its permanent activity this year. In the second part of this paper the results of hydrobiological studies of this expedition led in 2000-2009 in the Selenge River basin are given.

Key words: Mongolia, aquatic ecosystems, hydrobionts, fishes

Introduction

The history of Mongolian water-bodies and waterways research began more than 100 years ago, and covers the end of the 19th whole 20th and the beginning of 21th centuries. Superiority in the studies of natural conditions of Mongolia with simultaneous research on hydrofauna and hydroflora of its water-bodies belongs mainly to outstanding Russian travelers. The data on animal communities in the lakes and rivers of Mongolia are present in the papers by Potanin (1883), Pevtsov (1883), Peretolchin (1903) and Grum-Grzhimaylo (1914).

Historical overview of the hydrobiological investigations in Mongolia

The history of hydrobiological and ichthyological studies of Mongolian water-bodies is divided by Russian scientists into three main periods.

First of them refers to the beginning of the last century and is connected with the study of Hubsugul Lake (Kosogol), largest freshwater lake in Mongolia, which is one of the main sources of the river Selenge and through it is directly connected with Baikal Lake. The first paper worth to mention is that of Peretolchin (1903), in which the author gives the data about streams, depths, coastline of the lake, as well as fishes and fishery in the lake Hubsugul.

The first hydrobiological material from the basin of Hubsugul Lake was collected by Elpatievsky in 1903 during his work on expedition of the Zoological Museum, Moscow State University. His collections were processed by several well-known scientists, as Dorogostayskiy (1904), Ostenfeld (1907), Oestrup (1908) and Daday (1906, 1913).

In the work of Dorogostayskiy (1904) the list of 52 algae species in Hubsugul Lake were given for the first time, and a great similarity of algae flora with that of Baikal Lake was marked. Only a few number of Hubsugul algae species

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were not registered in Baikal Lake, such as *Bulbochaete varians* Wittr., *Navicula radiosa* var. *acuta* Grun., *Gomphonema subtile* Ehr., *Achnanthidium flexellum* Bréb., *Synedra capitata* Ehr., *Nitzschia vermicularis* Hantzsch, *Cyclotella antiqua* W. Sm.

Ostenfeld (1907) gave detailed geographic and hydrographic characteristics of Hubsugul Lake, and also he provided the data on species composition of the planktonic and benthic algae in the lake, small residual lakes located on lakesides and the rivers, influent into the lake. Species composition of algae, revealed by this author is almost twice exceeded (96 taxa) the list of Dorogostayskiy (1904). Only six taxa were common for two lists. Ostenfeld (1907) described two new planktonic algae taxa (*Dinobryon kossogolensis* Ostf. and *Peridinium umbonatum* var. *elpatiewskyi* Ostf.) from lake Hubsugul.

The subsequent paper by Oestrup (1908) was also dedicated to diatoms, and the author cited 204 taxa and described 7 new species and 5 variations. Thus, after publication of three aforementioned papers, the species number of algae in Hubsugul Lake and its basin was reached to 315 taxa.

The papers of Daday (1906, 1913) were dedicated to the review of invertebrates collected by V. S. Elpatievskiy in Hubsugul Lake, small lakes on the lakeside and rivers, influent into the lake.

Berg (1906) treated the fish collections form lake Hubsugul, and pointed out the similarity between the faunas of Hubsugul and Baikal lakes, and hence he included Hubsugul into the Baikal subregion of Holarctic. Based on these collections, Dorogostaiskiy (1923) described a new subspecies of arctic grayling, *Thymallus arcticus nigriscens* Dorogostaisky, and Lindholm (1929) revealed the representatives of Baikal endemic fauna among mollusks from Hubsugul, and described a new species, *Kobbeltochocolea michnoi* Ldh.

At the end of 19th and beginning of 20th centuries in the basin of the Selenge River in Mongolia the research on amphibians were undergone by Pevtsov (1881), Radlov (1891) and Ruzskiy (1916). To the basin of the river Selenge in Mongolia, the collections of expeditions leaded by P.K. Kozlov in 1924 and 1926 also should refer. The obtained materials were generalized in several papers by different authors (Bedryaga, 1898; Nikolskiy, 1905, 1918; Zarevskij, 1930). The first faunal review of the amphibian fauna of Hubsugul Lake region was made by Bannikov (1958).

The second period in research of hydrobionts of Mongolia began in the 20s and prolonged until the end of the 50s of the last century. An important role in the development of scientific research in Mongolia was played by Mongolian Commission, created in the USSR in 1925. The tasks of Mongolian Commission included organization and realization of expeditionary studies in Mongolia, publication of the research results and help rendering in activity of the Science Committee of Mongolian People's Republic, established in 1921. Large-scale geographic studies, which covered previously unknown areas, were organized in that period by the Mongolian Cmmision. In particular, the materials on morphometry and paleogeography of the lakes and river hydrogeography were obtained (Smirnov, 1932; Murzaev, 1952; Kuznetsov, 1959).

It is necessary to point out the study of hydrofauna of the upper reaches of the Selenge River, made by A. Dashdorzh in 1944-1945. The samples of water, plankton and benthos from the rivers in northern Mongolia, collected by A. Dashdorzh were treated by the fellows of the Irkutsk State University, A.V. Samarina and G.V. Vasileva. In the same collections, Kozhov (1946) revealed a representative of Baikal fauna, *Choanomphalus mongolicus* Kozovi; Bazikalova (1946) – a new species of amphipoda, *Rivogammarus kozovi* Bas.; Levanidov (1947) described four species of caddis flies; Borutskiy (1959) described two new species of Diaptomidae (*Arctodiaptomus anudarini* and *A. dachuricus*) and gave zoogeographic analysis of Calanidae fauna; Lukin (1958) processed the collections of leeches.

In 1953, Dashdorzh defended successfully his thesis work "To the knowledge of the water-bodies and hydrofauna of eastern and northern Mongolia (the Amur and Selenge basin on the territory of Mongolian People's Republic)". Ichthyological collections of Dashdorzh were deposited in the collection of Zoological Museum, Moscow State University, which was used by Nikolskiy (1956) in the writing of the book "The Fishes of the Amur Basin".

From the beginning of the 60s, the third period of the study of the lakes and rivers of Mongolia began. By that time, the work on faunistic inventory is finished.

In that period the studies on biology of commercial fishes were begun, and the age composition, growth rate and economical values of several fish species were specifically investigated.

In 1959-1960 at the lake Hubsugul a Joint Biological Expedition of the Irkutsk and Mongolian State Universities, headed by A.A. Tomilov and A. Dashdorzh was initiated. Based on expedition's materials, the first quantitative evaluations of planktonic organisms of Hubsugul Lake were made. It was shown that in summer, zoo- and phytoplanktons of the lake were very meager, which was similar to open waters of Baikal Lake (Kozhov *et al*., 1965). Borutskiy (1972) revealed a new crustacean species *Moraria* (*Baicalomoraria) tomilovi* Borutzkyi. The materials on parasites of commercial fishes were collected and treated (Tomilov & Cherepanov, 1967).

A great contribution to the study of hydrobionts in Hubsugul Lake was made by the second complex expedition of Irkutsk and Mongolian State Universities, which began to work in 1970. In that years microbial communities of the bottom and water column, chlorophyll content, phytobenthos, qualitative and quantitative composition of phytoplankton and its seasonal and yearly dynamics, primarily production, trophic relationships in pelagic zone of the lake and many other issues were studied. The results of studies were published in several books as "Natural Conditions and Resources of Hubsugul Region" (1972-1978), "Natural Conditions and Recources of Hubsugul Territories in Mongolian People's Republic" (1976) and in the "Atlas of Hubsugul Lake" (1989). In particular, one of these books contains an important review paper on fish fauna (Dashdorzh & Demin, 1977) and fish parasites in Hubsugul Lake (Pronin, 1972, 1976).

The study of hydrofauna was intensified substantially with organization of the Joint Soviet-Mongolian Complex Biological Expedition (later named as Joint Russian-Mongolian Complex Biological Expedition) by the Academy of Sciences of USSR and Mongolian People's Republic in 1970, and creation of an ichthyological team in this expedition in 1975.

The results of the works of this team were published in two volume monographs, "Fishes of the Mongolian People's Republic" (1983) and "Ecology and Economic Importance of Fishes of the Mongolian People's Republic" (1985).

In the first volume, an overall characteristic of the water-bodies and rivers of the country is given, the species composition of phyto- and zooplankton, review of fish fauna, identification keys, morphological description, chromosomal set, comparison with relative species and distribution of all 58 fish and one lamprey species are provided, along with information on the history of Mongolian fish fauna formation is considered. In the second volume, the results of the studies on ecology (distribution in the water-body, reproduction, feeding, growth, role in the ecosystem) of 25 common and some endangered fish and one lamprey species are given. Also the economic importance of fishes of Mongolia is estimated.

Dgebuadze (1986) published a detailed list of fish species of three water basins and carried out an analysis of fish communities with use of ratio of representatives of different living forms and ecological guilds of fishes in the basic water-bodies in Mongolia. Later, it was created a list and generalized the data on the rare and endangered fish species (Dgebuadze & Dulmaa, 1996).

The detailed production and hydrobiological studies made in 1978-1980 covered almost all the country, and published a monograph "Limnological Sketches of Mongolia" by Boulion (1985). It concludes the data on biological productivity of 16 lakes from different parts of Mongolia, rate of plankton photosynthesis, heterotrophic activity of bacteria, photosynthetic pigments, phosphorus and organic matter concentration in water.

An important result of the work of the team was a monograph "Nematodes of the fresh and brackish waters of Mongolia", written by Tsalolikhin (1985), including detailed description of 47 species of free living nematodes from 28 lakes and 13 rivers with the identification keys and a review of the origin, formation and development of the fauna of nematodes of Central Asia.

Paleobotanical team, worked in the frame

of this joint expedition in 1971-1980, made a considerable contribution to the study of lakes history of Mongolia. The study of rock-drill mountings of the bottom sediments by different biological methods allowed reconstruction of the changes of the levels of lakes, vegetation and climate in the late Quaternary time at reliable radiocarbon dating and publication of a large series of articles (Vipper *et al*., 1976, 1978, 1981, 1989; Smirnov, 1978; Dorofeyuk, 1988a, 1992; Dorofeyuk & Tarasov, 1998; Sevastyanov & Dorofeyuk, 1992; Sevastyanov *et al*., 1989; Tarasov *et al*., 2000a, b; Rudaya *et al*., 2009) and chapters in monographs (Gunin *et al*., 1999; Tarasov *et al*., 2004).

The results of algological analysis of the bottom sediments of freshwater lakes in Mongolia were obtained during the implementation of project "Synthesis and Paleoclimatic Interpretation of Late Quaternary Lake-level Records from Northern Eurasia" (Tarasov *et al*. 1994, 1996).

The taxonomic composition of diatoms in Mongolia was supplemented considerably. In Holocene sediments of nine lakes were registered 505 taxa of diatoms, from which 357 were new for Mongolia (Dorofeyuk, 1977, 1978, 1984, 1985, 1988b, 1992, 1994). Overwhelming majority of diatoms revealed in the bottom sediments lives also in modern waters. Based on their own data and analysis of literature sources, Dorofeyuk and Tsetsegmaa (2002) published a monograph, "Conspectus of Algae Flora of Mongolia", in which the data on distribution of 1574 taxa are included.

At the beginning of 1990s the collective authors published a monograph, "Methodology of ecological assessment of contemporary state of water ecosystems of MPR" (Sevastyanov *et al.* 1990), which was used further for the creation of the map "Ecosystems of Mongolia" (1995).

The first comprehensive basis on modern condition and history of the water-bodies of Mongolia is the book, "Limnology and paleolimnology of Mongolia" (Sevastyanov *et al.* 1994).

The book considers the questions of spatial distribution of the lakes, their genesis, and also hydrobiological characteristics of lacustrine water-bodies of Mongolia; the composition of microflora, phyto- and zooplankton, zoobenthos and ichthyofauna of these lakes are also given. On the basis of paleontological materials, the history of the lakes, starting from the Jurassic age to Holocene inclusive is elucidated. In the concluding part of the book the questions of recreation use of the lakes and basic nature-conservative measures, which can favor conservation and reproduction of lacustrine basins and their fish resource, are discussed.

In the aspect of ichthyological works in the last 25 years of the last century and beginning of the current century, the studies of unique endemic group of cyprinides – Altai osmans (genus *Oreoleuciscus*) were carried out. These fishes are characterized by exclusively high morphological and ecological variability, and selected them as a model group for research of diversification processes,. Originaly Varpakhovsky (1889) who described *Oreoleuciscus*, determind 8 species and 3 subspecies in the genus. Berg (1912) combined these taxa into three: *O. humilis*, *O. potanini* and *O. pewzowi*. Later morphological studies of Altai osmans have stimulated discussion on taxonomic status of five morphotype, which have been found in waters of Central Asiatic close basin (Ioganzen, 1940; Kafanova, 1961; Svetovidova, 1965; Gundrizer, 1976; Dgebuadze, 1982; Vasilieva, 1982; Baasanzhav *et al.*, 1983; Borisovets *et al*., 1984; 1985, 1987; Bogutskaya, 1990; 2001). Studies of ichthyological team also provided original data on reproduction, growth, feeding and parasites of Altai osmans (Dgebuadze & Ryabov, 1978; Baasanzhav *et al.*, 1985).

In the course of long-term research on periodically drying waters in the Lake Valley, a unique natural situation was revealed, which allowed describing the mechanism of diversification of Altai osmans at the late phases of ontogeny. Actually, it was demonstrated how a dwarf form of Altai osman turned into a lacustrine one (Dgebuadze, 1995). It was established that Altai osmans on the territory of Mongolia populated not only the waters of the Central-Asian closed basin, but also the rivers, small lakes of the Selenge River basin (Dgebuadze *et al.*, 2003, 2009). An evaluation of the degree of population difference of Altai osmans out of all main parts of the range of their habitats in Mongolia with the use of methods of osteological (Dgebuadze *et al.*, 2008), and population genetic analysis were carried out (Slynko & Dgebuadze, 2009).

Results of long-term fish ecology observations in Hubsugul Lake were generalized by Tugarina (2002). Knizhin jointly with other scientists

obtained interesting data on morphological and genetic variability of graylings in the Selenge River basin. They have suggested that grayling from Hubsugul Lake is subspecies of the Baikal grayling — *Thymallus baicalensis nigrescence* (Knizhin *et al.*, 2006). They consider also that arctic grayling in Mongolia not inhabited the Khovd River basin, but Mongolian grayling *Thymallus brevirostris* forms two morphotypes (Knizhin *et al*., 2008).

Hydrobiological investigations in the Selenge River basin

From the beginning of 21th century the main task of Russian hydrobiologists and ichthyologists has begun an evaluation of condition of water ecosystems of Mongolia under global climatic changes and anthropogenic impact, especially of the waters of the Selenge River basin. The importance of the Selenge River for Russia and Mongolia can hardly be overestimated. First, the river is a basic water-way, which feeds a unique water body – Baikal Lake. Second, catch basin of the Selenga River is located in the territory of two countries. In connection with this a great attention was paid to analysis of those changes, which happened in the water bodies and waterways of the Selenga River basin at recent years under an influence of climate change and human activity (primarily gold and other minerals mining). These effects are connected with the growth of temperature, chemical pollution, eutrophication, changing of the river flowing off character and lacustrine level regime, fishery, disappearance of habitats of amphibians and other organisms.

Some of the results of these studies have been published (Dgebuadze, 2004; Dgebuadse *et al*., 2003, 2005; Prokofiev, 2007a, b, c), but the greater part is presented in a monograph, "Aquatic Ecosystems of Selenge River Basin" (Dgebuadze *et al*. 2009). In the course of these works the studies on 7 lacustrine and 10 fluvial ecosystems of the Selenge River basin including its main riverbed were carried out.

In the ecosystems of Selenge River basin 176 species (including hybrids) of aquatic and semi-aquatic plants from 73 species and 37 families were found (Papchenkov, 2010).

The list of algae of the lakes and tributaries in the Selenga River basin consists of 1304 taxa (1105 species) refer belonging to 261 genera, 16 classes and 5 divisions (Dorofeyuk, 2009). Diatoms are remarkable for their high taxonomic diversity (Bacillariophyceae) - the most studied group of Mongolian algae (830 species and intraspecific taxa or 63.3% of revealed flora). In the work by Kulikovskiy *et al*. (2010) a new genus, *Boreozonacola* Lange-Bertalot, Kulikovskiy & Witkowski, 18 new species and 13 new combinations of diatoms were proposed, along with microphotographs of 242 taxa.

The greatest values of primary production in the lakes were registered in undersurface horizons of water, where photosynthetic activity is increased with decreasing of the size and depth of the water-bodies. Compared to 1970s and 1980s of the last century, an increase in trophic ability was marked (Korneva, 2009).

In the rivers and lakes of Mongolia, 43 taxa of heterotrophic protest-flagellates were found. The orders, Choanoflagellida, Kinetoplastida, Bicosoecida and Cercomonadida were presented with large species number. Total number and biomass of bacterial plankton in the rivers of the Selenge River basin fluctuated greatly also. According to the number of bacterial plankton, the rivers correspond to the categories of "polluted" and "satisfactory purity" (Kopylov *et al*., 2009).

In the examined water-bodies and waterways of the Selenge River basin, 80 species of plankton invertebrates, widespread in Palaearctic region were found. The diverse groups were constituted by Rotifera (47 species), Cladocera (22 spp.) and Copepoda (11 spp.). The prevalence of rotifers in the lakes evidences to a high content of organic and biogenic substances, receiving from drainage area; in the rivers their superiority is explained by high flow velocities (Krylov & Dulmaa, 2009).

In composition of macro-zoobenthos of eight lakes and the river Tuul, 76 species are revealed, from which 42 are recorded for the first time in Mongolia. The largest number of new species (33 species) is marked for Chironomidae. In the studied lakes the insignificant growth of macro-invertebrate productivity is observed, but in macro-zoobenthos composition the reservoirs are characterized as β-meso- and/or α-mesosaprobe waters (Shcherbina *et al*., 2009).

The studies of fish populations in recent years (2000-2009) allowed to expand the list of

Selenge River basin species substantially. This is connected with new findings (Prokofiev 2007a, b, c), as well as continuing process of invasion of alien species (Dgebuadze, 2004; Dgebuadze *et al.,* 2009).

One of the main factors, influencing on fish populations is gold mining in the rivers of the Selenge basin (Dgebuadze *et al.*, 2005). In particular, in the spawning rivers of the basin, where gold mining is going on, substantial silting of the grounds has led to violation of spawning condition of valuable salmonid fishes (taimen, lenok and arctic grayling). An increase of water turbidity, the lowering of flow velocity and heterogeneity of environment at separate sections, chemical pollution led to a drastic fall in number of rheophilic and oxyphilic fish species (taimen, lenok, arctic grayling, minnows), and to a growth of populations of the species adapting to new environment (golden carp, dace) (Dgebuadze *et al.*, 2009).

in meadow research station "Shaamar" and the route investigations in the northern and central Mongolia in 1983, 1984, 1990, 2007 and 2008 was carried out by Kuzmin. As a result of the studies on ecology of amphibians, the data on distribution, habitats, development, feeding and their role in water-meadow ecosystems were collected. The results were presented in the collected articles, "Herpetological studies in the MPR" (Vorobieva, 1986) and in a monograph, "Amphibians and Reptiles of the Mongolian People's Republic (Vorobieva & Darevskiy, 1988). In recent years, the issues of conservation of amphibians in connection with the worsening of conditions of the Selenge River basin as a consequence of prolonged drought in combination with a sharp increase of anthropogenic pressure on ecosystems are performed (Kuzmin, 2009).

The carried out evaluation of toxicological condition of lakes and rivers of the Selenga River basin has shown that their bottom sediments are classifying as not polluted. Only in local sections are marked as polluted, which were evoked either by the industrial wastewaters (particularly of the industrial complex of the city of Erdenet or by intensive gold mining). It is revealed that the sediments of the river Selenge in the closest to Mongolian and Russian boundary area are not toxic, which allow to assume the absence of direct negative influence to Baikal Lake from the main tributary of Mongolian part of drainage area (Pavlov *et al*., 2009).

All foregoing data allows concluding that the lakes and rivers of the Selenge basin are in breaking point. Several sections of the rivers located below the cities, rivers with intensive gold mining, and reservoirs with throw in bank zone are in condition of ecological crisis. There is a danger of substantial broadening of the zones of such critic situation.

As the priority measures of conservation of the unique water ecosystems of the Selenge basin can be suggested following: control and prevention of residential, industrial and transport waste waters into the water-bodies of the Selenge basin, realization of the rivers re-cultivation on which gold mining is going on, prohibition of throws along the banks of lakes and rivers and realization of other forest-protection measures, control of the process of alien species invasion.

Great attention should be also paid to other basins of Mongolia at present. In particular, the global warming led to the change of water cycle and water-bodies of the Central-Asian closed basin. Anthropogenic load on the water bodies of the basin is connected, first of all, with the construction of hydraulic structures (dams in the basins of the Khovd and Zavkhan rivers), increase of pollutions, and intensification of fishery. Evaluation of present condition of aquatic ecosystems and population parameters of hydrobionts of this basin remains as main purpose of hydrobiological research for the coming years.

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Хураангуй

Энэхүү өгүүлэлд сүүлийн зуу гаруй жилийн хугацаанд Оросын (Зөвлөлтийн) судлаачдын хийж гүйцэтгэсэн Монгол орны усан сангийн амьтан, ургамлын аймгийн судалгааг тоймлон өгүүлэв. Уг судалгааг 3 үе болгон ангилж болох бөгөөд эхний үе нь XIX зууны төгсгөл, XX зууны эхэн үеийг, 2-р үе XX зууны дунд үеийг, төгсгөлийн үе XX зууны төгсгөл, XXI зууны эхэн үеийг хамарч байна. Гидробиологийн судалгааны эхний үед зөвхөн Хөвсгөл нуур, Сэлэнгэ мөрний сав газарт судалгаа хийгдэж байсан бол, 2-р үеийн судалгаа Монголын Комисс, Монгол улсын Шинжлэх ухааны хүрээлэн байгуулагдсантай холбогдоно. Харин судалгааны 3-р үе нь 1970-аад онд үндэслэгдсэн МУИС, Эрхүүгийн их сургуулийн хамтарсан Хөвсгөл нуурын хамтарсан биологийн экпедици болон, Монгол, Оросын ШУА-ийн хамтарсан Биологийн иж бүрэн экспедицийн үйл ажиллагаагаатай шууд холбоотой. Монгол, Оросын ШУА-ийн хамтарсан экспедици энэ онд зйл ажиллагааныхаа 40 жилийн ойг тэмдэглэж байна. Өгүүлийн сүүлийн хэсэгт 2000-2009 онуудад дээрх экспедицийн хүрээнд хийгдсэн Сэлэнгийн сав газрын гидробиологийн судалгааны үр дүнг нэгтгэн тусгав.

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