Advances in Biology & Earth Sciences
Vol.6, No.2, 2021, pp.158-168

THE ORIGIN AND ZOOGEOGRAPHIC ANALYSIS OF THE FRESHWATER FAUNA OF THE RIVERS OF AZERBAIJAN

S.I. Aliyev[1,2*]

[1]Baku State University, Baku, Azerbaijan
[2]Institute of Zoology, Azerbaijan National Academy of Sciences, Baku, Azerbaijan

Abstract. The article provides detailed information on the formation of freshwater fauna in the rivers of Azerbaijan, its main stages and distribution areas. By analyzing the fauna complexes formed in the country, a clear idea of the number, composition and peculiarities of the species is formed.

Keywords: *freshwater, fauna, rivers, species.*

***Corresponding Author:** Saleh Aliyev, Baku State University, 23, Zahid Khalilov, AZ1148, Baku, Azerbaijan, e-mail: alisaleh56@mail.ru*

***Received**: 22 June 2021; **Accepted**: 02 August 2021; **Published**: 30 August 2021.*

1. Introduction

The systematic composition of freshwater reservoirs of such a heterogeneous country in terms of physical and geographical conditions as the Caucasus is naturally very variegated. Therefore, first of all, it is necessary to understand the species composition of the fauna and break it down into faunistic complexes. As a result, we will obtain sufficiently reliable material for judging under the influence of which faunistic complexes the freshwater fauna of the Caucasus developed and which of them constitute its core. For the latter, the routes and time of penetration of various fauna into the Caucasus should also be established, considering the paleontological material. After clarifying these issues, it will be possible to outline individual faunistic complexes in the composition of the freshwater fauna of the Caucasus and, finally, draw a general picture of the history of the formation of the freshwater fauna of the Caucasus based on the data obtained.

The water bodies of the Caucasus are inhabited by the fauna of several landscapes that have historically different ages, sharply differing not only in composition, in relation to the environment, but also in origin. Therefore, the study of the composition of individual complexes, the patterns of the geographical distribution of individual species of animals, the analysis of differences in the distribution and origin of one or another species and the elucidation of the causes of these differences is of great theoretical and practical importance.

At present, zoogeography of continental water bodies can be considered an independent science or a section of zoogeography, although its existence was considered controversial for a long time. The argument was that the distribution of freshwater animals is subject to the same laws as the distribution of terrestrial animals. However, the studies of Academician Berg (1934, 1940), Dzhadin (1952) and other scientists have shown that such views are groundless and are easily refuted by facts obtained in the analysis of the geographical distribution of freshwater animals, in

particular the fauna of fish and mollusks. Fish, in comparison with other freshwater animals, have an extremely important role in the zoogeographic zoning of individual land areas. Since fish settle in the water bodies of the globe slowly, they have retained the ancient features of distribution (Abdurahmanov, 1960). In addition, their species composition has been studied in more detail than that of invertebrates (Burchak-Abramovich, 1951). Therefore, in the work, a lot of attention is paid to fish, which clearly indicate the influence of climate.

2. Material and methods

Currently, the main methods of zoogeography are: 1) genetic-geographical, with the help of which the areas of distribution of species and the similarity of the investigated fauna with the fauna of other regions are analyzed; 2) paleontological, establishing the similarity of the modern fauna with the fauna of the past; 3) an ecological method based on an analysis of the living conditions of each organism.

In the zoogeographic analysis of the freshwater fauna of the Caucasus, along with the analysis of paleontological data, we took as a basis the faunistic complexes of Nikolsky (1953), who used them in the genetic analysis of the fish fauna of the Amur basin and other rivers of the Soviet Union.

Thus, by a detailed analysis of the ecological characteristics of individual species that make up the complex, we can restore the conditions in which the formation of this or that faunistic complex took place. It should be considered that the development of each complex proceeded in a certain landscape zone in its inherent specific feeding conditions. However, Yakovlev (1962), contrary to the opinion of Nikolsky (1953), believes that "the specificity of modern faunistic complexes is associated with more general manifestations of climate than those that determine the landscape-geographic zoning of the land. Fish, very close to modern ones in their morpho-biological characteristics, appear long before the emergence of modern landscape-geographical zones". It seems to us that the modern composition of faunistic complexes was formed in certain landscape zones in specific climatic and forage conditions, since climatic zones north of the tropics existed from the early Tertiary time and were located the same as now. This is confirmed by the fact that in the Tertiary period, Eurasia and North America were connected and the climate in connection was sufficient warm to ensure the exchange of many fish in the temperate zone. Therefore, the species that are part of each complex are organically linked between the fish and the surrounding biotic and abiotic environment. The species that form the complex in water bodies occupy various ecological niches and between them there are certain interspecific relationships. These include discrepancies in the dietary spectrum, adaptation of predator and prey, and differences in biology. reproduction (Nikolsky, 1953). The exclusion of one of these links leads to a radical restructuring of the entire complex, and with skillful use - to an increase in the fish productivity of reservoirs. Thus, the existing relationships between species within the faunistic complex are unstable, although they historically developed during the formation of the complex (Nikolsky, 1953). Consequently, these relations change as the complex is formed and they can be changed in the direction necessary for a person.

Based on the analysis of the fish fauna of the rivers of the USSR, Nikolsky (1953) identified 12 faunistic complexes: boreal foothill, boreal plain, arctic freshwater, arctic marine, tertiary plain freshwater, Pontic-Caspian fresh-water, Pontic-Caspian Sea, Near

Asian, highland sky, Turkestan plain, Indo-African, Chinese plain.

As part of the freshwater fauna of the Caucasus, we distinguish the following faunistic complexes by their origin: 1) Western Asia, 2) Mediterranean, 3) Ponto-Caspian freshwater, 4) Arctic freshwater, 5) tropical and subtropical, 6) Caucasian, 7) boreal (Alekperov, 2016). Each of these complexes is distinguished by its inherent habitat conditions and has a different degree of expression in the water bodies of the Caucasus (Bogachev, 1961). Prior to reviewing the characteristics of these complexes, it should be noted that each of them has a certain species composition, its own ecological appearance and area of a sufficiently long geological time.

Near Asian Complex. The boundaries of three zoogeographic regions converge within the limits of Western Asia: Holarctic, Sino-Indian and African (Berg, 1962). Therefore, in Near Asia we find two transitional regions: the Syrian, transitional between the Holarctic and African, and the Mesopotamian, transitional between the Holarctic and Sino-Indian.

The development of the Near Asian faunal complex proceeded in parallel with the formation of water bodies in Near Asia, Iran, Arabia, Syria, Palestine, Mesopotamia, Balujistan and Afghanistan. The paleogeographic conditions of Near Asia at the end of the Tertiary and Quaternary periods are highlighted in the work of Sinitsyn (1962), according to which in the Miocene there was a sea in the place of Central Iran, which later became shallow and disintegrated into separate salinized water bodies. In the Pliocene, the uplift of the Iranian plateau and the surrounding mountain ranges intensified, and the Taurus and Zagros mountains are higher.

In Near Asia in the Miocene, the sea was preserved only in the region of the southwestern Taurus, Turkish Mesopotamia and northwest of the lake Van. The interior regions of Near Asia were covered with freshwater lakes, in the sediments of which the mollusks *Planorbis and Bithynia* were found. The Pliocene for Near Asia is characterized by the uplifting of mountain ranges and the preservation of the regime of large lakes, but under different conditions. The Arabian Peninsula in the Neogene remained dry land, and Mesopotamia in the early Miocene was covered by the sea up to the foothills of the Taurus (Baryshev, 2014). At the beginning of the Pliocene in Mesopotamia, the sea was preserved only near the modern Persian Gulf. In the northwestern part, a landscape of an alluvial plain emerged with the large rivers Paleoevfrat and Paleottigrom. The Pliocene for Baluchistan is characterized by further cooling and watering of rivers associated with the uplift of the Himalayas.

In the Quaternary period, the Pliocene lowlands of Iran turned into high plains and plateaus, and the former plateaus became highlands. Pleistocene glaciation is noted only for the northern slope of Elburs and the western part of the Zagros. The border of the glaciers in Elbrus and Zagros passed at an elevation of 3000–3200 m. As a result, a pluvial regime was observed in the inner regions of the Iranian plateau.

In the Pleistocene, Near Asia experienced further uplift. Quaternary lacustrine deposits with a rich fauna of molluscs were found in the basins of the plateau and in the intermontane basins of Near Asia: *Viviparus, Valvata, Planorbis, Bithynia*. This fauna is more like the fauna of the Balkans and the USSR than to the fauna of Syria and Palestine (Baryshev, 2015; 2019).

During the periods of glaciation, the cooling spread to Near Asia. Glaciers up to 10 km long appeared in the eastern part of the Taurus. Isolated glaciers were even within the Anatolian plateau.

The foregoing allows us to conclude that at the end of the Neogene and in the

Pleistocene, freshwater bodies of Western Asia underwent a sharp change. These changes for the freshwater fauna of the Near East were mainly unfavorable, expressed in the impoverishment of the species composition of the fauna of the Near East faunistic complex.

The Near Asia complex includes 14 species and subspecies: turbellaria - *Phagocata armeniaca*, crustaceans - *Hemidiaptomus monticola*, *Asellus monticola*, caddis flies - *Hydropsyche consanguinea*, *Psychomyia shelkovnikovi, Plectrocnemis latissima, Siloambel proximus flexuosus, Orthetrum anceps*, fish - *feuciscjis cephalus orientalis, Alburnoides bipunctatus fasciatus, A. bipunctatus eclvwaldi, Varicorhinus capoeta, V. capoeta sevangi*.

The distribution of the crustacean *Hemidiaptomus monticola* is limited to the lakes of the Lesser and Greater Caucasus and Turkish Kurdistan. Of the 13 species and forms of the genus *Hemidiaptomus* in Near Asia, two species have been found so far (*H. monticola, H. kummerlòwei*), which is explained by the poor knowledge of the copepod fauna (Bezmaternykh, 2016).

Ecologically, the Near Eastern species are confined mainly to mountainous and foothill zones of rivers and feed on fouling stones, phytoplankton, remains of higher plants, plant detritus, and partly animal food. Most of this fauna is stenothermal and oxyphilic. Its representatives live on stones and stony ground of transparent rivers with cold summer water temperatures. The bentonic animals of this complex are exclusively lytoreophilic. The fauna of fish of the Central Asian complex, according to S. Berg (1949), is fully the fauna of the desert, confined to drainless water bodies, and it can be characterized as the fauna of water bodies of mountain feeding around dry subtropics. According to Yakovlev (1964), fish of this group (*Barbinae, Cyprinodontinae, Nemachilinae*) have closest relatives in the waters of South Asia and Africa, which indicates a more southern origin of the complex than the boreal one. "He further notes that poverty The species composition of the Central Asian complex is associated with aridization and a corresponding deterioration of conditions in the drainless water bodies of the plain areas.

Thus, we believe that the formation of the Near Asian complex of the Caucasus took place in the Lower Pliocene, but was finally formed in the Pleistocene under the influence of factors of the pluvial epochs, since most of the fauna of the Near East complex perished under the conditions of the pluvial epochs, accompanied by an increase in water turbidity, the amount of suspended solids and the destruction of fodder base for fish. As a result, species have survived that entered stagnant water bodies and could feed on plant debris. The main abiotic factors of the environment under which the formation of the Near East complex proceeded were the strong flow of water in the rivers, its turbidity and the absence of animal food. In similar abiotic and biotic environments in the rivers of Western Asia, animals eating only plant food could form, since at that time there were no bentonic animals and rheoplankton in the riverbeds, and there was always enough food in the river water flows and in the coastal zone. the form of remnants of terrestrial plants. Therefore, the species that make up the Western Asian faunal complex are mainly stenophages. However, in the future they underwent some environmental changes. For example, the *Epallage fatlme* larva, apparently, initially fed on plant debris, but then, in order to rapidly grow and develop, switched to feeding on mixed food - mayflies, caddis flies, freckles, chironomids, living with it in the same biotope.

Fish can be considered the most ancient components of the Central Asian

complex. All the rest of the groups of this complex are younger and became part of the Near Asian complex, apparently under the influence of the cold of the ice ages. Ecologically, this group has adapted to life in mountain rivers and springs and is distinguished by great demands on the purity of water. Therefore, its representatives also habitats in hot countries in mountain rivers, characterized by low water temperatures. According to modern views, the fauna of mountain rivers in temperate and high latitudes of the northern hemisphere is a relic of the Ice Age. The fauna of the mountain streams of tropical and temperate latitudes of post-glacial origin developed because of the gradual migration of organisms to high-mountain reservoirs from the plains.

The poverty of the Near East complex, as noted above, is explained by the conditions of the pluvial epochs. But this does not mean that the entire fauna of the rivers of Western Asia was destroyed in the pluvial epoch. Of course, some part of the former fauna remained in them, mainly fish and partially benthic animals from the group of littoreophiles, while psammorheophiles and peloreophiles were destroyed. As a result, the riverine biocenoses of Western Asia remained unsaturated. Their later enrichment occurred not due to the forms of stagnant water bodies, but due to the Mediterranean fauna and fauna of other faunistic centers.

Mediterranean Complex. Mediterranean species have an extensive distribution area, but in most cases, they are clearly kept within the boundaries of the Mediterranean region.

The Mediterranean fauna is biologically not very demanding on the conditions of existence and often with a rather wide ecological amplitude, contributing to the spread of species far beyond their original range. These types of distribution are mainly confined to water bodies located along the Sea Coasts, from where Mediterranean species have spread in various directions, especially very far to the north. A wider wave of propagation is observed in the west towards the Atlantic coast and in the east - in the reservoirs of the Black Sea and Caspian coasts and Central Asia (Ibrahimov, 2018). In the reservoirs of Near Asia (Iran and Turkey), they are undoubtedly found in greater numbers, which is facilitated by the similarity of the natural-historical conditions of these countries with the Mediterranean countries. In the fauna of the Caucasus, the species of the Mediterranean complex have a wide geographical distribution both in the water bodies of the lowland and in the foothill zone.

The composition of the Mediterranean faunal complex of the Caucasus includes 174 species and forms: leeches - *Limnatiis nilotica, Herpobdella lineata; molluscs - Physa acuta, Planorbis planorbis subangulatus, Anodonta cyrea, Melanopsis praerosa*; dragonflies - *Agrion splendens, Sympicna fusca, Ischnura pumilio, Crocothemis erythraea. Coenagrion puella, C. mercuriale, C. scitilum, C. Undeni, Aeschna affinis, Orthetrum brunneum, Lestes barbata, L. viridis, Onychogomphus forcipatus, Sympetrum meridionale, S. striolatum, 8. sanguineum, S. depressiusculum, S. fonscolombei, Anax imperator, A. parthenope*; beetles - *Ochthebius marinus meridienalis, Hydroporus marginalis; Oreodytes halensis, Dytiscus dimidiatus, D. persicus*; midges of the entire genus *Friesia* (5 species) - *Wilhelmia mediterranea, W. paraeqttina, dUmulium tarnogradskyi*; bull-goby - *Pomatoschistus Caucasians*; eagle fish - *Syngnathus ntgrollneatus caspius*; atherina - *Atherina-mochon pontica, A. mochon pontica natio caspla.* The range of the leech Limnatus nilotica extends from the Iberian and Balkan Peninsulas, North Africa to Afghanistan and India. In the USSR, it was found only in Turkmenistan in the river Murghab and in the Caucasus. Another species

of leech, *Herpobdella lineata,* is a eurytopic species, but prefers mainly small, very warming water bodies. From the fauna of mollusks *Physa acuta* appeared in the reservoirs of Azerbaijan in 1955 and was first discovered in the quarries of env. Mingechaur. Aquarium lovers played the main role in its settlement. Environmentally *Ph. acuta* is a eurytopic species but lives mainly among aquatic plants. Prefers reservoirs with high water temperatures (25-39°C). *Melanopsis praerosa* is a typical lithoreophilous species confined to shallow transparent rivers with high oxygen saturation of water. In the reservoirs of the Greater Caucasus, with the exception of small rivers (Karasu) of the Zagatala subtropical region, it is absent. These rivers are fed by spring, not associated with the glaciers of the Greater Caucasus.

The most diverse group among the Mediterranean fauna are aquatic beetles, accounting for about 61% of the total fauna. Most of them are eurytopic, confined to life in the aquatic environment. But some beetles live in silty soils and damp sands of the ripal zone of stagnant and flowing water bodies. Their larvae live only in the aquatic environment, and adults can go out into the air and even fly to other bodies of water in nearby areas. In the fauna of beetles, there are also typical rheophiles (*Potamophilus acuminatus*, etc.), which live in mountain rivers, streams, and springs. These species are oxyphiles, adapted to living in cold water. In general, Mediterranean species of beetles live mainly in highly overgrown lowland water bodies with high summer water temperatures.

In general, Mediterranean fish species in their biology are mainly associated with the sea, therefore they are marine relics of the Caspian. Since 1930, three fish species (*Mugil auratus, M. saliens, Plalichthys flesus luscus*) from the Mediterranean have also been acclimatized in the Caspian Sea. However, the basis of the ichthyofauna of the Caspian is currently brackish-water species, despite the fact that about 8-10 million years ago the Sarmatian seafood, which preceded the Caspian, was inhabited by purely marine ichthyofauna - *Gadidae, Bothidae, Soleida, Callionymidae, Serranidae, Trachinidae, Sphyraenidae, Carangidae, Scorpaenidae, Atherinidae, Mugilidae, Syngnathidae*, etc. (Rass, 1965). According to Rass, this fauna then completely died out due to cooling and desalination. About 5 - 6 million years ago it was replaced by the brackish fauna of the Pontic Sea. According to GS Rass, "the derivatives of the latter are brackish and anadromous species of kilka (*Clupeonella*), herring (*Alosa*), gobies (*Gobiidae*).

Pontic-Caspian Freshwater Complex. Ponto-Caspian species in freshwater bodies of the Caucasus are represented by 62 species and forms: *Cystobranchus fasciatus, Theodoxus danubia-lis, Iaera sarsi, Paramysis lacustris, Limnomysis benedeni, Chaetogammarus trichiatus, liker o gammarus haemobaphes, P. austora set sarsi, Orchestia bottae, Corophium curvispinum, Astacus leptodactylus, Rutilus rutilus, R. rutilus heckeli, R. rutilus caspius natio kurensis, R. frisii kutum, Scardinius erythrophthalmus, Chondus aspius, L. aspius taeniatus capito, B. capito natio platicephalus, B. bra, chycephalus caspius, B. mursa, B. tauricus, Chalcal-burnus chalcoides, Ch. chalcoides schischkovi, Alburnus alburnus, A. filippi, Blicca bjoerkna, B. bjoerkna transcaucasica, Abramis brama, A. brama orientalis, A. sapa, A. sapa bergi, Vimba vimba persa, V. vimba natio carinata, V. vimba tenella, Pelecus cultratus, Luci-Qperca volgensis, Neogobius cephalarges constructor, N. mela, nostomus, N. fluviatilis, Mesogobius gymnotrachelus, Proterorhinus marmoratus, Gobitis aurata, Nemachilus merga, N. brandti.*

The question of the method and timing of the propagation of marine elements in

the rivers of the Ponto-Caspian was resolved in different ways. A N. Derzhavin (1912, 1924, 1951) believed that marine crustaceans "in the rivers of the Ponto-Caspian basin are relics or pseudorelicts of Tertiary transgressions. In his work "Mizids of the Caspian" (1939) N.N. Derzhavin expressed the opinion that the transition of marine Ponto-Caspian crustaceans to fresh water took place in the Quaternary, and this transition did not occur simultaneously in the basins of different rivers. A.N. Derzhavin also admits the possibility of their resettlement up the rivers with the help of ships. Skorikov (1902), Zykov (1903), Zhadin (1940) and Mordukhai-Boltovskoy (1960) believe that marine elements penetrated the Ponto-Caspian rivers by active or passive migration.V.I. Zhadin also believes that passive migration of crustaceans is possible with the help of anadromous and semi-anadromous fish, which can carry the eggs of crustaceans up the river in their intestines. the method of spreading crustaceans is difficult to admit, since their eggs are deprived of any protective shells and die, yes just falling out of the marsupial bag.

Following A.N. Derzhavin, we believe that in the conditions of the Lower Kura and other water bodies of the South Caspian, crustaceans remained in their former habitat after the sea retreated, therefore they do not go beyond the Tertiary and Quaternary transgressions of the Caspian. As for the species found in areas not included in the Akchagyl transgression area, they settled there by active or passive migration (Alizade, 1954). The presence of *Limnomysis benedeni* in the lakes of Hajigabul and Akhchala, located in the Lower Kura region, also speaks in favor of the relict origin of marine crustaceans in the fresh waters of Azerbaijan.

Arctic Freshwater Complex. The Arctic freshwater complex includes the following species: *Alonopsis elongata, Daphnia longispina hyalina, Bytho-trephes longimanus, Polyphemus pediculus, Lota lota.*

Daphnia longispina hyalina is a typical plankton species of lakes and reservoirs. In the region of the Alps and in the northern part of the Holarctic, it has the greatest number of local and seasonal forms. In the Caucasus, it is found exclusively in the alpine lakes of the Lesser Caucasus at an altitude of 3000 m above sea level. m.

Polyphemus pediculus is widely distributed in the northern zone of the Holarctic, and therefore can be considered a species of arctic and subarctic origin. This species lives in both freshwater and brackish water bodies, and often rises high in foothill and mountain water bodies (Bening, 1941). So, in the Alps, it was found at an altitude of up to 2000 m, in the Tatras-1724 m, Kashmir-1582 m, and in the Caucasus-2021 m.

The time of penetration of the Arctic fauna into the Caspian, according to most authors, is considered the postglacial epoch, approximately 10 - 20 thousand years ago (Zenkevich, 1949). At that time, the basins of the Baltic, White and Caspian Seas were interconnected. However, the connection of the Caspian and the Polar Sea (we do not mean a direct connection), obviously, was short-lived, which explains the small list of northern species that entered the Caspian. The following species belong to the Arctic elements of the Caspian Sea: whitefish - *Stenodus leucichthys (Gul d.)*, Polychaete - *Manayunkia caspica Ann., Amphipods - Pontoporea affinis microphthalma Sars, Pseudalibrotus caspius Gr., P. platyceras Gr. caspius Gr.*, mysids - *Mysis caspia Sars, M. amblyops Sars, M. macrolepis Sars, M. microphthalma Sars*, isopods - *Mesidothea entomon caspia Sars*, copepods - *Limnocalanus grimaldii de Geer*, seal - *Phoca hispida caspia Gm el in* (Kashulin *et.al*., 2012).

Caucasus Complex. The Caucasian endemics did not include the species found in Talysh, the northeastern part of Azerbaijan, western Georgia, and the water bodies of

the North Caucasus.

In the fresh waters of the Caucasian Isthmus, 212 endemic species and subspecies have been recorded, which is about 17.3% of the total fauna. Below are the names of some of the endemics of the Caucasus: *Ephydatia fluviatilis teberdana, Loendrocoelum longipenis, Nais iorensis, Fredericella sultana transcaucasica, Hippeutis complanatus colchicus, Hydrobia akramowskii, Pyrgula terpoghassio sianuti, Horaingi, Pyrgula terpoghassianuti, Hora- Qhirocephalus skorikowi, Ch. weisigi, Apus cancriformis, Eulimnadia azerbaidschanica, Macrothrix tripectinata, Drepanomacrothrix stschel-kanowzewi, Cyprinotus inaequivalvis, Heterocypris rotundata, Herpetocypris fontinalis, Potamocypris tarnogradskyi, Hemidiaptomus lagodechiensis, H. behningi, Eudiaptomus atropateus, Asellus infirmus, Bathynella stammeri ciscaucasica, Gammarus matienus, Niphargus kurdus, N. lori, N. abricossovi, A '. smirnovi, N. abchasicus, N. borutzkyi, N. glontii, Synurella behningi, S. apscheronica, Zenkevitchia admirabilis, Lyurella hyrcana, A nopogammarus birsteini, A stacus pylzowi, A. colchicus, Lebertia caucasis, L. Affin. balcarica, LL komareki*, etc (Petrov, 2010).

Many endemic species of the Caucasus demonstrates the originality of the fauna of which intensive speciation took place and is taking place. If you look at the composition of this fauna, you can see that it is as variegated and varied as the variegated and varied territory of the Caucasus. The formation of endemic species took place mainly in the water bodies of Kolkhida, the Lesser and Greater Caucasus under the influence of transgressions of the seas, mountain-building processes, and glacial cooling. The isolation of the Caucasus from other continents also played a significant role in this matter.

The high peaks of the Azerbaijani part of the Greater Caucasus (Shahdag), currently 4243 m above sea level. m., in the Upper Sarmatian they rose above the surrounding sea by no more than 600-700 m (Budagov, 1965). This is confirmed by the presence of the Upper Sarmatian mollusks at an altitude of 3350 m.

Thus, it can be assumed that in the Caucasus, on the border of the Miocene and Pliocene, there was no alpine relief. In the Lesser Caucasus, as well as in Trialeti and Talysh, high mountains (up to 1500-2000 m in the M. Caucasus and up to 1000-1500 m in Trialeti and Talysh) were formed only in the middle of the Pliocene, in the age of the productive strata (Shapovalov, 2015).

3. Discussion

Summarizing the above, we note that the ancestor of the modern endemic fauna of the Caucasus was mainly the Upper Tertiary and Middle Tertiary fauna of the boreal complex. In the Pliocene, intensive speciation occurred under the influence of mountain building, transgressions and regressions of the seas, and in the Pleistocene, as a result of mountain building, cooling of the climate and the accompanying pluvial epochs. In the first case, the formation of new species took place exclusively in the water bodies of Colchis and the Lesser Caucasus in a temperate climate, and in the second, in addition to the Lesser Caucasus, in the springs and spring streams of the Greater Caucasus. In the latter, climate instability due to the ice ages of the north was of decisive importance.

Consequently, the instability of the climate during the ice ages in the north should have had an impact on the evolution of the freshwater fauna of the Caucasus since a change in the abiotic environment of an animal leads to a rapid change in its adaptive properties. If a species can live in changed conditions, then it has distinctive features

that give it the opportunity to live in new environmental conditions. These changes include the conditions under which the larvae of water-air insects live. In the mountain rivers of the Caucasus, insect larvae live on the lower surface of stones and thereby escape from drift down the river. A similar adaptation arose in them under the influence of the melted waters of glaciers. In the post-glacial epochs, due to an increase in air temperature, there was a significant melting of glaciers, leading to an increase in river runoff. However, this process in the Lesser and Greater Caucasus went differently. On the first, he contributed to the evolution of the fauna, and on the second, the complete destruction of the river fauna.

Subsequently, the settlement of the river waters of the Greater Caucasus proceeded at the expense of the fauna of the Lesser Caucasus and neighboring regions. Consequently, the instability of environmental conditions is one of the main factors regulating the rate of evolution.

In general, the instability of the climate that took place in the Caucasus during the Pleistocene accelerated the evolution of the freshwater fauna of the Caucasus. Therefore, we should not be surprised by the large number of endemic species in the Caucasian complex, since the modern history of the freshwater fauna of the Caucasus is characterized by its rapid evolution.

4. Conclusion

In this work, we set ourselves the task of showing the composition of the freshwater fauna of the Caucasus, the history of its origin, and giving the hydrobiological characteristics of some water bodies. The research helped to reveal that the reservoirs of the Transcaucasia, in comparison with those of the North Caucasus, have been studied most fully and comprehensively. Summarizing the available literature data and the results of our own research, we have outlined some areas to be investigated when carrying out hydrobiological work.

Special attention should be paid to the study of the species composition of several groups, primarily protozoa, turbellaria, nematodes, oligochaetes, ostracods, water mites, caddis flies and mayflies. The study of these groups will give science many new species of particular zoogeographic interest. For these purposes, it is necessary to carefully study the reservoirs of spring origin located in the foothill and mountain zones of the Lesser Caucasus and Talysh, where the climate was relatively warm during glacial cold snaps. When finding each new species, one should understand the question of how they penetrate into a given body of water. If, however, the emergence of new species took place in the investigated reservoir, then it is necessary to find out the factors that contributed to the emergence of new species or subspecies, and to establish whether sympathetic speciation took place in the water bodies of the Caucasus in aquatic organisms (for example, in fish) based on elementary populations.

In terms of biological productivity, a seasonal study of the abundance and biomass of microbenthos in fishery reservoirs is necessary. In addition, the role of pelagic protozoa in the life of water bodies, the primary production of phytoplankton photosynthesis, and the amount of detritus should be determined. These data should be used as the basis for biological substantiation for the reconstruction of the forage base and fish population of the reservoir. A comprehensive study of the ecological and biological characteristics of mass species, which are the main food for industrial fish, is extremely important. Knowledge of these issues will help to develop measures to

increase the fish productivity of reservoirs. It is also necessary to study the ecology of rare species of Mediterranean, Near Eastern, tropical and subtropical origin. The study of the ecology of these species can contribute to the solution of extremely important questions concerning the genesis of several species of these faunistic complexes.
In experimental work, it is necessary to clarify the optimal factors under which the normal and mass development of the species under study occurs. Of great interest is also a comparative study of the biological productivity of lakes located at different heights of the Caucasus. Work in this direction should cover all links of hydrobiological research.

Particular attention should be paid to the study of the influence of oil products and drainage waters on the fertility, growth, and development of individual hydrobionts, since in recent years there has been an increased pollution of the reservoirs of the Caucasus with sewage.

This list does not cover all the problems associated with the study of freshwater reservoirs of the Caucasus. As we study the reservoirs of the Caucasus, new problems will arise associated with the development of Industry and irrigated agriculture. However, research in these directions would contribute to an increase in the level of hydrobiological and zoological research in the Caucasus.

References

Abdurahmanov, Y.A. (1960). *The history of formation of current fish population of Azerbaijan freshwaters*. The scientific works of Institute of Zoology of the Academy of Science of Azerbaijan SSR, XII., 146 p.

Alekperov, I.X. (2016). *Freshwater free living ciliates of Azerbaijan basins*. Baku, Elm, 650 p.

Alizade, K.A. (1954). *Akchagyl stage of Azerbaijan*. Academy of Science of Azerbaijan SSR, 210 p.

Baryshev, I.A. (2014). Factors of formation of macrozoobenthos communities of rocky rapids and rapids of watercourses in Eastern Fennoscandia. *Journal of General Biology*, 2, 124-131.

Baryshev, I.A. (2015). Features of the formation of the structure of macrozoobenthos of the rapids of the rivers of the Karelian coast of the White Sea. *Transactions of the Karelian Scientific Center of the Russian Academy of Sciences*, 1.

Baryshev, I.A. (2019). Macrozoobenthos of the rivers of Eastern Fennoscandia. Dissertation, Petrozavodsk, 380 p.

Berg, L.S. (1934). Division of the Palaearctic region into zoogeographic regions based on the distribution of freshwater fish. Tr. I All-Union Geographical Congress, 3, 225 pages

Berg, L.S. (1940). The zoogeography of Near Asia freshwaters. *Scientific notes of Leningrad State University*, 60-66.

Bezmaternykh, D.M. (2016). Zoogeographic composition of macroinvertebrate lake systems in the south of the Ob-Irtysh interfluves. *News of the Altai Branch of the Russian Geographical Society*, *1*(40), 46–52.

Bogachev , V.V. (1961). *Materials and histories of the freshwater fauna of Eurasia*. Academy of Sciences of Ukrainian SSR, Kiev, 341 p.

Budagov, B.A. (1965). Modern and ancient glaciation of the Azerbaijan part of the Greater Caucasus. Academy of Sciences of Azerbaijan SSR, Baku, 180-192.

Burchak-Abramovich, N.I. (1951). To the history of the fauna of terrestrial vertebrates of Azerbaijan. Animal world of Azerbaijan. Baku: Academy of Sciences Azerbaijan SSR, 42-66.

Derjavin, A.N. (1951). The statement of history of Caspian fauna and freshwater basins of Azerbaijan. In *Animal world of Azerbaijan*, 7-34.

Dzhadin, V.I. (1952). *Molluscs of fresh and saline waters of the USSR*. Moscow, 376 p.

Ibrahimov, Sh.R. (2018). The history of development of parasite fauna. In *Parasite fauna of Caspian Se*a, Baku, Elm, 310-355.

Kashulin, N.A., Denisov, D.B., Valkova, S.A., Vandish, O.I., Terentyev, P.M. (2012). Modern trends of changes in freshwater ecosystems of European-Arctic region. *Works of Kolsk Scientific Center of Russian Academy of Sciences*, *1*(2), 7-54.

Mardukhai-Boltovskoy, F.D. (1930). *Caspian fauna in the Azov-Black Sea basin*. USSR Academy of Sciences, Moscow, 182 p.

Nikolsky, G.V. (1953). *On the biological specificity of faunistic complexes and the significance of their analysis for zoogeography*. Academy of Sciences of the USSR, 215 p.

Petrov, P.N., Shapovalov, M.I., Fery, H. (2010). New species of Ilybius Erichson, 1832 (Coleoptera: Dytiscidae) from the North Caucasus. *Russian Entomological Journal*, *26*(1), 41-45.

Rass, T.S. (1951). *Ichthyofauna of the Caspian Sea and some questions of its history*. Triology of the Institute of Oceanology, VI, 145 p.

Sinitsyn, V.M. (1962). *Paleogeography of Asia*. USSR Academy of Sciences, LA, 265 p.

Shapovalov, M.I., Prokin, A.A., Palatov, D.M., Kovalev, A.V. (2015). Notes on the distribution and ecology of the genus Stenelmis Dufour, 1835 (Coleoptera: Elmidae) in the Caucasus. *Zootaxa, 4052*(3), 366-372.

Skorikov, A.S. (1911). *A new species of crayfish from the Caucasus*. Caucasian Museum, 5, 88-102.

Yakovlev, V.N. (1962). *History of the freshwater ichthyofauna of the USSR and some questions of zoogeography.* Ph.D. thesis, Moscow State University, 1-45.

Zenkevich, L.A. (1949). *Fauna and biological productivity of the sea*. II ed. Soviet Science, 116p.

Zykov, V.P. (1903). Materials on the Volga fauna and the hydro-fauna of the Saratov province. *Bull. soc. Imp. Nat*., XVII, 103-134.