Ecological features and resource status of carp fish in the lower Amu Darya River

Ramatulla Temirbekov[1], *Ablatdin* Musaev[1], *Irina* Israilova[1*], *Azamat* Zholdasbaev[2], and *Nurlybai* Myrzambetov[1]

[1]Karakalpak Research Institute of Natural Sciences, Academy of Sciences of the Republic of Uzbekistan, Nukus, Republic of Uzbekistan, Berdakh Avenue, 41
[2]Karakalpak Institute of Agriculture and agrotechnologies, Nukus, X.Abdambetov Street

Abstract. This study presents the results of multi-year comprehensive scientific research conducted in the lower reaches of the Amu Darya River. The primary material for the study consisted of our own collections of ichthyological material of fish populations to determine their current status in fisheries. The research focused on various groups and statuses of carp fish. As a result of the study, the current composition of carp fish fauna in the lower reaches of the Amu Darya River, their ecological characteristics, and their commercial status in connection with the anthropogenic transformation of the river's hydrological regime were identified. Under these conditions, research is being conducted to create sustainable fish resources and their effective utilization, including the study of alternative water sources in the Southern Aral Sea region.

1 Introduction

The Amu Darya River basin is one of the largest rivers in Central Asia, located in an arid zone and subjected to intense impacts related to agricultural development and climate change. The hydrographic network of the lower Amu Darya consists of the main river channel, deltaic tributaries, numerous irrigation canals and branches, collector-drainage networks, and lakes. The flow of the Amu Darya is practically the sole source of water for the lower river basin territory and the main factor affecting the hydrological condition of its lower reaches and delta; collector-drainage flows, feeding some lakes either in combination with freshwater or independently, are less significant but also important; precipitation plays a minor role [1].

Geomorphologically, the lower reaches represent the ancient delta of the Amu Darya. This area is often flooded during the high-water period, when floodwaters, along with groundwater, which rises significantly during irrigation and leaching periods, form a network of lakes. This is crucial for the lower reaches of the Amu Darya, which is the river's terminal point and often remained without water during low-flow years.

The unstable ecological situation in the Amu Darya River and its basin negatively affects the ichthyofauna of the lower river course. Currently, natural fisheries water bodies in the lower reaches of the Amu Darya cover over 100,000 hectares. All these water bodies

* Corresponding author: i.israilova@mail.ru

are of fisheries importance. However, the instability of the water regime affects fish populations and their natural reproduction.

The problem of the altered hydrological regime of water bodies has become global in nature by now and has become a specialized area of biological research [2]

Significant efforts are being made to stabilize the ecological situation, regulate water supply, and revive the fisheries status and industry of the lower Amu Darya region.

The aim of our study was to analyse the dynamics of species composition, ecology, and resources of carp fish in the lower reaches of the Amu Darya River under conditions of total transformation of the region's hydro regime, as well as to orient towards the development of aquaculture (fish farming) in the existing conditions.

2 Object and methods of research

Standard ichthyological research methods were employed, including field observations, monitoring of the reproduction of key commercial species, fish catching, and biological analysis. Monitoring and collection of ichthyological material from fish populations were conducted to determine their current status in fisheries, along with observations of lake water parameters (temperature, oxygen, pH), hydrobiological, and hydrochemical analyses.

Fish catching was performed using various types of stationary nets, fyke nets, and traps. Some of the material was obtained from commercial catches of fisheries. Data processing followed standard methodology [3].

A map of the study area's ichthyofauna in the water bodies of the lower Amu Darya River was compiled (Figure 1).

Fig. 1. Map-scheme of the study area: I - Mezhdurechensk Reservoir; II - Sarbas Lake; III - Muynak Bay Lake; IV - Sudochye Lake; V - Zhaltyrbas Lake; VI - Dautkul Reservoir; VII - Sarykamysh Lake; VIII - Southern Karakalpak Main Collector (SKMC).

3 Results and Discussion.

During the study period, a total of 2849 specimens of carp species were collected and processed for size, weight, and age composition. The results are represented in Table 1

Table 1. Species composition and quantity of examined commercial carp fish from different water bodies in the lower reaches of the Amu Darya River for the years 2000-2018

№	Types of fish	Reservoirs							Total
		Mejdurech'ye	Sarbas	Muynak Bay	Sudochie	Dautkul	Zhaltyrbas	Reservoirs on the YuKMK highway	
1	*Cyprinus carpio* (Linnaeus, 1759)	84	287	127	498	2	16	115	**1129**
2	*Rutilus rutilus* (Linnaeus, 1758)	-	8	98	241		7	113	**467**
3	*Carassius gibelio*(Bloch 1782)	34	112	13	130	30	11	12	**342**
4	*Abramis brama* (Linnaeus, 1758) -	9	1	1	58				**69**
5	*Aspius aspius iblioides (*Kessler, 1872*)*	11	-	-	91	1		36	**139**
6	*Pelecus cultratus* (Linnaeus, 1758)	2	1	-	74	1			**78**
7	*Chalcalburnus chalcoides aralensis* (Berg, 1923)	-	-	-	6			38	**44**
8	*Scardinius erythrophthalmus* (Linnaeus, 1758)	-	3	-					**3**
9	*Luciobarbus brachucephalus* Kessler, 1872	7	1	-					**8**
10	*Ballerus sapa* (Pallas, 1814)	1	-	-	5				**6**
11	*Ctenopharyngodon idella* (Valenciennes. 1844)	54	30	6	23	1	2		**116**
12	*Hypophthalmichthys molitrix* (Valenciennes, 1844)	99	102	8	45	1	10		**265**
13	*Parabramis pekinensis* (Basilewski, 1855)	10	53	6	97		13	4	**183**
	Total	**311**	**598**	**259**	**1268**	**36**	**59**	**318**	**2849**

The alteration of the hydrological regime of the Amu Darya and the severance of its connection with the Aral Sea have had particularly negative impacts on the biota of the lower Amu Darya. The reduction in water inflow has altered the hydrological landscape of the region and created serious ecological problems. For instance, the average multi-year river flow in the delta of the Amu Darya (covering an area of 14,000 thousand hectares), which was 39.6 cubic kilometers per year, decreased by 35%, 48%, and 78% in 1975, 1985, and 2000, respectively [4; 5]. This led to the cessation of floodplain floods and a sharp decrease in habitat moisture (by 60%). The number of catastrophic low-water years increased after 2000, and the fluctuations in annual water inflows into the delta of the Amu

Darya ranged from 0.403 cubic kilometers in 2001 to 20.3 cubic kilometers in 2010. In these conditions, the aquatic ecosystems of the region steadily degraded and suffered significant losses in biodiversity and biological resources. Consequently, the status of water ecosystems, representing the water resources of the region's fisheries industry, changed significantly, causing serious damage to the region's fisheries economy, as most water bodies practically dried up.

Previously, due to natural channel processes in the delta of the Amu Darya, almost the entire hydrographic network constantly changed. Under the conditions of contemporary chronic low water levels, the hydrographic system changes less intensively, with the main phenomenon being the drying up of natural watercourses and the emergence of new artificial collectors and canals. Accordingly, the hydrography has radically changed, with almost all of it considered anthropogenic [6].

Changes in the composition of the fish population have resulted in the disappearance of many indigenous, migratory, and semi-migratory populations, out of the 40 indigenous fish species that inhabited the plains of the Amu Darya [7], almost all 12 endemic and relic species of the Amudarya basin disappeared, except for one species - Capoetobrama kuschakewitschi (Kessler, 1872).

The population of all three relic endemic sturgeons of the Amu Darya - Acipenser nudiventris Lovetzky, 1828, Pseudoscaphirhynchus kaufmanni (Bogdanow, 1874), and Pseudoscaphirhynchus hermanni (Kessler, 1877) - as well as the endemic to the Aral basin Aspiolucius esocinus (Kessler, 1874) and the Aral barbell Luciobarbus (Synonym *Barbus brachycephalus* Kessler, 1872) brachycephalus Kessler, 1872 critically declined. All these fish species are listed in the Red Book of Uzbekistan (2019).

Through scientific research, the current composition of carp fish fauna in the lower reaches of the Amu Darya River and its changes have been identified. Currently, the ichthyofauna of the lower Amu Darya comprises 37 fish species belonging to 13 families. Among them, 23 taxa (62.1%) belong to the Cyprinidae family. They dominate both in terms of the number of species and the size of populations, constituting more than half of the entire ichthyofauna of the region (Table 2).

Table 2. Species composition of carp fish in the lower Amu Darya basin, their status, and distribution of species among water bodies and sections of the lower Amu Darya

Type of fish	Reservoirs							Species status
	1	2	3	4	5	6	7	
Genus: Rutilus Rafinesque, 1820 *Rutilus rutilus* (Linnaeus, 1758)	+	+	+	+	+	+	+	C
Genus: Leuciscus Cuvier (ex Klein), 1816 *Leuciscus idus oxianus* (Kessler,1877)	-	-	-	-	-	-	-	3(NT)
Genus: Scardinius Bonaparte, 1832 *Scardinius erythrophthalmus* (Linnaeus, 1758)	-	+	-	-	+	+	+	C, R
Genus: Ctenopharyngodon Steindachner, 1866 *Ctenopharyngodon idella* (Valenciennes. 1844)	+	+	+	+	+	+	+	A, C
Genus: Mylopharyngodon Peters, 1881 *Mylopharyngodon piceus* (Richardson, 1846)	+	+	+	+	+	+	+	A, C, R
Genus: Aspius Agassiz, 1832 *Aspius aspius iblioides (*Kessler, 1872*)*	+	+	+	+	+	+	+	C, R
Genus: Luciobarbus Cuvier et Cloquet, 1816 *Luciobarbus brachucephalus* Kessler, 1872	-	+	-	-	-	+	-	1(EN)
Luciobarbus capitoconocephalus Kessler, 1872	-	+	-	-	+	+	+	2(EN)
Genus: Chalcalburnus Berg, 1932	+	+	+	+	+	+	+	C, R

Chalcalburnus chalcoides aralensis (Berg, 1923)								
Genus:Alburnoides Jeitteles, 1861 *Alburnoides taeniatus* (Kessler, 1874)	+	+	+	+	+	+	+	NC
Genus: Abramis Cuvier, 1816 *Abramis brama* (Linnaeus, 1758)	+	+	+	+	+	+	+	C, R
Ballerus sapa (Pallas, 1814)	-	+	-	-	-	+	+	2(VU:D)
Genus: Capoetobrama 1916 Berg. *Capoetobrama kuschakewitschi* (Kessler, 1872)	-	+	-	-	-	+	-	2(VU:D)
Genus: Pelecus Agassiz, 1835 *Pelecus cultratus* (Linnaeus, 1758)	+	+	+	+	+	+	+	C, R
Genus: Carassius Jarocki, 1822 *Carassius gibelio*(Bloch 1782)	+	+	+	+	+	+	+	C
Genus: Cyprinus Linnaeus, 1758 *Cyprinus carpio* Linnaeus, 1759	+	+	+	+	+	+	+	C
Genus: Hemiculter Bleeker, 1859 *Hemiculter leucisculus* (Basilewski, 1855)	+	+	+	+	+	+	+	A, NC
Genus: Pseudorasbora Bleeker, 1860 *Pseudorasbora parva* (Temminck et Schlegel, 1846)	+	+	+	+	+	+	+	A, NC
Genus: Hypophthalmichthys Bleeker, 1859 *Hypophthalmichthys molitrix* (Valenciennes, 1844)	+	+	+	+	+	+	+	A, C
*Hypophthalmichthys nobilis (*Richardson, 1846)	+	+	+	+	+	+	+	A, C
Genus: Parabramis Bleeker, 1865 *Parabramis pekinensis* (Basilewski, 1855)	+	+	+	+	+	+	+	A, C
Genus: Abbottina Jordan et Fowler, 1903 *Abbottina rivularis* (Basilewsky, 1855)	+	+	+	+	+	+	+	A, NC
Genus: Rhodeus Agassiz, 1832 *Rhodeus ocellatus* (Kner,18166)	+	+	+	+	+	+	+	A, NC

Notes:
Legend in the table: Reservoirs: 1 – West, Sudoche; 2 – Middle zone; 3 – Zhaltyrbas; 4 – Eastern Karateren; 5 – Sarykamysh; 6 – Tuyamuyun Reservoir; 7 – Reservoirs of the southern zone and the network of the South Karakalpak main collector (SKMK): A – acclimatizer; R – rare species; C - commercial, NC – non-commercial, small-sized. Designations of the status of protected species are as follows: 0-4 ( ) - category of the Red Book of the Republic of Uzbekistan (2019).

Among the carp fish in the lower Amu Darya, limnophilic cyprinids that prefer stagnant water with plant growth dominate in terms of lifestyle. Among the carp species of the lower Amu Darya, 9 species (39.13%) fall into this category, including ide, white and silver carp, asp, grass carp, Amur barbel, silver bream, common carp, and Amur pikeperch. Rheophilic species, which inhabit flowing waters (such as the Amu Darya channel or canals), account for 2 species (8.7%) - Capoetobrama kuschakewitschi and striped nase. Most species spend part of their lives in lakes or their shallow coastal waters affected by currents. These species belong to the rheo-limnophilic group, combining pelagic species that inhabit the upper water layers. Among them, there are 7 species (30.43%): bleak, rudd, tench, black carp, wels catfish, river bleak, and Korean loach. Limno-rheophilic species among the carp fish of the lower Amu Darya include 5 species (21.74%). They Inhabit more diverse

environments, combining fast-flowing and still water sections with silted substrates. These species include chub, Turkestan barbel, roach, Aral barbel, and Turkestan loach.

Regarding feeding habits, carp fish in the lower Amu Darya are distributed as follows: the largest number of species belong to the group of omnivores - 8 (34.8%); followed by herbivores - 6 (26%); benthivores - 5 (21.8%); predators - 2 (8.7%); and planktivores, also with 2 species (8.7%).

Regarding reproductive characteristics, limnophilic fish (10 species, 43.5%) and pelagophils (8 species, 34.8%) predominate in the complex of carp fish in the lower Amu Darya. Lithophils, psammo-lithophils, and species spawning on soft muddy substrates in shallow waters account for 4 species (17.4%), and one species – the wels catfish (4.3%) - is considered ostracophilic (Figure 2).

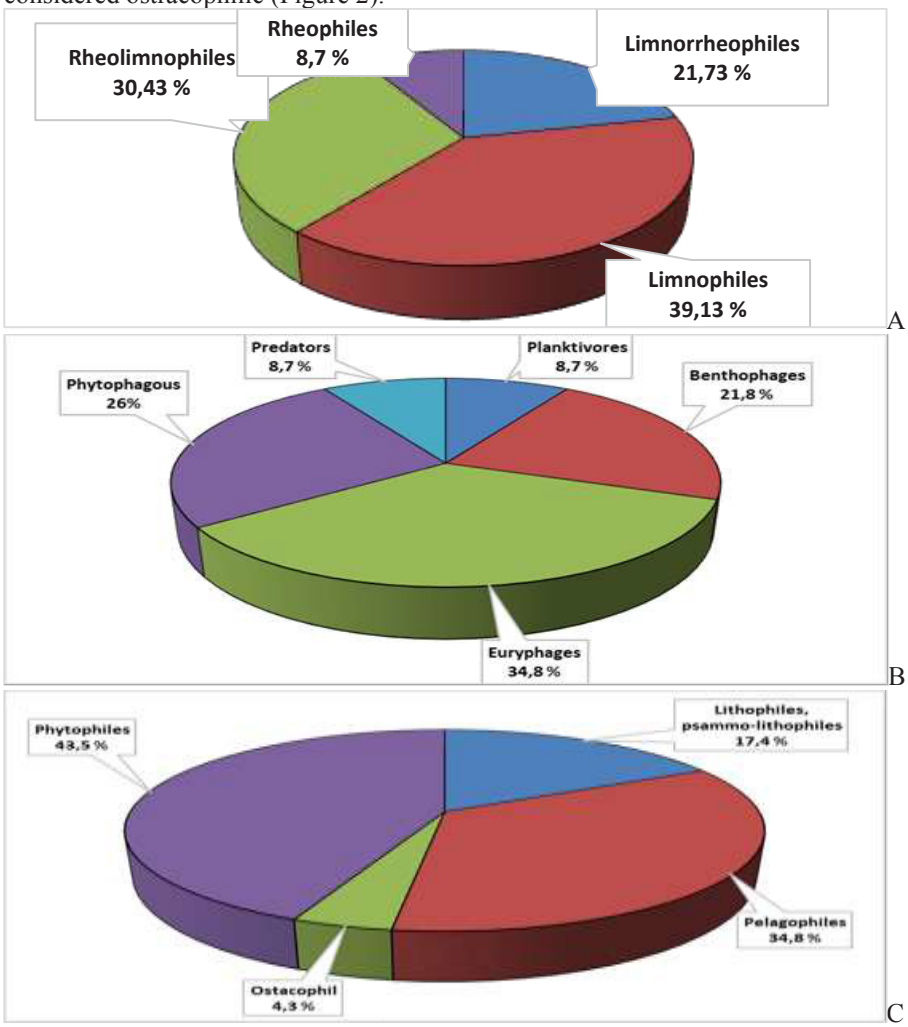

Fig. 2. Ecological structure of the carp fish complex of the lower reaches of the Amu Darya according to habitat conditions (A), type of nutrition (B) and characteristics of reproduction, spawning substrate (C)

4 Conclusion.

Thus, there has been a structural restructuring of fish communities in the water bodies and watercourses of the lower Amu Darya, accompanied by changes in species composition, lifestyle, ecological groups, and consequently, population productivity. Populations of lake-river limnophilic species that have transitioned to a sedentary lifestyle (such as carp and roach) have been preserved, as well as the ecologically plastic species, silver carp. Favorable conditions for spawning and the formation of commercial populations in the water bodies of the lower Amu Darya have emerged for rheophilic pelagophilic introduced carp species due to their population inhabiting the Amu Darya channel above the Tuyamuyun hydrocomplex.

As the instability of the hydrological regime in the lower reaches of the Amu Darya has caused problems in the development of fisheries, one of the solutions has been to determine the prospects for using alternative water sources in fisheries and to introduce and develop fisheries based on the application of modern intensive technologies, which are cost-effective for breeding warm-water fish species.

These data on water bodies are formed through regular monitoring of biotic and abiotic indicators of water bodies, assessing the development of ways and measures for realizing the bioproduction potential of water bodies, and increasing their fish productivity considering water quality and water supply conditions.

For the first time in a comparative aspect, the ecological characteristics of various types of water bodies in the Republic of Karakalpakstan have been studied. In experiments to study the adaptive abilities of tilapia (Oreochromis mossambicus), their relationship to environmental factors was examined.

In our republic, there are ponds with geothermal water supply. The use of such alternative water sources in aquaculture allows for the cultivation of warm-water fish species such as tilapia (Oreochromis mossambicus) and African catfish (Clarias gariepinus) year-round, thereby avoiding mass mortality of fry or adult individuals.

The research was conducted within the framework of scientific research of the Karakalpak Research Institute of Natural Sciences, Ecology of Fish group

References

1. Dukhovny V.A., Tuchin A.I., Tashmukhamedov B.A., Kurbanbaev E., Yu. de Schutter et al. *Southern Aral Sea region - new prospects* (2003)
2. Alimov A.F., Bogutskaya N.G. *Biological invasions in aquatic and terrestrial ecosystems* (Moscow, 2004)
3. Pravdin I.V. *Guide to the study of fish. Publishing house "Food Industry"* (1966)
4. Shiklomanov I.A. *Anthropogenic changes in river water content*. (Gidrometeoizdat, Leningrad, 1979)
5. Novikova N.M. *Water problems on the threshold of the new millennium*, 335-345 (1999)
6. Vereshchagina N.G., Chub V.E., Shchetinnikov A.A., Mukhametzyanova A.M. *Hydrometeorology and ecology*, **3 (78),** 118-126 (2015)
7. Nikolsky G.V., Pankratova V.Ya., Yagudina S.I. *Materials on fisheries in the middle and lower reaches of the Amu Darya* **I**, 3-79 (1993)