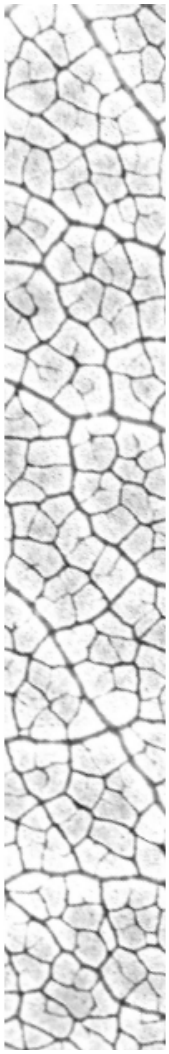

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Growth and length-weight relationships of Aral Sazan *Cyprinus Carpio Aralensis* Spishakow, 1935 (Cyprinidae; Osteichthyes) in the Sarysu River Watershed

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Abstract
A number of biological parameters of Aral sazan from the Sarysu river are described in comparison with outbred carp from spatially close reservoirs of Central Kazakhstan, as well as with previously published data. It was noted that the rate of linear growth in the Sarysu basin decreased compared to 50 years of the last century. In comparison with the growth of carp, the relative identity of its rate was noted. Linear-weight relationships (LWR) of sazans from the Sarysu river system show the predominance of linear growth over the weight, as well as in outbred Central Kazakhstan carp, contrary to existing data on East Asian populations (Amur carp) and Turkish carp. Based on the data obtained, it is concluded that the linear-weight growth indicators will not change when the Aral sazan is introduced into the Ishim and Nura river systems located to the north of Sarysu.

Keywords: Aral sazan, carp, growth, linear-weight relationships

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INTRODUCTION

Central Kazakhstan is located in the heart of Eurasian continent, which determines quite harsh conditions for existence of its biota, in particular - inhabiting the hydrosphere of the region. Low temperature of the winter period is replaced with dry and high-temperature summer parameters. These hydro-climatic features largely determine the low productivity of aquatic animal communities.

At the same time, this region is rich in mineral deposits, which determines the high point population density, and at the same time raises the question of the need to supply its food. In addressing the problems of food security of the population the important role belongs to the fishery. The least expensive way to obtain fish products - fishing in natural reservoirs. However, there is a definite problem here, which consists in the following: the indigenous fish fauna of the region is composed mainly of low-value species, among which carp dominates (*Carassius gibelio* (Bloch 1782), which has recently been actively replaced by invasive species *C. auratus* (L., 1758), and *C. carassius* (L., 1758) (Krainyuk 2011, Rehman 2015). Given the relatively rich species composition of fish reservoirs, the category of commercially valuable species include pike (*Esox lucius* L., 1758), tench (*Tinca tinca* (L., 1758) and in particular - sazan (*Cyprinus carpio* L., 1758) (Koehn et al. 2000). The natural area of the latter is limited by the Sarysu river basin (**Fig. 1**), located in the south-southwestern of region (Mitrofanov et al. 1988). Additionally, Berg (1905) wrote: “In the lakes of Tele-Kul (the lower reaches of Sarysu) and Ashi-Kul (lower reaches of Chu) a lot of sazan that make up an important subject of fisheries”. Since then, the situation here has changed except that, in relation to the total number of fish in the waters of the basin.

In the Aral Sea, after separation from a single reservoir, the so-called “Small Aral”, there is a gradual restoration of sazan populations (Mirzamasoumzadeh and Mollasadeghi 2013, Yermakhanov et al. 2013).

In 1905–1910, the Aral sazan was introduced into the reservoirs of the Balkhash – Ili basin (Petr and Mitrofanov 1998, Polat et al. 2014), while in the other reservoirs of Central Kazakhstan the outbred carp was artificially settled.

The results of stocking reservoirs by carp to the north of the meridian of Lake Balkhash show that there are obviously unsatisfactory conditions for its life activity

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Fig. 1. Aral sazan from the river Sarysu

and, above all, reproduction. Negative factors determining the hydro-climatic appearance of the region in most cases have a significant impact on its reproductive function, which reduces the productivity of carp populations. In those reservoirs where relatively stable conditions for its reproduction are stored, it turns into the so-called “sazan” form, acquiring a visual sazan morphotype, expressed, as a rule, in a more fusiform body.

Back in the 90s of the last century, carp (pedigree and bastard) was a fairly common trade dress, due to the massive stocking possible in a planned economy. At present, in the conditions of market relations, the cost of planting material and the possibilities of nature users are in contradiction with each other, as a result, fish production and end users have suffered.

The hydrological regime of the main watercourses of the region — the Esil and Nura rivers, which have ceased to be divided into stretches and now form a single flow system, has changed in accordance with the change in the average water cyclicity. The same can be said about the Sarysu river.

The above prerequisites raise the question of naturalization in the reservoirs of the region, including in rivers of fairly productive, self-replicating form, which has high demand in the market for the production of commercial fish. Historically, in many regions of the World, this form is a wild (in this case, Aral) sazan adapted to local conditions (Vilizzi 2011), including according to ethological features (Matsuzaki et al. 2009).

The creation of populations outside the natural range will also help reduce the risk of sazan extinction, which has emerged after the Aral disaster. Such a danger often threatens commercial carp species (see, for example, Ramasamy and Rajangam 2017). In addition, for the Aral sazan in r. Sarysu is threatened with genetic contamination when crossed with a common carp stocking in several areas in the basin (Krajnyuk 2018). In this case, only the apparent paucity of these stocking saves.

At the same time, the banal relocation of sazan from the Sarysu river basin to the Esil and Nurin basins will not give the desired effect. It is necessary to compare the habitat conditions in the donor and recipient reservoirs. The basin of the Sarysu river will not be able to fully meet the need for stocking material, which determines the participation of fish hatcheries in the production of stocking material of sazan. For the successful implementation of naturalization, it is necessary to evaluate the minimum quantitative indicators of relocation and stocking, including on the basis of genetic studies. In addition, it is necessary to assess the risks of acclimatization and naturalization of sazan in recipient basins, including parasitological ones.

Thus, based on the foregoing, it seems necessary to conduct comprehensive studies to assess the possibility of naturalization of sazan in the basins of the Esil and Nura rivers, where there is a need for additional fish products.

Growth rates are one of those indicators that can help assess the feasibility and effectiveness of acclimatization works. Comparison of this indicator between sazan and carp populations of the studied reservoirs can demonstrate the correctness of the chosen approach. This is the purpose of this study.

MATERIALS

This article provides materials on the study of the Aral sazan and carp from 9 reservoirs (sections) of Central Kazakhstan region (Karaganda and Akmola regions) (**Fig. 2**).

Aral sazan was caught at 2 points on the Sarysu river (only 33 specimens), from its near-current r. Kara-Kengir (examined 1 specimen) and from the Bosaga reservoir in the upper reaches of the Zhaman-Sarysu river (18 specimens).

Fig. 2. Map of sampling points

Table 1. Characteristics of reservoirs

#	Name	Coordinates	The area of the reservoir, the length of the river	Salinity, g/l
1	The Sarysu river, 180 km	N 46° 19' 09" E 67° 09' 33"	10.6 km	>9.5
2	The Sarysu river, Tuyemoynak	N 47° 51' 49" E 69° 05' 39"	7.2 km	6.0 – 9.0
3	The Kara-Kengir river	N 47° 42' 19" E 67° 56' 01"	3.1 km	-
4	The Bosaga reservoir	N 48° 21' 04'' E 72° 30' 05''	80 ha	<1.0
5	The Ishim reservoir	N 50° 39' 31" E 72° 50' 37"	220 ha	0.44
6	The Big Chebachye lake	N 53° 06' 48" E 70° 18' 01"	1856 ha	1.14
7	The Zhukey lake	N 52° 53' 30" E 70° 33' 38"	1720 ha	6.09
8	The Kokay lake	N 50° 28' 27" E 69° 23' 44"	2620 ha	1.38
9	The Sultankeldy lake	N 50° 32' 40" E 69° 30' 23"	3465 ha	2.80

It should be noted that in the reservoirs of the comparison group, the carp is extremely rare, therefore the material collected here in quantitative terms is not rich. So, on the Ishim reservoir - the highest in the system of the same name river, 5 specimens were caught. In the Big Chebachye lake - 6 specimens, the Zhukey lake - 15 specimens. Both reservoirs are located in the national park "Burabay" in Akmola region. In the Nura river basin, groups of carp from the lakes of the Kurgaldzhin nature reserve – the Kokay lake and the Sultankeldy lake (10 specimens from each reservoir), were studied. In total, the growth rates were calculated for 98 specimens of sazan and carp from the region's reservoirs.

Table 1 provides general information about the location of the studied reservoirs. In addition, (if available), data on water salinity are provided, as this contributes to the assessment of some environmental parameters of the species.

As follows from the data in **Table 1**, specimens of the sazan/carp inhabiting reservoirs and river sections with different hydrological and hydrochemical characteristics were studied.

METHODS

The fish was caught by gillnets with a mesh size of 20 to 120 mm. The body length L was measured (from the tip of the snout to the end of the scale cover), the weight M and fatness according to Fulton Q_F (Pravdin 1966) were determined.

Linear weight relationships (LWR) were determined according to Frose (2006). The ratio of weight and body length were analyzed by the basic transformed equation of linear-weight dependence:

$$W = a\,x\,L^b \quad (1)$$

where: W - body weight, L - its length, a and b - the coefficients of the equation.

To determine the age and carry out its back calculation, scales were taken from the fish. In stationary conditions, the scales were washed with water and viewed under a binocular microscope with a measuring scale.

Table 2. Length, body weight and the fatness coefficient of sazan and carp from the studied reservoirs

Reservoir, point	L		W		Q_F	
	M ± 95% CL	σ	M ± 95% CL	σ	M ± 95% CL	σ
The Sarysu river, 180 km	29.3±0.07	4.47	630±4.49	268	2.39±0.003	0.20
The Sarysu river, Tuyemoynak	24.6±0.04	2.63	407±2.07	144	2.67±0.002	0.16
The Bosaga reservoir	24.9±0.04	2.83	426±2.31	156	2.67±0.003	0.22
The Zhukey lake	28.5±0.08	4.94	784±6.48	400	3.18±0.004	0.25
The Kokay lake	31.8±0.04	2.21	877±3.17	160	2.70±0.002	0.12
The Sultankeldy lake	36.4±0.18	8.85	1474±21.71	1095	2.72±0.004	0.18

Table 3. Data of the growth back calculation of Aral sazan and carp from the reservoirs of Kazakhstan

Reservoir, year	Years											Source
	1	2	3	4	5	6	7	8	9	10	11	
Aral sazan, natural area												
The Sarysu river, Tuyemoynak	7.4	13.4	18.2	21.8	27.7	30.5	-	-	-	-	-	our researches
The Sarysu river, 180 km, 2018	8.2	14.3	19.9	23.6	28.0	31.6	-	-	-	-	-	our researches
The Kara-Kengir river, 2015	8.5	15.3	19.6	22.7	26.4	30.7	35.8	38.3	-	-	-	our researches
The Bosaga platform, 2013	7.6	12.3	19.1	23.2	26.9	-	-	-	-	-	-	our researches
The Sarysu river, 1952-53	8.9	17.4	22.3	26.8	30.9	35.4	-	-	-	-	-	(Yerestchenko 1959)
The Tilikol lake, 1964	8.6	14.8	20.8	25.4	26.9	29.3	-	-	-	-	-	(Mitrofanov et al. 1988)
The Aral sea, the Vozrozhdenie lake	12.6	21.5	29.3	36.0	41.6	46.5	-	-	-	-	-	(Nickolsky 1940)
The Aral sea, Karateren	12.8	21.5	28.7	34.3	38.4	-	-	-	-	-	-	(Nickolsky 1940)
The Raim lake	12.1	19.9	25.1	33.6	39.0	43.4	-	-	-	-	-	(Nickolsky 1940)
The Shardara reservoir, 1968	8.9	15.6	22.2	28.0	32.8	38.2	42.0	46.0	-	-	-	(Mitrofanov et al. 1988)
Aral sazan, reservoirs of immigration												
Lake Balkhash, 1930 years	8.8	16.0	21.0	25.5	28.0	-	-	-	-	-	-	(Nickolsky 1940)
Lake Balkhash, 1957-1960	8.6	16.3	21.5	23.8	25.8	29.0	31.5	35.9	38.3	40.6	-	(Mitrofanov et al. 1988)
The Ili river, Chilik	7.6	12.9	18.7	24.6	32.1	38.1	-	-	-	-	-	(Mitrofanov et al. 1975)
The Kapchagay reservoir, 1984	7.1	15.0	22.3	28.4	34.4	40.6	45.8	49.8	56.7	63.2	-	(Mitrofanov et al. 1988)
The Bukhtarma reservoir, 1967	8.6	15.3	22.7	29.1	35.4	40.7	45.1	47.5	-	-	-	(Mitrofanov et al. 1988)
Carp												
The Ishim reservoir, 2014	6.9	12.4	18.0	23.5	28.0	30.7	-	-	-	-	-	our researches
The Big Chebachye lake, 2016-18	9.0	14.1	19.0	23.2	26.8	30.9	33.4	37.3	-	-	-	our researches
The Zhukey lake, 2016	9.2	13.3	19.3	23.5	28.3	32.1	36.3	-	-	-	-	our researches
The Kokay lake, 2016	8.6	15.1	20.8	24.4	28.5	31.9	-	-	-	-	-	our researches
The Sultankeldy lake, 2016-17	8.2	13.9	18.3	22.8	27.8	31.5	35.1	39.4	44.3	50.0	54.9	our researches

The back calculation of growth was carried out by the method of simple Dahl-Lea proportions in the sense of Francis (1990). This method is not particularly accurate, however, it was used in the study of the growth of the Aral sazan in earlier works, which explains our choice, where we have involved in the study of a large layer of data available for the growth of this species in the region of interest to us.

The equation for calculating the growth rate is as follows:

$$L_i = (S_i \backslash S_g)\, x\, L_g \qquad (2)$$

where: L_g - the measured length of the fish, S_g - the length of scale from the center to the edge in the direction of measurement (radius), S_i - the length from the center of measurement of scales to the *i*-th annual ring, L_i - the calculated length of fish in the *i*-th age corresponding to the *i*-th annual ring.

The obtained data were processed using MS Excel 2003 (Korosov and Gorbach 2007) and IBM SSPS Statistics v. 22 (Buhl and Tzofel 2005). Statistical indicators were designated in the standard way: M - arithmetic average, 95% CL - 95% confidence limit, σ - standard deviation, R^2 - accuracy of approximation.

RESULTS AND DISCUSSION

Table 2 shows the main indicators of the studied sazan and carp specimens. The high values of the standard deviation in body weight clearly show that the analysis used a fairly wide size-age series, which has positive values for the validity of the analysis.

In general, biological indicators are quite close. The fatness of specimens from the Zhukey lake was somewhat increased, which is connected with the currently unlimited feed base. This reservoir is currently self-recovering from the strongest fish jam. The number of carp is still small and, given the high salinity of water, is unlikely to increase without artificial stocking.

Table 3 shows the results of our research in comparison with earlier data of other authors. It is worth noting that the materials from some reservoirs, attracted for comparison, have been performed for a long time. However, the results of research in this direction for about 30–40 years have not been published in the open press. This information was mainly contained in various kinds of research reports.

When comparing the growth rates of sazan samples from the Sarysu river of the middle of the last century (Yerestchenko 1959) and modern ones, it is clear that currently there is a slowdown of growth processes in its population, with a lag of 1 year in general. It is not excluded the possibility of operator error. In general, it should be noted that the growth of the Aral sazan in the system of the Sarysu river is not characterized by high rates of linear growth. The growth of the outbred carp in the reservoirs of Central Kazakhstan is, in principle, comparable to the growth of sazan from the Sarysu river.

Table 4. Variables and accuracy of approximation of LWR equation for *C. carpio* samples from experimental and literary data

Reservoir, point	LWR			Source, region
	a	b	R^2	
The Sarysu river, 180 km	0.0491	2.7851	0.9695	our researches
The Sarysu river, Tuyemoynak	0.0686	2.7042	0.9637	our researches
The Bosaga reservoir	0.0274	2.9908	0.9403	our researches
The Zhukey lake	0.0709	2.7591	0.9776	our researches
The Kokay lake	0.0979	2.6276	0.9622	our researches
The Sultankeldy lake	0.0540	2.8076	0.9920	our researches
The Anzali wetland	0.0294	2.7621	0.95	(Moradinasab et al. 2012) South Caspy, Iran
The Hongshui River	0.01237	3.03	0.987	(Que et. al. 2015) South-East China
The Nakdong River	0.0123	3.00	0.982	(Lee et al.. 2015) South Korea
The Kemer reservoir	0.0174	3.101	0.983	(Özcan 2008) Turkey, West Anatolia

Against this background, data on the growth rate of sazan in the Bukhtarma reservoir (Mitrofanov et al. 1988) are doubtful (especially in middle and older age) and could occur only at certain phases of naturalization in the reservoir, especially when comparing the data of same author for more southern reservoir - Shardara reservoir.

When comparing the growth rates, there is some weaker trend of faster growth in southern populations of sazan compared to northern ones. But, other factors, such as: over-population and associated food supply, hydrology of the reservoir and others, also have an impact on the growth and development of sazan. Water mineralization (within the limits of species preference) probably does not affect growth rates. The highest growth indicators were observed for the Aral Sea sazan (Nickolsky 1940), which was caused by the good conditions for its life that existed at that time.

Thus, an analysis of the data in **Table 3** shows that, within the natural areal, the sazan has mainly average growth rates. While in reservoirs of acclimatization, this indicator has mostly higher values. In the existing conditions for the infested sazan in the fish fauna there are no special trophic competitors. The practice of stocking reservoirs in the region, where the local fish fauna lived, shows that carp (sazan) very quickly occupies its ecological niche, squeezing aborigines. Perhaps the only significant competitor for this species may be the bream *Abramis brama* (L., 1758), provided it is initially high in numbers.

More concerns, in this regard, should cause the number of large predators, which can cause serious damage to young groups of fish.

The variable equations of linear-weight relations (**Table 4**) are relatively close for the studied Central Kazakhstan groupings, naturally, with some features.

So power index b in sazan from the Bosaga reservoir is actually equal to 3, which makes the ratio correct cubic. In other samples, allometry of linear-weight growth is negative, that is, linear growth prevails.

When comparing with the data of other authors at our disposal, it is clear that our samples and sazan from the Iranian part of the Caspian Sea (the European subspecies of sazan) have a greater linear growth, in contrast to the East Asian ones (another subspecies of Amur sazan *C. c. Haematopterus* (Temminck et Schlegel 1846) and Turkish (probably carp). In general, it is possible with some caution to suggest that the habitat for the carp is less satisfactory in the first cluster than in China and Turkey.

The above mentioned similarity of the studied indicators of outbred carp and Aral sazan in Central Kazakhstan region suggests the determining influence of hydro-climatic factors on the growth indicators of fish.

It is worth noting that the climatic difference between the Sarysu river area at Tuyemoynak station and on the border of Karaganda and Kyzyl-Orda regions is more noticeable than in comparison with the north of Karaganda region and the city of Astana. In the southern part of the flood begins in early March, while in the area of Tuyemoynak, as a rule, there will be no flood events for another two or three weeks. Following the opening of the headwaters of Sarysu, the flood almost immediately occurs on the Nura river, behind it, the Ishim river opens in a few days. A feature of the flood of the Sarysu river is that melt water goes over the ice, and does not reveal its pressure from below, as on other rivers. Therefore, in spite of the early onset of the breaking of ice, its southern part does not open much earlier than other rivers in the region.

Such a similarity of weather and climate phenomena of ice melting on the rivers of the region undoubtedly brings together the phenological preferences of the sazan groups that live there, which makes it possible to recommend the population from the r. Sarysu for use in relocation to other rivers in the region.

CONCLUSION

The growth rates of the Aral sazan and outbred carp from the natural reservoirs of Central Kazakhstan have a certain similarity, as well as the linear weight structure of the common ones. At the same time, in a temporal aspect, the growth processes are likely to have decreased over the last 60-70 years.

Such a similarity of growth processes with a certain commonness of individual parameters of the habitat (hydro-climatic and phenological factors) allows us to conclude that the existing rates of linear-weight growth in the sazan population remain in more northern

reservoirs. Naturally, the success of naturalization will also depend on other indicators.

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