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Maturation and reproductive biology of carp in the eastern delta Volga, Volga- Caspian fishery subdistrict

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ABSTRACT: In this study, we present the results of scientific work aimed at studying the state of the spawning carp (*Cyprinus carpio carpio*) population in the middle reaches of the Negreikin River, located on the eastern edge of the Volga Delta, Volga-Caspian fishery subdistrict. The study was conducted mainly in the spring and summer periods from March to August, and lasted until November 2023. The data collected during the study includes studies on the natural reproduction of carp, its age and size composition, growth, and the growth of spawning individuals. All aspects of the reproductive function of the carp have been thoroughly studied and analyzed. Important factors such as age, size, sex ratio dynamics, seasonal and annual maturity, and gonadosomatic index were studied. In addition, the fecundity of female carp and its relationship with body length, weight, and age were studied.

Keyword: *Cyprinus carpio carpio*; reproduction; gonadosomatic index; maturation

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INTRODUCTION

The Lower Volga is a remarkable natural phenomenon consisting of a network of >900 large branches and smaller channels (Valov *et al*., 2019). The Volga Delta is divided into two separate regions: eastern and western. The eastern region includes the Buzanskaya and Baldinskaya branches, while the western region covers Bakhtemir, Staraya Volga, and Kizan. The upper part of the delta begins where the Buzansky Arm separates from the Volga, and is characterized by a relatively simple structure of the river network. The middle part is a system of well-developed main waterways connected by side channels. The lower part is characterized by a high degree of fragmentation of the river network, with alternating sections of branching and confluence of watercourses (Kostyurin, 2000).

Carp (sazan) is a valuable fish for fishing on the Volga and Caspian Seas. It lives in the delta and mouth of the Volga, as well as in the coastal and shallow areas of the Northern Caspian Sea. It is a semi-anadromous species, and most of its population leads a semi-migratory lifestyle. During foraging, the semi-anadromous carp, which usually breeds in rivers, usually in their lower reaches, leaves the river mouths and remains in the sea near them. However, its migration routes are not clearly defined. The length of the migration route is short because the wintering, breeding, and feeding grounds are close to each other (Kazancheev, 1981).

In the spring, the carp leaves for the winter at the mouth of the river and in shallow water. Then it moves to neighboring areas and the desalinated part of the Caspian Sea, where it forms small groups that serve as places for pre-spawning and spawning accumulation. During the spawning period, carp can be found in shallow areas of the estuary coast and the shallow part of the Northern Caspian Sea. It is also caught in the Volga River delta with seines with a mesh size of 48-50-56 mm (Nelowkin, 1964; Kazancheev, 1981).

The decline in natural fish reproduction in the lower Volga Delta has become a critical issue, especially due to the sharp drop in freshwater fish catches over recent years. This alarming trend can be traced to a mix of natural and human influences. The altered hydrological conditions of the Volga River, resulting from water management practices, have not been favorable for fish reproduction.

The hydrological conditions of the Volga River, after the implementation of water management measures, have become unfavorable for fish. The natural relationship between water and temperature regimes has been disrupted, peak water levels have decreased, the rate of rise and fall of flood waves has sharply increased, and the duration of floods in the delta has decreased, leading to partial or complete loss of spawning grounds for passing, semi-passing, and semi-anadromous fish species (Taradina et al., 2008; Chavychalova, 2013; Chavychalova et al., 2021).

Currently, the timing, duration, and conditions of spawning, breeding grounds, and development of fish eggs and juveniles differ significantly from their former natural counterparts, which have a profound impact on the reproductive dynamics of the ichthyofauna.

Fish stocks in the lower reaches of the Volga Delta have been gradually declining since the middle of the last century, which is reflected in a reduction in commercial and even scientific catch of freshwater fish species, not to mention valuable sturgeon. During this period, the total catch of species and forms of semi-anadromous fish decreased from almost 300,000 tons to just over 40,000 tons per year (Vasilyeva et al., 2016; Belyaeva et al., 1989). In contrast to the situation at the beginning of the 20th century, currently, there has been a significant decrease in carp catches in the lower reaches of the Volga and the Northern Caspian. According to researchers, the reduction ranges from 30 to 50 times (Podolyako et al., 2013; Belogolova and Nikiforov, 2018; Khodorevskaya and Nekrasova, 2019; Chehomov, 2021).

In the year 2022, approximately 38,000 tons of semi-anadromous and riverine fish were caught. However, illegal and unreported fishing continues to be a problem, particularly affecting valuable species such as roach, pikeperch, carp, and pike (Barabanov and Abbakumov, 2018). Although the stocks and catches of pikeperch and carps have increased slightly, they are still far from their historical highs (Shipulin et al., 2023). It is worth noting that the stocks and catches of carps (Sazan) have been the lowest among semi-anadromous and riverine fish in the Volga-Caspian and North Caspian subdistricts in recent years (Shipulin et al., 2023).

After analyzing scientific papers on the reproduction of carp in the waters of the Volga Delta and the Caspian Sea as a whole, unfortunately, we found a lack of information about carp in the delta. However, relatively more data has been found about

it in other regions of the Caspian Sea, in particular, in the Caspian Sea, western and southern regions (Abdolmaleki and Puty, 2007; Rabazanov, 2017; Abdusamadov et al., 2020). It is extremely important to collect as much information as possible about this type of fish in a specific geographical and ecological region. Data on its reproductive biology and ecology, as well as on factors that directly or indirectly affect its evolutionary success, distribution, abundance, and productivity, are especially valuable.

Despite numerous studies on the biology of cyprinid fishes of the Caspian Sea and the Volga Delta, there are practically no publications specifically devoted to the reproduction of one of the most important species — carp. The work of Kuznetsov (2006) is almost the only documented study of the biological features of carp (sazan) reproduction in the Volga-Caspian region. Some studies have been devoted to the development of the reproductive organs of carp and the problems of their ecological reproduction in the reservoirs of the Central Caspian Sea and the Republic of Dagestan (Rabazanov et al., 2017; Kurbanov et al., 2019; Abdusamadov et al., 2020; Fazli et al., 2023). There are novels finding in this area (Song et al., 2026; Wen et al., 2026). In addition, a relatively large number of scientific papers have been conducted on the study of the biology and reproduction of carp in the rivers of the southern Caspian Sea in Iran (Larijani et al., 2024; Ghafari and Falahatkar, 2014; Mohammadnejad, 2022; Ghelichi et al., 2010; Ghojoghi et al., 2007; Vazirzadeh and Yelghi. 2015; Abbasi et al., 2019; Abbasi et al., 2022; Andarz et al., 2022). There are some works in the modern scientific literature devoted to the study of carp and its reproduction in the rivers of southern Kazakhstan. The latter is an arm of the Buzan River in the Volga Delta (Kim et al., 2018; Tumenov, 2019; Abdeshova, 2024; Barakov et al., 2024).

The conditions of the stock of the Volga carp (Sazan) and the extent of its exploitation by fishermen have revealed that the biological characteristics of the carp population in recent years have generally remained at the level of the average annual indicators. The average length of the carp was 58.4 centimeters, the average weight was 4.8 kilograms, and the average age was 6.8 years. The sex ratio in the catches was close to a 1:1 ratio. The gradual overgrowth of the strips and fish channels, the unfavorable flooding regime for the spawning grounds, the deteriorating conditions for carp breeding, the decline in the number of breeding individuals due to poaching, and the continued pressure of anthropogenic stress all contribute to the conditions and effectiveness of natural reproduction, which are the primary factors behind the decline in the yield of juvenile carp (Kuznetsov and Izherskaya, 2012).

Significant changes are currently taking place in this area due to human activity. Therefore, it is important to investigate aspects of the reproduction biology of carp, including changes in gonadosomatic parameters, the maturation cycle, sex ratio and fertility, as well as the spawning periods of this fish.

Therefore, our work is aimed at creating a more complete picture of reproductive variability in one of the areas where the carp is most successful.

MATERIALS AND METHODS

Sampling location

The Volga Delta is the second-largest natural feature in Russia (after the Lena Delta) and one of the most extensive in the world. Its area is slightly less than 9,000 square kilometers, and the length of the main riverbed, called the Volga-Bakhtemir, reaches 162 kilometers. In addition, there are more than 800 estuaries of natural watercourses, which make the delta a unique ecosystem (Mikhailova, 2013). The modern Volga Delta originates 54 kilometers above the city of Astrakhan, where the river splits into two main branches: the main Volga River, which is a continuation of the river within the delta, and the left Buzan. The northeastern border of the delta runs along the left bank of the Buzan arm, then along the left bank of the Akhtuba and the Kigach and Shirokaya channels. The latter are transferred to the Negreikin Bank.

Three kilometers from the start of the Shirokaya Channel, which is equivalent to 62.8 kilometers from the source of the Kigach Channel, this waterway splits into two branches: the Dvoyniki Channel and the Smirnovskaya Channel. After a distance of 4.5 kilometers, they reunite, forming a large Igolkinsky Bank channel with a length of 25.2 kilometers. In the gently sloping part of the Avandelta, this channel transforms into an artificially deepened Igolkinsky fish channel, which stretches for more than 40 kilometers (Atlas of riverbed morphodynamics of the Lower Volga…2009).

Negreikin Bank is located in the southeastern border of the Volga Delta and is a continuation of the Kigach River channel and is located within the Astrakhan region. The total length of the riverbed

of this watercourse (Kigach) is 93 km before its exit to the rolling part of Avandelta, of which about 30 km falls on Igolkin-Negreikin Bank. They represent the lower reaches and channel of the Kigach River, which is one of the main tributaries of the Volga and flows east.

The Negreikin stream is a significant pathway for semi-migratory fishes, who utilize it for their reproductive purposes (Barabanov and Nikiforov, 2018). Fish deposit their eggs in the tributaries and branches of this river. The reduction in the velocity of the current in the delta results in a substantial decrease in the amount of water flowing, creating an environment conducive to the growth of aquatic vegetation. This vegetation serves as a spawning ground for phytophilic fish.

Data collection

Ichthyological material was collected in the fishing stations northern and southern sections of Negreikin Bank and Staraya tributary (Fig. 1).

The materials for biological research were obtained as a result of experimental trapping in the Negreikin shoals. We purposefully collected samples (n=374) from early February to August 2023. Most of the samples (n=304), including 191 males and 183 females, were taken during the fishing seasons from February to April 2023. Some samples (n=70) were taken from May to July 2024. An additional 90 carp (Sazan) samples were collected between September and November at the same location. The standard length ± 1mm (hereafter "length") and weight ±1gr of each fish were measured using standard methods. Scales were used to estimate the age of the fish.

Regrettably, we were unable to conduct a comprehensive analysis of the water's physical and chemical properties due to the absence of specialized instrumentation. However, we did record the water temperature every five days throughout April, May, June, and July, when the water temperature in the riverbed remained relatively consistent during the final month (averaging between 18.2 and 20.5 ^{0}C).

All specimens were carefully examined to determine their sex and the stage of development of their reproductive organs. The sex is determined by an external examination of his sex glands.

The weight of the ovary was measured with an accuracy of 0.1 grams. In 70 females who have reached puberty and are at stage IV of maturity, 5 grams of caviar were taken from different parts of the ovary. Then, the number of eggs was recalculated to determine the absolute and relative fecundity.

The size at which 50% of individuals in a population reach sexual maturity is called Lm50.

Similarly, the age at which 50% of individuals in a population reach sexual maturity is called the age of first maturity. To determine the size at the time of the first sexual maturity, spawning was carried out. Individuals were considered sexually mature if they reached maturity stages from III to VI inclusive.

The gonadosomatic index (GSI) was calculated as the ratio of the mass of the gonads to the body

Figure 1. Geographical location of the area of study of carp, Negreikin Bank, Volga delta.

weight of the fish as a percentage: GSI (in %) = (wg/W) x 100, where wg = the total mass of the gonads (in grams), and W is the mass of the fish (in grams) (Bagenal and Braum, 1978). The spawning period was determined based on the frequency of appearance of mature individuals during each month and the analysis of the gonadosomatic index.

Absolute Fecundity (AF) was assessed using the gravimetric method: AF = OW × S/ws, where OW = ovarian mass, S = Number of eggs in the subsample, and ws = Mass of the subsample. Relative Fecundity (Fr) of individuals (Fr = AF/W), where W is body weight.

The condition of the sex glands was assessed visually, and the stages of their development were described using a six-point scale to determine the reproductive period (Sakun and Butskaya, 1963).

Stages I and II in late autumn, winter, and spring were considered immature (spawning did not occur this year), stages III-VI were considered mature, and they contribute to reproduction in the current year (Sakun and Butskaya, 1963).

Carp (Сазан), belonging to the group of fish with asynchronous egg development and prolonged spawning, has a seasonal reproductive cycle. Our field observations and the peculiarities of its ontogenesis reveal that female carp hibernate with ovaries at the fourth stage of maturity, as documented by Tyler and Sumpter (1996) and Fontaine et al. (2015).

For data analysis, we employed SPSS and Excel software packages.

RESULTS

According to our data, in 2023, the average surface water temperature of Negreikin Bank was 16.6 degrees Celsius in spring. At the end of April, the temperature gradually rose from 7.8 to 12.1 °C. By the end of May, the average temperature rose to 18.9 °C. The water temperature in this area reached its maximum in July (28.3 °C) and slightly decreased in August (Fig. 2).

As fish age, there is a tendency for body size to increase, but these changes can be quite significant depending on age. In our results, the coefficient of variation in body length and weight in different age groups ranges from 10 to 15%, and the distribution of values corresponds to the normal law. The variability of carp body size is especially pronounced in the first four years of life.

The water temperature during this period and until the end of April varied widely from 7.6 to 13.1 degrees Celsius.

A certain ratio of individuals of different sizes and ages can be observed in the fish population, which depends on life expectancy, puberty, reproductive ability, and mortality rate (Nikolsky, 1963).

In these spawning catches, there were carp (sazan) with a length (standard length) from 26 to

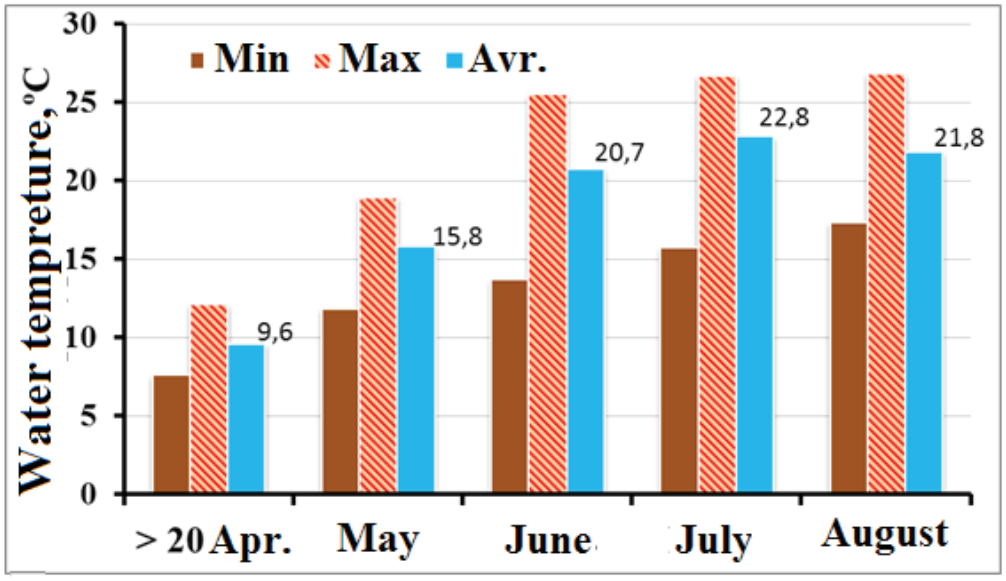

Figure 2. Average water temperature of the Negreikina riverine in the Volga Delta during the spawning season (April - August) in 2023.

73 cm. The largest numbers were individuals with a length of 35-45 cm, which accounted for 62% of the size range of the spawning carp population, with an average length of 41.9 ± 0.34 centimeters. This population included 12 age groups (from 2 to 13 years), and the majority of them were fish aged 4 to 5 years; their share is more than 58%, and the average age is 4.7 years. In this population, most fish weigh between 0.5 and 3.5 kg. The average weight of all individuals is 2.35 ± 0.46 kg, while their weight ranges from 0.4 to 8.3 kg (Fig. 3, a, b, and c). The average weight of males was 1.726 ± 0.53 kg, while the average weight of females was 2.673 ± 0.42 kg.

Naturally, as fish age, there is a tendency for body size to increase, but these changes can be very significant depending on age. In our results, the coefficient of variation in body length and weight in different age groups ranges from 6 to 8%, and the distribution of values corresponds to the normal law. The variability of carp (sazan) body size is especially pronounced only in the first four years of life.

The study found significant discrepancies in the growth rates of fish. The maximum increase was observed in the third year of life, when it was 83 mm. However, it should be noted that probably the largest increase in growth occurred in the second year, which, unfortunately, was not included in our sample. The percentage of increase varied, or rather decreased, from age to age of the fish (Fig. 4). The unit of measurement of the increase was per year. Fish showed high growth rates for the first time in four years of their life cycle.

The relationship between length and weight was separately assessed for males and females. The results of the analysis revealed that the body shape of males and females exhibited allometric growth. The analysis demonstrated that the body shape of females is allometric (P>0.01). Additionally, the length-weight relationships between males and females were significantly different (P<0.01). For females (n=104), the ratio was W = 2E- 06 SL^3.5618, R^2 = 0.965. For males (n=111), this ratio is W = 6E - 06 SL^ 3.3496, R^2 = 0.967. For pooled sexes (n = 215), the combined ratio was W = 3E- 06 SL^3.53, R^2 = 0.96 (Fig. 5).

In the case of the length-to-weight ratio, the value of b was significantly higher than the theoretical value of 3, especially for females (t = 3.56, P < 0.05) and representatives of both sexes (t = 3.53, P < 0.05), indicating a favorable growth in high allometric terms. Growth is slightly faster in weight

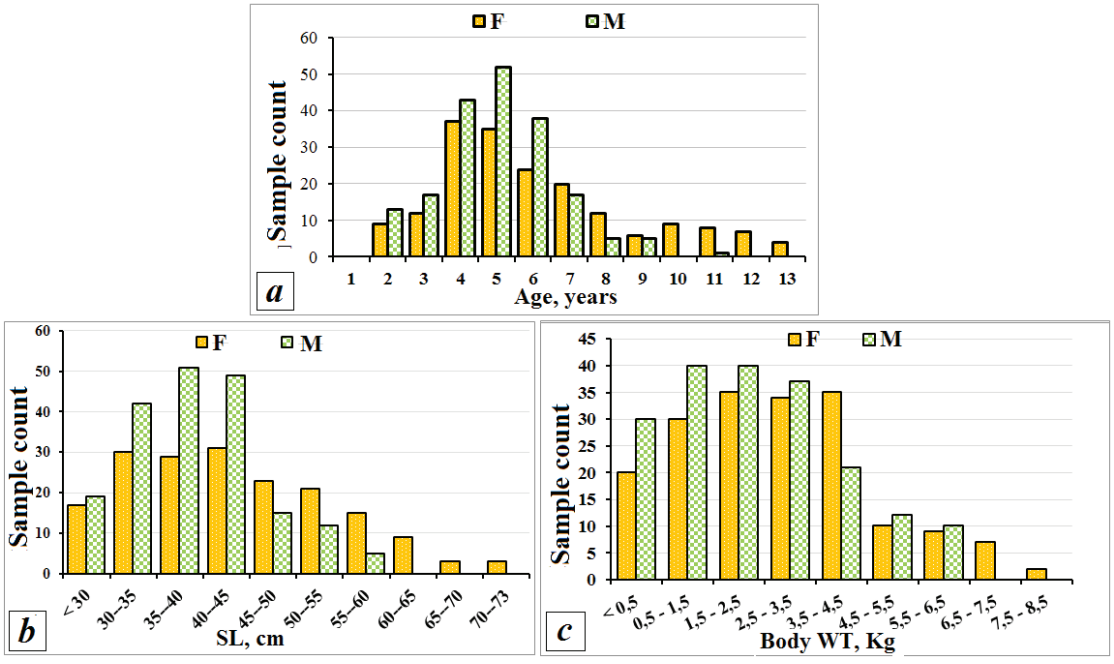

Figure 3. Age (a), size (b), and weight (c) composition of females and males in catches of the spawning herd of Carp (Sazan) in the Negreikina River, Volga Delta (2023).

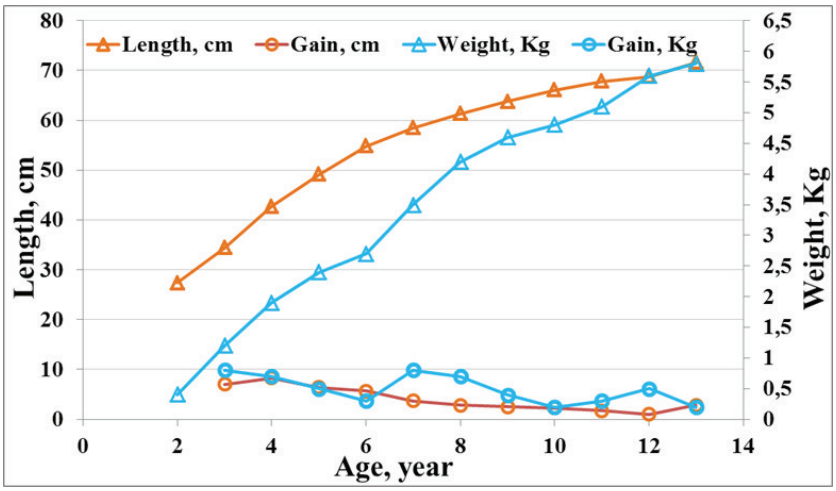

Figure 4. Length and weight growth and increment of the spawning carp population in the Negreikina River, Volga delta, 2023.

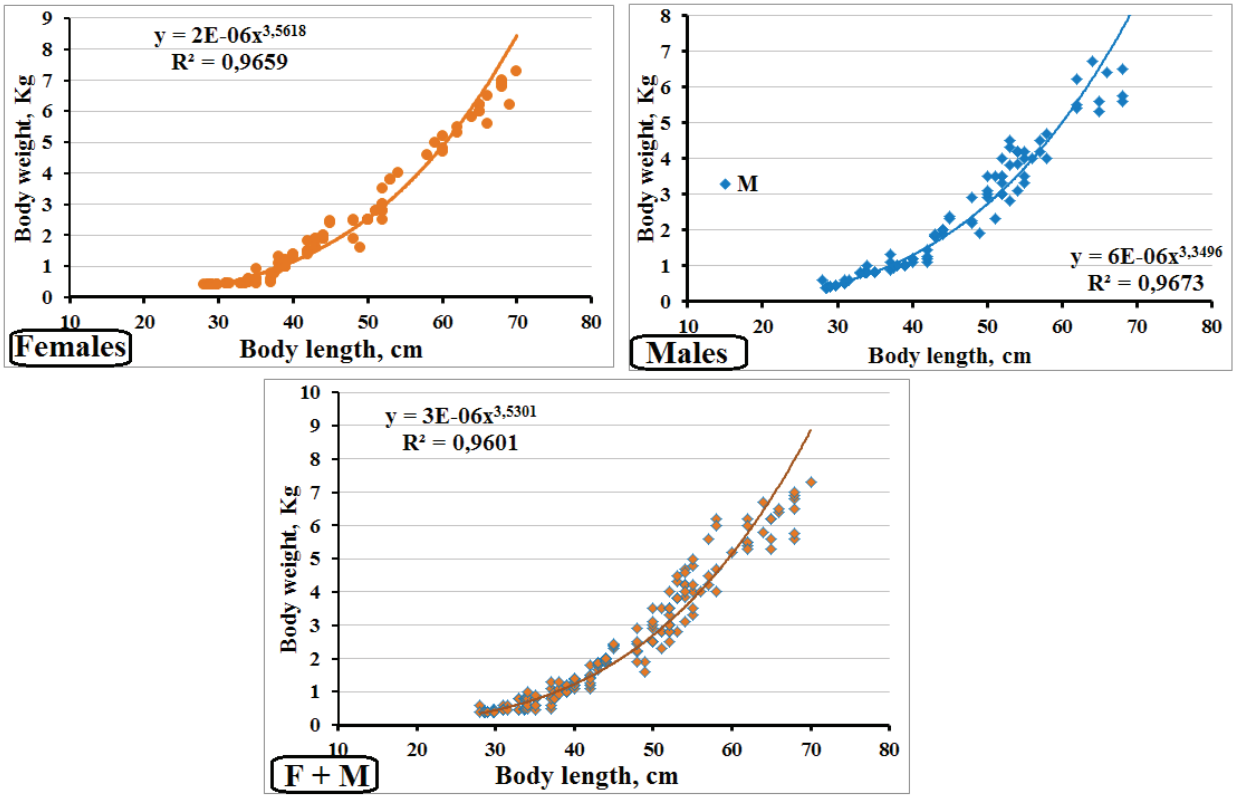

Figure 5. The relationship between body length and body weight in females, males, and pooled sexes of carp (sazan) breeding in the Volga delta.

than in length. In addition, there was a significant difference in the b value between the sexes (ANOVA, $P > 0.01$). It should be noted that such unconventional figures in terms of deviations from 3 to 3.56 for mature females seem to be reliable and are associated with the tendency of larger females to gain weight as they grow and have excess ovarian weight in mature females (Carlander, 1969; Pauly, 1983; Froese, 2006).

According to our results, at the end of April, most females and males have gonads of the IV stage of maturity, in late April and early May, fluid males and females appear. Intensive spawning occurred during 15-30 days, approximately from May 15 to June 15. It begins when the water temperature rises to ~17 °C at a depth of 20-40 cm and lasts until the temperature reaches an average of ~22 °C in the first decade of August.

The age structure of the mature fish population represents the distribution of individuals of various age categories. This structure is determined by the length of the fish's life cycle, age of puberty, reproductive potential, and average life expectancy (Nikolsky, 1980). In the population of carp (sazan) that were caught, a small number of individuals aged two years were found. There were a few more fish that were three years old. It is worth noting that there were a few older males. The proportion of males aged seven and eight years has decreased significantly. No males older than nine years and more than 68 centimeters long were found in the catches. Females over the age of nine dated until they were 13 years old. But their share together was less than 18%. The average age of the fish in the experimental catches ranged from 4.0 to 5.1 years (Fig. 3, A and B).

According to our result (Fig. 3), there is a noticeable age dynamics in the sex ratio of carp in the waters of the delta channels. The first five age groups are dominated by males. When fish reach mass sexual maturity (at the age of 4-5 years), the sex ratio remains different, about 1:1.7. Then the proportion of males begins to decrease sharply. In the last four age groups (10+ to 13+), only females are found, except one male aged 11 years.

In general, the sex ratio in this population is 1.3:1.0 in favor of males. This means that there are more males than females ~~among~~ mature fish, because males mature earlier and arrive at the spawning grounds earlier. In this case, such a deviation from the 1:1 ratio is not statistically significant at $p < 0.05$. This imbalance between the sexes was noticeable in spring and early summer towards male dominance and persisted until the population moved to wintering grounds (Fig. 6).

This pattern varies depending on the size of the group, except the disappearance of males at an older

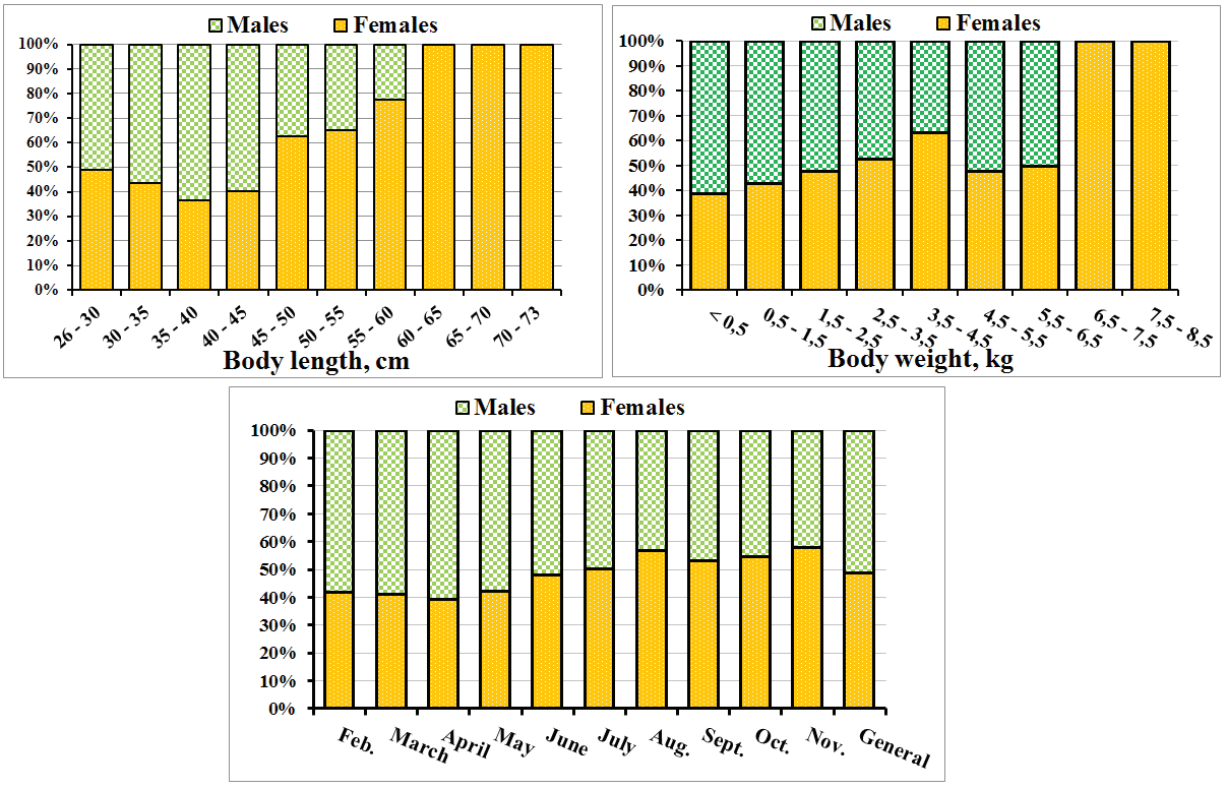

Figure 6. Dynamics of the sex ratio in the Carp (Sazan) of the Eastern Delta depending on body length, body weight, and season in the study area, 2024.

age. A similar pattern was observed in the sex ratio during carp (sazan) feeding, when females slightly prevailed over males during the autumn, and by November the indicator began to grow (Fig.6).

Length and age at first maturity are defined as the length or age at which 50% of individuals in a certain population become sexually mature (Lm50 or Am50), and most mature individuals develop germ cells in their gonads. In our results females mature a year later than males (Fig. 7A). As for the length, sexual maturity (Lm50) occurs in males at a length of 35.5 cm (Fig. 7B). During this period, adult female of carp (sazan) begin to exceed males in length by about 5 cm for the first time. For the first time, adult females reach a length of 39 cm. Full Sexual maturity in both sexes occurs when a length of about 50 cm is reached. In terms of age, male carp reach sexual maturity (Am50 — 2.7 years old), exactly one year earlier than females (Am50-3.7 years old) (Fig. 7A).

The nature of changes in Fertility can be expressed by the gonadosomatic index (GSI). During spawning migration to the delta, both females and males had fairly significant monthly changes in GSI values. In individuals of both sexes, it reaches its highest level in late autumn, increasing from August to November to 23.7%, and continues to increase until the end of autumn and during winter, after which they migrate to spawning grounds in rivers. In the riverine population, GSI reached its peak in February and March in females, amounting to 28 ± 2.65 and 28.5± 1.69%, respectively, while males reached their highest level after winter (17.7% in March; Fig. 8).

In Females, as in Males, lower GSI values were noted in July and August, from 13.4% to 7.2%, which decreased to a minimum of 7.54 in females and 3.82 in males in August. The decrease in GSI values in June means that the producer's sex glands have already grown back and are moving on to new maturation phases (Fig. 9). In females, the GSI value gradually increased from August to November. In November, the GSI value was 23.7 in females and 13.6 in males (Fig. 8).

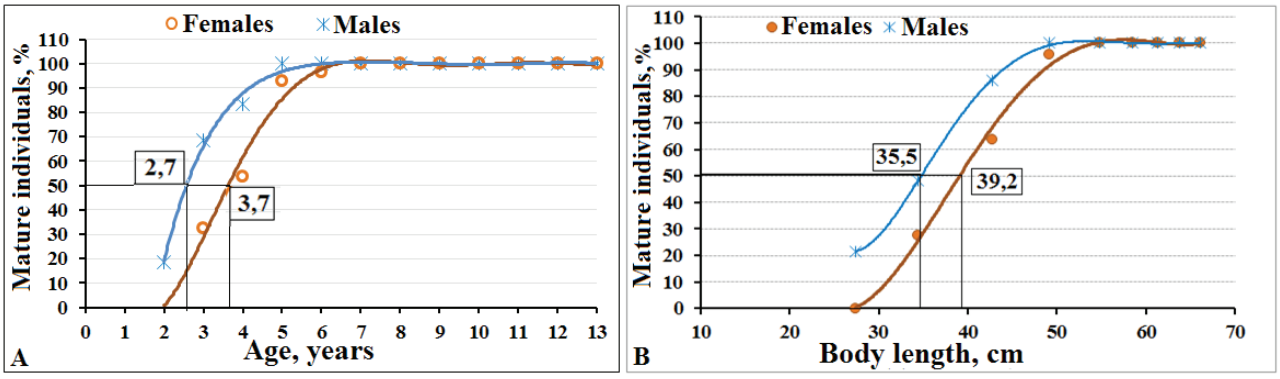

Figure 7. Logistic regression ratio of carp (sazan) maturity by age (A) and standard length (B).

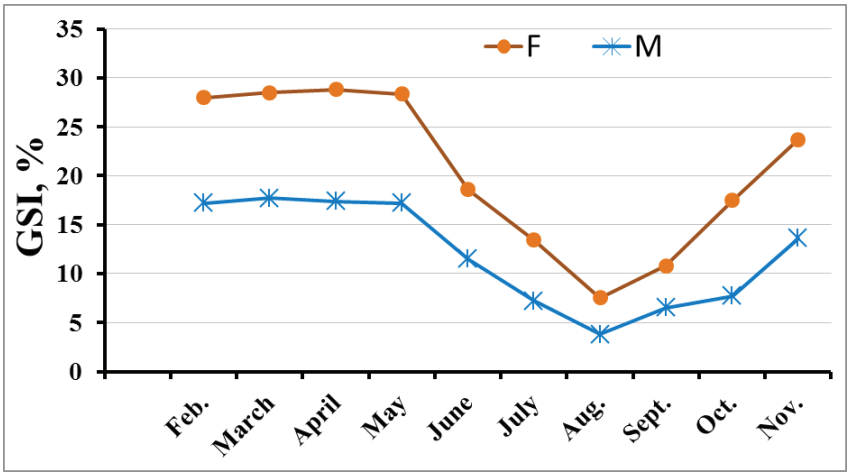

Figure 8. Seasonal dynamics of the gonadosomatic index of carp (sazan) during and after spawning in the Volga delta.

Spawning begins to occur here, from the end of March to May, at a temperature of 10-15 °C. The resting period of the sex glands is in the summer, and from September to March, they are in the development stage. Female river carp at the 4th and 4th-5th stages of maturity had a relatively high Gonadosomatic index (GSI). The GSI values significantly differed in males and females in different months ($\chi 2=19.317$, $p < 0.05$).

According to our observations, spawning took place here from the end of April to the last days of May at an average temperature of 14-19 °C. Until mid-June, we also found individual spawning carp specimens with partially mature sex glands (stages IV - VI of maturity (Fig. 9). It seems that these individuals sweep out the remaining part of mature eggs (apparently the third portion). In summer, the gonads form and transform, and from September to March, they actively mature (Fig. 9). During this period, the process of forming the potential fertility fund is completed due to the intensive trophoplasmic growth of oocytes.

The graph showing the monthly ratio of individuals at different stages of sexual maturity (Fig. 10) showed that in the period from February to July, individuals of the 2nd stage (which will be ready to spawn in subsequent years) were extremely rare among both females and males. However, their number increased markedly in August and September for both sexes.

Individuals at the most developed stages of maturity (3rd-4th+) were observed mainly in the period from September to May of the following year (Fig. 9). In addition, the seasonality of spawning was almost the same in individuals of both sexes, which once again confirms that the period from October to March/April of the following year it can be considered the spawning time.

The study of productivity in the form of carp fecundity was carried out by counting eggs from 70 females who reached sexual maturity. The standard length of the females ranged from 37 to 68 cm, and their total weight ranged from 0.93 to 6.4 kg. The weight of the gonads ranged between 184 and 2035 grams.

The absolute fecundity ranged from 43.8 to 785.64 thousand eggs, with an average of 272.815 ± 49.512 thousand eggs. Relative Fecundity ranges from 76.8 to 283.2 eggs per gram of body weight. Depending on the age groups, Fecundity increased from 43,802 eggs for the second age group to 785,640 eggs for the 7-year-old age group. This led to an increase in fecundity with age from 51,716 eggs per year in the early years to 57,782 eggs per year in the oldest individuals, indicating a slight increase with age,

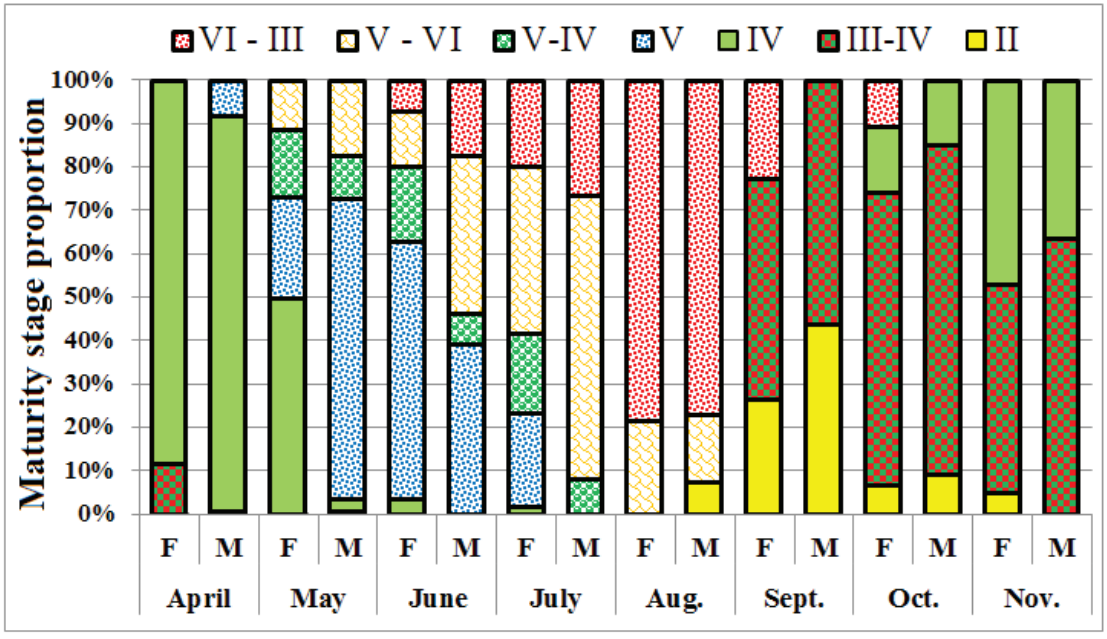

Figure 9. Monthly ratio of carp maturation stages at fishing sites in the northern and southern sections of Negreikin banks, Volga delta.

which is confirmed by a relatively moderate related correlation coefficient — R2 = 0.53 (Fig. 8D). It is well known that the level of Fecundity depends on the length, weight and, to a greater extent, on the weight of the female sex glands. Data on changes in the Fecundity of carp of the same size as in the rivers of the Volga River delta during the spawning period indicate significant differences ($P<0.05$).

As the length and weight of the carp increase, its average fertility also increases. However, the number of eggs laid by individuals of the same size and weight varies significantly. For example, in a group of fish with a length of 35 to 40 cm, fertility ranges from 43.8 to 100 thousand eggs. In the largest size group from 45 to 55 cm, the range is even wider, from 126 to 586.5 thousand eggs (Fig. 10 A). The same significant fluctuations in fertility are observed in carp in the same weight categories in the year of observation. These fluctuations can be 2-3 times higher (Fig. 10 B). However, this trend is not evident in all age groups. The only exception is four-year-old females, whose fluctuations ranged from 78 to 642,000 eggs, i.e., 6 times higher (Fig. 10 C). Figure 10 also shows the relationship between absolute fertility, body length, weight, and mass of the sex glands. The results demonstrate a relatively high correlation between the absolute fertility of fish and their length and body weight ($r = 0.91$, $p<0.01$) and the mass of the sex glands ($r=0.95$, $p<0.01$) (Fig. 10 D).

In our material, it was found that the relative Fecundity of carp from the eastern reservoirs of the Volga Delta ranges from 76.8 - 283.2 eggs per 1 g of body weight. However, the calculation of correlation coefficients (R2) indicates the absence of any direct relationship between relative Fecundity and body length, weight, and age of the carp (correlation coefficients are statistically insignificant).

DISCUSSION

First of all, it is worth noting that there is currently a lack of information about the biology of carp in the Volga-Caspian region, despite its commercial importance in the area. There is comparatively sufficient data on its biology, and especially its reproductive biology in the western and southern Caspian. These data are documented in scientific publications of Dagestani and Iranian specialists (Ramazanov, 2017; Kurbanov et al., 2019; Abdusamadov et al., 2020; Larijani et al., 2024; Mohammadnejad, 2022; Ab-

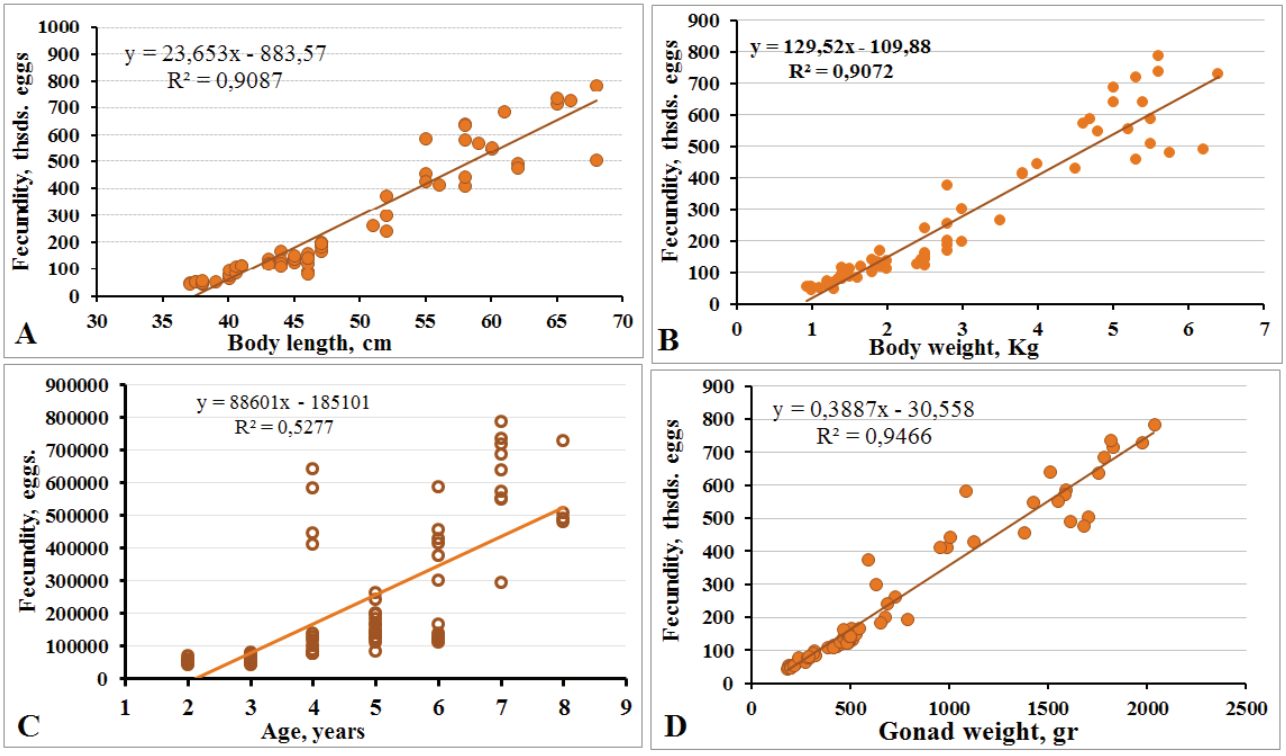

Figure 10. Relationship between absolute Fecundity and length, body weight, mass of sex glands and age of carp from the waters of the East Volga delta.

basi et al., 2019; Abbasi et al., 2022; Andarz et al., 2022). Although our research program did not aim to study the conditions of carp's spawning in the Volga delta, however, according to KaspNIRKh, the spawning season of semi-anadromous fish, including carp (Sazan), in the delta in the spring of 2023 was affected by poor watering of spawning grounds (KaspNIRKh, 2024). Moeover, there are many finding about fish ecology in Caspian Sea (Sattari et al., 2020; Bakhshalizadeh et al., 2013, 2023).

Recently, the population of this fish species, which migrates to rivers, has noticeably decreased. During the breeding season, they move from the shallow waters of the estuary coast and the Northern Caspian Sea to the Volga Delta and the lower reaches of the Volga. There they are caught in tidal zones with seines with mesh sizes of 48-50-56 mm. Sazan catches in the early 21st century were unevenly distributed in the Volga delta and shoals of the estuarine coastal zone, with the highest recorded on the eastern banks of Igolkinsky, Obzhorovsky, and Belinsky, accounting for up to 40% of the total catch of the area (KaspNIRKh, 2024).

As our results revealed, the carp (Sazan) of the Volga delta begins to spawn when the water temperature in the lower reaches of the delta reaches 13-15 ° C., and its peak occurs in the first half of May, where it releases the first batch of eggs, after which the second spawning period begins. At the same time, an optimal water level is necessary for the successful spawning and survival of fry after the release of the first batch of eggs in late May and mid-June (Koblitskaya, 2001). From the data on the number and ratio of females and males, and knowing that mature females are responsible for the yield of the spawning operation during the spawning period, it seems that carp (Sazan) spawning in the research area is relatively weak this season. Here, the effect of selectivity of the fishing gear used on the one hand is not excluded, or female carp prefer other places more favorable for spawning and feeding of juveniles higher up the Volga Aktyubinsk floodplain and the Buzan arm (Sidorova et al., 2004; Chavychalova et al., 2014; Abbakumov, 2015).

Mature female carp are known to play a key role in spawning yields. Given the data on the number and ratio of males and females, it can be concluded that carp spawning in this area was relatively weak this season. The ratio between length and weight was evaluated separately for Males and females. The results of the analysis showed that the body shape of Males and females was characterized by allometric growth, if not to say highly allometric. The analysis showed that the body shape of the females is allometric ($P>0.01$). In addition, the ratio of length and weight in males and females was significantly different ($P < 0.01$). The corresponding length and weight ratios for males and females are shown in Figures 3 and 4, respectively. The calculated equations of length versus weight were $W=0.00004\ SL^{2.8432}$ ($r2=0.9794$, $n=130$).; $W=0.00003\ SL^{2.9249}$ ($r2=0.9847$, $n=198$) and $W=0.00003\ SL^{2.8947}$ ($r2=0.9828$, $n=328$) for males, females, and males, respectively.

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