Assessment of the ecological state of the Maysky village reservoirs, Belgorod region, based on the analysis of morphological features of silver carp Carassius gibelio

V I Zheltukhina, M. A. Kulikova, E Yu Kolesnichenko and L A Manokhina
Belgorod State Agrarian University, Vavilova str., 1, Maysky village, Belgorod region, Russia
E-mail: valentinsoloveva@mail.ru

Abstract. Currently, pollution of aquatic ecosystems of diverse nature affecting the stability of fish population growth and, consequently, the sustainability of the ecosystem as a whole, is of special concern. The most common species of the Eurasian continent is the silver carp Carassius gibelio inhabiting lakes and rivers. The study of morphological features of the species makes it possible to reveal changes in the quality of water in reservoirs caused by various environmental factors.

1. Introduction
Rapid population growth, increased irrigated areas [1], urbanization and industrialization have led to unprecedented use of natural resources. In recent years, the volume of contaminants that enter water reservoirs has increased significantly [2].

The purpose of our research is to study the patterns of silver carp morphological features formation in the reservoirs of the Maysky village, Belgorod Region. The tasks include the study of silver carp morphological features depending on habitat conditions; assessment of silver carp growth stability by manifestation of fluctuating asymmetry and aquatic habitat quality by asymmetry coefficients (integral indicators of stable growth) [3].

Methods. The objects of our study were the reservoirs of the Maysky village, Belgorodsky district, Belgorod region: ‘Maysky – The Upper pond’ (location 1), ‘Maysky – The Lower pond’ (location 2), the pond near the sewage treatment plant (location 3).

The ecological state of water reservoirs was determined by the bioindication method, studying the fluctuating asymmetry and the phenodiviants frequency of five meristic features of the silver carp Carassius gibelio.

To assess the quality of the aquatic environment, the fluctuating asymmetry of the silver carp was studied according to the following features: the number of branchial stamens on the 1st branchial arch (Stamen branchiae SB); the number of scales in the lateral line (linea lateralis; LI); the number of rays in the pectoral fins (Pinna pectoralis PP); the number of rays in the pelvic fins (Pinna ventralis PV), and the number of pharyngeal teeth (Pharynx PH) [4].

Fish were caught using a fishing rod or water net. The sampling was carried out in 20 three years old species from each water body. The age was determined using binoculars by counting the number of arcs (rings) on the scales.
To analyze the asymmetry of qualitative features, integral indicators of growth stability (coefficients) were calculated. FAM (frequency of asymmetric manifestations) is calculated as the ratio of the number of features showing asymmetry to the total number of counted features. FAM / F is the average frequency of asymmetric manifestations per feature. FAMS (frequency of asymmetric manifestations by species) is calculated as the ratio of the number of species with an asymmetric feature to the total number of species [12]. Statistical processing was carried out using standard formulas.

2. Results

Data analysis showed that in the objects of study in locations 1, 2 and 3 the number of asymmetric species was 9, 8, 10 (table 1), representing 45, 40 and 50% of the total number of species (Fig. 1). The number of species asymmetric by 5 features in locations 1 and 3 amounted to 7, which was 35% of the total number of species in the sample. In location 2 the number of species asymmetric by 5 features was 2.3 times lower in relation to those of 1 and 3 (figure 1).

Table 1. The number of asymmetric species and asymmetric species according to different numbers of features

| Object of study                              | Total number of asymmetric species | Number of asymmetric species by 5 features | By 4 features | By 3 features |
|---------------------------------------------|-----------------------------------|-------------------------------------------|---------------|---------------|
| ‘Maysky – Upper pond’ (location 1)          | 9                                 | 7                                         | 1             | 1             |
| ‘Maysky – Lower pond’ (location 2)          | 8                                 | 3                                         | 5             | -             |
| The pond near sewage treatment plant (location 3) | 10                                | 7                                         | 2             | 1             |

When analyzing species asymmetric by 4 features only one was found in location 1, and two in location 3, which amounted to 5 and 10% of the total number of species in the studied group. In location 2 there were 5 species asymmetric by 4 features, which made 25% of the total number of species in the sample (figure 1).

The number of species asymmetric by 3 features was significantly fewer. Locations 1 and 3 had one species, or 5 %, location 2 - none. In all three locations there were no species asymmetric by one or two features.

Figure 1. The proportion of asymmetric species according to several features in each location, %.
Evaluating the studied biotopes according to the number of asymmetric species and features in them, we came to the following conclusions. A fairly stable picture was observed in ‘Maysky - Upper Pond’. The number of species for almost every feature was 9, i.e. 45% of the total number in the sample. Exception: species asymmetric by the number of branchial stamens on the 1st branchial arch were 35% fewer (Table 2). ‘Maysky - Lower Pond’ was characterized by the greatest diversity.

The number of species asymmetric by the number of branchial stamens on the 1st branchial arch was 5, or 25%, respectively. The number of species asymmetric by the number of scales in the lateral line and by the number of rays in the pelvic fins amounted to 7, or 35%. The number of species asymmetric by the number of rays in the pectoral fins and the number of species asymmetric by the number of pharyngeal teeth was 8, or 40% (figure 2).

Table 2 - The number of asymmetric features in each location

| The feature of fluctuating asymmetry | ‘Maysky upper pond’ (location 1) | ‘Maysky lower pond’ (location 2) | The pond near sewage treatment plant (location 3) |
|-------------------------------------|----------------------------------|----------------------------------|-----------------------------------------------|
| number of branchial stamens on the 1st branchial arch | 7 | 5 | 8 |
| the number of scales in the lateral line | 9 | 7 | 10 |
| number of rays in the pectoral fins | 9 | 8 | 10 |
| number of rays in the pelvic fins | 9 | 7 | 8 |
| number of pharyngeal teeth | 9 | 8 | 11 |

The pond near the sewage treatment plant has the following indicators. The number of species asymmetric in the number of branchial stamens on the 1st branchial arch and the number of species asymmetric in the number of rays in the pelvic fins is 8, or 40%.

The number of species asymmetric by the number of scales in the lateral line to the number of rays in the pectoral fins exceeds by 2 and makes 10 pieces, or 50%. However, the number of species asymmetric by the number of pharyngeal teeth is 11, or 55% (Fig. 2).

Comparing the most borderline ponds with each other (‘Maysky - Lower pond’ and a pond near the treatment plant), we can conclude that there is an increase in the number of species asymmetric in terms of SB, LI and PH - by 3, PP features - by 2, PV features - by 1.

Figure 2. The proportion of asymmetric features in each location, %.
The greatest increase in asymmetric features was observed in SB and amounted to 37.5%; the lowest PV was 12.5% (figure 3). The increase in features LI, PP, PH proceeded in the following order - 30Wh, 20, and 27.3%.

![Dynamics of asymmetric features growth](image)

Figure 3. Dynamics of asymmetric features growth between ‘Maysky - Lower pond’ and the pond near the sewage treatment plant, %.

The data analysis showed that the lowest index for FAM / F was in ‘Maysky - Lower pond’, which was 0.35 ± 0.03 and for FAMS - 0.4. The highest index for FAM / F was a feature of the pond near the sewage treatment plant 0.46 ± 0.02 and for FAMS - 0.5 (Figure 4).

![Integral indicators](image)

Figure 4. Integral indicators, FAM / F (frequency of asymmetric manifestations per feature) and FAMS (frequency of asymmetric manifestations by species).

Further, the quality of the environment was assessed in locations according to the integral indicator of growth stability proposed by V.M. Zakharov, 1987 (table 3).
Table 3. Assessment of the environment quality in locations according to the integral indicator of fish growth stability (according to V.M. Zakharov, 1987).

| Class          | The value of the fish growth stability indicator (FAM and FAMS) |
|----------------|---------------------------------------------------------------|
| 1 – clean      | under 0.35                                                   |
| 2 – relatively clean | 0.35–0.40                                                |
| 3 – contaminated | 0.40–0.45                                                   |
| 4 – dirty      | 0.45 – 0.50                                                  |
| 5 – very dirty | 0.50 and above                                               |

Morphological analysis revealed a disruption of stability in the studied fish growth in two locations: in the ‘Maysky - Upper pond’ (location 1) and in the pond near the sewage treatment plant (location 3). The ‘Maysky - Upper pond’ with the index of 0.42 falls within the range between 0.40–0.45, which is class 3 – ‘contaminated’ (Table 3). The pond near the sewage treatment plant with the index of 0.46 falls within the range between 0.45–0.50, with class 4 – ‘dirty’. The ‘Maysky - Lower Pond’ has class 2 – ‘relatively clean’ (0.35–0.40). In all the studied biotopes there were no species asymmetric by two or one feature.

Table 4. Frequency of asymmetric manifestations per feature in Carassius gibelio Bloch.

| The feature of fluctuating asymmetry | ‘Maysky upper pond’ (location 1) | ‘Maysky lower pond’ (location 2) | The pond near sewage treatment plant (location 3) |
|--------------------------------------|----------------------------------|----------------------------------|-------------------------------------------------|
| number of branchial stamens on the 1st branchial arch | 0.35                             | 0.25                             | 0.40                                            |
| the number of scales in the lateral line | 0.45                             | 0.35                             | 0.50                                            |
| number of rays in the pectoral fins  | 0.45                             | 0.40                             | 0.50                                            |
| number of rays in the pelvic fins    | 0.45                             | 0.35                             | 0.40                                            |
| number of pharyngeal teeth           | 0.45                             | 0.40                             | 0.50                                            |
| FAM/F                                | 0.42±0.03                        | 0.35±0.03                        | 0.46±0.02                                       |
| Class                                | 3                                | 2                                | 4                                               |

Since fluctuating asymmetry is an indicator of species growth stability [4], which in turn is associated with the conditions of the fish population existence in a particular water reservoir, the silver carp asymmetric in terms of the studied features indicate that the water quality of the lower pond is the most favorable. In the pond near the sewage treatment plant the proportion of asymmetric species and features is significantly higher, therefore, the quality of the aquatic environment is lower.
3. Conclusion
Thus, the possibility of assessing the aquatic environment quality depending on the stability of the Maysky silver carp growth (*Carassius gibelio* Bloch) using fluctuating asymmetry has been found. The great variety in the indicators of fluctuating asymmetry shows different conditions for the embryonic and postembryonic development of species. The high level of fluctuating asymmetry of species in the pond near the sewage treatment facilities indicates the highest degree of water pollution in the reservoir.

References
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