Towards ecological friendly pond aquaculture in the Ili River basin (Kazakhstan, Central Asia)

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Abstract. Aquaculture in Kazakhstan is today in a stage of rapid development. There are a large number of ponds in the Ili River basin, but aquaculture in most of them is carried out using routine methods. The problem is aggravated by the fact that for many rare representatives of the native fish fauna, ponds are one of the last refuges. This article presents the results of a study of fish diversity in 18 pond farms during the period 2007-2023. The results obtained showed the possibility of long-term coexistence of carp and such valuable commercial native fish species as the Balkhash marinka *Schizothorax argentatus*, the Ili marinka *Schizothorax pseudaksaiensis* and the Balkhash perch *Perca schrenkii*. Rearing predatory fish such as pike perch and snakehead in ponds is not only unprofitable, but also causes significant harm to the ecosystems of water bodies. On the contrary, the cultivation of pond farms in the basins of this region together with Balkhash marina carp, Ili marina and Balkhash perch not only allows for the preservation of these valuable native species and increases the mass of marketable fish, but also significantly relieves the nutrient loading on natural water bodies.

1 Introduction

Fisheries in natural reservoirs are approaching their maximum, therefore, to further increase fish production, the development of aquaculture is necessary [1,2]. In the Republic of Kazakhstan, this problem is especially acute due to the transboundary position of most large rivers, the main flow of which is formed outside this country. In the Ili River basin, the problem is aggravated by the high density of the human population and unsustainable management of water resources [3-6]. The indigenous fish fauna of this basin consists of several fish species with a high degree of endemism [7]. In the second half of the last century, more than 30 alien fish species were introduced here, which displaced the native ichthyofauna into small tributaries and ponds [8]

In the Ili River basin there are a large number of small lakes and ponds, created mainly during the Soviet era. The destruction of the Soviet system led to the decline of agriculture. A particularly acute crisis occurred in fish farming, as a result of which most of the ponds

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were abandoned. Currently, the government is intensively stimulating the development of aquaculture in the Republic of Kazakhstan [9-11].

The intensification of aquaculture leads to increased stress on pond ecosystems and the environment [1,12]. In Kazakhstan, the traditions of pond fish farming have been largely lost during the years of decline of this industry, and effective environmental monitoring of the condition of ponds is currently not carried out. Therefore, the purpose of the study was to find out whether it is possible to preserve valuable native fish species with an increase in the number of farms engaged in growing marketable fish in ponds?

2 Materials and Methods

The study was conducted from 2007 to 2023. In total, 18 ponds were studied near and in the city of Almaty, however, for various reasons (ban on tenants to conduct research, destruction of ponds), long-term monitoring was carried out only on 6 farms, growing mainly carp. Of these, the Kapchagay Spawning and Rearing Farm (KRF), the Kazakh Production and Acclimatization Station (KP), and the Almaty Pond Farm (AP) are specialized farms that have been growing fish for at least 50 years. Reservoirs K29, K32, ponds on the Aksengir River (Aks) were created mainly for irrigation needs.

We used a seine nets and a hand nets to catch fish. This method is sufficient to obtain data on the overall diversity and relative abundance of fish [13]. The method is traditionally used in Kazakhstan, which makes it possible to compare data obtained for different reservoirs and by different researchers [14]. Each reservoir was surveyed at least once every 2 years. We do not have data on the total volume of fish grown and/or sold at each farm. Therefore, subjective indicators such as the change of owners (tenants) and the condition of the reservoirs themselves were used as indicators of the success of their activities.

Spearman correlation and the principal components analysis (PCA) were used for statistical processing of the obtained data; similarity dendrograms of ponds were constructed using UPGMA and Complete linkage methods [15].

3 Results and Discussion

Three ponds were abandoned by tenants and dried up by 2011. Other tenants tried to raise the Amur snakehead Channa argus in 4 ponds in 2007-2008. This project probably turned out to be unprofitable because they abandoned the ponds after 2 years and by 2012 these ponds had turned into swamps. Two of the ponds are used as water parks and no fish farming activities have been undertaken in three of the ponds. Thus, only 6 out of 18 pond farms more or less consistently farmed fish during these 17 years.

During the research period, all three specialized fish farms (KRF, KP, AP) were transferred from state to private management, and then were in decline in production for more or less a long time. In different years, severe overgrowing and/or shallowing of ponds and accumulations of garbage on the banks were observed everywhere. By 2022, KP's ponds had fallen into complete disrepair. Reservoirs K-29 and K-32 changed their activities several times (recreational fishing, commercial farming of carp or pike perch) and also experienced periods of neglect.

The condition of the ponds on the Aksengir River remained relatively stable: commercial carp farming and recreational fishing were combined here, using water for agricultural needs.

Information on the fish species assemblages is presented in Table 1. Indigenous species with high palatability are the Balkhash marinka Schizothorax argentatus, the Ili marinka

Schizothorax pseudaksaiensis, the Balkhash perch Perca schrenkii, and the naked osman Gymnodiptychus dybowskii [16]. The first three species of fish have long become rare and are included in the international Red List [17] and/or the Red Book of the Republic of Kazakhstan [18].

Table 1. Frequency of occurrence of various fish species (proportion of the total number of studies in each reservoir)

Fish species		Water bodies					
Scientific name	English name	KRF	KP	AP	K29	K32	Aks
Aquaculture objects							
Cyprinus carpio	Common carp	1.00	1.00	1.00	0.41	0.88	1.00
Hypophthalmichthys molitrix	Silver carp	0.47	0.47	0.29	0.12	0.18	0
Ctenopharyngodon idella	Grass carp	0.59	0.29	0.18	0.12	0	0.18
Sander lucioperca	Sander, pike-perch	0.88	0	0.71	0.18	0.18	0
Aboriginal							
**Schizothorax argentatus*	Balkhash marinka	0	0	0	0.29	0.88	1.00
**Schizothorax pseudaksaiensis*	Ili marinka	0	0	0	0	0.47	0.88
* *Gymnodiptychus dybowskii*	Naked osman	0	0.59	0	0.47	0.71	0.88
Triplophysa dorsalis	Grey stone loach	0.29	0.59	0.59	0.12	0.06	0.88
Triplophysa strauchii	Spotted thicklip loach	0.47	0.82	0.82	0.59	1.00	0.88
**Perca schrenkii*	Balkhash perch	0.06	0.18	0.41	0.06	0.18	1.00
Alien species							
Carassius gibelio	Prussian carp	1.00	0.82	1.00	0.29	1.00	0.82
Abramis brama	Bream	0.71	0	0	0.18	0.06	0
Rutilus rutilus	Roach	0.88	0	0.59	0	0.18	0.71
Rhodeus ocellatus	Rosy bitterling	1.00	0	0.47	0	2	0
Abbottina rivularis	Abbottina	0.82	0.29	0.35	0.41	0.18	0
Pseudorasbora parva	Topmouth gudgeon, or Stone moroko, or Pseudorasbora	1.00	0.94	1.00	0.59	0.47	0.41
Oryzias sinensis	ricefish	1.00	0.12	1.00	0.47	0	0
Micropercops cintus	eleotris	1.00	0.88	1.00	0.82	0.29	0
Rhinogobius cheni	goby	1.00	0.94	0.88	0.71	0.71	0
Channa argus	Snakehead	0.82	0	0	0	0	0
*Indigenous commercial species							

A significant correlation of changes in diversity was found between the K-29 reservoir and KazPAS ponds ($r = 0.738$, $p = 0.01$). Great similarity in fish species composition was also found between ponds KRF and AP on the one hand, and K32 and Aks on the other (Figure 1A). In ponds K32 and Aks, native species were the most diverse and more common than in other ponds. The results of merging using UPGMA Complete linkage methods gave a similar picture with a difference in the level of cluster merging. The loads of the first three principal components were distributed approximately equally among all fish species. Based on the totality of joint encounters, all fish species were divided into three groups (Figure 1B): 1) native species, 2) carp and accompanying Prussian carp plus native gray loach, 3) alien species (grass carp, silver carp, pike perch, snakehead and small non-commercial kinds). A significant positive correlation exists between species in each group, and there is also a negative correlation between some native and alien species.

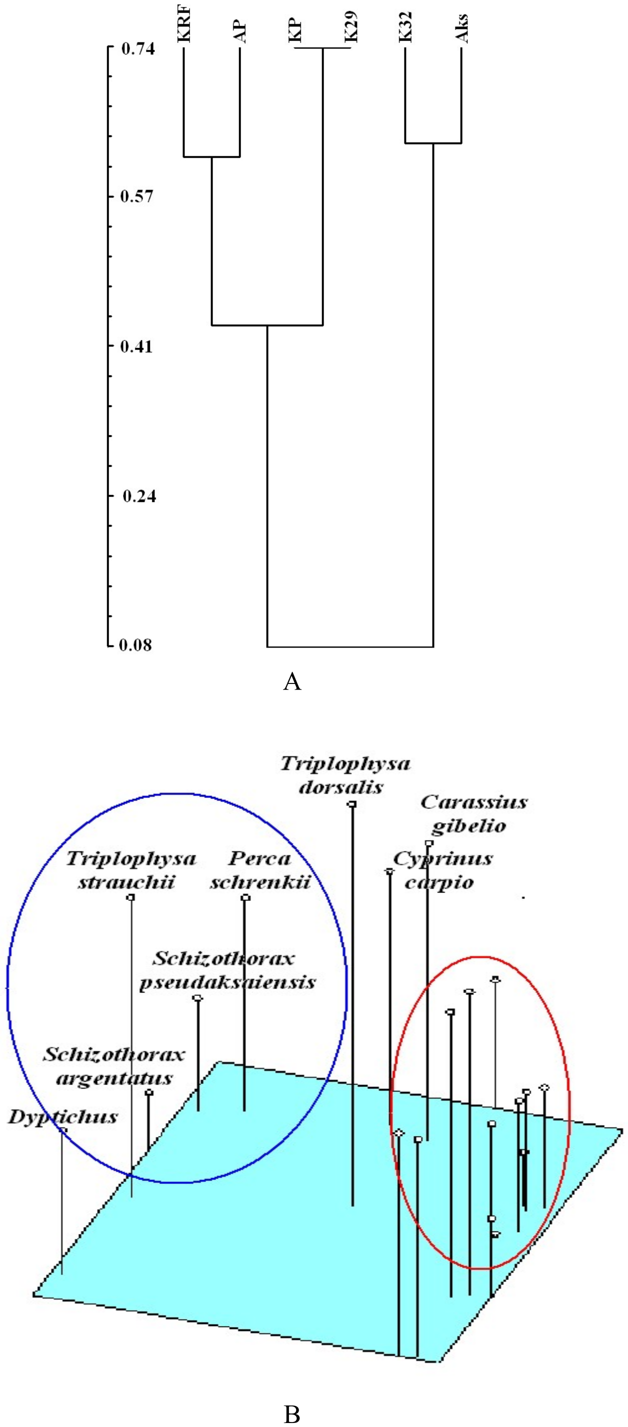

Fig. 1. Comparison of ponds by the diversity of fish species using UPGMA analysis (A) and the position of various fish species in the space of the first three principal components depending on the

frequency of joint meetings in the ponds (B): the blue oval unites only native fish species, the red other only alien fish species .

Based on subjective indicators, the most successful farm is Aksengir, where a consistently high diversity of native fish species was observed. The results obtained showed the possibility of long-term coexistence of carp and valuable commercial native fish species. The small number of farms studied and the lack of specific data on the amount of fish grown in each of these farms (current legislation allows private entrepreneurs not to provide this information) does not allow for deeper statistical processing of the data. We can only propose as a working hypothesis that the conservation of native ichthyofauna turns out to be possible/beneficial when rearing carp farming.

Here, the routine technology for growing carp was based on natural pond feed and feeding mainly low-protein crumbly feed and grain processing waste. At the same time, all native and non-commercial alien fish species are considered weeds and measures were taken to reduce their numbers.

Modern practice of growing carp in ponds has changed significantly. Fish farmers increase the stocking density of fish and intensively feed the carp with special granulated artificial feed with a high protein content from domestic or foreign manufacturers (e.g. Aller Aqua, Merke, BioMar and others). However, many fish farmers adhere to the old prejudice about the harmfulness of native fish species, especially Balkhash perch, and therefore strive to exterminate native species in ponds [19]. This is a very harmful misconception. It should be clearly understood that Balkhash perch and marinkas choose food items other than artificial food. The Balkhash and Ili marinkas prefer plant foods (macroalgae and aquatic plants) and benthos, and the Balkhash perch feeds on aquatic invertebrates and small fish. Under conditions of intensive feeding of carp, the flow of nutrients into the reservoir increases, followed by an increase in the biomass of aquatic plants and invertebrates [1; 12]. This additional biomass can be absorbed by valuable native fish species or small alien ones like Pseudorabora parva and others. The high taste of both marinkas and Balkhash perch makes them an excellent addition to carp production.

4 Conclusion

Over the course of the 17 years, only 6 of the 18 pond farms we selected for study consistently produced commercial fish. Of these, only two farms stably preserved such commercial native fish species as Balkhash marinka and Balkhash perch. Many fish farmers adhere to the harmful misconception that native species are undesirable in carp farms and strive to get rid of them.

Growing predatory fish such as pike-perch and snakehead in ponds is not only unprofitable, but also causes significant harm to the ecosystems of water bodies. These two alien fish species quickly destroy the native ichthyofauna and thus destroy the self-purification system of water bodies.

Our results confirm the need to introduce the concept of intensifying aquaculture in Kazakhstan through polyculture, proposed in 1995 by Zh.G. Sarsembayev [20]. Since most ponds in Kazakhstan have poorly regulated natural characteristics, fish farming should be based on maximum utilization of the incoming flow of nutrients through wide-spectrum polyculture. The disadvantage of valuable native species is their low growth rate. Therefore, without domestication and selection, growing marinkas in pure culture is unlikely to be highly profitable. However, given the high cost of perch on the foreign market [21], growing Balkhash perch may be promising. One should also take into account the existing practice of returning untreated wastewater from ponds to rivers, where the Balkhash marinka and the Balkhash perch perform the necessary ecosystem services to regulate the flow of nutrients and are thus an important element in the self-purification of water bodies.

In pond farms of the Ili River basin and the Balkhash basin as a whole, growing Balkhash marinka, Ili marinka and Balkhash perch together with carp will not only preserve these valuable native species and increase the mass of marketable fish, but will also significantly ease the nutrient load on natural reservoirs

Authors contribution

Conceptualization, N.S.M., G.B.K. and G.K.K; Methodology N.S.M., G.B.K. and I.N.M; Software and Formal Analysis, N.S.M. and I.N.M.; Investigation, G.B.K., G.K.K., M.B.K.; Resources, G.B.K. and M.B.K.; Writing – Original Draft Preparation, G.B.K. and G.K.K.; Writing – Review & Editing, N.S.M.; Visualization, G.B.K.; Supervision, N.S.M.; Project Administration, G.B.K.

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