IJABR

International Journal of Advanced Biotechnology and Research (IJABR)
ISSN 0976-2612, Online ISSN 2278–599X,
Vol-10, Issue-2, 2019, pp336-343
http://www.bipublication.com

Research Article

Crossbreeding in Commercial Fish Farming

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[Received: 13/01/2019; Accepted: 01/05/2019; Published: 03/05/2019]

ABSTRACT.

In commercial fish farming, the main value of hybrids lies in their higher productive qualities, which are due to the effect of heterosis, which depends on the non-additive action of genes (domination, super-dominance, epistasis) and on the homozygosity of parents in different genes of the same loci. Parskiy breed of carp includes two inbreeding groups of fish: scaly carp (strain M)andscattered carp (strain UM). Scaly carpswereobtained by hybridization between the local outbred scattered carp and Amur carp (S) followed by selection of the hybrids in six generations. Due to the hybridization of carp with the Amur wild carp there appeared a possibility of carp farming in Northern zones of the fishery. By crossing the carp of different breeds in order to obtain the effect of heterosis, i.e. phenotypic superiority of hybrids over non-hybrid peers, it was possible without economic costs, to obtain an increase in the growth of live weight, primarily that of fingerlings, and good material for growing at the end of the season; reduce the period of cultivation, which is important for the Northern (I and II) zones of fish farming. It was proved that the hybrids of the first generation carp grow well, due to increased viability and resistance to diseases. The use of heterosis is of great practical importance in aquaculture. Hybrid fingerlings have an increased heterosis and exceed the analogs by an average of 10-30% in growth rate, especially in the fry period when low temperature and a lack of feed.

To getgood material for growing the following hybrids of carp were promising: ♀♀ strain M(local)× ♂♂ strain UM (Ukrainian local); ♀♀ strain Szarvas × ♂♂ strain Cherepetskiy framed. It is important to choose hybrids of carp taking into account fish farming areas, the requirements of farms for the quality of fish meat, growth rate, exterior parameters, final weight, etc. It is possible to improve the effect of hybridization using global gene pool of common carp with a distant genetic determination that will give some productive forms.

Keywords: fish farming, aquaculture, crossing, heterosis, carp.

INTRODUCTION

Modern aquaculture is an actively developing production sector, which is becoming an important industry contributing to the food supply of the population with high-quality and safe products. Aquaculture is rapidly expanding its geographical boundaries, its products not only conquer sales markets, but also increase their share in the global fish market [8]. One of the main directions for the development of aquaculture in our country is currently pond fish farming [11]. Pond fish farming is one of the most ancient types of activity. Fish farming is a profitable and commercially viable business. To organize it, it is necessary to determine the most appropriate type of fish, the way of breeding and feeding, as well as the peculiarities of fish management [12]. Evaluation of the state of organic aquaculture, which is the production (cultivation) of aquatic species (fish, crustaceans, mollusks, algae, etc.), which guarantees high quality and safety of products in accordance with certain principles, is based on numerous statistical data [10]. By breeding carp of various breeds, in order to obtain the effect of heterosis, that is, the

phenotypic superiority of hybrids over non-hybrid peers, it is possible to obtain an increase in live weight, primarily that of fingerlings, and good material for growing at the end of the season; reduce the period of cultivation, which is important for the Northern (I and II) zones of fish farming.So, it is important to use heterosis in modern domestic aquaculture.

The term “heterosis” (translated from Greek 'change, transformation') is an increase in the viability of hybrids due to the inheritance of a specific set of alleles of various genes from their heterogeneous parents. The term was first introduced in 1914 by American researcher A. Schell, at the suggestion of another American researcher E. East instead of “Heterozygosis”, which had designated “hybrid force” since 1907. The term “heterosis” was first described by the academician of Petersburg Academy of Science J. Kohlreiter in 1766, i.e. even before G. Mendel's discovery of his laws. So, experiments on crossing more than 50 species of plants were described. Based on his work, J. Kohlreiter suggested using hybrid power in different cultures in practice, but the scientific knowledge of that time did not allow this natural phenomenon to be implemented in practice [9].

Heterosis is a complex phenomenon and it is not peculiar to all properties in the same degree. Usually, heterosis is manifested in those characteristics that are most susceptible to inbreeding depression and are characterized by low heritability. Heterosis is most pronounced according to the properties that develop in animals in the early period of life (survival rate, growth rate in the initial stages of postembryonic development, etc.). To a lesser extent, it is manifested in such features as growth rate and efficiency, etc., which are formed in animals in the later periods of individual development.

The manifestation of heterosis in various economically useful traits has its own characteristics. According to the features that have undergone very long selection, usually the best results are observed not in 1st generation hybrids, but in purebred animals or hybrids with higher pedigree levels in one of the breeds. Heterosis is a very complex natural phenomenon. The etiology of its manifestation has not yet been established. There are many different theories about the nature of heterosis: the hypotheses of dominance, super dominance, genetic balance, balance of enzymes, vitality, zootechnical concept of heterosis, etc.It is believed that heterosis depends on the nonadditive effect of genes (dominance, super dominance, epistasis) and on the homozygosity of parents for different genes of the same locus.

When increasing the livestock production, it is important to use the effect of heterosis. In animal husbandry, the phenomenon of heterosis has been used in practice for more than 2 thousand years. Thus, in horse breeding, mules (hybrids between horse and donkey) are obtained, having vivid heterosis of the strong body type, viability, endurance, and longevity [13,14]. The effect of heterosis is actively used in other industries, in particular in pig breeding, cattle breeding, poultry farming, plant growing [3,7]. In fish farming, the use of the heterosis phenomenon is not new. So, most often, one can hear about hybrids of silver carps, sturgeons (beluga with sterlet - bester, Russian and Siberian sturgeon, etc.). V.S. Kirpichnikov, who has devoted his scientific work to hybridization of fish and the problem of heterosis, is considered the founder of investigations on fish genetics [4].

In order to promote cross-breeding in commercial fish farming by means of hybridization, the Ministry of Agriculture of the Russian Federation, the Federal Fisheries Agency, the Administration of Rostov oblast, associations "Rosrybkhoz" and "Rostovrybkom" held alignment meeting “The results of introducing F1 carp hybrids and the prospects for the production of breeding products, ensuring the effective development of commercial fish farming”. The meeting took place on June 8, 2018 in the city of Semikarakorsk in Rostov oblast on the basis of the breeding farm of LLC "SlobodaSagva" of the Big Fish Association. The most common breed in pond fish farming in Russia is the Parskiy breed of carp, which includes two intrabreed groups of fish: scaly carps (strain M) and scattered carps (strain UM) [1,2].

Scaly carps were obtained by hybridization between a purebred local carp and an Amur carp (C), followed by selection of hybrids in six gen-

erations. Strain M was named according to the principle - "local" carp. The fish of M strain have a continuous scale covering, and the scattered ones, in this case, are rejected. The strains difference in scale covering also makes it possible to contain carp groups of the same age without any additional marking. Along with the layering, fish farm “Para” has a brood stock of Amur carp, which is intended for crossing with the fish of UM strain. The presence of two carp strains and Amur carp strains has made possible for fish farm “Para” to pass completely to industrial crossing, allowing to use the heterosis effect [5,6].

It is known that heterosis depends on the degree of kinship between parental individuals: the more distant relatives are the parental individuals, the more heterogeneous is the effect of the first generation hybrids. This is what they tried to take into account when forming strains M and UM in Parskiy breed. According to the observations of Yu.P.Bobrova [1] showed the best results were demonstrated by cross-breeding of strain M females UM strain males, as well as UM strain females with Amur carp males. The cross breeds had best survival rates (10–20 % higher) and fish productivity (2.3 dt / ha more) in comparison with individuals of the initial strains [14].

The relevance of using heterosis in modern fish farming, when developing the technology for growing large carp planting material, is in little doubt. So, the aim of the investigations is to establish the effectiveness of the use of heterosis in the production of carp hybrids and to determine the best combinations of initial breeds.

MATERIALS AND METHODS

The studies were carried out in the Federal State Budgetary Educational Institution of Higher Education “Ryazan State Agrotechnological University Named after P.A. Kostychev" (FSBEI HE RSATU), in the scientific and educational center "Aquaculture and Fisheries ", in the framework of the thematic plan-task for the implementation of research works commissioned by the Ministry of Agriculture of the Russian Federation at the expense of the federal budget for 2018 on the topic "Development of the technology of growing large carp planting material".

The paper analyzed the data on the cultivation of various hybrids in fish farms that are part of the association “State-Cooperative Association of Fisheries (Rosrybhoz)”: fish farm “Para” in Sarayevskiy district of Ryazan oblast (head of the breeding section, head of the laboratory K.I. Budanova), ACJSC Kolomenskiy fish farm "Osenka" in Kolomna district of Moscow oblast (director M.V. Ukleykin, chief fish farmer S.N. Borovik) and breeding unit LLC "Slobodskaya-Sagva" of Rostov oblast, Semikarakorsk (director A.I. Mandryka, manager of "Big Fish Association" A.L. Ershov).

In the calculations, the data from the control catches of fingerlings were used, and various carp hybrids bred in farms at the present time were compared. The arrangement of crosses in several combinations of Parskiy breed was analyzed: ♀♀ strain M × ♂♂ strain UM; ♀♀ strain UM × ♂♂ strain M; ♀♀ strain UM × ♂♂ strain C and ♀♀ strain M × ♂♂ strain C. Such parameters as weight gain (g) and fish productivity (dt / ha) were compared.

Currently, not so many achievements (total 50 and 20 about carp) have been made in the state register of breeding achievements of the Russian Federation in aquaculture. Hence, it is important to mention the story of the best success in aquaculture in central Russia - breeding of Parskiy breed. The selection work began almost with the organization of fish farm "Para", which was commissioned in 1933. In the 1950s under the leadership of K.A. Golovinskaya some breeding technologies were purposefully trialed. A lot of effort and money was invested in breeding the breed and, in fact, it was approved in 1999.

Parskiy carp is a breed of the pond carp Cyprinuscarpio L., created by long-term selection in fish farm “Para” of Ryazan oblast, with the direct participation of the Federal State Unitary Enterprise All-Russian Research Institute of Freshwater Fisheries (ARRIFF). Already by the mid-1950s, fish farm "Para" became one of the largest high-intensity full-system pond farms, where selective breeding of carp hybrids with Amur carp for increasing fecundity was successfully done. In 1964, fish farm "Para" got the

Ukrainian scattered carps, created under the guidance of A.I. Kuzema and V.G. Tomilenko, which were brought from the Donrybkombinat and EPO "Yakot" ARRIFF.In 1965, the first offspring of the intermixed strains M and UM was obtained, then the best yearlings were selected with 20 % severity of selection and in the fall two-year-olds were selected with 30 % severity of selection. Since 1971, mass reproduction and introduction of offspring from the pedigree herd of Parskiy carp began.Since 1975, since the creation of the laboratory of bioequipment for the production of fish stocking material at ARRIFF, the activity of the experimental station for carp fingerlings has been activated in fish farm "Para".The introduction of the developed technology in fish farm "Para" allowed the fish productivity of nursery ponds to be increased to 20-23 dt / ha with a standard weight of carp fingerlings. Since 1977, only young tiny fishes weighing 25–30 mg have been put into production nursery ponds, which made it possible to increase the survival rate of fingerlings significantly. The work on Parskiy carp breeding was carried out on the basis of hybridization and mass selection, as well as the creation of optimal conditions for management of spawners and replacement stock, and the organization of industrial crossing to avoid the harmful effects of inbreeding. The main method of selection was the mass selection for increased fecundity when the factory method of reproduction and in the weight of the fish. And the main selection parameter was its intensity (1):

$$V = \frac{n \times 100}{N}, (1)$$

where N and n are the number of fish before and after selection.

In addition, the selection differential (S) was used - the differences between selected and raised individuals in terms of the average weight of fish (g).

RESULTS

Parskiy breed was created on the basis of hybridization of the initial carp group with the Amur carp using rigorous mass selection. The fish is characterized by high fecundity, good growth rate and survival. The resulting stock of carp at the time of creation exceeded the fish-biological norms by 3-5 times. The yield of yearlings from winter ponds was higher by 22-25 %. At the time of testing the livestock of the new breed of carp was 2,460 spawners and over 30,000 species of the replacement stock. At the same time, from the point of view of breeding strains U and UM belong to Parskiy breed and their crossing gives hybrids that are actually purebred.

The active work with the breed continued intensively, and from 2010 to 2016, the fish farms continued to receive various hybrids of Parskiy carp. According to our investigations, the productivity of a part of hybrids drastically exceeds the average index of other studied hybrids and purebred fish (Figures 1-7). Most often, heterosis appeared when crossing ♀♀ strain M × ♂♂ strain UM.

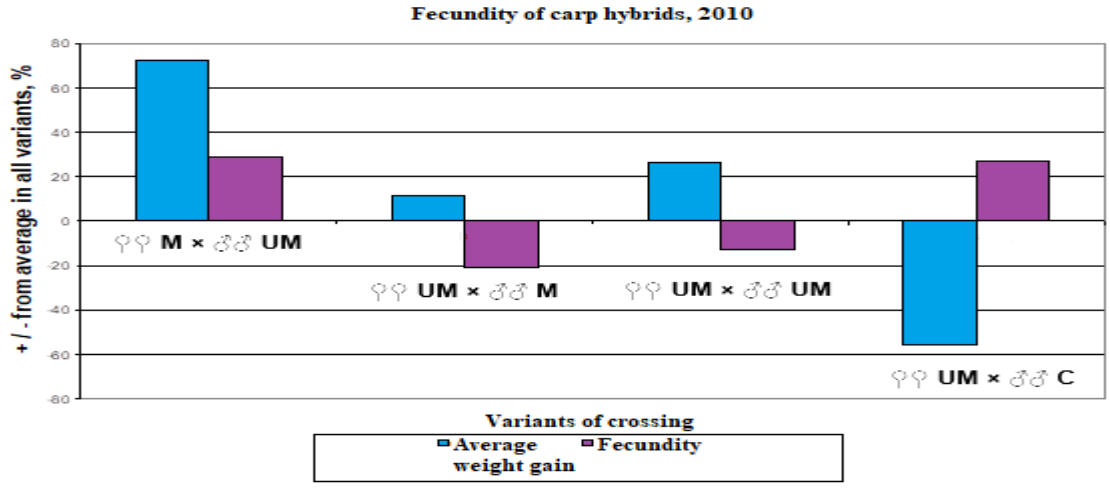

Figure 1. Fecundity of carp hybrids in 2010

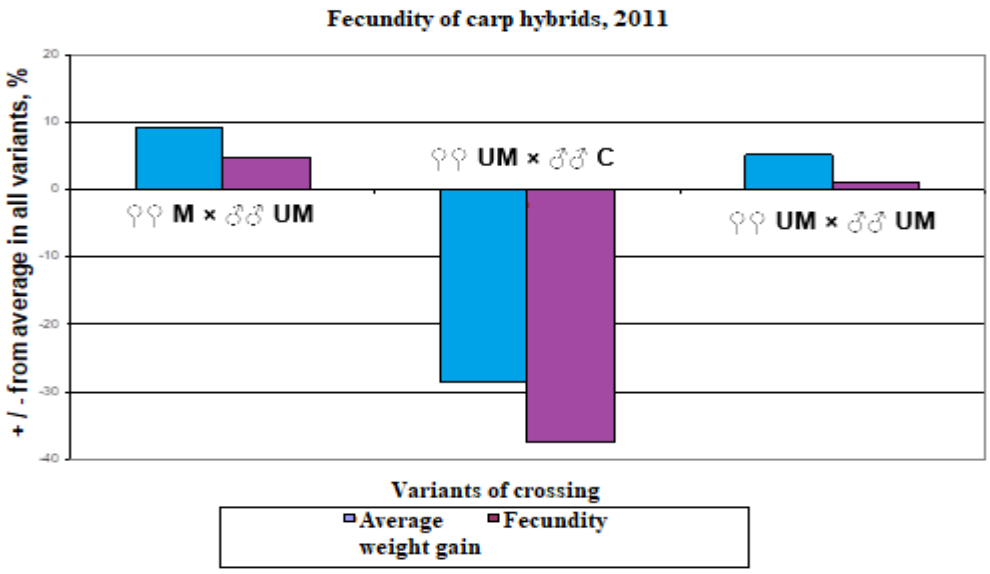

Figure 2. Fecundity of carp hybrids in 2011

In 2012, 11 ponds were stocked with hybrids (fish larvae) of Parskiy carp. The density was 20 thousand pcs. / ha.

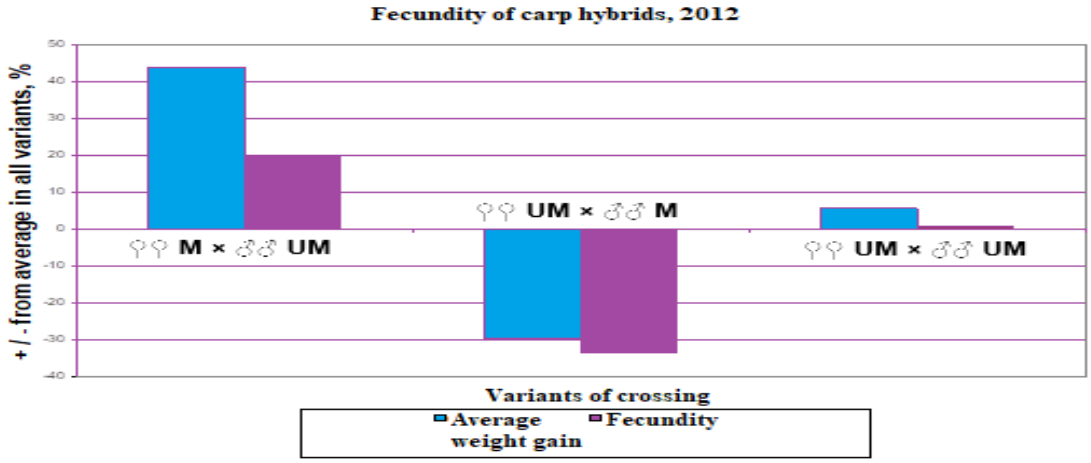

Figure 3. Fecundity of carp hybrids in 2012

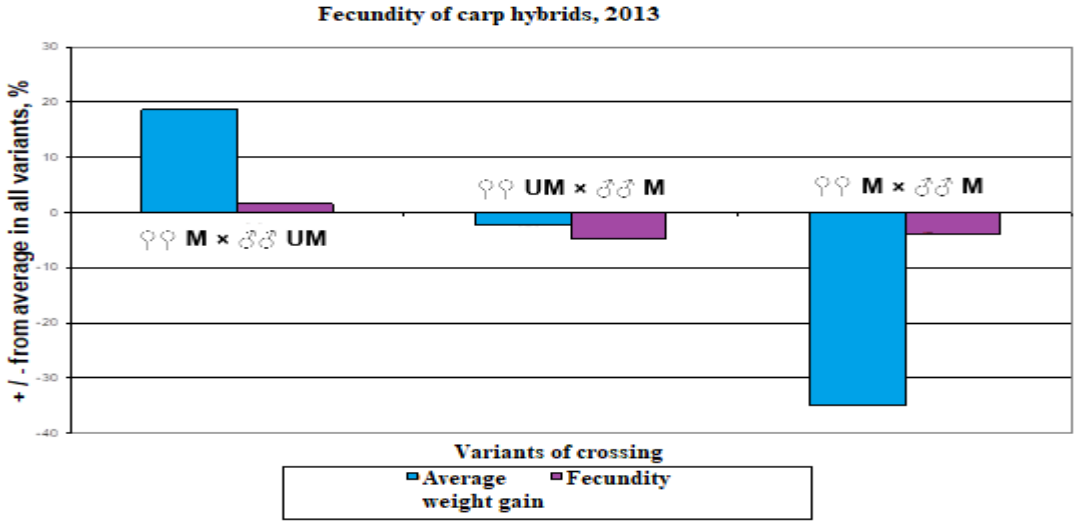

Figure 4. Fecundity of carp hybrids in 2013

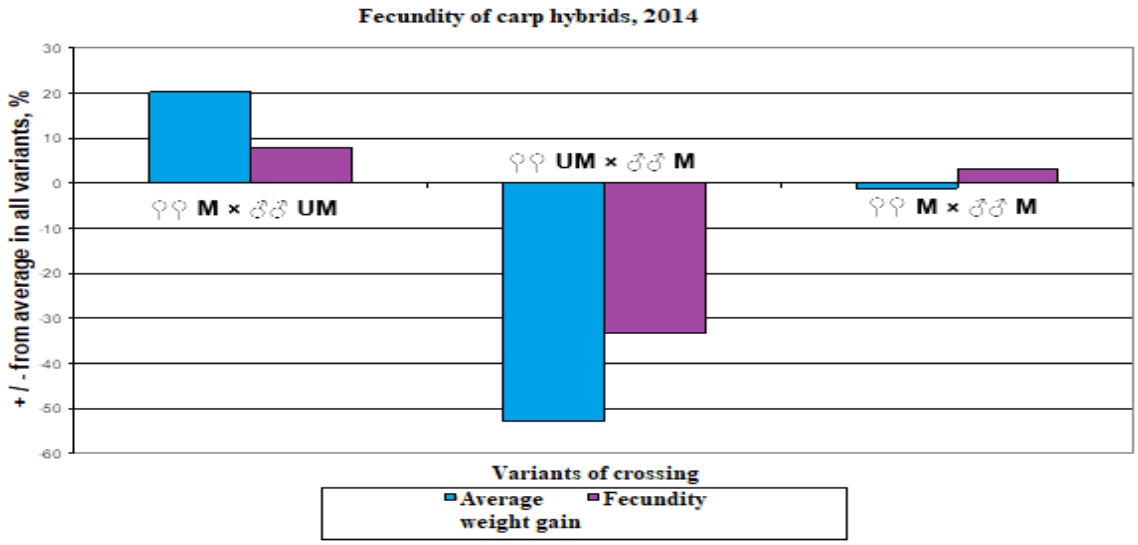

Figure 5. Fecundity of carp hybrids in 2014

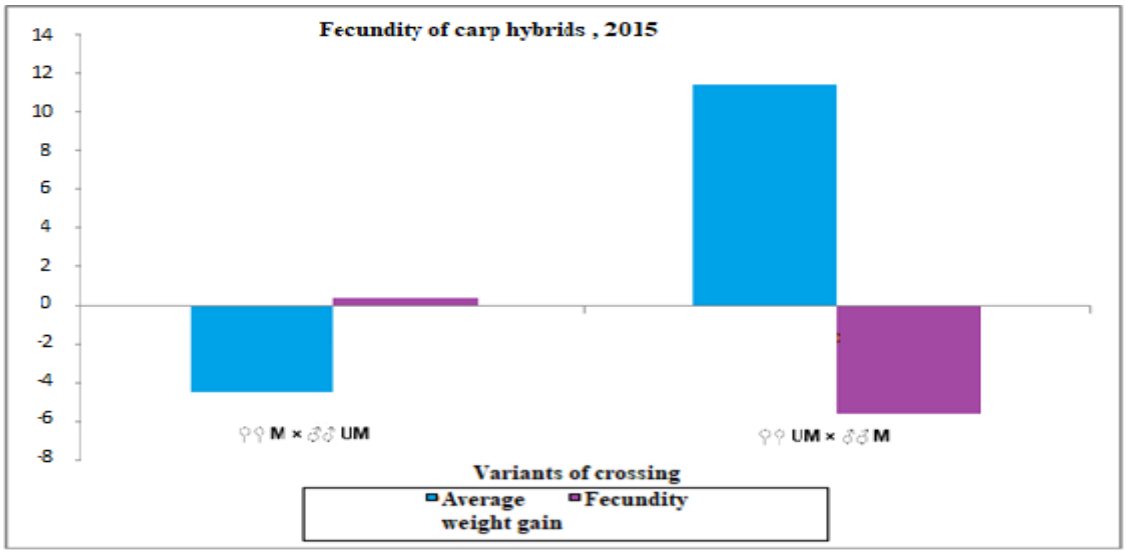

Figure 6. Fecundity of carp hybrids in 2015

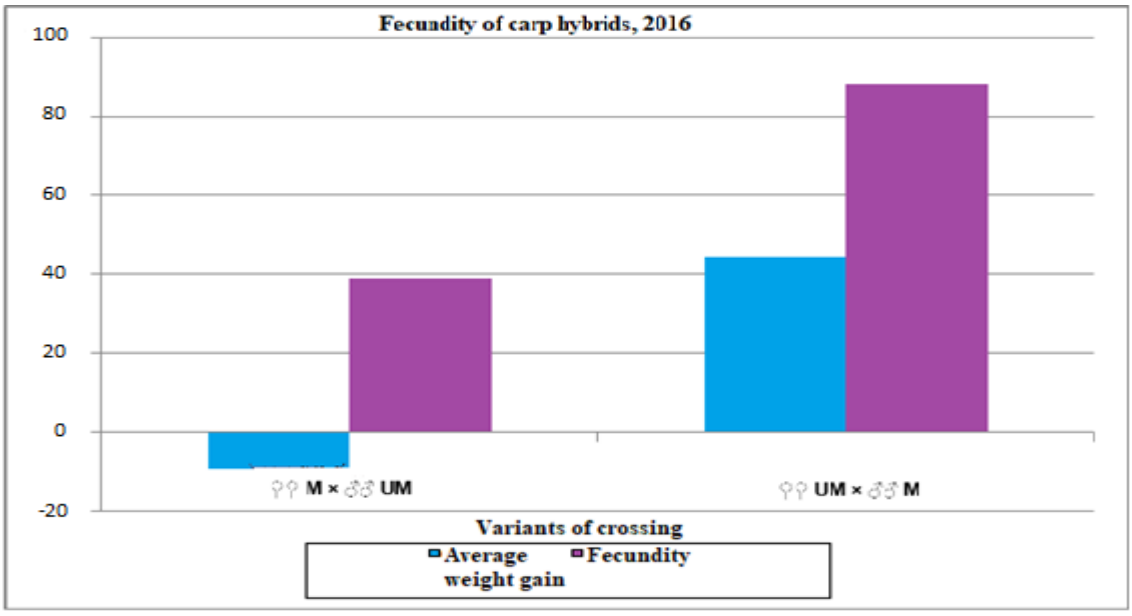

Figure 7. Fecundity of carp hybrids in 2016

In the breeding unit LLC "SlobodskayaSagva" (Association "Big Fish"), hybrids were also tested. The results of growing fingerlings of carp Szarvas × Cherepetskiy framed, where Szarvas breed served as a control, are shown in Table 1.

Table 1 - Tests of hybrids in LLC "SlobodskayaSagva"

Pond	Area, ha	Placed, thousand pcs.	Additionally placed silver carp, thousand pcs.	Cultivation results at the end of the season		
				Weight gain, g	Fecundity, dt / ha	Feeding ratio
No.1	10	Hybrid - 80	50	370	23.7	3.0
No. 2	10	Sarvas - 50	50	330	13.2	4.5

According to the results of cultivation, hybrids exceed the weight gain of purebred Szarvas by 12.1 %, the weight of the caught carp by 92.7 %, and the feeding ratio turned out to be much lower - by 1.5 units. The introduction of such a technology of crossing yielded a high economic effect due to an increase in the fish-breeding parameters of growing this hybrid in aquaculture.

CONCLUSIONS

It is necessary to emphasize that in 2018 the weight gain of the fish stock of carp from F1 larvae also exceeds the standard. For example, in CJSC Breeding Fish Farm "Sharapovskiy" (Belgorod oblast, Novooskolskiy district, IV zone of fish farming) the weight gains of carp yearlings (hybrid ♀♀ strain M × ♂♂ strain UM) on August 1, were 40-85 grams and those in fish farms of the "Big Fish" Association were 85-170 grams.

The Kolomna fish farm "Osenka", located in the first area of fish farming, also had good results in growing carp fingerlings, where the weight gain was on average 70.5-87.5 grams. It should be noted that on August 1, 2017 the weight gain was 68.9 grams, i.e. the fish farm of the northern fish farming zone can achieve similar parameters with the farm from the southern zone.

Based on the investigations, in 2018, Association “State-Cooperative Association of Fisheries (Rosrybkhoz)” decided to distribute at least the following hybrids: Angelinskiy mirror × Angelinskiy scaly, Cherepetskiy framed × Hungarian (Szarvas), Cherepetskiy scaly × Hungarian (Szarvas), Parskiy scaly × Central Russian, Parskiy mirror × Central Russian; Parskiy scaly × Parskiy mirror; types of Parskiy, Central Russian, Ukrainian and domesticated common carp breeds; Selinskiy × Stavropolskiy.

During the spawning campaign, enterprises could sell 775 million larvae, but 436.5 million pieces of carp hybrids were produced for their own needs and sold to fish farms of various forms of ownership.

We recommend using other carp breeds from central and eastern Europe when searching for successful hybrids: Likhvinskiy scaly, Izobelinskiy, scaly carp “Trebon”, mirror carp “Zdar”, mirror carp “Pohorellice”, scaly carp “Southern Bohemia”, mirror carp “Southern Bohemia”, scaly carp “MarianskeLazne”, mirror carp “Milevsko”, scaly carp “Zdar”, etc.

In conclusion, it is necessary to emphasize that in due course, thanks to the hybridization of carp with the Amur carp, it became possible to promote carp breeding in the northern regions of the country. In our opinion, for growing large planting stock the following carp hybrids are promising: ♀♀ strain M × ♂♂ strain UM, ♀♀ Szarvas strain × ♂♂ Cherepetskiy framed strain.

We consider it urgent to continue work on finding successful carp hybrids with a high heterosis effect. Moreover, hybrids should be selected taking into account the area of fish farming, the requirements of farms for the quality of fish meat, growth rate, exterior parameters, the final weight, etc.

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