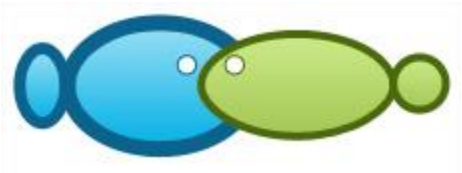

Comparison of the survival rate of largemouth bass (*Micropterus salmoides*) fingerlings during the winter period in ponds and a wintering complex in the northern part of Ukraine

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Abstract. The climatic conditions of the northern part of Ukraine are not optimal for growing largemouth bass (*Micropterus salmoides*), especially during the first year of life. Given the fact that the spawning of this species in ponds only begins in early June, juveniles do not reach the size required for successful wintering during the first growing season, which leads to a high mortality rate in the wintering ponds. At the same time, keeping largemouth bass juveniles in a wintering complex, in closed insulated buildings with concrete pools located partialy below ground level, allows to constantly maintain the water temperature in the range of 6–10°C, significantly increases the degree of survival of largemouth bass fingerlings and makes cultivation of this species economically reasonable. In addition, during the maintenance of largemouth bass fingerlings in the pools of the wintering complex, they are trained to eat pellets, which significantly increase the absolute, average daily and relative gains during the second year of cultivation. Despite the additional costs for aeration equipment, filtration and disinfection of water, not to mention construction work, and given the fact that due to the high temperature of water and the large amount of silt in the ponds, largemouth bass fry feed training in the middle of summer is technically impossible, thus rearing juveniles in the wintering complex is actually the only method that allows aquaculture of this species in the northern regions of Ukraine. This article will indicate, analyze and compare the results of studies to determine the degree of survival of juveniles of largemouth bass in ponds and concrete pools in a wintering complex during the first winter period.
Key Words: aquaculture, concrete pools, feed training, fry, mortality, pellets.

Introduction. The largemouth bass (*Micropterus salmoides*) is a fish species adapted to the freshwater biotopes with moderate climatic conditions (Tidwell et al 2019). Within the native range on the North American continent, the main forage fish species for largemouth bass are gizzard shad (*Dorosoma cepedianum*), threadfin shad (*Dorosoma petenense*), bluegill (*Lepomis macrochirus*), as well as juveniles of catfishes (Ictaluridae), especially brown bullhead (*Ameiurus nebulosus*) (Hodgson & Hansen 2005; Purdom et al 2015). A feature of these fish species, mentioned above, are the spawning period at the same time or later compared to largemouth bass, and when largemouth bass fry begin to feed on fish, which usually occurs when they are 25 - 30 mm long, due to available natural forage base before the end of the first growing season, they reach the size required for successful wintering (Huskey & Turnigan 2001). Thus, the average length of largemouth bass at the age of one year in the United States is approximately 122 mm (Beamesderfer & North 1995). Largemouth bass juveniles that feed on fish grow much faster than their peers, whose diet is dominated by aquatic insects and crustaceans, which, in most cases, affects on the growth rate of fish in subsequent years (Olson 1996; Ludsin & DeVries 1997).

On the northern territory Ukraine, the spawning season of most native fish species falls on the period from the first decade of April to the second decade of May. Taking into account the fact that the spawning of largemouth bass in local fishery reservoirs begins

only in the first half of June, when the age of juveniles of local fish species is already 1.5 - 2 months, its fingerlings until the end of the first growing season feed mainly with zooplankton and larvae of aquatic insects, which significantly slows down their growth rate. Thus, the average length of largemouth bass juveniles in ponds of fish farms in the northern part of Ukraine at the end of the first growing season is about 5 cm. At the same time, the mortality rate of juveniles of largemouth bass in ponds during the winter period is directly related to the size of the fish, and the acceptable level of survival for successful aquaculture is observed among individuals, whose length before wintering is more than 100 mm (Gutreuter & Anderson 1985; Goodgame & Miranda 1993; Post et al 1998).

Taking into account the climatic and ichthyological features of fishery reservoirs in the northern regions of Ukraine, which do not allow growing fingerlings during the first season to wintering size, the Institute of Fisheries of the National Academy of Agrarian Sciences of Ukraine developed the following technique. After the end of the first growing season in ponds, largemouth bass juveniles are transported to the pools of the wintering complex, where the fish stay until the next spring. This approach allows to get enough amounts of fish for further rearing, and achieve the main goal by the end of the third year of growing - to get largemouth bass with weight more than 1 kg, which are popular both as food-fish and as a desirable target for anglers. This article presents the results of a study designed to determine and compare the degree of survival of largemouth bass fingerlings in the conditions of a wintering complex and regular wintering fish farm ponds.

Material and Method. This study took place at the Experimental Fish Farm "Nyvka" of the Institute of Fisheries of the National Academy of Agrarian Sciences of Ukraine during the winter of 2019-2020. Throughout the study, the main part of the fingerlings of largemouth bass (*Micropterus salmoides*) during the winter period was stocked in the concrete pools of the wintering complex, and only the control group was stocked in the regular wintering ponds.

The water exchange of the wintering ponds of the experimental fish farm was carried out through independent water supply. The experimental pools were equipped with sluices for regulating the filling and discharge of water, and with electric pumps for additional saturation of water with oxygen during the freeze-up period. The flow of water into the ponds occurred constantly throughout the winter period, complete water exchange took place over 12-15 days. The wintering ponds were supplied with water from the Nivka River through a network of canals and ponds located by a cascade system. The ponds were filled with water in a period from seven to ten days before the planned fish stocking, which was in the second or third decade of November. Wintering of juveniles of largemouth bass in the ponds took place from mid-November to the first half of April.

During the wintering of largemouth bass fingerlings in the fishing ponds, constant monitoring of the main physical and chemical parameters of the water was carried out. Thus, the average temperature over ten-day terms throughout the entire wintering period varied within 1.2 - 6.3°C. The lowest water temperature was recorded from the second decade of December to the first decade of March, when the average value of this parameter was approximately 1.7°C. The temperature of water was measured with a liquid thermometer.

Despite of the constant water supply and flow, the average ten-day values of the concentration of dissolved in water oxygen in the ponds during the winter were not stable and fluctuated within 3.7 – 6.9 O_2/dm^3. The lowest level of water saturation with oxygen was observed in the period from the third decade of December to the third decade of February, when the average values of the dissolved in water oxygen were 3.7–5.2 O_2/dm^3. The concentration of dissolved oxygen in water was measured with a portable galvanic oximeter.

The pH was in the range of 7.4 - 7.6, which corresponds to the standard values for largemouth bass. Permanganate index and dichromate oxidizability were also within the normal range and did not exceed 4.89 mg O_2/dm^3 and 12.23 mg O_2/dm^3,

respectively. The water mineralization level during the winter ranged from 840.3 to 889.1 mg/dm^3. The chemical parameters of aquatic environment were determined in the chemical laboratory of The Institute of Fisheries of the National Academy of Agrarian Sciences of Ukraine.

During the wintering of largemouth bass juveniles in ponds, the amount of free ammonia (NH_3) did not exceed the permissible limits and was in the range of 0.003-0.008 mg N/dm^3. However, there was an excess of the standard values for ammonium nitrogen (NH_4-N), the concentration of which reached 4.14 mg N/dm^3, and nitrites (NO_2), the concentration of which reached 0.17 mg N/dm^3, with the boundary values of these compounds being of 2.0 mg N/dm^3 and 0.1 mg N/dm^3, respectively. At the same time, the concentration of nitrates (NO_{3-}) was within the normal range for largemouth bass and varied between 1.38 and 1.46 mg N/dm^3. Other hydrochemical indicators which exceeded the norm values include chlorides. The concentration of these compounds during the study was in the range of 205.4 - 216.7 mg/dm^3. The values of mineral phosphorus (P) and total iron (Fe) did not exceed the limits of permissible values and were within 0.30–0.37 mg P/dm^3 and 0.48–0.59 mg Fe/dm^3.

For the wintering of largemouth bass juveniles two wintering ponds with an area of 0.4 and 0.5 ha and an average depth of 2.0-2.5 m were used. Each of the ponds was stocked with 500 fingerlings. Thus, the stoking density in wintering pond No. 1 was 1250 ind/ha, and in wintering pond No. 2 - 1000 ind/ha. A constant water exchange of the ponds was ensured throughout the entire wintering period. For the additional saturation of the water with oxygen electric pumps were used, located near the surface. Every day, 0.25 kg of chironomid larvae (5.28 - 5.60% of the weight of wintering fish) from the same batch that was used to feed the fish in the wintering complex, were applied into each of the ponds at the point of water supply. To reduce the probability of fish death due to the deterioration of the physical and chemical parameters of the environment, the water supply of the ponds was from separated cascade systems.

In the concrete pools of the wintering complex the temperature regime was more favorable for largemouth bass. Considering the fact that the building of the wintering complex was not heated during the fish keeping, the temperature indicators of the water in the pools depended from the ambient temperature. However, this dependence was much less significant compared to wintering ponds. At the time of juveniles stocking into the pools the water temperature was 9.6 °C, and during the wintering period the average values of this parameter did not fall below 5.7 °C. During wintering in the concrete pools, the lowest water temperature was observed in the period from the third decade of January to the first decade of March, and the average value was 5.9°C. The temperature of water was measured with a liquid thermometer.

During the rearing of largemouth bass juveniles in the pools of the wintering complex, due to constant active aeration and the work of pumps, a more favorable oxygen regime was observed. The average concentration of dissolved in water oxygen during ten-day terms in the pools of wintering complex fluctuated within 7.2 - 8.1 O_2/dm^3. The concentration of dissolved oxygen in water was measured with a portable galvanic oximeter.

The hydrochemical indicators of the wintering complex pools were more consistent with the standard values for largemouth bass. Throughout the entire period of fish wintering the pH was in the range of 7.2 - 7.6. Permanganate index and dichromate oxidizability did not exceed 5.78 mg O_2/dm^3 for the first indicator and 8.63 mg O_2/dm^3 for the second indicator. The level of water mineralization in the pools was 281.4 - 295.7 mg/dm^3. The maximum value of free ammonia (NH_3) in the pools of the wintering complex was 0.006 mg N/dm^3, ammonium nitrogen (NH_4-N), nitrites (NO_2) and nitrates (NO_{3-}) were in the ranges of 0.32-0.41 mg N/dm^3, 0.05 – 0.07 mg N/dm^3 and 0.36 – 0.45 mg N/dm^3, respectively. Indicators of mineral phosphorus (P) were within the normal range and stood at 0.18 - 0.25 mg P/dm^3. At the same time, in the water of the concrete pools of the wintering complex was periodically observed an increase of the level of total iron (Fe) to 0.92–0.95 mg Fe/dm^3, which approached to the maximum permissible values for largemouth bass, but did not exceed them. The chemical

parameters of aquatic environment were determined in the chemical laboratory of The Institute of Fisheries of the National Academy of Agrarian Sciences of Ukraine.

In the wintering complex largemouth bass juveniles were stocked in six concrete pools with a volume of 10 m³. The size of each pool was 3x2x1.7 m, and a part of the concrete pool is below ground level. The average weight of one fish was 7.62 g, the total weight of all fish was 65.35 kg, and the stocking density was 134 ind/m³. The pools were supplied with water from an artesian well. The filtering equipment in each of the pools included a 63-watt electric pump with an output of 10000 liters per hour, a canister filter with a capacity of 80 liters, filled with foam rubber of different densities and a plastic sinking load, fitted with a built-in 30-watt ultraviolet lamp.

During the first two weeks, the fingerlings were fed once a day with chironomid larvae in an amount of 1% of the total initial weight of the fish. Later, to the fish diet were added pelletes with a diameter of 2 mm in the amount of 10% of the weight of the daily portion of the bloodworm, or 0.1% of the total initial weight of the fish. For the fish feeding were used Aller Aqua Performa No. 2 pellets, which have 53% crude protein, 14% crude fat, 14% carbohydrates, 10% ash, 1% fiber, the amount of nitrogen in dry matter is 9.2% and phosphorus is 1.4%. Each week, the portion of pellets in the daily rate was increased by 10% until it reached 90% of the total feed, or 0.9% of the total initial weight of the fish.

Results and Discussion. Largemouth bass (*Micropterus salmoides*) wintering results of juveniles in the ponds of Experimental Fish Farm "Nyvka" are shown in Table 1.

Table 1

The results of wintering largemouth bass juveniles in the ponds of Experimental Fish Farm "Nyvka" (2019-2020)

Indicators	*The name and area of the reservoir*	
	Wintering pond No. 1 (0.4 ha)	*Wintering pond No. 2 (0.5 ha)*
The number of fish in the ponds	500 ind	500 ind
Stocking density	1250 ind/ha	1000 ind/ha
Body weight of fish before wintering (M ±m, n=30)	8.93±0.51 g	9.74±0.63 g
Body weight of fish after wintering (M ±m, n=30)	7.49±0.38 g	8.32±0..55 g
Weight loss	16.12%	14.63%
Survival rate	8.3%	9.5%

Considering the results of the study, it can be concluded, that both in wintering pond No. 1 and in the wintering pond No. 2, a rather low rate of survival of fingerlings of largemouth bass was recorded, at the level of 8.3% and 9.5%. These figures indicate that when rearing largemouth bass juveniles during the first year with extensive technique, the fish do not reach the size required for successful wintering in the covered with ice ponds, which leads to a significant level of mortality and inefficiency of the entire rearing scheme of this species in the climate of northern Ukraine. A slightly higher survival rate was observed in the wintering pond No. 2, which is most likely due to the higher average fish body weight before wintering. It should be noted that during the stay of the fish in the ponds were created optimal conditions for wintering, in accordance with the possibilities. In reservoirs with an unfavorable oxygen regime or other physical and chemical factors of the aquatic environment, the survival rate of fingerlings may be even lower.

Analyzing other indicators, given in Table 1, it can be noted that among largemouth bass juveniles with an average body weight of 9.74 and 8.93 g, a different grade of weight loss during the wintering period was observed. Among the larger fish, an average absolute body weight loss was 1.42 g with the relative level of weight loss

14.63%. Among largemouth bass juveniles with a lower initial weight, the average absolute body weight loss was 1.44 g, while the value of the relative weight loss was 16.12%. Despite of the lower rates of absolute and relative body weight loss of fingerlings in pond No. 2, the overall survival rate in both ponds was insufficient to obtain enough fish for further rearing and successful aquaculture.

The results of wintering of largemouth bass juveniles in concrete pools of the wintering complex are shown in Table 2.

Table 2

The results of wintering largemouth bass juveniles in the wintering complex (2019-2020)

Indicators	*Value*
Volume of pools (m^3)	10
Stocking density (ind/m^3)	134
Duration of the wintering period (days)	141
The number of fish at the beginning of wintering (ind)	8576
The number of fish at the end of wintering (ind)	8291
The total weight of fish at the beginning of wintering (kg)	65.35
Total weight of fish at the end of wintering (kg)	65.59
Average fish weight at the beginning of wintering (M±m, n=30) (g)	7.62±0.47
Average fish weight at the end of wintering (M±m, n=30) (g)	7.91±0.63
Weight gain (%)	3.81
Survival rate (%)	96.7

Wintering of largemouth bass juveniles in the wintering complex was more successful than wintering in the farm ponds. With a sufficiently long wintering period (141 days), from 8576 initial fingerlings of largemouth bass, successfully overwintered 8291 individuals, thus, the survival rate was 96.68%. It is also necessary to note that the largest number of dead individuals throughout the stay of fish in the wintering complex was observed during the first two weeks after the stocking of fingerlings into the pools, which is most likely associated with injury to juveniles during the fish seining from ponds and further transportation, as well as adaptation of largemouth bass to new conditions of the aquatic environment.

Considering the extremely low survival rate of largemouth bass fingerlings in conditions of wintering ponds that are covered with ice (8.3 - 9.5%), its extensive aquaculture on the territory of Ukraine, in most cases, can be successful only if there is a wintering complex in the fish farm, equipped with an appropriate facility for the successful keeping of fish during the cold season. In such circumstances, a fairly high level of survival of largemouth bass juveniles (96.7%) was noted, as well as a slight increase of body weight (3.81%). In addition, in the wintering complex largemouth bass fingerlings can be feed trained, which, in the future, will make it possible to grow this fish during the second and third season using semi-intensive and intensive techniques.

Conclusions. According to results of the study, mentioned above, it can be concluded that the successful rearing of largemouth bass (*Micropterus salmoides*) in the climate of the northern part of Ukraine, at present, is possible only with a controlled rearing of its juveniles in a wintering complex during the first winter period. Among the two control groups, that were left in the wintering ponds, the survival rate was only 8.3% and 9.5%, even with the best possible conditions and constant feeding, which makes economically unfeasible the growing of the largemouth bass during the next seasons. However, when keeping largemouth bass fingerlings in the wintering complex, the survival rate was 96.7%, which is completely sufficient to obtain the required amount of fish for further successful rearing. In addition, feed training of the largemouth bass juveniles in a wintering complex allows using semi-intensive and intensive rearing techniques during the second and third growing season, which, in turn, allows obtaining fish with weight of more than 1 kg at the end of the third year of growing.

Conflict of interest. The authors declare that there is no conflict of interest.

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