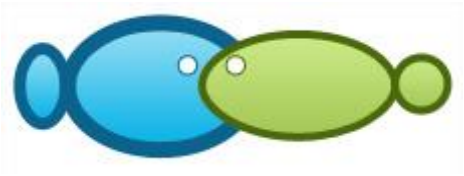

Growing of two years old largemouth bass (*Micropterus salmoides*) in ponds and concrete pools with extensive, semi-intensive and intensive techniques in the northern regions of Ukraine

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Abstract. Largemouth bass (*Micropterus salmoides*) is one of the fish species for which the breeding and cultivation on the territory of Ukraine is difficult. Such difficulties are primarily associated with unfavorable climate for growing, as well as with a lack of knowledge for successful aquaculture of this species, the rearing of which significantly differs from the cultivation of usual species in local aquaculture. However, at present, many fish farms in the northern and central regions of Ukraine successfully grow largemouth bass, which indicates significant progress in this sector of fisheries. Numerous attempts to grow largemouth bass using exclusively a natural food base, that were made over the past century, did not have significant success, which indicates that the aquaculture of this species on the territory of Ukraine requires the use of intensification techniques, including the use of pellets for fish feeding. And only now, when the largemouth bass began to be considered as the main object of cultivation, over the past five years the methods of its intensive cultivation have been mastered, we can observe the successful development of this species aquaculture on the territory of Ukraine. This article will indicate the results of studies, conducted in the state enterprise Experimental Fish Farm "Nyvka" of the Institute of Fisheries of the National Academy of Agrarian Sciences of Ukraine (Kyiv region) in 2020, when largemouth bass were grown with extensive and semi-intensive techniques in ponds using forage fish and pellets, as well as with intensive techniques in concrete pools using exclusively pellets. Comparison and analysis of the obtained results was also carried out.
Key Words: aquaculture, feed training, intensification, pellets, rearing.

Introduction. Even though the largemouth bass (*Micropterus salmoides*) was first introduced to the territory of modern Ukraine in 1889 (Kozlov 1998), almost all attempts of acclimatization and growing of this species were unsuccessful. Among the factors, contributing to such failures, are unfavorable local climatic conditions, earlier spawning of most native species, competition with other predatory fishes, as well as the lack of use of intensification methods in largemouth bass aquaculture. In the entire history of introduction into local water bodies, only one case of successful naturalization of this fish was noted in the Shatsky Lakes of the Volyn region (Yevtushenko et al 2011). This situation is most likely associated with the wide distribution in these water bodies of another introduced species, the brown bullhead (*Ameiurus nebulosus*), whose juveniles form the food base for largemouth bass (Nosal & Simonova 1958). In local aquaculture, largemouth bass have always been growing as an additional species to reduce the number of nuisance fish in the ponds with common carp (*Cyprinus carpio*). Largemouth bass (*Micropterus salmoides*) aquaculture dates back more than a hundred years (Moffitt 2001), but most of the culture techniques, that are currently used in fish farms, are based on pond fish farming with a minimum level of intensification (Long et al 2015). However, such extensive rearing techniques require many ponds both for largemouth

bass and the fish they feed on. It should be noted that to increase the weight of a largemouth bass by 1 kg, about 5 kg of forage fish are needed, which creates huge inconveniences during cultivation (Nelson et al 1974). Also, the rearing of largemouth bass in the northern regions of the native range and within the introduced territories with similar climatic conditions requires the use of intensification techniques, first, accustoming the fish to eat pellet (feed training), with further intensive feeding throughout the entire growing period (Heidinger 2000; Tidwell et al 2000). The delay in temperature-dependent growth and mass accumulation by largemouth bass in the northern territories can have a significant impact throughout the growing period; as a result, the fish may not reach marketable weight (0.50-0.75 kg) by the end of the second year of rearing (Tidwell et al 1998).

The use of pellets at different stages of rearing is a standard technique of intensification of the largemouth bass aquaculture in the United States (McCraren 1975; Snow & Wright 1975; Sloane 1993). Feed trained largemouth bass can reach a length of 15-20 cm and a weight of 180-220 g at the end of the first year of cultivation, and by the end of the second year reach a weight of < 0.6 kg, which is popular at the fish markets (Brandt 1991; Cochran et al 2009). Similar trends are observed in other countries. For example, until 2006 the largemouth bass in the ponds of fish farms in China were mainly fed with frozen low-value fish, or with a mixture of frozen fish and artificial feed (Zhu et al 2006). However, with the development of intensive rearing techniques for largemouth bass with high stocking densities, pellets are becoming more and more popular (Li et al 2012; Zhou et al 2015).

When growing the fingerlings of largemouth bass in Ukraine, due to the silting of a large parts of the ponds and relatively low levels of dissolved in water oxygen during the summer period, feed training of juveniles occurs during the winter period in indoor pools. Thus, intensive fish farming occurs mainly during the second and third years of growing of the largemouth bass. This article presents the results of a study, where largemouth bass were grown during the second growing season with extensive and semi-intensive techniques in ponds and with intensive technique in concrete pools.

Material and Method. Largemouth bass (*Micropterus salmoides*) were reared in 2020 in an extensive manner during the second growing season, and cascade ponds were used at the state enterprise Experimental Fish Farm "Nyvka" of the Institute of Fisheries of the National Academy of Agrarian Sciences of Ukraine (Kyiv region). Two ponds of 0.6 ha and two ponds of 1 ha were used for this growing technique. The ponds were stocked with one-year-old largemouth bass from indoor pools, used for wintering of the fish, with an average weight of 7.91 ± 0.63 g and a stocking density of 2000 pcs/ha.

The water temperature in the fish farm reservoirs was 21-26°C for 107 days of the growing season. The average seasonal concentration of dissolved oxygen in water was 5.6–5.7 O_2/dm^3, and in most cases the average daily values of this parameter were in the range of 4.7–7.5 O_2/dm^3. During the summer period, when the water temperature in the ponds increased to 27-28°C, there was a decrease of the average daily concentration of dissolved in water oxygen to 3.6 O_2/dm^3.

During the spring and summer periods in the ponds was observed an increase of the concentrations of some organic and mineral substances, as well as deterioration of some indicators of water quality. An increase of permanganate ($KMnO_4$) and dichromate (CrO_4^{2-}) oxidation to 23.92 and 59.8 mg O_2/dm^3 was recorded, which exceeds the standard values by 1.6 and 1.2 times, respectively (Bessonov & Pryvezentsev 1987). The maximum recorded value of free ammonia nitrogen (NH3-N) was at the level of 0.05 mg N/dm^3, which corresponds to the upper limit of the allowable value for this parameter. In addition, we can note the maximum value of the sodium + potassium ($Na^+ + K^+$) complex, which is 127.0 mg/dm^3 with an upper allowable level up to 50 mg/ dm^3, as well as the concentration of chlorides at the level of 163.9 mg/dm^3 with a standard value up to 70 mg/ dm^3. Other indicators of organic and mineral substances in water of the ponds were within the normal range during the growing season.

Largemouth bass is a predator, therefore, when it is grown using extensive and semi-intensive techniques, the required amount of forage fish should be present in the

ponds. During the study of largemouth bass rearing throughout the second year using extensive techniques, when only forage fish was the food source, the average amount of forage fish in the ponds was 2823.94 kg/ha. Among forage fish, 44.75% were Prussian carp (*Carassius gibelio*), 37.48% - stone moroko (*Pseudorasbora parva*), 16.53% - common bleak (*Alburnus alburnus*), 1.24% - Amur bitterling (*Rhodeus sericeus*).

The rearing of largemouth bass for the second growing season in 2020 in ponds with semi-intensive techniques, when both forage fish and pellets were used, was done using two ponds of 0.6 ha and two ponds of 1 ha. The ponds were stocked with one-year-old feed trained largemouth bass from indoor pools with an average weight of 7.91 ± 0.63 g and a stocking density of 2000 pcs/ha.

The physical and chemical parameters of water in the ponds did not differ from those during the cultivation of largemouth bass with extensive technique. At the beginning of the growing season the ponds were stocked with forage fish with an average amount of 2833.08 kg/ha. Among forage fish, 42.74% were Prussian carp (*Carassius gibelio*), 38.58% - stone moroko (*Pseudorasbora parva*), 17.43% - common bleak (*Alburnus alburnus*), 1.25% - Amur bitterling (*Rhodeus sericeus*).

It should be noted, that for more efficient feeding of largemouth bass with pellets, the concentration of fish in a certain area is necessary. During the cultivation of in ponds, fish can be evenly distributed over the entire area of the reservoir and not approach to the feeding place. Given the above situation, the future place for feeding of the largemouth bass must be chosen according to a presence of factors, which can concentrate fish. During the study, areas for feeding were chosen in places near the water supply of the pond, where a large concentration of the largemouth bass was observed. It is desirable to carry out feeding at the same time, because the fish will approach the selected areas in advance. During the main part of the second rearing season, the fish in the ponds were fed twice a day, at 8:00 and 18:00. In a study of growing of the largemouth bass with a semi-intensive technique, fish were fed with pellets in the amount of 1% of average body weight at the start of a 30-day rearing period. Given the fact that largemouth bass very rarely eat pellets from the bottom of the pond (Kubitza & Lovshin 1997), if possible, it is advisable to feed them with suitable floating or slowly sinking pellets. During the study, pellets, produced by Aller Aqua company, where used. During the first one-third of the season, the fish were fed with sinking pellets from the Performa series with a diameter about 3 mm, which included 53% of crude protein, 14% of crude fat and 14% of carbohydrates. Subsequently, the fish were fed with sinking pellets from the Rep M series with a diameter of 6 mm, which contained 45% of protein, 15% of fat and 20.3% of carbohydrates, as well as a mixture of astaxanthin + canthaxanthin pigments in an amount of 40 mg/kg.

Largemouth bass rearing in concrete pools with intensive technique during the second growing season was done using outdoor concrete pools with an area of 85 and 140 m². Pool walls were covered with 3 mm thick PVC film. The pools were stocked with one-year-old feed trained largemouth bass with an average weight of 7.91 ± 0.63 g and a stocking density of 30 pcs/m².

All physical and chemical parameters of the water in the pools during the study did not exceed the standard values for largemouth bass rearing and were favorable for its cultivation. In particular, the concentrations of dissolved oxygen in water were generally similar to those when fish were reared in ponds. However, during the growing season of fish in concrete pools, due to more efficient aeration, a more stable oxygen regime was observed, and even in the summer months at the highest temperatures, the average daily values of dissolved in water oxygen did not fall below 4.2 O_2/dm^3.

During the second growing season of the largemouth bass with intensive technique in pools, only pellets were used to feed the fish. Since largemouth bass is a carnivorous species, it is difficult to find appropriate pellets for this fish. To successfully feed largemouth bass with pellets, they must meet specific requirements. First, they should include natural ingredients of animal origin, such as meals, hydrolysates, and fats, obtained from fish and crustaceans. Such components attract fish and increase feeding efficiency and feed intake (Barrows 2000). Just like with most predatory fish species, the growth of largemouth bass, even at the last stage of rearing before obtaining marketable

weight (400-700 g), depends on the amount of protein, which comes with the feed. Thus, to obtain maximum weight gain, pellets must contain from 45% to 60% of crude edible protein. The total part of fats in the pellets, produced for the largemouth bass, ranges from 9% to 14% (Coyle et al 2000; Yadav et al 2018). However, some feed studies have shown that for maximum growth rate of the largemouth bass, the amount of fats in the pellets should be near the upper limit of this range (Chen et al 2012; Huang et al 2017). Predatory fish usually are not adapted to use easily digestible carbohydrates as an energy source. However, their excessive amount of carbohydrates in feed can adversely affect the health of the fish and leads to the accumulation of glycogen in the liver with further necrosis of the liver tissue (Goodwin et al 2002). Therefore, during the cultivation of the largemouth bass, it is desirable to use pellets with an amount of carbohydrates, which does not exceed 16-18%. During the second year of rearing of the largemouth bass in concrete pools the same pellets as the ones used in ponds were used. The daily rate of pellets during the second growing season of largemouth bass in concrete pools was 5% of the average body weight of the fish at the beginning of the 30-day rearing period.

Results and Discussion. At the end of the second growing season of largemouth bass using the extensive technique, the average fish weight was 151.28±9.06 g, the survival rate was 75.6%, and the average fish density of the ponds was 212.9 kg/ha. For this sampling 30 fish were randomly selected. The indicators of absolute, daily average and relative gain are shown in Table 1.

Table 1

Indicators of absolute, daily average and relative gain of largemouth bass in ponds during the second year of cultivation with extensive technique (M±m, n=30)

Growing period	*Month of growing*	*Average weight at the end of the period (g)*	*Gain per month*		
			Absolute (g)	*Daily average (g)*	*Relative (%)*
April 10 – May 10	I	10.66±0.86	2.75	0.09	29.62
May 10 – June 10	II	19.11±1.36	8.45	0.27	56.86
June 10 – July 10	III	47.50±3,30	28.39	0.95	85.23
July 10 – August 10	IV	93.86±6.38	46.36	1.50	65.59
August 10 – September 10	V	126.28±8.35	32.42	1.05	29.45
September 10 – October 10	VI	144.33±8.91	18.05	0.62	13.34
October 10 – November 10	VII	151.28±9.06	6.95	0.22	4.70

The total duration of rearing of the largemouth bass during the second year with extensive technique was 214 days. Considering the indicators of intensity of growth of the largemouth bass during the second growing season, it can be noted, that at the end of the cultivation period the fish reached an average weight of 151.28±9.06 g; during the seven months, the indicators of average daily gain were in the range of 0.09 - 1.50 g; absolute gain 2.75 - 46.36 g; relative gain 4.70 - 85.23%. On the impact of the temperature regime as one of the main factors of the aquatic environment, it should be noted that the largest monthly gains of the largemouth bass were observed during the summer period with an average monthly water temperature of 23.9 - 25.4°C.

The duration of cultivation of the largemouth bass during the second growing season with semi-intensive technique, was 214 days. At the end of the second growing season of the largemouth bass with semi-intensive technique, the average fish weight was 297.46±17.35 g, the survival rate was 82.4%, and the average fish density of the ponds was 474.4 kg/ha. For this sampling 30 fish were randomly selected. The indicators of absolute, daily average and relative gain are shown in Table 2.

Table 2

Indicators of absolute, daily average and relative gain of largemouth bass in ponds during the second year of cultivation with semi-intensive technique (M±m, n=30)

Growing period	*Month of growing*	*Average weight at the end of the period (g)*	*Gain per month*		
			Absolute (g)	*Daily average (g)*	*Relative (%)*
April 10 – May 10	I	13.32±1.08	5.41	0.18	50.99
May 10 – June 10	II	29.94±2.13	16.62	0.54	76.84
June 10 – July 10	III	85.76±5.95	55.82	1.86	96.49
July 10 – August 10	IV	176.92±12.03	91.16	2.94	69.41
August 10 – September 10	V	240.67±15.91	63.75	2.06	30.53
September 10 – October 10	VI	281.16±16.84	40.49	1.35	15.52
October 10 – November 10	VII	297.46±17.35	16.30	0.53	5.63

Analyzing the growth rates of the largemouth bass during the second growing season using both live fish and pellets, we can note the similarity of dynamics of the intensity of mass accumulation to extensive technique, regarding the increase of absolute, daily average and relative gains. In particular, the average weight of fish at the end of the growing season was 297.46 ± 17.35 g; the absolute gain during this period was in the range of 5.41 - 91.16 g; the daily average gain 0.18 - 2.94 g; relative gain 5.63 - 96.49%. However, the significantly higher relative gain during the initial rearing stage with semi-intensive technique compared to extensive technique, may be due to high concentration of the largemouth bass near the pellets feeding areas, thus the use of artificial feeds significantly increased during the first and second months of cultivation. Just like for the extensive method, the largest gains of the largemouth bass during the rearing season was observed in summer.

The total duration of rearing of the largemouth bass during the second year with intensive technique was 214 days. At the end of the growing period, the largemouth bass average fish weight was 356.08±16.32 g, the survival rate was 88.5%, and the average fish capacity of the pools was 8.7 kg/m². For this sampling 30 fish were randomly selected. The indicators of absolute, daily average and relative gain are shown in Table 3.

Table 3

Indicators of absolute, daily average and relative gain of largemouth bass in pools during the second year of cultivation with intensive technique (M±m, n=30)

Growing period	*Month of growing*	*Average weight at the end of the period (g)*	*Gain per month*		
			Absolute (g)	*Daily average (g)*	*Relative (%)*
April 10 – May 10	I	14.07±0.98	6.16	0.21	56.05
May 10 – June 10	II	32.99±1.96	18.92	0.61	80.41
June 10 – July 10	III	96.54±5.60	63.55	2.12	98.12
July 10 – August 10	IV	205.52±11.24	108.98	3.52	72.16
August 10 – September 10	V	283.18±14,11	77.66	2.51	31.78
September 10 – October 10	VI	333.89±15,65	50.71	1.69	16.44
October 10 – November 10	VII	356.08±16.32	22.19	0.72	6.43

The gains per month during the growing season, in most cases, repeated the dynamics of those with semi-intensive technique, but with higher rates. In particular, the average weight of fish at the end of the growing season was 356.08 ± 16.32 g; the absolute gain per month of the largemouth bass was in the range of 6.16 - 108.98 g; the average daily gain 0.21 - 3.52 g; relative gain 6.43 - 98.12%. Also, taking into account the comparison of the average weight at the end of each rearing period and the errors of the arithmetic mean, it can be concluded, that the growth of largemouth bass with intensive technique was more uniform compared to extensive and semi-intensive techniques.

Despite the same initial average weight of reared fish, the largest increase of the average body weight of the largemouth bass at the end of the rearing season was observed with the intensive growing technique. Also, comparing the average weight of fish at the end of the season using different rearing techniques, it can be noted that the weight of fish grown with the semi-intensive technique (297.46 g) exceeded the weight of fish grown with the extensive technique (151.28 g) by 96.63%; the weight of fish grown with intensive technique (356.08 g) exceeded the weight of fish grown with semi-intensive technique (297.46 g) by 19.71%; the weight of fish grown with intensive technique (356.08 g) exceeded the weight of fish grown with extensive technique (151.28 g) by 135.38%. The lower survival rate of the largemouth bass at the end of the second growing season with extensive technique compared to semi-intensive and intensive techniques, may indicate a higher degree of cannibalism among largemouth bass that were feed only with live fish. The use of pellets also permitted the increase of fish density, which was the lowest with extensive technique. The intensification of the growing process affected the indicators of absolute, daily average and relative gains, which were lower when growing the largemouth bass on a natural food base.

The rearing of largemouth bass in the northern regions of Ukraine during the second year of life with extensive, semi-intensive and intensive techniques did not make it possible to obtain fish of marketable weight (> 0.5 kg) at the end of the growing season. However, the cultivation of largemouth bass in pools with the maximum use of intensification methods, in particular, active pellet feeding, made it possible to obtain fish with an average weight of 356.08 ± 16.32 g and to get the closest to the marketable weight indicator. Thus, for the northern territory of Ukraine, it is possible to recommend the rearing of the largemouth bass with a three-year cycle, when the fish reaches a marketable weight at the end of the third growing season. Further use of intensification methods and active feeding of fish with pellets during the third growing season in ponds and pools creates the prerequisites for obtaining largemouth bass with weight > 1 kg, which are in demand not only as fish for human consumption, but also as an object of recreational and sport fishing. Such use of intensification in the process of growing of the largemouth bass can contribute to the development on the territory of Ukraine for the provision of recreational services and related markets.

Conclusions. Considering the results of the study, we can conclude that the use of intensification techniques significantly increases the growth rate of largemouth bass (*Micropterus salmoides*), and exactly semi-intensive and intensive techniques can be recommended as preferable for growing of this fish on the territory of northern regions of Ukraine. If we talk about the choice of specific technique, then in this case all depends on the resources that the fish farmer has. If you have a pond farm with a lot of nuisance fish, it is preferable and cost-effective to grow largemouth bass using a semi-intensive technique that allows you to obtain fish of marketable weight at the end of the third rearing season. This variant will be preferable for farms that grow largemouth bass for fish markets. However, if you are limited in resources, and have only a small land plot at your disposal, as well as when growing of largemouth bass for sale to owners of reservoirs who provide sport fishing services, it would be more appropriate to use intensive techniques that allow you to get the maximum growth rate of fish during the minimum amount of time. Considering that the demand for trophy largemouth bass (with weight > 1 kg) in recreational fisheries is always high, this type of aquaculture may be more profitable than growing largemouth bass as a food fish.

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

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Received: 30 December 2022. Accepted: 08 February 2023. Published online: 31 May 2023.
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How to cite this article:
Gushchin V., Polishchuk O., 2023 Growing of two years old largemouth bass (*Micropterus salmoides*) in ponds and concrete pools with extensive, semi-intensive and intensive techniques in the northern regions of Ukraine. AACL Bioflux 16(3):1561-1568.