Growing of fingerlings of the largemouth bass (*Micropterus salmoides*) in Ukrainian fish farms during the first year of life

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Abstract. According to the needs of more rational use of water bodies, as well as to the popularization of recreational fishing and development of fishing tourism, on the territory of Ukraine events for the selection and breeding of new fish species, expanded introduction of polyculture and an increase in number of fish species in local aquaculture are being held. One of these promising fish species can be the largemouth bass (*Micropterus salmoides*) from the Centrarchidae family, native to freshwater reservoirs of North America, and which is widely grown in fish farms all over the world, especially in the United States and China. Over the last 120 years, from the first try of Prince Gorchakov in 1889 to the present, numerous attempts of growing of this fish species on the territory of modern Ukraine have been made, but almost all of them were unsuccessful. And only now, thanks to the greater availability of information and the intensification of aquaculture, a current method of breeding and rearing of the largemouth bass has been developed, which, however, requires further improvement. One of the greatest problems of the developed method is the high mortality rate of juveniles during the first winter period due to the late spawning of the largemouth bass in the local climate, a short period of active growth and a relatively long freeze-up period. This article will provide information about the world practice of obtaining and rearing of juveniles of the largemouth bass in pond fish farms, will briefly describe the methods of growing of fry and fingerlings of this fish, which are used in dozens of fish farms on the territory of all Ukraine over the past 5 years, as well as possible ways of intensification of the process to reduce the mortality rate of juveniles in unfavorable climatic conditions.
Key Words: breeding, Centrarchidae, climate conditions, intensification, juveniles, rearing.

Introduction. The Largemouth bass, or trout-perch (the local name of this fish in Ukraine), belongs to the fish from the Centrarchidae family (better known as sunfishes), which also includes the bluegill (*Lepomis macrochirus*), the rock bass (*Ambloplites rupestris*), the white and black crappie (*Pomoxis annularis*; *Pomoxis nigromaculatus*), as well as many other fish species (Nicholas et al 2009; Nosal & Simonova 1958). Common features of fishes from this family are a relatively round body shape, as well as the presence of individual spots on the back of the gill covers. All species of the Centrarchidae family are native to the freshwater bodies of North America. The largemouth bass belongs to the genus *Micropterus*, which is also known as black basses (MacCrimmon & Robbins 1975).

The scientific name of the largemouth bass, *Micropterus salmoides*, means "small fin" and "salmon-like body". The largemouth bass was first described in 1802 by the French scientist Bernard Germain de Lacepede (Henshall 1881). Originating from the reservoirs of North America located to the east of the Rocky Mountains, the largemouth bass was widely settled both on the territory of its native continent and beyond (MacCrimmon & Robbins 1975).

The factors that contributed to the spread of the largemouth bass in aquaculture of many countries include its popularity as an object of recreational and sport fishing, excellent taste, as well as its use in polyculture as an additional object of cultivation (Figure 1).

Figure 1. The largemouth bass has become a popular recreational fishing target in Ukrainian fish farms.

For example, an increase in the natural fish production of ponds with joint cultivation of the largemouth bass fingerlings and one-year-old common carp *(Cyprinus carpio)* is 10%; with the joint cultivation of one-year-old largemouth bass and two-year-old common carp is 20%; with the joint cultivation of two-year-old largemouth bass and three-year-old common carp - 25% (Anishchenko 1941). However, the previous unsuccessful attempts of cultivation of the largemouth bass on the territory of Ukraine, which were carried out in the 50-60s of the XX century, were most likely associated with the cultivation of this fish as an additional object of aquaculture. And only now, when this species began to be the main object of cultivation, with the active assistance of The Institute of Fisheries of the National Academy of Agrarian Sciences of Ukraine, attempts of growing of the largemouth bass in local pond fish farms have become successful.

Material and Method. In this section we will describe the methods of breeding and cultivation of fry and fingerlings of the largemouth bass in the local fish farms during the first year of life, which were observed by the author over the past five years in several dozen pond fish farms throughout Ukraine, especially on the territory of Kiev, Cherkassy and Kherson regions, from the simplest to the most intensive, with a detailed description of each stage and references to world practice and an indication of the local characteristics of aquaculture of this species.

Preparation of spawning ponds and filling them with water. Preparation of spawning ponds before stocking of broodfish in Ukrainian fish farms is carried out according to generally accepted methods. In autumn earthen ponds must be drained and completely dried, and their bottom must be treated with quicklime. The amount of quicklime depends on the pH of the pond soil: at a pH of about 5, the rate of application of quicklime is 1.5-2.0 t/ha, at a pH of 3.5-4 the rate of application of quicklime can be increased to 2.5-5.0 t/ha. When plastic lined ponds are used for spawning, they should be cleaned of bottom sediments, not excluding waste funnels and sedimentation tanks. In spring, ideally, filling of ponds with water should begin in 1 to 7 days before stocking

of the broodstock. To prevent the spawning pond from predatory aquatic insects and their larvae, water is passed through a fabric filter with a mesh diameter of 1,000 μm. Plastic lined ponds must be provided with a spawning substrate. The number of spawning trays or mats in each pond should be equal to the number of males.

Pond fertilization. Fertilization of ponds promotes fish farming by increasing the quantitative and qualitative indicators of the natural forage base. The amount of fertilizer applied depends on many factors, and there is no ready-made scheme for fertilizing a pond without taking all factors into account. Abiotic and biotic factors that affect successful fertilization include the depth of the reservoir, the length of the coastline, the rate of water exchange, turbidity, water temperature, the species of plants and animals that are present in the reservoir, and the dietary preferences of farmed fish (Piper et al 1982). Chemical indicators of water and bottom sediments, the presence of which must be considered, include nitrogen, phosphorus, pH, acidity, alkalinity, calcium, and magnesium (Boyd 1979). Other factor to consider are the age of the ponds: older ponds tend to require more fertilization than new ones (Mischke & Zimba 2004). The amount and frequency of fertilization depends on the region and the natural forage base of the reservoir. Both organic and mineral fertilizers can be applied to ponds where spawning of the largemouth bass or further rearing of fry is planned.

Application of organic fertilizers. This type of fertilizer can accelerate zooplankton development by providing a direct source of nutrients for it even before the mass phytoplankton «bloom» begins. They also provide a source of carbon for potentially carbon-limited phytoplankton and heterotrophic organisms (Boyd 1990). To increase the production of zooplankton, organic fertilizers are recommended to be applied to new or "sterile" ponds (Piper et al 1982). The organic fertilizer used in the largemouth bass ponds with fry is generally preferred to the most common local crops or by-products, such as soybean meal, rice bran, cottonseed meal, alfalfa meal, chopped hay or straw, and animal manure. As a rule, the choice of organic fertilizer depends on its availability in a particular area, its cost, and previous experience of use. The content of carbon, nitrogen and phosphorus in organic fertilizers can be very different (Wedemeyer 2001).

Application of mineral fertilizers. When growing largemouth bass in the fish farms on the territory of Ukraine, as an inexpensive source of nitrogen, phosphorus, and potassium, which directly stimulate the growth of phytoplankton, mineral fertilizers are usually used. Considering the known composition of mineral fertilizers, their application rates are much easier to calculate than rates of organic fertilizers. Dissolved inorganic nutrients stimulate the growth and reproduction of phytoplankton, thereby promoting the development of zooplankton (Piper et al 1982). There are different schemes for applying mineral fertilizers to ponds. According to one of them, after filling the spawning or nursery ponds with water (depending on the method of growing of the largemouth bass fry), superphosphate is added in the amount of 8 kg/ha (35μg/l for ponds with an average depth of 1 m) and nitrogen is added in the amount of 9 kg/ha with an interval of 1 week until the level of zooplankton reaches its peak, which usually occurs after 3-4 fertilizations (Snow 1970a). After the amount of zooplankton has increased to the required level, it is recommended to apply fertilizers fortnightly to maintain its concentration and stop applying them approximately 10 days before the planned transfer of fry (Snow 1970a).

A combination of organic and mineral fertilizers is common practice, especially in spawning ponds where water is frequently discharged and time to form a sufficient natural forage base is limited. It was observed that the combination of organic fertilizers and superphosphate in a ratio of 3:1 provides higher fish production than using only organic fertilizers (Piper et al 1982). While the costs associated with organic fertilization are higher, the increase in fish production while applying organic and mineral fertilizers justifies the additional expenses. It is recommended to use the following combination of organic and mineral fertilizers in nursery ponds for the largemouth bass. It is necessary to start applying fertilizers in 2 to 3 weeks before the fry stocking. Initially, 168 kg/ha of

chopped peanut haulm is applied; in 10 days should be applied 100 kg/ha of mineral fertilizers with a mass fraction of total nitrogen of 16% and a mass fraction of total phosphates of 20% (16-20-0) with reiteration in 10 days in a quantity of 50 kg/ha (Simco et al 1986).

Selection and preparation of broodstock. When breeding the largemouth bass, preference is given to natural spawning (when fish can independently choose a pair for themselves). If the required number of reservoirs is available, the broodstock should be divided into ponds by age group and gender. This procedure allows broodfish to be provided with the required amount of feed, to prevent premature spawning and to reduce the workload during the capture of brood fish and their stocking in spawning ponds. Older fish usually mature and spawn earlier, and the presence of broodstock of different ages in the spawning ponds can lead to the appearance of fry of different sizes and contribute to cannibalism (Piper et al 1982). The broodstock of the largemouth bass is launched into spawning ponds at the rate of 200-350 kg/ha with the same number of males and females (Hutson 1990).

Gender differences of the largemouth bass are not clearly expressed. Several techniques can be used to distinguish females from males (Snow 1963). Mature fish can only be distinguished by gender directly before spawning. In other periods the morphological characteristics of males and females do not differ enough to determine their gender. Broodstock are selected for spawning in early spring, when the water temperature is constantly below 15°C. Females ready for spawning can be easily distinguished from males or immature females by turning belly up and examining side by side. In ready-to-spawn females, a stretched, swollen, soft, drooping ovarian region and a swollen, red, protruding anus can be seen. Mature males usually excrete a small amount of milt during the palpation. For palpation the fish is turned belly up and slowly, but with little effort, press on the sides or in the middle of the abdominal region. Males that freely excrete milt on palpation are selected for spawning.

In the southern United States, the largemouth bass can reach maturity in 1 year with a minimum weight of 180 g (Swingle 1950). Given that the growth rate of the largemouth bass in the northern part of its range is slower, the fish can reach maturity at the age between 2 and 5 years. Good results can be obtained by using for spawning fish with a minimum weight of 320 g (Snow 1965). One of the main factors for the maturation of broodstock is the availability of sufficient amount of forage fish of suitable size at water temperatures > 15°C. To achieve a 1 kg body weight gain, the largemouth bass needs approximately 5.1 kg of fish (Piper et al 1982).

The most common fish species used in the aquaculture of Ukraine for feeding the broodstock of the largemouth bass before spawning are Prussian carp (*Carassius gibelio*), stone moroko (*Pseudorasbora parva*), common bleak (*Alburnus alburnus*) and Amur bitterling (*Rhodeus sericeus*). Usually, these fish species are present in large numbers in local pond fish farms when growing common carp (*Cyprinus carpio*) and compete with its juveniles for forage base, thereby reducing the common fish production. In autumn, during the fishing of feeding carp ponds, all additional low-value fish of a suitable size are stocked into a separate pond for winter, and in the spring are used for feeding the broodstock of the largemouth bass. Usually, the number of fish for feeding is determined as 2% of the broodstock body weight per day for a 30-day period (Brandt & Flickinger 1987). So, if the weight of the broodstock is 200 kg, it is necessary to stock about 120 kg of forage fish into the pond to provide them with enough food. It should be noted that it is not advisable to stock forage fish directly into spawning ponds because it will reduce the food supply for fry and complicate their catch.

Spawning behavior. The spawning behavior of the largemouth bass is closely related to the increase of water temperature in the reservoir after the end of the winter period. The largemouth bass spawning within a particular region occurs almost at the same time. Spawning usually continues from early spring to mid-summer, depending on the geographic latitude of the range. Within the northern and southern climatic zones in the United States, the largemouth bass can spawn from February to July (Heidinger 1975).

Spawning of this species begins at a water temperature of about 18°C and reaches its maximum at 22-24°C. The spawning period in most cases lasts for 3-4 weeks (Waters & Noble 2004). In fish farms on the territory of Ukraine spawning of the largemouth bass usually occurs from the end of May to the beginning of July.

The male of the largemouth bass chooses and prepares the spawning bed and protecting it from other fish. Preference is given to sheltered, shallow areas with a hard bottom or fibrous substrate such as tree roots. Also, for the largemouth bass spawning can be used an artificial fibrous substrate (Isaac & Staats 1992). Usually, such substrates are placed in ponds at 3-6 m from one another at a depth of 0.5-1.0 m, not far from the shore, which makes it easy to observe spawning activity. Also, this fish protects eggs and fry (Figure 2).

Figure 2. The male of the largemouth bass guards the newly hatched fry.

When brood fish are stocked into spawning ponds, it instinctively tends to stick together at first time. In a few days males begin to select areas for spawning and protect them. After the nest is built, the male becomes territorial and keeps close to breeding ground, trying to attract the female for spawning. After a short courtship, the female lays eggs, and the male fertilizes them. After the end of spawning, the male continues to guard the nest. Spawning can occur at any time from morning to late evening. Clear water helps to identify the location of eggs within the spawning beds. If the water is dark or turbid, the presence of eggs is determined by direct examination of the spawning substrates without removing from the water. If the male guarding the nest reluctantly swims away during examination, eggs are probably present.

The incubation period depends on the water temperature and can range from 317 hours (13 days) at a water temperature of 10°C to 49 hours (2 days) at a water temperature of 28°C (Heidinger 1975). Incubation should proceed with a constant water temperature and minimal fluctuations. Larvae hatch from eggs incubated at 20.1°C in 3-4 days, while larvae hatch from eggs incubated at 22.2°C in only 2 days (Matthews et al 2012). The hatched larvae begin to swim in 7-9 days at a water temperature of 20-22°C, and in 5-7 days at a water temperature of 24-26°C (Matthews & Stout 2013) (Figure 3).

Figure 3. The largemouth bass larvae in a few hours after hatching.

To reduce the difference in size and weight indicators and prevent cannibalism, spawning substrates with eggs should be transferred from spawning ponds to the nursery ponds for one to three days. The substrates with eggs are transferred between ponds in boxes filled with water without removing them from the water. After hatching, the size of the larvae is rather small, ranging from 3 to 5.5 mm. Growth and development continue throughout the yolk sac resorption period, which can last for 120 hours or even more. When switching to external feeding, the size of the larvae is from 5.5 to 6.5 mm, and their amber or cream color becomes slightly brown. If there is a sufficient food base in the ponds, the largemouth bass fry grows rather quickly and their average length at the age of about two weeks is 10-12 mm (Figure 4).

Figure 4. The average length of the largemouth bass fry in two weeks after hatching is 10-12 mm.

The technique of spawning and rearing fry in one pond. The technique of spawning and rearing fry in one pond is the oldest and easiest one in the largemouth bass aquaculture. Brood fish are stocked into spawning ponds when the water temperature approaches 15°C and allowed freely to pair and spawn. Stocking densities are usually between 25 and 100 fish/ha (White 1981). Broodstock are left in the pond until the fry are large enough to be caught and transferred to nursery ponds, which usually occurs in 30-45 days after the stocking of brood fish (Hutson 1990). The technique of spawning and rearing fry in one pond has some advantages over other techniques involving the transfer of eggs or larvae from the spawning pond to the nursery ponds. It allows fry to be reared up to > 15 mm when they are easier to count, providing better control of stocking density. Furthermore, the stocking of larger fry into nursery ponds provides their higher survival rate (Kurten 2001). When spawning and rearing in the same pond, fry is usually different in size and age, so before the next stage of rearing they must be sorted. Considering the active cannibalism of the broodstock, this technique is effective for growing fry up to 25 mm. To stimulate primary productivity, as well as for the further development of zooplankton and insect larvae to satisfy the nutritional needs of fry at different stages of growth, ponds are usually fertilized.

The eggs transfer technique. With this technique, the brood fish are stocked into the spawning ponds in the same way as with the previous one, with higher stocking density – about 100-200 fish/ha. When preparing spawning ponds, the main attention is paid to the water clarity, no fertilizers are applied. For spawning and transferring the eggs of the largemouth bass to nursery ponds many fish farms use fibrous spawning mats (Isaac & Staats 1992). Every day the spawning mats are checked for eggs. Substrates with eggs are transferred from spawning to nursery ponds, where the larvae hatch. Subsequently, the fry is left in nursery ponds and reared to the required size (Hutson 1983). The disadvantages of this technique include the fact that the number of larvae hatched from the eggs remains unknown, which can lead to too high or low stocking density per unit area of a particular pond. This, in turn, complicates the rearing of fry, makes their numbers unpredictable, and may require a significantly larger pond area than other techniques.

The larval transfer technique. With this technique, the brood fish are stocked into the spawning ponds in the same way as with the eggs transfer technique, but in this case, floating larvae are transferred from the spawning to the nursery ponds. When eggs or larvae are transferred directly from spawning ponds, the water in the ponds should be clear after filling, which makes it possible to observe the larvae and spawning activity. Because the larvae will be caught from reservoirs even before switching to external feeding, in this case spawning ponds also do not require fertilization. To visually determine the presence of groups of floating larvae, fish breeders often use special tools to contrast them. For example, it can be white blades of boat oars or light-colored bucket lids attached to a long handle. These tools are immersed under the water surface near the coastline. After the larvae begin to swim, their flocks remain near the spawning beds for several days, where they can be caught with small-mesh nets, small seines, net traps or by draining the pond (Hutson 1990). A standard weight index of 275 pcs/g can be used to count the number of the largemouth bass swimming larvae (Glenewinkel et al 2011).

The larval transfer technique allows controlling the stocking density for specific rearing purposes, such as fry size (White 1981). It also makes it easier to stock the larvae of the same size and age into ponds to reduce cannibalism, which can significantly reduce the number of fry during the first growing season. But unfortunately, when using this technique, not all larvae can be caught in the spawning pond, which leads to the appearance of a difference in size and group cannibalism. The presence of groups of fry of different sizes increases during the spawning period; therefore, most fish farms practice transferring to the nursery ponds only larvae from the first spawned fish with a time difference of no more than a few days. Other disadvantages of this technique include a decrease in the duration of male's courtship period for offspring, given the fact

that the extraction of spawning substrates with eggs and their replacement with new ones stimulates the continuation of the spawning activity of males and leads to their collisions.

Spawning of the largemouth bass in outdoor pools. Spawning of the largemouth bass in outdoor pools has several significant differences from spawning in ponds, at least from the most common technique of spawning and rearing fry in one pond. First, during spawning in ponds, the male of the largemouth bass digs out the nest on the soft ground of the pond bed, which, for obvious reasons, cannot be done on the bottom of a cement pool. Also, in the case of pools location far from pond fish farms, it is quite problematic to provide the largemouth bass with enough forage fish. In addition, forage fish in pools can become a source of infectious diseases. Considering the above, during the spawning of the largemouth bass in outdoor pools, it is very necessary to provide them with the required amount of spawning substrate (most often, spawning mats). It is also very desirable to use a feed trained broodstock, accustomed to consuming artificial feeds (pellets).

For spawning of the largemouth bass in Ukrainian fish farms most often concrete pools with a size of 20 x 7 m and a depth of 1.5 m, which are filled with 1 m of water are used. Fish, which were selected as a potential broodstock in autumn, are kept in concrete tanks during the winter at a water temperature of 8-10°C with a stocking density of 20-25 pcs/10 m^3. The placement where the fish is located must have natural light, and each pool must be equipped with a pump and a mechanical filter with a built-in ultraviolet lamp, through which all water in the pool must pass within 1 hour. Additional aeration is also used. In most cases, every week it is necessary to change about 30% of water in the pools with fresh one, while controlling parameters such as pH, ammonia nitrogen and nitrites. Fish in the pools are fed daily with pellets or frozen shrimp (*Palaemon* spp.) until visual saturation, or every five days in the amount of 1% of the body weight of the broodstock (Brandt & Flickinger 1987).

Approximately two weeks before the scheduled spawning period, the water temperature in the wintering pools is gradually raised to 14-15°C, but it should not exceed 16°C for a long time. At the same time, spawning outdoor pools are filled with water. It is better to use a well or an artesian well as a source of water, which will make it possible to prevent entering in the pools of unwanted micro or macro-organisms. Pools should be free of sediment and thoroughly washed before filling with water. It is desirable that the spawning ponds are in a well-lit area, which contributes to faster heating of the water. The brood fish are stocked into the spawning pools when water temperature reaches 14-15°C, the selection takes place in the same way as before stocking into the spawning ponds. In a pool measuring 20 x 7 m, 5 spawning mats are placed near the longitudinal walls at 4 m from each other and fixed with large pebbles. Twenty ready to spawn fish are stocked into one pool and continue to feed them. The pellets should contain 45-50% of protein and no more than 20% of fats and carbohydrates, otherwise, fatty degeneration of the liver and the accumulation of glycogen in it may be observed (Cardeilhac 2009). The amount of feed is increased to 1% of the body weight of the broodstock per day. The pools should also have active aeration.

In a week after stocking of brood fish in the pools, the males divide the area of their bottom into separate sections in accordance with the location of the mats. After another week, as a rule, pair spawning begins, which usually takes place early in the morning, before sunrise. Due to the shallow depth and water clarity in the pools, the presence of eggs on the mats can be determined visually. In case of doubt about the presence of eggs on the substrate, an underwater camera can be used. Every morning the spawning substrates are checked and, if mats with eggs are present, they are removed and placed vertically in the incubation pools. The mats are transferred immersed in water; the duration of their stay in the transfer containers should not exceed 15 minutes. The water level in each incubation pool must be sufficient to completely submerge of spawning mats. To ensure the circulation of water around the mats, air diffusers are installed along the walls of the pools.

The larvae that have begun to swim are carefully caught using small-mesh nets and are transferred to pools with an area ranging from 20 to 30 m². At first, the water level should be 20-27 cm with a further increase to 50-70 cm. The stocking density of larvae should be about 600 pcs/m². After switching to external feeding, the larvae of the largemouth bass are fed with small zooplankton, for example, rotifers, raised in a pond or in a separate pool. The number of feedings is 2-3 times per day. Later, when the length of the fish reaches 1.5-2.0 cm, the fry begins to feed with larger zooplankton, for example, cladocerans or copepods, as well as larger rotifers. During the first 25 days, the largemouth bass fry give preference to cladocerans, especially representatives of the genus *Moina* (*Moina* spp.) and *Daphnia* (*Daphnia* spp.). When the length of the fish exceeds 2 cm, they can be fed with aquatic oligochaetes, after which the process of feed training can start (Li 2008) (Figure 5).

Figure 5. During the first month, the largemouth bass fry prefers to stay in schools and feeding on the initial stages with rotifers, cladocerans or copepods and, a little later, aquatic oligochaetes.

The technique of «warm» feed training. Feeding fish with artificial feed (pellets) is a standard intensification technique in aquaculture. In some species, such as rainbow trout (*Oncorhynchus mykiss*) and channel catfish (*Ictalurus punctatus*), the larvae after switching to external feeding are ready to intake artificial feed. In the case of the largemouth bass, the transition to pellets requires feed training of fish to consume non-living food items. Such training is possible during the appropriate period of development, while in natural conditions the juveniles of the largemouth bass shift from eating zooplankton and small insects to feeding on live fish, which usually occurs when the total length of the fry is 25-35 mm (Huskey & Turnigan 2001). This natural phase can be used for feed training of juveniles of the largemouth bass. Feed trained largemouth bass retain the obtained skills throughout life (McCraren 1974).

There are many techniques of "warm" fed training of the largemouth bass, but the most common methods involve initial training of fry to consume minced fish (Kubitza et al 1997) or freeze-dried krill (Skudlarek et al 2007), followed by pellets.

Before the start of feed training of juveniles of the largemouth bass, the fry raised in ponds or pools are caught and launched into water tanks with a stocking density of

700 pcs/m^3, ensuring sufficient water exchange and active aeration (Coyle et al 2009). The duration of feed training is usually about two weeks. Fish that have not started to consume artificial feed can be left for a second course of feed training. It is desirable that the water temperature during the "warm" feed training was at least 24°C, and the best results are achieved when the water temperature is 26-28°C (Coyle et al 2009).

When using the technique of the largemouth bass fry feed training with fish, it is grinded to the consistency of mince and used to envelop and soften floating pellets with a diameter of about 1.5 mm one hour before feeding. The initial weight fraction of wet fish is 20%, dry pellets is 80%, and every three days the fraction of grinded fish in the mixture is reduced by about 25% until it is completely converted to pellets. It should be noted that despite the recommendations to use floating pellets for the largemouth bass feeding, they often contain a large amount of carbohydrates (>20%), which can lead to the accumulation of glycogen in the fish liver after a while (Cardeilhac 2009). Therefore, for further feeding of fish in ponds, it is advisable to use slowly sinking pellets with high protein value (45-50%) and fewer carbohydrates.

When using the technique of the largemouth bass juveniles feed training with freeze-dried krill (FDK), the fry is initially fed with FDK, followed by a gradual transition to commercial pellets with a diameter of 1.5 mm. For 1-3 days the fish are fed only with FDK, for 4-6 days their diet consists of 75% FDK and 25% pellets (ratio 75:25), for 7-9 days the ratio of FDK and pellets is 50:50, for 10-12 days the ratio of FDK to pellets is 25:75, then the fish are fed only with pellets (Coyle et al 2009). At the beginning of training process, the amount of feed that is fed to the fish is 10% of their initial mean body weight per day. The total amount of feed for one day is divided into two parts and fed to the fish twice at 9:00 and 16:00. On the 8^{th} day, due to the increased feed intake, the daily amount of feed is enlarged to 15% of the initial mean body weight of the fish. After feed training, the fish are stocked into the ponds and fed twice a day to the end of the growing season. Fish that at the end of the growing season have reached a total length of 10 cm or more, with appropriate supervision can successfully winter in ice-covered water bodies, including the ponds of the fish farms (Post et al 1998). The depth of the ponds for the largemouth bass wintering should be at least 2.5 m, they should have sufficient water supply and equipped with pumps to maintain the holes in the ice cover to prevent suffocation.

The technique of «cold» feed training. Cultivation of juveniles of the largemouth bass in Ukrainian pond fish farms has certain peculiarities due to the specificity of local climatic conditions and fishery water bodies. First of all, considering the rather late beginning of spawning season of the largemouth bass in local fish farms, the fry reaches the suitable size for feed training (25 mm) in the middle of July, when the air temperature during the daytime can reach 28-32°C, and the concentration of water dissolved oxygen reaches the lowest annual rates. Considering the above, when catching the largemouth bass fry under such circumstances, a very high mortality rate is observed, which makes fish farming economically unprofitable. Also, for the largemouth bass spawning in local fish farms often used "old" ponds built 50-60 years ago for growing common carp (*Cyprinus carpio*), bighead carp (*Hypophthalmichthys nobilis*) and grass carp (*Ctenopharyngodon idella*). The central part of such ponds is covered with a thick layer of silt, which additionally complicates the catch of 20-25 mm fry. Considering the above, when using the most widespread technique of spawning and rearing fry in one pond under local conditions, after catching the broodstock the fry is left in the same pond where the spawning took place until the end of the warm season. Given the fact that in this case large zooplankton, as well as aquatic insects and their larvae form the basis of the diet of fry (Ludsin & DeVries 1997), the growth of juveniles is rather slow, and the average length of fingerlings during the final fish harvesting in autumn is 45-50 mm and weight is around 8-9 g. With specified morphometric parameters, there is a rather high mortality rate of fingerlings during wintering in ice-covered ponds of fish farms, therefore, after being caught in October-November, they are sorted and transported to wintering complexes, where the process of feed training occurs (Figure 6).

Figure 6. The largemouth bass fingerlings in the pool of the wintering complex.

The winter complex is a closed building with the possibility of heating, where from 6 to 20 concrete or plastic pools with a capacity of 5-15 m³ are installed. Pools are thoroughly washed and disinfected before fish stocking. It is advisable that the temperature in the pools before stoking of fingerlings approximately matched to the water temperature in the ponds where the fish were caught. After temperature adaptation, the fingerlings are weighed and stocked into pools with a stocking density of 2,500-3,000 pcs/10m³. To prevent the spread of infectious diseases, each pool is equipped with a separate mechanical filter with a built-in ultraviolet lamp. The pump must provide the circulation of all the water in the pool through the filter in one hour. Since the main purpose of the wintering complex is successful wintering of fingerlings without their growing, as well as to reduce heating costs, during the winter period the water temperature in the pools is +8-12°C. It is necessary to change about 30-40% of water in the pools with fresh one every week.

The process of feed training begins in a few days after stocking of fingerlings into the pools. During the first 14 days, fish are fed 3 times a week with live bloodworms (the larvae of non-biting midges from Chironomidae family) in an amount of approximately 1% of their total initial body weight. When the fish get used to the bloodworms and begin to gather in one large group during feeding, a small amount of slowly sinking pellets with a diameter of 2 mm is added. During the feed training the following sequences must be followed. At first, the fish are given a small amount of bloodworms, and when their concentration at the feeding area becomes as high as possible, a small number of pellets are thrown into the "crowd" and wait until the pellets are completely eaten by the fingerlings. Bloodworms and granules are not mixed. These steps are repeated 5-7 times. After that, the fish is fed with the remaining bloodworms. In the future, the fingerlings are fed in the same way 3-4 times a week, gradually increasing the quantity of pellets. After about a month, most of the fish begin to consume pellets, and bloodworms are no longer used to concentrate them. However, a certain number of fish are not accustomed to eating pellets, therefore, to maintain the maximum number of juveniles, until the end of the period of keeping fingerlings in the wintering complex, the fish are first fed until

visually satiation with pellets, and then they are given bloodworms in an amount of 0.1 - 0.2% of the initial total body weight of fish in each pool. Excessive use of pellets during the early feed training phase can lead to higher mortality rate among fingerlings. Also, given the fact that juveniles of the largemouth bass are reluctant to eat pellets from the bottom of the pool (Willis & Flickinger 1981), especially when the water temperature is <20°C, after the end of feeding the feed residues in the pool must be removed to prevent the process of rotting. It should be noted that feed training of the largemouth bass fingerlings in a water with temperature lower than generally accepted recommendations is most likely possible due to the use of live bloodworms as an "intermediate feed", in contrast to non-living food objects (minced fish, FDK), which are used with standard «warm» techniques.

The transportation of the largemouth bass fingerlings from the wintering complex to the ponds begins when the water temperature outdoor reaches 7-10°C. At the same time, it is desirable that the difference in water temperature in pools and ponds does not exceed 3°C. The fingerlings must be sorted before stocking into the ponds. Large and medium sized fish, which have been feed trained, are raised in monoculture in ponds with a stocking density of 5,000 pcs/ha (Heidinger 2000) (Figure 7).

Figure 7. From the wintering complex juveniles of largemouth bass are launched into ponds with a stocking density of 5,000 pcs/ha.

Smaller fish, that have not been accustomed to consume pellets, are used as biomeliorators in ponds with annual common carp to reduce the number of low-value fish species. During the second growing season, the largemouth bass are heavily fed with pellets with high protein content (45-50%). The amount of feed varies according to the water temperature and is about 1% of the initial body weight of the fish at the beginning of the growing season, with a gradual increase to 30-40% during July and August, and a decrease to 10% a month before the final fish harvesting (October-November). With this technique, at the end of the second growing season most fish reach weights in the range of 300-350 g, which, in fact, corresponds to some other results, obtained with feed training of the largemouth bass during the first growing season (Kubitza & Lovshin 1997) (Figure 8).

Figure 8. With sufficient amount of pellets, the largemouth bass reach 300-350 g at the end of the second growing season.

Consequently, with the technique of intensive cultivation of the largemouth bass in ponds, at the end of the third season the fish can grow up to the weight of 1 kg or even more.

Results and Discussion. The analysis of methods indicated in this article allows to an overview, that despite unfavorable climatic conditions, as well as biotic and abiotic factors of local reservoirs, a functioning methodology of breeding and growing of largemouth bass in the ponds of local fish farms on the territory of Ukraine can be achieved. However, these methods require further research to intensify individual stages of cultivation to increase fish productivity, as well as to reduce costs associated with the necessity to use special equipment.

An unsolved problem remains the low survival rate of fingerlings during wintering in ponds, which creates the need for a wintering complex, and not every fish farm can afford to have it. It is necessary to conduct studies about the possibility of feed training of juveniles of the largemouth bass at an earlier age, which will enable them to reach large sizes during the first period of active growth and to successfully winter in ponds.

Cannibalism is also a big problem during the process of growing of fry and fingerlings of the largemouth bass. This phenomenon, in most cases, arises from the uneven growth of fry, the difference in the spawning time of different pairs of fish, and the insufficient natural food base. The solution of this problem can be sorting of fingerlings every 2 weeks, launching of broodstock of approximately the same weight and size into the spawning ponds (the largest individuals of the largemouth bass spawn the first, the smallest ones - the last), as well as the improvement of methods of organic and mineral fertilizers application to increase the natural food base for fry.

Conclusions. Despite the fact that in many countries of the world the largemouth bass is common in fisheries, and its breeding and cultivation technique has been improved over the decades, for the territory of Ukraine the use of foreign methods without making appropriate adjustments according to climatic conditions, as well as biotic and abiotic

factors of local water bodies, can be unprofitable, and even unpromising, taking into account the previous negative experience of the largemouth bass aquaculture in 19th and 20th centuries. Considering the above, it is necessary to conduct new scientific research on further intensification of the production of juveniles of the largemouth bass in warm-water pond fish farms, as well as the possibility to combine the rearing of fry in ponds during the warm season with their cultivation in recirculating aquaculture systems in winter. The development of modern research and technology, the intensification of breeding methods, the greater availability of information, as well as climate change create the preconditions for the successful breeding and rearing of the largemouth bass on local fish farms as one of the most valuable representatives of modern freshwater aquaculture, especially for the development of recreational fishing and fishing tourism.

Conflict of Interest. The authors declare no conflict of interest.

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