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THE INFLUENCE OF THE POPULATION DENSITY ON THE DEVELOPMENT OF THE SPECIES *SANDER LUCIOPERCA* (LINNAEUS, 1758) IN THE POSTEMBRYONIC PERIOD

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Abstract

The pikeperch (Sander lucioperca, L. - 1758) is one of the freshwater species recently introduced in intensive aquaculture. In the last decade there have been made great efforts in the direction of developing the intensive culture of this species. The population density is a very important technological parameter for fish growth, in all stages of development and is specific to the species, age and technology applied, the most difficult to achieve and with the most significant losses being recorded in the post-embryonic period. Therefore, the growth of the pikepech in the post-embryonic period was experienced in "Evos" type fiberglass pools, in three experimental versions, with three different population densities like: V1 - 1000 ex./basin, V2 - 2000 ex./basin and V3 - 3000 ex./basin. There were two critical moments in the post-embryonic development period: the first was at the beginning of exogenous feeding time, and the second during the swelling of the gas bladder. The experiments were performed at S.C.D.P Nucet, in triplicate, during three growing seasons (2018, 2019 and 2020). The best results were obtained in V1 version, where the survival rate was 69.5% in 2020, the average individual growth rate in 2019 was 1.555 g/ex., and the Fulton coefficient was between 0.93 and 1.13.

***Key words**: density, fry, pikeperch, survival weight.*

INTRODUCTION

The pikeperch (*Sander lucioperca* L.), is a species of interest to fish farmers due to its marketing qualities (Jankowska et al., 2003) and rapid growth (Terlecki, 1955; Nagiec´ 1961; Steffens, 1986), as well as for fishermen (Wołos et al., 1998; Bninska and Wołos, 2001) and is present in most of continental waters on the Romanian territory (Dobrotă et al., 2021). The results of studies conducted in several European countries, including Germany, France and Finland, indicated that one of the main obstacles in the growth and development of the pikeperch culture is in the post-embryonic development period (Hilge and Steffens, 1996). Data from the speciality literature on the methods of the pikeperch intensive breeding larvae are very limited and none of the available reports on this subject analyze the impact of population density on the development of this species (Schlumpberger & Schmidt, 1980; Steffens, 1986; Ruuhijärvi et al., 1991; Hilge & Steffens, 1996; Ruuhijärvi & Hyvärinen, 1996; Mamcarz et al., 1997). After hatching at 18-21 days old, the pikeperch can be fed with mixed feed (*Artemia* sp. and artificial feed), followed exclusively by artificial feed (Szkudlarek, 2004) up to commercial size (Zakes et al., 2000).

The post-embryonic stage, in fish in general, and in pikeperch in particular, is an absolutely necessary stage in the producing process of a one summer old juveniles.

We are disscusing about bringing the fry to the independent larvae stage, which are very fragile immediately after hatching (skin respiration due to the absence of gills, and the inability to feed on exogenous organisms due to the absence of the mouth) and vulnerability to bioaggressors. Szkudlarek & Zakęś (2002) studied and mentioned the effect of population density on the survival and growth performance of pikeperch larvae under controlled growth conditions.

The intensive growth techniques of the American pikeperch (*Stizostedion vitreum*) have been developed and experimented for a long time, and in the opinion of Molnar et al. (2004), they can be applied at least in part to the European one (*Sander lucioperca* L.).

A team of researchers from Hungary (Molnar et al., 2004) conducted an extensive experiment to evaluate the effect of accustoming pikeperch larvae with additional feed and the effects of population density on feeding strategy and behavior.

MATERIALS AND METHODS

The experimental works took place in the years 2018, 2019 and 2020 at the Research and Development Station for Fish Farming of Nucet. In order to carry out the experimental works in the post-embryonic period in the intensive system of pikeperch larvae, the population density was the variable factor. The degree of repeatability was 3 times, and as a feeding modality, mixed feeding was adopted. The works for the development of the pikeperch in the post-embryonic period were carried out in the pilot installation for growing in fiberglass tubs, with a useful volume of 1,000 liters ("Evos" basins), installed in the Incubation Station no. 1 (Figure 1). The "Evos" type basins are round in shape and are fed through an external pipe with free fall, and the evacuation is done centrally, with the creation of a circular current. The optimum height of the water layer is between 0.40-0.65 m. The baths tubs were supplied with a water quantity of 7-15 l/min, depending on the temperature.

Figure 1. Pilot installation ("Evos" type basin) for raisingand the development of pikeperch larvae in the post-embryonic period

Experimental development works in the post-embryonic period in intensive system of pikeperch larvae, were carried out according to the following working methodology: establishing experimental versions; preparation of the pilot station for the population; larval population; feeding; monitoring the environmental conditions into the growth modules ("Evos" type basins); monitoring the development and health of the larvae; fishing the pikeperch larvae at the end of the growing period, establishing the value of specific indices and discussing the results.

From the specific literature data, the population density of such growth modules in the post-embryonic period depends primarily on the degree of intensification, with a gap of variation from 1-10 exemplares.

The working methodology took into account the following aspects:

- three experimental variant were established in terms of population density;
- "Evos" type pools/experimental variant: 3;
- degree of repeatability: 3;
- feed type: in three stages, natural food in the live state, mixed (live food/fodder) and only with fodder, all three stages well determined in number of days;
- administration: *ad libitum*, only during the day (12 hours), with permanent food consumption control and three-day monitoring of the main physico-chemical parameters of technological water (temperature, oxygen content, pH, organic matter, etc.);
- duration of the post embryonic period: 40 days.
- the experimental version regarding the population density were (Table 1 and Figure 2):
    - variant I: 1000 ex./basin;
    - variant II: 2000 ex./basin;
    - variant III: 3000 ex./basin.

In the post-embryonic pikeperch development stage, in all experimental variants, feeding strategy was adopted and implemented for a 30-40 days period as follows:

- pikeperch larvae were fed both live food and fodder;
- the first 10 days, the larvae feeding was done with live food (*Artemia salina nauplii*) obtained from directed culture within S.C.D.P. Nucet;
- after the 10 days of live food administration, mixed feeding (live food + fodder, in equal percentages, with a 60% of crude protein content) was changed to a 10 days period, a time in which pikeperch larvae are starting to get used to consume both fodder and live food, the live food ration being reduced daily, so that at the end of the 10 days, it represented 10-15% of the total fodder;

Table 1. Population of the "Evos" baths with 7-8 days old larvae

Nr. crt	Experimental Variant	Basin Volume (l)	Ex. / basin	Nr. basine	Ex. total/year
1	Variant 1 (V1)	1000	1000	3	3000
2	Variant 2 (V2)	1000	2000	3	6000
3	Variant 3 (V3)	1000	3000	3	9000

- almost 20 days of feeding exclusively with fodder, the live food being administered sporadically, once every three days for 5 days, an then, only with fodder, until the age when the growth parameters were reached and the appearance of the cannibalism phenomenon was observed (40 days);
- the feed daily rations, in the form of live food, mixed food (live food + fodder) or only fodder, were established according to the mass of consumers evaluated at 5 days for each experimental variant;
- in all feeding stages, both live food and fodder were mixed or separately administered, in 1-2 hours intervals according to the *ad libitum* system;
- the feed amount was gradually increased as the young fish gained weight and their numerical approximation at the date of the "control fishing".

RESULTS AND DISCUSSIONS

The experimental works of postembryonic development of the larvae in the intensive system were carried out in three experimental variants, in which the variable factor was the population density. They took place over 3 years, in the period 2018-2019-2020 in almost identical conditions, both technically and technologically. The biotechnological indicator on the number of larvae per experimental variant being dependent primarily on the population density is obvious that at a higher population density also the number of larvae is higher or vice versa even in conditions where the population density also influenced the percentage survival.
Analyzing the data on the larvae growth and development in the post-embryonic period (Tables 2 and 3) by the following biotechnological indicators: average mass (W med./ex., Figure 3), total length (TL), survival rate (Figure 4) and the Fulton coefficient (Figure 5) the following are found:

Figure 2. The 7-8 day old pikeperch larvae population

Average mass (W) - g/ex.
- the pikeperch larvae highest average mass after 40 days was obtained in the experimental version V2 in 2019 (1.555 g/ex.), and the lowest was obtained in the V3 version (2018 of 0.821 g/ex);
- in 2018 the highest average weight was obtained in variant V1 (1.414 g/ex.), the lowest in V3 variant (0.821 g/ex.), and in variant V2 the average weight (1.078 g/ex.) was obtained;
- in 2019 the highest average weight was obtained in variant V1 (1.555 g/ex.), the lowest in variant V2 (0.969 g/ex.), and in variant V3 the average weight (0.792 g/ex) was obtained;
- in 2020 the highest average weight was obtained in variant V1 (1.489 g/ex.), the lowest in variant V3 (0.880 g/ex.), and in variant V2 the average weight (1.110 g/ex.) was obtained;
- in conclusion, in all study years, the highest average weight was obtained in variant V1, followed by variant V2, and the lowest average weight in variant V3.

Total length (TL) - mm/ex.
- the highest average total length of pike larvae after 40 days was obtained in the experimental variant V1 in 2019 (55.0 mm/ex.), and the smallest was obtained in the variant V3 (41 mm/ex.) in the year of 2019;
- in 2018, the highest total length was obtained in variant V1 (50 mm/ex.), the smallest in variant V3 (42.0 mm/ex.), and in variant V2 the average total length of 45 mm/ex. was obtained;
- in 2019, the highest total length was obtained in variant V1 (55 mm/ex.), the smallest in variant V3 (41 mm/ex.), and in variant V2 the average total length of 44 mm/ex was obtained;

Table 2. The values of the biotechnological indicators for the development of the pikeperch by variants/years in the post-embryonic period in the years 2018, 2019 and 2020

Year	Variant	Basin	No. ex. populated	No. ex. achieved	Average W (g)	Average L (mm)	Sv (%)
2018	V1	B1	1000	638	1.236	48	63.8
		B2	1000	681	1.682	54	68.1
		B3	1000	696	1.325	49	69.6
	V2	B4	2000	986	1.206	48	49.3
		B5	2000	1036	1.065	45	51.8
		B6	2000	1148	0.964	43	57.4
	V3	B7	3000	1422	0.947	44	47.4
		B8	3000	1228	0.702	40	40.9
		B9	3000	1331	0.815	42	44.4
2019	V1	B1	1000	642	1.715	58	64.2
		B2	1000	675	1.523	54	67.5
		B3	1000	593	1.428	52	59.3
	V2	B4	2000	1059	1.052	47	53.0
		B5	2000	1078	0.928	43	53.9
		B6	2000	1111	0.926	43	55.6
	V3	B7	3000	1442	0.712	40	48.1
		B8	3000	1387	0.865	42	46.2
		B9	3000	1566	0.798	41	52.2
2020	V1	B1	1000	682	1.68	56	68.2
		B2	1000	656	1.328	51	65.6
		B3	1000	748	1.46	55	74.8
	V2	B4	2000	1170	1.296	49	58.5
		B5	2000	1221	0.928	43	61.1
		B6	2000	1040	1.105	44	52.0
	V3	B7	3000	1535	0.767	42	51.2
		B8	3000	1407	0.988	44	46.9
		B9	3000	1632	0.886	43	54.4

Table 3. Average results on experimental variants

Year	Variant	Basin	Average survival. (%)	Average W/variant (g)	Average Total Lenght / variant (mm)	Fulton Coeficient
2018	V1	B1+B2+B3	67.2	1.414	50	1.130
	V2	B4+B5+B6	52.8	1.078	45	1.180
	V3	B7+B8+B9	44.2	0.821	42	1.090
2019	V1	B1+B2+B3	63.7	1.555	55	0.930
	V2	B4+B5+B6	54.1	0.969	44	1.130
	V3	B7+B8+B9	48.8	0.792	41	1.140
2020	V1	B1+B2+B3	69.5	1.489	54	0.945
	V2	B4+B5+B6	57.2	1.11	45	1.210
	V3	B7+B8+B9	50.8	0.88	43	1.110

- in 2020, the highest total length was obtained in variant V1 (54 mm/ex.), the shortest in variant V3 (43 mm/ex.), and in variant V2 the average total length of 45 mm/ex was obtained;
- in conclusion, in all the study years, the highest average total length was obtained in variant V1, followed by variant V2, and the lowest average total length in V3 variant.

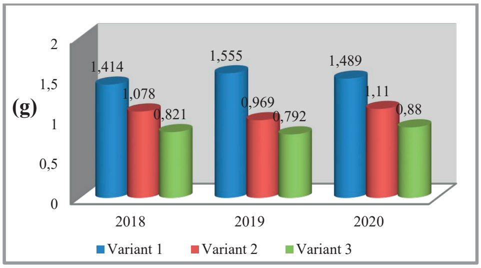


Figure 3. Average weight variation

Survival rate (%)

- after 40 days of post-embryonic growth, the highest survival rate was obtained in the experimental variant V1 in 2020 (69.5%), and the lowest was obtained in the variant V3 in 2018 of 44.2%;
- in 2018, the highest percentage of survival was obtained in variant V1 (67.2%), the lowest in variant V3 (44.2%), and in variant V2 a survival rate of 52.8% was obtained;

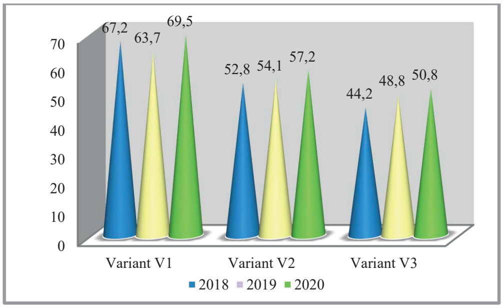


Figure 4. Survival rate variation

- in 2019, the highest survival rate was obtained in variant V1 (63.7%), the lowest in variant V3 (48.8%), and in variant V2 a survival rate of 54.1% was obtained;
- in 2020, the highest survival rate was obtained in variant V1 (69.5%), the lowest in variant V3 (50.8%), and in variant V2 a survival rate of 57.2% was obtained;
- in conclusion, in all the study years, the highest average survival percentage was obtained in variant V1, and the lowest in variant V3.

The Fulton coefficient also had similar values in all experimental variants, falling in the range 0.930 - 1.210, as follows:

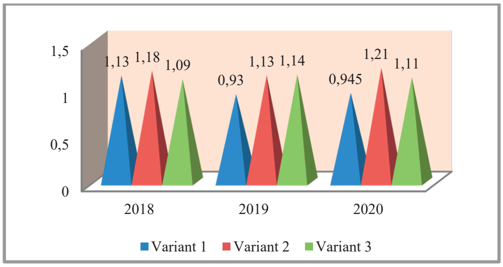


Figure 5. Fulton coefficient variation

- in 2018 the highest Fulton coefficient was obtained in variant V1 (1.130), the lowest in variant V3 1 (1.090), and in variant V2 it was 1.180;
- in 2019 the highest Fulton coefficient was obtained in variant V3 (1.140), the lowest in variant V1 (0.093), and in variant V2 it was 1.130;
- in 2020 the highest Fulton coefficient was obtained in variant V2 (1.210), the lowest in variant V1 (0.945), and in variant V3 it was 1.110.

The observations and data on the growth and development of lark larvae in the post-embryonic period in an intensive system in the "Evos" type basins, of the morpho-physiological characteristics observed macro and microscopically are:

I. At the age of 7-10 days (figure 6 a):

- existing yolk sac but with small dimensions;
- gill buds without being covered by lids;
- transparent body through which the brain and the primordia of the spine are observed;
- the larvae swim lightly.

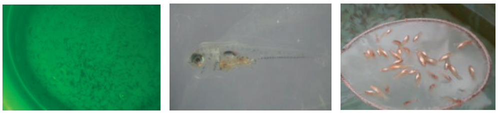
II. At the age of 17-18 days (figure 6 b):

- less transparent body with a tendency to colorate to yellowish, with pigment spots that cover almost entirely the surface of the body;
- well-developed mouth located in the ventral position;
- teeth are observable on the lower jaw in the incipient phase of formation;
- the intestine formed from the larval stage has a more accentuated curvature in the ventral area of the stomach;
- the larvae swim easily in the mass of the water in search of food;
- food consisting mainly of supplementary food and juvenile forms of plankton (algae, rotifers, cladocerans, less adult forms, organisms that have fallen into the water with the supply water from the settling tank through the filtration system).

III. At the age of 27-28 days (figure 6 c):

- the body is no longer transparent, the pigment spots of brown color cover almost the entire surface of the body;
- the fins are almost entirely formed, which allows the larvae to swim quickly in search of food;
- the stomach is well individualized;

▪ intestinal contents that highlight the presence of live food and additional feed and traces of cladocere from the water of the settling tank.



(a) (b) (c)

Figure 6. Post embrionic larvae of 7-10 days old (a), pikeperch larvae of 17-18 day sold (b), pikeperch larvae of 27-28 days old (c)

<u>*IV. At the age of 40 days*</u> (figure 7):

- body shape similar to that of the adult;
- specific color (green-gray back, less often yellow-gray, the sides are gray-silver, with darker stripes, arranged transversely, the abdominal region with a lighter color);
- body completely covered with scales;
- alert swimming specific to predatory fish species;
- tendency to manifest cannibalism phenomenon;
- the stomach content reveals the presence of the feed in proportion of 90% in different phases of digestibility and nd the remaining 10% live food.

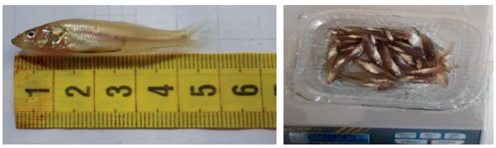


Figure 7. Pikeperch larvae at the end of the post-embryonic period

CONCLUSIONS

The pikeperch (*Sander lucioperca* L. - 1758) is one of the freshwater species recently intro-duced in intensive aquaculture.

Therefore, the growth of the pikepech in the post-embryonic period was experienced in "Evos" type fiberglass pools and there were two critical moments in the post-embryonic develop-ment period: the first was at the beginning of exogenous feeding time, and the second during the swelling of the gas bladder.

The best results were obtained in the version with 1000 ex./basin, where the survival rate was 69.5% in 2020, the average individual growth rate in 2019 was 1.555 g/ex., and the Fulton coefficient was between 0.93-1.13.

REFERENCES

Bnińska, M, & Wołos, A. (2001). Management of selected Polish commercial and recreational lake fisheries activities. *Fish Manage Ecol.,* 8, 333–343.

Dobrotă, G., Oprea, L., Dobrotă, N.G., Costache, M., Marica, N., & Radu, S. (2021). Aspects regarding the controlled reproduction of pikeperch (Sander lucioperca Linne, 1758) in industrial aquaculture systems, *Scientific Papers. Series D. Animal Science*, LXIV(2).

Hilge, V., & Steffens, W. (1996) Aquaculture of fry and fingerlings of pike-perch (*Stizostedion lucioperca* L.) – a short review. *J Appl.Ichthyol.,* 12, 167–170.

Jankowska, B., Zakęś, Z., Zmijewski, T., & Szczepkowski, M. (2003) Fatty acid profile and meat utility of wild and culture dzander, *Sander lucioperca* (L.). *Electronic Journal of Polish Agricultural Universities,* 6(1). http://www.ejpau.media.pl/ volume 6/issue1/ fisheries/art-02.html

Mamcarz, A., Kucharczyk, D., Kujawa, R., & Skrzypczak, A. (1997) Influence of fishdensity on survival, growth and cannibalism development of pikeperch (*Stizostedion lucioperca* L.) larvae. In: Creswell L, Harache Y (eds) *Island aquaculture and tropical aquaculture: Proc 2nd Int Workshop Aquacult Percid Fish*. European Aquaculture Society, Oostende, Belgium, pp 343–346

Molnar, T., Hancz, C., Bodis, M., Müller, T., Bercsényi, M., & Horn, P. (2004). The effect of the initial stocking density on the growth and survival of the pikeperch finger lingreare dunder intensive conditions. *Aquacult. Int*., 12, 181-189.

Nagiéć, M. (1961) The growth of pikeperch *Lucioperca lucioperca* (L.) in the lakes of Northern Poland. *Roczniki Nauk Rolniczych,* 77B, 549–580

Ruuhijärvi, J., & Hyvärinen, P. (1996) The status of pike-perch culture in Finland. *J Appl.Ichthyol.,* 12, 185–188.

Ruuhijärvi, M., Virtanen, E., Salminen, J., & Muyunda, M. (1991) The growth and survival of pike-perch (*Stizostedion lucioperca* L.), larvae fed formulated feeds. In: Lavens P, Sorgeloos P, Jespers E, Ollevier F (eds) LARVI'91 – *Fish Crustacean Larvicult Symp*. European Aquaculture Society, Gent, Belgium, pp 154–156.

Schlumpberger, W., & Schmidt, K. (1980) Vorla¨ufiger Stand der Technologie zur Aufzucht von vorgestreckten Zandern, (*Stizostedion lucioperca* L.). *Z Binnenfischerei DDR,* 27, 284–286.

Steffens, W. (1986) *Intensive fish production*, 1st edn (in Polish). Warsaw, PL: PWRiL Publishing House.

Szkudlarek, M. (2004) *Factors influencing the rearing effectiveness of zander, Sander lucioperca (L.) larvae under recirculation system conditions*. PhD thesis, Inland Fisheries Institute, Olsztyn, Poland Klein Breteler.

Szkudlarek, M., & Zakes´, Z. (2002) The effect of stocking density on the effectiveness of rearig pikeperch, *Sander lucioperca* (L.), summer fry. *Arch Pol Fish,* 10, 115–119.

Terlecki, W. (1955) *Rearing of pikeperch stock material*, 1st edn. Warsaw, PL: PWRiL Publishing House.

Wołos, A., Teodorowicz, M., & Brylski, H. (1998) Socio-economic analysis of recreational fisheries in two departments of the Polish Anglers Association, based on the results of the registration of anglers' catches. In: Hickley P, Tompkins H (eds) *Recreational fisheries, social economic and management aspects. Fishing News Book*, Oxford, pp 34–47

Zakęś, Z., Szczepkowski, M., & Szkudlarek, M. (2000) Production of pikeperch, *Stizostedion lucioperca* (L.) to market size in water recirculation systems. *In: Grinzˇevskij MV (ed) Presnovodnaja akvakul'tura v Central'noj I Vostocˇnoj Evropie: dostizˇenija I perspektivy*. Institut Rybnogo Hozjaistva, Kiev, Ukraine, 214–216.