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THE INFLUENCE OF THE FOOD TYPE ON THE DEVELOPMENT OF PIKE-PERCH (*Sander lucioperca*, Linneaus -1758) IN THE POST-EMBRYONIC PERIOD

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Abstract

The culture of the pike-perch(Sander lucioperca, L.-1758), in intensive aquaculture, is difficult to achieve due to its character as an active predator in the water mass. In recent years, significant quantities of pike-perch are requested by consumers, being more and more numerous those who prefer this species. Choosing the most appropriate food category is very important, because it can make the difference between the success or failure of development in the post-embryonic development stage. The experimental works for the development of the pike-perchtook place in three variants, with different food being administered, as follows: variant 1 - zooplankton (Daphnia sp.) was administered, variant 2 - prussian carp larvae (Carrassius gibelio) were administered and variant 3 - granulated feed was administered.The growth was carried out in "Evos" fiberglass tanks. The results obtained were very good in variant 2. Good results were also obtained in the other two variants (variant 1 and variant 3). The decision of the way of post-embryonic development remains at the farmer's choice..

Key words*: food, post-embryonic development, Sander lucioperca, survival, weight.*

INTRODUCTION

The culture of pike-perch (*Sander lucioperca*, L.-1758) is currently carried out in extensive or semi-intensive systems as a complementary species. Through the intensive growth of this species, it has been demonstrated that it can consume additional food such as granulated fodder (Bódis et al., 2007; Ebrahimi & Vahabzadeh, 2014; Hubenova et al., 2015; Javid & Falahatkar, 2021).

Results regarding the feeding of pike-perch fingerlings with additional feed have been made since the "90s" by Zakęś & Demska-Zakęś, (1996); Zakęś (1999) și Horváth et. al. (2013).

A group of researchers from Hungary(Molnar et. al., 2004) carried out an ample experiment, through which they evaluated the effect of the pike-perch fry accommodation to feed. They also tested the effects of stocking density on behavior and feeding. The method of feeding (live food or granulated feed) proved to have a significant effect on feed consumption and implicitly on the increase in growth. Fish feed with live food had the fastest growth rate (Gardeur et. al., 2007; Hamza et. al., 2007; El Kertaoui et. al., 2019). On the contrary, according to those presented by other researchers, it was shown that stocking density did not significantly influence individual growth. But at higher densities, the specific consumption was better. Thus, both the stocking density and the type of feed influence the feeding behavior (Rasouli et al., 2014).

The objective of this experiment was to establish a regime of supplementary feeding as suitable as possible for the larvae of the pike-perch, so as to find an effective correlation between the growth rate and the type of food administered.

MATERIALS AND METHODS

The experimental works were carried out for three consecutive years, at the Research and Development Station for Fisheries Nucet.The variable factor in this experiment was the type of food administered.

The experiments were carried out in "Evos" type fiberglass tanks, with a capacity of 1000 liters (Figure 1). The shape of the tanks is parallelepiped, have rounded corners and they are supplied with water from the outside by

free fall.The evacuation is carried out through a pipe centrally located at the bottom of thetank, thus obtaining a circular current in the tank.
The average water level in the experimental tanks was approximately 0.55 cm. The technological water flow was correlated with the temperature, being 8-14 l/minute/tank.

Figure 1. Evostype fiberglass tanks (original photo)

To maintain proper hygiene, the fiberglass tanks are washed and disinfected with $Ca(ClO)_2$, then filled with water and stocked. The vertical water level initially rises to 0.3-0.35 m. With the development of the fish, the water level rises to 0.55-0.6 m on the 20th day of post-embryonic period.
The experimental variants were carried out in triplicate, the variable being the type of food administered. Since the pike-perch is an active predatory species in which cannibalism is easily manifested and the predatory instinct is quickly triggered (Dobrotă et al., 2022), it was decided to stock 1000 exemplars/tank (Figure 2). At the same time, the quality of food is very important for the development of fish during the post-embryonic period, in the first year of growth or later and is specific to the species and the applied technology (Dobrotă et. al., 2022).
The realization of the experiments was carried out in stages, as follows (Table 1):

- to obtain conclusive results, three experimental variants were established, in triplicate, with different feeding for each variant;
- a number of 3 tanks were used for each experimental variant;
- the experiments took place in three consecutive seasons;
- granulated fodder and live food were used for feeding;
- feed was administered "ad-libitum" and its consumption was monitored as well as the environmental conditions of the technological water;
- theperiodof post-embryonic development was 41 days.

The quantity and method of administration of food

During the period of post-embryonic development in the pike-perch, feeding was done as follows:
■ in variants 1 and 2, live food was distributed (*zooplankton and prussian carp larvae*), and in variant 3 granulated feed (*Aqua Garant Start*);
■ for all experimental variants, during the first 10 days, a mixture of boiled egg yolk (50%) was administered with an extruded granulated feed (*Aqua Garant Start*, 50%), intended specifically for feeding fish at this stage of development. The mixture was distributed 5 times a day between 8^{00} - 20^{00} hours;
■ when the pike-perch fry reached the age of 17 days, they switched to the specific feeding for each experimental variant, as follows:
→ variant 1 – administration of live food (*Daphnia* sp.) from cultures from SCDP Nucet;
→ variant 2 – administration of fish larvae (*Carasus auratus*);
→ variant 3 – feeding with Aqua Garant Start granulated feed 0.4 mm.
■feeding for variants 1 and 2 was carried out twice a day, at 8^{00} and 15^{00}, and the amount depending on how it is consumed by the fish material;
■ for variant 3, the administration method was chosen with the help of automatic belt feeders, between 8^{30}-20^{30} hours (Figure 3);
■ the feed administered increased quantitatively with the increase in weight of the fish;
■ at approximately 37 days, the fish showed the phenomenon of cannibalism, so they were transferred to the rearing ponds in the first summer.

Table 1.Stocking formula of "Evos" tanks with 7-8 day old larvae

No.	The experimental variant	Tank volume (l)	Ex./tank	No. tanks	Total ex./ variant	Food type	No. years
1	Variant 1 (V1)	1000	1000	3	3000	zooplankton	3
2	Variant 2 (V2)	1000	1000	3	3000	fish larvae	3
3	Variant 3 (V3)	1000	1000	3	3000	feeding with fodder	3

Figure 2. Stocking with 7-8 day old larvae (original photo)

Table 2. Hydrochemical parameters recorded (average values) during the three years of study from the water source and experimental tanks

No. crt.	The chemical parameter		U.M.	Parameter values		
				Optimum according to Order MMGA no. 161/2006	Water source	Experimental modules (Evostype)
					Average of the three years	
1	pH		pH units	7-7.8	7.2	7.4
2	Calcium(Ca^{2+})		mg/l	90-120	34.4	33.6
3	Magnesium(Mg^{2+})		mg/l	10-40	14.1	15.56
4	Ca^{2+}/ Mg^{2+}		mg/l	5	2.43	2.15
5	Total hardness		(^{0}D)	12	8.06	8.28
6	Alkalinity		mg /l	200-400	176.9	189.1
7	Organic substance		mg $KMnO_4$/l	20-60	16.8	20.56
8	Disolved oxygen		mg/l	5-12	4.25	5.2
9	Nitrates(NO^-_3)		mg/l	2.5-4	0.062	0.156
10	Nitrites(NO^-_2)		mg/l	0.03	0.0012	0.0024
11	Phosphates(PO^{3-}_4)		mg/l	0.05-1.5	0.042	0.086
12	Chloride	Cl^-	mg/l	40	9.54	10.6
		NaCl	mg/l	30	15.78	17.53
13	Ammonia (NH^+_3)		mg/l	lack	lack	lack
14	Ammonium (NH^+_4)		mg/l	0.5-1	0.14	0.54

RESULTS AND DISCUSSIONS

Monitoring the environmental indicators of technological water from the source and the Evostype experimental tanks

The quality of the growth environment is of particular importance because it can guarantee the success in the post-embryonic development period. During the development period of the pike-perch fry in the "Evos" tanks (with different types of food), water samples were taken 2 times a week to monitor the hydrochemical indicators. Dissolved oxygen and water temperature were recorded daily. The dissolved oxygen value was over 5.5 mg/l (Figure 4). In order to maintain oxygen above this value, measures have been initiated, such as: cleaning the tanks of uneaten food and fish excrement, constant water flow, etc.

The main hydrochemical parameters of the water from the supply source and from the experimental basins ("Evos" type tanks), were within optimal limits for fish farming water,

according to the Ordinance MMGA no. 161/2006 (Table 2).

Figure 3.Automatic belt feeders (original photo)

Figure 4. Monitoring dissolved oxygen and water temperature (original photo)

Figure 5. The phenomenon of cannibalism (original photo)

Figure 6. Biometric measurements at the end the postembryonic period (original photo)

Evaluation of the growth performance of pike-perch fry

The growth and development of the pike-perch during the post-embryonic development period was 41 days (586-668 degree days), ending with the appearance of the accentuated phenomenon of cannibalism (Figure 5).

The experimental works in the post-embryonic period were carried out under similar technological conditions in all variants and in all years of the study, the only variable element being the food administered.

The main biotechnological indicators monitored in the growth and development experiments during the growth period, in an intensive system, in the pike-perch (*Sander lucioperca*, L. 1758) (Table 3 and Figure 6) were: average weight (W); survival rate (%); feed conversion ratio (FCR); real growth rate (Sr); daily growth rate (GR) (Olaniyi et. al., 2013).

Average mass of fish material (W) - g/ex

⟶ the best value of the average mass obtained after 41 days was in variant 2, tank T5 in the first year of study of 4.154 g/ex, and the lowest was obtained in variant 3, tank T9, from the third year of study of 1.878 g/ex;

⟶ in the first year of study, the best value was in variant 2 of 4.103 g/ex, the lowest in variant 3 of 1.927 g/ex and of 2.545 g/ex in variant 2;

⟶ in the second year of study, the best value was in variant 2 of 4.08 g/ex, the lowest in variant 3 of 1.961 g/ex and 2.479 g/ex in variant 2;

⟶ in the third year the best value was in variant 2 of 4.094 g/ex, the lowest in variant 3 of 1.962 g/ex and of 2.477 g/ex in variant 2;

⟶ we can conclude that, the best value obtained in all the years of study was in variant 2, variant 1 ranked second and variant 3 had the lowest value (Figure 7).

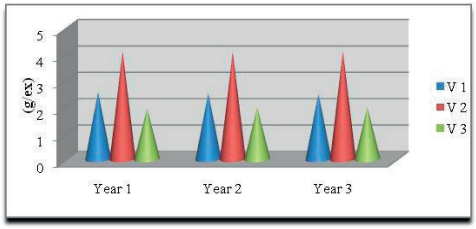

Figure 7. Average mass variation

Table 3. The main biotechnological indicators obtained at the end of each experimental period (average values/experimental variants/years)

The year	Variant	Tank	SV med. (%)	W medium (g)	LT Average (mm)	Sr (g)	GR (g/day)	FCR (g feed/g biomass gain)	SGR (%/day)
1	V1	T1+T2+T3	61.8	2,545	65	1571.1	37.41	1.97	16.37
	V2	T4+T5+T6	65.2	4,103	75	2673.4	63.65	2.18	17.59
	V3	T7+T8+T9	46.9	1,927	59	902	21.48	1.67	14.95
2	V1	T1+T2+T3	60.8	2,479	65	1505.5	35.85	1.93	16.26
	V2	T4+T5+T6	65	4.08	77	2652.2	63.15	2.18	17.58
	V3	T7+T8+T9	47.3	1,961	60	925.4	22.03	1.68	15.17
3	V1	T1+T2+T3	61.4	2,477	64	1520.3	36.2	2,3	16.36
	V2	T4+T5+T6	65	4,094	76	2658.5	63.3	1.97	17.55
	V3	T7+T8+T9	46.8	1,962	60	916	21.81	1.83	15.01

Note: V1– zooplankton feeding; V2 – feeding with fish larvae (prussian carp); V3 – feeding with granulated fodder

Survival rate (%)

⟶ the best value of the survival rate obtained after 41 days was in variant 2 T4 tank, in the second year of study of 66.8%, and the lowest was obtained in variant 3, T9 tank, in the third year of study by 45.6%;

⟶ in the first year of study, the best value was recorded in variant 2 of 65.2%, the lowest in variant 3 of 46.9% and of 61.8% in variant 1;

⟶ in the second year of study, the best value was recorded in variant 2 of 65.0%, the lowest in variant 3 of 47.3% and of 60.8% in variant 1;

⟶ in the third year of study, the best value was recorded in variant 2 of 65.0%, the lowest in variant 3 of 46.8% and of 61.4% in variant 1;

⟶ we can conclude that the best value obtained in all the years of study was in variant 2, variant 1 was in 2nd place and variant 3 recorded the lowest value (Figure 8).

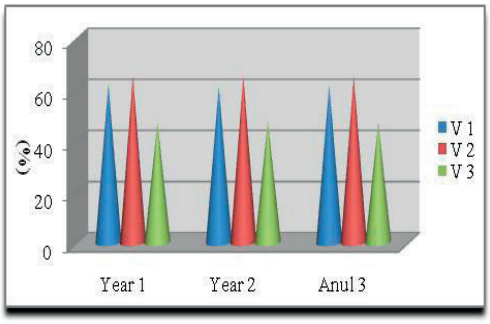

Figure 8. Variation in survival rate

When pike-perch consumes food different from the specific one, it shows a state of stress. With the increase in age and weight, it acquires the morphological and behavioral characteristics of adults, begins to feed actively in the water mass and has the instinct to catch organisms that move in front of it, they trigger its attack instinct. Also, the swimming of his peers can trigger this instinct, which he attacks, causing injury or even death. In the variants where live food was administered (prussian carp larvae or zooplankton), a lower rate of cannibalism was observed.

Feed conversion ratio (FCR)

⟶ the best value of the conversion coefficient was in variant 3, the T9 tank in the second year of study, of 1.63, and the weakest was in variant 1, the T2 tank, in the second year of study, of 2.4;

⟶ in the first year of study, the best value was in variant 3 of 1.67, the lowest value being in variant 2 of 2.18 and 1.97 in variant 1;

⟶ in the second year of study, the best value was in variant 3 of 1.68, the lowest value being in variant 2 of 2.18 and 1.5 in variant 1;

⟶ in the third year of study, the best value was in variant 3 of 1.83, the lowest value being 2.3 in variant 1 and 1.97 in variant 2;

⟶ we can conclude that, the best value obtained in all the years of the study was in variant 3, on the 2nd place was variant 1 and the lowest value was variant 2. The very good quality of the granulated feed that was administered in variant 3, and a higher

conversion coefficient was obtained than the other experimental variants. Thus, we can explain the superiority of the conversion coefficient in variant 3 compared to variants 1 and 2 by the fact that live food has a high water content (Figure 9).

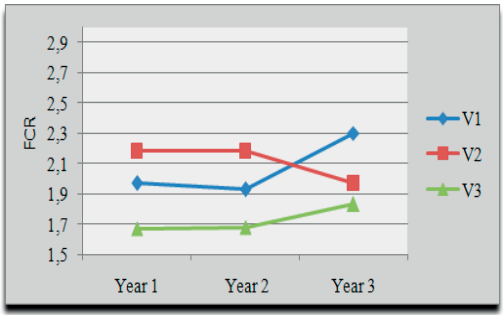

Figure 9.Variation in feed conversion ratio (FCR)

Real growth rate (Sr)

Real growth rate (Sr) registered different values in the three variants as follows: in variant 1 it was 1505-1571 g; in variant 2 of 2652-2673 g and in variant 3 of 902-925 g (Figure 10).

Close values were recorded within the experimental variants. The administration of food specific to the pike-perch was a determining factor in achieving a higher growth rate.

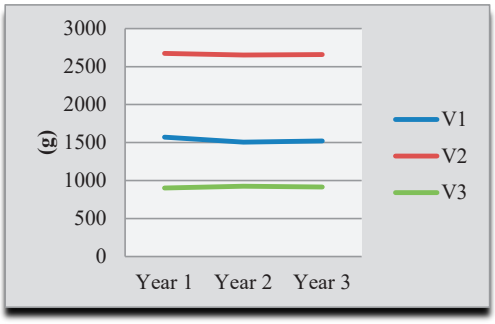

Figure 10.Variation in real growth rate (Sr)

Daily growth rate (GR)

Daily growth rate (GR) was different for each variant, with values of 35.85-37.41 g/day in variant 1, with 63.15-63.65 g/day in variant 2 and 1.48-22.03 g/day in variant 3 (Figure 11). Close values were recorded within the experimental variants.

Parameters that influenced the daily growth rate were: the percentage of survival obtained at the end of the post-embryonic period, the total amount of biomass obtained and the individual mass.

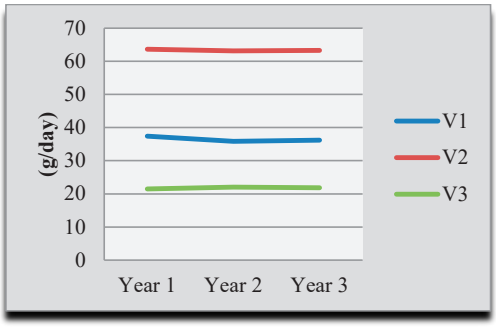

Figure 11.Variation of daily growth rate (GR)

The Pearson coefficient had positive values during the entire period of the experiments, resulting in the fact that the biological material developed homogeneously, this being due to the abundance of food in all experimental variants. The positive correlation between the length of the fish and their mass also shows the homogeneous development within the experimental variants (Table 4).

Table 4. The average correlation between length-weight within the experimental variants

Year	Experimental variant	Correlation	Pearson coefficient
I	1	Positive	0.785
	2	Positive	0.799
	3	Positive	0.582
II	1	Positive	0.996
	2	Positive	0.990
	3	Positive	0.988
III	1	Positive	0.882
	2	Positive	0.998
	3	Positive	0.758

The coefficient of variability demonstrates that the variable body mass comes from the type of food administered, which caused the development of variable batches of fish (Table 5).

It is noted, superior results obtained in variants 2 and 3 where live food was administered in terms of the percentage of survival and average mass, compared to variant 3 where the feed consisted of granulated fodder.

Table 5. Minimum, maximum, average values, standard deviation and coefficient of variability of body mass, between experimental variants

Year	Variant	No. ex. stocked	No. ex. harvested	Mass (g)			CV (%)
				M min.	M max.	M mean ± SD	
I	1	3000	1853	2.021	2.988	2.546 ± 0.21	13.01 ± 0.015
	2	3000	1957	3.707	4.586	4.102 ± 0.22	19.99 ± 0.018
	3	3000	1406	1.349	2.202	1.926 ± 0.15	12.18 ± 0.012
II	1	3000	1825	2.068	2.981	2.478 ± 0.23	10.29 ± 0.03
	2	3000	1950	3.604	4.488	4.081 ± 0.25	15.95 ± 0.022
	3	3000	1418	1.507	2.315	1.962 ± 0.27	10.58 ± 0.016
III	1	3000	1844	2.088	2.993	2.478 ± 0.18	14.63 ± 0.015
	2	3000	1948	3.716	4.585	4.095 ± 0.22	19.25 ± 0.018
	3	3000	1405	1.409	2.582	1.963 ± 0.19	10.48 ± 0.016

CONCLUSIONS

The average weight of the pike-perch species, obtained at the end of the post-embryonic development period, had significantly different values between the three experimental variants. Very good values were recorded in variant 2, good values in variant 1 and slightly appreciable values in variant 3.

The most obvious difference was determined by the survival rate, which recorded significantly higher values in the variants where live food was administered compared to the variant where granulated feed was administered.

The specific growth rate recorded similar values. Biotechnological indicators such as: real growth rate [Sr], survival rate (Sv), daily growth rate [GR]and feed conversionratio (FCR) were differentiated from which it follows that the availability of pike-perch specific food favors growth and decreases the manifestation of cannibalism.

The quality and type of food administered have a positive or negative effect on the growth and development of *Sander lucioperca*, during the post-embryonic development period.

Since pike-perch is a predatory species, even if it has good environmental conditions and very good food, after the age of 36 days it starts to become predatory. Organisms in motion that are near him trigger his attack instinct and he no longer differentiates between his peers and other fish, thus manifesting the phenomenon of cannibalism.

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