THE EFFECT OF LIVE PREY FISH FEEDING ON ACCEPTANCE OF DRY FEED OF PIKEPERCH *(SANDER LUCIOPERCA* L.*)*

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Abstract

The aim of the experiment was to find out whether pikeperch *(Sander lucioperca* L.*)* trained on pellet feed would accept artificial pellets again, after consuming prey fish. Yearlings of pikeperch previously accustomed to pellet feeding were subjected to the following four treatments during a 23 day long experiment:

- Control (C): fish were fed with pelleted feed during the whole experiment
- Two days (2D): fish were fed with topmouth gudgeon (*Pseudorasbora parva)* for two days and after one day of starvation, with pelleted feed until the end of the experiment

- Eight days (8D): fish were fed with topmouth gudgeon for eight days and after one starvation day with pelleted feed until the end of the experiment.
- Fifteen days (15D): fish were fed with topmouth gudgeon for 15 days and after one starvation day with pelleted feed until the end of the experiment.

The fish accepted dry pellets after two as well as eight days of predation, but refused to do so after 15 days of predation. Growth loss was observed in the 15D groups, although in the other treatments the growth rate also dropped. Even then, the difference was still significant between the 15D treatment and the others. According to the results, a few days of prey fish feeding does not affect the acceptance of dry feed in pikeperch.

Key-words: pikeperch, dry-feed, prey fish

Összefoglalás

Vizsgálatunkban arra kerestük a választ, hogy a táp elfogadására megtanított süllő *(Sander lucioperca* L.*)* folytatja-e a tápevést zsákmányhal fogyasztás után. Négy kezelést alkalmaztunk a 23 napos kísérlet során:

- Kontroll: a halakat kereskedelmi táppal etettük végig a kísérlet ideje alatt.
- 2 napos kezelés: A halakat 2 napon keresztül etettük kínai razbórával (*Pseudorasbora parva),* majd egy nap kihagyás után, ismét táppal kaptak.
- 8 napos kezelés: 8 napon keresztül etettünk zsákmányhalat, majd egy nap kihagyás után kezdtük meg ismét táp etetését ezekben a csoportokban.
- 15 napos kezelés: 15 napos razbóra fogyasztás, és egy nap szünet után kaptak ismét tápot a süllők.

A halak a 2, és 8 napos ragadozás után is folytatták a tápevést, míg a 15 napos ragadozás után már nem tudtak visszaszokni a tápfogyasztásra. A 15 napos kezelés esetében tapasztaltunk tömeg csökkenést, de ezzel együtt a többi kezelésnél is visszaesett a tömeggyarapodás. mértéke. Ennek ellenére még mindig szignifikáns különbségeket találtunk a 15 napos kezelés és a többi között. Az eredményeink alapján megállapíthatjuk, hogy tápra szoktatott süllő néhány napos zsákmányhal fogyasztás után még könnyen visszatér a tápfogyasztáshoz, két hét ragadozás után azonban nagy valószínűséggel elveszíti ezt a képességét.

Introduction

The intensive farming of European percid fishes started in the last 15-25 years (Kestemont & Mélard, 2000). The biggest interest on the European markets is in pikeperch, due to its good meat quality (Policar et al. 2012). The markets are undersupplied. In Eastern Europe, pond production is unstable, and it is unlikely to increase in quantity due to the limited availability of prey fish (Hilge & Steffens, 1996). The only way to increase the production is by using intensive systems, which is now done mainly in Western Europe (Policar et al. 2012). Now a lot is already known about the weaning of pikeperch fry (Ostaszewska, 2005; Zienert & Heidrich, 2005; Kestmenont, 2007; Szkudlarek & Zakęś, 2007; Szczepkowski, 2011; FAO, 2012), and fingerlings (Zakes & Demska, 1998; Ljunggren et al., 2003; Zienert & Heidrich, 2005; Bódis et al. 2007; Policar et al. 2012; FAO, 2012) to artificial diet.

The intensive systems used for grow out phase are mainly indoor recirculating systems (Philipsen & de Braak, 2008; Rónyai & Csengeri, 2008). There were also experiments (Bódis & Bercsényi, 2009; Schlumpberger & Zeitbarth, 1981) carried out in cage systems. Jokelainen et al. (2009) suggest this type of production system for grow out phase in Finland, but also mention RAS (recirculating aquaculture system).

In Eastern Europe in the last five years, a few newly adapted combined technologies are becoming more and more popular. In Hungary, due to the increase in production costs (Gyalog et al., 2011), some farmers started to use pond-in-pond and pond RAS technologies (Juchniewicz, 2009; Borbély, 2008; Gál et al., 2009; Gál et al., 2010; Gál et al., 2011). Pond-in-pond technology is a system, where floating fish tanks are stocked intensively in an extensive pond. The clean water filtered by the pond is pumped through the tanks. The pond RAS is a production system, where few intensively stocked small ponds are connected to a bigger extensive pond. The water is pumped from the bigger pond to the small ponds, and then it flows back. With these systems the farmers can use their existing infrastructure more intensively with lower investment costs, than in the case of indoor RAS.

Pikeperch can be a possible candidate species for these combined systems, due to its high value. Currently it is not known what happens, when a pikeperch trained to accept artificial feed eats live prey fish for shorter or longer periods as in such systems the encounter between them is highly possible. The aim of our experiment was to find out whether the trained pikeperch will continue to feed on pellets if live forage fish was provided for a given period.

Materials and Methods

Technological parameters

The experiment was carried out in a pilot scale recirculation system. The whole system volume was 9.5 m^3, with nine fish tanks (tank volume was 635 l). The water was treated with a lamellar sedimentation tank (approximately 900 l, cleaned every three days), a moving bed biofilter (1.5 m^3) and two UV lamps (18 watt each). Twenty-five percent of the system volume was changed daily with tap water. The salt concentration of the system was maintained between 2.5-3.0 g/l (Németh et al., 2013).

The experiment took place in three fish tanks of the whole system. Each fish tank had four cages (67 l each) in it. This way we had 12 experimental groups. Each cage was aerated individually by air, with an air stone from the main air supply. In the experimental tanks oxygen supply was added for emergency purposes. Under the cages we used 10 Siberian sturgeon (*Acipenser baerii*) (average weight 400 grams) for cleaning the fish tank of faeces, and uneaten feed originating from the cages. In the other fish tanks of the system pikeperch (*Sander lucioperca*) and Siberian sturgeon were reared in a density of 12 kg/m^3 (30 % Siberian sturgeon; 70 % pikeperch).

Feeding protocol and treatments

Seven days prior to the experiment 10 individuals were randomly stocked into each cage and fed the same pelleted feed as before. After seven days the fish were measured and weighed (10.94 $\pm$ 0.47 cm; 10.43 $\pm$ 1.64 g).

During the experiment, a 3 mm pellet sized commercial feed with 49 % protein and 10 % fat content was applied. As prey fish, topmouth gudgeon (*Pseudorasbora parva)* was used. This fish is an introduced, invasive species in Europe, considered as an ideal forage fish for pikeperch. The weight of the prey fish was 0.45-0.50 grams. Fish were fed three times a day (8:00; 13:00; 21:00) by hand in the case of artificial feed, and once a day by prey fish in the morning. In the case of pelleted feed 6 % of the body weight per day was given in order to be sure that each fish would have access to it. The prey fish was fed according to the appetite of the pikeperch in the morning. The experiment lasted for 23 days.

The trial had four treatments in three replicates:

- Control: fish were fed with commercial feed during the whole experiment (C).
- Two days: pikeperch was fed with topmouth gudgeon (*Pseudorasbora parva)* for two days and after one day of starvation, we switched to artificial feed (2D).
- Eight days: The fish were fed with topmouth gudgeon for eight days and after one starvation day, they were fed with commercial feed (8D).
- Fifteen days: We fed the fish with prey fish for 15 days and after one starvation day they were fed with artificial feed (15D).

Collected data

Total length and weight were measured in each group in the beginning, on day 16, and on the last day of the experiment (day 23). During the trial, the following parameters were recorded:

- daily: the temperature (^{o}C), the oxygen saturation (%) and concentration (mg/l) in each tank of the experiment (Hach Lange HQ-LDO),
- every two and three days: the salinity (ppt – based on conductivity) and pH (Hanna instruments, HI 98130),

- every three days: the NH_3/NH_4^+, NO_2^-, NO_3^- concentration (mg/l) (sera NH_4/NH_3; NO_2; NO_3 -Test),
- weekly: the approximate average weight/growth of fish in the other fish tank

We calculated specific growth rate (SGR) too, with the following equation:

Specific growth rate (SGR) = $(\ln Wt - \ln W0)/t \times 100$ (in % bw/d);

Wt: weight at time t; W0: initial weight

Data handling and analysis

The data management and descriptive statistical analysis were done by Microsoft Excel. Further statistical tests were done by SPSS 20.0. We used one-way analysis of variance (ANOVA) with a post-hoc Tukey test to test the difference between the treatment means in case of the growth data.

The length-weight relationships were evaluated by ANCOVA (analysis of covariance). We wanted to see if there is any difference between the data measured on the 15th and 23rd day of the experiment the case of each treatment separately. The idea behind the methodology is, that if there is no difference between the length-weight relationships (L-WRC) measured on the 23rd day compared to the (L-WRC) measured on 15th day in a treatment separately, it means that most of the fish were feeding. If there is a difference – the condition of the fish decreased. The minimum levels of significance were set at $P<0.05$ for one-way ANOVA, mean comparisons, and ANCOVA.

Results

Environment

With the used equipment, we could not hold the oxygen saturation above 70 % in the system with the amount of fish we were keeping in it (Table 1). The lowest oxygen saturation was 51 %. There were only 7 days, when the saturation went below 60 % during the trial. These oxygen saturation levels result in decreased growth rate, but do not inhibit the feed intake according to Stejskal et al. (2012). The average oxygen concentration was 5.5 ($\pm$ 0.6) mg/l, 6.0 ($\pm$ 0.8) mg/l and 5.8 ($\pm$ 0.8) mg/l in the three experimental fish tanks.

The temperature (22.3 $\pm$ 1.1 ^oC), pH (7 $\pm$ 0.1), nitrate concentration (34.6 $\pm$ 11.8 NO_3^- mg/l) and salt concentration (2.7 $\pm$ 0.2 ppt) showed acceptable levels and were stable during the experiment. The ammonia concentration was sufficiently low, too (0.1 $\pm$ 0.1 NH_4/NH_3 mg/l). We had problems with nitrite in the last 10 days. The average concentration in the first 13 days rose from 0.66 $\pm$ 0.2 mg/l to 2.1 $\pm$ 0.2 mg/l. Unfortunately, there is no data available on the nitrite tolerance of pike-perch. According to Krupova et al. (2005) we calculated and found that we had a high $Cl^-/N\text{-}NO_2^-$ ratio (>3000). This should be enough to inhibit the toxic effect of nitrite.

Table 1. Different water quality parameters

		0-15 days	15-23 days	0-23 days	S.E.M of 0-23 days
Temperature (^oC)		22.7	21.4	22.3	1.1
Oxygen (%;mg/l)					
	Tank2	64 ; 5.3	66 ; 5.7	64.7 ; 5.5	6.9 ; 0.6
	Tank3	69 ; 5.8	70 ; 6.3	69.9 ; 6	7.8 ; 0.8
	Tank4	65 ; 5.5	71 ; 6.2	76.6 ; 5.8	8.1; 0.8
pH		7.05	6.99	7	0.1
Salt (ppt)		2.68	2.84	2.7	0.2
NH_4^+/NH3 (mg/l)		0.13	0.00	0.1	0.1
NO_2^- (mg/l)		1.3	2	1.5	0.8
NO_3^- (mg/l)		30	45	34.6	11.8

Even with that, in the last two weeks the growth of the fish in the other fish tanks stopped and then decreased. This can be seen in Figure 1, which shows the average bodyweight and SGR of all non-experimental fish tanks together. Please note that the experiment was between 23rd August and 14th September. The growth did not increase between 6th and 13th September, and decreased between 13th and 20th September. Even though there was still growth with a 2.49 % specific growth rate (SGR).

According to the measured parameters of the environment, we can conclude that it was not ideal, but fish production was still possible in the experimental fish tanks.

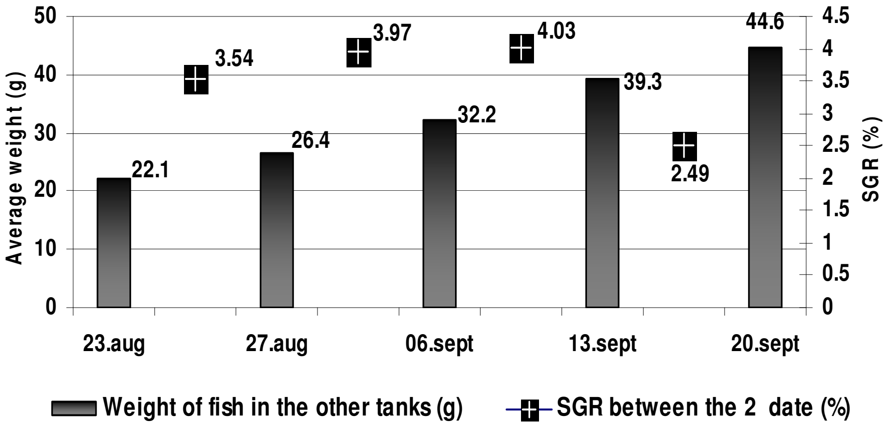

Figure 1. The average bodyweight and SGR of fish in all non-experimental tanks

** The SGR data shown describe the growth rate between the two dates.*

***The experiment was led between 23rd of August and 14th of September*

Growth results

In Figure 2 weight data on days 0, 15 and 23 are shown. At the start of the experiment there were no differences among the treatments in terms of weight. On day 15 we found significant ($p < 0.0001$) differences between the C treatment (15.2 ± 2.06 g) and the 15D treatment (18.1 ± 2.95 g). The other two treatments (2D - 13.8 ± 2.50 g, 8D - 15.2 ± 2.19 g) significantly differed from the 15D groups in weight, but did not from the C treatment. In each treatment we experienced growth, so the fish were feeding during the experiment.

On day 23 the 2D (14.9 ± 3.21g) treatment significantly ($p < 0.0001$) differed from the 15D (17.9 ± 2.64 g) group, but not from the C (16.2 ± 2.46 g) and 8D (16.3 ± 3.34 g) groups. The 15D treatment, after its higher growth during the prey fish feeding period, lost weight (0.2 g on average) in the last week of the experiment.

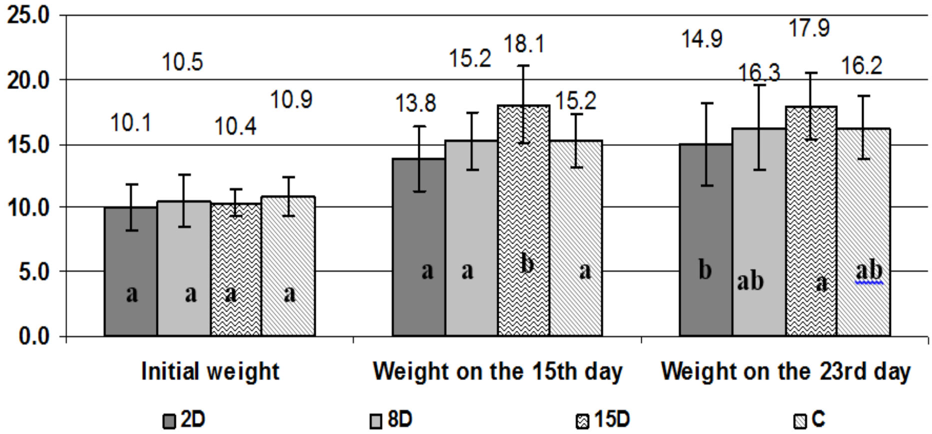

Figure 2 Average weight in each treatment on days 0, 15 and 23 of the experiment. Mean and +/- SD values are presented

Table 2 shows the calculated SGR data. In the first two weeks of the experiment the SGR was much better than in the third week of every treatment. The growth rate was significantly better in the first 15 days in the 15D treatment. In the last week of the experiment in these groups the average SGR had a negative value. In other treatments the SGR was still positive, but the growth rate dropped nearly 4 - 7-fold. The difference from 15D treatment was still significant. This shows that in the 15D treatment the drop in growth was slightly larger than in the other treatments.

Table 2. Calculated SGR data (mean+SEM) between 0-15 days and between 15- 23 days. Different superscripts indicate significant difference at p<0.01.

	C	2D	8D	15D
SGR 0-15 d	2.4 (0.25)[a]	2.2 (0.19)[a]	2.7 (0.59)[a]	3.9 (0.2)[b]
SGR 15-23 d	0.47 (0.13)[a]	0.53 (0.26)[a]	0.47 (0.25)[a]	-0.05 (0.13)[b]

Length-weight relationship results

In Figure 3 we show the length-weight relationships of the 2D treatment. The data show that after two days of prey fish feeding all fish continued feeding on dry pellets. There was no significant difference by ANCOVA between the measured data on days 15 and 23. So the fish were still feeding after 2 days of prey fish feeding.

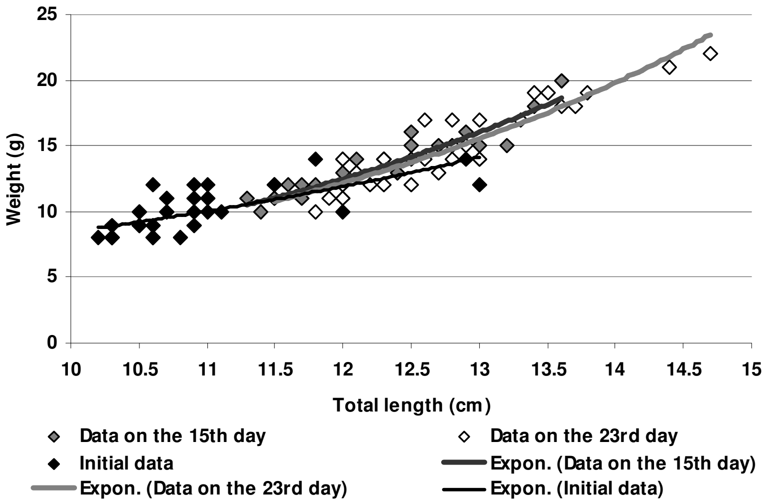

Figure 3. Length-weight relationships during the experiment in the 2D treatment

Figure 4 shows the data of the 8D treatment during the experiment. In this case too, after eight days of feeding on prey fish there was no significant difference between the data collected on days 15 and 23 by ANCOVA. The condition was weaker on the 15th day of the experiment compared to initial data. This phenomenon is the result of switching back to dry feed after 8 days. We detected the growth of the first 8 days of prey fish feeding, but then they did not start to feed on dry feed immediately. During the last week in these groups we experienced depressed growth (Table 2), just like in the control groups, and there was no significant difference between them. So the fish were still feeding after 8 days of prey fish feeding.

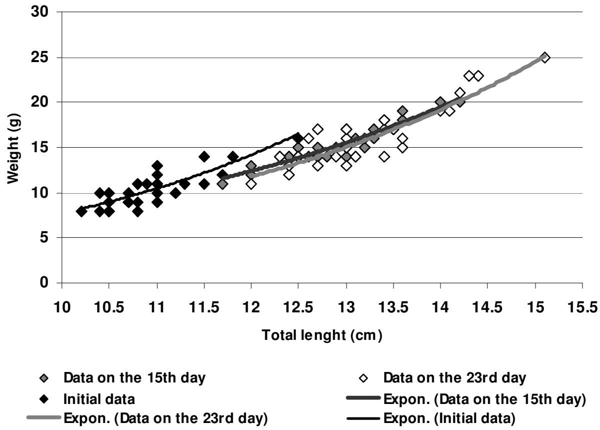

Figure 4. Length-weight relationships during the experiment in the 8D treatment

Figure 5 shows the same results in the case of 15D treatment similarly to the previous figures. The results of this treatment showed significant differences ($p< 0.000?$) between days 15 and 23 by ANCOVA. This means that the condition decreased significantly in the last week of the experiment. According to this statement the fish were not feeding on pellets after 2 weeks of prey fish feeding.

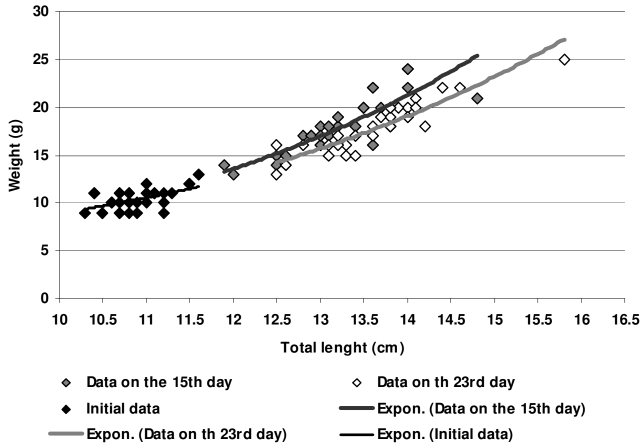

Figure 5. Length-weight relationships during the experiment in the 15D treatment

Figure 6 shows the length-weight relationships of the control group. In this case, like in the 2D and 8D treatments there was no significant difference between the last two measured data sets.

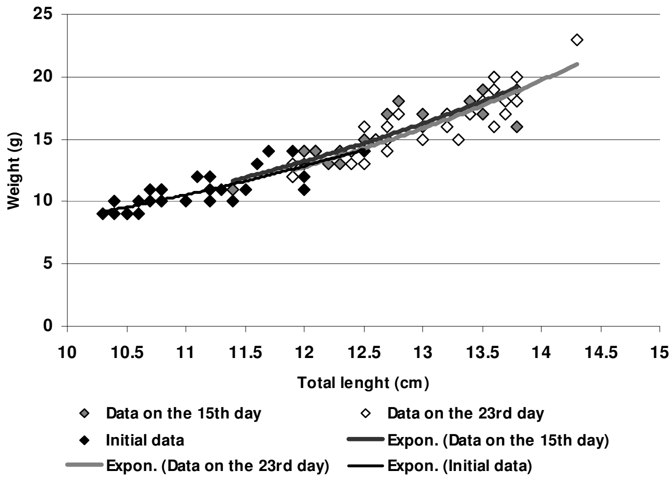

Figure 6. Length-weight relationships during the experiment in the control (C) groups

Conclusions

The decreased growth rates mask the results of the 3rd week of the experiment, but it is still detectable that after eight days of predation the acceptance of pellets still exists. We think that the decrease in condition (Fig. 4) in the 8D treatment is due to the fact that following the eight days of live fish feeding the fish did not start to feed immediately. It is probable that they were not hungry enough until they started to feed on dry feed again. Unfortunately we were not able to test this hypothesis, because we did not measure them when we stopped the prey fish supply of these cages. However, we will keep this phenomenon in mind when designing future experiments. The feeding did not start in the 15D group after 15 days of predation. The control groups do not approve this statement, because of the decreased growth in the last week. We do not know the reason for this immense drop in growth not just in the control groups but in each treatment. The growth data from the other fish tanks also do not approve this drop in the experimental tanks, because there was not such a huge drop in growth. The higher nitrite values are not the cause, as there is a high salt concentration of the water. The handling stress caused by the measuring and weighing cannot be the cause either, since the fish were feeding properly when the experiment started with the same handling stress. It seems to us pikeperch may forget the learned skill of dry feed acceptance after 15 days of predation, but this statement should be tested further to be approved.

According to our results, a few days of prey fish feeding will not affect the acceptance of dry feed by pikeperch. The results suggest that pikeperch can be reared in a pond-in-pond or pond RAS systems, even when the chance of encounters between trained pikeperch, and prey fish is high.

This amount of prey fish feeding in intensive culture conditions also has some advantages. We can boost the growth of pikeperch with the prey fish, since we received significantly better growth results in the first two weeks of the experiment. The nutritional value of live fish supplements the dry feed. With uncertainty caused by the phenomenon of the last week of the experiment, the investigation should be repeated with longer prey fish feeding intervals to see when the pikeperch will actually forget the acceptance of dry feed. The next step of this study is to see if the fish will continue feeding in a semi-natural environment.

Acknowledgement

Present article was published in the frame of the project TÁMOP-4.2.2.A-11/1/KONV-2012-0064, "Regional effects of weather extremes resulting from climate change and potential mitigation measures in the coming decades". The project is realized with the support of the European Union, with the co-funding of the European Social Fund.

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