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RESEARCH ARTICLE

Effect of various feed rations on the growth parameters of European perch, *Perca fluviatilis* (L.), reared in a recirculating aquaculture system

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Abstract. The aim of the study was to determine the influence various feed rations had on the growth, feed conversion, and variation in body weight of European perch, *Perca fluvatilis* (L.), reared in a recirculating system. The three feed rations applied were: 0.5% (group F 0.5), 0.8% (group F 0.8), and 1.1% (group F 1.1) of the fish biomass. The fish in each group were marked individually and assigned to size classes: small (class S – 58.7 g), medium (class M – 77.3 g), and large (class L – 106.6 g). The stock in each tank with a volume of 1 m^3 was 21 individuals (three replicates for each group). The experiment was 56 days long. The highest mean body weight after eight weeks of rearing was determined in group F 1.1. The final body weight of this group was 7.5% higher than in group F 0.8 and 21.5% higher than in group F 0.5 ($P < 0.05$). The daily growth rate (DGR) of the fish fed the largest feed ration (group F 1.1) was 2.5 times higher than in the group fed the smallest feed ration (group F 0.5). The specific growth rate (SGR) ranged from 0.26% day^{-1} (group F 0.5) to 0.70% in group F 1.1, and the differences among the groups were statistically significant. The experimental results showed that the best perch rearing results were obtained using daily feed rations of 1.1% of fish biomass. Under such conditions, perch obtained larger relative and absolute daily specific growth rates.

Keywords: percids, feeding level, growth, RAS, *Perca fluviatilis*

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Introduction

Perch is a species that is in market demand because it is highly palatable. Its availability from catches in natural basins is limited since this fish reacts negatively to disadvantageous changes in the natural environment that have been progressing for many years. This has resulted in increased interest in rearing this fish under controlled conditions. Research has been undertaken to develop methods for the intensive rearing of perch in recirculating systems. The results of these studies have permitted describing many of the aspects of perch culture, including determining the conditions necessary for artificial reproduction (Kucharczyk et al. 1996) and optimal temperatures during rearing, and it was also confirmed that fish of 150-200 g market size can be obtained in one rearing season (Mélard et al. 1996). High fish growth rates are possible to achieve by maintaining optimal biotic and abiotic conditions for given species. The most important of these are water temperature, light regime, and stocking density. The type and quantity of the feed delivered affect the normal growth and development of fish, so these aspects are also important. Information regarding optimal feeding requirements is lacking for perch. High feeding rates should be used when rearing predatory fish such as perch to reduce aggression among them during rearing. However, in perch, it has been confirmed that intense feeding can have a negative impact in the form of excessive fat stores in the fish (Jankowska et al. 2007). Applying excessive feed rations can also decrease water quality by increasing concentrations of harmful nitrogen compounds that are released both by unconsumed feed and fish metabolism (Thomas and Piedrahita 1998, Zakęś 1999, Stejskal et al. 2009). During rearing, these compounds place a heavy burden on water treatment equipment in recirculating aquaculture system and cause stress in fish (Chang et al. 2005). The application of restrictive feed rations can lower growth rates and result in increased intragroup differentiation and competition (Zakęś et al. 2003), which can lead to increased incidences of mutually inflicted injury (Andrew et al. 2004). Thus, applying appropriate feed rations can significantly impact the effectiveness of perch rearing. The overall objective of the present study was to investigate the influence of various feed rations on the growth performance and feed conversion ratio of European perch *Perca fluviatilis* (L.) reared in RAS.

Materials and methods

Sources of perch for growth trials

Materials, origin, and conditions of the initial stage of breeding

The experimental material was perch fry obtained through the artificial reproduction of wild spawners conducted at the Department of Aquaculture, Inland Fisheries Institute in Olsztyn. After initial rearing lasting eight months, perch fry were transported to the Department of Sturgeon Fish Breeding in Pieczarki. The fish were stocked into rearing tanks with working volumes of 2 m^3 that were part of a recirculating system. After three months of rearing, the experiment proper began.

Growth trial

The fish were divided into three groups with different doses of feed: 0.5% (group F 0.5), 0.8% (group F 0.8) and 1.1% (group F 1.1) of fish biomass in the tanks. There were three replicates for each group. At the beginning of the experiment, the mean fish body weight in all the groups was 80.7 ± 0.6 g, and total length was 16.7 ± 0.2 cm. The stock in each tank with a volume of 1 m^3 was 21 individuals. The fish in each group were tagged individually with Carlin tags placed near the dorsal fin, and the fish were divided into three size classes of seven individuals each. The mean body weight of the fish in the size classes were as follows: small individuals (class S) with body weights of 58.1 ± 0.3 g (size class 50-65 g), medium (class M) – 77.3 ± 0.2 g (size class 70-85 g), and large (class L) – 106.6 ± 2.0 g (size class 90-125 g). Prior to tagging and weighing, the fish were anesthetized in a solution of the anesthetic Propiscin (Kazuń and Siwicki 2001) at a concentration of 1.5 ml l^{-1}.

The experiment lasted 56 days, during which daily water temperature was monitored, and water quality parameters were monitored once per week (Table 1). The water flow rate through the tanks was maintained at 12 l min^{-1}. Measurements of water oxygen content and pH were taken with a Cyber Scan 5500 meter (Eutech Instruments, USA). The concentration of total ammonia nitrogen (CAA = NH_4^+-N + NH_3-N) was determined using direct nesslerization, while nitrites were determined with the sulphanilic acid method (Hermanowicz et al. 1999) with a spectrophotocolorimeter (Carl Zeiss 11, Germany).

The fish were fed E- 2P Stella feed (Nutreco, France) 24 h per day by automatic band feeders. The granulation size of the feed was 4 mm, and the composition of the feed was 42% protein, 22% fat, and

Table 1
Physicochemical parameters of water at the outflow of the culture tanks during the experiment (mean values ± SD)

Parameter	Value
Water temperature (°C)	19.3 ± 0.9
Oxygen content (mg O_2 dm^{-3})	5.6 ± 0.2
Maximum CAA (mg CAA dm^{-3})	0.08 ± 0.01
Nitrite concentration (mg NO_2^- dm^{-3})	0.04 ± 0.04
pH range	7.19 ± 0.18

17.8% carbohydrates. The digestible energy of the feed was 20 MJ kg^{-1}. Every morning, the tanks were cleaned of feces and uneaten feed residue. During the experiment behavior and fish mortality were observed.

Sample and statistical analysis

In order to determine fish growth rates and condition coefficient, feed conversion ratio, and adjusted daily feed rations, individual measurements of standard length (SL) and total length (TL; ± 5 mm) and body weight of fish (± 0.1 g) were performed every seven days. During these measurements, the number of injured individuals was also noted. On the final day of the experiment, the sex ratio was determined among the largest individuals (5 per tank) and the smallest individuals (2 per tank). The sex of the fish was determined using a catheter inserted into the body cavity through the genital opening (Zakęś 2009). The stock hierarchy stability was calculated and expressed as the percentage of individuals that were in the same size class on the initial and final days of the study (Zakęś et al. 2001).

The data collected also served to calculate the values of the following:

- daily growth rate (DGR, g d^{-1})

$$DGR = (BW_f - BW_i)\ t^{-1}$$

- specific growth rate (SGR, % d^{-1})

$$SGR = 100\ (\ln BW_f - \ln BW_i)\ t^{-1}$$

- protein efficiency ratio (PER)

$$PER = (BW_f - BW_i)\ PI^{-1}$$

- fish condition coefficient (F)

$$F = 100\ BW_m\ TL^{-3}$$

- body weight variation coefficient (V, %)

$$V = 100\ (SD\ BW^{-1})$$

- feed conversion ratio (FCR)

$$FCR = TFC\ (FB - IB)^{-1}$$

- survival (%)

$$S = 100\ (IN\ FN^{-1})$$

where:

BW_f and BW_i – mean final and initial body weights (g), BW – body weight (g), BW_m – mean body weight (g), t – experiment duration (days), PI – protein intake (g), SD – standard deviation of body weight, IB and FB – initial and final stock biomass (g), IN and FN – initial and final stock numbers, TFC – total amount of feed consumed (g). The results were analyzed statistically with Statistica 5.0 PL. Single factor analysis of variance (ANOVA) and Tukey's test (HSD) ($P \leq 0.05$) were used to determine the significance of differences in the mean values of the rearing parameters among the groups analyzed.

Results

After eight weeks of rearing, the highest mean body weight of 119.2 g was noted in group F 1.1. The final body weight in this group was 7.5% higher than in group F 0.8 and 21.5% higher than in group F 1.1 ($P \leq 0.05$, Table 2), and statistically significant differences were noted from the second week of rearing (Fig. 1). Differences in the final body length and total length were statistically significant between groups F 1.1 and F 0.5. The daily growth rate (DGR) of the fish fed the largest feed ratio was 2.5 times higher than in the group fed the smallest feed ration (Table 2). The specific growth rate (SGR) ranged from 0.26% day^{-1} in group F 0.5 to 0.70% in group F 1.1. Values of the feed conversion ratio (FCR) ranged from 1.38 to 2.05 and were the lowest in group F 0.8 (Table 2).

The highest value of the protein efficiency ratio (PER) was also noted in group F 0.8. Throughout the rearing period, condition coefficient values increased in all groups, and they were significantly higher in groups F 1.1 and F 0.8 than in the group with the

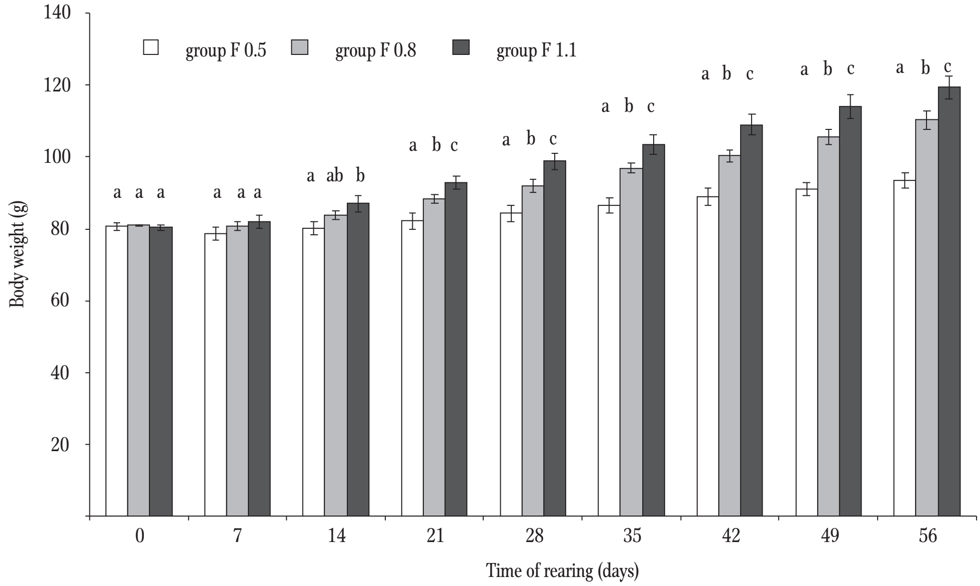

Figure 1. Body weight increases in perch (*Perca fluviatilis*) fed different feed rations in subsequent weeks of culture (0.5% fish biomass – group F 0.5; 0.8% – group F 0.8; 1.1% – group F 1.1; mean values ± SD, n = 3). Values marked with a letter index in the same week do not differ significantly statistically (P > 0.05).

Table 2

Effects of feed level (mean values ± SD, n = 3) on the growth, condition, survival, dominance hierarchy and percent of bitten individuals perch (*Perca fluviatilis*) reared over 56 days. Fish were divided into three groups with different doses of feed: 0.5% (group F 0.5), 0.8% (group F 0.8) and 1.1% (group F 1.1) of fish biomass in tank

Specification	group F 0.5	group F 0.8	group F 1.1
Body weight (g)	93.5 ± 2.2^{a}	110.2 ± 2.6^{b}	119.2 ± 3.2^{c}
Total lenght TL (cm)	18.9 ± 0.2^{a}	19.4 ± 0.2^{ab}	19.9 ± 0.2^{b}
Body lenght SL (cm)	17.0 ± 0.2^{a}	17.3 ± 0.1^{ab}	17.6 ± 0.2^{b}
Daily growth rate (DGR, g d^{-1})	0.23 ± 0.02^{a}	0.52 ± 0.05^{b}	0.69 ± 0.06^{c}
Specific growth rate (SGR, % d^{-1})	0.26 ± 0.02^{a}	0.55 ± 0.04^{b}	0.70 ± 0.06^{c}
Protein efficiency ratio (PER)	1.18 ± 0.16^{a}	1.73 ± 0.13^{b}	1.58 ± 0.11^{b}
Condition coefficient F	1.84 ± 0.03^{a}	2.05 ± 0.04^{b}	2.11 ± 0.03^{b}
Feed conversion ratio (FCR)	2.05 ± 0.30^{a}	1.38 ± 0.10^{b}	1.51 ± 0.11^{b}
Body weight variation coefficient V (%)	33.8 ± 4.2^{a}	33.1 ± 1.8^{a}	28.8 ± 1.4^{a}
Survival (%)	98.4 ± 2.7^{a}	100.0 ± 0.0^{a}	100.0 ± 0.0^{a}
Stock hierarchy stability (%)	81.0 ± 0.0^{a}	69.8 ± 2.8^{a}	74.6 ± 14.6^{a}
Bite wounds (%)	46.0 ± 7.3^{a}	41.3 ± 13.7^{a}	28.6 ± 4.8^{a}

*Data in rows with different letter indexes differ significantly statistically (P ≤ 0.05)

smallest feed ration (group F 0.5). The values of the final coefficient of variation of body weight in all the groups ranged from 33.8 to 28.8% and did not differ significantly statistically. Survival was high, ranging from 98.4% in group F 0.5 to 100% in groups F 0.8 and F 1.1, and it did not differ significantly statistically. The application of different feed rations also had no statistically significant impact on the stability of stock hierarchy. The highest value of this coefficient was obtained in group F 0.5 – 81%. From the second week of rearing, individuals exhibited visible traces of bites by other fish, and on the final day of the experiment, these fish were from 28.6% to 46% of all the fish (Table 2).

Increased feed rations had a statistically significant influence on the final body weight of the smallest perch (class S). The greatest increase in body weight was obtained by the fish from the group fed

Table 3
Effects of feed level (mean values ± SD, n = 3) on the growth, condition, survival, dominance hierarchy, and percentage of bitten individuals of perch (*Perca fluviatilis*) from different size classes reared over 56 days. Fish were divided into three groups with different doses of feed: 0.5% (group F 0.5), 0.8% (group F 0.8) and 1.1% (group F 1.1) of fish biomass in tanks, and three groups with different initial mean body weights

	Class S			Class M			Class L		
Specification	group F 0.5	group F 0.8	group F 1.1	group F 0.5	group F 0.8	group F 1.1	group F 0.5	group F 0.8	group F 1.1
Initial body weight (g)	57.9 ± 0.3^{a}	58.2 ± 0.4^{a}	58.0 ± 0.3^{a}	77.3 ± 0.2^{a}	77.5 ± 0.1^{a}	77.2 ± 0.1^{a}	106.8 ± 3.0^{a}	107.0 ± 0.5^{a}	105.8 ± 2.4^{a}
Final body weight (g)	67.4 ± 2.9^{a}	80.5 ± 4.1^{b}	90.4 ± 5.0^{b}	84.7 ± 2.5^{a}	98.3 ± 7.3^{b}	109.6 ± 3.8^{b}	127.9 ± 7.2^{a}	151.8 ± 5.6^{b}	157.7 ± 5.8^{b}
Initial standard lenght (cm)	15.2 ± 0.1^{a}	15.3 ± 0.2^{a}	15.1 ± 0.3^{a}	16.4 ± 0.5^{a}	16.5 ± 0.1^{a}	16.5 ± 0.3^{a}	18.1± 0.2^{a}	18.2 ± 0.1^{a}	17.9 ± 0.2^{a}
Final standard lenght (cm)	15.6 ± 0.1^{a}	15.9 ± 0.2^{b}	16.2 ± 0.2^{b}	16.8 ± 0.3^{a}	16.9 ± 0.2^{a}	17.3 ± 0.2^{a}	18.6 ± 0.3^{a}	19.2 ± 0.3^{b}	19.5 ± 0.2^{ab}
Specific growth rate (% d^{-1})	0.27 ± 0.08^{a}	0.58 ± 0.10^{b}	0.79 ± 0.10^{b}	0.16 ± 0.05^{a}	0.42 ± 0.13^{b}	0.63 ± 0.07^{b}	0.35 ± 0.10^{a}	0.62 ± 0.06^{b}	0.74 ± 0.06^{b}
Initial condition coefficient F	1.65 ± 0.04^{a}	1.62 ± 0.07^{a}	1.70 ± 0.09^{a}	1.77 ± 0.16^{a}	1.72 ± 0.01^{a}	1.72 ± 0.06^{a}	1.80 ± 0.05^{a}	1.77 ± 0.02^{a}	1.84 ± 0.05^{a}
Final condition coefficient F	1.78 ± 0.05^{a}	1.97 ± 0.02^{b}	2.09 ± 0.04^{c}	1.80 ± 0.06^{a}	2.03 ± 0.06^{b}	2.11 ± 0.06^{b}	1.91 ± 0.16^{a}	2.14 ± 0.10^{a}	2.13 ± 0.07^{a}
Initial body weight variation coefficient V (%)	8.1 ± 0.7^{a}	5.6 ± 3.6^{a}	6.8 ± 2.5^{a}	5.8 ± 0.8^{a}	5.6 ± 0.8^{a}	5.5 ± 0.4^{a}	10.3 ± 1.0^{a}	8.9 ± 2.3^{a}	8.9 ± 1.7^{a}
Final body weight variation coefficient V (%)	14.0 ± 5.2^{a}	14.9 ± 5.0^{a}	19.1 ± 5.3^{a}	13.9± 3.3^{a}	21.0 ± 6.1^{a}	14.9 ± 3.9^{a}	21.7 ± 3.2^{a}	15.1 ± 4.4^{a}	14.1 ± 2.8^{a}
Survival (%)	100.0 ± 0.0^{a}	100.0 ± 0.0^{a}	100.0 ± 0.0^{a}	95.2 ± 8.2^{a}	100.0 ± 0.0^{a}	100.0 ± 0.0^{a}	100.0 ± 0.0^{a}	100.0 ± 0.0^{a}	100.0 ± 0.0^{a}
Stock hierarchy stability (%)	80.9 ± 8.2^{a}	71.4 ± 0.0^{a}	71.4 ± 14.3^{a}	71.4 ± 0.0^{a}	57.1 ± 0.0^{a}	61.9 ± 21.8^{a}	90.5 ± 8.2^{a}	80.9 ± 8.2^{a}	90.5 ± 8.2^{a}
Bite wounds (%)	42.9 ± 14.3^{a}	42.9 ± 28.6^{a}	23.8 ± 21.8^{a}	52.4 ± 16.5^{a}	57.1 ± 28.6^{a}	38.1 ± 29.7^{a}	47.6 ± 21.8^{a}	23.8 ± 21.8^{a}	23.8 ± 8.2 ^{a}

*Values with the same letter indexes in the same row do not differ significantly statistically ($P > 0.05$) in the same size classes the largest feed ration (F 1.1); the final body weight in this group was 11% higher than that in group F 0.8 and 25% higher than that in group F 0.5 (Table 3). The final body length of the fish from class S at the end of the experiment was also the highest in group F 1.1 and differed statistically significantly from that of the fish in group F 0.5. The relative increase in body weight in groups F 1.1 and F 0.8 was twofold higher than it was in group F 0.5. The value of the condition coefficient increased in all the groups, and the highest values were noted in group F 1.1 (Table 3). Survival in this fish size class during the experiment was 100%. No statistically significant differences were noted in stock hierarchy stability, and the highest value attained was in group F 0.5 at 80.9%. The share of injured individuals at the end of the experiment was the smallest in group F 1.1 at 23.8%, while in groups F 0.5 and F 0.8 it was the same at 42.9%.

Among medium-sized individuals the greatest mean body weight at the end of the experiment was attained by the fish in group F 1.1. It was higher than the body weight of the fish from group F 0.8 by 10% and from group F 0.5 by 23%. The final body length in the different groups did not differ significantly statistically (Table 3). The relative increase in body weight was the lowest in group F 0.5 and was twofold lower than that in group F 0.8 and threefold lower than in group F 1.1. The condition coefficient value was the highest in group F 1.1 (2.11) and was statistically significantly higher in comparison to that of group F 0.5 (1.80). The other rearing parameters of the fish from class M did not differ significantly statistically (Table 3).

The greatest increase in body weight among the fish from size class L was attained by group F 1.1, in which the final mean body weight was 157.7 g. The final body weight in groups F 1.1 and F 0.8 was statistically significant in comparison to that in group F 0.5 (Table 3). The body length of perch from groups F 1.1 and F 0.8 was statistically significantly greater than that of the fish fed the smallest feed ration. The body weight specific growth rate in group F 0.5 was significantly statistically lower than in the other two groups. However, no statistically significant differences were noted among any of the groups with regard to differences in the final values of the condition coefficient, the coefficient of variation of body weight, or survival. Stock hierarchy stability in groups F 1.1 and F 0.5 was 90.5% and was higher than that in group F 0.8 (80.9%). The share of injured individuals at the end of the experiment was the lowest in groups F 0.8 and F 1.1 (23.8%).

On the final day of the experiment, a larger share of females (75.6%) than males (24.4%) was noted among the largest fish, while the share of males among the smallest fish was 72.2% of all individuals.

Discussion

The size of the daily feed ration is one of the most important aspects of proper fish feeding during controlled culture (Fiogbé and Kestemont 2003). It can impact both fish growth and normal development (Fiogbé et al. 1996, Kestemont et al. 2001). Increasing feed quantities usually results in greater fish growth provided that the maximum feed ration that the fish can consume under given conditions is not exceeded (Cotton and Walker 2005).

The results of the experiment indicate that increasing the daily feed ration from 0.5 to 1.1% of fish biomass resulted in growth rates (relative and absolute daily specific growth rates, final fish body weight and lengths) that were increasingly greater. Nonetheless, the specific growth rate (SGR) values obtained during the current experiment were lower than those reported by other authors investigating perch rearing. In the current experiment, the value in the group fed the largest feed ratio was 0.7% day^{-1}, while Fontaine et al. (1996) reported a value of 1.4 in European perch with body weights of 25-48 g that were held at a temperature of 22°C. In other studies, Fontaine et al. (1997) obtained a maximum SGR value of 1.86 in perch fed in excess (3% of stock biomass) at a temperature of 21.4°C. It seems that this was the result of the higher feed rations (2-4% of stock biomass) and water temperatures applied in these experiments. Mélard and Kestemont (1995) readed perch of a body weight of 100 g at a temperature of 20°C and reported a 20% lower SGR in comparison to fish of the same body weight cultured at a temperature of 23°C. Another factor that could have led to the lower growth rates was the higher fish body weight in the present experiment, because with increasing body weight the values of specific growth rate decrease (Mélard et al. 1995). This was observed clearly in perch fed in excess after they had attained a body weight exceeding 50 g (Fontaine et al. 1997). Juell and Lekand (2001) also reported similar results. However, the low-level feed rations applied in this experiment did not increase mortality in comparison to that in the studies cited above. Growth heterogeneity was at the same level in all groups during rearing. This indicates the feed rations did not affect the deepening growth heterogeneity of the perch, and could be sufficient in relation to their needs. One of the causes of growth heterogeneity in perch is detected in sexual growth dimorphism (LeCren 1958, Schott et al. 1978), which was observed in our experiments. This is manifested as faster female growth rates in comparison to those of males. It is possible that different growth rates occur in females and males at the beginning of sexual maturation under the stimulating influence of estrogen in the ovaries and the inhibiting effects of androgen in the testis (Malison and Garcia-Abiado 1996). The effect of this is increased feed consumption and conversion in females as compared to males (Malison et al. 1988). Fontaine et al. (1997) have demonstrated that restrictive feed rations can inhibit the manifestation of dimorphism in perch. From a practical viewpoint, the effects of great growth heterogeneity are disadvantageous, since they can lead to increased food competition and reinforce domination and hierarchy phenomena within stocks. Since this is particularly apparent when food resources are limited, it is likely the reason why the highest feeding coefficient values were noted in the group fed the smallest feed ration (group F 0.5), in which the largest fish (class L) consumed the most feed leaving the other fish with limited access to it.

Under natural conditions perch is a schooling species. This has also been confirmed by observations during controlled rearing, which have indicated, among other things, that perch held in isolation grow more slowly than fish held in groups (Strand et al. 2007). Between individuals, however, there are interactions that are reflected in cannibalism (Baras et al. 2003) and competition for feed. Mutual aggression among the fish in the present experiment was observed and resulted in numerous wounds to the perch, the most common of which were bites to the tail fins and damaged eyes. The first bitten individuals were noted after the first week of the experiment. This phenomenon was noted in all of the feed ration groups and in all size classes. Similar observations were reported in the rearing of pike, *Esox lucius* L., fed the same feed rations (Kozłowski et al. 2012). In this experiment, injured fish were only noted in the groups fed with doses of 0.5 and 0.8% of fish biomass. This increased aggression among fish could result from reactions to dietary stress stemming from limited access to feed. In most cases, fish with damaged eyes darken in color and lose weight. Darkened skin and eye colors occur in salmonids during social interactions; the losers of territorial battles also lose their position in the hierarchy and become subordinate fish (O'Connor et al. 1999, Höglund et al. 2000, 2002). According to O'Connor et al. (1999), the darkening of skin color is a physiological reaction that permits visually identifying subordinate fish.

The results of the experiment indicate that the formation of fish size stock hierarchy is stable in perch. The hierarchy was best maintained in group F 0.5, where over the 80% of fish remained in the same size class at the end of experiment. In terms of size class, the most stable was the group of the largest individuals, which maintained its dominant position within the group. The same results were obtained when rearing pike fed with the same feed rations (Kozłowski et al. 2012). The greatest changes expressed by the coefficient of stock hierarchy stability were noted in class S. This was probably because the fish in class S are the most flexible with regard to changes in body weight. A large share of individuals from this size class shifted to larger class L or to smaller class S. Confirmation that the largest fish maintained their dominant position (class L) could be that they attained the highest specific growth rates in the groups fed the small and medium-sized feed rations (groups F 0.5 and F 0.8) despite the fact, as mentioned previously, that smaller fish are potentially able to achieve better specific growth rates (Mélard et al. 1995). This has only been confirmed with the application of the largest feed ration (group F 1.1), which was presumably linked to the fact that the smaller individuals had greater access to feed. The results indicate that the best perch rearing results were attained with a daily feed ration of 1.1% of the fish biomass. Under such conditions, perch obtained larger relative and absolute daily specific growth rates. The feed rations applied did not affect the deepening of size differentiation among perch, and could be sufficient in relation to their needs.

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Author contributions. M.K. designed the research; M.K., I.P., K.W., A.Sz., and M.S.; performed the research; K.W. and M.S. analyzed the data; M.K. and M.S. wrote the paper.

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