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THE EFFECT OF APPLICATION OF SEMIMOIST FEEDING MIXTURE WHEN CONVERTING THE ADVANCED FRY OF ZANDER (*SANDER LUCIOPERCA*) TO INTENSIVE CULTURE CONDITIONS

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Abstract

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Conversion success of pond-reared zander (*Sander lucioperca*) fry was evaluated using three different converting methods: direct conversion to dry feed (Bio-Optimal Start 0.8 mm; variant A), three–day application of semimoist feeding mixture on the base of fish (variant B) and three-day application of semimoist mixture + three-day co-feeding of semimoist mixture and dry feed (variant C). Two replicates per treatment were applied. These three methods were evaluated regarding specific growth rate (SGR), condition coefficient (K), survival and cannibalism. Mean initial total length (TL) of fish was 35.22 ± 2.15 mm and mean individual weight (w) was 0.31 ± 0.05 g. There were 600 individuals in each circular tank. The initial stock density was 2 fish.l^{-1}. Fish survival during a 14-day period of rearing ranged from 34.33 % (variant C) to 50.33 % (variant A). Significantly ($P < 0.05$) better conversion performance was achieved with variants A and B than with the variant C regarding all parameters.

zander, growth, conversion, cannibalism, intensive conditions, semimoist feed

Zander, *Sander lucioperca* (Linnaeus, 1758) is a commercially important species of ichthyofauna of the Czech Republic. Its present occurrence in open waters is affected to a large extent with stockfish restocking. Approximately 40 t of marketable zander are annually produced in polyculture ponds in the Czech Republic. It is a favourite and sought out object of angling and annual catches from fishing grounds range between 125 and 165 t (BROŽOVÁ, 2005). The given volume of catches must be assured by stocking sufficient numbers of stocking material obtained from aquaculture. Zander belongs to the most valuable and most expensive fish species on the market. In association with the development of European aquaculture, zander and perch belong to very promising fish species with anticipated enhancement of marketable production from intensive aquaculture of both species being in great demand of the European market.

Use of advanced fry of zander reared in ponds proves to be useful for possible production of stockfish under controlled conditions of intensive aquaculture. This advanced fry is adapted and converted to artificial diet under controlled conditions. Survival rate during the period of conversion is of decisive importance for the total success of stockfish rearing and it ranges within 24–80%, most frequently about the 50% limit (ZAKĘŚ, 1997a,b; 1999; SZKŪDLAREK and ZAKĘŚ, 2002; LJUNGGREN *et al.*, 2003; BARÁNEK *et al.*, 2004; MOLNÁR *et al.*, 2004b).

Various methods of conversion may be employed: direct conversion to dry diet (ZAKĘŚ, 1997a,b; 1999; SZKŪDLAREK and ZAKĘŚ, 2002; BARÁNEK *et al.*, 2004), application of natural food (zooplankton, tubifex worms and chironomid larvae) followed by co-feeding with dry diet (ZIENERT and WEDEKIND, 2001; MOLNÁR *et al.*, 2004b; ZIENERT and

STEINL, 2004), appropriately an application of minced fish flesh (MOLNÁR *et al.*, 2004a). Application of a semimoist feeding mixture is another possibility. A semimoist feeding mixture was effective when converting the advanced fry of *Perca flavescens* to dry diet (BROWN *et al.*, 1996). In zander and perch, fish fed with a semimoist feeding mixture showed worse specific growth rate (SGR) and lesser filled stomach if compared to those fed with agglomerated marine larvae feed (LJUNGGREN *et al.*, 2003). In the Department of Fisheries and Hydrobiology, Mendel University of Agriculture and Forestry in Brno, a semimoist feeding mixture based upon fish flesh was successfully used in the previous intensive rearing of fry and stockfish of sturgeons, wels and perch (JIRÁSEK *et al*., 1997; MAREŠ and JIRÁSEK, 1999; MAREŠ and HILLERMANN, 2002). In 2004, an experiment with application of semimoist feeding mixture for advanced zander was performed (BARÁNEK *et al.*, 2004). Upon the results gained, it was decided to test a possibility of using the semimoist feeding mixture in an experiment with advanced fry of zander in 2005. According to the results of studies to date (ZAKĘŚ, 1997a, b; SZKŪDLAREK and ZAKĘŚ, 2002; LJUNGGREN *et al.*, 2003), we assessed the first 14 days of rearing because the majority of losses occur during this period and it is of key importance for the total success of conversion of zander fry from natural food to dry diet. The goal of our experiment was to compare the method of direct conversion to dry diet to the two conversion methods employing semimoist feeding mixture based upon fish flesh.

MATERIAL AND METHODS

Source of experimental fish

Advanced fry of zander was obtained from pond nursing (Pohořelice Fish Farming Co.). Brood fish were spawned in a storage pond using the method of semiartificial spawning and the nest with fertilized eggs was transfered to a small pond (0.27 ha) where the advanced fry was nursed till the age of 30 days. Fish after the harvest were transported in PE bags under oxygen atmosphere to the experimental recirculation facility of the Department of Fishery and Hydrobiology. Mean (n = 100 specimens) initial total length (TL) of fish was 35.22 ± 2.15 mm and mean individual weight (w) was 0.31 ± 0.05 g. Mean condition coefficient [K = weight in g × 100 × (standard length in cm)$^{-3}$] was 1.23 ± 0.12.

Culture facilities

Experimental rearing to verify the effectiveness of conversion lasted for 14 days. Fish were stocked into the experiment after 1-day starvation (harvest, transport, stocking) without previous condition period (enhancement of fish condition with application of natural food). Fish which died due to handling when stocked were replaced on the first day of experiment in the morning. Total number of 3600 specimens of advanced fry were stocked into 6 green circular plastic tanks of 300 l volume with 70 cm height of water column, coupled to a recirculation system. The recirculation system with simple biofilter and aeration was of 6 m^3 total volume and daily exchange of water was up to 10%. Fish were randomly divided into three experimental groups. The goal of the experiment was to compare three methods of conversion whilst two of them utilized semimoist feeding mixture (SFM) based upon fish flesh (Tab. I). Every experimental group was stocked in two replicates. Initial stocking density was 2 specimens.l^{-1}. Light intensity in the rearing room was low (30–40 lux) in light regime 16 hours of artificial illumination and 8 hours without illumination (total darkness).

I: *Experimental design*

Variant / Day (D)	A	B	C
1	Bio-Optimal Start	SFM	SFM
2	Bio-Optimal Start	SFM	SFM
3	Bio-Optimal Start	SFM	SFM
4	Bio-Optimal Start	Bio-Optimal Start	Co-feeding (SFM + Bio)
5	Bio-Optimal Start	Bio-Optimal Start	Co-feeding (SFM + Bio)
6	Bio-Optimal Start	Bio-Optimal Start	Co-feeding (SFM + Bio)
7 to 14	Bio-Optimal Start	Bio-Optimal Start	Bio-Optimal Start

Water quality

Water temperature was registered daily with mean value 23.5 ± 0.57 °C. Oxygen saturation and pH level (WTW pH/Oxi 340i) were also measured daily and mean values were 93.8 ± 1.67 % and 8.1 ± 0.11, respectively. The $N\text{-}NH_4^+$ content in the experiment was lower than 0.3 $mg.l^{-1}$ and $N\text{-}NO_2^-$ content was lower than 0.1 $mg.l^{-1}$ (WTW PhotoLab Spektral). Water inflow through jets was set equilibrated to all tanks and it provided water circulation with exchange of the total volume in the tank once per hour (5 $l.min^{-1}$).

Feeding

Fish starved one day prior to the experiment. In variant A, dry commercial diet Bio-Optimal Start (BIOMAR, Denmark) with 0.8 mm particle size was used from the beginning to the end of experiment. Feed was administered 12 h daily in excess (DFR 9 % of biomass weight – Bw) by means of a belt feeder. In variants B and C, the SFM (DFR 15 % of Bw) was fed manually for the first three days in frequency of 7 feedings in 2 h interval (7:00–19:00). The semimoist mixture of own production was based upon fresh flesh of silver carp (50 % fish flesh, 35 % fish meal, 5 % dried whey, 5 % soy flour without fat, 5 % biofactor complement Aminovitan). The SFM was prepared on mincing machine, frozen, stored in a freezer and administered to the fish by grating on a hand grater (particle size ca. 1.5–3.5 mm). In the variant B since the day 4 of experiment, only the commercial diet was administered by means of belt feeders. In variant C, the SFM was fed along with the dry diet manually for next 3 days in decreasing frequency and amount. Since the day 7 of experiment, all groups were given artificial diet only (DFR 6 % of Bw). Feed remnants were removed regularly twice a day from the experimental tanks.

Chemical analysis

After assessing the effect of diet composition on the production and composition of fish body, the diets used were analysed. The semimoist feeding mixture contained in fresh matter 35.72 % crude protein, 6.30 % fat and 6.72 % ash with 52.59 % dry matter. Commercial diet contained 53.12 % crude protein, 21.53 % fat and 11.39 % ash with 93.55% dry matter. Chemical analysis of pooled sample of fish at the beginning of experiment revealed the following composition of fish body: 15.44 % dry matter, 11.56 % crude protein, 1.99 % fat, 2.54 % ash. After termination of the test, 30 specimens of each feeding variant (pooled sample of both replicates) were sacrificed, homogenized and chemically analysed for body composition. Crude protein was determined by means of Kjeldahl method (N × 6.25), dry matter was determined by drying at 105 °C for 24 h. Fat was analysed by ether extraction using the Soxhlet method. Ash was determined by means of burning in furnace at 550 °C for 8 h.

Data collection and statistical analysis

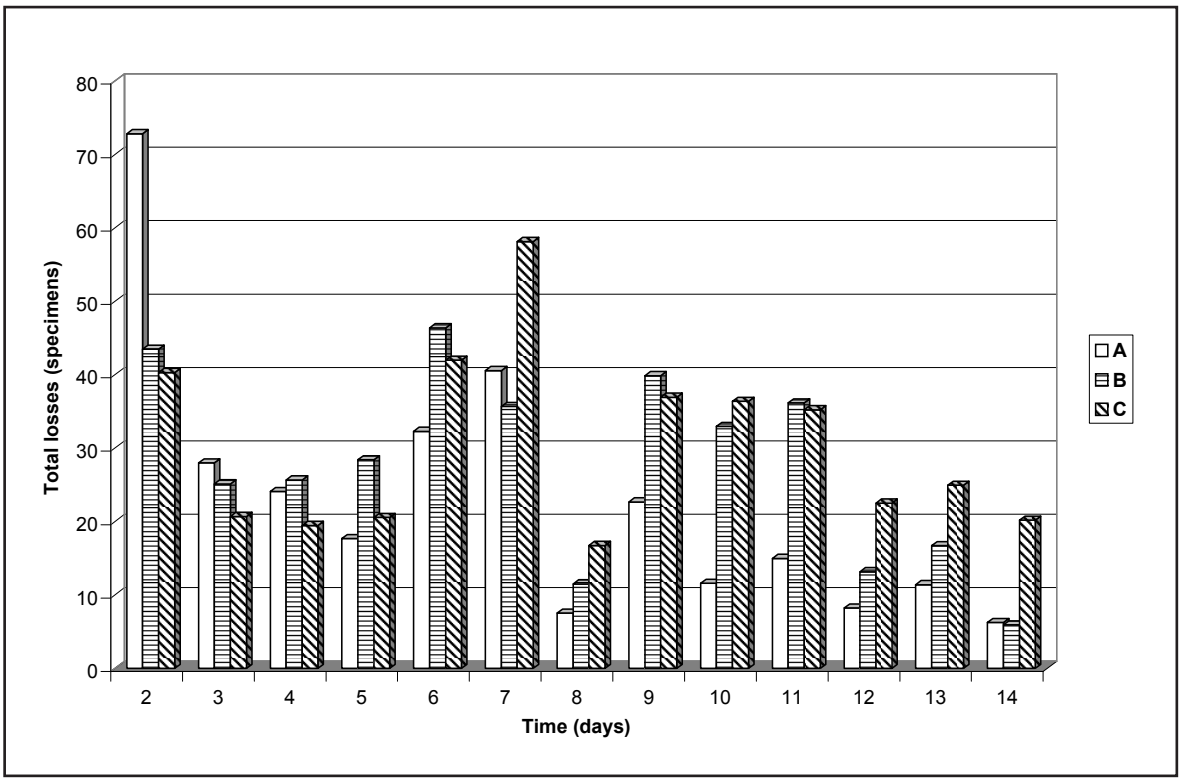
Circular tanks were checked twice a day to register mortality, cannibalism and to remove appropriate cannibals from tanks. Dead fish were removed twice a day and in case of expressive damage of tail fin, they were involved into losses caused by cannibalism. In case of removal of a cannibal with prey from the tank, both fish were involved into losses caused by cannibalism. At the end of experiment, 25 fish were sampled from each tank (50 fish from each experimental variant), fish were anaesthetized with clove oil (0.03 $ml.l^{-1}$) and individually measured [TL (total length), SL (standard length) with 1 mm precision and w (weight) with 0.01 g precision]. Growth was quantified by means of specific growth rate (SGR = [ln (final weight) – ln (mean initial weight)] × $days^{-1}$ × 100). Condition coefficient was computed (K = weight in g × 100 × (standard length in cm)$^{-3}$). Food conversion ratio (FCR) was not assessed, as feeding was administered in excess during the experiment and the diets used did differ in dry matter. Altogether 30 fish from each variant were used for analysis of chemical composition of fish body at the end of experiment. Statistical assessment of the parameters studied (TL, w, SGR, K, survival rate, cannibalism) employed the analysis of variance test (ANOVA) and Scheffe´s multiple comparison method in Unistat programme. Duration of the experiment in days was assigned as D_1–D_{14}.

RESULTS

Most fish in variants B and C began to intake the SFM already during the first two days of experiment, fry in the variant A began to intake the feed during the first week of experiment. In all tanks, food was taken from water surface or from the water column, the SFM in variants B and C was exceptionally taken also from bottom of the tank.

At the beginning of experiment (till D_3), the highest losses were registered in variant A fed with dry diet. The SFM was very well accepted by the fish what could be documented by lower losses in experimental variants B and C during the first three days of experiment (Fig. 1). During D_4 to D_6, the highest losses were registered in variant B. Part of the fish taking SFM rejected the artificial diet and starved. Since D_7, the highest losses were registered in variant C, where a lon-

ger habit to SFM manifested negatively on the readiness to intake the artificial diet. Both variants using SFM thus showed higher survival rate and intake of food particles from the beginning of experiment but a significant part of the fish rejected the administered artificial diet in the following period. The variant C showed expressively higher losses also at the end of experiment (Fig. 1). This fact can be demonstrated by higher survival rate for the whole experimental period in variant A (Tab. II). The variant A significantly differed in survival rate from the variant C ($P < 0.05$).



1: *Mean total losses in experimental treatments*

II: *Growth, survival and cannibalism of the zander fry (mean ± SD)*

Specification	Experimental groups		
	A	B	C
Final TL (mm)	43.98 ± 3.91^{a}	43.14 ± 4.91^{ab}	41.66 ± 4.78^{b}
Final SL (mm)	37.54 ± 3.18^{a}	36.62 ± 4.35^{ab}	35.00 ± 4.01^{b}
Final w (g)	0.86 ± 0.23^{a}	0.81 ± 0.32^{ab}	0.64 ± 0.28^{b}
Condition coef. (K)	1.6 ± 0.13^{a}	1.59 ± 0.14^{a}	1.41 ± 0.22^{b}
SGR (%.d^{-1})	7.14 ± 1.75^{a}	6.47 ± 2.43^{a}	4.56 ± 3.13^{b}
Cannibalism (%)	28.92 ± 5.54^{a}	33.92 ± 5.54^{a}	37.92 ± 1.06^{a}
Natural mortality (%)	20.75 ± 0.82^{a}	26.25 ± 4.36^{a}	27.75 ± 1.06^{a}
Survival (%)	50.33 ± 4.71^{a}	39.83 ± 1.18^{ab}	34.33 ± 2.12^{b}

*Means with different superscript indicate significant difference at $P < 0.05$ level.

Growth rate was very similar in experimental variants A and B. The highest mean total length, standard length and weight was gained by fry in variant A. Variants A and C were found significantly differing in these parameters also but the difference between variants A and B was insignificant ($P > 0.05$). No difference was found for the condition coefficient (K) and SGR between variants A and B (K 1.6 and SGR

7.14 %.d^{-1} vs. K 1.59 and SGR 6.47 %.d^{-1}, respectively) but these variants significantly differed from variant C (K 1.41 and SGR 4.56 %.d^{-1}).

Any significant difference among the experimental groups was registered neither for the level of cannibalism, nor for natural mortality. Losses due to cannibalism ranged within 28.92–37.92 %. Compared to total losses, the losses due to cannibalism aimed over 50% in each variant (55–58 % from the total losses). Very similar results were gained in both the variants A and B, the variant A showed better results in survival rate and SGR but without a significant difference. The three-day application of SFM followed by three-day co-feeding of SFM and artificial diet in variant C showed significantly worse results of all parameters studied except for cannibalism and natural mortality, when compared to direct conversion to artificial diet in variant A.

The results gained can be also confirmed by means of analysis of chemical composition of body of fish fry at the end of experiment (Tab. III). Both the variants A and B were very close to each other in protein and fat content while the variant C showed expressively lower protein and fat content (2.5 % less protein and 3 % less fat) along with lower dry matter content what confirmed worse growth and condition of fish in this variant. Fish body composition in this variant was very similar to initial values at the beginning of experiment.

III: *Chemical composition of fish body at the end of the experiment (in % of wet matter)*

Variant	Dry matter (%)	Crude protein (%)	Crude fat (%)	Ash (%)
A	21.01	13.61	5.72	2.59
B	20.55	13.45	5.42	2.54
C	15.86	11.05	2.72	3.09

DISCUSSION

Results of the experiment confirmed that the advanced fry of zander (Za_a) nursed under pond culture conditions could be, after gaining mean TL 35 mm and w 0.30 g, successfully converted directly to inert diets under the conditions of controlled aquaculture. In contrary to other authors (ZAKĘŚ, 1999; BAER *et al.*, 2001; MOLNÁR *et al.*, 2004a,b; ZIENERT and STEINL, 2004), we did not feed the fry with frozen natural food or minced animal tissues during the initial habit-forming phase.

ZAKĘŚ (1999) considers the initial size of Za_a to be the key factor determining the effect of intensive rearing of juvenile zander under controlled conditions, as it decides about the level of adaptation during conversion to dry diets. The period of forming the habit to intake and utilize dry diet lasts for 14–28 days depending on the initial size of Za_a. According to HILGE (1990), the fry of zander can be exclusively fed with dry feed since the TL 40–50 mm. According to BAER *et al.* (2001), the Za_a can be directly converted to dry feed only after gaining 0.65 g weight. ZIENERT (2003) considers the 0.50 g weight to be suitable for conversion.

Survival rate gained in fry of variants A (50.3 %) and B (40 %) fed from the beginning of adaptation with dry or semimoist feed is comparable to data stated by ZAKĘŚ (1997b), SZKŪDLAREK and ZAKĘŚ (2002) and MOLNÁR *et al.* (2004b). Also the losses caused by cannibalism (29–38%) during the first 14 days of rearing refer to data of SZKŪDLAREK and ZAKĘŚ (2002) and MOLNÁR *et al.* (2004b). With initial application of semimoist diet in the variant B, the survival rate was lower than that with direct conversion to dry diet in variant A, in contrary to results of BARÁNEK *et al.* (2004), where higher survival rate has been gained by variant fed with SFM. The worst productive result was gained with fry of variant C, which was initially fed with semimoist diet followed by its co-feeding with dry feed. This feeding variant concerned in fact a double conversion and the fry which has been inured to semimoist feed from the beginning of adaptation, prefered ingestion of this type of feed to the dry diet which it threw up after intake.

LOVELL (1989) already pointed out the advantages of using semimoist diets during the initial habit of juvenile fish to inert diets. Better ingestion of these feeds is most probably associated with their plastic consistence and favourable taste features. Values of parameters SGR (7.1 and 6.5 %.d^{-1}), coefficient of condition (1.6) and levels of protein and fat content in muscle of fry of the feeding variants A and B demostrate the possibility and usefulness of exclusive use of dry or semimoist diet from the beginning of conversion of Za_a from ponds to controlled aquaculture conditions already from the weight of 0.30 g.

SOUHRN

Vliv použití polovlhké krmné směsi na převod rychleného plůdku candáta obecného (*Sander lucioperca*) do podmínek intenzivního chovu

Cílem našeho experimentu bylo srovnat tři metody převodu rychleného plůdku candáta obecného na suchou dietu: přímý převod na suchou dietu (Bio-Optimal Start 0,8 mm, varianta A), 3denní aplikace polovlhké krmné směsi na bázi rybího masa (varianta B) a 3denní aplikace polovlhké krmné směsi s následnou 3denní kombinací polovlhké směsi se suchou dietou (varianta C). Každá varianta byla uskutečněna ve dvou opakováních. Tyto tři metody převodu byly vyhodnoceny pomocí specifické rychlosti růstu (SGR), koeficientu kondice (K), úrovně přežití a kanibalismu. Počáteční průměrná celková délka těla (TL) ryb byla 35,22 ± 2,15 mm a průměrná individuální hmotnost činila 0,31 ± 0,05 g. Do každé nádrže bylo nasazeno 600 ks ryb. Počáteční hustota obsádky byla 2 ks.l^{-1}. Přežití po 14denní periodě převodu se pohybovalo v rozmezí od 34,33 % (varianta C) do 50,33 % (varianta A). Statisticky průkazně ($P < 0.05$) lepších výsledků převodu dosáhly varianty A a B oproti variantě C. Z výsledků provedeného experimentu je zřejmé, že metoda přímého převodu rychleného plůdku candáta obecného na suchou dietu je srovnatelná s metodou využívající krátkou (3denní) aplikaci polovlhké krmné směsi na bázi rybího masa.

candát obecný, růst, převod, kanibalismus, intenzivní podmínky, polovlhká směs

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