Intensive rearing of the nase *Chondrostoma nasus* (L.) larvae using dry starter feeds and natural diet under controlled conditions

P. Spurný, J. Fiala, J. Mareš

Department of Fisheries and Hydrobiology, Mendel University of Agriculture and Forestry, Brno, Czech Republic

ABSTRACT: We performed intensive rearing of larvae of the nase *Chondrostoma nasus* (L.) in a feeding experiment until 21 days from the initiation of exogenous nutrition under laboratory conditions at a temperature 26°C. Two dry starter feeds (a feed for salmonids and a starter feed of the artificial plankton type) differing in the composition of nutrients (50% and 60% of proteins, 12% and 16% of fat, respectively) and natural food (*Artemia salina* nauplii) were used. Cumulative survival rate, individual weight (w), total length (TL), specific weight growth rate (SWGR), specific length growth rate (SLGR) and condition factor (CF) were assessed. One-way analysis of variance (ANOVA) was used for statistical processing of data. High survival rate 99.3% and the highest ($P < 0.01$) growth rate of nase larvae (TL = 22.0 mm, w = 69.2 mg) were found when feeding the natural food. The application of dry feed of the artificial plankton type resulted in higher survival (98.8%) and significantly higher ($P < 0.01$) growth of both length and weight (TL = 17.5 mm, w = 42.5 mg) compared to the nase fed with dry feed for salmonids (survival rate 77.3%, TL = 15.9 mm, w = 24.5 mm). In the course of the experiment the value of Fulton's coefficient increased from initial 0.57 to 0.79 in fish fed with artificial plankton to 0.65 in fish fed with natural food and to 0.61 if dry feed for salmonids was used. We conclude that with an appropriate starter feed the successful intensive rearing of larval nase can be carried out under controlled conditions.

Keywords: nase; larvae; feeding; growth; survival

The nase *Chondrostoma nasus* (L.) is an important natural element of the ichthyofauna of the Danube and Oder Rivers in the Czech Republic. Until recently, nase belonged to a dominant fish species of the barbel zone of our running waters (Baruš *et al*., 1995). Anthropogenic effects (water pollution, reduction of gravel bank area, increasing silting of spawning grounds, modern methods of angling, etc.) dramatically reduced its stocks in the second half of the 20th century (Lusk, 1995; Lusk and Halačka, 1995).

The first artificial propagation and rearing of nase in Europe was performed on the Avel River in Germany in 1922, followed by Romania in the mid-1950's (Peňáz and Hofbauer, 1973). In the Czech Republic, the first artificial stripping of this species was carried out by Peňáz and Hofbauer (1973) directly at the spawning ground in the Oslava River in April 1973. These authors also performed the first successful intensive rearing of nase larvae (up to total length 37.9 mm) in troughs upon live zooplankton and pelleted feed for trout fry. A long-term decrease in the nase abundance in most of the Central European rivers led to the development of artificial propagation technology (Hochman and Peňáz, 1989) and to the rearing of early age stages of this species in ponds (Wolnicki and Myszkowski, 1998) or in special ponds, the so-called "dike ponds" (Lusk and Krčál, 1988; Lusk, 1997).

Intensive rearing of fish larvae is one of the promising ways of increasing the abundance of rheophilic fish species in running waters (Fiala, 2001). Water temperature is an important factor affecting the growth rate of nase larvae (Wolnicki and

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Górny, 1994a,b; Keckeis *et al*., 2001). Specification of nutritional requirements is another important prerequisite to manage successfully the technology of intensive rearing of fry of rheophilic fish species (Wolnicki *et al*., 2000). Pedersen (1997) focused on nutritional and energetic requirements of young fry of fish. Wolnicki and Myszkowski (1998), Kujawa *et al*. (1998) and Fiala and Spurný (1999) presented the results of successful intensive rearing of nase larvae when dry starter feeds were used.

The aim of the present paper was to compare the survival rate, growth and condition of nase larvae intensively fed with dry starter feeds or with natural food.

MATERIAL AND METHODS

Eggs were obtained by artificial propagation from spawners caught in the Svitava River at the locality Brno-Husovice. After hatching larvae aged 6 days were placed into a non-circulation tank. Water temperature was increased from 19.1°C to 26.0°C within 24 hours according to Wolnicki and Górny (1994b), who found the highest growth and survival rates of nase larvae in the temperature range of 26–28°C. In two days all the larvae swam up. Larvae at the age of 8 days were stocked into rearing tanks and the experiment was initiated on the next day.

It was conducted during 21 days in 9 non-circulation aquaria of the capacity 7.5 l each. The aquaria were stocked with 150 nase larvae each (stocking density 20 larvae/l). Water was aerated and filtrated through inner filters during the feeding period (12 hours a day). Filtration also caused the circulating flow of water with velocity of about 1 cm/s. The walls of aquaria were cleaned daily and half of the water capacity was exchanged.

All the rearing aquaria were placed in a trough of 150 l. The circulation in the trough maintained the same temperature in all rearing aquaria. The water temperature 26°C control operated daily from 06.00 to 22.00, at night the water temperature decreased to 22°C. A light/dark cycle of 16L : 8D was applied. Basic hydrochemical parameters (water temperature, dissolved oxygen content and pH) were controlled daily (Table 1).

Three feeding groups were studied in triplicate. Group A was fed with a dry starter recommended by the producer for initial feeding of salmonids, group B received a dry starter feed indicated by the producer as "artificial plankton" (Table 2). The control group (C) was fed with live *Artemia salina* nauplii (hereinafter only artemia).

Table 1. Basic hydro-chemical parameters of culture conditions during 21 days of nase larvae rearing

Parameters	Mean ± SD
Water temperature (°C)	26.0 ± 0.2
O_2 content (mg/l)	6.69 ± 0.2
O_2 saturation (%)	83.4 ± 1.8
pH	7.19 ± 0.3

SD = standard deviation

Dry starter feeds were administered manually *ad libitum* every two hours from 08.00 to 20.00 hours. The calculated values of daily feed conversion for the starter feeds in the experiment ranged from 6.1% to 8.4% of the actual total weight of fish biomass. Artemia were also administered from 08.00 to 20.00 hours but in a 3-hour interval. Daily feed conversion of artemia decreased from 50% to 25% of the actual total biomass of fish in the course of the experiment.

Samples of 30 specimens per replication were taken from each feeding group in 7-day intervals and fixed in a 4% formaldehyde solution for 6 months. Larvae were sampled in the evenings, always 2 hours after fish feeding. Survivals were calculated for three 7-day periods separately. Cumulative survival is a

Table 2. Content of compounds (% dry matter) and total energy content of dry diets (MJ/kg) used during 21 days of nase larvae rearing

Groups	A	B
Crude protein	50.0	60.0
Fat	12.0	16.0
Carbohydrates	19.0	8.0
Fibre	2.5	0.5
Dry matter	91.5	91.0
Ash	8.0	6.5
Total energy*	20.0	21.8

*total energy content was calculated according to the coefficient of Jobling (1994) product of survivals of these three periods. The total length (TL, mm) was measured to the nearest 0.25 mm, wet weight (w, mg) was taken to the nearest 0.1 mg. In addition, wet weight of the group C larvae (artemia diet) was taken immediately after fixing the samples due to updating the daily food quantity. The following methods of computation were used for the assessment of selected indices:

Condition factor $CF = (w/TL^3) \times 100$

Specific weight growth rate

$$SWGR = [(w_2/w_1)^{1/t} - 1] \times 100$$

Specific length growth rate

$$SLGR = [(TL_2/TL_1)^{1/t} - 1] \times 100$$

where: w_1, TL_1 = final values
w_2, TL_2 = initial values
t = time (days)

The results were statistically evaluated by the one-way analysis of variance (ANOVA).

RESULTS

The highest growth of nase larvae was found with the application of natural food in group C (SLGR = 2.69%/d, SWGR = 8.92%/d). Growth rates of larvae fed with the dry diet of the "artificial plankton" type were SLGR 1.58%/d and SWGR 6.42%/d. The poorest growth was found in the group fed with the dry diet for salmonids, SLGR 1.11%/d, SWGR 3.67%/d. A similar trend was found out for the values of the other productive indices studied, as reported in Table 3.

A high cumulative survival of nase larvae (99.3%) was found when natural food was used (group C), and a similar value (98.8%) was obtained in group B. The application of the feed for salmonids resulted in a reduced survival – 77.3%. The published data characterize the natural mortality of larvae and they do not include fish sampled for further analyses. The mortality of larvae was examined from day 6 to day 21 of the experiment. The highest daily mortality 5.7%/d was registered in group B on days 16 and 18 from the beginning of dry feed uptake.

The significantly highest ($P < 0.01$) individual weight (w = 69.2 mg) and total length (TL = 22.0 mm) were found in fish fed with live artemia. Comparing the feeding treatments based on dry diets, significantly higher ($P < 0.01$) mean individual weight and coefficient of condition (w = 42.5 mg, CF = 0.79) as well as significantly higher ($P < 0.05$) mean total length of the fish (TL = 17.5 mm) were found for treatment B (diet of the "artificial plankton" type).

Table 3. Basic length, weight and Fulton's coefficient of nase larvae at the beginning (S) of larval period and after 21 days (A, B, C) of intensive rearing (Mean ± SD)

Groups	S	A	B	C
Total length (mm)	12.6 ± 0.6	15.9^b ± 0.6	17.5^b ± 1.3	22.0^a ± 1.6
Individual weight (mg)	11.5 ± 1.5	24.5^C ± 4.1	42.5^B ± 14.5	69.2^A ± 17.3
Fulton's coefficient	0.57 ± 0.04	0.61^B ± 0.07	0.79^A ± 0.09	0.65^B ± 0.08

Within rows, insignificant differences are followed by the same letter (capital font for $P > 0.01$; small font for $P > 0.05$)

Table 4. Values of selected parameters after 21 days of nase larvae rearing under laboratory conditions

Groups	A	B	C
		n = 30	
Survival rate (%)	77.3	98.8	99.3
SLGR (%/d)	1.11	1.58	2.69
SWGR (%/d)	3.67	6.42	8.92
Daily length increment (mm/d)	0.16	0.23	0.45
Daily weight increment (mg/d)	0.62	1.48	2.75

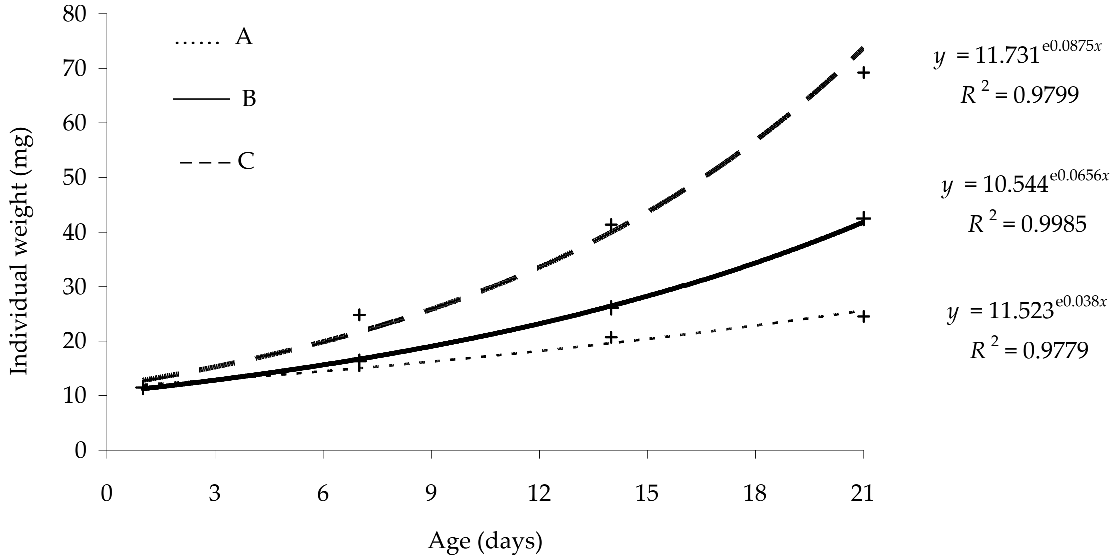

Figure 1. The growth rate of nase larvae during 21 days of intensive rearing under laboratory conditions

DISCUSSION

Survival rate of larvae at the age of 3–4 weeks after the onset of exogenous nutrition is a decisive factor for success in their initial rearing under controlled conditions. This was demonstrated by Peňáz (1971), who considered the period of initial rearing for at least 20–25 days, related to water temperature, relevant for objective assessment of embryonic mortality of larvae of rheophilic fish species. Cumulative survival of nase larvae in our experimental variants amounted to 77.3–99.3% on day 21 of the experiment. Comparable survival of nase larvae (88–99%) was reported by Wolnicki and Myszkowski (1998) in their experiments using artemia nauplii, as well as by Wolnicki and Górny (1994b) using size-graded zooplankton. The high survival of 98.8% on dry feed "artificial plankton" is similar to that obtained on artemia (99.3%).

The exclusive administration of dry feeds in our experiments provided the survival rate of larvae on the level of 77.3% (dry feed for salmonids) or 98.8% (artificial plankton). This value is already fully comparable with the application of artemia (99.3%).

Wolnicki and Górny (1994b) successfully nursed nase larvae of 45–65mg individual weight within 15 days upon live zooplankton. In the present experiment the larvae fed with artemia reached individual weight of 69.2 mg after 21 days of feeding with 50–25% of the stock weight. When using the dry feeds, significantly lower individual weights of nase larvae were found compared to the variant fed with artemia (at the level of 61.4% in the group fed with artificial plankton, or 35.4% in the group fed with dry feed for salmonids). The former value is similar to the result by Wolnicki and Myszkowski (1998), who found that the growth rate of nase larvae fed with dry diet might amount to 70% of the values obtained with natural food.

Dabrowski (1982, 1984) considered the cyprinids to be the most difficult fish from the aspect of successful initial rearing of larvae on dry diets. Relatively high survival and growth of nase larvae fed in our experiment with artificial plankton (98.8% cumulative survival, 42.5 mg individual weight, 17.5 mm TL and the highest CF 0.79) confirm the previously published results of Wolnicki and Myszkowski (1998). These authors experimentally confirmed a possibility of the successful initial feeding of nase, barbel and vimba bream larvae upon dry feeds in complete absence of natural food. Considering our experimental groups with the exclusive application of dry feeds, we obtained significantly higher length-weight parameters of nase larvae in the group fed with a mixture containing 60% proteins and 16% fat, compared to that with 50% proteins and 12% fat. It could be anticipated upon the producer-declared ingredients used for the mixture that this above-standard feed should be of higher biological value and should have a more adequate content of specifically effective substances. It is also demonstrated that the level of fat in dry diets for common carp larvae recommended by Meske (1986) and Szlaminska *et al*. (1990) to range between 12% and 20% is acceptable for the nase larvae.

The exclusive application of dry feeds for the initial feeding of nase larvae resulted in relatively lower production results than identical experiments performed on larvae of barbel (Fiala and Spurný, 2001). Nevertheless, considering the larval survival and growth and based on the obtained results it is possible to recommend this intensive method of nursing for a broader practical use. This method of intensive culture will enable to carry out a more effective rearing in ponds although in fisheries practice ponds are usually stocked with yolk-feeding larvae, thus highly uncertain as to their survival. It also enables a long-term nursing of nase larvae and juveniles under controlled conditions till the next spring, as successfully realised by Fiala (2001). Even in autumn nase juveniles obtained from the pond culture may be included in the intensive culture after adaptation. Further intensive culture of the nase over the winter season will provide with juveniles of higher weight in the next spring for restocking the running waters. Restocking with rheophilic cyprinids is more efficient in the spring (Philippart *et al*., 1989). This method begins to be used in fishery practice.

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ABSTRAKT

Intenzivní odkrm larev ostroretky stěhovavé *Chondrostoma nasus* (L.) při použití startérových krmných směsí a živé potravy v laboratorních podmínkách

V krmném experimentu jsme realizovali intenzivní odchov plůdku ostroretky stěhovavé *Chondrostoma nasus* (L.) do věku 21 dnů od zahájení exogenní výživy v laboratorních podmínkách při teplotě vody 26°C. Použitými dietami byly dvě suché startérové směsi (krmná směs určená pro salmonidy a startérová směs typu „umělý plankton“) odlišného nutričního složení (proteiny 50 a 60 %, tuk 12 a 16 %) a živá potrava (*Artemia salina* v naupliovém stadiu). U pokusných ryb jsme sledovali úroveň přežití, individuální hmotnost (w), celkovou délku těla (TL), specifickou rychlost hmotnostního (SWGR) a délkového (SLGR) růstu a také kondiční stav – koeficient vyživenosti dle Fultona (CF). Zjištěné výsledky byly statisticky vyhodnoceny metodou jednocestné analýzy variance (ANOVA). Vysoká úroveň přežití 99,3 % a statisticky vysoce průkazně ($P < 0,01$) nejvyšší rychlost růstu larev ostroretky (TL = 22,0 mm, w = 69,2 mg) byly zjištěny při aplikaci živé potravy. Použití suché krmné směsi „umělý plankton“ umožnilo dosažení vyšší úrovně kumulativního přežití larev (98,8 %) i statisticky vysoce průkazně ($P < 0,01$) vyšší intenzity jejich délkového i hmotnostního růstu (TL = 17,5 mm, w = 42,5 mg) v porovnání se shodnými produkčními a růstovými ukazateli ostroretky krmené suchou směsí pro lososovité ryby (úroveň přežití 77,3 %, TL = 15,9 mm, w = 24,5 mm). Hodnota Fultonova koeficientu se v průběhu experimentu zvýšila z počáteční hodnoty 0,57 na hodnotu 0,79 u ryb varianty krmené umělým planktonem, na 0,65 u skupiny ryb krmené živou potravou a na hodnotu 0,61 v případě aplikace suché směsi pro lososovité ryby. Dosažené hodnoty sledovaných ukazatelů prokazují, že při použití vhodného startérového krmiva lze intenzivní odchov plůdku ostroretky stěhovavé realizovat v kontrolovaných podmínkách s produkčně i ekonomicky přijatelnými výsledky.

Klíčová slova: ostroretka; plůdek; rozkrm; růst; přežití

Corresponding Author

Doc. Ing. Petr Spurný, CSc., Ústav rybářství a hydrobiologie, Mendelova zemědělská a lesnická univerzita v Brně, Zemědělská 1, 613 00 Brno, Česká republika
Tel. +420 545 133 266, fax +420 545 211 128, e-mail: fishery@mendelu.cz