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USE OF FROZEN ZOOPLANKTON IN THE INTENSE REARING OF EUROPEAN CATFISH (*Silurus glanis* L.) LARVAE

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A B S T R A C T. European catfish (*Silurus glanis* L.) larvae were reared for 14 days on artificial feed or mixed food (artificial feed and frozen zooplankton) used for initial 3, 6 or 9 days of rearing. Better growth and food conversion rate were observed in fish fed for initial 9 days mixed food (final body weight 0.87-0.90 g per ind., SGR 28.01-28.31% per day, and FCR 0.42-0.46), comparing to the fish fed artificial feed only (final body weight 0.71-0.72 g per ind., SGR 26.62-26.66% per day, and FCR 0.57-0.59). No statistically significant differences in fish survival were observed. Shorter (3 or 6 days) feeding mixed food did not result in statistically different growth rate or feed conversion rate.

Key words: EUROPEAN CATFISH, FISH, FROZEN ZOOPLANKTON, REARING, LARVAE, *Silurus glanis*

INTRODUCTION

In the last years, fish culturists became interested in rearing of European catfish as an additional fish in carp ponds, in open waters, and in special fishing grounds, as an attractive game fish. European catfish larvae may be reared in ponds using natural food (Wiśniewolski 1989), or in tanks on live or mixed food (live and artificial feed) (Wiśniewolski 1989, Mejza et al. 1993, Kołdras et al. 1994). Rearing of catfish larvae on artificial feed only is also possible (Heymann 1990, Kozłowski et al. 1995, Wolnicki 1995, Kamiński, Wolnicki 1996, Wolnicki, Starzonek 1996). Using natural food (zooplankton, oligochaetes, yeast or certain bacteria) as a source of exogenous proteolytic enzymes, together with artificial feed, promotes digestive processes in guts of fish larvae (Dąbrowski, Glogowski 1977, Lauff, Hofer 1984, Hofer 1985). This results in better growth and food conversion rate (Hamáčkova et al. 1992, Kozłowski et al. 1995), but involves a risk of introducing dangerous diseases. Laboratory studies (Tóth, Papp 1986, Kozłowski et al. 1995, Wolnicki 1995, Wolnicki, Starzonek 1996) show that brine shrimp (*Artemia salina*) cysts and nauplii are „safe" food, however due to high price and small size they seem inadequate for commercial-scale rearing. Tubifex (*Tubifex sp.*) used in Hungary (Horvath 1977, Tóth et al. 1980, Rónyai, Ruttkay 1990), and zooplankton applied in Poland (Szlamińska 1984, Wiśniewolski 1989, Mejza et al. 1993,

Kołdras et al. 1994), and in other European countries (Kouřil et al. 1984, Mareš, Kouřil 1988, Ziebarth 1991) are still basic natural food used in large-scale catfish rearing. Using live food in feeding catfish larvae requires stable and abundant food supply, which in Polish climate is not always possible. This problem may be solved by working out a method of zooplankton conservation (e. g. freezing). Frozen zooplankton was used in European catfish rearing by Ziebarth (1991) as an addition to artificial feed. Frozen zooplankton stored for 1 year at –18°C was successfuly used in feeding whitefish larvae (*Coregonus lavaretus* L.) (Kleifeld-Kriebitz, Roesch 1987). Biochemical studies revealed no changes in the activity of proteolytic enzymes during freezing or storage of frozen zooplankton (Grabner et al. 1981). However, fast leaching of the enzymes from damaged cells was observed during unfreezing – in zooplankton thawed in water at 9°C only 27% of the initial enzyme activity was observed after 10 minutes, the remaining part leached into water (Grabner et al. 1981).

Rearing European catfish larvae on artificial and mixed food (artificial feed and frozen zooplankton) was carried out in the Experimental Fishery Center „Dgał". The aim of the study was eveluation of the use fulness of frozen and stored at –18°C zooplankton as complementary food used together with artificial feed in rearing catfish larvae. Additionally, the effect of duration of zooplankton feeding on fish growth and survival was evaluated.

MATERIAL AND METHODS

The experiment was carried out in semi-commercial and laboratory scale. In semi-commercial version, 4 tanks (1x2x0.5 m) of 400 dm^3 volume were used (type D), and in laboratory version – 12 small rotation tanks (type M) of 40 dm^3 each. In both versions, one water recirculation system with sedimentation tank and shelf biological filters with diatomite was used. Constant water flow providing water exchange in the tanks every 20 minutes was maintained over the entire rearing period. Water temperature and dissolved oxygen (DO) content were measured daily at the water outflow. Every 2 or 3 days chemical analyses of water were done, including ammonium nitrogen ($N\text{-}NH_4$).

Each tank was stocked with European catfish larvae at the age of 4 days (L. t. 11.87 mm, W_0 16.5 mg), with yolk sac still present. Initial stock density in D tanks was 12.5 ind. dm^{-3}, and in M tanks 14 12.5 ind. dm^{-3}. Initial water temperature 23°C was elevated overnight to 28°C. Average temperature of rearing was 28.4±2°C. Four experi-

mental feeding groups were applied, each in 4 replicates (3 M and 1 D tank in each). G0 included fish fed over trout feed only the entire rearing period (Dana Feed DAN-EX-4000 containing 46% of crude protein, and 19% of crude fat). G3 included fish fed mixed food: trout feed, and aditionally frozen zooplankton for 3 first days of rearing. G6 and G9 included fish fed trout feed and frozen zooplankton added for 6 or 9 days respectively. Feeding started on the next day after stocking. Pellets were supplied continuously using conveyor feeders, for 22 hours a day. Daily zooplankton doses were constant, 50 g per D tank, and 5 g per M tank. Zooplankton supply frequency decreased from 5 times a day during the first 3 days of rearing, to 4 times a day in the next 3 days, and 2 times a day in the further 3 days.

Spring zooplankton, frozen and stored for 1-4 months at –18^{o}C was used in the experiment. It was harvested in the ponds, concentrated by filtration, and frozen in plastic bags preventing its drying out.

Beginning from the 10 day of rearing, all fish were fed trout pellets exclusively.

The tanks were cleaned twice a day, and dead fish were counted and removed.

On the 6 and 12 day of rearing, the fish were immersed for 20 minutes in formaldehyde solution (20 cm^3 per 100 dm^3 of water) to prevent diseases.

The experiment finished after 14 days. Immediately before start of feeding, initial sample was collected (n=50 ind.) and preserved in 4% formaldehyde solution. Next samplings took place after 3, 6, and 9 days (n=30 ind.). After the end of rearing, the fish were counted. Thirty fish from each M tank, and 50 fish from each D tank were individually weighed (anesthetized using phenoxiethanol), with ±0.01 g accuracy. Formaldehyde-preserved fish were measured using microscope micrometer (with ±0.01 g accuracy), and weighed using torsion balance (with ±0.2 mg accuracy).

Feed conversion rate (FCR), and specific growth rate (SGR) were calculated for each experimental group, according to the formulas:

$$FCR = P \cdot (B_k - B_0)^{-1}$$

where: P – amount of feed used [g]

B_k – final fish mass [g]

B_0 – initial fish mass [g]

$$SGR = (\ln W_k - \ln W_0) \cdot 100\% \cdot t^{-1}$$

where: W_k – final individual average body mass [mg]

W_0 – initial individual average body mass [mg]

t – number of days of rearing

The results were subjected to ANOVA, assuming $P<0.05$.

RESULTS

No considerable fluctuations of chemical parameters ($N\text{-}NH_4$ 0.05-0.2 mg dm^{-3}, $N\text{-}NO_2$ 0.01-0.04 mg dm^{-3}, pH 7.1-7.6) were observed during the experiment, and their values fitted the range appropriate for Cyprinid fish rearing (Krüger, Niewiadomska- Krüger 1990). Changes of dissolved oxygen level are shown in Fig. 1.

From day 11 of rearing, considerable decrease of O_2 concentration in the outflowing water was observed despite unchanged water flow. This was related to fast fish growth and increasing amount of supplied feed, which resulted in higher oxygen consumption.

Fish growth in 3, 6, and 9 days, and final results of rearing are shown in Tab. 1.

Statistically significant differences ($P<0.05$) in fish growth between fish fed mixed food, and those fed pellets only were observed after 6 days in D tanks, and after 9 days of rearing in M tanks. In both types of tanks these differences increased at the end of the experiment. The highest final average body mass was noted in G9 group, and the lowest in G3 and G0 groups (Tab. 1). The difference was statistically significant

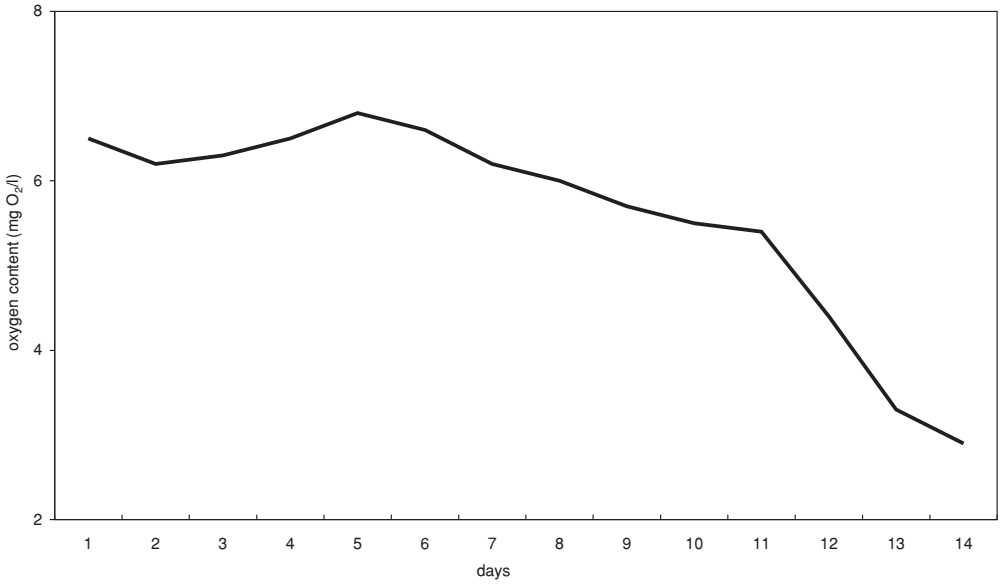

Fig. 1. Changes of dissolved oxygen level in water during rearing of European catfish larvae.

TABELA 1

Growth of European catfish after 3, 6, and 9 days of feeding, and final results of rearing (standard deviation in parentheses)

Tank type	W_3	L.t. $_3$	W_6	L.t. $_6$	W_9	L.t. $_9$	W_{14}	SGR	FCR	Survival
	[mg/ind.]	[mm]	[mg/ind.]	[mm]	[mg/ind.	[mm]	[mg/ind.]	[%/day]		[%]
G0	51.6 $^{a\,b}$	16.67 $^{b\,c}$	121.3 $^{b\,c}$	23.33 ^{c}	254.0 $^{a\,b}$	29.29 $^{a\,b}$	710.2 $^{a\,b}$	26.66 $^{a\,b}$	0.59 ^{a}	82.13 ^{a}
M	(9.7)	(1.29)	(24.7)	(1.3)	(62.6)	(2.27)	(16.6)	(1.83)	(0.09)	(7.94)
G3	52.9 ^{b}	16.75 $^{b\,c}$	109.4 ^{a}	22.49 $^{a\,b}$	249.7 $^{a\,b}$	28.57 ^{a}	704.3 ^{a}	26.49 ^{a}	0.59 ^{a}	83.83 ^{a}
M	(7.9)	(0.81)	(20.1)	(1.52)	(59.5)	(2.07)	(20.6)	(2.21)	(0.1)	(6.61)
G6	54.1 ^{b}	16.86 ^{c}	128.6 ^{c}	23.39 ^{c}	289.0 $^{c\,d}$	30.07 $^{b\,c}$	796.3 $^{b\,c}$	27.40 $^{b\,c}$	0.49 $^{a\,b}$	87.30 ^{a}
M	(9.0)	(0.92)	(20.9)	(1.18)	(83.2)	(2.7)	(21.8)	(2.1)	(0.04)	(5.51)
G9	53.6 ^{b}	16.89 ^{c}	124.0 $^{b\,c}$	23.10 $^{b\,c}$	310.8 ^{d}	30.56 ^{c}	894.8 ^{d}	28.31 ^{d}	0.42 ^{b}	90.07 ^{a}
M	(8.1)	(0.94)	(25.5)	(1.69)	(68.2)	(1.7)	(20.7)	(1.83)	(0.02)	(0.45)
G0	47.7 ^{a}	16.02 ^{a}	101.5 ^{a}	21.63 ^{a}	235.1 ^{a}	28.13 ^{a}	721.2 $^{a\,b}$	26.62 $^{a\,b}$	0.57	79.06
D	(10.1)	(1.03)	(30.2)	(2.29)	(77.6)	(2.47)	(22.9)	(2.32)		
G3	50.3 $^{a\,b}$	16.24 $^{a\,b}$	113.6 $^{a\,b}$	22.24 $^{a\,b}$	260.4 $^{a\,b\,c}$	28.91 $^{a\,b}$	720.0 $^{a\,b}$	26.67 $^{a\,b}$	0.56	81.61
D	(7.3)	(0.75)	(32.1)	(1.97)	(62.5)	(2.16)	(21.4)	(2.08)		
G6	54.3 ^{b}	16.91 $^{b\,c}$	135.0 ^{c}	23.62 ^{c}	268.6 $^{a\,b\,c}$	29.34 $^{a\,b\,c}$	740.4 $^{a\,b}$	26.79 $^{a\,b}$	0.52	85.27
D	(5.7)	(0.62)	(21.5)	(1.22)	(87.5)	(2.75)	(23.7)	(2.43)		
G9	50.9 $^{a\,b}$	16.24 $^{a\,b}$	134.2 ^{c}	23.39 ^{c}	287.9 $^{b\,c\,d}$	29.95 $^{b\,c}$	870.4 $^{c\,d}$	28.01 $^{c\,d}$	0.46	85.17
D	(5.3)	(0.58)	(29.2)	(1.2)	(52.2)	(1.56)	(24.7)	(2.19)		

In columns values with the same superscripts do not differ significantly (P<0.05)
W_3 – average individual body mass (number indicates days of rearing)
L. t.$_3$ – average total length of fish (number indicates days of rearing)
SGR – specific growth rate
FCR – feed conversion rate

(P<0.05). Final body mass of fish of G3 and G6 groups did not significantly differ from that of G0 group (Tab. 1).

Feed conversion rate (FCR) was the lowest in G9 group, statistically different from the values obtained for G0 and G3 (Tab. 1).

Survival of the fish was high, and did not significantly differ among the groups for particular tank type (Tab. 1).

Cumulated mortality is shown in Figs 2 and 3.

The highest increase of mortality was observed in all groups between days 4 and 10 of rearing. Mortality in M tanks (Fig. 2) and in D tanks (Fig. 3) differed, but the final fish survival was similar (Tab. 1). The differences resulted from cannibalism, particularly strong in D tanks, which might have been related to their shape. Fish mortality due to cannibalism was the highest in G3 and G0 groups, 8.6 and 9.8%, respectively,

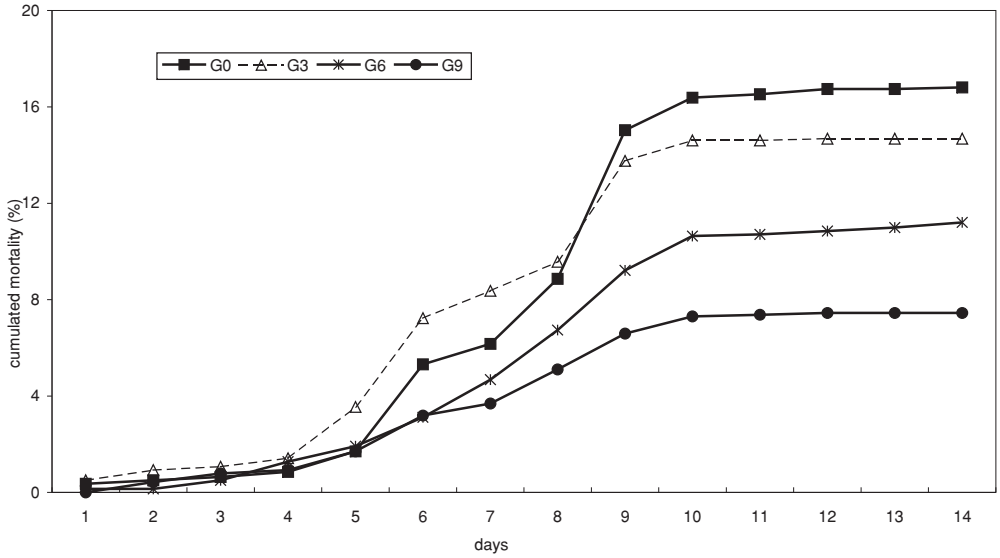

Fig. 2. Cumulated mortality of European catfish larvae in M tanks during rearing on artificial feed supplemented with frozen zooplankton (G0 – fish fed artificial feed only, G3 – fish fed for first 3 days mixed food – artificial feed and frozen zooplankton, G6- fish fed for first 6 days mixed food, G9 - fish fed for first 9 days mixed food).

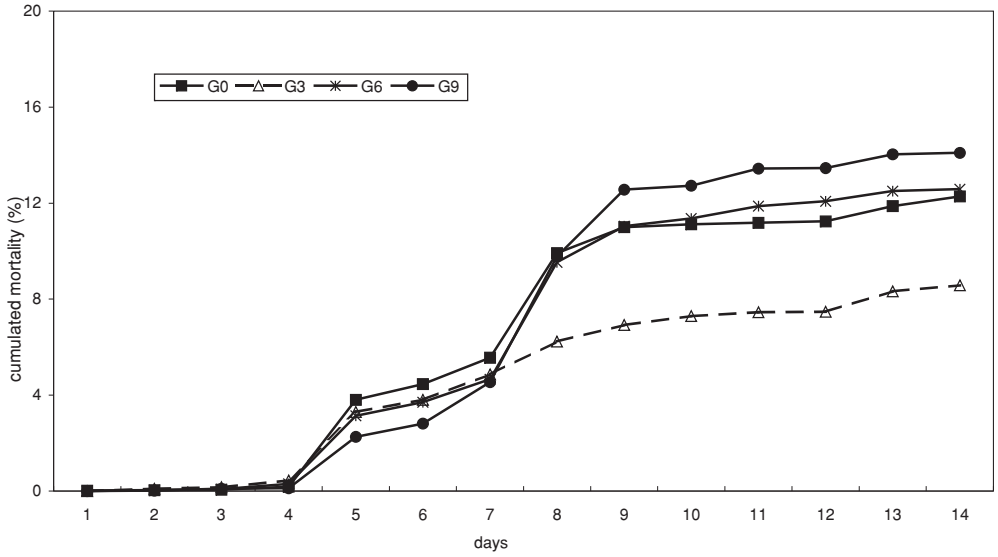

Fig. 3. Cumulated mortality of European catfish larvae in D tanks during rearing on artificial feed supplemented with frozen zooplankton. See the legend to Fig. 2.

while in G6 and G9 equal to 2.1 and 0.7%. In M tanks, fish loss due to cannibalism ranged from 1.1 to 2.6%.

DISCUSSION

The results obtained for G0 group fed exclusively trout feed are one more evidence (Kozłowski et al. 1995, Wolnicki 1995, Kamiński, Wolnicki 1996, Wolnicki, Starzonek 1996) that European catfish larvae may be reared on artificial feed alone. However, the larvae fed mixed food (pellets and frozen zooplankton) grew faster, similarly as in the case of supplementation of artificial feed with brine shrimp (Kozłowski et al. 1995).

Comparison of the results of the present study with the data of other authors obtained under similar conditions (Wolnicki 1995, Kamiński, Wolnicki 1996, Wolnicki, Starzonek 1996) revealed that trout pellets DAN-EX-4000 might be used in mass rearing of European catfish larvae.

Several times higher final body mass of fish (0.7-0.9 g), and comparable survival (79-90%) show that initial rearing of catfish larvae should be extended to at least 14 days.

Owing to simple method of freezing and storage of zooplankton at –18^{o}C, abundant zooplankton source is not necessary during fish rearing. Moreover, low temperature kills any fish parasite common among live zooplankton (Kouřil et al. 1984, Szlamińska 1984, Mareš, Kouřil 1988, Wiśniewolski 1989, Ziebarth 1991, Mejza et al. 1993, Kołdras et al. 1994) or in tubifex (Horvath 1977, Tóth et al. 1980, Rónyai, Ruttkay 1990).

Frozen zooplankton in catfish rearing should be added to artificial feed for at least 9 days, which considerably increases growth rate of larvae comparing to fish fed pellets alone. No effect of supplementary feeding with zooplankton on fish survival was observed (similar in all experimental groups, 79-90%). It was also similar to that observed in rearing of catfish larvae on mixed food, including trout pellets and live zooplankton – 77.2% (Wiśniewolski 1989), or brine shrimp – 67-73% (Kozłowski et al. 1995).

Successful attempt of using frozen zooplankton as supplementary food in feeding European catfish larvae with artificial feed encourages further studies on using it in rearing of other fish species which cannot be fed pellets alone.

CONCLUSIONS

1. The results of the present study confirmed the value of frozen zooplankton which may be used instead of brine shrimp, live zooplankton or tubifex, as supplementary food constituent added to artificial feed in rearing of European catfish larvae.
2. Frozen zooplankton should be added to artificial feed for at least 9 days.
3. Using mixed food (artificial feed and frozen zooplankton) increases growth and food conversion in catfish larvae comparing to the fish fed artificial feed alone, but does not affect fish survival.

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STRESZCZENIE

WYKORZYSTANIE ZOOPLANKTONU MROŻONEGO W INTENSYWNYM PODCHOWIE LARW SUMA EUROPEJSKIEGO (*Silurus glanis* L.)

Przeprowadzono 14-dniowy podchów larw suma (Silurus glanis L.) na paszy sztucznej i pokarmie mieszanym (pasza sztuczna plus zooplankton mrożony) stosowanym przez 3, 6 lub 9 pierwszych dni podchowu. Stwierdzono lepszy wzrost i wykorzystanie paszy w grupie ryb żywionych przez pierwszych 9 dni podchowu pokarmem mieszanym (końcowa masa ciała 0.87-0.90 g/szt, SGR 28.01-28.31 %/dzień i FCR 0.42-0.46) w porównaniu do ryb żywionych wyłącznie paszą sztuczną (końcowa masa ciała 0.71-0.72 g/szt, SGR 26.62-26.66 %/dzień i FCR 0.57-0.59). Przy krótszym okresie (3 lub 6 dni) stosowania pokarmu mieszanego istotne różnice we wzroście i wykorzystaniu paszy nie wystąpiły. Nie stwierdzono istotnych różnic w przeżywalności ryb. Wykorzystana w doświadczeniu metoda mrożenia i przechowywania zooplanktonu w temperaturze -18°C, pozwala na jego łatwe zastosowanie jako dodatku uzupełniającego paszę sztuczną w żywieniu larw suma. Można również przypuszczać, że będzie on też użyteczny przy podchowie innych gatunków ryb, których podchów wyłącznie na paszy sztucznej sprawia trudności.

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