Arch. Ryb. Pol.	Archives of Polish Fisheries	Vol. 7	Fasc. 2	297 - 306	1999

THE EFFECT OF LIGHT AND STOCKING DENSITY ON THE RESULTS OF REARING OF EUROPEAN CATFISH (*Silurus glanis* L.) LARVAE

Jacek Kozłowski, Paweł Poczyczyński

Warmia and Masuria University in Olsztyn

ABSTRACT. Two experiments were carried out on European catfish larvae fed artificial feeds, in which the effects of light and stocking density on fish growth and survival were studied. In experiment 1 the fish were reared in illuminated (group A) or dark (group B) tanks, for 28 days, at 28°C, in water recirculation system. The final average fish body length was 61.1 mm (A) and 62.0 mm (B), and body weight: 2265.5, and 2192.0 mg respectively. No statistically significant differences were observed (Chi-square test, P<0.05). Total fish mortality reached 80.1% (A), and 69.3% (B), in which losses due to cannibalism represented 53.7% and 43.7% respectively. Fish survival was 19.9% in group A and 30.7% in group B. Statistically significant differences were observed between the groups.

In experiment 2, European catfish larvae were reared in 3 groups of different stocking density: 15 ind. dm^{-3} (C), 25 ind. dm^{-3} (D), and 50 ind. dm^{-3} (E), for 21 days at 26°C, in water recirculation system. The final average fish body length reached 21.4, 20.5, and 21.6 mm in C, D, and E groups respectively, and did not significantly differ. Fish body weights were 88.3, 78.7 and 79.0 mg respectively, and the value for group C was significantly higher compared to D and E (Chi-square test, P<0.05). Fish mortality was 43.6%, 51.1% and 72.9% in C, D, and E respectively, of this cannibalism represented 20.3, 22.9 and 36.2%. Survival was higher at lower stocking densities, and equal to: 56.4% (C), 48.9% (D), and 27.1% (E). Mortality, survival and cannibalism were significantly lower in group E compared to C and D.

Key words: EUROPEAN CATFISH, REARING, LIGHT, STOCKING DENSITY

INTRODUCTION

Success of rearing of freshwater fish larvae depends on many factors. The effect of water temperature (McCormick et al. 1971, 1972, Hokanson 1977, Heming et al. 1982, Łuczyński 1990) and food composition (Dąbrowski 1984, Poczyczyński et al. 1990, Dąbrowski, Culver 1991, Kozłowski et al. 1995) are most widely studied. There are little data, however, on the effect of light and stocking density on the results of rearing, except the most important commercial species, such as salmonid fish, common carp, channel catfish, or tilapia.

The present study was undertaken to assess the influence of photoperiod and stocking density on success of rearing of European catfish larvae.

MATERIAL AND METHODS

EXPERIMENT 1

Feeding larvae of European catfish of average initial body weight 13.8±2 mg were reared in 6 flow-through aquaria of 25 dm^3 each, supplied with recirculated water of 28±1^oC. The entire water volume in the tanks was exchanged every 20 minutes. The fish were divided into two experimental groups, each in three replicates. Group A was reared in the aquaria illuminated from 7:30 a.m. to 8:30 p.m.,using dispersed light of 44 lx. Group B was kept in darkness (the tanks were lighted only for cleaning). Initial stocking density was 600 ind. per tank (24 ind. dm^{-3}). Fish feeding started immediately after stocking. For the first 5 days the fish were fed mixed food (artificial feed and decapsulated Artemia cysts). Later on, the larvae were given Danish commercial trout pellets Aller Molle Krystal 3600. Food was supplied 5 times a day, at 3 hour intervals. Dead fish were counted and removed before each feeding. The aquaria were cleaned manually twice a day (before the first and the last feeding), removing non-consumed food and feces. The experiment lasted 28 days.

Every 7 days (on 7, 14, 21, and 28 day of the experiment) 20 fish were sampled from each tank (60 individuals in each experimental group). They were anesthetized using 2-phenoxyethanol, weighed with 1 mg accuracy, and measured with 0.1 mm accuracy. After depuration, the fish were returned to the tanks. On the sampling days, all live fish were counted and weekly loss due to cannibalism was calculated according to the formula:

$$K = [P - (Z + M)] \cdot 100\%,$$

where:

K – victims of cannibalism (%)

P – number of fish at the beginning of the week (ind.)

Z – number of fish at the end of the week (ind.)

M – number of fish that died during the week (ind.)

The results on fish body weight and length, cumulative mortality, survival, and cannibalism were analysed using Chi – square test.

Specific growth rate (SGR) was also calculated for various phases of rearing according to the formula:

$$SGR \quad \frac{\ln W_2 \quad \ln W_1}{t}$$

where:
W_1 – initial average individual body weight (mg)
W_2 – final average individual body weight (mg)
t – rearing duration (days)

EXPERIMENT 2

European catfish larvae of initial average body weight 16.8±1.5 mg were divided into 3 experimental groups, each in 2 replicates. In group C the initial stocking density was 15 ind. dm^{-3}, and in groups D and E – 25 and 50 ind. dm^{-3} respectively (375, 625, 1250 fish per tank). The fish were reared in darkness, at 26±1°C, for 21 days.

The samples of 30 individuals from each tank (60 fish from each group) were taken on 7, 14, and 21 day of rearing. The fish were fed exclusively trout pellets Aller Molle Krystal 3600. Tank volume, water exchange rate, feeding and cleaning frequency, sampling, and statistical analysis of the results were identical as in the experiment 1.

Fish health was monitored during the rearing. Physico-chemical water parameters (pH, DO and ammonia concentration) were measured daily.

RESULTS

EXPERIMENT 1

Average body weight and length (l. t.) of European catfish larvae obtained in the experiment 1 are shown in Table 1. The length did not differ between the groups, and at the end of rearing was equal to 61.1 mm and 62.0 mm in A and B group respectively. Statistically significant differences in fish body weight were observed on 14 and 21 day of rearing; the fish kept in the darkness (B) were heavier than those from illuminated tanks. In the last week of rearing growth rate of the latter increased, and the final fish weights did not significantly differ (Table 2), reaching 2265.5 mg (group A) and 2192.0 mg (group B).

Specific growth rate (SGR) differed considerably in the successive weeks of rearing (Table 2). The fastest growth was observed in the second week of the experiment (25.30% a day in A group, and 27.88% in B), and the slowest – in the first week (6.66% and 9.10% respectively). Average SGR for 28 days of rearing was 18.22% for group A and 18.10% for B.

TABLE 1

Average individual total body length and weight, and total biomass of fish in experiment 1. Standard deviations in parentheses. Groups with the same denominator do not significantly differ in rows (Chi-square test, P<0.05)

Day of rearing	Group A (illuminated aquaria)			Group B (dark aquaria)		
	Mean length [mm]	Mean weight [mg]	Total biomass [g]	Mean length [mm]	Mean weight [mg]	Total biomass [g]
7	13,0a (1,1)	22,0b (5,4)	32,1	14,1a (1,2)	26,1b (9,6)	38,3
14	22,3a (3,1)	129,3b (121,0)	113,5	24,7a (3,3)	183,8c (94,5)	172,4
21	37,7a (5,6)	585,7b (330,2)	239,6	41,2a (4,5)	704,2c (311,4)	419,0
28	61,1a (9,6)	2265,5b (1354,0)	405,5	62,0a (8,2)	2192,0b (1112,8)	819,8

TABLE 2

Specific growth rate – SGR (% per day) of European catfish larvae in various phases of rearing

Day of rearing	Experiment 1 Experimental group		Experiment 2 Experimental group		
	A	B	C	D	E
1 – 7	6,66	9,10	6,24	4,92	3,52
8 – 14	25,30	27,88	6,75	9,41	6,96
15 – 21	15,11	19,19	10,72	7,73	11,63
22 – 28	19,33	15,80	-	-	-
1 – 21	17,85	18,73	7,56	7,35	7,37
1 – 28	18,22	18,10	-	-	-

“Natural” mortality (resulting from causes other than cannibalism) was higher in group A, and reached 26.4 % at the end of the experiment, while it was 22.6 % in group B (Fig. 1). Cannibalism was also more pronounced in illuminated tanks, reaching 53.7% compared to 46.7% in dark tanks, and the difference was statistically significant. The final fish survival in group A (19.9%) was significantly lower than in group B (30.7%) (Fig. 1). Higher, survival and higher growth rate resulted in higher fish biomass in dark tanks (Table 1). The final total fish biomass was 819.8 g in group B and only 405.5 g in group A.

EXPERIMENT 2

Average fish body weight and length (l. t.) of European catfish larvae in the experiment 2 are shown in Table 3. Fish body length did not significantly differ, and

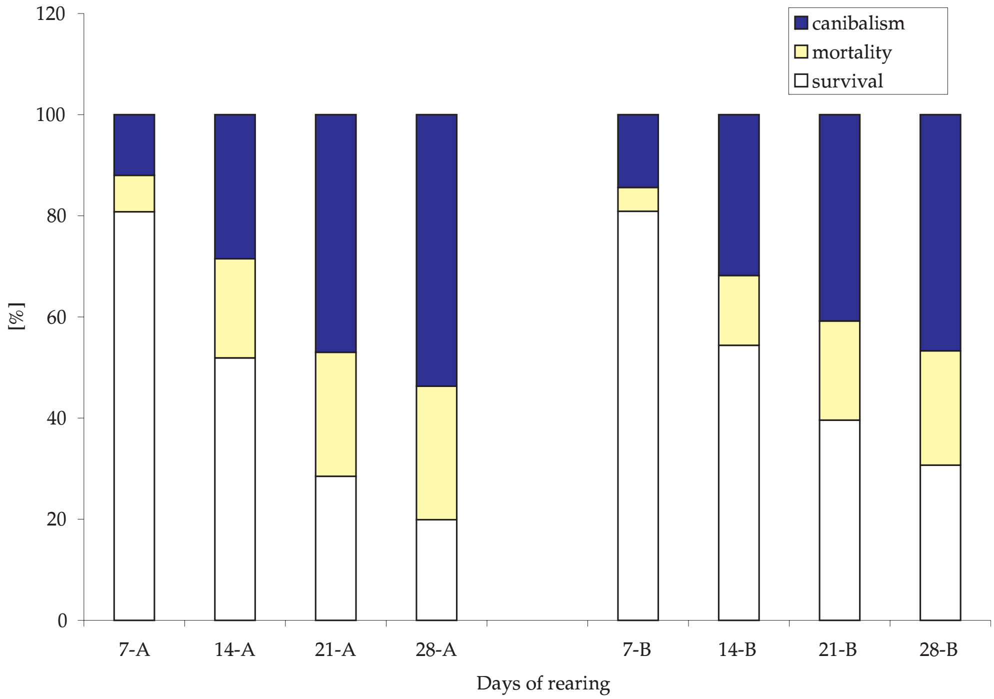

Fig. 1. Survival, natural mortality, and cannibalism level of European catfish in experiment 1.

reached 21.4, 20.5, and 21.6 mm in groups C, D, and E respectively. Body weight in group C (88.3 mg) was significantly higher ($P<0.05$) than in groups D and E (78.7 and 79.0 respectively).

TABLE 3

Average individual total body length and weight, and total biomass of fish in experiment 2. Standard deviations in parentheses. Groups with the same denominator do not significantly differ in rows (Chi-square test, $P<0.05$)

Day of rearing	Group C (15 szt.*dm^{-3})		Group D (25 szt.*dm^{-3})		Group E (50 szt.*dm^{-3})	
	Mean length [mm]	Mean weight [mg]	Mean length [mm]	Mean weight [mg]	Mean length [mm]	Mean weight [mg]
7	14,4a (0,5)	26,0bc (3,5)	14,4a (0,4)	23,7c (2,6)	14,0a (0,3)	21,5cd (2,1)
14	18,2a (1,3)	41,7b (9,9)	18,1a (1,0)	45,8b (8,2)	17,5a (1,1)	35,0c (8,8)
21	21,4a (1,7)	88,3b (24,0)	20,5a (2,0)	78,7c (17,9)	21,6a (2,1)	79,0c (35,0)

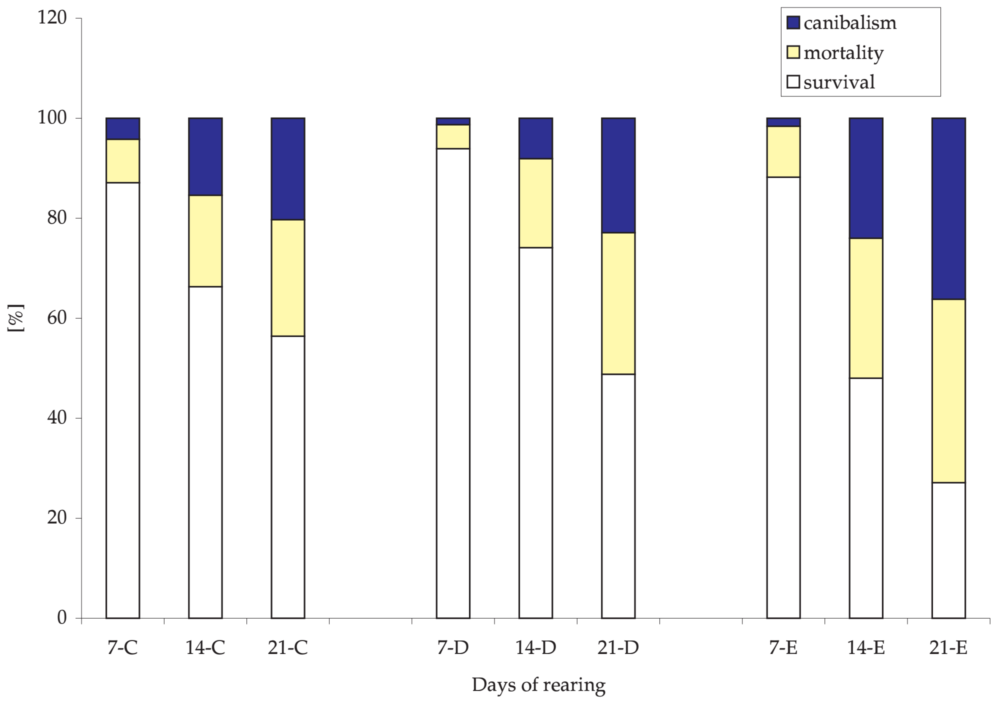

Fig. 2. Survival, natural mortality, and cannibalism level of European catfish in experiment 2.

Specific growth rate (SGR), similarly as in the experiment 1, was the lowest in the first week of rearing, and the highest, except group D, in the third week (Table 2). SGR values were less variable than in experiment 1. Growth was, however, much slower, and equal to 7.56, 7.35 and 7.35% per day for the entire 21 day long period compared to 17.5 and 18.73% over 21 days of the experiment 1 (Table 2).

Natural mortality of larvae at the end of the experiment reached 23.3% in group C, 28.3% in D, and 36.7% in group E (Fig. 2). Fish loss caused by cannibalism was 20.3, 22.9, and 36.2% respectively. The final survival was directly related to the initial stocking density. In group C (initial stocking density 15 ind. dm^{-3}) 56.4% of the fish survived, in group D (25 ind. dm^{-3}) - 48.9%, and in group E (50 ind. dm^{-3}) – only 27.1%. All three parameters were significantly lower in group E compared to C and D.

No infectious or parasitic diseases were observed in any experiment. Water quality met the requirements of European catfish juveniles (Voynarovich 1960).

DISCUSSION

The two experimental factors – light and stocking density - considerably affected fish survival, while they had less influence over the fish growth. Differences in fish survival among the experimental groups were mainly due to different level of cannibalism.

In the first experiment cannibalism was 7% lower in case of fish reared in darkness (group B) than in group A. Light caused aggressive behavior of fish, they crowded at the bottom, near the walls, and in tank corners. The fish reared in darkness were evenly dispersed in the entire water volume and did not crowd.

In the second experiment all fish were kept in darkness, and losses due to cannibalism were lower than in the first experiment. In this experiment the level of cannibalism was directly related to stocking density. Statistically significant differences were also observed in natural mortality, which was indirectly related to aggressive behavior of the fish. At higher stocking densities, the fish which captured prey were immediately disturbed by other individuals trying to take it. Such behaviour resulted in numerous injuries, and the wounded fish, although not eaten, usually died. In natural waters, under conditions of feeding competition, cannibalism among juveniles of the same year-class is considered a natural way of regulating population density, especially in predatory fish (Loadman et al. 1986, Hecht, Pienaar 1991). Cannibalism was also observed in many fish species reared under controlled conditions, and fed to satiation (Chevalier 1973, Giles et al. 1986, Hecht, Appelbaum 1986).

Cannibalism is not limited to predatory fish – it was also observed in juveniles of such species as common carp, grass carp, and bighead carp (Dąbrowski, Poczyczyński 1988, Van Damme et al. 1989, Hecht, Pienaar 1991). It was, however, never noted in course of rearing coregonid or salmonid larvae. In the latter, cannibalism occurred at fingerling stage (Hecht, Pienaar 1991). Thus, such behavior may be related rather to initial size of the hatched larvae and their growth rate than to predatory or non-predatory way of living of adult fish.

In fish, prey size is related to the mouth size, since prey is ingested without mincing (Dąbrowski, Bardega 1984). Thus, in such fish as catfish or carp, producing relatively small larvae of high growth rate (SGR up to 40% per day, or higher), individual body size differentiates very early, and bigger fish are able to prey on smaller ones after several days from the beginning of rearing.

In salmonid fish, which produce larger larvae, and specific growth rate is much lower than in catfish or carps, cannibalism among the fish of the same year-class does not occur or starts later, at the fingerling stage.

In case of coregonids (especially in white fish), the larvae are rather small but they grow slowly, and their specific growth rate, even under optimum thermal and trophic conditions, rarely exceeds 10-12% a day. In that group no larval cannibalism was observed, either in fish reared on artificial feed or on natural food (Champigeulle, Rojas Beltran 1990, Mamcarz et al. 1995, Kozłowski et al. 1996).

Cannibalism was more pronounced in the first experiment, when the catfish grew faster. Similar results were obtained by Poczyczyński et al. (unpublished) in the experiment on European catfish reared under laboratory (slow growth) and intensive (fast growth) conditions. In slow-growing (16% a day) group losses due to cannibalism during 16 days were 5-7%, and in fast-growing group (42% a day) 15-20% of fish were eaten in 13 days.

These data indicate that high specific growth rate is accompanied by lower fish survival, mainly due to increased cannibalism. On the other hand, cannibalism may be reduced by fish rearing in darkness, at stocking densities under 25 ind. dm^{-3}.

In the second experiment, increase of fish body weight and length was lower than in the similar periods of the first experiment. This resulted from at least two causes. In the second experiment water temperature was lower by $2^{o}C$, and this must have affected fish growth rate (McCormick et al. 1971, 1972, Łuczyński 1990). Moreover, in the second experiment the fish were not fed Artemia cysts which were used in the first experiment. According to Kozłowski et al. (1994), even small addition of natural food may considerably improve catfish growth rate in the initial period of rearing.

Additionally, catfish growth rate in the second experiment might have been reduced due to high share of deformed larvae. Despite cautious selection, quality of stocking material was probably lower than in the first experiment.

REFERENCES

Champigneulle. A., Rojas-Beltran R. 1990 - First attempts to optimize the mass rearing of whitefish (Coregonus lavaretus L.) larvae from Leman and Bourget Lakes (France) in tanks and cages - Aquat. Living Resour. 3: 217-228.

Chevalier, J. R. 1973 - Cannibalism as a factor in first-year survival of early stages of walleyes - Trans. Am. Fish. Soc., 102: 739-744.

Dabrowski K., Bardega R. 1984 - Mouth size and recommendation of feed size preferences in three cyprinid fish - Aquaculture, 40: 27-40.

Dabrowski, K., Culver D. 1991 - The physiology of larval fish. Digestive tract and formulation of starter diets - Aquacult. Mag., 3/4: 49-61.

Dabrowski, K., Poczyczynski P. 1988 – Comparative experiments on starter diets for grass carp and common carp larvae - Aquaculture, 69: 317-332.

Giles N., Wright R. M., Nord M. E. 1986 - Cannibalism in pike fry, *Esox lucius* L., some experiment with fry densities - J. Fish. Biol. 29: 107-113.

Hecht T., Appelbaum S. 1988 - Observations on intraspecific aggresion coeval sibling cannibalism by larvae and juvenile *Clarias gariepinus* (Clariodae: Pisces) under controlled conditions - J. Zool. Lond., 214: 21-44.

Hecht T., Pienaar A.G. 1991 – Cannibalism: the hidden mortality factor in larviculture - Larvi'91 - Fish & Crustacean Larviculture Symposium. Lavens P., Sorgeloos P., Jaspers E., Ollevier F. eds. Europ. Aquacult. Soc., Spec. Publ. 15: 277.

Heming T. A., McInerney J. E., Alderice D. F. 1982 – Effect of temperature on initial feeding in alevins of chinook salmon (*Oncorhynchus tshawytscha*) – Can. J. Fish. Aquat. Sci., 39: 1554-1562.

Hokanson K. E. F. 1977 – Temperature requirements of some percids and adaptations to seasonal temperature cycle – J. Fish. Res. Bd. Can., 34: 639-648.

Kozlowski J., Mamcarz A., Poczyczynski P., Chybowski L., Jozsa V. 1995 – Rearing of European sheatfish (Silurus glanis L.) larvae on different dry and natural food - Larvi'91 - Fish & Crustacean Larviculture Symposium. Lavens P., P., Jaspers E., Roelants I. eds. Europ. Aquacult. Soc., Spec. Publ. 24: 293-297.

Kozłowski J., Poczyczyński P., Dostatni D., Mamcarz A. 1996 - Tank-cage method of rearing coregonid (C*oregonidae)* fish. I Politrophic lake - Acta Acad. Agricult. Tech. Olst. Protectio Aquarum et Piscatoria. 22:15-28.

Loadman, N. L., Moodie G. E. E., Mathias J. A. 1986 - Significance of cannibalism in larval walleye (*Stizostedion vitreum*) - Can. J. Fish. Aquat. Sci., 43: 613-618.

Luczynski M. 1990 - Temperature requirements for growth and survival of larval vendace, *Coregonus albula* (L) – J. Fish Biol., 38: 29-35.

Mamcarz A., Kozłowski J., Poczyczynski P., Chybowski L., Dostatni D. 1995 – Polish experiment on stimulated hatching and large-scale rearing of European coregonid larvae (Coregonidae) on dry diets – ICES mar. Sci. Symp., 201: 143-147.

McCormick J. H., Jones B. R., Syrett R. F.1971 - Temperature requirements for growth and survival of larval cisco (*Coregonus artedii*) - J. Fish. Res. Bd. Can., 28: 924-927.

McCormick J. H., Hokanson K. E. F., Jones B. R. 1972 – Effects of temperature on growth and survival of young brook trout, *Salvelinus fontinalis* – J. Fish. Res. Bd. Can., 29: 1107-1112.

Van Damme, P., Appelbaum S., Hecht T. 1989 - Sibling cannibalism in Koi carp, *Cyprinus carpio* L., larvae and juveniles under controlled condition – J. Fish Biol., 34: 855-863.

Voynarovich E. 1960 – Oxygen consumption of the larvae of pike (*Esox lucius* L.) and sheat fish (*Silurus glanis* L.) at temperatures of 0.5 to 28(C – Ann. Inst. Biol. Humg. Scient., 27: 32-47.

STRESZCZENIE

WPŁYW OŚWIETLENIA ZBIORNIKÓW I ZAGĘSZCZENIA OBSAD NA WYNIKI PODCHOWU LARW SUMA EUROPEJSKIEGO (*Silurus glanis* L.)

Wykonano dwa eksperymenty na larwach suma europejskiego, badając wpływ oświetlenia zbiorników i zagęszczenia obsad na efekty podchowu na paszy sztucznej.

W doświadczeniu pierwszym wylęg żerujący suma podchowywano w dwóch wariantach: grupę A w zbiornikach oświetlonych, grupę B w ciemności. Podchów prowadzono przez 28 dni w temperaturze 28°C w obiegu zamkniętym. Końcowe średnie długości całkowite ryb wynosiły odpowiednio w grupach A i B: 61,1 i 62,0 mm, zaś średnie masy 2265,5 i 2192,0 mg. Pod względem tych parametrów nie stwierdzono

istotnych statystycznie różnic pomiędzy grupami (test X-kwadrat, P<0,05). Śmiertelność obsad wynosiła w grupie A 80,1 zaś w grupie B 69,3%, z czego ofiarą kanibalizmu padło odpowiednio 53,7 i 43,7%. Przeżywalność obsad wyniosła w grupie A 19,9% i w grupie B 30,7%. Pod względem przeżywalności obsad i poziomu kanibalizmu wystąpiły pomiędzy grupami różnice statystycznie istotne.

W doświadczeniu drugim wylęg żerujący suma podchowywano w trzech wariantach, różniących się zagęszczeniem obsad: grupę C podchowywano w zagęszczeniu 15 szt.•dm^{-3}, wobec 25 szt.•dm^{-3} i 50 szt.•dm^{-3} w grupach D i E. Podchów prowadzono przez 21 dni w temperaturze 26°C w obiegu zamkniętym. Końcowe średnie długości całkowite ryb wynosiły odpowiednio w grupach C, D i E: 21,4; 20,5 i 21,6 mm, zaś średnie masy: 88,3; 78,7 i 79,0 mg. Nie stwierdzono istotnych statystycznie różnic pomiędzy grupami w średniej długości ciała, natomiast średnia masa ryb z grupy C była statystycznie większa niż ryb z pozostałych grup (test X-kwadrat, P<0,05). Śmiertelność obsad wynosiła w grupie C 43,6%, wobec 51,1 i 72,9% w grupach D i E, z czego ofiarą kanibalizmu padło odpowiednio 20,3; 22,9 i 36,2%. Przeżywalność obsad była tym wyższa im mniej liczebne były obsady początkowe zbiorników: w grupie C przeżyło 56,4% osobników, w grupie D 48,9% a w grupie E 27,1%. Pod względem przeżywalności obsad śmiertelności i poziomu kanibalizmu grupy C i D różniły się statystycznie od grupy E.

ADRESY AUTORÓW:

Dr Jacek Kozłowski
Dr Paweł Poczyczyński
Uniwersytet Warmińsko-Mazurski
Katedra Biologii i Hodowli Ryb
10-719 Olsztyn, ul. Oczapowskiego 5