

Arch. Ryb. Pol.	Archives of Polish Fisheries	Vol. 7	Fasc. 1	151 - 160	1999
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THE EFFECT OF INITIAL STOCKING DENSITY ON GROWTH OF EUROPEAN CATFISH (*Silurus glanis* L.) LARVAE UNDER CONTROLLED CONDITIONS

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ABSTRACT. Intensive initial rearing of European catfish (*Silurus glanis*) larvae was carried out. Initial densities of the fish were: 10, 15, 20, and 25 ind./dm³. The fish grew faster at lower densities. Average final individual body weights of the fish were: 1.71, 1.55, 1.42, and 1.27 g, and average body lengths (Lt): 5.60, 5.56, 5.51, and 5.30 mm, respectively. Survival was high and similar in all experimental groups (74.5-83.7%). The highest catfish production of initial stock number 1000 ind. was obtained at the lowest stocking density (10 ind./dm³). It was equal to 1.35 kg/m³. In all remaining groups: of 15, 20, and 25 ind./dm³ production was lower by: 17% (1.15 kg/m³), 13.8% (1.19 kg/m³), and 28.6% (1.05 kg/m³).

All tested stocking densities (10-25 ind./dm³), and method of rearing used in the experiment are applicable to commercial conditions, but the period of rearing at higher densities (20-25 ind./dm³) should be limited to 12-14 days due to considerable decrease of fish condition.

Key words: EUROPEAN CATFISH, FISH, REARING, LARVAE, *Silurus glanis*,
DENSITY DISTRIBUTION

INTRODUCTION

European catfish has become popular in Poland as an additional fish in carp ponds, and reared in polyculture with cyprinid fish. Possibilities of such polyculture were described by Wiśniewolski (1989). Recently some successful attempts of rearing catfish have been done under controlled conditions, using artificial feed (Heymann 1990, Kozłowski et al. 1995, Wolnicki 1995, Kamiński, Wolnicki 1996, Wolnicki, Starzonek 1996, Hamackova et al. 1997), or mixed food – artificial feed and natural food (Wiśniewolski 1989, Ziebarth 1991, Hamackova et al. 1992, Mejza et al. 1993, Kozłowski et al. 1995). Artificial feeds were also useful in commercial-scale rearing of European catfish larvae (Wiśniewolski 1989, Ziebarth 1991, Mejza et al. 1993, Kołdras et al. 1994, Kamiński, Wolnicki 1996). Stocking density seems one of the most important factors affecting the results of catfish rearing. In numerous studies various stocking densities were applied: from low - 3-10 ind./dm³ (Szłamińska 1986, Kamiński, Wolnicki 1996), to high – 100 ind./dm³ (Wiśniewolski 1989, Kozłowski et al. 1995), or

even 120-150 ind./dm³ when reared on live food (Mares, Kouril 1988). The results obtained by various authors cannot be, however, compared due to different conditions (water temperature, way of feeding and type of food, duration of rearing etc.). Thus, an experiment was performed in the Experimental Fish Hatchery „Dgał” to study the effect of initial stocking density (from 10 to 25 ind./dm³) on the results of intensive rearing of European catfish larvae under controlled conditions.

MATERIAL AND METHODS

European catfish larvae were reared under controlled conditions, at a semi-commercial scale, in 500 dm³ tanks (2*1*0.5 m, at water level 0.25 m), with water recirculation and purification system. Water flow was maintained so that the oxygen level would not drop below 5 mg/dm³. Water temperature and oxygen level at the water outlet were measured daily. Chemical analyses of water: ammonium nitrogen (N-NH₄), nitrite nitrogen (N-NO₂), and pH were performed every 2-3 days. The fish were kept in darkness.

Each tank was stocked with European catfish larvae aged 5 days (L.t. = 10.8 mm, w₀ = 14.9 mg) with the yolk sac still present. The fish were divided into 4 groups of various stocking density: 10 (group A), 15 (group B), 20 (group C), and 25 ind./dm³ (group D), two replicates each. The fish were reared at 26.3±1.8°C, and fed trout starter (Aller Molle Krystal 3600) containing 53% of crude protein, and 12% of crude fat. The feed was supplied 22 hours a day using conveyor feeders. Daily feeding rate was equal to 30% of fish weight at the beginning of rearing, and from the third day on this amount was increased every 2 days by 50%. The fish were fed ad libitum in all groups. Additionally, until 12-th day of rearing, the fish were supplied twice a day with frozen zooplankton (stored at -18°C for 1-3 months), at constant rate of 3 g per every 1000 fish.

The tanks were cleaned twice a day, and dead fish were counted and removed. Every 3 days the fish were bathed in formaldehyde solution (200 mg/dm³) for 20 minutes, and on 7 and 14 day in chloramine B solution (50 mg/dm³) for 30 minutes.

The experiment lasted 16 days. Before the beginning of feeding, a sample of 50 fish was taken and preserved in 4% formaldehyde solution. The fish were also sampled after 7, 10, and 13 days of rearing (35 individuals from each tank), and preserved in the same way. After the end of the experiment, the fish were counted, and 50 individuals from each tank were weighed and measured (anaesthetised using 2-phenoxyethanol), with 0.001 g and 0.01 cm accuracy.

Food conversion rate (FCR), specific growth rate (SGR), and condition (K) coefficients were calculated according to the formulas:

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

where:

P - amount of consumed food [g],

B_k - final fish biomass [g],

B_0 - initial fish biomass [g].

$$SGR = (\ln w_k - \ln w_0) \cdot 100\% \cdot t^{-1},$$

where:

w_k - final individual body weight [g],

w_0 - initial individual body weight [g],

t - duration of the experiment [days].

$$K = 100 \cdot W \cdot L^{-3},$$

where:

W - individual body weight [g],

L - total body length (L.t.) [cm].

The differences among the groups were tested using analysis of variance (ANOVA in STAGRAPHICS 4.2), at $p < 0.05$.

RESULTS

During the experiment N-NH₄ concentration ranged from 0.03-0.35 mg/dm³, N-NO₂ - from 0.01 to 0.05 mg/dm³, and water pH - from 7.3 to 8.1, not exceeding values accepted for cyprinid fish rearing (Kruger, Niewiadomska-Kruger 1990). On the 11-th day of rearing, the fish were invaded by *Ichthyobodo necatrix*. The invaded fish were immersed in 200 mg/dm³ formaldehyde solution and in 1% solution of Na Cl, for 20 minutes in each of them.

Dynamics of average body weights in all experimental groups after 7, 10, 13 and 16 days is shown in Fig. 1, dynamics of fish body lengths - in Fig. 2, and changes of condition coefficient - in Fig. 3.

The final results of rearing of catfish larvae are summarised in Tab. I. Maximum average individual body weight, total length, condition coefficients, and specific growth rate were obtained by the fish of A group, and the lowest values were obser-

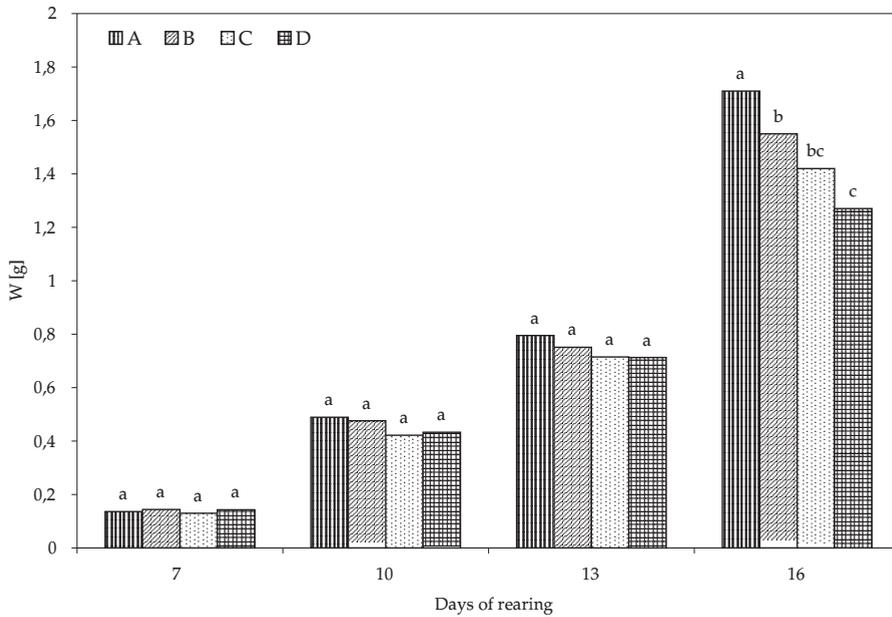


Fig. 1. Increase of average body weight (W) of catfish larvae after 7, 10, 13, and 16 days of rearing at various densities A – 10 ind./dm³, B – 15 ind./dm³, C – 20 ind./dm³, D – 25 ind./dm³. The same letter index indicates values that do not differ significantly ($p < 0.05$)

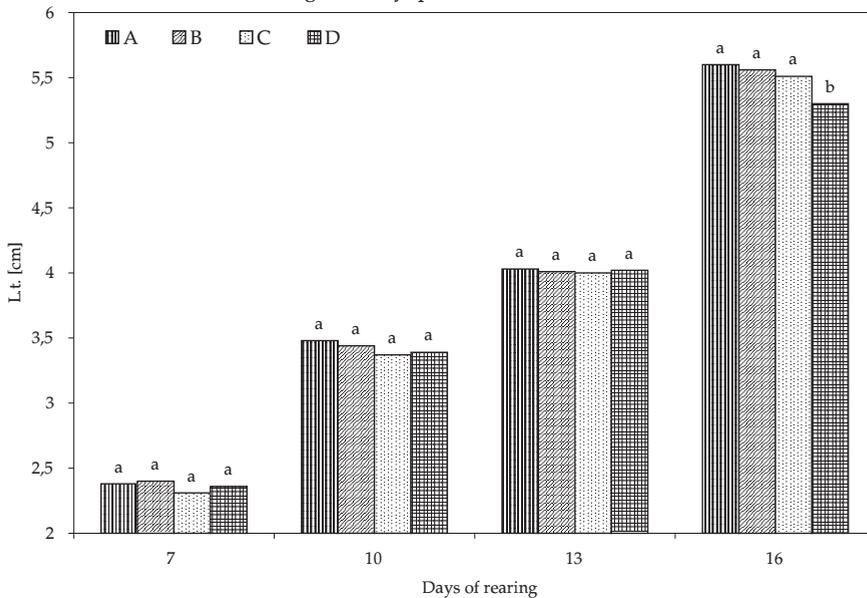


Fig. 2. Increase of average total body length ($L.t.$) of catfish larvae after 7, 10, 13, and 16 days of rearing at various densities A – 10 ind./dm³, B – 15 ind./dm³, C – 20 ind./dm³, D – 25 ind./dm³. The same letter index indicates values that do not differ significantly ($p < 0.05$)

ved in group D (Tab. I). Statistically significant differences of body weight were observed between A and B, C, D groups, and between B and D (Fig. 1). No differences were found between B and C, and between C and D groups. Final body length of fish differed significantly only between A, B, C and D group (Fig. 2).

TABLE I

Final results of 16- day rearing of European catfish larvae at various initial stocking densities (standard deviation in parentheses). Initial fish densities are given in brackets (ind./dm³) under the group symbol

Group	W	L.t.	K	SGR	FCR	Survival [%]
	[g]	[cm]	[g/cm ³]	[%/dzień]	[g/g]	
A	1.71	5.60	0.96	29.4 ^a	0.45	79.0 ^a
[10]	(±0.52)	(±0.51)	(±0.17)	(±1.9)		76.5-81.6
B	1.55	5.56	0.90	28.9 ^{ab}	0.50	74.5 ^a
[15]	(±0.37)	(±0.44)	(±0.14)	(±1.7)		70.1-78.9
C	1.42	5.51	0.84	28.3 ^b	0.47	83.7 ^a
[20]	(±0.35)	(±0.46)	(±0.08)	(±1.6)		81.9-85.4
D	1.27	5.30	0.84	27.6 ^c	0.55	82.7 ^a
[25]	(±0.34)	(±0.52)	(±0.07)	(±1.8)		79.4-86.1

Data in columns having the same superscript do not differ in a significant way ($P < 0.05$)

W - average body weight

L.t. - mean total length

K - condition factor

SGR - specific growth rate

FCR - food conversion rate

Condition coefficients were significantly different ($p < 0.05$) already after 13 days of rearing: group A differed from B, C, and D, B and C differed from D (Tab. I).

The lowest value of food conversion coefficient (0.45) was noted in group A, and the highest (0.55) in group D (Tab. I).

Survival of fish was high in all experimental groups (Tab. I), and mortality was low during fish rearing, except one tank of group B (30%), where strong invasion of *Ichthyobodo necatrix* was observed (Fig. 4).

Mortality increased between 4 and 7, and 11 and 15 day of rearing in all groups (Fig. 4). In the first case mortalities probably took place amongst the individuals unable to feed, or showing body malformations. The second mortality peak was caused by *Ichthyobodo* invasion.

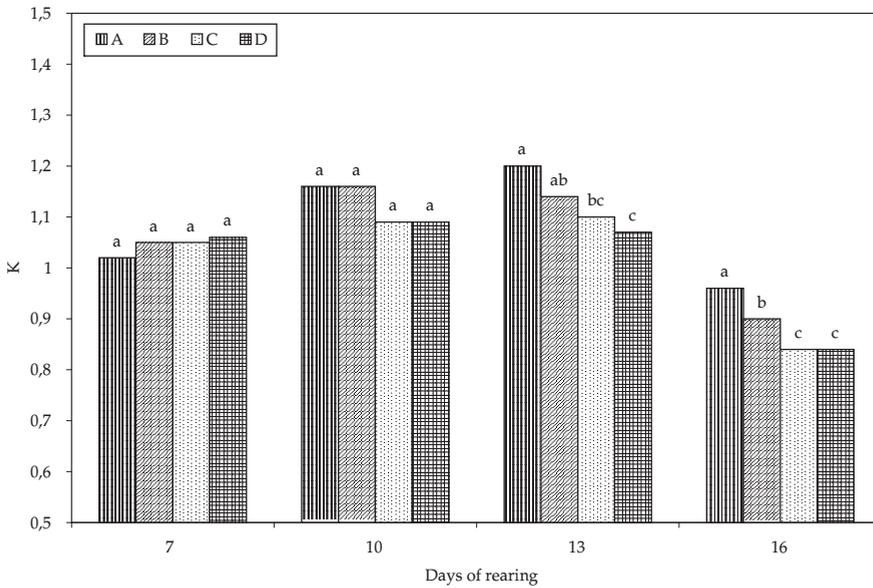


Fig. 3. Changes of condition coefficient (K) of catfish larvae after 7, 10, 13, and 16 days of rearing at various densities A – 10 ind./dm³, B – 15 ind./dm³, C – 20 ind./dm³, D – 25 ind./dm³. The same letter index indicates values that do not differ significantly (p<0.05)

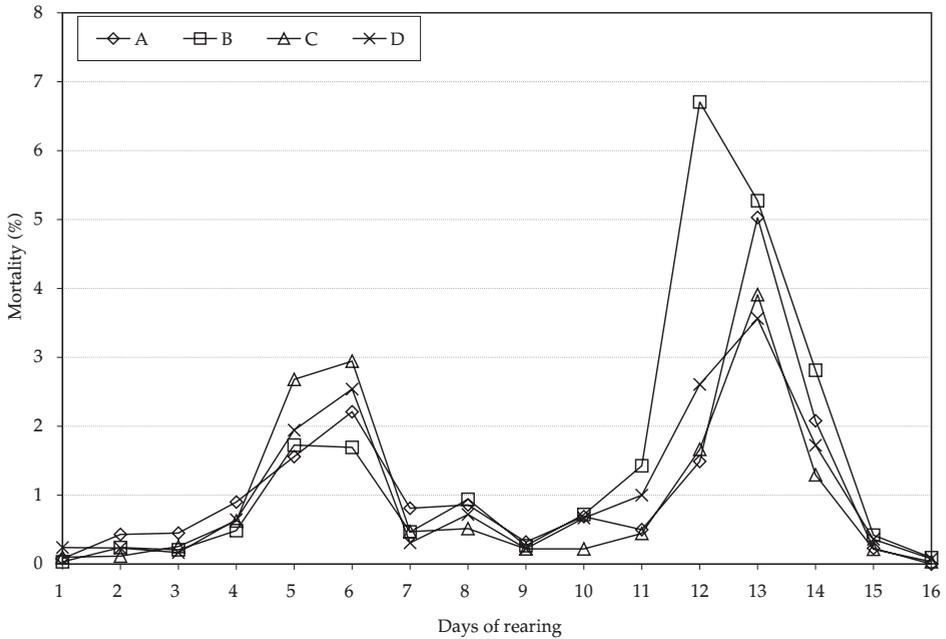


Fig. 4. Mortality of catfish larvae during 16 days of rearing at various densities A – 10 ind./dm³, B – 15 ind./dm³, C – 20 ind./dm³, D – 25 ind./dm³

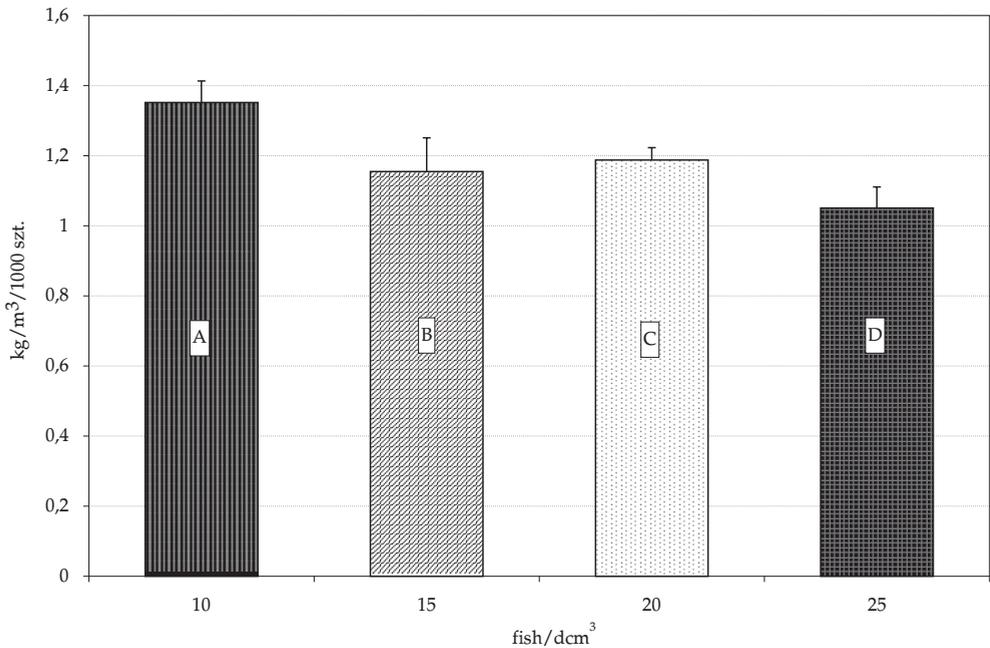


Fig. 5. Production of catfish fry (kg/m^3) obtained from 1000 individuals after 16 days of intensive rearing at various initial stocking densities ($\text{ind.}/\text{dm}^3$). Standard deviation given at the top of the bars.

Catfish production at the initial number of 1000 larvae was the highest in the group of the lowest stocking density $10 \text{ ind.}/\text{dm}^3$ – $1.35 \text{ kg}/\text{m}^3$ (Fig. 5). In all other groups of stocking densities: 15 , 20 , and $25 \text{ ind.}/\text{dm}^3$, production was lower by: 17% ($1.15 \text{ kg}/\text{m}^3$), 13.8% ($1.19 \text{ kg}/\text{m}^3$), and 28.6% ($1.05 \text{ kg}/\text{m}^3$), respectively.

DISCUSSION

The results of the experiment showed that European catfish grew better at lower initial stocking densities. Final individual body weight of fish reared in density of $10 \text{ ind.}/\text{dm}^3$ was 10% higher compared to the fish from group of $15 \text{ ind.}/\text{dm}^3$. It was also 19.5% higher than in group of $20 \text{ ind.}/\text{dm}^3$, and 34.6% higher than at $25 \text{ ind.}/\text{dm}^3$. Despite considerable differences, the fish growth even at the highest density of $25 \text{ ind.}/\text{dm}^3$ (average body weight 1.27 g, average total body length 5.3 cm) was similar or better compared to the results obtained by other authors who fed catfish in a similar way. For example, Ziebarth (1991) who reared catfish larvae on mixed food containing trout starter, live and frozen zooplankton, at 24°C and initial stocking density of

30 ind./dm³ (from day 6 – 10 ind./dm³), obtained catfish of 0.4-1.2 g after 15 days of rearing. Wiśniewolski (1989) after 28 days of rearing at 21.3°C, on trout starters and zooplankton, at initial stocking density 87-100 ind./dm³, obtained catfish fry of 0.14-0.21 g, and 2.8-3.0 cm. Kozłowski et al. (1995), after 21 days of rearing (initial stocking density 100 ind./dm³), at 24°C, obtained fish of 0.34 g on mixed diet of decapsulated brine shrimp cysts and trout starter.

Survival of catfish larvae after 16 days of rearing (74.5-83.7%) was also similar to the values obtained by other authors on natural food, artificial feed, or mixed diet (Kouril et al. 1984, Toth, Papp 1986, Mares, Kouril 1988, Wiśniewolski 1989, Heymann 1990, Ziebarth 1991, Hamackova et al 1992, Mejza et al. 1993, Kozłowski et al. 1995, Kamiński, Wolnicki 1996, Hamackova et al. 1997).

Higher initial densities (over 25 ind./dm³) in catfish rearing require further studies, as from the day 13 of rearing the differences of condition coefficients between the groups of higher and lower densities increased considerably. This may indicate that fish growth was density-limited.

CONCLUSIONS

- European catfish larvae grew faster at lower stocking densities.
- Production of catfish fry after 16 days of rearing (for 1000 individuals of initial stock) was the highest in the group of lowest initial density – 10 ind./dm³ (1.35 kg/m³). In the remaining groups of initial density 15, 20 and 25 ind./dm³, production was lower: by 17% (1.15 kg/m³), 13.8% (1.19 kg/m³), and 28.6% (1.05 kg/m³), respectively.
- Stocking density did not significantly affect the final fish survival which was high in all experimental groups (74.5-83.7%).
- All stocking densities and the method of rearing used in this study may be successfully used on a commercial scale, but rearing at higher densities (20-25 ind./dm³) should be limited to 14-12 days due to the decrease of condition coefficient.

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STRESZCZENIE

WPLYW RÓŻNEGO ZAGĘSZCZENIA POCZĄTKOWEGO OBSAD NA WZROST LARW SUMY EUROPEJSKIEGO (*Silurus glanis* L.) W CZASIE INTENSYWNEGO PODCHOWU W WARUNKACH KONTROLOWANYCH

W skali półtechnicznej na obiegu z recyrkulacją wody przeprowadzono 16-dniowy intensywny podchów larw sumy (*Silurus glanis* L.) przy zastosowaniu różnych zagęszczeń początkowych obsad wynoszących: 10 szt./dcm³, 15 szt./dcm³, 20 szt./dcm³ i 25 szt./dcm³ wody. Larwy sumy żywiono przez 12 dni pokarmem mieszanym (granulat pstrągowy plus zooplankton mrożony), a następnie samym granulatem pstrągowym. Paszę zadawano przez 22 godz./dobę. Średnia temperatura wody w czasie podchowu wynosiła 26.3 ± 1.8°C. Stwierdzono szybszy wzrost ryb podchowiwanych w niższych zagęszczeniach obsad. Uzyskano narybek sumy o średniej masie ciała wynoszącej (odpowiednio do zagęszczeń obsad): 1.71,

1.55, 1.42 i 1.27 g i średniej długości całkowitej: 5.60, 5.56, 5.51 i 5.30 cm. Obliczono współczynniki: kondycji (0.96, 0.90, 0.84 i 0.84), dobowego przyrostu średniej masy jednostkowej (29.4, 28.9, 28.3 i 27.6%/dzień) i pokarmowe (0.45, 0.50, 0.47 i 0.55). Testowane zagęszczenia początkowe obsad nie wykazały ich wpływu na przeżywalność końcową ryb, która była wysoka i wyrównana we wszystkich grupach (74.5-83.7 %). Po 13 dniach podchowu nie stwierdzono statystycznie istotnych ($P < 0.05$) różnic we wzroście ryb, ale kondycja ich w grupie o zagęszczeniu początkowym obsad 25 szt./ dcm^3 była istotnie niższa niż kondycja ryb z grup o zagęszczeniu początkowym obsad 10-15 szt./ dcm^3 . Produkcja narybku suma po 16 dniach intensywnego podchowu w przeliczeniu na 1 m^3 wody i 1000 sztuk obsadzonych larw była najwyższa w grupie o najmniejszym zagęszczeniu początkowym obsad, tj. 10 szt./ dcm^3 (1.35 kg). W pozostałych grupach o zagęszczeniu początkowym 15, 20 i 25 szt./ dcm^3 była ona niższa odpowiednio o 17 % (1.15 kg), 13.8 % (1.19 kg) i o 28.6 % (1.05 kg).

Wykorzystana metoda podchowu larw suma i testowane w przeprowadzonym doświadczeniu zagęszczenia początkowe obsad mogą być z powodzeniem stosowane w praktyce, ale okres podchowu przy wyższych zagęszczeniach początkowych (20-25 szt./ dcm^3) korzystnie jest skrócić do 14-12 dni.

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