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Short communication

THE IMPACT OF PHOTOPERIOD AND STOCKING DENSITY ON THE GROWTH AND SURVIVAL OF NARROW-CLAWED CRAYFISH (*ASTACUS LEPTODACTYLUS* Esch.) LARVAE

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ABSTRACT. The aim of the study was to determine the impact of various photoperiods and stocking densities on the growth and survival of narrow-clawed crayfish larvae. The four-week rearing period was carried out in 50 dm^3 tanks in a closed recirculating system. The tanks were stocked with larvae two weeks post hatch with an average body length of 11.2 ± 0.9 mm (TL) and weight of 32.3 ± 2.5 mg. There were three stocking densities (300, 600, and 1200 specimens m^{-2}) and two photoperiods (groups L – 24-hour illumination and groups D – 24-hour darkness). The crayfish were fed ad libitum every 12 hours with granulated feed (45% protein, 6-12% lipid). The experiment indicated that photoperiod had a significant impact ($P < 0.05$) on the crayfish survival rate, while stocking density impacted growth. Crayfish survival was almost two times higher with 24-hour illumination than it was with 24-hour darkness at each of the stocking densities. The survival and the growth rate of crayfish decreased as the initial stocking density increased. The final biomass of the crayfish stocks reared in 24-hour darkness was similar for each of the stocking densities applied, but the biomass of stocks reared with 24-hour illumination increased along with the stocking densities used. This indicates that it is possible to apply initial densities even greater than 1200 specimens m^{-2} during crayfish rearing with 24-hour pond illumination.

Key words: NARROW-CLAWED CRAYFISH (*ASTACUS LEPTODACTYLUS*), REARING, LARVAE, PHOTOPERIOD, STOCKING DENSITY

One of the ways to intensify crayfish cultivation is to rear larvae under controlled conditions using granulated feed. Since the rearing requirements of the signal (*Pacifastacus leniusculus* Dana), noble (*Astacus astacus* L.) and narrow-clawed crayfish (*Astacus leptodactylus* Esch.) are similar, the same rearing techniques are applied (Ackefors and Lindqvist 1994). To date, most published information regarding the application of granulated feed refers to signal and noble crayfish, and there is little information regarding its use with narrow-clawed crayfish. In Poland, only natural food is used in the first few weeks of rearing narrow-clawed crayfish; granulated,

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artificial feed is not provided until later rearing stages (Strużyński and Niemiec 2001). Illumination conditions and stocking densities are basic factors that can impact crayfish stock survival and growth. Crayfish are nocturnal (Bojsen et al. 1998, Lozan 2000), thus, it is reasonable to assume that rearing in darkness under controlled conditions might stimulate an increased crayfish growth rate. In studies conducted to date either a natural photoperiod or one similar to it (L12 : D12) have usually been applied (Ackefors et al. 1989, Policar and Kozak 2001). The results of studies on the impact that illumination intensity and the duration of the photoperiod have on the survival and growth of crayfish have been ambiguous (Nynström 1994, Saez-Royuela et al. 1996). There are also significant differences in the recommended initial stocking density in crayfish rearing from about 100 specimens m^{-2} (Gydemo and Westin 1989, Gydemo and Westman 1993, Ackefors and Lindqvist 1994, Nynström 1994) to even 3,000 specimens m^{-2} of stage two larvae (Policar and Kozak 2001).

The aim of the current study was to determine the impact photoperiods and stocking densities had on the growth and survival of narrow-clawed crayfish larvae reared under controlled conditions on granulated feed.

The material for the study consisted of narrow-clawed crayfish larvae two weeks post hatch. All of the specimens were in stage II of larval development, i.e. they had molted once. Their average total body length was 11.2 ± 0.9 mm (TL) and the average body weight was 32.3 ± 2.5 mg. Rearing was carried out in rotation tanks with a volume of 50 dm^3 in a recirculating system equipped with a thermal regulation system and a biological filter. Each tank was outfitted with one hiding place per specimen made of garden hose cut into 2-3 cm segments. There were three initial stocking densities - 300, 600 and 1200 specimens m^{-2}, and two photoperiod variants - 24-hour illumination (groups L – 100 lux) and constant darkness (groups D – 0 lux). There were two replicates of each stocking density and photoperiod. The crayfish were reared for four weeks and fed with artificial, granulated feed (45% protein and 6-12% lipids) provided ad libitum every 12 hours.

Measurements of water temperature and oxygen content were taken daily using an OxyGuard electronic measurement device. Every two to three days water samples were collected for analysis - pH was determined with a PM 600 electronic device; ammonia nitrogen $N\text{-}NH_4$ (Nessler method) and nitrite nitrogen $N\text{-}NO_2$ (sulfanil method) were determined with the colorimetric method (spectrophotometer Spekol 11). The average water temperature during rearing was 21.8 ± 0.3°C, and water oxygenation was above 6 mg O_2 dm^{-3}. At a water pH of 8.0-8.3, the ammonia nitrogen content did not exceed 0.1 mg N-NH_4 dm^{-3}, while that of nitrite nitrogen was not greater than 0.05 mg N-NO_2 dm^{-3}.

After the rearing period ended, all of the crayfish specimens were removed from the water and counted. The whole stock was weighed to the nearest 0.1 g. The average crayfish weight was calculated by dividing the stock biomass from each pond by the number of specimens it contained. Each of the pond stocks was photographed, and then the length of individual crayfish specimens was measured (30 specimens from the D groups and 15 from the L groups). The measurements were taken to the nearest 0.1 mm using the MultiScan computer program. The results were analyzed statistically using Statistica 5.1. One-way analysis of variance (ANOVA) was applied, and then the post-hoc averages were compared using the Duncan's test, at a significance level of $\alpha = 0.05$.

The results of the experiment results indicate that photoperiod had a significant impact on crayfish survival, while stocking density influenced the growth rate ($P < 0.05$). At all stocking densities, the survival of the crayfish in tanks that received 24-hour illumination was nearly two times higher than that of specimens held in the dark (Table 1). The highest crayfish survival (70%) was obtained in group L300, and the lowest (15.5 and 18.8%) in groups D600 and D1200. The fastest specific growth was observed in the crayfish from groups D600 and D1200; this was undoubtedly influenced by a survival rate that was several times lower than in the other groups. Crayfish survival and growth rate decreased as the initial stocking density increased (Table 1). Other authors have also reported that increased stocking density has a decidedly negative impact on crayfish growth (Ackefors et al. 1989, Gydemo and Westin 1989, Ackefors and Lindqvist 1994).

TABLE 1

Impact of the modified photoperiod (groups L – 24-hour illumination, groups D – 24-hour darkness) and stocking density (300, 600 and 1200 specimens m^{-2}) on the growth and survival of narrow-clawed crayfish larvae during the four-week rearing period. The average values in columns with different indexes differ significantly statistically ($P < 0.05$)

Group	Body weight (mg)		Body length (mm)		Survival (%)	
	average	SD	average	SD	average	SD
L300	234	15	17.2^c	1.9	70.0^a	2.8
L600	201	8	16.3^d	1.3	58.0^b	0.0
L1200	167	2	15.2^e	1.7	47.8^c	2.5
D300	201	46	16.3^d	1.6	45.0^c	4.2
D600	288	17	18.8^a	2.9	15.5^d	2.1
D1200	261	28	18.0^b	2.4	18.8^d	2.5

The final biomass of the crayfish stocks reared in 24-hour darkness was similar at all stocking densities, while in 24-hour illumination it increased as stocking density increased (Fig. 1). The highest stock biomass (96 g m^{-2}) was recorded in group L1200, and the lowest (27 g m^{-2}) in group D600. This indicates the possibility of using initial stocking densities even higher than 1200 specimens m^{-2} when crayfish are reared in 24-hour illumination. Most authors recommend applying an initial stocking density of 50-150 specimens m^{-2} (Ackefors et al. 1989, Gydemo and Westin 1989, Gydemo and Westman 1993, Ackefors and Lindqvist 1994, Nynström 1994). The maximum stocking densities applied in noble crayfish rearing were close to 3000 specimens m^{-2} in the III stage of development (Policar and Kozak 2001). During further rearing, these authors decreased the stocking densities to about 480 specimens m^{-2} as recommended by Hager (1996).

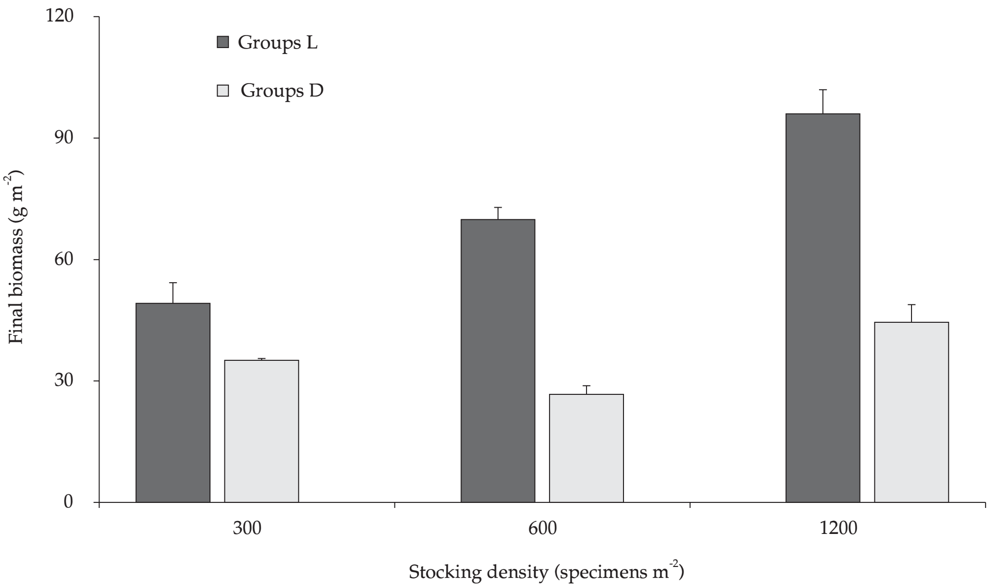

Fig. 1. Impact of the modified photoperiod (group L – 24-hour illumination, groups D – 24-hour darkness) and stocking density on the final biomass of the narrow-clawed crayfish stock.

The results obtained in the current study indicated that the stock survival and specific body weight of the narrow-clawed crayfish decreased as the initial stocking density was increased. Nynström (1994), who obtained similar results rearing signal crayfish, identified three factors in addition to stocking density that influence crayfish survival - the number of hideouts, illumination intensity (> 600 lux) and food availability. The highest mortality rate during the rearing of signal crayfish larvae was observed in the first 40-60 days (Saez-Royuela et al. 1995). In another study, Saez-Royuela et al. (1996) did not confirm that lengthening the natural illumination cycle had a significant impact on the survival and growth of signal crayfish. They compared the growth of signal crayfish larvae reared in a natural photoperiod (L13.5-15 : D9-10.5) and a modified one (L24 : D0) with the application of additional illumination at an intensity of 850 lux. According to Lozan (2000), signal crayfish display 33% of their diurnal activity during the day, while narrow-clawed and noble crayfish - only 16 and 12%, respectively. It would be useful to verify if lengthening the natural photoperiod during narrow-clawed crayfish rearing is recommended, and if it has a positive impact on the results. It is equally significant to determine what the impact is of various illumination intensities on the effectiveness of narrow-clawed crayfish rearing, as, in the current study, the illumination intensity was 100 lux, which is several times lower than that recommended for signal crayfish (Nynström 1994).

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STRESZCZENIE

WPŁYW FOTOPERIODU I ZAGĘSZCZENIA OBSAD NA WZROST I PRZEŻYWALNOŚĆ LARW RAKA BŁOTNEGO (*ASTACUS LEPTODACTYLUS*)

Celem pracy było określenie wpływu fotoperiodu i zagęszczenia obsad na wzrost i przeżywalność larw raka błotnego. Czterotygodniowy podchów prowadzono w basenach o objętości 50 dm^3 w obiegu recyrkulacyjnym. Baseny obsadzono larwami w wieku 2 tygodni od wyklucia, o średniej długości ciała 11,2 ± 0,9 mm (TL) i masie ciała 32,3 ± 2,5 mg. Zastosowano trzy warianty zagęszczenia obsad: 300, 600 i 1200 sztuk m^{-2} oraz dwa fotoperiodu: grupy L – całodobowe oświetlenie i grupy D – całodobowe zaciemnienie. Raki karmiono ad libitum, co 12 h paszą granulowaną o zawartości 45% białka i 6-12% tłuszczu. Przeprowadzone doświadczenie wykazało istotny wpływ fotoperiodu na przeżywalność, a zagęszczenia obsad na wzrost raków ($P < 0,05$). Przy całodobowym oświetleniu basenów przeżywalność raków była blisko dwukrotnie wyższa niż przy całodobowym zaciemnieniu w każdym z użytych zagęszczeń obsad. Przeżywalność i tempo wzrostu raków malały wraz ze wzrostem zagęszczenia początkowego obsad (tabela 1). Przy całodobowym zaciemnieniu basenów uzyskano podobną końcową biomasę obsad raków w każdym z użytych zagęszczeń. Natomiast przy całodobowym oświetleniu biomasa obsad rosła wraz ze wzrostem użytych zagęszczeń (rys. 1). Wskazuje to na możliwości stosowania jeszcze większych niż 1200 sztuk m^{-2} zagęszczeń początkowych obsad przy podchowie raków prowadzonym w warunkach całodobowego oświetlenia basenów.