The Effect of Photoperiod on Growth and Survival of Juvenile Freshwater Prawn, *Macrobrachium rosenbergii*, in Nursery Tanks

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ABSTRACT. To achieve marketable size (> 30 g) in the limited growing season available in temperate areas, post-larval freshwater prawn, *Macrobrachium rosenbergii*, must be grown to a larger size (from 0.01 to > 0.2 g) prior to pond stocking. This is known as the nursery phase. Little research has been conducted on the effects of different management and environmental factors on juvenile prawn growth and survival during this 30-60 day period. The objective of this study was to evaluate the effects of three different photoperiods on growth and survival of juvenile freshwater prawn during nursery production. Four hundred post-larval (PL) freshwater prawns (0.025±0.04 g) were stocked into nine 170-L nursery tanks at 2.3 PL/L with artificial substrate added to each tank at a rate to achieve a density of 430 PL/m^2 of substrate. Tanks were randomly assigned to one of the following photoperiod regimens: 24 hours darkness (L0:D24); 12 hours light:12 hours darkness (L12:D12); or 24 hours light (L24:D0), with three replicate tanks per treatment.

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Journal of Applied Aquaculture, Vol. 11(4) 2001

Freshwater prawn were fed a trout diet containing 42% protein and 8% lipid according to a feed table. After 60 days, there was no significant difference ($P > 0.05$) in average individual weight of freshwater prawn exposed to the different light regimens (overall mean 0.86 g). Survival was significantly greater ($P < 0.05$) in prawn raised under continual light conditions (L24:D0) (72%) than those raised under L12:D12 (59%) or continual darkness (L0:D24) (58%); values for these latter two treatments did not differ significantly ($P > 0.05$). This study indicates that continual light conditions have a positive impact on survival of freshwater prawn juveniles during the nursery phase.

KEYWORDS. Photoperiod, *Machrobrachium rosenbergii*, growth, survival

INTRODUCTION

Freshwater prawn, *Macrobrachium rosenbergii*, culture has become increasingly popular in temperate regions (Kentucky, Tennessee, and Arkansas) of the U.S. and production has increased rapidly over the past five years (Tidwell and D'Abramo 2000). In temperate regions production includes three distinct phases: brackishwater larval period (hatchery); freshwater indoor-tank period of growth to advanced stocking size (nursery); and pond grow-out (D'Abramo et al. 1995). The nursery phase allows for the production of marketable sized (> 30 g) individuals in the limited growth period (120 days) of temperate production, by increasing the growing season by growing post-larvae (PL) to advanced juvenile stages (> 0.2 g) in temperature-controlled tanks prior to pond stocking. In nursery production, prawn attain an average weight of approximately 0.3 g in 30-60 days (D'Abramo et al. 1989). However, little research has been conducted on the effects of different management practices or environmental factors on juvenile freshwater prawn growth and survival during this period.

In crustaceans, photoperiod has been shown to affect food consumption (Minagawa and Murano 1993; Minagawa 1994), molting frequency (Constanon-Cervantes et al. 1995), cannibalism (Gardner and Maguire 1998), and growth performance (Aiken et al. 1983). However, the actual effects of photoperiod are highly variable among different genera. Conflicting results have been reported on the effects of photoperiod on juvenile prawn. Withyachumnarnkul et al. (1990) reported that freshwater prawn juveniles grown for

110 days in total darkness (L0:D24) had greater weight gains and higher survivals than those grown under other light regimens (L12:D12, L16:D8, or L20:D4). However, Lin (1991) reported that growth and survival of freshwater prawn larvae increased with increasing photoperiods.

Since the nursery phase of temperate prawn production takes place indoors, it is relatively easy to manipulate lighting conditions within the tanks. The purpose of this study was to compare the effect of different photoperiods (continual darkness, a 12L:12D light regimen, and continual light) on growth and survival of juvenile freshwater prawn under simulated nursery conditions.

MATERIALS AND METHODS

Four hundred freshwater prawn post-larvae (0.025±0.04 g) were stocked into each of nine 170-L semi-square, polyethylene tanks housed in a temperature-controlled greenhouse at the Aquaculture Research Center, Kentucky State University, Frankfort, Kentucky. Artificial substrate, in the form of horizontally-layered sheets of 0.625-cm black plastic mesh supported by a PVC frame, was provided to achieve a density of 430 PL/m^2. Tanks were randomly assigned to one of three photoperiod treatments: 24 hours darkness (L0:D24); 12 hours light:12 hours dark (L12:D12); or 24 hours light (L24:D0). Each of the three replicate tanks within a treatment were housed together within an 8-mm black plastic light-proof enclosure. In the treatments that received light, two 60-watt full-spectrum fluorescent bulbs (Sylvania, Danvers, Massachusetts[1]) were suspended above the three tanks for illumination. The L12:D12 treatment was controlled by a timer. Light intensity was measured at 1850 lux at the water's surface, using a Broad Range LUX/FC meter (Aquatic Ecosystems Inc., Apopka, Florida).

Freshwater prawn were fed a #4 crumble (42% protein and 8% lipid) commercial trout diet (Silver Cup, Murray, Utah) according to rates and schedules recommended by D'Abramo et al. (1989). The daily ration was divided into two equal feedings (0900 and 1500).

All experimental units received approximately 5 L/minute of tempered water from an outside reservoir pond. Water temperatures in all tanks were maintained at 28°C by flowing water through a common heat pump unit. Each tank was aerated by an air stone supplied with air from a regenerative blower. Water temperature and dissolved oxygen were measured twice daily (0800 and 1500), using a YSI Model 55 oxygen meter (YSI Industries, Yellow Springs, Ohio). Total ammonia-nitrogen and nitrite-nitrogen were measured 3 times per week using a DREL 2000 spectrophotometer (Hach Company, Loveland, Colorado); pH was measured daily with an electronic pH meter (pH pen;

1. Use of trade or manufacturer's name does not imply endorsement.

Fisher Scientific, Cincinnati, Ohio). Un-ionized ammonia was calculated as a percentage of total ammonia, based on temperature and pH, using a table provided by Boyd (1979).

Total duration of the experiment was 60 days, which corresponds to the normal maximum length of the nursery phase for juvenile prawn in temperate regions. Treatments were evaluated in terms of prawn growth and survival. Growth performance values were calculated as follows: feed conversion ratio (FCR) was calculated from FCR = total diet fed (g)/ total wet weight gain (g); specific growth rate (SGR, %/day) was calculated from = $[(\ln W_f - \ln W_i)]/t(100)$: where W_f = final weight; W_i = initial weight; and t = time in days (Ricker 1975).

Growth, survival, and water quality data were compared by analysis of variance (ANOVA) using Statistix version 4.1 (Analytical Software, Tallahassee, Florida). If ANOVA indicated significant differences among treatments, Fisher's Least Significant Difference test (LSD) was used to determine differences among means ($P < 0.05$). All percentage and ratio data were transformed to arc sin values prior to analysis (Zar 1984). Data are presented as untransformed values to facilitate interpretation.

RESULTS AND DISCUSSION

There was no significant difference in water quality values among the three treatments either by week or over the entire study period. Overall means for water quality variables were: temperature, 28.1±0.0°C; dissolved oxygen, 6.4±0.2 mg/L; pH, 7.9±0.1; total ammonia-nitrogen, 0.52±0.01 mg/L; un-ionized ammonia, 0.03±0.01; and nitrite-nitrogen, 0.08±0.0 mg/L. These values represent suitable culture conditions for freshwater prawn juveniles (New 1995).

Average weight at harvest and SGR were not significantly different ($P > 0.05$) among freshwater prawn grown under the different light regimens and averaged 0.86 g and 6.4%/day, respectively (Table 1). Survival was significantly higher ($P < 0.05$) in freshwater prawn grown under continual light conditions (L24:D0) (72%) than for freshwater prawn grown under conditions of 12L:12D (59%) or 24-hour darkness (58%); values for the latter two treatments were not significantly different ($P > 0.05$) from each other (Table 1). Total production (g/L) was significantly higher ($P < 0.05$) for freshwater prawn grown using 24L:0D (1.1 g/L) than for prawn grown under 12L:12D or 0L:24D (0.95 and 0.83 g/L, respectively). FCR for freshwater prawn grown under continual light (L24:D0) (1.2) were significantly lower ($P < 0.05$) than for freshwater prawn grown under 12L:12D (1.4) or 0L:24D (1.6). The FCR of freshwater prawn grown at 12L:12D was significantly lower ($P < 0.05$) than in

TABLE 1. Mean±SE for production characteristics of juvenile freshwater prawn subjected to either continual light (L24:D0), 12 hrs light and 12 hrs darkness (L12:D12), or continual darkness (L0:D24) for 60 days. Means within each row followed by different letters are significantly different ($P \leq 0.05$). Values are means of three replicate groups.

	Light Schedules		
	L24:D0	L12:D12	L0:D24
Mean individual weight (g)	0.85±0.03a	0.91±0.08a	0.83±0.07a
Survival (%)	72.3±0.9a	59.1±7.3b	57.7±3.1b
Total production (g/L)	1.10±0.04a	0.95±0.07b	0.83±0.02b
FCR	1.2±0.0c	1.4±0.1b	1.6±0.0a
SGR (%/day)	6.4±0.0a	6.5±0.1a	6.4±0.1a

those grown at 0L:24D, indicating a consistent direct increase in feed conversion efficiencies with increases in length of light exposure.

These data differ from those presented by Withyachumnarnkul et al. (1990), who stated that freshwater prawn juveniles grown under total darkness had better growth and survival rates (42%) than those cultured under other light-dark periods. However, closer examination of the author's data reveals that survival percentage was actually higher (48%) in the treatment with the longest period of illumination (L20:D4). Continual light was not tested, and no statistical analysis was possible, as there was no replication. However, results from the present study are in agreement with Lin (1991), who reported that growth and survival of freshwater prawn larvae were improved with increasing photoperiod length.

Studies on the effect of light regimens in other crustaceans have generally addressed larval development and are highly variable among species. Different light conditions have been reported to affect the molting frequency in crustaceans. Aiken et al. (1983) reported larger individual weights in American lobsters, *Homarus americanus*, cultured in continual darkness and that duration of light did not affect molting frequency. Gardner and Maguire (1998), working with the Australian giant crab, *Pseudocarcinus gigas*, larvae, found that increasing photoperiod increased the molting frequency and resulted in increased cannibalism and reduced survival. Continual darkness has been reported to reduce molting frequency in red swamp crayfish, *Procambarus clarkii*, possibly by altering the relationship between the X-organ molt inhibiting hormone and the Y-organ molting hormone (Constanon-Cervantes et al.

1995). In contrast, Bishop and Herrnkind (1976) found increased molting frequency in pink shrimp, *Penaeus duorarum*, grown in complete darkness and suggested that this species may have an endogenous molt rhythm in the absence of light.

The effect of different light conditions on molting frequency in freshwater prawn is currently unknown. It is possible that freshwater prawn are similar in this respect to pink shrimp, which demonstrated an increase in molting frequency when raised in complete darkness (Bishop and Herrnkind 1976). This would potentially make the freshwater prawn more susceptible to cannibalism. Freshwater prawn display territorial aggressive behavior toward conspecifics to establish dominance (Schmalback et al. 1994; New 1995) and freshwater prawn which have recently molted (soft shelled) are particularly vulnerable to territorial and cannibalistic attack from other freshwater prawn (New 1995).

Smith and Sandifer (1979) reported a significant preference in post-larva freshwater prawn to dark or shaded areas in nursery tanks. This study found improved survival when freshwater prawn juveniles were grown under continual light conditions. It may be that continual light results in reduced activity in freshwater prawn juveniles, a strategy of photophobic species for avoidance of visual predators during the day by seeking cover (Hecht and Pienaar 1993). Improved feed conversion efficiencies could also be potentially explained by reduced energy demands due to reduced activity levels in freshwater prawns raised under continual light conditions.

This study indicates that continual light conditions have a positive impact on survival, total production, and feed conversion efficiency of freshwater prawn juveniles during nursery production. Further refinement of light schedules, quantity, and quality could potentially further improve production.

ACKNOWLEDGMENTS

The authors would like to thank Ranhi Thornton for aiding in water quality analysis and James Johnson for continued effort in support of this project. This research was funded by a USDA-CSREES grant to Kentucky State University under agreement KYX-80-00-09A.

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