EFFECT OF STOCKING DENSITY ON EXTENSIVE PRODUCTION OF FRESHWATER SHRIMP IN COAL MINE RECLAMATION PONDS

by

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Abstract: The use of post-mining reclamation ponds for the production of freshwater shrimp was evaluated by examining different stocking densities. Juvenile shrimp (Macrobrachium rosenbergii) averaging 0.5g each were stocked into four existing ponds at Peabody's Ken Surface Mine at 6,175; 12,350; 18,500; and 24,700/ha (2,500, 5,000, 7,500, and 10,000/acre) on June 1, 1995. Shrimp were fed twice a week for 103 days, with harvest conducted September 13, 1995. Survival averaged 40%, overall. Average individual weight size was inversely related to stocking density ranging from 52 g (8.7 shrimp/lb) at 6,175/ha to 20.3 g (22.7 shrimp/lb) at 18,500/acre. Total production was directly related to stocking density ranging from 97 kg/ha (86 lbs/acre) at low density to 211 kg/ha (188 lbs/acre) at 18,500/ha shrimp acre. The major difficulty was at harvest due to difficulty in draining ponds. Construction of designed culture ponds with gravity drains during reclamation could greatly enhance survival, harvestability, and commercial feasibility.

Additional Key Words: Freshwater shrimp, density, reclamation

Introduction

During the post-mining reclamation process ponds are often constructed for silt control and wildlife enhancement. In western Kentucky alone over 2,000 water acres have been constructed, and represent an underutilized resource. If consideration was given during construction to criteria of water depth and bottom configuration ponds could be constructed that would be amenable to production of aquaculture species. This would allow the reclaimed land to more quickly be returned to a productive capacity and potentially provide a new cash crop for small farmers in the region.

Due to logistics of many post-mining sites daily feeding and intensive management procedures may be difficult. Because of this, extensive production methods, and species suited to them, may be the most promising approach. Extensive culture normally implies that mechanical aeration is not available and that the animals derive a large portion of their nutrition from natural productivity. The freshwater prawn (Macrobrachium rosenbergii) is a benthic omnivore (Pilay 1990) which can efficiently utilize natural productivity (Tidwell et al.1997). Prawns are also a high value product with a value of $22-26.5/kg ($10-12/lb) live weight (New 1995). If prawn production could be shown to be biologically feasible, design criteria for aquaculture production ponds could be adopted during the reclamation process when costs differences would be relatively minor. The present study was designed to evaluate the biological feasibility of growing prawns in post-reclamation ponds and the effects of stocking density on their survival, growth, and total production.

Materials and Methods

Description, preparation, and stocking of ponds

Ponds were located at Ken Surface Mine, Rockport, KY. Four ponds were selected from nine candidates based on depth ($\leq$ 3 m), size (< 1-ha), exposure to prevailing winds (for aeration and circulation), and accessability. These ponds had total alkalinity values measured at 50-65 mg/l, total hardness 80-120 mg/l, and afternoon pH of 8.3-8.7. These values represent conditions well suited for freshwater prawns (Vasquez et al. 1989). Approximately one week prior to stocking, ponds were treated with Rotenone at 2.0 mg/l and calcium hypochlorite

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at 10 mg/l available chlorine to remove competing and predatory fish and insects.

Juvenile prawns averaging 0.5 g were transported by truck from a commercial supplier (Aquaculture of Texas, Weatherford, TX) and stocked on 1 June 1995. The ponds were randomly assigned one of four stocking densities: 6,175; 12,350; 18,500; and 24,700/ha (2,500; 5,000; 7500; and 10,000/acre) immediately prior to stocking.

Sampling

A 3.2 mm square mesh seine was used to collect a sample of ≥ 50 prawns from each pond monthly during the study period. Prawns composing the sample were counted, group-weighed, and returned to the pond.

Feeding

Prawns were fed twice weekly, a calculated percentage of body weight based on size dependent feeding rates recommended by Daniels and D'Abramo (1994). The diet was similar to the formulation utilized by Tidwell et al. (1993) and contained approximately 32% protein. Dietary ingredients were processed into 5 mm sinking pellets by a commercial feed mill (Farmers Feed, Lexington, KY).

Water Quality

Dissolved oxygen (DO) and temperature of all ponds were monitored twice weekly using a YSI Model 57 oxygen meter (Yellow Springs Instruments, Yellow Springs, OH). The pH of each pond was determined in the afternoon, twice weekly, using an electronic pH meter (Hanna Instruments, Ltd., Mauritius).

Harvest

One day prior to harvest on 12 September 1995, water depth in ponds was lowered to approximately 1.0 m. One the following day, prawns were seine harvested from each pond using a 1.3 cm square mesh seine. After three successive seinings, ponds were drained completely. Remaining prawns were manually harvested from the pond bottom and purged in clear water. Total bulk weight and number of prawns harvested from each pond were recorded.

Results and Discussion

Water quality appeared acceptable throughout the culture period. Since no mechanical aeration or circulation was used, benthic conditions could have differed as measurements were taken on surface waters and ponds may have been thermally stratified.

Correlation analysis (Steel and Torrie1980) on stocking density (prawns/ha), harvest density (prawns/ha), survival (%), total production (kg/ha), pond size (g) indicated significant relationships ($P < 0.10$) between harvest density and total production ($P < 0.05$) and harvest density and average prawn size ($P < 0.10$). A significant relationship ($P < 0.05$) was also indicated between total production and average prawn weight. These relationships were investigated using regression analysis with harvest density as the independent variable vs total production as the dependent variable and with average weight as the dependent variable. Regression analysis was also run with production as an independent variable and average weight as dependant variable.

Regression of total production on harvest density (Neter and Wasserman 1974) was highly significant ($P < 0.01$). There was a positive relationship between the two

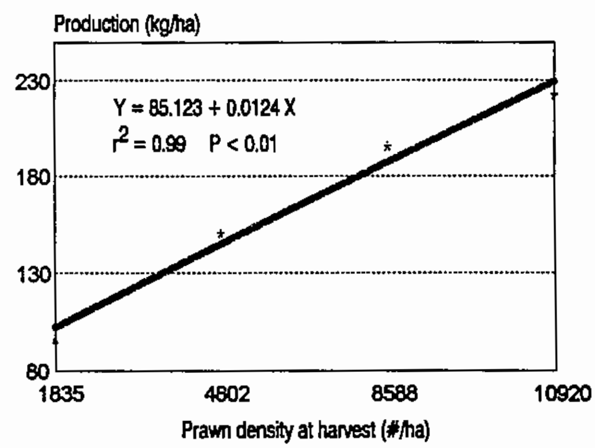

Figure 1. The relationship between total production (y) and prawn density at harvest (x).

variables with production increasing as harvest density increased (Figure I).

The r^2-value indicates that under these conditions 99% of the variation in total production is accounted for by harvest density. The negative relationship between average prawn weight and harvest density was also described well by a straight line (Figure II) as indicated by statistical significance of the regression ($P < 0.10$). Their coefficient of determination (r^2) indicates that harvest density accounts for 87% of the observed variation in harvest weight.

The interaction of different mortality rates with different stocking rates actually determined the "functional" density through the remainder of growout. If mortality had occurred late in the production cycle stocking rate would

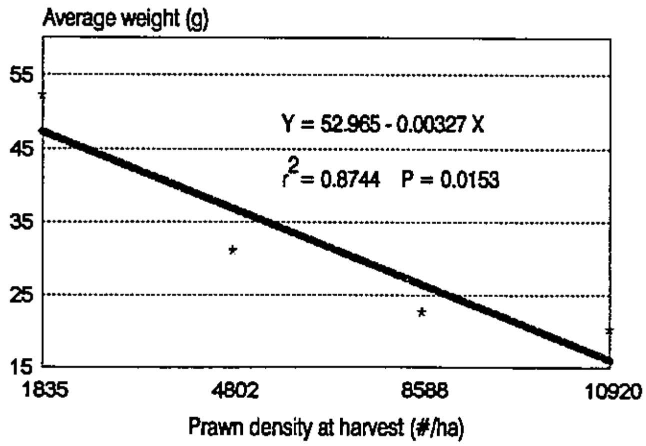

Figure 2. The relationship between average individual prawn weight (y) and prawn density (number) at harvest (x).

likely have had a stronger influence. The regression of average prawn weight on total production (Figure III) was also statistically significant ($P < 0.05$).

If a harvestable weight of ≥20 g (MacLean et al. 1989) is used as a target size then this regression equation

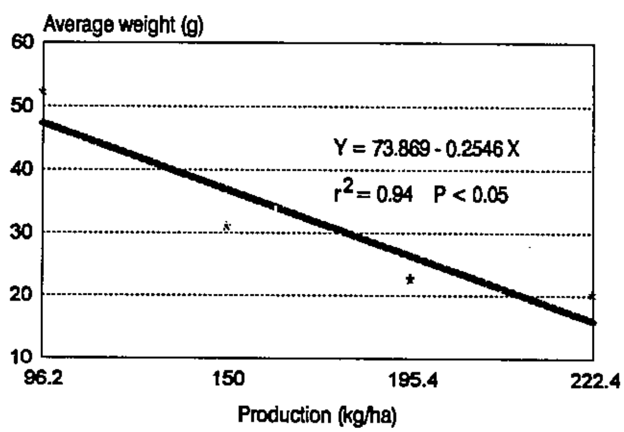

Figure 3. The relationship between average individual prawn weight (y) and total production (x).

yields a maximum productivity of approximately 212 kg/ha, to maintain an average weight of approximately 20 g. This would likely represent the carrying capacity (kg/ha) of this unaerated system. In contrast, Tidwell et al. (1997) reported that the carrying capacity of an aerated system with no feed input was approximately twice that amount (425 kg/ha), an aerated and fertilized system was five times greater (1056 kg/ha) and aerated with daily feed six times greater (1,261 kg/ha).

These results indicate that production of freshwater prawns in post-mining reclamation ponds is biologically feasible, but that per unit production of harvest size shrimp is low (approximately 200 kg/ha). In ponds with proximity to electrical power productivity could likely be increased by mechanical mixing and fertilization. In more remote locations use of wind powered mixing devices should be evaluated. Another possible approach would be to stock complimentary finfish species in polyculture with the prawns (Landau 1992). This could potentially decrease stratification and increase total pond productivity by feeding in different ecological feeding niches.

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