A Preliminary Evaluation of Naturally Occurring Organisms, Distillery By-Products, and Prepared Diets as Food for Juvenile Freshwater Prawn *Macrobrachium rosenbergii*

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ABSTRACT. The relative acceptability and suitability of naturally-occurring pond organisms identified as likely natural food items for juvenile freshwater prawn, *Macrobrachium rosenbergii*, were evaluated under controlled conditions. The potential of direct consumption of materials used as organic pond fertilizer (distillers dried grains with solubles [DDGS] was also evaluated. Growth and survival of prawn fed gastropods, oligochaetes, zooplankton, or DDGS were compared with those fed a nutritionally-complete pelleted diet (control). Groups of five juvenile prawn (average weight 1.66 ± 0.10 g) were stocked into eighteen 7.5-L glass aquaria. Dietary treatments were evaluated in triplicate aquaria for 21 days. Prawn fed live zooplankton exhibited a significantly higher rate of weight gain ($P < 0.05$) than prawn in other treatments, as measured by differences in slopes of regression lines for weight gain over time. There were no significant differences ($P > 0.05$) in rates of gain for prawn fed a complete diet and those fed DDGS or gastropods. Prawn fed oligochaetes grew significantly slower ($P < 0.05$) than those fed the prepared diet. Results indicate that juvenile prawn as large or larger

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than 2g can utilize live zooplankton and that DDGS may be consumed directly by prawn. Thus, DDGS may serve a dual role as a feed and pond fertilizer. Additional research in pond management strategies that maximize zooplankton and gastropod numbers and the potential of DDGS as a combination food/fertilizer in freshwater prawn production ponds should be conducted. *[Article copies available from The Haworth Document Delivery Service: 1-800-342-9678.]*

INTRODUCTION

Feed costs constitute 40% to 60% of operational costs in production of the freshwater prawn *Macrobrachium rosenbergii*, (D'Abramo and Sheen 1991). Initial efforts to reduce feed costs for aquacultured species generally concentrate on replacement of expensive animal protein with plant protein meals, which are generally less expensive (Piedad-Pascual et al. 1990; Tidwell et al. 1993). Elimination of vitamin and mineral premixes from the diet may also be considered (Trino et al. 1992; Tidwell et al. in press). Corbin et al. (1983) suggested that the major portion of macronutrients (i.e., protein) for freshwater prawn need to be supplied by prepared diets, but that required micronutrients (i.e., vitamins and minerals) might be derived from normal, or stimulated, productivity of natural foods in the culture pond. Tidwell et al. (in press) found that prawn fed a supplemental diet (without fish meal or vitamin and mineral supplements) and cultured in ponds organically fertilized with distillers dried grains with solubles (DDGS) grew as well as those fed a complete feed in unfertilized ponds. Pond sampling indicated that benthic macroinvertebrate populations were significantly reduced in ponds where prawn were fed a supplemental diet, compared to ponds where prawn received complete feed. Tidwell et al. (in press) stated this was probably due to increased predation by prawn, to secure nutrients not provided in the supplemental diet. However, increased consumption of these invertebrates by prawn was implied rather than observed.

Studies of food habits of crustaceans are difficult (D'Abramo and Sheen 1991). Sampling of crustacean stomachs may be misleading due to small stomach and sample sizes, small size of prey items, mastication of food items to small, unidentifiably-sized particles, and a rapid rate of catabolism and stomach emptying (Brown et al.

1992). Another method to evaluate feeding habits would be to provide natural food items under controlled conditions where consumption, suitability, and prawn growth could be monitored. The present study was designed to evaluate relative acceptability and relative nutritional quality of three benthic macroinvertebrates identified as potential forage organisms for freshwater prawn raised in earthen ponds and the potential of direct consumption of materials used as organic pond fertilizer.

MATERIALS AND METHODS

The study was conducted at the Aquaculture Research Center, Kentucky State University, Frankfort, Kentucky. Juvenile prawn were shipped by air from a commercial hatchery (Aquaculture of Texas, Weatherford, Texas[1]) on June 6, 1994 and distributed into two 1,113 liter circular tanks, partially filled with plastic netting to provide substrate. On July 5, 1994, five prawn (individual mean weight 1.66 ± 0.10 g) were hand counted and stocked into each of 18 7.5-L aquaria. To prevent prawn escape, each aquarium was covered with a 0.6-mm plastic mesh cover with a 5.7-cm hole in the center to provide refuge and prevent cannibalism.

Each aquarium contained two artificial habitat units to provide refuge and prevent cannibalism. Each unit consisted of five 8-cm attached segments of 2.5-cm diameter polyvinylchloride (PVC) pipe, arranged to allow entry from either end. Each aquarium was supplied with a continual flow of de-chlorinated tap water at a rate of 1.0 L/minute. Water was continually aerated by gentle bubbling with an airstone, and lighting was provided by fluorescent ceiling lights in the laboratory.

Food Items and Feeding Rates

Food items chosen for this evaluation (oligochaetes, gastropods, and mixed zooplankton) were three major classes of organisms identified as potentially important forage organisms for prawn,

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

based on the results of a previous investigation (Tidwell et al. in press).

All food items were fed once daily. For a model oligochaete, commercially-purchased redworms were fed. Worms were cut into 2.5-cm pieces, weighed, and either fed immediately or stored under refrigeration (4°C) in 40-mL vials. Feeding rate was based on consumption, so some segments would be left uneaten 2-3 h post feeding. For gastropods, pond snails were captured daily from outdoor ponds, counted, weighed, and fed live and intact at a rate in excess of previous measured consumption. Mixed zooplankton were collected daily from outdoor ponds and fed at a rate (five organisms/mL) previously used by Mims and Schmittou (1989) and Webster et al. (1991). Concentrations used at each feeding were determined by counting organisms (mostly *Daphnia* spp.) in two 1-mL samples, using a Sedgewick-Rafter counting cell. Water flow was stopped in these aquaria for 2 hours immediately prior to feeding in order to prevent zooplankton from being flushed out of the tank.

The formulation of the control diet is described in Tidwell et al. (1993). The diet was fed at 15% of body weight per day, based on recommendations by D'Abramo et al. (1989) for prawn of this size. The organic fertilizer material (DDGS) was fed at a rate (18% of body weight) isonitrogenous with the control diet. The DDGS used were a composite mix from different distilleries as supplied by the Distillers Feed Research Council (Ft. Wright, Kentucky). Unconsumed feed and debris were siphoned from all aquaria daily, approximately 2-3 hours post-feeding.

Prawn in all tanks were weighed and counted weekly, and calculated feed rates (Control and DDGS) were adjusted accordingly. Water temperature and dissolved oxygen were measured every other day, using a YSI Model 55 dissolved oxygen meter (YSI Instruments, Co., Yellow Springs, Ohio). Total ammonia-nitrogen and pH were measured weekly using a HACH DR/2000 Spectrophotometer (HACH Col, Loveland, Colorado) and an electronic pH meter (Omega Engineering, Inc. Stanford, Connecticut), respectively. Overall means ($\pm$ SE) for these variables were: water temperature 25.8 ± 0.06°C; dissolved oxygen, 5.06 ± 0.48 mg/L; pH, 7.52 ± 0.18;

total ammonia, 0.10 ± 0.09 mg/L and represent conditions suitable for prawn culture.

Statistical Analysis

The duration of the study was 21 days. Weekly individual weight gains (n = 4) were regressed against sample period (days post-stocking) and tested for significance of regressions (Dowdy and Wearden 1983). Treatment effects were also evaluated by using Student's t-test to determine significant differences in slopes of the regression lines (Snedecor and Cochran 1980).

RESULTS

Survival averaged 85% overall and did not differ significantly ($P > 0.05$) among treatments. Mean survivals for the five treatments were: control–80%, DDGS–80%, oligochaetes–87%, and zooplankton– 93%.

As shown in Table 1, the regression equation for weight gain on culture days for prawn fed the control diet was highly significant ($P < 0.01$). The coefficient of determination (r^2) was very high (0.99). These data indicate that prawn fed the control diet grew at a steady

TABLE 1. Intercept, slope, probability level, and coefficeint of determination (r^2) for regression equations calculated for weight gain (%) on culture days in juvenile prawn, *Macrobrachium rosenbergii*, fed control feed, distillers dried grains with solubles (DDGS), or natural pond organisms (oligochaetes, gastropods, and zooplankton).

Feed	Intercept (α)	Slope (β)	Probability	r^2
Control	−1.3900	1.3521	0.0073	0.9855
DDGS	−1.1150	1.1321	0.0348	0.9315
Oligochaetes	−1.9030	1.0931	0.0205	0.9595
Gastropods	7.2260	1.3744	0.1542	0.7153
Zooplankton	−2.0820	1.6954	0.0209	0.9586

rate (i.e., 99% of weight change is explained by days cultured) and that culture conditions were suitable for prawn during the study period.

Regression equations for weight gain over time were statistically significant ($P < 0.05$) for prawn fed oligochaetes, zooplankton, and DDGS but were not statistically significant ($P > 0.05$) for prawn fed gastropods. As shown in Figure 1, slopes of regression lines for prawn fed DDGS, gastropods, and/or the control diet were not significantly different ($P < 0.05$), indicating no difference in the rate of growth for animals fed these food items. There was a significant difference ($P < 0.05$) in the slope of the regression line for prawn fed oligochaetes and those fed the control diet, with prawn fed oligochaetes having a slower rate of growth. The slope of regression lines for prawn fed zooplankton was significantly greater ($P < 0.05$) than the control, indicating a faster rate of gain.

DISCUSSION

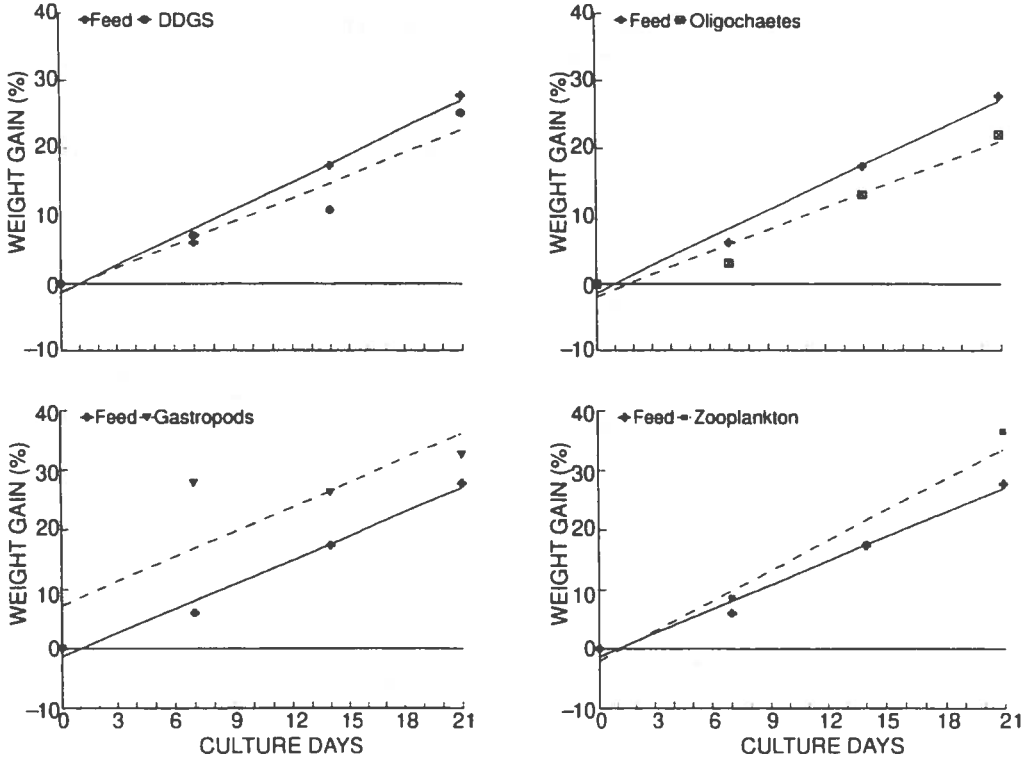
For earthen pond culture of freshwater prawn the role of natural productivity is important but largely undefined (Corbin et al. 1983). A better understanding of the ability of prawn to utilize natural forages and the relative nutritional importance of different natural food organisms would assist in implementing management practices that would favor the most important organisms.

The DDGS used in the present study were readily consumed by prawn and supported growth rates that were not different from those fed a prepared diet. Results could possibly vary if a more extended culture period or a different source of DDGS was used.

Prawn fed exclusively oligochaetes had survival percentages higher than prawns fed the prepared diet or DDGS but did not gain weight as rapidly. Pond studies indicate that oligochaetes are the most prevalent benthic macroinvertebrate and show the largest response to prawn predation (Tidwell et al., in press). The utilization of gastropods (snails) appeared to be a learned behavior, with not all prawn able to utilize them equally. Some prawn learned quickly to extract the body of the snail from the intact shell and grew rapidly. Other prawn did not, and their growth lagged.

Prawn fed exclusively live zooplankton grew better than those

FIGURE 1. Relationship between percentage weight gain and culture days, prawn fed forage organisms (dashed lines) (oligochaetes, gastropods, and zooplankton), and an organic pond fertilizer (distillers dried grains with solubles [DDGS]) compared with prawn fed a prepared diet (solid lines).



fed the prepared diet or other food items. The ability of prawn larger than larvae to utilize zooplankton has been difficult to assess, due to difficulties in identifying stomach contents of crustacea (Brown et al. 1992). Brown et al. (1992) demonstrated that third instar red swamp crayfish, *Procambarus clarkii*, fed zooplankton alone or in combination with other food items grew at higher growth rates than crayfish fed other foods. Huner and Naqvi (1984) reported that juvenile and adult *Procambarus* spp. were able to consume zooplankton. Mitchell and Collins (1989) reported that *Daphnia* were nutritionally important to juvenile yabbie, *Cherax destructor albidus*. Zooplankton are known to be rich in protein. Hepher (1989) reported that cladocerans and copepods contain 57 and 52% protein, respectively, while oligochaetes contain 49% and molluscs (gastropods) contain approximately 40%.

Data presented here indicate that juvenile prawn (>2 g) can utilize live zooplankton as the sole food source and grow satisfactorily within this size range. Hird et al. (1986) suggested that cannibalism (the primary cause of mortality in the current study) in crustaceans may be a method of satisfying the dietary need for arginine. The pelleted diet used here (controls) may be most limiting in arginine as suggested by amino acid profiles of prawn tail muscle and eggs, reported by Tidwell et al. (1993). The diet contains 5.4% arginine, while according to Ivleva (1969) *Daphnia* (the major component of the zooplankton fed in this study) are a rich source of arginine (10.92%). This could partially explain the higher survival and growth rates of prawn fed zooplankton compared to those fed the control diet. Another explanation could be that zooplankton remain nutritionally intact for a long period of, time while prepared diets may leach nutrients and break down more rapidly. This is important for slow feeders such as prawn.

Pond management strategies that maximize production of and access to zooplankton for juvenile prawns may reduce feed costs and improve prawn growth through more efficient use of natural productivity. The potential dual role of DDGS as a direct feed source and organic fertilizer should be evaluated under field conditions. The value of provision of zooplankton as supplemental food organisms in the nursery phase of prawn culture in tanks should also be investigated.

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