Mud crab (*Scylla serrata*) culture in tidal flats with existing mangroves

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Abstract

The performance of the mud crab *Scylla serrata* (Forsskal) in 200 m^2 pens installed in tidal flats with existing mangroves was determined in a factorial experiment with stocking density (0.5 or 1.5/m^2) and feed (salted fish by-catch or a mixed diet of 75% salted brown mussel flesh and 25% salted fish by-catch) as main factors. Duration of the experiment was 160 days. Results showed no interaction between feed and stocking density so data were pooled for each feed and stocking density treatment. There was no significant differences in growth, feed conversion ratio (FCR), survival, and production among two types of feed. Regardless of feed, the FCR was significantly more efficient and survival significantly higher at 0.5 than at 1.5/m^2 stocking density. Growth, however, was not significantly different. Cost-return analysis on a per crop/200 m^2 basis showed that the use of either of the two stocking density levels with either of the two types of feed was economically viable with a return on capital investment of 65-87%. Partial budgeting analysis, however, revealed that net earnings were increased by P1,128.00 if crabs were stocked at 1.5/m^2 and P881.00 if fed a mixed diet of 75% salted brown mussel flesh and 25% salted fish by-catch compared with crabs stocked at 0.5/m^2 and fed salted fish by-catch alone.

Introduction

In the Philippines, fishing villages are generally located in fringes of arable land along coastal plains and the people are dependent on fishing as a source of income. The common denominator of these villages is the presence of large areas of tidal flats with existing mangroves. To utilize the aquaculture potential of these mangroves, mud crab culture was introduced to provide alternative livelihood for fishers in the village. A rearing system (pen) was designed such that the main function of mangroves as nursery grounds for fish and crustacean fry and juveniles was not hampered. The design allowed inundation of the system at highest tide. Structures were installed to minimize siltation of canals and retain water depth requirement of the cultured species.

The present study was undertaken to determine the performance of the mud crab *Scylla serrata* Forsskal in this type of rearing system (200 m^2 pens installed in tidal flats with existing mangroves) when stocked at two stocking density levels and fed two types of feed.

Materials and methods

The study was conducted in 200 m^2 pens installed in existing mangroves at New Buswang, Kalibo, Aklan, central Philippines in collaboration with the USWAG Foundation, Inc; Department of Environment and Natural Resources - Kalibo (DENR); the local government unit of the Municipality of Kalibo (LGU-Kalibo) and the people's organization Kalibo Save the Mangrove Association (KASAMA).

A completely randomized 2 x 2 factorial experiment with stocking density (0.5 or 1.5/m^2 of mixed sex mud crab) and feed (salted fish by-catch or mixed diet of 75% salted fresh brown mussel *Modiolus metcalfei* flesh and 25% salted fish by-catch) as the main factors was replicated thrice.

The pen enclosures used nylon net (12 mm mesh and 2 mm twine diameter) and bamboos as structural framework. The lower end of the enclosures was buried 60 cm into the bottom while the inner side of the upper end was lined with 30 cm wide plastic sheet (gauge #18) to prevent crab stock from escaping. The bottom of the pens was provided with peripheral and central canals 50 cm deep and 50-100 cm wide representing about 20-30% of the pen area.

The set-up was flooded during high tide but a dike, 40-50 cm wide and 50 cm high, was constructed surrounding the enclosure to retain additional water level of 30-50 cm during lowest tide. Thus, the water level in pens at low tide if measured from the bottom of the canal was maintained at 80-100 cm. The dike was further enclosed with fine-meshed nylon screen to minimize siltation of canals in pens; however, net with a wider mesh size (5 mm) was used at the side where drain gates are installed. Two 50 cm wide and 50 cm high drain gates were installed to allow draining of pens at night time for 3 consecutive nights every 7 days to expose mangrove roots. Continuous submergence of mangrove roots may cause death of mangroves (J.H. Primavera, pers. comm.).

The crabs were fed 10% of the crab biomass daily when the carapace length was ≤6 cm and 5% when ≥ 6 cm, with 40% of the daily feed ration given at 0700 h and 60% at 1700 h. Stock sampling was done monthly. The daily ration was then adjusted based on overall estimate of the survival for all treatments and the estimated biomass for each treatment replicate.

The growth, apparent FCR, survival, production, and cost of production were calculated from the total harvest. The means were compared by analysis of variance and Duncan's multiple range test (SAS 1988). The economic viability of the culture methods was evaluated by cost-return and partial budgeting analysis (Shang 1990).

Results

There was no interaction between stocking density levels and feed on the growth, apparent FCR, survival, and production of mixed sex mangrove-reared mud crab so that data were pooled for each feed and stocking density treatment (Table 1). There was no significant differences in growth, FCR,

Table 1. Growth, FCR, survival, and production (mean ±SE) of mixed sex mangrove-reared mud crab *Scylla serrata* using pooled data*

	Stocking density		Feed	
	0.5/m^2	1.5/m^2	Salted fish by-catch	Salted mixed diet
Body weight (g)	317.4 ±9.13^a	316.4 ±5.96^a	310.0 ±3.96^a	324.0 ±8.43^a
Weight gain (g)	297.4 ±9.02^a	298.1 ±4.90^a	290.8 ±3.73^a	304.7 ±7.39^a
Carapace length (cm)	7.82 ±0.14^a	8.00 ±0.09^a	7.92 ±0.08^a	7.89 ±0.12^a
Carapace width (cm)	11.55 ±0.14^a	11.71 ±0.08^a	11.69 ±0.09^a	11.17 ±0.14^a
SGR (%/day)	1.74 ±0.08^a	1.79 ±0.03^a	1.75 ±0.08^a	1.75 ±0.03^a
FCR	5.30 ±0.34^b	7.60 ±0.63^a	6.70 ±0.63^a	6.20 ±0.84^a
Survival (%)	56.00 ±0.34^b	33.00 ±3.61^b	44.00 ±5.04^a	45.00 ±5.36^a
Production (kg/200m^2)	17.77 ±0.93^b	31.34 ±3.48^a	23.59 ±3.91^a	25.56 ±3.76^a

*There was no interaction between stocking density levels and diets so data were pooled for each stocking density or diet treatment. Values±SE with similar superscripts within stocking density or feed treatment are not significantly different (P>0.05)

survival, and production between the two types of feed. Regardless of feed, the FCR was significantly more efficient and survival significantly higher at the 0.5 than at 1.5/m^2 stocking density. Growth, however, was not significantly different across stocking densities. Proximate analysis of the feeds used is shown in Table 2.

The total investment (Table 3) was expressed in terms of development cost and operating cost (variable and fixed costs). The development cost consisted of cost of materials for the construction of net enclosures. Labor was not included as it was assumed to be provided by family members. Crab juveniles and feed comprised the major component of the variable costs (47-54% and 42-47%, respectively). Production costs are summarized in Table 4 for the two stocking densities and two types of feed.

Table 2. **Proximate analysis of feedstuffs (% dry matter)**

	Salted fish by-catch*	Salted brown mussel flesh
Moisture	4.72	5.35
Crude protein	47.08	32.16
Crude fat	5.14	3.52
Crude fiber	1.18	1.06
Nitrogen-free extract	3.18	7.74
Ash	43.42	55.52
Metabolizable energy (Kcal/100 g)	263.00	198.00

*Fish by-catch consisted of *Mirogobius* sp.

Table 3. **Investment required for a mixed sex mangrove-reared mud crab monoculture. Values in Philippine pesos are on per 200 m² pen/crop basis***

	Stocking density		Feed	
	0.5/m²	1.5/m²	Salted fish by-catch	Salted brown mussel
Development costs				
Construction of net enclosures	5,275	5,275	5,275	5,275
Total development cost	5,275	5,275	5,275	5,275
Operating costs				
Variable costs				
Crab juveniles	850	2,580	1,700	1,700
Feeds	860	2,178	1,580	1,315
Materials for pen preparation	76	76	76	76
Miscellaneous expenses**	36	96	67	62
Total variable cost	1,822	4,900	3,423	3,153
Fixed costs				
Interest on capital investment***	211	211	211	211
Depreciation	26	26	26	26
Total fixed cost	237	237	237	237
Total operating costs	2,059	5,137	3,660	3,390
Total investment	7,334	10,412	8,935	8,665

*Prevailing market price in Iloilo, Philippines as of December 1997

**2% of variable cost

***8% of capital investment per year

Table 4. **Costs-and-returns and partial budgeting analysis for a mixed sex mangrove-reared mud crab monoculture. Values in Philippine pesos are on a 200 m² pen/crop basis**

	Stocking density		Feed	
	0.5/m²	1.5/m²	Salted fish by-catch	Salted brown mussel
Total revenues at sale price of P350 for female, P270 for male and P310 for mixed sex*	5,509	9,715	7,313	7,924
Less: Operating cost	2,059	5,137	3,660	3,390
Net revenue	3,450	4,578	3,653	4,534
Production cost (/kg)	116	264	155	133
Return-on-investment	65	87	69	86
Incremental benefit		4,206		611
Incremental cost		3,078		(270)
Net benefit		1,128		881

*Prevailing prices in Roxas City, Philippines export market at the time of harvest, February 1998

The sale price (Table 4) per kg of mud crab produced [P350 for fat or roed females, P270 for full males and P310 for fat or roed mixed sex (exchange rate at harvest, February 1998 is P35 = $1)] was based on the farm gate price offered by exporters. Price of mud crab in the export market in the Philippines fluctuates with season and is highest in December to February. Net revenue was highest at 1.5/m². Net revenue went up as stocking density level was increased from 0.5 to 1.5/m². The use of either of the two stocking density levels with either of the two types of feed was economically viable with a return on investment of 65-87%. Partial budgeting analysis (Table 4), however, revealed that net earnings were increased by P1,128.00 if crabs were stocked at 1.5/m² and P881.00 if fed a mixed diet of 75% salted brown mussel flesh and 25% fish bycatch.

Discussion

The growth, survival, FCR and production of mixed sex mangrove-reared mud crab were not influenced by feed type but were more affected by stocking density levels. The two stocking density levels did not adversely influence the growth of crab, however, the FCR, survival, and production were significantly affected. Similar observation was reported by Triño et al. (in press) for pond-reared mixed species of *Scylla serrata* and *S. tranquebarica.*

An investigation on the effect of stocking density on the performance of mud crab fed fish by-catch (Baliao *et al.* 1981) and a mixed diet of 75% fresh brown mussel flesh and 25% fish by-catch (Triño *et al.* in press) pointed out that the lower the stocking density the higher the survival. This observa-

tion is in agreement with the trend noted in this study. Survival of 56±1.9% at 0.5/m^2 and 33±3.61% at 1.5/m^2 were obtained.

Production, net revenue, and return on investment (ROI) were higher at 1.5/m^2 primarily due to high yield but may not be cost-efficient whereas survival and production cost were higher and lower respectively at 0.5/m^2.

From the economic point of view, the study shows that mixed sex *S. serrata* monoculture in tidal flats with existing mangroves is a viable aqua-mangrove integrated farming venture in the Philippines using either of the stocking density levels (0.5 or 1.5/m^2) with either of the diets (salted fish by-catch alone or a mixed diet of 75% salted brown mussel flesh and 25% salted fish bycatch) with return-on-investment of 56-87%. Higher profit, however, can be earned from the 1.5/m^2 stocking density and mixed diet due to high yield and cost-efficiency of the diet.

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