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An Analysis of Biological Characteristics of *Macrobrachium rosenbergii* (de Man) in Relation to Pond Production and Marketing in Thailand

C. KWEI LIN[1,3] and MALI BOONYARATPALIN[2]

[1]*Great Lakes Research Division, University of Michigan, Ann Arbor, MI 48109 (U.S.A.)*
[2]*National Inland Fisheries Institute, Bangkhen, Bangkok (Thailand)*
[3]Present address: Agricultural and Food Engineering Division, Asian Institute of Technology, P.O. Box 2754, Bangkok (Thailand)
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ABSTRACT

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Data on production and marketing of giant freshwater prawn were collected over a 7-month grow-out period through collaboration with a medium-sized commercial prawn farm in central Thailand. Juvenile prawns with an average weight of 4.2 g were stocked at a density of 6 prawns/m^2 in three 0.5-ha earthen ponds. Average growth rate determined during the first 3 months of the grow-out period was 0.4 g/prawn per day; prawns of marketable size were harvested selectively during the remaining 4 months of the rearing period, resulting in a total accumulated yield of 1.3 tonnes/ha with an average prawn weight of 32 g and 60% survival. As different sexes and sizes of prawns were sold at different prices, the harvests were customarily sorted into several categories: large, medium, and small males, long-clawed males, soft shells, females with eggs, females without eggs, and terminal males. The total weight and number of prawns recorded for each of these categories showed that the female to male ratios were 1.6:1 and 4:1 by weight and number, respectively while the ratio of short to long-clawed males was 3:1 by weight and 4:1 by number. Four percent of the marketable population was termed "soft shells" and 64% of the females bore eggs. The ratio of head weight to tail weight of marketable prawns varied substantially among the different categories: 1.0:1 for females, 2.5:1 for long-clawed males, and 1.6:1 for short-clawed males. Females predominated in the first and second 1.5-month harvest periods while males predominated in the final 1.5 months of the harvest. The economic yield of prawn culture was not only determined by the biomass, but also by the population structure of the various biological categories and the harvest season.

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INTRODUCTION

Commercial farming of giant freshwater prawns in Thailand has been expanding rapidly (New et al., 1982; Lin, 1988) since its introduction in the late 1960s (Ling, 1969). The production area in 1983 was recorded to be 3000 ha with an annual production of 3000 tonnes (Royal Thai Dept. Fisheries, 1985); current production is estimated to be 5000–6000 tonnes. Such rapid expansion of freshwater prawn farming in Thailand is attributed to the bio-geographical fitness of the prawn and to anthropological factors. As *Macrobrachium rosenbergii* is indigenous to many parts of Thailand its biological adaptation and broodstock supply for pond farming have not been a major concern. Relatively abundant surface water and the favorable climate prevailing in most parts of central Thailand make prawn culture possible throughout the year. In contrast, the climatic conditions in temperate regions limit prawn culture to a single grow-out season during the warm months, making prawn farming less productive and requiring more managerial manipulation to maximize the yield (Brody et al., 1980; Smith et al., 1981; R'anan and Cohen, 1983; Karplus et al., 1986a,b). Since the prawn is a traditional item in the diet of Thai people, the domestic market has been the major outlet for pond-cultured prawns, and the seemingly insatiable consumer demand has been the driving force for prawn farm expansion.

Most prawns are marketed fresh as whole animals and priced according to different morphological categories. Unlike many foreign consumers who only eat the tail portion, in Thailand, prawns are prepared and consumed with their heads on, a desirable feature in most Thai cuisine. Consequently, large-size males, despite their relatively high heat to tail ratio, command a considerably higher price than females. However, the production of marketable male biomass is generally much lower than for females for most pond production in Thailand. This feature of female-dominated production is independent of stocking size and density (Karplus et al., 1986a,b). Based on differences in market price, the prawns are customarily sorted into several categories and priced in the following order: (1) large, (2) medium and (3) small short-claw males, (4) long-claw males, (5) females without and (6) with eggs, (7) "soft shells" (newly molted), and (8) terminal males. Terminal males are prawns that have stopped molting and whose shells appeared rough and soiled. Thus, the composition of the population is of primary importance to biomass production as well as economic yield of prawns. This labor-intensive sorting process is probably unique to Thailand. In contrast, post-harvest processing and marketing of prawn products in other countries are less sophisticated as only tails are consumed, making the product much less competitive to penaeid shrimp (Smith et al., 1980).

The current production and marketing strategies practised among Thai prawn farmers have evolved from artisanal to a relatively sophisticated pro-

duction system. Despite the success of large-scale prawn farming in Thailand, little production and marketing information has been documented. We present here results of a detailed investigation on the population structure of various morphotypes in relation to production and marketing for a typical medium-size farm in Thailand.

MATERIAL AND METHODS

The prawn grow-out trials were conducted for a period of 7 months from March through September 1985. Three 0.5-ha earthen ponds, belonging to a commercial prawn farm, were dried and limed with 600 kg/ha of agricultural lime before filling the ponds with water from an irrigation canal. Wild fish were removed from the incoming water using nylon nets in the pond inlets. The water level of the ponds was maintained at 1 m, with periodic changes at a rate of 60–70% of pond volume every 10–14 days depending on the pond water quality. Poor water quality was indicated by green water with a visibility of less than approximately 30 cm and prawns congregated on the upper edges at dawn. Details on pond dynamics and water quality of the prawn culture are presented elsewhere (Lin, 1988).

Juvenile prawns, with a mean weight of 4.2 g, were seined from nursery ponds and stocked at a density of 6 prawns/m^2. Prawns were fed twice daily (early morning and evening) with a formulated diet at 5% body weight per day during the first 3 months and 3% thereafter. Formulated feed, made monthly at the farm, contained approximately 30% crude protein with the following ingredients (% dry weight): fresh trash fish (23%), soybean meal (23%), broken rice (23%), rice bran (9%), leucaena meal (4%), shrimp shells (4%), fish meal (9%), calcium phosphate (1%), vitamin and mineral premix (4%). Prawn growth rate was determined monthly for the initial 3 months by taking cast net samples at 10 evenly-spaced locations in each pond. Standard length (eye orbit–telson) and body weight (all weights reported as wet) were measured for 100–300 prawns/pond at each sampling time. Marketable size prawns were harvested selectively by seining at approximately 1.5-month intervals starting at the fourth month of the grow-out period. At each partial harvest, prawns below marketable size were returned to the same pond. Total harvest was made at the end of the 7-month grow-out cycle by seining, followed by hand picking after the ponds were drained. The prawns below marketable size harvested by seining were restocked into new ponds and are referred to as restocking; those picked by hand after draining the ponds are recorded as remaining. Sexes were not determined for the restocking and remaining populations, but the prawns were counted and weighed.

The crop at each harvest was sorted into the following categories: long-clawed males, short-clawed males of large (no. 1, >90 g/prawn), medium (no. 2, 70–90 g/prawn), and small (no. 3, 50–70 g/prawn) sizes, females with and without

eggs, soft shells and terminal males. The total weight for each category was determined and the number of prawns was estimated based on count of a 1–2 kg sample. Average weight and length of whole prawn, claw, head and tail were determined by measuring 30 individual prawns of each category. The market price for each category of prawn was obtained from the farmer after prawns were sold to the dealer.

RESULTS

Data collected for total production, growth rate, and survival rate of prawns showed great similarity among the three replicate ponds (Table 1). During the 7-month grow-out period, the average yield was 711 kg/pond which extrapolates to an annual yield of 2343 kg/ha. The average prawn grew from 4 to 36 g, with an average daily weight gain of 0.4 g during the 3-month preharvest period. The survival rate throughout the grow-out period was 60%, or 4 juveniles/m^2.

Population structure

Table 2 shows the population structure and biomass of each category of marketable prawn as well as the number and weight of unmarketable prawns. The marketable yield comprised 77% of the entire population and 88% of the total weight. Only 19% of the marketable prawn population were males while 77% were females of which 64% bore eggs at the time of harvest. When based on weight, the marketable yield was comprised of 36% males and 59% females. The remaining percentage was made up by soft-shell prawns which were not sorted into sexes. Individual prawn weight ranged widely from 26 g for the smallest females without eggs in the first harvest to 130 g for the largest long-clawed male in the final harvest (Fig. 1). The average weight of the no. 1, long-clawed and soft shells was over 80 g/prawn; no. 2 and no. 3 males averaged 60–80 g and 50–60 g, respectively, while the females with and without eggs aver-

TABLE 1

Accumulated biomass yield (number and weight), survival rate, and weight gain of prawns in three rearing ponds during a 7-month grow-out period

Pond	Total count		Total weight (kg)		Survival (%)	Weight gain	
	Stocking	Harvest	Stocking	Harvest		Total (kg)	Mean (g)
1	32 760	19 826	130.4	708.8	60	578.4	31.7
2	31 920	19 156	135.7	718.4	60	582.7	33.2
3	33 064	19 676	142.5	706.6	59	564.1	31.6
Mean	32 581	19 552	136.2	711.3	60	575.1	32.2

TABLE 2

Population structure and total weight composition of marketable and undersized prawns of various categories (values are means, x, and standard deviations, s.d., of three rearing ponds)

Type	Weight (kg)				Number of prawns			
	x	s.d.	%	s.d.	x	s.d.	%	s.d.
Female + egg	233.8	2.2	33.0	0.6	7358	119	37.6	0.9
Female − egg	131.9	11.3	18.6	1.6	4162	331	21.3	1.6
Male no. 1	57.5	2.7	8.1	0.3	566	27	2.9	0.2
Male no. 2	81.0	10.1	11.4	1.4	1129	146	5.8	0.8
Male no. 3	29.1	7.1	4.1	1.0	530	141	2.7	0.7
Long claws	51.9	2.3	7.3	0.3	562	28	2.9	0.2
Terminal males	3.4	1.4	0.5	0.2	34	14	0.2	0.1
Soft shells	33.4	3.4	4.7	0.4	672	66	3.5	0.4
Restocking	70.7	2.7	10.0	0.4	3184	226	16.3	1.1
Remaining	18.0	7.1	2.6	0.9	1354	477	6.9	2.3
Marketable	622.5	12.8	87.5	1.4	15015	154	76.8	1.9
Unmarketable	88.7	9.8	12.5	1.5	4538	432	23.2	1.9
Total prawns	711.3	5.1	100.0	0.0	19553	287	100.0	0.0

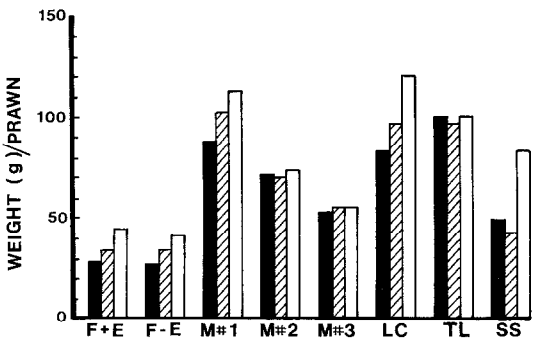

Fig. 1. Weight variation (g/prawn) among biological categories of prawns from three partial harvests. Solid bar represents the first harvest, striped the second, and blank the third; F + E, females with eggs; F–E, females without eggs; M # 1, large males; M # 2, medium males; M # 3, small males; LC, long-clawed male; TL, terminal males; SS, soft-shell prawns.

aged less than 40 g. The size of each category also varied among the three harvests, particularly the female and large male populations. In general, their sizes were smaller in the first harvest and the progression was probably the result of partial cropping which reduced population density by 35% at each of the first two harvests.

The population structure and yield of prawns among the three harvests exhibited considerable variation (Fig. 2). While the number of females com-

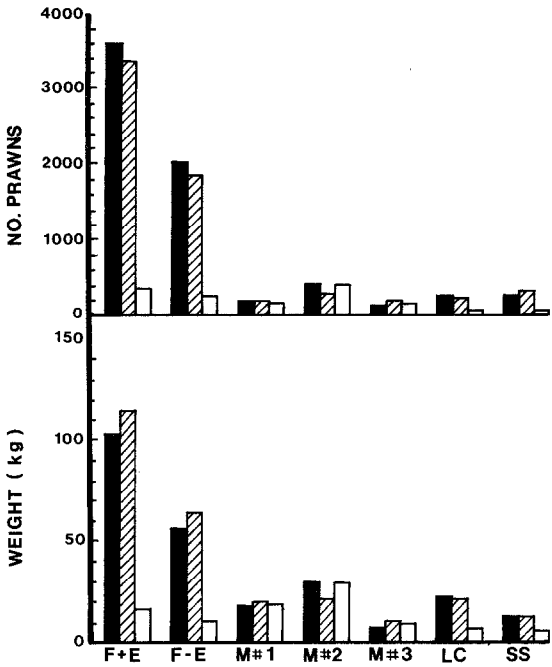

Fig. 2. Total biomass wet weight and population structure among biological categories of prawns from three partial harvests (see Fig. 1 for symbols).

prised greater than 80% in each of the first and second harvests and 43% in the third, their respective biomass in each of these three harvests was only 63%, 67%, and 28%. Over 50% of the female population bore eggs in the first and second harvests compared to only 20% in the third. Sexes were not determined for the 23% unmarketable population.

Variation in body proportions

Both length and weight proportions of claw, tail, and head varied considerably between males and females as well as between the long- and short-clawed males (Table 3). For long-clawed males, the average claw length was 130% of body length and claw weight was 23% of whole prawn weight with the tail weight being 28% of total weight. In contrast, the claw of short-clawed males measured only 84% of the body length and 10% of the total weight, while the tail was 38% of total weight. Female prawns possessed relatively small claws, measuring 62–65% of body length and 6–7% body weight, and had proportionately greater tail weight (an average of 50%). Furthermore, the head weight for long- and short-clawed males comprised 72 and 62% of the body weights, respectively, compared to 49–52% for the females.

TABLE 3

Proportions (% mean ± 1 s.d.) of claw length and weight, and head and tail weights in relation to total body length and weight, and claw weight to head weight for male and female prawns

Proportion	Male		Female	
	Long-claw	Short-claw	With eggs	Without eggs
Claw length / Total length	130±10	84±14	62±5	65±9
Claw weight / Total weight	23±5	10±3	7±2	6±2
Claw weight / Head weight	32±6	14±4	13±4	13±5
Head weight / Total weight	72±3	62±2	52±1	49±1
Tail weight / Total weight	28±3	38±2	47±2	51±2

TABLE 4

Variation in market price (US$/kg) for different prawn categories in three partial harvests at different times of the year

Type	6 June 1985	28 July 1985	27 Sept. 1985
Female + egg	2.1	2.6	3.3
Female – egg	2.4	2.9	4.3
Male no. 1	4.7	5.6	6.7
Male no. 2	4.3	5.0	6.5
Male no. 3	3.5	4.3	5.3
Long claws	2.7	3.7	5.1
Terminal males	1.2	1.2	1.4
Soft shells	2.5	3.1	3.5

Marketing

As the price of prawns differed with prawn size and form, as well as season of harvest, the economic yield for pond culture was not a linear relationship with the harvestable biomass (Table 4). The overall price was lower in June and higher during the latter part of the year. Large males (no. 1, > 80 g/prawn) with short claws commanded the highest price at US$ 4.7–6.7/kg and terminal males the lowest price at US$ 1.2–1.4/kg. Despite their large average sizes, the long-clawed males and soft shells were sold at a price comparable with the smaller females at US$ 2.5–5.0/kg. Females with eggs were less desirable than those without. Fig. 3 shows the income derived from various prawn categories in each of the three harvests. During the first and second harvests, the income

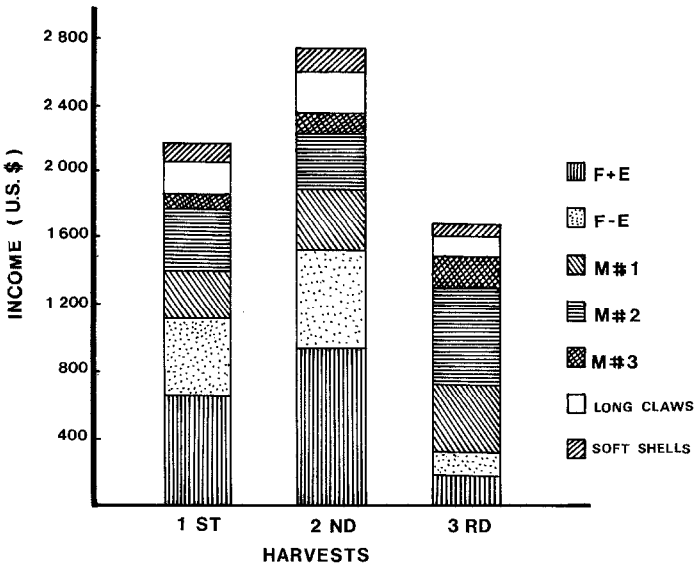

Fig. 3. Comparison of income composition from a one-ha yield by biological categories for prawns from three harvests (see Fig. 1 for symbols).

from the female crop accounted for approximately 50% of each harvest while the female biomass was greater than 60%. However, by the third harvest, economic yield from females was only 20% since the biomass had dropped to 28% of the total yield, while the income from males increased to 70% and the yield equaled 65% of the biomass. The price increase coupled with the proportionately higher production of male biomass improved the income from the third harvest.

DISCUSSION

Detailed analyses on production and marketing of pond-reared freshwater prawns in Thailand clearly showed that the economic income is not only related to the total yield but also depends on the structure of the population in terms of such features as sex ratio, male size differential, and claw types. The present data indicated that the total marketable population was dominated by females (male:female = 0.25). Smith et al. (1981) also found that significantly more females occurred in all experimental ponds stocked with a mixture of postlarvae and juveniles or with juveniles only. The occurrence of greater female abundance has been observed not only under various stocking densities (Karplus et al., 1986a), but also with various size-graded juveniles (Karplus et al., 1986b). The numerical female dominance in the marketable lots might be explained by the common fact that females grew more evenly in size and reached marketable size in greater percentages, while males are polarized into

large and small (petit) populations. Brody et al. (1980) observed that the unmarketable petit males constituted as much as 50% of the male population. In our case, it was probable that the majority of the unmarketable population (23%) were petit males. Unfortunately, the sexing of restocked and remaining populations was not carried out because their small body size obscured the external sex features, making accurate sexing difficult. From the processing viewpoint, a dominant yield of females would be advantageous if the market demand was only for the tail portion of the product since the average tail weight was approximately 50% of the total female body weight compared to 38% for average short-claw males. However, this is not the case in Thailand, where most of the prawns are marketed domestically and consumed whole. Generally, the price increases with larger prawn sizes, thereby making males more valuable. Thus, it would be desirable to increase the male constituent of the population in grow-out ponds.

The practice of intermediate, partial harvest in Thailand is definitely a sound management strategy for two reasons. One, the females that dominated the population and matured relatively early at a small size (30–40 g) could be selectively removed in the early harvest. The current data show that females comprised 63% of the total marketable biomass in the first harvest after 4 months of grow-out, and 65% of those females bore eggs. In fact, harvesting females prior to their gravid stage would be advantageous because the eggless females command a better price. Under the current culture practice, the ponds were started with a density considered to be optimal (6 prawns/m^2), but each partial harvest substantially reduced population density in the ponds. Continuous restocking with postlarvae or juveniles to sustain the density was not practised for the reason that the competition between the newly stocked cohorts and original residents might in fact adversely affect production. Malecha (1986) reported that competition between the two cohorts significantly lowered production. The second reason is that intermediate harvestings also removed the large males and allowed the production to shift gradually to males which commanded a comparatively greater price.

The processing yield of the prawn product varies considerably with claw type and sex and one of the most disadvantageous features in freshwater prawn marketing is the product's low processing yield (tail meat) which ranged from 28% for the long-claw males to 51% for the eggless females. Apparently, the proportion of tail yield decreases with increasing prawn size and females offer significantly greater yield than males of all sizes (Smith et al., 1980). In comparison, tail yield of penaeid shrimp, on average, comprises greater than 60% of the whole body with little variation between sexes (National Marine Fisheries Service, 1978).

The existence of short- and long-clawed male populations has long been recognized and is of concern to both farmers and biologists alike. To farmers and consumers, long-clawed males, through large in body weight (80–130 g/

prawn), are less desirable because of the greater proportion of claw waste, ranging from 18 to 28% of prawn weight compared to 7–13% for the short-clawed males. Although the long-claw population in the current study comprised less than 10% of the total marketable population, their aggressive sexual and territorial behavior may exhibit a much greater influence on production than their numerical minority status would indicate. In practice, the long-claw males were fast growers and most of them were removed during the earlier partial harvests. In contrast, the orange short-clawed variety was reported to be of superior quality because of its proportionately greater tail weight and more docile nature (Sandifer and Smith, 1977). Therefore, increasing the proportion of short-claw males, either through broodstock manipulation or managerial strategies as those proposed by Malecha (1986), would be a viable means of augmenting biomass and economic yield of prawn farming in Thailand or elsewhere in the world.

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