# Yield of freshwater prawn *Macrobrachium rosenbergii* (Decapoda) after removing its females from a continuous polyculture system with tilapia (Pisces) in Puerto Rico[1,2]

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## ABSTRACT

**Presence of freshwater prawn females is an important biological factor causing size variation during the growing process and negatively affecting production. Removal of the females during the growing cycle would improve yield efficiency. This study determined how yield, survival, and mean weight of freshwater prawn *Macrobrachium rosenbergii* are affected by removal of females from a continuous polyculture system with red tilapia. In treatment 1, only the captured commercial-size female prawns were harvested monthly, harvest starting on day 130 after initial stocking. In treatment 2, all captured distinguishable female prawns, regardless of their size, were removed. Juvenile prawns (1.2 g) and fingerling red tilapia (32 g) were stocked at five prawns and one fish per square meter. The prawn yield (mean weight) was 1,988 kg/ha (40 g) in T1, and 2,346 kg/ha (40 g) in T2. No significant effects on prawn yield, final mean weight, feed conversion ratio or mortality resulted from continually removing female *M. rosenbergii* from the polyculture. However, there were significant differences in mean weight (T1 = 54 g and T2 = 59 g) and percentage (T1 = 85% and T2 = 78%) of prawn reaching commercial size.**


**Key words: continuous, polyculture, *Macrobrachium*, tilapia, Puerto Rico**


## RESUMEN

**Producción de camarón de agua dulce *Macrobrachium rosenbergii* (Decapoda) después de remover sus hembras en un sistema continuo de policultivo con tilapia (Pisces) en Puerto Rico**

**La presencia de hembras del camarón de agua dulce es un factor biológico importante que causa en los machos una variación de tamaño durante**


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**el proceso de crecimiento y que afecta negativamente la producción. La remoción de los camarones hembras durante el ciclo de crecimiento podría mejorar la eficiencia de producción. Este estudio determinó cómo la producción, supervivencia, y peso medio del camarón de agua dulce, *Macrobrachium rosenbergii*, son afectados a través de la remoción de las hembras de un sistema continuo de policultivo con tilapia roja. En el tratamiento 1 (T1), solamente los camarones hembras de tamaño comercial se cosecharon mensualmente empezando 130 días después de la siembra inicial. En el tratamiento 2 (T2), se removieron todos los camarones distinguibles como hembras, independientemente del tamaño. Se sembraron camarones juveniles (1.2 g) y alevinos de tilapia roja (32 g) a razón de cinco camarones y un pez por metro cuadrado. La producción de camarón (peso medio) fue de 1,988 kg/ha (40 g) en T1 y 2,326 kg/ha (40 g) en T2. No se observaron efectos significativos en producción, peso medio final, factor de conversión alimenticio o mortalidad del camarón como resultado de remover continuamente las hembras de *M. rosenbergii* del policultivo. Sin embargo, se verificó una diferencia significativa para el peso medio final (T1 = 54 g y T2 = 59 g) y porcentaje (T1 = 85% y T2 = 78%) de camarones que alcanzaron peso comercial.**

**Palabras clave: continuo, policultivo, *Macrobrachium*, tilapia, Puerto Rico**

## INTRODUCTION

The polyculture of fish and prawns appears to be a rational method of production because these species do not compete with one another for food and space in the pond. The fish inhabit the water column whereas prawns live in the benthic zone, feeding on bottom-dwelling animals and detritus. Polyculture increases the marketable biomass from the ponds, utilizes the culture environment efficiently, and improves water quality (Cohen et al., 1983), thus providing economic waste management (Olsen, 1996).

The freshwater prawn *Macrobrachium rosenbergii* displays highly variable growth rates because of heterogeneous individual growth (HIG). Because of the HIG phenomenon, resulting in aggression and territorial behavior, as well as cannibalism, production is hindered. This loss in production is a major obstacle for the prawn industry (Landau, 1992). Various management strategies have been used in *M. rosenbergii* culture to reduce the HIG effect, including stocking at low rates (<2.5 prawns/m$^2$) to decrease social interaction, stocking at relatively high rates (25 prawns/m$^2$) to break down the pecking order by crowding, stocking uniform-size or single-sexed juveniles, providing supplementary substrates, and harvesting by culling in continuous culture. Another strategy could be to remove the females. The presence of females is considered an important biological factor causing morphotype distribution and sexual differentiation in *M. rosenbergii* (Hulata et al., 1988; Sagi et al., 1988), which is directly related to the HIG phenomenon. Removing the females should improve the production efficiency of the remaining prawns.

This study determined how yield, survival, and mean weight of freshwater prawn *Macrobrachium rosenbergii* are affected by continuously removing females from a polyculture system with red tilapia hybrids *Oreochromis niloticus* × *Oreochromis mossambicus*.

## MATERIALS AND METHODS

The experiment was carried out at the Lajas Agricultural Experiment Station of the Puerto Rican Commercial Aquaculture Research and Development Center, Department of Marine Sciences, University of Puerto Rico, Mayagüez Campus. The experiment used a completely randomized design with two treatments, each one replicated four times. In treatment 1 (T1), the captured commercial-size female prawns (≥11 cm orbital length) were harvested monthly, starting 130 days after initial stocking. In treatment 2 (T2), the harvesting process was similar, except that all captured distinguishable female prawns, regardless of their size, were removed. In both treatments, male prawns and red tilapia of commercial size were also harvested.

Eight 0.7-ha rectangular ponds (1-m mean depth) were utilized. Juvenile prawns (mean wt ± SD) (1.2 ± 0.1 g) and sex-reversed fingerling red tilapia (32 ± 16 g) were obtained from the Aquaculture Center and stocked at the rate of five prawns and one fish per square meter. The sex-reversed fingerlings were hand-sexed by inspecting the genital papillae; they were counted, weighed, and stocked. During days 36, 69, 100 and 130, a sample was taken including 100 prawns and 100 fish that were counted, weighed collectively, and returned to their respective ponds. These samples provided growth rate information for adjusting feeding rates. The assumed monthly mortality rates of 4% and 7% in fish and prawns, respectively, that were used to calculate the daily food ratio and the restocking rate, were based on previous work with both species at the same experimental station (Cabarcas, 1995; García-Pérez et al., 2000; McGinty and Alston, 1987). The restocking first occurred on day 130, and continued monthly thereafter.

A commercial sinking pelleted tilapia feed (crude protein 31%) produced by the Puerto Rico Federation of Farming Association was provided daily. Feeding rates were adjusted for fish biomass only. Intentionally, the prawns were not fed, and therefore depended on residual feed supplied to the fish or on natural production of food organisms in the pond. The daily feeding rate from day 1 to day 30 was 5% (20 kg/ha); then it was reduced to 3.5% (37 kg/ha) from day 31 to day 60; and further reduced to 2.2% (50 kg/ha) from day 61 to day 129. From day 130 (first partial harvest) to day 557 (final harvest), the feeding ratio was adjusted by the mean weight of fish not reaching commercial size. The feeding rate as a percentage of body weight ranged from 2 to 4% during days 130 to 557, and the daily amount of added feed fluctuated from 34 to 57 kg/ha. For avoiding a condition of low dissolved oxygen and thus maintaining water quality, the latter value was not exceeded. The animals were fed twice daily at the shallow end of each pond. During the overall 557-day experimental period, no feed was added to the ponds on 43 days because of adverse rainy and cloudy weather conditions. Fish 27 cm in total length and prawns 11 cm in orbital length (occipital ridge to the tip of the telson) were considered as commercial-size individuals. These size limits were chosen arbitrarily for the classification of marketable prawns in Puerto Rico.

The first partial harvest occurred on day 130 and continued at 30-day intervals. At each partial harvest, the ponds were lowered by 30 cm and seined twice. The seine allowed small fish and prawns to escape through the mesh. At final harvest, each pond was seined twice, drained, and the remaining prawns and fish were collected manually. Fish and prawns were weighed in lots.

Daily weight gain and specific growth rates (SGR) were used to evaluate fish growth before the first harvest. Weight gain (g/d) was calculated as mean final weight (Wf) minus mean initial weight (Wi) divided by culture days. The SGR was calculated by using the formula of Webster et al. (1997): SGR (%/d) = [(ln Wf-ln Wi)/d] × 100. The fish feed conversion ratio (FCR) was based solely on the estimated mean weight of the tilapia, because they were the only animals fed deliberately. However, the overall FCR included both fish and prawns. We calculated survival (%), At value (percentage of animals reaching the specified commercial-size), Wf (g), growth (g/d), SGR (%), fish and overall FCR, total yield (kg/ha), recruits (kg/ha), as well as commercial- and non-commercial-size animals (kg/ha).

The data were analyzed by t-test and chi square test (Steel and Torrie, 1980) by using Minitab for windows computer program for statistics (Minitab, Inc.). Significant differences were determined between treatments at the 5% level ($P < 0.05$).

## RESULTS

No significant differences ($P > 0.05$) were found between T1 and T2 for mean weight, SGR or daily weight gain for fish and prawns. The commercial fish mean weight, SGR, and weight gain were 455 g, 0.83%/d, and 3.2 g/d in T1; and 407 g, 0.8%/d, and 2.8 g/d in T2. For prawns these values were 53 and 60 g, 2.2 and 2.4%/d, 0.39 and 0.44 g/d, for T1 and T2, respectively. The FCR and survival rate were not significantly different ($P > 0.05$). Final fish FCR and overall FCR were 3.3 and 2.2 in T1; and 3.3 and 2.3 in T2, respectively. Fish survival rate was 49% in both treatments; the prawn survival rate was 40% in T1 and 45% in T2.

No significant differences (P > 0.05) were found between T1 and T2 in final mean weights of commercial and non-commercial-size fish, or total weight. During the initial 373-day partial period of culture, 4,499 and 4,767 kg/ha of fish was harvested in T1 and T2, respectively (Table 1). The daily mean gain in biomass was 10.6 kg/ha in T1 and 10.9 kg/ha in T2. In T1, the final overall mean weight of harvested fish was 390 g, 94% (At value) of which reached a commercial-size of 27 cm with a mean weight of 407 g. Non commercial-size fish had a mean weight of 234 g. In T2, these values were 398 g, 95%, 415 g and 232 g, respectively (Table 2). Recruits were weighed in lots but not counted. For T1 and T2, the mean total weight for recruits

TABLE 1.—*Partial and total commercial-size, non-commercial-size, and overall fish and prawn production ± SD (kg/ha) in T1 and T2*[1].

| | Yield ± SD (kg/ha) | | | |
|---|---|---|---|---|
| | T1 | | T2 | |
| Day Interval | Fish | Prawn | Fish | Prawn |
| Partial commercial | | | | |
| 1-130 | 922 ± 74 | 186 ± 23 | 1,450 ± 429 | 184 ± 48 |
| 131-160 | 1,037 ± 381 | 93 ± 15 | 975 ± 106 | 113 ± 25 |
| 161-189 | 815 ± 466 | 58 ± 13 | 479 ± 180 | 43 ± 4 |
| 190-220 | 62 ± 61 | 62 ± 30 | 64 ± 49 | 41 ± 19 |
| 221-248 | 425 ± 174 | 55 ± 19 | 646 ± 305 | 57 ± 19 |
| 249-276 | 489 ± 101 | 69 ± 22 | 517 ± 116 | 60 ± 17 |
| 277-310 | 297 ± 87 | 89 ± 90 | 275 ± 70 | 96 ± 9 |
| 311-345 | 208 ± 49 | 90 ± 52 | 244 ± 80 | 79 ± 12 |
| 346-373 | 244 ± 85 a | 52 ± 17 a | 117 ± 40 b | 82 ± 5 b |
| 374-400 | 163 ± 91 | 89 ± 35 | 113 ± 50 | 85 ± 43 |
| 401-430 | 102 ± 49 | 99 ± 11 | 103 ± 56 | 119 ± 99 |
| 431-460 | 90 ± 41 | 141 ± 31 | 123 ± 122 | 113 ± 39 |
| 461-491 | 134 ± 52 | 130 ± 17 | 142 ± 71 | 118 ± 27 |
| 492-522 | 281 ± 215 | 124 ± 53 | 268 ± 87 | 106 ± 42 |
| 523-557 | 632 ± 224 | 353 ± 207 | 570 ± 199 | 526 ± 46 |
| Total commercial | 5,545 ± 550 | 1,690 ± 202 | 5,762 ± 610 | 1,822 ± 297 |
| Non-commercial | 356 ± 175 | 298 ± 89 a | 324 ± 180 | 524 ± 47 b |
| Overall | 5,901 ± 800 | 1,988 ± 290 | 6,086 ± 928 | 2,346 ± 134 |

[1]T1 = commercial-size female prawns (≥11 cm orbital length) were harvested monthly. T2 = all captured distinguishable female prawns, regardless of their size, were removed.

[2]Means in each row followed by different letters are significantly different at P < 0.05.

TABLE 2.—*Mean weight (g) and commercial- and non-commercial-sized fish total production (kg/ha) in T1 and T2.*[1]

| | Mean weight ± SD (g) | | Total weight ± SD (kg/ha) | |
|---|---|---|---|---|
| Total length (cm) | T1 | T2 | T1 | T2 |
| Non-commercial | | | | |
| 17 | 119 ± 2 | 110 ± 0 | 9 ± 2 | 8 ± 2 |
| 19 | 152 ± 11 | 156 ± 13 | 42 ± 27 | 38 ± 23 |
| 21 | 210 ± 10 | 199 ± 14 | 98 ± 44 | 77 ± 20 |
| 23 | 259 ± 3 | 260 ± 19 | 99 ± 22 | 96 ± 42 |
| 25 | 339 ± 23 | 322 ± 1 | 108 ± 65 | 105 ± 59 |
| Total | 234 ± 2 | 232 ± 13 | 356 ±146 | 324 ±133 |
| Commercial | | | | |
| 27 | 386 ± 4 a[2] | 395 ± 2 b | 4,209 ± 624 | 4,245 ± 561 |
| 29 | 471 ± 22 | 474 ± 6 | 1,089 ± 251 | 1,328 ± 314 |
| 31 | 585 ± 5 a | 525 ± 31 b | 234 ± 157 | 189 ± 52 |
| 33 | 700 ± 29 | ND | 13 ± 13 | ND |
| Total | 407 ± 15 | 415 ± 3 | 5,545 ± 298 | 5,762 ± 798 |
| Overall | 390 ± 17 | 398 ± 4 | 5,901 ± 800 | 6,086 ± 928 |

[1]T1 = commercial-size female prawn (≥11 cm orbital length) was harvested monthly. T2 = all captured distinguishable female prawns, regardless of their size, were removed.
[2]Means in each row followed by different letters are significantly different at $P < 0.05$.
ND: No data

was 1,749 kg/ha and 1,764 kg/ha, respectively, representing 23% of the total fish biomass harvested.

No significant differences ($P > 0.05$) were found between T1 and T2 for final mean weight of non-commercial-size prawns, commercial yield, total weight (overall), or monthly mean harvest, except for the 346- to 373-day interval partial harvest, in which T2 (82 kg/ha) was higher than T1 (52 kg/ha; Table 1). During the initial 373-day partial period, 754 kg/ha and 755 kg/ha of prawns was harvested in T1 and T2, respectively. Daily mean gain was 3.6 kg/ha in T1 and 4.2 kg/ha in T2 (Table 1). A significant difference ($P < 0.05$) was found in non-commercial prawn yield over the full experiment.

The percentage yield for commercial and non-commercial-size prawns and the final mean weight of commercial-size prawns were significantly different ($P < 0.05$) between treatments (Figure 1). For T1 and T2, 85% and 78% of the prawns (At value) reached commercial size with a mean weight of 54 g and 59 g, respectively. The remaining 15% and 22% of the population averaged 16 g and 18 g, respectively. The final mean weight of 40 g/prawn in both treatments was of course not significantly different ($P > 0.05$).

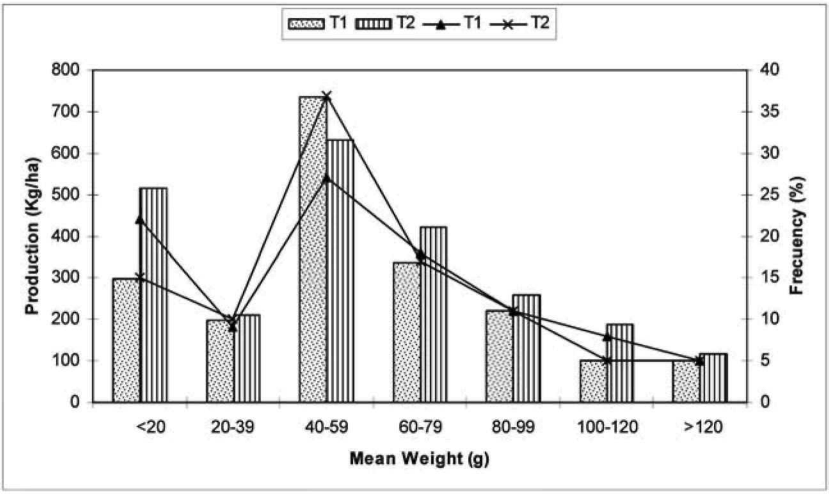


FIGURE 1. Production (kg/ha, bars) and frequency (%, lines) of freshwater prawns by commercial (>20 g) and non-commercial (<20 g) mean weight groups in treatments 1 (T1) and 2 (T2).

## DISCUSSION

In this study, the daily weight gain of the tilapia was in the normal range of 2.4 to 3.3 g reported in other studies (Head et al., 1996; Nitzan et al., 1996; Sarig and Arieli, 1980). The SGR value for tilapia observed in the present study is almost twice that considered a conservative SGR value of 1% by Nitzan et al. (1996).

It has been shown that the FCR varies with stocking size, density, and type of organism cultured. Reported FCR values for freshwater prawn-fish polyculture systems range from 0.7 (Perry and Tarver, 1987) to 5.6 (Siddiqui et al., 1997). The high FCR found in this study (>2.2) might be explained by the high mortality values for tilapia (51%) and prawns (57%) in addition to the long culture period (557 d). In a previous experiment García-Pérez et al. (2000) obtained a low combined FCR (1.3) in a prawn-tilapia polyculture, probably because of better tilapia survival (85%) and a shorter culture period (143 d).

Tilapia mortality fluctuates according to the duration of the culture period and the system used, as summarized in Table 3. No massive fish mortalities were noted; however, visual observation verified bird predation during daylight and at night. The mean fish size

TABLE 3.—*Comparison of different tilapia monoculture and polyculture systems. B: batch, C: continuous, M: monoculture, ND: no data, P: polyculture, SD: standard deviation. Cohen et al., 1983 (a), García-Pérez et al., 2000 (b), Hulata et al., 1990 (c), Wohlfarth et al., 1985 (d), Cabarcas, 1995 (e), Mair et al., 1995 (f), Lovshin et al., 1990 (g), Present study (h).*

| Period (days) | Density (fish/m$^2$) | Yield (kg/ha) | Total yield (kg/m$^2$) | Total yield (kg/ha/d) | Harvest (g/ind) | Survival (%) | System | Author |
|---|---|---|---|---|---|---|---|---|
| 75 | 1 | 1,095 | 0.110 | 14.6 | 248 | 98 | P, B | a |
| 143 | 1 | 2,769 | 0.277 | 19.4 | 331 | 84 | P, B | b |
| 143 | 1 | 2,940 | 0.294 | 20.6 | 346 | 85 | M,B | b |
| 148 | 1 | 3,721 | 0.372 | 25.1 | 384 | 79 | M,B | c |
| 111 | 0.7 | 1,156 | 0.116 | 10.3 | 191 | 89 | P, B | d |
| 216 | 1 | 3,429 | 0.343 | 15.9 | 400 | 54 | P, C | e |
| 216 | 1 | 3,619 | 0.362 | 16.8 | 405 | 56 | P, B | e |
| 237 | 2 | 3,800 | 0.380 | 16.0 | 160 | 92 | M,B | f |
| 270 | 1 | 2,760 | 0.276 | 10.2 | 328 | 85 | M,B | g |
| 557 | 1 | 5,994 | 0.599 | 10.8 | 394 | 49 | P, C | h |
| 212 | 1.1 | 3,128 | 0.313 | 16.0 | 320 | 77 | M, P, B, C | Mean |
| 119 | 0.3 | 1,401 | 0.140 | 4.8 | 91 | 17 | ND | SD |

(394 g) and daily yield (10.8 kg/ha) obtained in the present study are within the range found by other researches (Table 3). Prolific breeding of tilapia in ponds is normal. Lovshin et al. (1990) and Sarig and Arieli (1980) showed that female tilapia fingerlings smaller than 40 g were mistaken for males during hand sexing. In this experiment, on five occasions mean weight of the restocked fish was 30 g, or less; however, the continuous harvest process did not permit the formation of stunted populations; 94% of the harvested fish reached commercial size.

Daily weight gain and SGR values for *M. rosenbergii* in this study are in the normal range of 0.06 to 0.43 g and 1.4 to 3.3%/d, respectively, as reported in other studies (Siddiqui et al., 1997; Sadek and Moreau, 1996; Brick and Stickney, 1979). Survival of *M. rosenbergii* varies greatly, ranging from 0% (Scott et al., 1988; Crawford and Freeze, 1982) to 97% (Romaire et al., 1985). Survival is dependent upon stocking density, initial stocking size, water quality, feeding regime, and other factors. Causes of mortality include cannibalism, which may be as high as 4% monthly (AQUACOP, 1990), the seining process (New, 1990), bird predation (Cabarcas, 1995), or physical stress due to space limitations (Huner et al., 1983). The daily prawn yield (3.9 kg/ha) obtained in the present study falls in the range reported in the literature, but tends toward the lower end of that range. The 57 g for the final mean commercial-size prawn in the present study represents the highest value found in the literature consulted (Table 4).

Ra'anan and Cohen (1983) considered HIG as an economic problem because about 25% of the prawn population remains below commercial size (<25 g). The monthly and selective harvesting conducted during this study did not significantly improve HIG, because 15% (T1) and 22% (T2) of the harvested population was below 20 g. Other disadvantages of this continuous harvest system include high labor cost and difficulty in determining the standing crop. Frequent harvesting involved lowering the water level in the ponds to improve the catch of fish and prawns, but this technique exposed the animals to bird predation, which was a probable cause of the low fish-prawn survival encountered. This critical issue must be prevented in order to achieve better results. The pond banks were also exposed to erosion. After twelve months, seining was difficult because the accumulation of silty mud increased the weight of the seine.

Given the small number of replicates per treatment, no significant effects ($P > 0.05$) on production, mean weight, FCR or prawn mortality resulted from monthly removal of the female *M. rosenbergii* from the polyculture ponds. Further research to evaluate the continuous polyculture system for a shorter period of time would be desirable.

TABLE 4.—*Comparison of different prawn monoculture and polyculture systems. B: batch, C: continuous, M: monoculture, ND: no data, P: polyculture, SD: standard deviation. Sadek and Moreau, 1996 (a); Tidwell et al., 1998 (b); Tidwell et al., 2000a (c); Tidwell et al., 1995 (d); Tidwell et al., 1994 (e); Siddiqui et al., 1997 (f); Tidwell et al., 2000b (g); Cohen et al., 1983 (h); Daniels et al., 1995 (i); De Souza et al., 1995 (j); D'Abramo et al., 1989 (k); García-Pérez et al., 2000 (l); Smith et al., 1981 (m); Lin and Boonyaratpalin, 1988 (n); Cabarcas, 1995 (o); Present study (p).*

| Period (days) | Density (prawns/m$^2$) | Yield (kg/ha) | Total yield (kg/m$^2$) | Total yield (kg/ha/d) | Harvest (g/ind) | Survival (%) | System | Author |
|---|---|---|---|---|---|---|---|---|
| 93 | 5 | 1,433 | 0.143 | 15.4 | 38 | 67 | M, B | a |
| 106 | 5.9 | 1,164 | 0.116 | 11.0 | 34 | 58 | M, B | b |
| 106 | 7.4 | 1,638 | 0.164 | 15.5 | 23 | 90 | M, B | c |
| 109 | 4 | 929 | 0.093 | 8.5 | 31 | 76 | M, B | d |
| 110 | 4 | 1,268 | 0.127 | 11.5 | 41 | 78 | M, B | e |
| 112 | 5 | 1,340 | 0.134 | 12.0 | 29 | 94 | M, B | f |
| 113 | 4 | 1,449 | 0.145 | 12.8 | 36 | 84 | P, B | g |
| 132 | 5 | 724 | 0.072 | 5.5 | 18 | 81 | M, B | h |
| 133 | 4 | 1,033 | 0.103 | 7.8 | 34 | 75 | M, B | i |
| 133 | 5.9 | 1,335 | 0.134 | 10.0 | 27 | 82 | M, B | i |
| 133 | 5 | 1,206 | 0.121 | 9.1 | 34 | 72 | P, B | j |
| 140 | 4 | 943 | 0.094 | 6.7 | 35 | 58 | M, B | k |
| 140 | 5.9 | 1,117 | 0.112 | 8.0 | 26 | 78 | M, B | k |
| 140 | 5 | 1,350 | 0.135 | 9.6 | 30 | 93 | M, B | f |
| 143 | 7 | 1,344 | 0.134 | 9.4 | 55 | 36 | M, B | l |
| 143 | 7 | 905 | 0.095 | 6.0 | 31 | 43 | P, B | l |
| 168 | 4.3 | 995 | 0.995 | 5.9 | 26 | 87 | M, B | m |
| 210 | 6 | 1,422 | 0.142 | 6.8 | 36 | 68 | M, C | n |
| 216 | 5 | 1,223 | 0.122 | 5.7 | ND | 46 | P, C | o |

TABLE 4.—*Comparison of different prawn monoculture and polyculture systems. B: batch, C: continuous, M: monoculture, ND: no data, P: polyculture, SD: standard deviation. Sadek and Moreau, 1996 (a); Tidwell et al., 1998 (b); Tidwell et al., 2000a (c); Tidwell et al., 1995 (d); Tidwell et al., 1994 (e); Siddiqui et al., 1997 (f); Tidwell et al., 2000b (g); Cohen et al., 1983 (h); Daniels et al., 1995 (i); De Souza et al., 1995 (j); D'Abramo et al., 1989 (k); García-Pérez et al., 2000 (l); Smith et al., 1981 (m); Lin and Boonyaratpalin, 1988 (n); Cabarcas, 1995 (o); Present study (p).*

| Period (days) | Density (prawns/m$^2$) | Yield (kg/ha) | Total yield (kg/m$^2$) | Total yield (kg/ha/d) | Harvest (g/ind) | Survival (%) | System | Author |
|---|---|---|---|---|---|---|---|---|
| 216 | 5 | 527 | 0.053 | 2.4 | ND | 20 | P, B | o |
| 557 | 5 | 2,167 | 0.217 | 3.9 | 57 | 43 | P, C | p |
| 162 | 5.2 | 1,213 | 0.162 | 8.8 | 34 | 68 | M, P, B, C | Mean |
| 95 | 1 | 335 | 0.189 | 3.4 | 9 | 21 | ND | SD |

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