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Growth, repetitive breeding, and aquaculture potential of the spiny lobster, *Panulirus ornatus*

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Abstract
A pair of subadult *Panulirus ornatus* was reared in the laboratory from July 2001. The female grew from 0.6 to 1.3 kg and the male from 0.5 to 1.6 kg in 2 years before the first mating in July 2003. In 6 months, from July to December 2003, the pair mated and spawned 3 times, producing 1.6 million eggs and 1.1 million phyllosoma larvae. Mating occurred 25 and 63 days after moulting. The female spawned 2–3 days after mating and the incubation time ranged from 23 to 27 days. The phyllosoma larvae were released over 2 successive days. The growth rate reduced after first mating in both the male and female and the female expended 42% of the total weight gain for egg production.

Keywords *Panulirus ornatus*, growth rate; repetitive breeding; egg production

INTRODUCTION

Among the spiny lobsters exported live from India, *Panulirus ornatus* (Fabricius, 1798), which is termed “tiger” in the export trade, enjoys the highest value. This species is also the largest tropical lobster, growing to over 6.5 kg. Attainment of 300 g in the first year from puerulus stage (<1 g) was reported for this species by Tamn (1980). *P. ornatus* grows faster in the laboratory than other tropical lobsters such as *P. homarus*, *P. polyphagus*, and *P. versicolor* (Radhakrishnan & Vijayakumaran 1990; Vijayakumar & Radhakrishnan 1997). Because of its faster growth rate and attainment of sexual maturity at c. 1 kg size, it is considered as the ideal species for aquaculture. About 15% of *P. ornatus* exported from India is in the size group of 300–500 g (Vijayakumar & Radhakrishnan 1997) and a sizeable number of juvenile *P. ornatus* below 300 g size are caught on the south-east coast of India. These can be fattened for short periods in indoor tanks or in open sea cages for value addition. The National Institute of Ocean Technology, Chennai, India has initiated attempts to rear the phyllosoma larvae of *P. ornatus* from captive breeders for continuous availability of larvae for experiments.

METHODS

Two *P. ornatus* females weighing 545 and 596 g and a male weighing 510 g were collected in late July 2001. The smaller female died after 2 months and the remaining two were reared along with other species of lobsters such as *P. homarus* and *P. polyphagus* at the NIOT laboratory at Chennai. In January 2003, the pair of *P. ornatus* were transferred to a rectangular cement tank of 5.3 m² area without artificial shelter. The lobsters were fed with green mussel, *Perna viridis* and occasionally with the marine clam, *Donax cuneatus*. Moulting and growth of these lobsters were monitored. Moultng times were recorded and the lobsters were measured 10 days after each moult. As soon as the female spawned, she was removed and retained in an
individual broodstock tank (capacity: 700 litre). The number of eggs carried by the lobster was estimated by using counts from three weighed subsamples, each having more than 200 eggs, and the weight of the whole egg mass. The total weight of whole egg mass was calculated as the difference between the weights just after spawning and after complete release of larvae. The eggs were examined for the fertility status when first spawned and periodically until the release of larvae. Even when the female did not retain any sperm mass, it was observed for further egg deposition for one more week, after the release of the last batch of phyllosoma larvae, before it was returned to the broodstock tank. Temperature, salinity, pH, and dissolved oxygen in the broodstock tank were monitored daily.

The water quality parameters in the broodstock tank from January to December are plotted in Fig. 1. Salinity ranged from 26.9 to 35.0 psu, temperature from 24.9 to 31.2ºC, pH from 7.85 to 8.40, and dissolved oxygen from 4.79 to 6.47 mg/litre from January to December in 2003 in the broodstock tank.

RESULTS

The growth of male and female lobsters is given in Fig. 2. Distinct increase in growth was observed after the lobsters were removed to the broodstock tank in January and fed ad libitum with green mussel. In 18 months from July 2001 to January 2003, the weight of the female increased from 596 to 1040 g, whereas that of the male increased from 510 to 990 g. However the female, which moulted twice and attained the maximum weight of 1324 g (before first mating) in May, lost weight once it mated and spawned in July 2003. It moulted once after the first release of phyllosoma larva. In the 12-month period in 2003, the weight of the female increased by 226 g. At the same time it lost 165 g in egg/larval production. In the male, extension of intermoult period and reduction in weight gain was observed after first mating. From January to July 2003, the male moulted 3 times and increased its weight by 400 g. From July to December it moulted only once and the weight increase was 199 g. Initially, when they were reared together with other species of lobsters, not all moultings were recorded and individual growth was not monitored. From January 2003, moult and growth after each moult were recorded. The intermoult period ranged from 103 to 130 days in the female and from 57 to 99 days in the male.

The chronology of repetitive breeding and temporal sequence of moulting, mating, spawning, and larval release are given in Table 1. The female lobster mated and spawned 3 times within a period of 6 months from July to December 2003, with two matings in one intermoult period. The weight of eggs and the number of phyllosoma released are given in Table 2. A total of 1 625 683 eggs were produced and 1 135 827 phyllosoma larvae were released during this period. The average hatching percentage was 70.62 with a range of 62.92-77.01. On two occasions, the larvae were released in two batches, with maximum release on the first day in the first brood and on the second day in the third brood. Remaining eggs, which were less than 1–2% of the total and were mostly unfertilised or malformed, and egg cases were shed along with the release of the second batch of larvae. When the larvae were released in one batch in the second brood, the remaining eggs and egg cases were shed 2 days after the release of the larvae. In addition, small amounts of eggs were shed on a few occasions before the release of larvae. A single spawning was observed on the second or third day after mating. Even though a sperm mass was present in the sternum, no second spawning was observed over a 12-day period after release of phyllosoma.

DISCUSSION

The growth rate of P. ornatus is considerably higher than that obtained for P. homarus (Radhakrishnan & Vijayakumaran 1990; Vijayakumaran & Radhakrishnan 1997). The weight increase for 18 months up to February 2003 was 444 g for female and 590 g for male. Higher weight increase was obtained in the subsequent months because of improvement in the rearing conditions and provision of abundant quantity of quality feed, the green mussel. Despite this, the female lost weight once it started mating and spawning. Similar observations on reduction of weight in females after breeding starts were reported in captive broodstock of P. homarus by Vijayakumaran et al. (2004a). The male grew faster than the female but also lost weight after it started mating. For commercial aquaculture, males and females have to be grown separately after they attain maturity to get maximum growth rate by preventing them from mating and breeding. However, this should not be a major problem in rearing P. ornatus, since maturity is attained at a larger size than the peak market size (<1 kg).
Fast growth rate and attainment of sexual maturity above the size required for marketing, makes P. ornatus the most ideal species of spiny lobster for aquaculture. This study, even though involving only a pair of lobsters, indicates that P. ornatus can be successfully bred in captivity to produce phyllosoma throughout the year. Three spawnings in 6 months just after attaining sexual maturity confirm the view expressed by Chittleborough (1976) and Vijayakumar et al. (2004a) that spiny lobsters can breed 6 times or more in captivity if ideal conditions and nutritionally rich feed are given. The average brood size of P. ornatus obtained in this study, 541 894 ± 98 755 is much lower than the average of 1 121 507 ± 576 158 reported from wild breeders by Vijayakumar et al. (2004b). This could be because...
Table 1  Chronology of repetitive spawning and temporal sequence of reproduction in *Panulirus ornatus* from July to December 2003.

<table>
<thead>
<tr>
<th>Spawning details</th>
<th>Mating</th>
<th>Spawning</th>
<th>Larval release</th>
<th>Moultung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Third</td>
<td>01 Dec 2003</td>
<td>03 Dec 2003</td>
<td>29 and 30 Dec 2003</td>
<td></td>
</tr>
</tbody>
</table>

Table 2  Egg number and phyllosoma larvae released from one female *Panulirus ornatus*. (CL, Carapace length.)

<table>
<thead>
<tr>
<th>CL (mm)</th>
<th>Body wt (g)</th>
<th>No. of brood</th>
<th>Egg wt (g)</th>
<th>Egg no.</th>
<th>Phyllosoma no.</th>
<th>Incubation period (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>110.7</td>
<td>1320</td>
<td>First</td>
<td>72</td>
<td>654 540</td>
<td>411 866</td>
<td>22</td>
</tr>
<tr>
<td>111.0</td>
<td>1320</td>
<td>Second</td>
<td>46</td>
<td>470 220</td>
<td>338 250</td>
<td>22</td>
</tr>
<tr>
<td>111.0</td>
<td>1324</td>
<td>Third</td>
<td>49</td>
<td>500 923</td>
<td>385 771</td>
<td>26</td>
</tr>
</tbody>
</table>

of the small size of the breeder in its first year of egg production. It is reported that *P. polyphagus* produces fewer eggs in the first year of egg production (Kagwade 1988a,b). Considerable reduction in brood size in repeat spawnings within the same season has been reported for *Panulirus argus* (Creaser 1950), *P. japonicus* (Iono 1950), *P. inflatus* (Briones & Lozano 1992), *P. homarus* (Vijayakumaran et al. 2004a), and *P. ornatus* (MacFarlane & Moore 1986). The results in this study also indicate that the brood size was maximum in the first spawning and lower but about equal in the second and third spawning. It is noteworthy that a second spawning from one mating, as reported in *P. homarus* (Vijayakumaran et al. 2004a) was not found in *P. ornatus*.

Mating in some species of spiny lobsters occurs after the female mouls, as the moult provides her with fresh ovigerous setae on the endopods of pleopods for attachment of eggs (Kittaka & MacDiarmid 1994). In *P. ornatus*, the length of the ovigerous setae increases with every moult after maturity and no shedding of the setae was recorded at moult. In some tropical species, a second mating takes place either before or after the release of larvae from the previous brood (Creaser 1950; MacFarlane & Moore 1986; Briones & Lozano 1992). In *P. ornatus*, a second mating was observed 16 days after release of phyllosoma and complete shedding of the remaining eggs. Chittleborough (1976) observed that moultung and mating in the female might be separated by 2–97 days in *Panulirus cygnus*. In *P. ornatus*, the interval between moultung and mating was 63 days for the first and 25 days for the second mating and moultung did not precede the third mating.

MacFarlane & Moore (1986) reported low levels of infertility and egg loss in *P. ornatus*. In this study the fertilisation was almost 100%, and on an average, 70.62% hatching success was achieved. It could further be improved in captive breeders as most of the egg loss was caused by handling and disturbance of lobsters while taking measurements.

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