Available online at: www.mbai.org.in doi: 10.6024/jmbai.2012.54.2.01701-03

Fecundity and viability of eggs in wild breeders of spiny lobsters, *Panulirus homarus* (Linnaeus, 1758), *Panulirus versicolor* (Latrielle, 1804) and *Panulirus ornatus* (Fabricius, 1798)

M. Vijayakumaran, A.Maharajan*[1], S. Rajalakshmi[2], P. Jayagopal[4], M. S. Subramanian[3] and M. C. Remani

[1]National Institute of Ocean Technology, Velacherry – Tambaram Road, Pallikaranai, Chennai – 601 302, India
[2]P.G. & Research Department of Zoology, Khadir Mohideen College, Adirampattinam-614701, Thanjavur Dist, Tamil Nadu.
[3]Department of Zoology, Kanchi Mamunivar Centre for Post Graduate Studies, Lawspet-605008, Puducherry.
[4]Central Marine Fisheries Research Institute, Madras Research Centre, 75- Santhome High Road, Chennai – 600 028, Tamil Nadu.

*Correspondence e-mail: athimaha@yahoo.co.in

Received: 26 Sep 2011, Accepted: 15 Jul 2012, Published: 10 Dec 2012

Original Article

Abstract

Berried lobsters collected from landing centres and lobster holding centres were used for larval rearing of the spiny lobsters, *Panulirus homarus* (Linnaeus, 1758), *Panulirus ornatus* (Fabricius, 1798) and *Panulirus versicolor* (Latrielle, 1804). Fecundity of the lobsters used for larval rearing was calculated as the number of eggs deposited on the ovigerous setae on the pleopods. The number of eggs in a single brood ranged from 1,20,544 to 4,49,585 in *P. homarus*. 5,18,181 to *P.ornatus* 1,979,522 and that of *P. versicolor* as 1,70,212 to *P.versicolor* 7,33,752. The tropical lobsters are reported to and therefore breed two times or more in a year. The absolute (annual) fecundity of these lobsters is expected to be higher. The phyllosoma larvae released, as percentage of fecundity, was maximum in *P. homarus* 85.7, 49.7 in *P. ornatus* and 74.0 in *P. versicolor*. Handling of lobsters at the landing and holding centres and aerial transport resulted in high percentage of eggs in arrested development, complete or partial shedding of eggs and release of weak phyllosoma larvae. Severe bacterial infection leading to complete shedding of eggs was recorded in a few breeders collected from holding centres.

Keywords: *Fecundity; viability of eggs; Panulirus homarus; Panulirus ornatus; Panulirus versicolor.*

Introduction

Breeders of three species of Indian spiny lobsters, *Panulirus homarus, Panulirus ornatus* and *Panulirus versicolor* were collected from the wild and used for larval rearing. The brood size and fecundity of these lobsters were estimated and presented in this paper. Transportation of wild caught berried females is difficult and often results in bacterial infections, which causes severe loss of eggs and or hatching of weak phyllosoma larvae (Kittaka and MacDiarmid, 1994). The breeders collected in this study were subjected to handling at many places and the transportation period ranged from few minutes to 24 hours involving aerial transport. The fertility and viability of the eggs and bacterial infections as a result of handling and transportation of breeders were also studied and presented.

Material and methods

Berried spiny lobsters, *P. homarus*, *P. ornatus* and *P. versicolor*, caught in bottom-set gill nets were collected from the landing centre and the primary holding centre at Kovalam, near Chennai, (southeast coast of India) and from a nearby secondary holding centre for one year. The breeders were brought to the field laboratory of the Central Marine Fisheries Research Institute at Kovalam and maintained in filtered

seawater with adequate aeration. The lobsters collected from the landing centre, within 200 meters from the laboratory, were transferred immediately to rearing tanks. From other centers, they were transported in cloth bags or thermocol containers. The secondary holding centre, which was the main exporting unit in Chennai, received lobsters from Kanyakumari, about 750 km away, in addition to local collections. These lobsters were packed in thermocol boxes and transported by train or bus to Chennai. The transportation time ranged from 18 to 24 hours.

After measuring the carapace length (CL) and total length (TL), the berried lobsters were weighed after shaking off the adhering water from the egg mass. Three samples of eggs, containing around 200-250 numbers, were taken and weighed to 0.01mg accuracy. The number of eggs in the samples was counted accurately to determine the weight of single egg and to estimate the number of eggs in the brood. Total egg mass in a brood was calculated by the difference between initial weight (with egg) and the weight after release of larvae and complete shedding of egg cases. The fertilization and developmental status of the eggs were determined by observing about 100 to 150 eggs under light microscope. Eggs that have developed initially but ceased to develop further compared to those in advanced development in a brood have been marked as eggs with arrested development.

Berried lobsters were reared in FRP tanks (capacity: 100 - 200 l) and fed ad libitum the green mussel *Perna viridis* and the marine clam, *Donax cuneatus*, daily in the evening. Feed remains were removed in the morning and 80% of water was exchanged daily. Salinity of the seawater ranged from 32-34 psu and the pH from 7.5 to 8.2. The temperature varied between 25-30^{0}C and the dissolved oxygen was maintained above 4ml/l. The number of phyllosoma larvae released was calculated by taking ten sub samples from the rearing tanks after thorough mixing. Breeders with remnant of spermatophoric mass in the sternum were monitored to note if a second spawning occurred after the release of the larvae. Breeders with mottled appearance of eggs and with mucus like exudates from the egg giving foul smell were sampled for microbiological studies.

All statistical calculations were done following Snedecor and Cochran (1967) and the average values are expressed as mean $\pm$ SD.

Results and discussion

The smallest breeder of *P. homarus* had a CL of 52.2mm while the biggest one had a CL of 94.4mm. The number of eggs in a single brood varied from 1,20,544 in the smallest lobster to 4,49,585 in the biggest one. Mean egg weight in different size groups varied from 11.5 g to 51.0 g (Table 1). Wide variation was found in the weight and numbers of eggs in some size groups since few lobsters were carrying a second brood with a single mating. The second brood from a single mating, which could be distinguished by the presence and nature of spermatophore in the sternum, was smaller than the first one in most of the lobsters.

P. ornatus had the biggest brood among the three lobsters with 5,18,181 to 19,79,522 eggs in a single brood (CL 104.4 to 145.1mm) (Table 2). The number of eggs in a brood of *P. versicolor* (CL 66.0 to 95.0 mm) ranged from 1,70,212 to 7,33,752 (Table 3). In *P. homarus* maximum 86.0% of eggs were fertilized, while the figures for *P. ornatus* and *P. versicolor* were 72.9% and 83.5% respectively (Fig 1). However, many eggs were observed to be in an arrested stage of development in all the three species. Eggs in arrested development varied from 16.6 $\pm$ 0.14% in *P. versicolor* to 28.1 $\pm$ 3.34 % in *P. ornatus*. was 20.1 $\pm$ 11.05% *P. homarus* (Fig 1). While few breeders shed all eggs with in a few days of collection, some

Table 1. Number of eggs in a single brood in the spiny lobster, *Panulirus homarus* (Mean $\pm$ SD)

Carapace Length (mm)	Total Weight (g)	Weight of egg mass (g)	Number of eggs	Phyllosoma Numbers	% hatching
52.2	156.8	11.5	120544	27085	30.08
56.7	187.5	18.5	129827	81500	64.69
62.9	279.4	33.7	251132	77724	30.94
68.4	326.0	37.1	283245	93870	27.36
73.7	441.6	34.3	291067	123057	37.88
77.0	475.6	33.6	312147	-	-
83.6	571.5	36.6	332617	-	-
87.8	647.9	40.6	340107	36333	14.88
94.4	850	51.0	449585	14000	4.59
Mean + SD					
72.96$\pm$ 13.4	437.37$\pm$ 201.59	32.99$\pm$ 8.47	278919$\pm$ 84585.98	50396.56$\pm$ 43911.03	23.38$\pm$ 20.93

Table 2. Number of eggs in a single brood in the spiny lobster, *Panulirus versicolor* (Mean ± SD)

Carapace Length (mm)	Total weight (g)	Weight of egg mass (g)	Number of eggs	Phyllosoma Numbers	% hatching
66.1	310	40	283687	210000	74.02
71.2	400	62	439716	125000	28.42
73.4	450	59	447375	224403	50.16
76.4	500	24	170212	68000	39.95
76.1	500	62	470123	140331	29.85
81.4	560	60	454958	64604	14.21
81.5	620	35	248226	46000	18.53
95.1	850	70	733752	0	0
			Mean + SD		
75.2± 5.51	523.8± 162.38	51.5± 16.27	406006± 174121	109792± 109792	31.9± 22.98

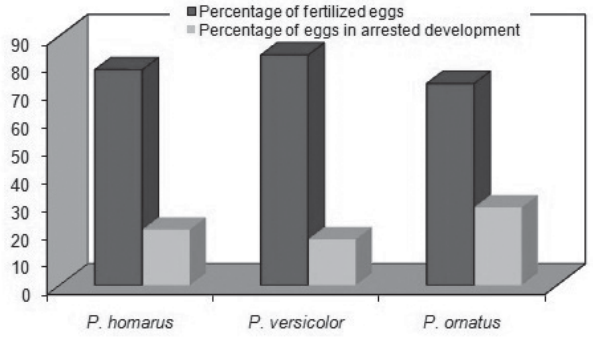

Fig. 1. Percentage of fertilized eggs and percentage of egg arrested development in *P. homarus*, *P. versicolor* and *P. ornatus*

others periodically shed small quantities of eggs. Shedding of the remaining egg mass along with egg cases after the first release of phyllosoma was noticed in a few lobsters. In majority of cases the phyllosoma larvae were released in two batches in two consecutive days with the maximum number released on the first day.

The number of phyllosoma larvae released by *P. homarus* ranged from 0 to 1,23,057 and the hatching percentage ranged from 0 to 64.69, with a mean of 23.38±20.93. In *P. ornatus* and *P. versicolor* also shedding of the whole egg mass was recorded. In *P. ornatus*, the number of larvae released ranged from 0 to 4,11,846 with a mean of 2,70,883 ± 1,53,021 (Table 3). The hatching percentage ranged from 0 to 72.7 with a mean of 34.2 ± 26.07. The number of larvae released by *P. versicolor* ranged from 46,000 to 2,10,000 with a mean of 1,09,792 ± 79,510 (Table 2). The hatching % ranged from 0 to 74.0 with a mean of 31.9 ± 22.98. Maximum hatching in all the three species was obtained in breeders collected directly from the landing centre and minimum hatching and complete shedding of eggs were recorded in the breeders collected from the secondary holding centre. These lobsters were exposed to aerial transport for a period ranging from 18 to 24 hours.

Few lobsters, especially from the secondary landing centre

Table 3. Number of eggs in a single brood in the spiny lobster, *Panulirus ornatus* (Mean ± SD)

Carapace Length (mm)	Total weight (g)	Weight of egg mass (g)	Number of eggs	Phyllosoma Numbers	% hatching
104.4	1049	57	518181	312000	60.21
107.9	1250	65	664441	399395	60.11
110.7	1320	40	571428	411846	72.07
111.8	1306	46	630137	338250	53.68
116.4	1550	215	1467576	370562	25.25
118.1	1500	170	1086262	312000	28.72
129.5	1715	185	1262797	379470	30.05
131.1	2000	250	1597444	30200	1.89
133.3	2000	235	1551155	155116	10.01
145.1	2800	290	1979522	0	0
			Mean + SD		
120.8± 13.22	1649± 511.28	155.3± 95.98	1132894± 516819	270883± 153021	34.2± 26.07

had eggs with mottled appearance with interspersed live and dead eggs. One *P. homarus*, transported from a holding centre in Kanyakumari, had severe bacterial infection leading to exudation of mucus-like secretion from the egg mass, emanating foul odour. The lobster became moribund and was sacrificed for pathology examination. Fourteen colonies of gram-negative bacteria were isolated from the rearing water, eggs and tissues of the moribund lobster.

The size of a single brood was largest in *P. ornatus* followed by *P. versicolor* and *P. homarus* and was in line with the maximum size attained by these lobsters in nature. The size of *P. ornatus* was larger than that of the other two species. The brood size of 1,979,522 recorded in *P. ornatus* (weight: 2.8 kg) is as large as two million eggs reported for the largest lobster, Jasus verreauxi, by Kensler (1967) and 1.95 million eggs reported for *P. argus* (Bertelsen and Mathews, 2001). Since *P. ornatus* grows to over 6.5 kg, the size of the single brood is likely to increase in larger lobsters as bigger the lobsters the larger are the number of eggs. Murugan *et al.* (2004) have observed that under captive breeding, *P. ornatus* could produce three spawnings in six months and MacFarlane and Moore (1986) have suggested that this species could spawn 3 to 4 in a year. The fecundity of *P. ornatus* could thus be four times the average production of 1,121,507 for breeders weighing 1.5 kg and in the fourth or fifth year age group.

P. versicolor is reported to breed at 66 mm CL and the observed range in this study is from 66 to 95 mm CL. As in the other tropical species of spiny lobsters, it is possible that it can spawn up to four times a year and produce 1.5 million eggs at an average size of 77.7 mm CL. In both *P. ornatus* and *P. versicolor*, the total number of samples were inadequate to make any definite conclusions on the fecundity and the data given are only indicative.

A good representative sample of *P. homarus* breeders of different size groups ranging from 51.6 to 96.1 mm CL indicated a trend that the brood size is proportional to the CL of lobsters and the number of eggs produced increases with the size of lobsters. However, caution should be exercised in expressing this relationship since wide variations in the total egg weight and the numbers of eggs were recorded in almost all size groups due to the smaller size of brood in the second spawning from a single mating. Egg numbers expressed per g body weight indicates that the maximum number was for the size group 61-70 mm carapace length (Fig 3). About 66% of the breeders belonged to the size group of 61-80 mm CL and this is the dominant size group in the fishery as evident from the export of live lobsters (Vijayakumaran and Radhakrishnan, 1997). Mohan (1997) has reported that the size group ranging from 70.1 -75 mm and 80.1- 85 mm

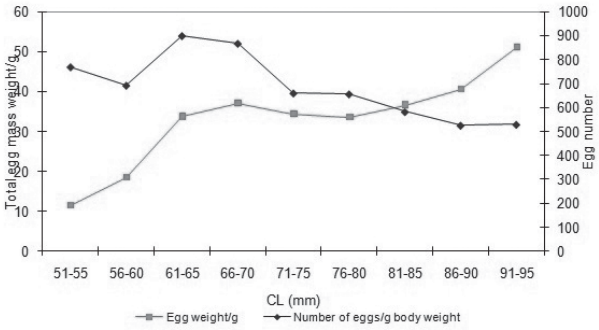

Fig. 2. Total egg weight and eggs/g body weight in *P. homarus*

carapace length contribute 44 and 35.8% of eggs produced by the same species in different regions of the Dhofar coast in the Sultanate of Oman. Hence this size group may be contributing more to the reproduction and recruitment in *P. homarus*. Vijayakumaran *et al*. (2004b) reported that the captive breeders of *P. homarus* spawned 4 times in an year. Berry (1971) also has observed that 3-4 spawning per year is possible for *P. homarus* in a breeding season and it can be assumed that this species might spawn 4 times a year in nature. The fecundity then could be a minimum of 4 times the mean value of 2,84,285. The maximum number of eggs (628,930) recorded for *P. homarus* (Fig. 4) compares well with the maximum of 6,67,000 reported for the same species by Mohan (1997), but is less than the estimate of 9,00,000 by Berry (1971).

Number of eggs produced per g body weight was calculated from CL and egg numbers for *P. argus* in South Florida by

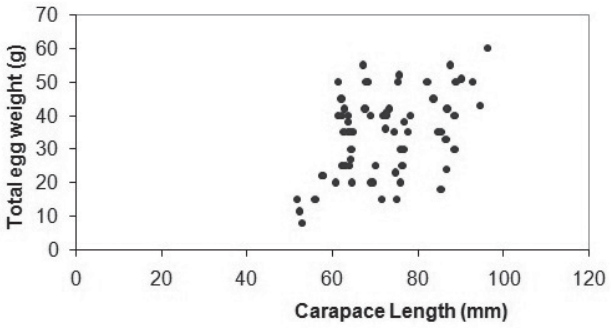

Fig. 3. Relationship between carapace length and total egg weight in *P. homarus* (n=107)

Bertelsen and Mathews (2001). Maximum reproductive effort of 830 eggs per g body weight was for lobsters between 90 and 95 mm CL, with 500 and 700 eggs per g for the sizes below 80 and above 95CL respectively. A similar trend is seen in *P. homarus* with the size group 61-70 mm CL having maximum number of eggs (867-899) per g body weight (Fig 2). However, a clear formula for *P. homarus* can be worked out only after studying a larger sample of egg production

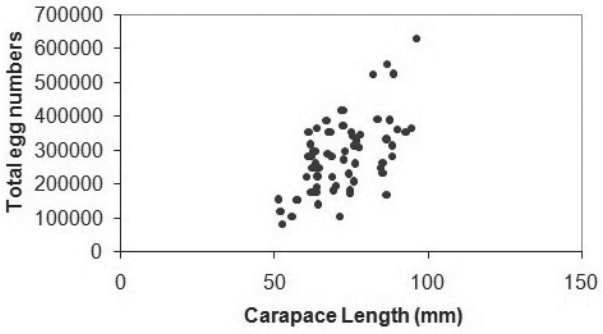

Fig. 4. Relationship between carapace length and egg numbers in *P. homarus* (n=107)

in the first spawning as the range of egg weight in this study indicates that the smaller clutch size is from second spawning from a single mating. Chubb (1994) has expressed the opinion that in species with a smaller number of eggs in the second clutch, the eggs produced in the first clutch by lobsters with fresh sperm deposition should be considered to estimate fecundity. The larger size groups of (CL > 86 mm) had the lowest number of eggs per g body weight (525/g). The number of eggs produced per g body weight for *P. ornatus* and *P. versicolor* were 737/g and 716/g respectively. These results suggest that the number of eggs produced per g body weight by different species of palinurid lobsters do not vary much.

The percentage of fertilized eggs varied from 72.8 in *P. ornatus* to 83.1 in *P. versicolor*. This is in contrast to the observation of very low levels of infertility and egg loss reported for *P. ornatus* by MacFarlane and Moore (1986). A sizeable percentage of eggs were seen in arrested development at various stages, which could be a direct impact of handling and exposure of eggs to air.

Egg loss and production of weak phyllosoma larva were some of the problems encountered with wild breeders. Handling at the landing centre, the primary holding centre and the secondary holding centre, duration of transport and the holding of lobsters in sub-optimal conditions at the holding centres were some of the reasons for egg loss, weak larval production and infection of eggs. The lobsters were caught by bottom set gillnet and would have struggled to detach from the net for several hours. More often than not, the eggs were squeezed at the primary and secondary holding centres to remove adhering water and reduce the weight of lobster. The duration of transport had a direct effect on the viability of egg. Maximum hatching of phyllosoma obtained was from the breeders collected directly from the landing centre. Breeders collected from the secondary holding centre had the lowest hatching, with partial or complete shedding of eggs. Eggs were shed either completely or in batches before, along with or after the release of phyllosoma larve. Bacterial infection also was recorded in these breeders.

Eggs with mottled appearance were due to dead and infected eggs and in one of the breeders the infection was so severe that the mucoid exudates from the egg emanated foul smell. Most of the bacteria isolated from the infected eggs were gram negative. The lobster became moribund in two to three days as the infection spread and was sacrificed.

When wild breeders are used for larval production, it should be transported in well aerated seawater as soon as it is caught and aerial exposure should be avoided to obtain good hatching and healthy larvae. Development of captive broodstock should be given top priority to get healthy larvae for any programme on larval rearing of spiny lobsters.

Acknowledgements

We thank Dr. P. V. Sreenivasan and Dr. E. Vivekanandan, Principal Scientists, Central Marine Fisheries Research Institute, Madras Research Centre, Chennai for critically reviewing the manuscript.

References

Berry, P.F. 1971. The biology of the Spiny lobster, *Panulirus homarus* (Linnaeus) of the east coast of southern Africa. *Investigation Reports Oceanographic Research Institute*, 28: 1-75.

Bertelsen, R.D. and T.R. Mathews. 2001. Fecundity dynamics of female spiny lobster *(Panulirus argus)* in a South Florida fishery and Dry Tortugas Park Lobster sanctuary. *Mar. Freshwat. Res.*, 52: 1559-65.

Chubb, C.F. 1994. Reproductive biology: Issues for management. In: Phillips, B.F.; Cobb J.S, Kittaka J, (Eds) *Spiny lobster management*. p.181-212 Fishing News Books, Blackwell Scientific Company, Oxford.

Kensler, C.B. 1967. Fecundity in the marine spiny lobster *Jasus verreauxi* (H. Milne Edwards) (Crustacea: Decapoda Palinuridae). *N. Z. J. Mar. Freshwat. Res.*, 1: 143-55.

Kittaka, J. and A.B. MacDiarmid. 1994. Breeding. In: Phillips, B.F.; Cobb, J.S.; Kittaka, J., (Eds.) *Spiny Lobster Management*. p. 384-401 Fishing News Books, Blackwell Scientific Company, Oxford.

MacFarlane, J.W. and R. Moore. 1986. Reproduction of the ornate rock lobster, *Panulirus ornatus* (Fabricius), in Papua New Guinea. *Aus. J. Mar. Freshwat. Res.*, 37: 55-65.

Mohan, R. 1997. Size structure and reproductive variation of the spiny lobster *Panulirus homarus* over a relatively small geographic range along the Dhofar coast in the Sultanate of Oman. *Mar. Freshwater Res.*, 48: 1085-91.

Murugan, T., M.C. Remany., T. Mary Leema., Dilip Kumar Jha., J. Santhanakumarm., M. Vijayakumaran., R. Venkatesan and M. Ravindran. 2004. Growth and breeding of the spiny lobster, *Panulirus ornatus* (Fabricius 1798). Abstract. *7th International Conference and Workshop on Biology and Management of Lobsters*, Hobart, Tasmania, 8-13 February, 2004.

Snedecor, G.W. and W.G. Cochran. 1967. Statistical methods. Sixth Edition, Iowa State University Press. 535 pp.

Vijayakumaran, M. and E.V. Radhakrishnan. 1997. Live transport and marketing of spiny lobsters in India. *Mar. Freshwater Res.*, 48: 823-28

Vijayakumaran, M., T. Senthil Murugan., M.C. Remany., T. Mary Leema., Dilip Kumar Jha., J.Santhanakumar., R. Venkatesan and M. Ravindran. 2004b. Captive breeding of the spiny lobster *Panulirus homarus* (Linnaeus, 1758). Abstract. *7th International Conference and Workshop on Biology and Management of Lobsters*, Hobart, Tasmania, 8-13 February 2004.