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GROWTH ASSESSMENT OF SPINY LOBSTER (*PANULIRUS HOMARUS*) UNDER OPEN SEA CAGE CULTURE IN THARUVAIKULAM OF TAMIL NADU COAST, SOUTH INDIA

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ABSTRACT
Suspended floating open sea cage for the aquaculture of juvenile spiny lobsters, *Panulirus homarus* was assessed at Tharuvaikulam village of Tamil Nadu coast, India. Juvenile lobsters were grown for 101 days and regularly fed with live clam (*Donax* sp) as natural feed. Juvenile lobsters with average weight of 75.75 g in the cage grew to an average weight of 104.50 g in 101 days with average wet weight gain and survival rate of 28.75g and 88.50 % respectively. The mean weight gain showed highly significant ($p < 0.001$) positive relationships with culture period. The mean growth values showed no significant difference between the cages. The present study suggests that floating open sea cage culture gave better growth for under sized spiny lobsters by fattening method.

INTRODUCTION

Lobster culture is getting increasing attention for live lobsters and lobster tails in the internal and export market. Spiny lobster catches fluctuating widely and the quantity landed are insufficient to meet the requirements. Growing lobsters in captivity is one of the strategies to cope with the increasing demand. Growth pattern of various species of spiny lobsters under captive conditions have been well reported (Radhakrishnan and Vijayakumaran, 1984; 1987). Lobsters are high valued marine crustaceans and they have a commanding market value in both international and domestic markets especially in south-east Asian countries (Vijayakumaran and Radhakrishnan, 1997). Several essential requirements for the commercial farming of aquatic organisms are required (Codd, 1976). Tropical spiny lobsters have characteristics such as adaptable to captive conditions, less cannibalistic and relatively faster growth in sub-tropical and temperate regions, which make them suitable for aquaculture (Philipps *et al.*, 1977). In view of these facts, any realistic approach towards spiny lobster culture from wild to commercial sizes. Presently, about 1539 t of lobsters are being commercially exploited annually from the Indian EEZ and continuation of indiscriminate exploitation of this resource can lead to severe setback on the fishery (CMFRI, 2008). Realizing the importance of aquaculture, significant advances were made in lobster culture in countries *viz*., Vietnam, Taiwan, Singapore and New Zealand. In India, except for some studies conducted by Vijayakumaran *et al*. (2009) on *Panulirus homarus* and *Panulirus ornatus* and in few centres such as Bhavanagar in Gujarat on *Panulirus polyphagus* (Suseelan *et al.,* 1992), proper attention has not been given for growing to marketable size. Experimental culture of spiny lobsters in tanks has also proved their hardiness and high growth rate (Radhakrishnan and Vijayakumaran, 1984; 1987) although aggression and cannibalism were observed under high stocking density (Van Olst *et al*., 1980). Growth response of *P. homarus* in cage culture was studied by Srikrishnadhas *et al*. (1983). Kaleemur *et al*. (1997) studied growth patterns of different size groups of *P. homarus* in captive conditions. Illustrated accounts on cultivable species of Indian lobsters including their distribution, biology and prospects for culture using naturally available baby lobsters in cages and trays were reported by Suseelan *et al*. (1992) and Radhakrishnan (1994; 2004). Syda Rao *et al*. (2010) conducted an experiment on culture of juvenile's spiny lobsters in land-based FRP tanks and in floating cage at Vizhinjam Bay. With this consideration, growth of spiny lobster in floating FRP cages at Tharuvaikulam coast of Tamil Nadu was conducted.

MATERIALS AND METHODS

The present study was carried out with spiny lobster (*Panulirus homarus*) at Maritech Research and Extension Centre, Tharuvaikulam village (Thoothukudi, South India). Juveniles were procured from a private company at Kanyakumari and collected juvenile lobsters were kept in FRP tank (300 litres capacity) containing seawater with continuous aeration and

transported to the Maritech Research and Extension Centre, Tharuvaikulam, Thoothukudi by truck vehicle. They were reared in 8 FRP cages (Each cage size: 5 x 5 feet size in top; 4 x 4 feet neck of the cage) with facility for free flow of water in and out of the each cages and installed at the open sea of Tharuvaikulam Village.

Before starting the experiment, all the juveniles lobsters were conditioned for 2 days. At the commencement of the experiment, 250 numbers of juvenile lobsters for each cage (with an average weight of 75.75 g; average mean total length of 10.60 mm) was stocked. About 2000 juvenile lobsters (250 juvenile lobsters x 8 cages) were used. The feeding was given at the rate of 5 % of the body weight. Juvenile lobsters fed live clams (*Donax* sp) by hand twice daily. The feed intake was checked daily and uneaten clams along with shells were removed manually once in week. The feeding trial was done for 101 days after a two days period of acclimatization. The standard formulae and definitions were used to assess growth, feed utilization and other relative parameters as given by (Lamek Jayakumar *et al.,* 2011, Lende, *et al.*, 2015). Important parameters *viz*., average weight gain, survival rate, feed conversion ratio, feed conversion efficiency, specific growth rate, (SGR - % per day) and biomass production have been calculated (Lamek Jayakumar *et al*., 2011). Based on the information derived from biological data, statistical relationships (Two Way ANOVA, Student's t test and linear correlation) of different cages were analyzed following the Biostatistical methods of Christenson (1996).

RESULTS AND DISCUSSION

The calculated different bio-growth parameters for different lobsters fed with live clam as diet for spiny lobster are given in Table 1.

Monthly moulting was occurred and the same has been removed from 8 cages. The Average Daily Growth (ADG) recorded in different cages was ranged from 0.27 to 0.30 g.

In an open sea net cage experiment conducted at Thoothukudi Harbour, Sreekrishnadas *et al*. (1983) reported 0.6 g growth per day with low survival rate (57.5%) for *P. homarus*. However, Vijayakumaran *et al*. (2009) observed growth of 0.33 - 0.97 g per day for juveniles in small FRP and mild steel floating cages at open sea sites attaining final mean weight ranging from 215 - 245 g during a period of 132 -164 days. The weight increase recorded in the present study is partly substantiated by Vijayakumaran *et al*. (2009). The survival rates obtained were ranged from 87 % to 89 % in all the cages, which is comparable with the survival rates of 70- 95 % for *P. ornatus* as reported by the lobster growers in Vietnam

Table 1: Bio-growth performance of spiny lobster *Panulirus homarus* under floating FRP cages

Sl. no	Parameters	FRP Cage 1	FRP Cage 2	FRP Cage 3	FRP Cage 4	FRP Cage 5	FRP Cage 6	FRP Cage 7	FRP Cage 8
1	Mean initial length (cm)	10.00	10.50	11.00	11.00	10.00	10.50	11.00	11.00
2	Mean final length (cm)	12.00	12.50	13.00	13.00	12.00	12.50	13.00	13.00
3	Mean increase in length (cm)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
4	Mean initial weight (g)	75.00	74.00	76.00	77.00	75.00	74.00	77.00	78.00
5	Mean final weight (g)	105.00	103.00	104.00	105.00	105.00	104.00	105.00	105.00
6	Mean Weight Gain (g)	30.00	29.00	28.00	28.00	30.00	30.00	28.00	27.00
7	Average Daily Growth (g/day)	0.30	0.29	0.28	0.28	0.30	0.30	0.28	0.27
8	Initial number stocked (numbers)	250	250	250	250	250	250	250	250
9	Final number obtained (numbers)	220	223	220	223	218	220	223	223
10	Survival Rate (SR)	88	89	88	89	87	88	89	89
11	Average production / cage (Kgs)	23.100	23.000	23.880	23.415	22.890	22.880	23.415	23.415
12	Specific Growth Rate SGR) % / day	0.33	0.33	0.31	0.31	0.33	0.33	0.34	0.29
13	Wet feed fed (kg) with shell	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00
14	Wet feed fed (kg) without shell	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
15	Feed Conversion Ratio (FCR)	2.59	2.61	2.51	2.56	2.62	2.62	2.56	2.56
16	Feed Conversion Efficiency (FCE)	38.50	38.33	39.80	39.00	38.15	38.13	39.00	39.00

Table 2: Correlation between mean body weight gain of *Panulirus homarus* with days of culture

Sl.No	Mean of X (days of culture)	Mean of Y (mean weight gain)	Degrees of freedom	Intercept value (a)	Slope (b)	Correlation coefficient	Level of significance
Cage 1	51	90.00	0	74.7000	0.3000	1.0000	$p<0.001$
Cage 2	51	88.50	0	73.7100	0.2900	1.0000	$p<0.001$
Cage 3	51	90.00	0	75.7200	0.2800	1.0000	$p<0.001$
Cage 4	51	91.00	0	76.7200	0.2800	1.0000	$p<0.001$
Cage 5	51	90.00	0	74.7000	0.3000	1.0000	$p<0.001$
Cage 6	51	89.00	0	73.7000	0.3000	1.0000	$p<0.001$
Cage 7	51	91.00	0	76.7200	0.2800	1.0000	$p<0.001$
Cage 8	51	91.50	0	77.7300	0.2700	1.0000	$p<0.001$

Table 3: Student's t-test analysis of the data relating to growth of spiny lobster species with different cages

Sl. No.	Parameters	X_1	X_2	Degrees of freedom	Student's t value	Level of Significance
1	Cage 1 x Cage 2	74.5	104	2	26.3856	NS
2	Cage 1 x Cage 3	75.5	104.5	2	41.0122	NS
3	Cage 1 x Cage 4	76	105	2	29	NS
4	Cage 1 x Cage 5	75	104.5	2	59	NS
5	Cage 1 x Cage 6	74.5	104.5	2	42.4264	NS
6	Cage 1 x Cage 7	76	105	2	29	NS
7	Cage 1 x Cage 8	76.5	105	2	19	NS
8	Cage 2 x Cage 3	75	103.5	2	25.4912	NS
9	Cage 2 x Cage 4	75.5	104	2	15.809	NS
10	Cage 2 x Cage 5	74.5	104	2	26.3856	NS
11	Cage 2 x Cage 6	74	103.5	2	59	NS
12	Cage 2 x Cage 7	75.5	104	2	15.809	NS
13	Cage 2 x Cage 8	76	104	2	12.522	NS
15	Cage 3 x Cage 5	75.5	104.5	2	41.0122	NS
16	Cage 3 x Cage 6	75	104	2	29	NS
17	Cage 3 x Cage 7	76.5	104.5	2	39.598	NS
18	Cage 3 x Cage 8	77	104.5	2	24.5968	NS
19	Cage 4 x Cage 5	76	105	2	29	NS
20	Cage 4 x Cage 6	75.5	104.5	2	18.3412	NS
21	Cage 4 x Cage 7	77	104.5	2	55	NS
22	Cage 4 x Cage 8	77.5	105	2	55	NS
23	Cage 5 x Cage 6	74.5	104.5	2	42.4264	NS
24	Cage 5 x Cage 7	76	105	2	29	NS
25	Cage 5 x Cage 8	76.5	105	2	19	NS
26	Cage 6 x Cage 7	75.5	104.5	2	18.3412	NS
27	Cage 6 x Cage 8	76	104.5	2	13.8245	NS
28	Cage 7 x Cage 8	77.5	105	2	55	NS

* NS – Non significance

Table 4: One way ANOVA between different cages with time bound variations in *Panulirus homarus*

Source of Variation	Sum of square	Degrees of freedom	Mean sum of Square	F stat	F crit	p value
Between cages	3306.25	1	3306.25	2373.718	4.60011	Non-significant
Within cages	19.50	14	1.392857			
Total	3325.75	15				

Table 5: Economic features of spiny lobster mariculture in open sea floating cage system

A) Stocking details		
1	Total number of cages	08
2	Stocking rate / cage (numbers / cage)	250
3	Mean Body Weight at the time of harvest (g)	104.500
4	Mean initial length CL at the time of harvest (cm)	12.60
5	Total number of juvenile lobsters stocked	2000
6	Final numbers harvested	1770
7	Mean survival rate (%)	88.50
8	Seed source	Natural Collection
9	Days of culture	101
B) Non - Recurring cost		
8	Cost of the cages (Rs.13,000 / cage x 8 cages)	1,04,000.00
C) Recurring cost		
9	Seed cost (150 kgs x Rs.350 per Kg)	52,500.00
10	Feed Cost (4800 kgs x Rs. 2.50 per Kg)	12,000.00
11	Other expenses (transportation, labour, maintenance etc.	9000.00
12	Depreciation (20 % of Non-recurring cost)	20,800.00
Sub total		94,300.00
D) Harvest Details		
13	Total harvested weight of lobsters (kgs) from 8 cages	185.995
14	Selling price (Rs / Kg)	1100.00
15	Total revenue (185.995 Kgs x Rs. 1100 / Kg)	2,04,595.00
E)	Net revenue (Rs. 2,04,595 – Rs. 94,300)	1,10,295.00
F)	Cost of production / kg (Rs. 94,300 – 185.995 Kgs)	507.00
G)	Net profit / Kg (Rs. 1100 / Kg – Rs. 507 / Kg)	593.00

(Vijayakumaran *et al*. 2009). However, Jeffs and James (2001) recorded 67% mortality in experimental trials on sea cage farming of juvenile lobsters at the end of 6 months of stocking.

The Specific Growth Rate (SGR) in all the test cages ranged from 0.29 to 0.34 % / day and highest SGR was observed in cage 7. The SGR achieved in lobsters maintained in all the cage during the present study were slightly less than that observed (0.43%) by Vijayakumaran *et al*. (2009) and Syda Rao *et al*. (2010).

The calculated feed conversion efficiency in all the cages groups varied between 38.13 and 39.00 %. Similarly, the calculated Feed Conversion Ratio (FCR) in different test cages was ranged from 2.51 to 2.62 on wet weight basis. The mean weight gain showed highly significant ($p < 0.001$) positive relationships with days of culture (Table 2).

Student's t-test confirmed that mean growth values showed no significant difference between all the cages (Table 3). One way ANOVA of the data collected also affirmed that among the different cages, mean growth values showed no significant difference between the cages (Table 4).

No cannibalism was occurred but, mortality was occurred. The economic features of spiny lobster mariculture in open sea floating cage system were also worked out and are given in Table 5.

The calculated cost of production / kg of spiny lobster were Rs. 507. But, Lipton *et al*. (2010) reported that the cost of production / kg of lobsters were to the tune of Rs. 687 which was higher than the present study under different cages.

In the present study, good growth and survival of *P. homarus* was obtained in floating sea cage culture by fattening methods

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