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Effect of stocking density on growth and survival rate of Spiny Lobster (*Panulirus polyphagus*) in cage culture system

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Abstract

In the present study, cage culture of spiny Lobster in 124days was carried out and effect of different stocking density on growth and survival was find out. At present there are no commercially feasible lobster farming practices anywhere in the world. Maximum growth was obtained in treatment with 20 lobsters/cage with weight gain of 48.95% followed by 45.65% and 42.45 % weight in a treatment with 10 lobsters/cage and 30 lobsters/cage respectively. Survivability recorded from 30 lobsters/cage was observed to be 24.66% whereas it was 21% in 20 lobsters/cage and 0 % in 10 lobsters/cage, this was affected due to low temperature during winter season. Maximum FCR recorded during experiment were 39:1, 35:1 in treatment 30 and 20 numbers stocking density respectively. Among all treatment better growth in term of SGR recorded was from 20 lobsters/cage followed by 30 lobsters/cage and 10 lobsters/cage stocking density and it was 0.38, 0.35 and 0.31 respectively.

Key words: Cage culture, FCR, SGR, Spiny Lobster

Introduction

Spiny Lobster (*Panulirus polyphagus*) culture is getting increasing attention in recent times due to the intense demand for live lobsters and lobster tails in the national and international market. Culture-based grow out of tropical spiny lobster is an emerging and unique industry that faces a numbers of challenges and opportunities. Increasing global demand, a high market value, and concern for the sustainability of wild stocks have created significant interest in the development of spiny lobster aquaculture (Radford and Marsden, 2005; Simon and James, 2007).

High value crustacean production in 2004 was 7.4% with 16.3 % of the total value

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(Syda Rao, 2008). Earlier 1950's production was below 1 million tones, production in 2004 reported to have risen to 59.4 MT with a value of US $ 70.3 billion. In 2004, countries in the Asia and the Pacific region accounted for 91.5% of the production quantity and 80.5 % of the value (Radhakrishnan, 2008). The period 2000-04 showed higher growth in production of crustaceans in particular, and of marine fish (Radhakrishnan, 2008) recent data should be incorporated. Production in the cage-reared *P. ornatus* industry is estimated to exceed 3000 tonnes annually at an export value of US$90 M (Williams, 2007). Global aquaculture production has undergone remarkable changes, with production scaling up from less than a million tonnes in the early 1950's to 48.1 million t in 2005. Aquaculture has become the world's fastest growing sector of food production, increasing nearly 60 fold during the last five decades (FAO, 2007).

India has lost a substantial amount of foreign exchange by supplying juveniles to overseas countries for farming (Charles and Peter, 2003). The fisheries sector is contributing nearly 2 percent of the total GDP. In India three species are the most suitable for farming *P. homarus* of southwest and southeast coast, *P. polyphagus* of North West coast and *P. ornatus* of southeast coast (Charles and Peter, 2003). Previous studies have shown that tropical species are more promising for commercial production due to fast growth rate. Lobster above 60 g grows faster than the smaller ones. About one fourth of the commercial lobster's catches comprise juveniles of about 60-90 g size, which fetch hardly US$ 0.2 per individual or about US$ 2-3 per kg. If they are grown to a marketable size of about 200g, they will fetch US$ 3 per individual or about US$ 14- 15 per kg. Furthermore, the size of the lobster catch from the fishing grounds is on the decline. Lobster fishing grounds are discontinuous along the Indian coasts. The resources include a few species of coastal and deep-sea forms as mentioned earlier.

To avoid targeted fishing of juvenile lobsters and to protect the breeding stock, the Ministry of Commerce, Government of India has banned export of undersized lobsters by a Gazette notification in July 2003 (Venkatesan, 2004). Currently, almost all global lobster production is from capture fisheries, where stocks are either overexploited and in decline or at their maximum sustainable yield. Commercially viable hatchery technology is yet to be developed (Williams 2007). However, recent awareness of profitability by fattening lobsters to marketable size is changing the trend of the exporting juveniles for fattening. Lobster fattening is slowly getting commercialized in Kerala, Andhra Pradesh, and Tamil Nadu and now in Gujarat state. Fattening of young ones caught from wild requires only little inputs and technological application.

Looking to the vast area of Gujarat

coastline, cage culture of shellfishes should be given prime importance, so that unutilized coastal sea water can be converted for local employment generation and harvest of lobsters (in tones) will generate more foreign exchange earnings by its export. Already cage culture for fattening the lobster is in practice where farmers stock lobster with very high stocking density which leads toll on the growth of the lobster. Therefore, the present study was carried out to see the effect of stocking density on different growth parameters and survival of *Panaulirus polyphagus* in cage culture.

Materials and Methods

Experimental site

Experiments were carried out at Sarkeshware bay, Jafrabad Saurashtra coast (Lat. 20º 49′ 52.82′′ N and Long. 71º 17′ 38.05′′ E) of Gujarat, India. Duration of experiment was for 124 days which was initiated on 10th October 2009 to 10th February 2010.

Experimental design and experimental site:

A complete randomized design (CRD) was employed in the present investigation. Other details are as under:

No. of replication: Five

No. of treatment: Three (Stocking density)

Treatment Detail:

Total 10 lobsters / cage were stocked.

Total 20 lobsters / cage were stocked.

Total 30 lobsters / cage were stocked.

Each lobster was fed by mix diet at 5% of their body weight.

Total nos. of cages (C): 15 cages

Saurashtra region, South - west direction and Diurnal tide is the major source of seawater at cage site.

Cage construction

Cage material was PVC pipe ½ inch diameter, GI tripod joint, Nylon mesh (5mm), Sinker of cement stone and thermocole floats The dimension of a cage was 2x1x1m^3. The cage has a main frame made of ½ inch diameter PVC Pipe which is fitted to a GI tripod joint. 5 mm nylon mesh sizes net were used for encircling the PVC frame, from all the sides. Cage top end were closed by nylon mesh giving 10 cm x 10 cm for feed drop manually. Cages were placed at Sarkeshware bay of Saurashtra coast (India) with water depth of 0.8 m during low tide and 1.2 m during highest tides. Thermocole float were fitted to top edge corner of a cage and to the bottom of cage cement stone weighing 5 kg as flexible sinker.

Collection of Lobsters

The lobsters were collected from Mahuva, Jafrabad, Rajpara and Navabunder coast of Gujarat and then transported using mobile van loaded with 100 lit tanks and containers to the experiment site. Lobsters were fed with clams, squid and trash fish meat during the storage of live specimen after collection. During the storage,, lobster were placed in a holding tank for 3 to 4 hrs having water temperature 22-23 C° using ice cube, to slow down the metabolic activity to make them ready for transportation.

Stocking density:

Total 10, 20 and 30 of *P. polyphagus* of 90 ± 10 g were stocked in respective cages.

Feeding:

Daily mix feeding (e.g. clams, squid meat, trash meat in the ratio of 0.2:0.5:0.3 per kg) was given at 5% of the body weight as per treatment. Daily unconsumed meat was siphoned out and discarded.

Growth monitoring and sampling:

Seven lobsters were randomly selected from the cage, for weighing and total length measurement.

Biometric Observation

P. polyphagus

The biometric observations were recorded from seven randomly selected *P. polyphagus* from the five replicate rearing cages.

Average wet weight gain (g)

Randomly seven *P. polyphagus* were collected by scooping from cage and then weighed by a physical balance, as per Kemp and Britz, 2008. The observations were recorded fortnightly. Wet weight gain (gm) was recorded using the formula given below

Wet weight gain% = (Final weight (g) – Initial weight (g))* 100/Initial wet weight (g)

Total length

Total length of lobster will be calculated as per Simon and Michael (2005) by formula given below:

Total length = Carapace length + abdominal length

Feed Conversion Ratio

Weight of the feed fed to the animal divided by the weight of animal growth.i.e

Feed conversion ratio = weight of feed fed (g)/fish weight gain

Specific Growth Rate (SGR)

Growth rates were calculated as specific growth rate (SGR) % body weight per day was recorded by using formula as

Specific Growth Rate (SGR) = 100 x (ln FBW- lnIBW)/D

where:

FBW is final body weight (g) (weight at the end of the time interval studied)

IBW is initial body weight (g) (weight at the beginning of the time interval studied)

D is number of days

Survival (%)

Final survival of *P. polyphagus* was recorded on the last day (124th day) of experiment with the formula given below

Survival Rate % = No of live *P. polyphagus* at harvest * 100/ No of lobster at initial stocking

Net weight gain (g)

It was calculated as per the formula

Net weight gain (g): Final weight (g) – initial weight at stocking (g)

Statistical analysis

All data presented are expressed as means± standard error and was subjected to two way analysis of variance (ANOVA), followed by Duncan's Multiple Range Test with the help of SPSS-16.0 version software.

Results and Discussion

Before the experiment starts, almost all the lobsters were well acclimatized for the cage condition. In the post summer season, the result obtained were encouraging, but on initiation of winter season few of the lobster skipped feeding and profuse mortality took place. The growth in term of weight gain was more in 10 no. stocking density/ cage and more feed was consumed but in mid winter season all the lobster died due to low temperature.

Water parameters are conducive as cages were placed in a bay where diurnal tide flush away all the waste material from the surrounding but uneaten feed which was dropped within the cage used to smell too much after 24 hrs.

Biometric Observation

Total length and weight

The Initial length varied from approximately 14.99 ± 0.10 to 15.3 ± 0.22 cms in all the treatments while initial weight of lobsters varied in all replicate with average 88.35 ± 0.46 g. The detailed result is presented in Table 1.

Specific growth rate (SGR)

Specific Growth Rate (g/day) in cages with stocking density 10 no/cage was more than in the cages having 20 no and 30 nos/cage. Weight increment (g) during the 124 days of culture was 45.65 g in cages with (10 nos/cage), 48.95 (g) in cages with (20 nos/cage) and 42.45 (g) in cages with (30 no/cage) fed with mix feed (clams meat, squid meat and trash fish meat). Maximum increment in weight was in those cages with 20 nos/cage (48.95g) as compared to 10 nos/cage and 30 nos/cage (Table 2).

Survival

As mentioned in Table 3, maximum survival% were obtained from the cages having 30 no (24.66%) (Out of 150 lobsters, 113 were found dead) while in cages with 20 nos /cage 21%) (Out of 100 lobsters 79 were found dead). In those cages having 10 nos /cage (Out of 50 lobsters 50 were found dead) and that was because of low water temperature and stress conditions prevailed during winter season. As per (Table 4) maximum mortality were seen in 10 nos/cage at the end of experiment at period and least mortality in the cage 30 nos/cage this is due to lowering of temperature in winter season.

Table 1: Initial length and weight of lobsters

Cage No.	Stocking Density (No./ cage)					
	10		20		30	
	Ave. TL	Ave. TW	Ave. TL	Ave. TW	Ave. TL	Ave. TW
1	15.42±0.67	89.07±3.67				
2	15.57±0.34	88.65±4.33				
3	15.14±0.69	89.94±3.87				
4	15.07±0.88	86.57±5.99				
5	15.35±0.47	91.05±3.80				
6			15.28±0.48	88.51±4.76		
7			15.21±0.56	88.30±4.91		
8			15.35±0.55	89.00±4.03		
9			15.14±0.55	86.21±4.58		
10			15.00±0.40	85.85±3.94		
11					15.28±0.47	89.74±3.81
12					15.21±0.34	87.45±2.76
13					15.35±0.5	88.75±5.4
14					15.28±0.47	87.87±4.89
15					15.28±0.69	88.45±6.24
Mean	**15.31±0.20[a]**	**89.05±0.95[a]**	**15.19±.068[a]**	**87.57±0.43[a]**	**15.28±0.12[a]**	**88.45±0.36[a]**

Average Total Length = Ave. TL; Average Total Weight = Ave. TW

Initial Average Total Length (cm) and Total Weight (g)

Values in rows with common superscripts do not differ significantly (P>0.05)

FCR

Maximum feed intake were in the cage with 30 no/cage with 62 kg (Fig 1) from which during experiment net weight gain (g) was 45.65 g having FCR 39:1, whereas in stocking density of 20 no/ cage total feed utilized was 44.64 kg with net weight gain 48.95 g and FCR 35:1but least in stocking density of 10 no/ cage with 17.82 kg against & net weight gain was 42.45 g (here FCR could not be calculated because all experimental animals died due to winter shock).

Table 2: Average growth (g) of lobsters during rearing

Date	10	20	30
10 Oct 2009	88.35	88.35	88.35
25 Oct 2009	100.3	99.2	100.4
11 Nov 2009	108.8	106.3	108.2
26 Nov 2009	117.1	115.3	113.6
11 Dec 2009	122.8	121.1	119.3
26 Dec 2009	127.3	125.8	123
10 Jan 2010	131.4	129.4	125.1
25 Jan 2010	134	132.8	127.3
10 Feb 2010	Nil	137.3	130.8
(Final wt)	134	137.3	130.8
Net weight gain (g)/lobster	45.65	48.95	42.45
SGR (g/ day)	0.36	0.39	0.34
Lobster survival in no/5 cage.	00	21	37

N = 7 No. of lobsters/ cage were averagely checked out fortnightly

Initial average Weight = 88.35 ± 0.46 g

DOC: 124 days*

Table 3: Survival and growth data of *Panulirus polyphagus* stocked in different density

	Stocking Density (No./Cage)		
Parameter calculated	**10**	**20**	**30**
Days of culture	124	124	124
Initial no. lobsters*	50	100	150
Final no. of live lobsters*	0	21	37
Mortality (no.)*	50	79	113
Survival %	0	21	24.66
Avg. Initial weight (g)	88.35 ± 0.46	88.35 ± 0.46	88.35 ± 0.46
Avg. Weight increment (g)	41.7	48.95	42.45
Weight increment (%)	47.14	55.40	48.04
FCR	00	35:1	39:1
SGR (g/day)	0.368	0.394	0.342

N = 7 No of lobsters

Table 4: Mortality v/s Survival no during experiment

Cage No.	**Stocking density of lobsters No/Cage**					
	10		**20**		**30**	
	Total No.	**Mortality No.**	**Total No.**	**Mortality No.**	**Total No.**	**Mortality No.**
10 Oct 2009	50	00	100	00	150	00
25 Oct 2009	46	04	93	07	142	08
11 Nov 2009	41	05	84	09	131	11
26 Nov 2009	34	07	75	09	117	14
11 Dec 2009	29	05	64	11	100	17
26 Dec 2009	18	11	51	13	79	21
10 Jan 2010	04	14	34	17	53	26
25 Jan 2010	02	02	26	08	43	10
10 Feb 2010	00	00	21	05	37	06
Survival no.	00		21		37	
Survival %	0		21		24.66	

Replicate : 5 DOC=124 days

TREATMENT

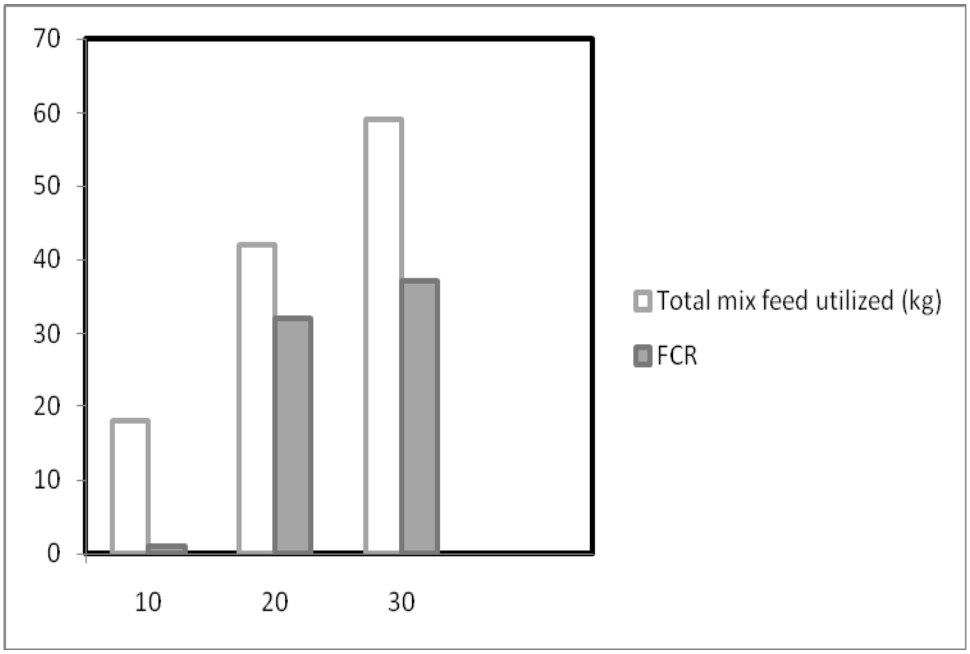

Fig 1: Comparison of feed utilized (kg) & FCR among stocking density

Feeding

Recent experiments with *P. argus* in Florida revealed that feeding juveniles spiny lobsters rations of frozen clams, shrimp, squid and oysters at 100 % of their body weight once daily at the onset of dusk resulted in significantly better growth than those fed 50 % of their body weight twice daily (Cox and Davis, 2006); same trend was recorded in present study when twice feeding a day, most of the feed remain uneaten but feeding once gave good result in maintenance of water quality and feed was consumed to 55%.

Feeding was done with mix meat (clam meat, squid meat and trash fish meat). Most preferable feed type as per record is clam / bivalve compared to squid than trash fish as squid meat and trash fish meat were found sometimes uneaten.

Joseph, (2004) reported that wet FCR of more than 10 can still be profitable, same trend was observed but he further stated that taste and color of cultured lobster is inferior to wild caught lobsters, same trend was observed as culture lobster color faded.

Pony fish (Leiognathus spp); pomfret; snails, oyster, clams and cockles; small swimming crab, other crabs and shrimp. Finfish comprise about 70% of the diet, with 30% shellfish. The most preferred fish (comprising 30%) lizard fish whereas according to Crear *et al*. 1999, mussels have shown to be superior to prepared pellet feeds in growth trials of juvenile *J.edwardsii*; in present study there were no consistent differences in growth at moult between the mussel treatment and squid treatments in the trial and most preferable was bivalve meat (*Crassostrea graphoides*) and least preferable was trash fish compared to squid and mixed feed type.

James and Tong (1998) reported that spiny lobster *Jasus edwardsii* fed with a fresh natural diet (clams flesh) same trend were recorded lobsters usually discard red meat feed) as per Kalidas and Shyam (2005) they reported that (red meat) fat content may be avoided because feeding fatty fish will not only deteriorate water quality but also foul smell persist only due to decomposition of fat; same trends were observed during present study when weighed (as per body weight) red meat was added as feed material to lobster treatment than same quantum was recollected after a day whereas Simon and James, (2007) reported that fresh clams have consistently produced better growth rate and survival than formulated diets provided in spiny lobsters cage culture; same trends were observed during present study that lobster accepted clam/ bivalve meat than any other feed type.

According to Radhakrishnan (2008) in Gujarat state, juvenile of *P. polyphagus* (30-50 g) were stocked in intertidal pits (21 x 7 x 1 m3) at 20 no/m2 attained 100- 125 g in 90 days. The present study is agreement with the above result. Water temperature is one of the most important environmental factors determining the growth rate of crustaceans (Tong *et al*., 1997) specific growth rate (SGR) was significantly different between temperatures, with the highest values recorded for the 24 and 28 °C treatments (Kemp and Britz, 2008). The growth rate (5.2 mm CL) of *P. ornatus* in Torres Strait is the highest recorded for any spiny lobster in the first year of benthic life and this is likely due to combination of warm water temperature (>28° C), low density and low competition (63 no/ha^{-1}) (Dennis *et al*., 1997).Similar result was obtained in present study also. Lobsters stocked at 15,000 in a 500 / m² had recorded growth rate of 1 g/ day tail weight after 60 days of holding (Assad *et al*., 1996). Sea floor cages (3 x 3 x 1 m) have been used for holding and feeding wild caught juveniles in Mexico (Lozano - alvarez, 1996), and other studies have attempted to increase the biomass of wild caught lobsters with mixed result. Recent experiments with *P. argus* in Florida revealed that feeding juveniles spiny lobster rations of frozen clams, shrimp, squid and oysters at 100% of their body weight once daily at the onset of dusk resulted in significantly better growth than those fed 50 % of their body weight twice daily (Cox and Davis, 2006). Similar observation was also reported in present study.

Conclusion

Based on the results obtained from the experiments, it seems quite indicative that higher Stocking density results in less growth rate and less stocking density results in mortality of all lobsters and this may be due to lower temperature during winter season, so it is advisable to carryout rearing of lobster in summer season whereas experiment of lobster culture can be taken up in pit which may show good growth and survival in the same.

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