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# Growth performance of spiny lobster, *Panulirus homarus* (Linnaeus, 1758)

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The present study was undertaken to evaluate the growth performance, biochemical composition, feed utilization and water quality parameters of spiny lobster, *Panulirus homarus* in indoor culture. The fattening experiments was carried out with five different fresh feeds *viz.* green mussel, clam, oyster, trash fish and pellet feed. Indoor experimental culture of juvenile lobster, *Panulirus homarus* lasted for 75 days to find better growth rate and survival. There was a reasonable change in the carapace length and weight of lobsters fed with clam and green mussel. Their Biomass was significantly better than other three feeds *viz.* oyster, pellet feed and trash fish. The spiny lobster, *Panulirus homarus* fed with clam, green mussel and oyster can increase the size of carapace length compared with the trash fish and pellet fed one. The maximum growth performance was seen during the 75$^{th}$ day on the clam fed experiment which was found to be ranged between (6.7 ± 0.02 - 7.2 ± 0.03 cm) in carapace length, (6.1 ± 0.1 - 6.7 ± 0.08 cm) in body length, (12.8 ± 0.03 - 13.8 ± 0.08 cm) in total length and (105 ± 0.07 - 112 ± 0.08 g) in total weight. The maximum protein content (15.10 ± 0.34 g/100 g), carbohydrate (1.25 ± 0.06 g/100 g), lipids (5.25 ± 0.13 g/100 g) and moisture (76.15 ± 0.9 g/100 g) was noted in clam feed experiment. The maximum feed was also utilized during the clam fed experiment (45.39 ± 0.03 g). The moderate feed utilization were observed during the green mussel fed experiment (42.51 ± 0.02 g). The lowest feed utilization was observed in pellet fed experiment (23.75 ± 0.01 g). The water quality parameters were analyzed in the culture tank before and after the experiment.

**[Keywords:** Clam Green mussel, Oyster, *Panulirus homarus*, *Panulirus ornatus*, Pellet feed, Trash fish]

## Introduction

Aquaculture is one among the fastest developing economic sectors in the world. Presently, Asia contributes about 90 % of the total aquaculture production globally. Spiny lobsters (*Palinuridae*) are one of the world's most valuable seafood species. The species, *Panulirus homarus* is an important omnivorous species occurring predominantly along the east coast of India. Good growth is obtained under captive rearing with conventional diet like clam meat[1,2]. Lobsters are invertebrates with a hard protective exoskeleton; like most arthropods, lobster must moult to grow which leaves them vulnerable. During the moulting process, several species change colour. Lobster have 10 walking legs, the front three pairs bear claws, the first of which is larger than the others[3].

There is considerable interest in the aquaculture of spiny lobsters worldwide because of the increasing market demand that cannot be met by wild populations. World production of spiny lobsters fluctuates is an around 40,000 tonnes per annum. With quota restrictions imposed in most countries, there is no much scope for increasing the current landings of wild catch. Due to its long and complex larval life, spiny lobster did not attract the attention of aqua culturists for enhancing their production by farming. Introduction of live trade of the spiny lobsters coupled with the demand for small sized ones (150 - 350 g) have brought spiny lobster culture to the limelight[4]. Spiny lobsters consume a wide range of marine organisms including slow moving benthic invertebrates such as mollusks, echinoderms, polychaete worms and crustaceans as well as occasional amounts of possibly incidental macroalgae[5]. This diet selection characterizes spiny lobsters as opportunistic carnivores, which have evolved to utilize food efficiently that is high in protein, low in lipid and contains moderate to high levels of carbohydrate (i.e., glycogen)[6].

Lobsters in India are mostly collected from wild and are reared in pens, done fattening and are been exported to other countries for a good profitable price. Commonly lobsters are been fed with clam meat, trash fishes and oyster meat. Lobsters are delicious food in many countries because of their fine flavour. Even in this age of abundant food supply, Lobsters have an excellent market demand and price[7]. Live lobsters has higher price compared to frozen ones[8], as they are important export items and expensive delicacies[9]. Lobster business today is a lucrative fishing enterprise because of its unlimited demand[10]. Based on all the above facts, the present work is attempted to carry out the growth performance of spiny lobster, *Panulirus homarus* in the indoor culture and fed with different feeds *viz.* green mussel, clam, oyster, trash fish and pellet feed to know their efficiency.

## Materials and Methods

### Sample collection

The experimental animal, spiny lobster *Panulirus homarus* were collected live from Mandapam region of Ramanathapuram district, Tamil Nadu, India.

### Packaging of collected spiny lobster

The collected wild lobsters was transferred to a plastic container filled with sea water in an aerated condition along with battery air pump

### Package of live spiny lobster during transportation

The water temperature in the tank along with lobster were gradually brought up to 26-28 °C (depending upon travelling time). Care was taken to avoid the contact of animals with container and the water was continuously aerated using battery air pump to facilitate uniform cooling and $O_2$ supply. These processes were done in order to maintain the physiological and metabolic activity of animals for extended survival in live transport.

### Experimental set up

The lobster culture experiment was carried out in five experimental culture tanks (FRP) each of 1000 litres capacity in the culture laboratory of CAS in Marine Biology, Annamalai University, Parangipettai, Tamil Nadu, India. These tanks were arranged on a metallic stand and each tank were filled with 300 litres of filtered seawater and the tanks were continuously aerated. 10 spiny lobsters weighing around 60 gram were chosen. The lobsters were segregated equally in five experimental tanks (two lobsters per tank). The fattening experiments were carried outwith five different fresh feeds *viz.* green mussel, clam, oyster, trash fish and pellet feed. The feeds were collected from Annankovil landing centre and Vellar estuary.

Feeding was done at the rate of 10 – 15 % of the whole body weight per day with fresh feeds depending on the feed acceptance and the left over feed was collected with the help of a siphon. Feeding was done between 6-8 h a day. Before each feeding, the faecal matter was removed and the feeds like clam, green mussel and oyster were given in live condition. The pellet feed and trash fishes was given in fresh conditions.

### Water quality parameters

The water quality parameters were monitored frequently and the water was changed monthly. Water samples were collected from 15 cm depth in each culture tank. The temperatures of culture tank water sample were measured using a mercury centigrade thermometer with 0.5 °C accuracy. The pH was observed using portable pen type electronic pH meter with an accuracy of ± 0.1 (Hanna instruments-Italy). The concentration of ammonia ($NH_4$), nitrate ($NO_3$), nitrite ($NO_2$) and dissolved $O_2$ was estimated by using the modified Winkler's method as described by Strickland and Parsons[11].

### Growth performance

The growth performance of spiny lobster *Panulirus homarus* was observed and recorded at specific intervals from initial day, 15$^{th}$ day, 30$^{th}$ day, 45$^{th}$ day, 60$^{th}$ day and 75$^{th}$in the indoor culture tank.

### Carapace, body and total length

The carapace, body and total length were recorded from the *Panulirus homarus* lobsters from each of the experimental tanks of differential feeds.

### Total weight

The total weight of experimental species of *Panulirus homarus* was measured with the help of an electronic compact scale.

### Biochemical analysis

Tissues taken from the spiny lobster *Panulirus homarus* were analysed for biochemical parameters based on the established procedures for protein[12], lipids[13] and carbohydrates[14]. Moisture content was estimated by drying the samples to constant weight at 85 °C in drying oven (GCA, model 18EM, Precision Scientific group, Chicago, Illinois, USA).

## Results

**Growth performance of spiny lobster, *P. homarus* before experiment**

The average growth performance of spiny lobster, *Panulirus homarus* (Male and Female) were recorded before starting the experiment . Carapace length (5.4 ± 0.05 and 4.8 ± 0.05 cm), body length (5.5 ± 0.2 and 4.8 ± 0.03 cm), total length (10.2 ± 0.03 and 9.8 ± 0.1 cm), total weight (60 ± 0.02 and 50 ± 0.03 g) were recorded from the total of 10 lobsters species respectively and in shown in Table 1.

**Growth performance at 15$^{th}$ day**

The growth performances of spiny lobster *Panulirus homarus* was compared with 5 different feeds such as green mussel, clam, oyster, trash fish and pellet feed and are shown in Table 2. The growth performance such as carapace length (5.8 ± 0.03 cm), body length (5.7 ± 0.08 cm), total length (11.5 ± 0.08 cm) and total weight (78 ± 0.05 g) change were found to be higher in clam fed female *Panulirus homarus* followed by green mussel fed, trash fish fed and pellet fed lobsters. Both clam fed and mussel fed has more values than other feeds. The minimum growth performance of carapace length (5.8 ± 0.02 cm), body length (5.2 ± 0.03 cm), total length (11.0 ± 0.04 cm), and total weight (63 ± 0.03 g) were recorded in green mussel fed female. The lowest was recorded in pellet fed female with carapace length (4.5 ± 0.03cm), body length (4.9 ± 0.1 cm), total length (9.4 ± 0.03 cm), and total weight (60 ± 0.01 g). Moderate growth performances were recorded in oyster and trash fish fed male and female with carapace length (5.5 ± 0.03 and 4.7 ± 0.02 cm), body length (5.6 ± 0.01 and 5.1 ± 0.5 cm), total length (10.5 ± 0.1 and 11.5 ± 0.08 cm), total weight (60 ± 0.05 and 67 ± 0.01 g), respectively.

**Growth performance at 30$^{th}$ day**

The growth performance of *Panulirus homarus* measured at 30$^{th}$ day and is shown in Table 3.

The maximum growth performances with carapace length (6.0 ± 0.05 cm), body length (5.9 ± 0.02 cm), total length (11.9 ± 0.07 cm) and total weight (82 ± 0.08 g) were recorded in clam fed female lobster. The minimum growth performance was recorded in green mussel fed female with carapace length (5.7 ± 0.08 cm), body length (5.1 ± 0.1 cm), total length (10.8 ± 0.02 cm), and total weight (69 ± 0.1 g). The lowest growth performance was recorded with carapace length (4.6 ± 0.07 cm), body length (4.9 ± 0.05 cm), total length (9.5 ± 0.05 cm) and total weight (63 ± 0.05 g) were recorded in pellet fed female. The

Table 1 — Initial growth performance in *P. homarus*

| Types of feed | Carapace length (cm) | | Body length (cm) | | Total length (cm) | | Total weight (g) | |
|---|---|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female | Male | Female |
| Green mussel | 5.4±0.05 | 5.2±0.03 | 5.0±0.06 | 4.6±0.03 | 10.4±0.06 | 9.8±0.04 | 55±0.05 | 50±0.03 |
| Clam | 5.2±0.03 | 4.8±0.05 | 5.0±0.02 | 5.2±0.03 | 10.2±0.01 | 10.0±0.02 | 65±0.05 | 60±0.06 |
| Oyster | 5.0±0.01 | 4.5±0.04 | 5.1±0.02 | 5.0±0.03 | 10.1±0.07 | 9.5±0.05 | 56±0.05 | 60±0.02 |
| Trash fish | 5.0±0.20 | 4.8±0.35 | 5.5±0.2 | 5.0±0.2 | 10.5±0.01 | 9.8±0.1 | 60±0.1 | 65±0.2 |
| Pellet feed | 4.8±0.08 | 4.1±0.05 | 4.6±0.06 | 4.8±0.02 | 9.4±0.03 | 8.9±0.05 | 60±0.04 | 58±0.03 |

Table 2 — 15$^{th}$ day of growth performance in *P. homarus*

| Types of feed | Carapace length (cm) | | Body length (cm) | | Total length (cm) | | Total weight (g) | |
|---|---|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female | Male | Female |
| Green mussel | 5.8± 0.03 | 5.6±0.04 | 5.2±0.05 | 5.0±0.02 | 11.0±0.04 | 10.6±0.03 | 60±0.01 | 63±0.03 |
| Clam | 5.6±0.04 | 5.8±0.02 | 5.0±0.1 | 5.7±0.08 | 10.6±0.07 | 11.5±0.08 | 75±0.07 | 78±0.05 |
| Oyster | 5.2±0.02 | 4.8±0.01 | 5.3±0.05 | 5.2±0.7 | 10.5±0.1 | 10.0±0.09 | 60±0.05 | 63±0.03 |
| Trash fish | 5.5±0.03 | 4.7±0.02 | 5.6±0.01 | 5.1±0.5 | 11.1±0.1 | 9.8±0.05 | 65±0.03 | 67±0.01 |
| Pellet feed | 5.0±0.05 | 4.5±0.03 | 4.8±0.04 | 4.9±0.1 | 9.8±0.05 | 9.4±0.03 | 62±0.01 | 60±0.04 |

Table 3 — 30$^{th}$ day of growth performance in *P. homarus*

| Types of feed | Carapace length (cm) | | Body length (cm) | | Total length (cm) | | Total weight (g) | |
|---|---|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female | Male | Female |
| Green mussel | 5.9±0.06 | 5.7±0.08 | 5.3±0.01 | 5.1±0.03 | 11.2±0.05 | 10.8±0.02 | 69±0.1 | 72±0.01 |
| Clam | 5.8±0.01 | 6.0±0.05 | 5.2±0.03 | 5.9±0.02 | 11.0±0.01 | 11.9±0.07 | 78±0.1 | 82±0.08 |
| Oyster | 5.2±0.04 | 5.0±0.03 | 5.4±0.01 | 5.3±0.05 | 10.6±0.04 | 10.3±0.08 | 65±0.06 | 68±0.07 |
| Trash fish | 5.8±0.1 | 4.9±0.05 | 5.7±0.02 | 5.2±0.08 | 11.5±0.07 | 10.1±0.09 | 67±0.04 | 70±0.03 |
| Pellet feed | 5.1±0.1 | 4.6±0.07 | 4.8±0.06 | 4.9±0.04 | 9.9±0.03 | 9.5±0.05 | 65±0.01 | 63±0.05 |

moderate growth performance was recorded in oyster, and trash fish fed male and female with carapace length (5.0 ± 0.03 and 5.8 ± 0.01 cm), body length (5.2 ± 0.03 and 5.7 ± 0.02 cm), total length (10.3 ± 0.08 and 11.5 ± 0.07 cm) and total weight (65 ± 0.06 and 70 ± 0.03 g), respectively.

**Growth performance at 45th day**

The growth performance of *Panulirus homarus* recorded on 45th day of the experimental culture as shown in Table 4.

The maximum growth performance was recorded in clam fed female with carapace length of (6.8 ± 0.01 cm), body length (5.9 ± 0.2 cm), total length (12.7 ± 0.05 cm) and total weight (95 ± 0.08 g). The minimum growth performance was recorded in clam fed female with carapace length of (5.2 ± 0.20 cm) body length (5.6 ± 0.03 cm), total length (11.6 ± 0.03 cm) and total weight (80 ± 0.06 g). The lowest growth performance was in female with carapace length (4.8 ± 0.05 cm), body length (4.9 ± 0.04 cm), total length (9.7 ± 0.02 cm) and total weight (65 ± 0.07 g) with pellet fed experiment. The moderate growth performance was recorded in oyster, and trash fish feed with male and female carapace length (5.2 ± 0.2 and 6.0 ± 0.05 cm), body length (5.5 ± 0.03 and 5.7 ± 0.06 cm), total length (10.7 ± 0.1 and 11.7 ± 0.03 cm) and total weight (73 ± 0.09 and 80 ± 0.06 g), respectively.

**Growth performance at 60th day**

The growth performance of *Panulirus homarus* on 60th day in the experimental culture was recorded and shown in Table 5. The maximum growth performances of female with carapace length (6.9 ± 0.02 cm), body length (6.6 ± 0.09 cm), total length (13.5 ± 0.03 cm) and total weight (110 ± 0.05 g) was recorded in clam fed culture. The minimum growth performance of male with carapace length (6.5 ± 0.01 cm), body length (6.3 ± 0.05 cm), total length (12.8 ± 0.04 cm) and total weight (100 ± 0.05 g) was recorded in green mussel fed culture. The lowest growth performance was in female with carapace length (4.9 ± 0.07 cm), body length (4.9 ± 0.03 cm), total length (9.8 ± 0.05 cm) and total weight (67 ± 0.06 g) was recorded in pellet feed. The moderate growth performances of *Panulirus homarus* was recorded in oyster and trash fish fed with male and female carapace length (5.5 ± 0.03 and 6.0 ± 0.02 cm), body length (5.5 ± 0.05 and 5.7 ± 0.02 cm), total length (11.1 ± 0.09 and 11.7 ± 0.05 cm) and total weight (73 ± 0.02 and 90 ± 0.07 g), respectively.

**Growth performance at 75th day**

The growth performance of *Panulirus homarus* on 75th day of experimental growth culture was recorded and is shown in Table 6.

This was the final day of the laboratory experimental culture of spiny lobster *Panulirus homarus*. The maximum growth performances was found in female with carapace length of (7.2 ± 0.03 cm), body length (6.7 ± 0.08 cm), total length (13.8 ± 0.08 cm) and total weight (112 ± 0.08 g) were recorded in clam fed culture. The minimum growth performance was recorded in male with carapace length (6.6 ± 0.08 cm), body length (6.4 ± 0.02 cm), total length (13.0 ± 0.05 cm) and total weight (104 ± 0.1 g) in green mussel fed culture. The lowest growth performance was recorded in female with carapace length (5.0 ± 0.08 cm), body

Table 4 — 45th day of growth performance in *P. homarus*

| Types of feed | Carapace length (cm) | | Body length (cm) | | Total length (cm) | | Total weight (g) | |
|---|---|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female | Male | Female |
| Green mussel | 6.2±0.01 | 6.0±0.05 | 5.8±0.08 | 5.6±0.05 | 12.0±0.06 | 11.6±0.03 | 84±0.02 | 80±0.06 |
| Clam | 6.3±0.03 | 6.8±0.01 | 5.8±0.06 | 5.9±0.2 | 12.1±0.03 | 12.7±0.05 | 92±0.01 | 95±0.08 |
| Oyster | 5.3±0.05 | 5.2±0.20 | 5.4±0.05 | 5.6±0.03 | 10.7±0.10 | 10.8±0.08 | 70±0.05 | 73±0.09 |
| Trash fish | 5.9±0.1 | 5.1±0.08 | 5.7±0.08 | 5.3±0.05 | 11.6±0.03 | 10.4±0.05 | 68±0.01 | 70±0.05 |
| Pellet feed | 5.2±0.07 | 4.8±0.05 | 5.0±0.02 | 4.9±0.04 | 10.2±0.01 | 9.7±0.02 | 66±0.03 | 65±0.07 |

Table 5— 60th day of growth performance in *P. homarus*

| Types of feed | Carapace length (cm) | | Body length (cm) | | Total length (cm) | | Total weight (g) | |
|---|---|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female | Male | Female |
| Green mussel | 6.5±0.08 | 6.3±0.03 | 6.3±0.05 | 5.7 ±0.06 | 12.8±0.04 | 12.0±0.06 | 100±0.05 | 95±0.02 |
| Clam | 6.5±0.01 | 6.9±0.02 | 6.0±0.04 | 6.6±0.09 | 12.5±0.1 | 13.5±0.03 | 102±0.02 | 110±0.05 |
| Oyster | 5.5±0.03 | 5.2±0.06 | 5.6±0.03 | 5.7±0.02 | 11.1±0.09 | 10.9±0.07 | 82±0.05 | 90±0.07 |
| Trash fish | 6.0±0.02 | 5.2±0.05 | 5.7±0.01 | 5.5±0.05 | 11.7±0.05 | 10.7±0.01 | 73±0.02 | 78±0.09 |
| Pellet feed | 5.4±0.04 | 4.9±0.07 | 5.1±0.08 | 4.9±0.03 | 10.5±0.09 | 9.8±0.05 | 70±0.07 | 67±0.06 |

Table 6 — 75th day growth performance in *P. homarus*

| Types of feed | Carapace length (cm) | | Body length (cm) | | Total length (cm) | | Total weight (g) | |
|---|---|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female | Male | Female |
| Green mussel | 6.6±0.08 | 6.5±0.05 | 6.4±0.02 | 5.8±0.1 | 13.0±0.05 | 12.3±0.03 | 104±0.1 | 98±0.05 |
| Clam | 6.7±0.02 | 7.2±0.03 | 6.1±0.1 | 6.7±0.08 | 12.8±0.03 | 13.8±0.08 | 105±0.07 | 112±0.08 |
| Oyster | 5.6±0.05 | 5.4±0.02 | 5.6±0.08 | 5.8±0.02 | 11.2±0.01 | 11.2±0.05 | 85±0.03 | 93±0.05 |
| Trash fish | 6.0±0.03 | 5.3±0.01 | 5.8±0.05 | 5.5±0.05 | 11.8±0.02 | 10.8±0.01 | 75±0.1 | 80±0.09 |
| Pellet feed | 5.5±0.06 | 5.0±0.08 | 5.1±0.03 | 4.9±0.06 | 10.6±0.07 | 9.8±0.06 | 71±0.04 | 69±0.07 |

Table 7 — Biochemical composition of five different diet feed culture experiment after 75th day lobster *P. homarus*

| Types of feed | Biochemical parameter (%) | | | |
|---|---|---|---|---|
| | Crude protein | Carbohydrates | Lipids | Moisture |
| Green mussel | 38.8 ± 0.08 | 32.5 ± 0.06 | 7.80 ± 0.2 | 78.07 ± 0.12 |
| Clam | 39.7 ± 0.34 | 34.2 ± 0.06 | 7.70 ± 0.08 | 78.05 ± 0.52 |
| Oyster | 38.2 ± 0.02 | 32.1 ± 0.05 | 7.25 ± 0.13 | 76.15 ± 0.9 |
| Trash fish | 37.6 ± 0.21 | 31.6± 0.089 | 7.15 ± 0.09 | 78.25 ± 0.52 |
| Pellet feed | 36.4 ± 0.24 | 31.2± 0.07 | 6.85 ± 0.16 | 77.35 ± 0.43 |

length (4.9 ± 0.06 cm), total length (9.8 ± 0.06 cm) and total weight (69 ± 0.07 g) in pellet fed. The moderate growth performance of *Panulirus homarus* were recorded in oyster and trash fish fed male and female with carapace length (5.4 ± 0.02 and 6.0 ± 0.03 cm), body length (5.5 ± 0.05 and 5.6 ± 0.08 cm), total length (10.8 ± 0.01 and 11.2 ± 0.05 cm) and total weight (75 ± 0.1 and 93 ± 0.05 g), respectively.

**Biochemical composition of different feed in *P. homarus***

Biochemical compositions of the lobsters such as protein, carbohydrates, lipids and moisture were observed on the 75th day of harveststst in the experimental animals fed with five differential feeds such as green mussel, clam, oyster, trash fish, and pellet feed shown in Table 7. Among the five different feeds the highest crude protein content was recorded in clam (39.7 ± 0.34 %) and the lowest crude protein content was recorded (36.4 ± 0.24 %) in pellet fed. The higher carbohydrate content was recorded in clam fed (34.2 ± 0.06 %) and the lower carbohydrate content was recorded (31.2 ± 0.089 %) in pellet fed than that of other fed experimental lobsters. The lipid content was higher in green mussel fed (7.80 ± 0.2 %) and the lower was recorded in pellet fed (6.85 ± 0.16 %) than that of other fed experimental lobsters. Similarly, the maximum moisture content was recorded in trash fish fed (78.25 ± 0.52 %) and the lowest was recorded in oyster fed (76.15 ± 0.9 %).

**Feed taken and feed wastage in *P. homarus* (per day)**

The feed taken and feed wastage by *Panulirus homarus* per day in the experimental period were recorded and is shown in Table 8.

The maximum feed taken was in clam feed (45.39 ± 0.03 g) and the minimum feed taken was observed in pellet fed experiment (23.75 ± 0.01 g). The moderate feed taken was of green mussel feed (42.51 ± 0.02 g). The feed wastage per day was also observed in *Panulirus homarus* culture experiment and is shown in Table 7. The maximum wastage of feed was in pellet feed (26.25 ± 0.1 g) and the minimum feed wastage was in clam fed (4.61 ± 0.01 g). The moderate wastage of feed was recorded in trash fish fed (14.77 ± 0.02 g).

Table 8 — Feed utilization in spiny lobster *P. homarus*/day

| Feeds | Given (gram) | Utilize (gram) | Waste (gram) |
|---|---|---|---|
| Green mussel | 50 | 42.51±0.02 | 7.49±0.05 |
| Clam | 50 | 45.39±0.03 | 4.61±0.01 |
| Oyster | 50 | 40.64±0.06 | 9.36±0.07 |
| Trash fish | 50 | 35.23±0.05 | 14.77±0.02 |
| Pellet feed | 50 | 23.75±0.01 | 26.25±0.1 |

**Water quality parameters in the experimental tank**

The water quality parameters of experimental tank were monitord on the initial day and monthly. The water quality parameters like DO, pH, temperature, salinity, ammonia, nitrate and nitrite were recorded in experimental culture tank of *Panulirus homarus* and the results are shown in Table 9.

## Discussion

The present study examines the growth performance of *Panulirus homarus* carapace length, body length, total length, and total weight for 75 days under laboratory condition with 5 different feeds such as green mussel, clam, oyster, trash fish and pellet feed analysing the biochemical compositions. The results observed are in support of earlier works of Vijayakumaran[15] and Lipton[16].

Table 9 — Water quality parameters monitored in spiny lobster *P. homarus* culture tank before and after experiment

| Experiments | DO | pH | Temperature (°C) | Salinity (ppt) | Ammonia (mg/l) | Nitrite (mg/l) | Nitrate (mg/l) |
|---|---|---|---|---|---|---|---|
| Before | 5.8±0.05 | 7.9±0.03 | 27±1°C | 32.1±0.06 | 0.33±0.07 | 3.26±0.47 | 2.43±0.30 |
| After | 6.2±0.08 | 8.1±0.02 | 28.5±1°C | 32.5±0.05 | 0.34±0.03 | 3.63±0.52 | 2.65±0.15 |

Initially in the experimental period, the increase in carapace length, body length, total length and total weight was recorded in all animals of *Panulirus homarus*. The result can be correlated with the earlier reports[17-19]. However, after 75 days of experiment, the increase in total length and total weight was recorded in accordance with the finding of earlier works[20,21]. Barrento *et al.*[22] reported that the protein and fat content in lobster meat was 23 % and 4 %, respectively.

The present study has also displayed a downward trend of growth performance when showing length and weight of *Panulirus homarus* which is a contrary effect that growth performance are high in carapace length (7.2 cm), body length (6.7 cm), total length (13.8 cm) and total weight (112 g) in 70 days experiment[23]. This also recorded that body length, carapace length surveillance growth rate, body mass, wet weight were significantly between them as observed by Vijayakumaran[15] with the growth of 0.33 - 0.97 g per day for *P. homarus* in small FRP and mild steel floating cages at open sea sites attaining final growth weight ranging from 215 - 245 g during a period of 132 - 164 days. The growth performance increased in the present study is partly substantiated by Vijayakumaran[15]. The growth performance was obtained and observed from 15$^{th}$ day in all experimental set up, which is comparable with the total length and total weight (11.5 cm and 78 g), (11.8 cm and 82 g), (12.7 cm and 95 g), (13.5 cm and 110 g), (13.8 cm and 112 g) for clam feed as reported by lobster growth in *Panulirus homarus.*

On 75$^{th}$ day the biochemical composition like crude protein, carbohydrates, moisture and lipids contents of *Panulirus homarus* were measured and presented in Table 7. Similar results were reported by Glencross[25]. Among all the experimental feeds, the clam and oyster fed experiments were found to be higher with crude protein (39.7 %). A direct linear relationship between protein level and growth rate was also found in the spiny lobster, *Panulirus cygnus*[24] and *Panulirus ornatus*[25] in feed experimental formulated diets. Smith[26] reported that increasing the crude protein content of feed for juveniles of *Panulirus ornatus* from 320 to 600 g kg$^{-1}$ resulted in better yield.

The feed that gave the highest lipid content of *Panulirus homarus* experiment was with green mussel fed experiments with 7.80 ± 0.13 % when compared to all experiments. However, optimal performance reported by Smith[24] in the two series of protein /lipid feeds obtained with energy ratios of 29.1 and 29.6 mg kg$^{-1}$. These values are similar to those reported as being optimal with the southern spiny lobster, *Jasus edwardsii*[27] and close to optimal for the black tiger shrimp, *Penaeus monodon*[28,29].

In the present investigation, the carbohydrates and moisture of 32.2 ± 0.07-34.2 ± 0.06 % respectively constituted the biochemical composition of the *Panulirus homarus* (Table 7). It remains similar to the earlier reports by many researchers[23,30-33]. These sources of carbohydrates had no significant influence on the protein digestibility (82.88 %)[34]. Previous studies have shown a linear growth response with increasing carbohydrates and moisture in the spiny lobster, *Panulirus homarus*[25] and *Panulirus cygnus*[24].

Feeding experiments were conducted on the spiny lobster *Panulirus homarus* with wet diets containing five protein sources *viz.* green mussel, clam, oyster, trash fish and pellet feed. The utilization of feed given and waste of feed per day were recorded and shown in Table 8. The highest utilized feed of *Panulirus homarus* experiment was with clam fed (45.34 g/100 g) compared with the other four feeds. Previous studies have shown a linear feed utilization with the P*anulirus homarus* in the fishmeal, squid meal, and clam meal[35]. The growth of *Panulirus homarus* in clam meat fed experiment (eyestalk ablated) as Radha Krishnan and Vijayakumaran[1] have reported 0.30 g/day. Mohamed and George[36] reported the growth of *Panulirus homarus* as 0.21 ± 0.02 g/day by cage culture experiment. The result indicates that the clam fed gave the highest growth performance followed by green mussel, oyster, trash fish and pellet fed experiments.

Water quality parameters like DO, pH, temperature, salinity, ammonia, nitrite, nitrate during the growth trail period were found to be in the acceptable range for *Panulirus homarus* culture experiment as evidenced by Crear *et al.*[17], Thom[37], New[38], and Mallasen *et al.*[39]. The water quality parameters such as temperature are of great significance as it regulates various abiotic

characteristics and biotic activities of an aquatic ecosystem[40]. The similar observations were made by Padmavathiamma *et al.*[41], Damotharan *et al.*[42], Nedumaran *et al.*[43], and Gopinath *et al*.[44]. Salinity is of paramount importance to a number of species and references the aggregation of suspended particles. Similar trend in pH was reported by Srinivasan *et al*.[45], from velar estuarine system, Palanichamy & Rajendran[46], from Palk Bay, Prabhu *et al.*[47], from point Calimerecostal waters, Sundaramanikam *et al.*[48] from Uppanar estuary, and by several other researchers from Parangipettai and Nagapattinam coastal waters[42-44.]

## Conclusion

Based on the literature survey and finding, the present study revealed that the five different types of feeds such as green mussel, clam, oyster, trash fish and pellet feed has shown considerable effect on *Panulirus homarus*. The maximum growth performance during the 75$^{th}$ day was observedon the clam fed experiment in carapace length, body length, total length and total weight. The protein, carbohydrate, lipids and moisture was present maximum in clam fed experimental *Panulirus homarus*. All these conclude that the clam feed is the potential healthy food for indoor culture experiment of spiny lobster *Panulirus homarus* as an alternative feed instead of pellet feed.

## Conflict of interest statement

We declare that we have no conflict of interest.

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