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EFFECTS OF FOOD DENSITY ON FEEDING AND MOULTING OF PHYLLOSOMA LARVAE OF THE SPINY LOBSTER *PANULIRUS HOMARUS* (LINNAEUS)

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ABSTRACT

Feeding response of the laboratory reared second stage phyllosoma larvae of the spiny lobster *Panulirus homarus* was studied individually on a diet of newly hatched *Artemia salina* nauplii. The density of food affected feeding and moulting under experimental conditions. With increase in density of *Artemia* nauplii from 1 to 100/60 ml, consumption also increased from an average of 0.5 to 27.8 nauplii/day. Percentage consumption increased from 50 when offered 1 nauplius/ 60 ml to 80 at a ration of 5 nauplii and thereafter decreased gradually to 27.8 at a density of 100 nauplii/60 ml.

Density showed positive correlation (p 0.05) with the number of nauplii consumed. The second stage phyllosoma required 30 days to complete third moult at a food density of 5 nauplii/60 ml and only 17 days at a density of 60 to 100/60 ml. Since there was no appreciable difference in moulting frequency of individuals offered more than 60 nauplii, maximum growth of phyllosoma may be obtained at a food density of 60 nauplli/60 ml.

INTRODUCTION

ESTIMATION of optimum feeding level is an important factor in controlled culture of larval stages of many fish and shellfish. Optimum rations help to prevent cannibalism by underfeeding, fouling of water by overfeeding and to avoid wastage of larval foods which are generally expensive. Studies on optimum food requirement of phyllosoma larvae of palinurid lobsters are limited (Inoe, 1965 ; Saisho, 1966) and no such study is reported for Indian lobsters.

All attempts to rear the larvae of palinurids in the laboratory from hatching to puerulus have been unsuccessful due to lack of suitable feeds to meet the changing nutritional requirements. However early larval stages are successfully fed on *Artemia* nauplii (Inoe, 1965 ; Jhonson and Knight, 1968 ; Dexter, 1972). Live or freshly killed chaetognaths, fish larvae, ctenophores and hydromedusae also proved to be excellent food sources (Mitchel, 1971). But the difficulty in obtaining sufficient numbers percludes these as food sources in lengthy laboratory studies (Dexter, 1972). Hence nauplii of *Artemia* remains as one of the best feeds for early larval stages of palinurid larvae.

The present study is intended to estimate the effects of density of *Artemia salina* nauplii on feeding and moulting frequency of phyllosoma larvae of the Indian spiny lobster *Panulirus homarus*.

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Material and Methods

Laboratory hatched phyllosoma larvae of the spiny lobster *Panulirus homarus* were fed on live *Artemia salina* nauplii from the second day after hatching. Majority of the larvae moulted into II stage after eight days. To determine optimum density of *Artemia* nauplii required as food daily, it was necessary to hold the larvae individually and culture them at a series of feeding levels. Experiments were conducted in the field laboratory of the Central Marine Fisheries Research Institute, Kovalam, Tamil Nadu, India.

Healthy II stage larvae were selected and reared individually in transparent plastic containers (capacity 125 ml) containing 60 ml of sea water. They were divided into nine groups, each containing four larvae and were fed on freshly hatched *Artemia salina* nauplii in the following rations : 1, 5, 10, 20, 40, 60, 80 and 100 per day. One of the groups was maintained without feeding to study the effect of starvation.

Artemia nauplii were counted and fed to the respective groups daily in the morning after changing water. Sea water used in the study was filtered through 1μ cartridge filters. Before changing water unfed nauplii of the previous day were removed and counted. Moulting of the larvae was recorded whenever it occurred. The moults were removed and preserved in 5% formalin.

The experiment was conducted in ambient water temperature which ranged from 25.4°C to 30°C with an average of 28.1°C. Salinity of the sea water used varied between 32‰ and 34.5‰. Larvae were kept under natural day light condition which prevailed in the laboratory. The study lasted for 37 days and at the end developmental stages attained by the larvae were recorded.

Results and Discussion

The number of nauplii consumed by the larvae increased from an average of 0.5 in the group given 1 nauplius to 27.8 in that offered 100 nauplii per day (Fig. 1), showing a positive correlation with density of food ($r = 0.959$, p 0.05). It is also evident from Fig. 1 that the larvae are capable of consuming more than 27.8 nauplii, if they are offered more than 100 nauplii per day.

Efficiency of consumption, measured as percentage of available food consumed, was greatest at lower feeding levels (Fig. 1). The reason is that at lower feeding levels the food supply was insufficient to meet the nutritional requirement of the larvae. Percentage of food consumed decreased gradually from 80 to 27.8 between daily rations of 5 and 100 nauplii. But at the lowest density of 1 nauplii/60 ml per day the percentage consumption was only 50, since the larvae became progressively weaker and were unable to catch the prey on its own effort.

Size increase over time (moulting frequency) and size increase per moult are considered as indices of growth in many crustaceans. In *Carcinus* and some other crustaceans nutrition influences size increase over time by controlling moulting frequency and not size increase per moult (Aiken, 1977). In his study size increase per moult could not be measured as it would result in harming the larvae. Preserved moults also could not be measured accurately and hence moulting frequency is considered as growth.

Under starvation and at the lowest ration of 1 nauplius per day the larvae did not moult at all and survived only for 14 and 17 days

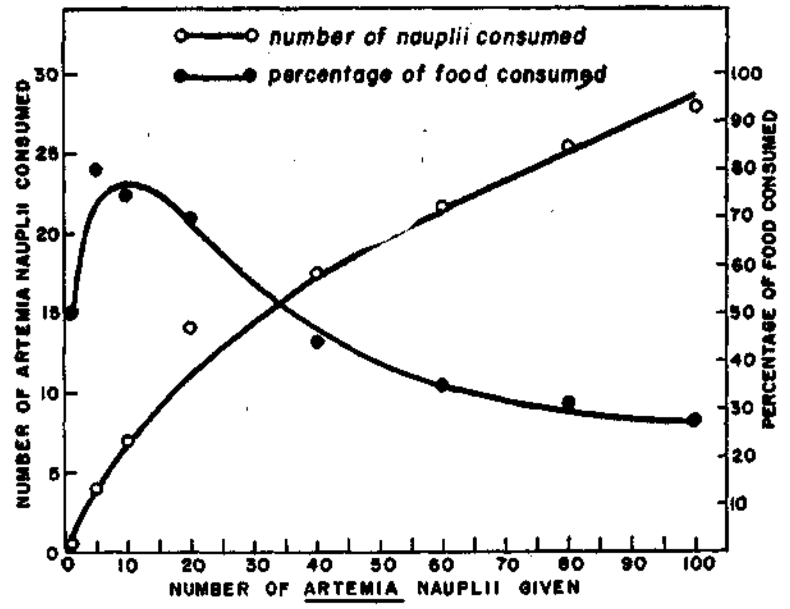

FIG. 1. Number of *Artemia salina* nauplii consumed and percentage consumption in relation to density of nauplii by the phyllosoma larvae of *Panulirus homarus*.

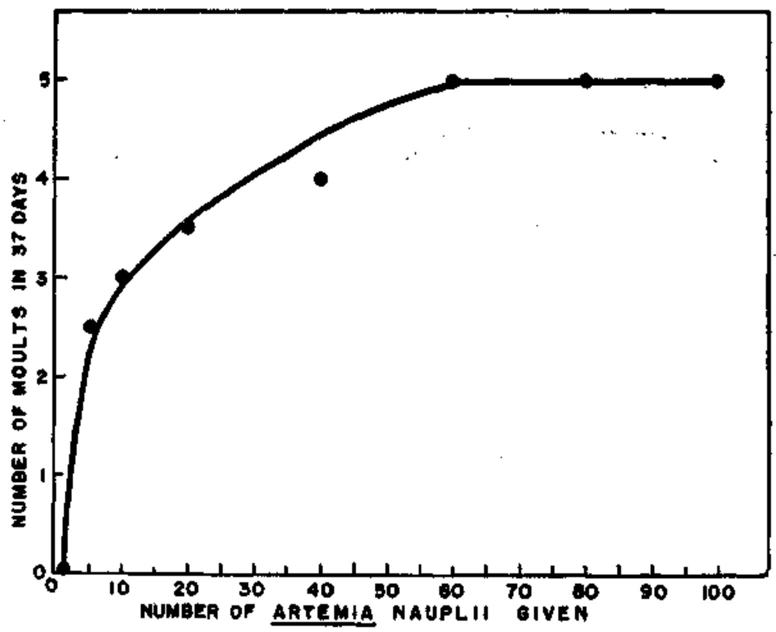

FIG. 2. Moulting frequency of phyllosoma larvae of *Panulirus homarus* in relation to density of food (*Artemia salina* nauplii).

respectively. Starvation and shortage of food resulting in reduced moulting frequency was reported in larvae of the American lobster *Homarus americanus* also by Carlberg and Van Olst (1976). Moulting frequency in *P. homarus* larvae increased from an average of 2.5 when 5 *Artemia* nauplii were offered daily to 5 at a ration of 60 nauplii (Fig. 2) indicating that food availability influences moulting frequency. The same phenomenon has been observed in the phyllosoma larvae of *Panulirus japonicus* by Saisho (1966). He was able to shorten the intermoult period of the first three stages of the phyllosoma of *P. japonicus* by increasing brine shrimp nauplii from 3-5 to 30-40 per ml. Increase in food density from 60 nauplii to 100 eventhough resulted in more consumption did not increase moulting frequency in *P. homarus* larvae. Maximum consumption, therefore, does not indicate maximum growth in phyllosoma larvae of *P. homarus*.

Inoe (1965) suggested that the phyllosoma larvae of *P. japonicus* can be cultured by maintaining 4 brine shrimp nauplii per ml of water, but size of the food should be altered with stage of phyllosoma. Our study indicates that a density of 1 freshly hatched *Artemia salina* nauplius per ml of water is optimum for culturing phyllosoma larvae of *P. homarus* individually since maximum moulting frequency could be attained at a ration of 60 nauplii/60ml of water per day in our experiment. Under this ration the larvae consumed at an average 21.6 nauplii per day. By offering 1.25 freshly hatched *Artemia salina* nauplii per ml to phyllosoma larvae cultured in groups of three, Radhakrishnan and Vijayakumaran (1986) obtained growth rates comparable to the maximum reported here. In their study the larvae consumed only 15.1 ± 0.94 nauplii per day to give this growth rate, indicating that when cultured in groups the larvae consume less and give maximum growth rate.

Total number of moults, the number of days required for each moult and the developmental stage attained by the larvae at the end of the experiment are presented in Table 1. With increase in ration from 5 to 60 nauplii per day

TABLE 1. *Total number of moults, number of days required for each moult and the developmental stage attained after 37 days by II stage phyllosoma larvae* Panulirus homarus *under varying ration of* Artemia salina *nauplii (The larvae took 8 days to reach II stage after one moult)*

Moult	Number of days taken under different ration of nauplii								
	0/day	1/day	5/day	10/day	20/day	40/day	60/day	80/day	100/day
I	—	—	8.5	7	7	6	6	6	6.5
II	—	—	13.5	8	5.5	7	5	5	5.5
III	—	—	8	15	8.5	5	6	6	6
IV	—	—	—	—	12	10	9	8	8.5
V	—	—	—	—	—	—	7	8	7.5
Stage attained after 37 days, by the larvae	Died after 14 days	Died after 17 days	IIIc	IIIc	III c & IV a	IV b	V a	V a	V a

intermoult period decreased from 8.5 to 6 days between the first and second moults; from 13.5 to 5 days between the second and third moults; from 15 to 6 days between third and fourth moults and from 12 to 8 days between fourth and fifth moults. The reduction in intermoult period with increase in density of food suggests that moulting is controlled by the nutritional status of the larvae. Individuals receiving lower rations were only in III c stage or in IV a stage at the end of the experiment (37th day), whereas those receiving higher rations reached V a stage (Table 1). It is observed that at food densities of more than 40 nauplii/60 ml III stage larvae reached IV stage after only two moults, skipping an intermediary moult. At densities lower to this, the larvae required three moults from III to IV stage. Density of food therefore is correlated with speedy development by skipping some of the stages. This finding is supported by the observations of other workers also. Carlberg and Van Olst (1976) opined that in palinurids increased number of larval stages can result from lack of food essential for growth. Robertson (1968) is of the view that other things being equal a well fed larva will be further advanced in the next stage than a poorly fed one.

The study was concluded after 37 days since larvae started dying. Slight reduction in feeding was observed towards the end of the experiment. Many workers (Robertson, 1968; Dexter, 1972) have attributed the reduction in feeding in late larval stages of palinurids to changing nutritional requirements of the larvae. Rearing of palinurid larvae can be carried out with success only if we are able to find out suitable feeds for different larval stages.

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