EFFECT OF EYESTALK ABLATION IN THE SPINY LOBSTER *PANULIRUS HOMARUS* (LINNAEUS): 3. ON GONADAL MATURITY

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ABSTRACT

Eye ablation induced accelerated gonadal growth in males and females, indicating gonad inhibiting principles in the eyestalk. Eyestalk removal resulted in 'pink haemolymph' in maturing and mature females and also inhibited the development of secondary sexual characters in them. The normal antagonistic relationship of moulting and reproduction was changed to one of synergism in ablated lobsters. Ablation of eyestalks initiates relatively strong moulting tendency than reproduction in *P. homarus*.

INTRODUCTION

Bilateral eyestalk ablation has been reported to accelerate gonad development as well as moult cycle in many crustaceans including shrimp (Panouse 1943; Demeusy 1965; Fingerman and Fingerman 1976; Rangneker and Deshmukh 1968; Aiken and Waddy 1976; Mauviot and Castell 1976; Quackenbush and Herrnkind 1981; and Nagabushanam and Kulkarni 1982). It has been suggested that the gonadal development in decapods is controlled by inhibiting hormone (GIH) factors produced by X-organ sinus gland complex in the eyestalk which in turn is assumed to control the synthesis of gonad stimulating substances (GSH) that probably originate in the brain and thoracic ganglion. Reviewing the literature on decapod reproductive endocrinology, Adiyodi and Adiyodi (1970) postulated the presence and inter-relationship of six hormones in controlling moulting and reproduction in decapod crustaceans. The role of eyestalk hormones on gonadal development in palinurid lobsters has been recently studied by Quackenbush and Herrnkind (1981 and 1983). The present paper reports on the effect of bilateral eyestalk ablation on gonadal development of juvenile, maturing and mature lobster *Panulirus homarus*.

MATERIAL AND METHODS

Gonad condition of ablated and control juvenile, maturing and mature *Panulirus homarus* was observed in Experiments I-V, where food was given *ad libitum* twice daily (for details refer Radhakrishnan and Vijayakumaran 1984).

The maturity stage and weight of the gonads of lobsters that died during the course of the experiments were also recorded. The wet and dry weight of the gonads of lobsters in these experiments were grouped and presented in 10-mm-carapace-length intervals. The gonad condition of starved control and ablated lobsters (Radhakrishnan and Vijayakumaran 1984) were also examined. One more experiment on the effect of eyestalk ablation on gonadal maturity of maturing *P. homarus* was conducted in November, the beginning of the breeding season of *P. homarus* at Kovalam. Twenty maturing lobsters with an average carapace length of 52.4 mm and weight 127.9 g were divided into two groups, each group containing five males and females. Both eyestalks of one of the groups were ablated. Both the groups were fed with equal quantity of clam meat (of *Meretrix casta*) once a day. The experiment had to be discontinued after 16 days, since all the ablated lobsters died due to asphyxiation. The carapace length, weight, gonad weight and maturity stage of all the control and ablated lobsters were recorded.

The ovary stage and morphological criteria for development stages of ovary have been classified following Berry (1971). Gonad index (GI) was calculated by the formula

$$\frac{\text{Gonad wet weight}}{\text{Weight of the lobster}} \times 100$$

Appearance of secondary sexual chracters in females and the reproductive behaviour of males and females of both ablated and control groups were observed.

Results

Gonadal development in males

Eyestalk ablation is noticed to result in significant size and weight increase in vasa deferentia of juvenile, maturing and mature males. However, development of androgenic gland and spermiogenesis was not examined in this study. The gonad index of ablated males in all the experiments was higher than that of control animals. In ablated males gonad index increased with increase in size, whereas in control lobsters it showed increase up to 75.9 mm carapace length and thereafter decrease (Table 1). Percent dry matter in gonads also showed increase with size in both ablated and control lobsters, the value being higher in ablated lobsters, which indicates real tissue synthesis. Hypersecretion of matrix was observed in the swollen vas deferens of ablated males.

Gonadal development in females

Ablation accelerated ovary development in juvenile, maturing and mature *P. homarus*. The gonad index of ablated and control females are shown in Table 2. In juvenile lobsters (Expt. I and II) ovary reached only stage II (pink, light

TABLE 1. *Gonad index and per cent dry matter in gonad of male (ablated and control)* P. homarus.

ABLATED					CONTROL				
Carapace length (mm)	No. of lobsters	Weight (g)	Gonad index	Per cent dry matter in gonad	Carapace length (mm)	No. of lobsters	Weight (g)	Gonad index	Per cent dry matter in gonad
46-55.9 (51.3)	6	96-149 (124.0)	1.7±0.4	33.1±3.6	46-55.9 (49.0)	4	104-116 (108.0)	0.7±0.1	32.6±2.0
56.65.9 (59.7)	8	153.240 (182.3)	2.6±0.6	37.1±3.8	56-65.9 (63.3)	8	180-285 (236.3)	0.9±0.4	36.9±4.2
66-75.9 (68.6)	9	244-304 (266.6)	3.7±1.7	41.7±1.3	*66-75.9 (70.8)	6	270-345 (313.1)	1.6±0.5	40.1±2.7
76-85.9 (78.2)	3	395-429 (408.0)	4.63±0.3	45.9±1.7	*76-85.9 (77.7)	4	350-415 (375.8)	1.31±0.2	40.2±2.2

* Values for larger size groups of control specimens are taken from other rearing experiments which are treated similarly.

TABLE 2. *Gonad index and per cent dry matter in gonad of female (ablated and control)* P. homarus.

ABLATED					CONTROL				
Carapace length (mm)	No. of lobsters	Weight (g)	Gonad index	Per cent dry matter	Carapace length (mm)	No. of lobsters	Weight (g)	Gonad index	Per cent dry matter
46-55.9 (51.8)	5	110-165 (131.5)	1.1±0.6	27.6±7.2	46-55.9 (49.9)	7	89.5-141 (116.5)	0.25±0.1	26.8±2.2
56-65.9 (61.0)	7	159-297 (224.6)	1.0±0.7	37.2±5.9	56-65.9 (63.5)	9	224-262 (23[illegible].0)	0.6±0.3	26.9±4.6
66-75.9 (69.9)	8	239-470 (326.0)	1.8±0.8	36.5±1.0	*66-75.9 (71.2)	6	350-410 (37[illegible].0)	0.95±0.4	26.4±5.8
76-85.9 (80.2)	4	404-500 (471.0)	1.0±0.5	32.0±9.5	*76-85.9 (76.8)	3	420-520 (47[illegible].0)	0.7±0.2	29.1±6.2

* Values for larger size groups of control specimens are taken from other rearing experiments which are treated similarly.

orange) after 108 days and 96 days respectively, whereas in control lobsters the ovary was in stage I (white, flattened). In maturing and mature lobsters (Expts. III, IV and V) the ovary was in stage IV (bright coral red) in ablated ones and in stage II in controls at the end of the experiments, which lasted 36 to 65 days.

The ovaries of maturing females, which were ablated in November, were also found to be in stage IV after 16 days when they all died apparently due to asphyxiation. Ovaries of the control lobsters in this experiment remained in stage II itself. The average gonad index of two females which moulted during this period was 1.2. The three which did not moult, however, had a higher gonadal index of 1.5 (average), which is 25% higher than that of the moulted ones. The gonad index of the controls was an average of 0.4. Ablation of maturing and mature lobsters in most part of the year accelerated the development of the ovary significantly. However, ablation of maturing and mature lobsters in reproductive season yielded a higher GI of 1.5 to 2.6 compared to that obtained in post-breeding season, 0.8-1.5, though both attained stage IV.

The ovary of a starved ablated lobster also advanced to stage IV after 47 days, in which time it had completed two moults. The first moult was seven days after ablation and the lobster oviposited and subsequently shed the unfertilized ova before the second moult.

In many of the maturing and mature ablated females "pink haemolymph" was found before the first moult when the period taken to moult was over ten days and between first and second moults in those which moulted within ten days of ablation.

Development of secondary sexual characters

The secondary sexual characters such as decalcified 'window' on the sternal plate and the ovigerous setae on pleopods did not appear in female lobsters ablated in immature stage and reached the size at which normally these characters appear. Normally, in laboratory-reared *P. homarus,* these characters appear at the onset of sexual maturity (55 mm CL) (Radhakrishnan, 1977).

Reproductive behaviour

Abnormal reproductive behaviour was noticed in ablated males; even those males with less than 45 mm carapace length forcefully deposited spermatophoric mass on the sternal plate of other ablated males and immature females. Normally male lobsters of above 55 mm carapace length was found to mate with females but not with other males, even though in another species of spiny lobster, *P. ornatus,* collected from wild, one instance of spermatophoric-mass deposition on a male measuring 60 mm carapace length was noticed by us at Madras.

Discussion

Accelerated gonad development in both males and females of *P. homarus* by bilateral eyestalk ablation indicates the presence of Gonad Inhibiting Hormone (GIH) factors in the eyestalk. Ablation in juveniles brought the ovary only to previtellogenic stage, which is in agreement with the view of Adiyodi and Adiyodi (1970) that the ovary needs to reach a particular stage before they respond to the declining titre of the GIH. Quackenbush and Herrnkind (1981) also had reported that in *P. argus* ovaries of the females below 70 mm carapace length did not become vitellogenic after bilateral eyestalk ablation.

In maturing and mature *P. homarus*, the ovary readily responded to the removal of eyestalk, which is evident from the high gonad index, a function of reproductive activity of marine invertebrates (Bennet and Giese 1955, and advanced development of ovary. Quackenbush and Herrnkind (1981) reported that the gonad index of ablated and non-moulted *P. argus* females was about three times that of the moulted ones and opined that in *P. argus* eyestalk ablation accelerated either moulting or reproduction but not simultaneously. In *P. homarus*, however, the 25% difference in gonadal index of moulted and non-moulted ablated females was due to the higher weight gain in moulted ones, indicating that ablation accelerated both moulting and gonadal development. However, as reported earlier (Radhakrishnan and Vijayakumaran 1983), in ablated *P. homarus* the relative emphasis is on moulting and somatic growth rather than on gonadal growth. This view is further supported by our subsequent observation of ablated *P. homarus* moulting with fertilized eggs and even with "naupliosomae' on their pleopods (unpublished). These lobsters have mated and oviposited after eyestalk ablation.

The cause of the "pink haemolymph" in ablated lobsters is not clearly understood. According to Adiyodi (1968) the Female Specific Protein (FSP) accumulates in the haemolymph prior to the onset of vitellogenesis. Whether this is due to lack of FSP uptake by ovary or to resorption from the ovary is not known. Aiken (1980) noticed pale green haemolymph in mature female *Homarus americanus* and suggested that either of these events would produce the colouration of the haemolymph. Further studies on transport of vitellogenin from the hepatopancreas through the blood is required to establish the appearance of "pink haemolymph" in *P. homarus*.

The non-development of secondary sexual characters such as decalcified 'windows' on the sternal plate and ovigerous setae on the pleopods in eyestalk-ablated females show the regulatory role of GIH in controlling the development of these characters. Adiyodi and Adiyodi (1970), citing similar results in *Carcinus maenus* and *Pachygrapsus marmoratus*, had also suggested that probably GIH allows time for the development of brooding characters inasmuch as it restrains the rate of vitellogenesis in the ovary.

The effect of eyestalk ablation is more pronounced in the male gonads and the difference in gonad index between control and ablated is higher in males than females (Tables 1 and 2). It will be interesting to find out to what extent the higher gonad development induced by eyestalk ablation is responsible for the lower percent of tail weight in males (Radhakrishnan and Vijayakumaran 1983).

The observation that ablated males of even less than 45 mm carapace length deposists spermatophoric mass on other lobsters irrespective of the sex, and even on lobsters in advanced moulting stage (D4), shows that their reproductive activity is accelerated. Besides, they develop an urge to deposit the spermatophoric mass. This indescriminate deposition of spermatophoric mass may be due to the high pressure developed in the vas deference from hypersecretion of matrix. If the resulting spermatophoric mass is deposited on a reproductively active ablated female this can lead to fertilization, oviposition and release of phyllosoma larvae, provided the lobster does not moult before the hatching of the larvae. To what extent the antagonistic relationship of moulting and reproduction in normal *P. homarus* is altered by eyestalk ablation is not clear and it necessitates further studies on isolation and characterization of hormones controlling, moulting, growth and reproduction.

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