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# Effect of eyestalk ablation on moulting and growth in the mudspiny lobster *Panulirus polyphagus* (Herbst, 1793) held in captivity

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## ABSTRACT

The effect of eyestalk ablation on moulting and growth in juveniles (20-40 mm carapace length, CL) and sub-adults (50–70 mm CL) of the mudspiny lobster *Panulirus polyphagus* was assessed through laboratory experiments. Eyestalk ablation resulted in increased frequency of moulting in juvenile and sub-adult males and females. Ablated lobsters showed a higher rate of growth at each moult as compared to the unablated ones. Growth increment, in terms of both carapace length and weight, was particularly high among the juvenile males. Ablated juvenile males showed an average increase in CL by almost 74% in about 114 days (0.7% increment per day) while the unablated ones showed an increase in CL of about 45% in 115 days (0.4% increment per day). Ablated juvenile males showed maximum weight gain of 370% in 114 days (3.3% per day) while control males showed an increase of 174% in 115 days (1.5% per day). The percentage increase in CL showed a decreasing trend with size in all the animals. Analysis of variance of the growth increments in terms of CL revealed significant difference ($\infty$=0.05) between the growth rates of ablated and control juvenile males and between the ablated juvenile males and females.

Keywords: Eyestalk ablation, Growth, Lobster, Moulting, Mudspiny lobster, *Panulirus polyphagus*

## Introduction

The role of the eyestalk in regulating the process of moulting, and the moult and growth-enhancing effect of eyestalk ablation on crustaceans hve been well documented over more than a century (Abramowitz and Abramowitz, 1940; Smith, 1940; Passano, 1960). The moult inhibiting hormone (MIH), which is considered to be one of the main regulators of moulting is produced by the X-organ-sinus gland complex housed in the crustacean eyestalk. High levels of MIH during the intermoult period suppress the synthesis of moulting hormones produced by the Y-organs (a pair of hypodermal glands on either side of the thorax). Although the effect of eyestalk ablation in lobsters has been a subject of study in the past, conclusions have been conflicting, and the advantages of employing this method to enhance growth in captivity in different lobster species are yet to be clearly defined. Most studies relate to eyestalk ablation in the clawed lobster *Homarus americanus* (Flint, 1972; Rao *et al*., 1973; Sochasky *et al*., 1973; Mauviot and Castell, 1976). The response of palinurid lobsters to eyestalk ablation has also been documented (Travis, 1951, 1954; Dall, 1977; Aiken, 1980; Quackenbush and Herrnkind, 1981; Radhakrishnan and Vijayakumaran, 1984). Research in India has been largely focused on the rock spiny lobster *Panulirus homarus*. Radhakrishnan and Vijayakumaran (1984) demonstrated growth acceleration in this species, following eyestalk ablation. The observations made on *P. polyphagus* were based on preliminary investigations and there has not been any further report ratifying growth acceleration following eyestalk ablation in this species.

This paper outlines the results of investigations done to study the effect of eyestalk ablation on growth in *P. polyphagus* held in captivity in order to assess the suitability of the technique in achieving higher growth performance in culture systems.

## Materials and methods

Juveniles (20-40 mm CL) and sub-adults (50 – 70 mm CL) of *P. polyphagus* collected from the trap gillnet catches at Sutrapada and short-trip trawl catches at Veraval were acclimatised to laboratory conditions at the Veraval Regional Centre of the Central Marine Fisheries Research Institute, Bhidiya, Veraval, Gujarat. The lobsters were fed *ad libitum* on meat of the gastropod, *Turbo* sp. The experiments were carried out in 400 l capacity fibre glass tanks (3 x 4') using seawater of 36 to 37 ppt salinity and 7.9 to 8.1 pH. Water temperature ranged from 27 to 29.5 °C. The animals were exposed to similar lighting conditions of 8 h normal light and 16 h darkness, using black polythene covers. One set of 10 animals (5 males: 5 females) was maintained as control while a second set was ablated. In order to minimise stress on the lobsters, one of the eyestalks was ablated on the first day and the next eyestalk was ablated the following day, as suggested by Radhakrishnan and Vijayakumaran (1984). The eye-stalks were cut at their base with sterilised, fine scissors. The lobsters were held in precooled water to reduce heart rate and check the loss of hemolymph while removing the

eyestalks. The ablated lobsters were dipped in 1ppm erythromycin saline to avoid infection.

The lobsters were fed *ad libitum* twice a day @ 5% of the biomass with meat of the gastropod, *Turbo* sp. All the animals were weighed at the start of the experiment and accurate measurements of the carapace length, CL (mm) (distance along the dorsal midline from the transverse ridge between the supraorbital horns to the posterior extremity of the cephalothorax) were taken on a vernier scale. Each animal was tagged. Records of all moults that occurred during the course of the experiments and increments in morphometrics of whole moults were noted. The experiment was run for a period of 90 days, at the end of which the final CL (mm) and wet weight (g) of the animals were recorded. ANOVA (Snedecor and Cochran, 1967) on these measures of growth was done to interpret the effects of eyestalk ablation on growth in the lobsters.

## Results and discussion

*Effect of eyestalk ablation on moulting*

Eyestalk ablation resulted in increased frequency of moulting in both juvenile and sub-adult male and female *P. polyphagus*. While the intermoult period was found to increase with increasing size in both ablated and control lobsters, the relative duration was found to be lesser in the ablated lobsters. There was not much difference between the intermoult periods in male and female juvenile lobsters, where as sub-adult males were found to have relatively lesser intermoult duration than the females. This difference was reflected in both, ablated and control lobsters. Ablated and control juveniles of either sex moulted five times within 130 days. Ablated sub-adults moulted four times in 150 days while control sub-adults moulted only three times in 150 days (Table 1). No mortality was recorded among the control or ablated lobsters during the experiment.

*Effect of eyestalk ablation on growth*

Ablated lobsters showed a higher rate of growth at each moult as compared to the unablated ones. The difference in CL increments was particularly high among the juvenile males (Table 2). The ablated ones showed an average increase in CL by almost 74% in about 114 days (0.7% increment per day) while the unablated ones showed an increase in CL of about 45% in 115 days (0.4% increment per day). The average increase in CL in ablated juvenile

Table 1. Average intermoult period (±-SD) for ablated and control *P. polyphagus*

| Sex | Size group (CL in mm) | Duration of experiment | Experimental group | Initial CL (mm) | Intermoult period (days) | | | | | Number of moults |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Upto I moult | I - II | II - III | III - IV | IV - V | |
| M | 20 - 40 | 130 days | A | 32.87+/-4.74 | 18.8+/-3 | 22.8+/-1.6 | 25.8+/-4.4 | 30+/-4.9 | 27.3+/-1.2 | 5 |
| | 20 - 40 | 130 days | C | 31.71+/-4.11 | 23.2+/-2.6 | 25+/-3 | 27.8+/-7.2 | 32.5+/-8.3 | 33+/-1.4 | 5 |
| M | 50 - 70 | 150 days | A | 61.82+/-5.92 | 31+/-2.83 | 35.2+/-1.92 | 39.4+/-2.3 | 42.5+/-1.29 | | 4 |
| | 50 - 70 | 150 days | C | 62.06+/-5.5 | 39.8+/-4.82 | 48.6+/-4.77 | 54.25+/-3.5 | | | 3 |
| F | 20 - 40 | 130 days | A | 36.7+/-8.9 | 17.2+/-3.7 | 24+/-5.3 | 27.6+/-5.1 | 30.6+/-5 | 31+/-2 | 5 |
| | 20 - 40 | 130 days | C | 35.4+/-9.71 | 27+/-9.2 | 32.2+/-8.2 | 36.6+/-8.6 | 35.3+/-5.1 | 32** | 5 |
| F | 50 - 70 | 150 days | A | 60.5+/-7.2 | 33.6+/-5.8 | 39.2+/-5.4 | 48.4+/-7.4 | 43+/-2.8 | | 4 |
| | 50 - 70 | 150 days | C | 60.3+/-6.02 | 42+/-10.7 | 51+/-9.4 | 57+/-5.3 | | | 3 |

**only one animal moulted
*M – Male; F – Female; CL – Carapace length*
*A – Ablated, C – Control*

Table 2. Average CL increment (±S.D) per moult for ablated and control *P. polyphagus*

| Sex | Size group (CL in mm) | Duration of experiment | Experimental group | Initial CL (mm) | Increase in CL (mm) | | | | | Number of moults |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Upto I moult | I - II | II - III | III - IV | IV - V | |
| M | 20 - 40 | 130 days | A | 32.87+/-4.74 | 5.5+/-0.5 | 5.9+/-0.8 | 5.44+/-1.1 | 5.2+/-1.16 | 4.6+/-0.42 | 5 |
| | 20 - 40 | 130 days | C | 31.71+/-4.11 | 3.2+/-0.33 | 3+/-0.25 | 3.2+/-0.76 | 3.53+/-0.64 | 3.8+/-0.42 | 5 |
| M | 50 – 70 | 150 days | A | 61.82+/-5.92 | 9.8+/-1.9 | 6.3+/-2.1 | 3.9+/-1.5 | 3.8+/-0.8 | | 4 |
| | 50 – 70 | 150 days | C | 62.06+/-5.5 | 4.7+/-1 | 5.2+/-0.57 | 4.9+/-0.83 | | | 3 |
| F | 20 - 40 | 130 days | A | 36.7+/-8.9 | 3.2+/-0.38 | 4.2+/-0.8 | 3.8+/-0.5 | 3.8+/-1.4 | 3.7+/-1.2 | 5 |
| | 20 - 40 | 130 days | C | 35.4+/-9.71 | 3+/-0.51 | 3.1+/-0.5 | 3.2+/-0.49 | 3.8+/-0.55 | 3.6** | 5 |
| F | 50 – 70 | 150 days | A | 60.5+/-7.2 | 5.4+/-1.4 | 4.9+/-1.3 | 4.3+/-0.7 | 2.95+/-0.4 | | 4 |
| | 50 – 70 | 150 days | C | 60.3+/-6.02 | 2.2+/-0.7 | 2.5+/-0.6 | 2.8+/-0.5 | | | 3 |

**only one animal moulted
*M – Male; F – Female; CL – Carapace length*
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females was 52% in 118 days (0.45% increment per day) while the unablated ones showed an increase in CL of 38% in 123 days (0.3% increment per day). The increments in ablated and control sub-adult males were 38% in 140 days (0.3% per day) and 23% in 132 days (0.2% per day) respectively. The growth rates were found to be lower in both ablated and control sub-adult females - 27% in 138 days (0.2% per day) and 12% in 136 days (0.1% per day), respectively. The percentage increase in CL showed a decreasing trend with size in all the animals (Table 3).

Weight increments were found to follow almost the same trend as CL increments (Table 4). Ablated male juveniles showed maximum weight gain of 370% in 114 days (3.3% per day) while control males showed an increase of 174% in 115 days (1.5% per day). In ablated juvenile females, the weight gain was 245% in 118 days (2% per day) while in the control animals, it was 157% in 123 days (1.3% per day). Ablated sub-adult males showed weight increments of 145% in 140 days (1% per day) while control lobsters showed increments of only 75% in 132 days (0.6% per day). In sub-adult females, the ablated lobsters showed 100% weight increment in 138 days (0.7% per day) while the control lobsters showed the lowest weight increment of only 37% in 136 days (0.2% per day) (Table 5).

Analysis of variance of the growth increments in terms of CL revealed significant difference ($\infty$=0.05) between the growth rates of ablated and control juvenile males and between the ablated juvenile males and females. In terms of weight, significant difference was noticed between the growth increments of ablated males and females .

Eyestalk ablation has been described as one of the most effective methods of accelerating moulting frequency, and hence, growth in several crustaceans, particularly shrimps (Abramovitz and Abramovitz, 1940, Smith, 1940, Scudamore, 1947, Bauchau, 1948, Passano, 1953, Hartnoll, 2001). Donahue (1951) and Flint (1972) reported delayed moulting in *H. americanus* following eyestalk ablation. Such contradicting reports have also been documented in the case of palinurid lobsters. Travis (1951, 1954) did not find eyestalk ablation effective in promoting moulting and growth in *Palinurus argus*. Dall (1977) reported a similar negative response to eyestalk ablation in *Palinurus cygnus.* These reports gave rise to speculations concerning the role of eyestalk in the production of MIH and Aiken (1980) reported that MIH functioned primarily to regulate seasonal moulting and was therefore insignificant in tropical lobsters. He concluded that eyestalk ablation did not accelerate moulting in palinurid lobsters. Quackenbush and

Table 3. Increase in CL (%) in ablated and control *Panulirus polyphagus*

| Sex | Size group (CL in mm) | Duration of experiment | Experimental group | Increase in W (%) | Days | Increase in W (%) per day |
|---|---|---|---|---|---|---|
| M | 20 - 40 | 130 days | A | 73.828 | 113.8 | 0.652 |
| | 20 - 40 | 130 days | C | 44.538 | 115.2 | 0.384 |
| M | 50 - 70 | 150 days | A | 38.346 | 139.6 | 0.27 |
| | 50 - 70 | 150 days | C | 22.716 | 131.8 | 0.17 |
| F | 20 - 40 | 130 days | A | 51.952 | 118 | 0.448 |
| | 20 - 40 | 130 days | C | 38.38 | 123.4 | 0.312 |
| F | 50 - 70 | 150 days | A | 27.16 | 138.4 | 0.196 |
| | 50 - 70 | 150 days | C | 11.694 | 135.75 | 0.092 |

*M – Male; F – Female; CL – Carapace length*
*A – Ablated, C – Control*

Table 4. Average weight increment (±S.D) per moult for ablated and control *P. polyphagus*

| Sex | Size group (CL in mm) | Duration of experiment | Experi-mental group | Initial weight (g) | Increase in weight (g) | | | | | Number of moults |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Upto I moult | I - II | II - III | III - IV | IV - V | |
| M | 20-40 | 130 days | A | 31.4+/-11.12 | 15.71+/-3.8 | 21.27+/-3 | 24.57+/-4.8 | 28.31+/-5.6 | 28.4+/-1.2 | 5 |
| | 20-40 | 130 days | C | 28.321+/-9.75 | 8.23+/-2.4 | 9+/-2.6 | 11.45+/-5.1 | 13.02+/-4.1 | 14+/-0.35 | 5 |
| M | 50-70 | 150 days | A | 169.34+/-44.29 | 80.45+/-10.4 | 82.6+/-16.1 | 43.04+/-15.9 | 46.07+/-9.1 | | 4 |
| | 50-70 | 150 days | C | 170.72+/-41.4 | 36.65+/-6.6 | 45.43+/-3.4 | 46.46+/-5.3 | | | 3 |
| F | 20-40 | 130 days | A | 43.94+/-26.19 | 10.69+/-3.9 | 16.21+/-5 | 16.97+/-3.7 | 18.8+/-1.6 | 18.6+/-2.4 | 5 |
| | 20-40 | 130 days | C | 40.91+/-29.6 | 10.05+/-6 | 11.48+/-5.4 | 13.45+/-5.24 | 13.83+/-5.9 | 10.506** | 5 |
| F | 50-70 | 150 days | A | 164.78+/-53.26 | 43.03+/-6.3 | 43.4+/-6 | 45.24+/-5.9 | 30.33+/-1.3 | | 4 |
| | 50-70 | 150 days | C | 161.7+/-43.19 | 16.83+/-3.9 | 19.9+/-2.3 | 28.01+/-4 | | | 3 |

**only one animal moulted
*M – Male; F – Female; CL – Carapace length*
*A – Ablated, C – Control*

Table 5. Increase in weight (%) in ablated and control *Panulirus polyphagus*

| Sex | Size group (CL in mm) | Duration of experiment | Experimental group | Increase in W (%) | Days | Increase in W (%) per day |
|---|---|---|---|---|---|---|
| M | 20 - 40 | 130 days | A | 369.93 | 113.8 | 3.262 |
| | 20 - 40 | 130 days | C | 173.524 | 115.2 | 1.484 |
| M | 50 - 70 | 150 days | A | 144.496 | 139.6 | 1.014 |
| | 50 - 70 | 150 days | C | 74.746 | 131.8 | 0.558 |
| F | 20 - 40 | 130 days | A | 245.108 | 118 | 2.144 |
| | 20 - 40 | 130 days | C | 156.618 | 123.4 | 1.268 |
| F | 50 - 70 | 150 days | A | 99.84 | 138.4 | 0.708 |
| | 50 - 70 | 150 days | C | 37.266 | 135.75 | 0.288 |

*M – Male; F – Female; CL – Carapace length; W - Weight*
*A – Ablated, C – Control*

Herrnkind (1981) reported accelerated gonadal development in *Panulirus argus*, but failed to obtain significant weight gains following eyestalk ablation. Radhakrishnan and Vijayakumaran (1982, 1984) reported acceleration of moulting frequency and consequent weight gain following eyestalk ablation in *P. homarus*. They found that bilateral eyestalk ablation in *P. homarus* resulted in accelerated moulting and gonadal development in all size groups (from early juveniles to adults), irrespective of the reproductive status and the season, indicating the presence of MIH and gonad inhibiting hormone (GIH) in the eyestalk.

In the present study also, the role of the eyestalk in growth is evidenced by the acceleration in moulting and growth observed in the juveniles, particularly the males. However, unlike in the case of *P. homarus* (Radhakrishnan and Vijayakumaran, 1982, 1984) the effects of eyestalk ablation in *P. polyphagus* seem to change with sex and size. Juvenile males responded best to eyestalk ablation, in terms of growth. Although the differences in growth rates were found to be statistically significant only in juvenile males, there was a general trend of improved growth increments in the ablated lobsters, suggesting the possibility of obtaining better growth in captive rearing of *P. polyphagus*, particularly in the juvenile grow-out phase.

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