EFFECT OF EYESTALK ABLATION IN SPINY LOBSTER *PANULIRUS HOMARUS* (LINNAEUS): 1. ON MOULTING AND GROWTH

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Abstract

Bilateral eyestalk ablation accelerated moulting frequency and weight gain in juvenile, maturing and mature *Panulirus homarus*, irrespective of their reproductive status. Three- to seven-fold increase in weight gain was obtained on eyestalk ablation. Ablation also did not incapacitate the lobsters in locating food, nor did it interfere with regeneration of autotomised limbs. The study indicates the presence in *P. homarus* of the Moult Inhibiting Hormone (MIH) and the Gonad Inhibiting Hormone (GIF) factors in the eyestalk.

Introduction

It has been reported that the eyestalk ablation accelerated moulting and weight gain in the American lobster *Homarus americanus* (Sochasky et al 1973, Rao et al 1973, Aiken and Waddy 1975, Mauviot and Castell 1976), but there are very few reports on the effect of eyestalk ablation in palinurid lobsters. Travis (1954) could not induce moulting in *Panulirus argus* by eyestalk ablation and concluded that there is no moult-inhibiting substance in the eyestalk. Dall (1977) also did not get any positive response to eyestalk ablation in *P. cygnus*. He therefore suggested that, in palinurid lobsters, the moult inhibiting hormone (MIH) is either secreted by neurosecretory cells situated elsewhere or, if secreted by cells within the eyestalk, not secreted in significant quantities. Subsequent experiments, with injected crustecdysone (Dall and Barclay 1977), certainly indicated lack of interference from MIH. Based on these observations, Aiken (1980) concluded that eyestalk ablation apparently does not accelerate moulting in palinurid lobsters. However, very recently, Quackenbush and Herrnkind (1981) reported increased gonadal development and accelerated moult cycle in eyestalk ablated *P. argus*.

The present report deals with the moulting and weight gain obtained as a result of eyestalk ablation in the palinurid lobster, *Panulirus homarus*. at the Field laboratory of Central Marine Fisheries Research Institute, at Kovalam, Madras.

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Material and Methods

Juvenile, maturing and mature *P. homarus* were collected by hand-picking from the surf-ridden areas and by operating bottom-set gill net in nearshore waters of Kovalam. The experimental lobsters were acclimatised to laboratory conditions, and were fed on a diet of clam meat (of *Meretrix casta*). The experiments were conducted in rectangular fibreglass tanks (90 cm x 60 cm x 60 cm) as well as in 1.2 m-diameter polyethylene-lined tanks. Salinity of the seawater, used as medium, varied between 32 and 35‰ and the water temperature between 22 to 33.8°C. A total of eight experiments were carried out.

Experiments

Experiments I-V

The objective of the experiments I-V was to study the effect of eyestalk ablation on feeding, growth, moulting, survival and gonad development of different sizes of *P. homarus*. Healthy lobsters ranging from 24.0 mm carapace length (CL) and 14 g weight to 71.7 mm CL and 297 g weight were used. The eyestalks were ablated at the base with a cauterizer. To minimise stress on the lobster, one of the eyestalks was ablated at first, and the other on the subsequent day. The lobsters were released back to the rearing system immediately after ablation.

Equal number of males and females were used in all the experiments except the sixth, where three females and two males were used. Lobsters were fed *ad libitum* on clam, *Meretrix casta,* twice daily. In experiment III, however, the green mussel *Perna viridis* and chopped trash fish were given, once daily for the first two months and, afterward, clam alone as in other experiments. Weighed quantity of food was given everyday in the evening and the remains were taken out and weighed next morning. After the removal of the leftover, three-fourth of the water in the rearing tank was replaced by fresh filtered seawater. After three hours food was offered again and, further three hours later, the feed-remains were taken out and water changed completely. The carapace length, total length and weight of the lobsters were measured every month. The maturity condition was also noted at the time of measurement. Majority of the lobsters moulted at night, and, when it occurred, moulting was recorded and the carapace length and weight of exuvia were noted. For interpretation of moulting and growth, group-averages were taken.

Experiment VI

In this experiment, equal quantity of food, at *ad libitum* feeding level, was given to both ablated and control groups once every evening, to find out whether the growth acceleration of ablated lobsters was solely due to increased consumption or due to physiological changes caused by ablation or to a combination of both. Water was changed completely once every morning. All other conditions were similar to those mentioned in the previous experiments. One of the lobsters from this experiment was reared for 249 days and the moult cycle followed up to seven moults. After two moults, the lobster was fed *ad libitum* once daily.

Experiment VII

This experiment was to study whether maximum growth in ablated lobsters could be obtained by feeding *ad libitum* only once a day. All other conditions were similar to the previous experiments.

Experiment VIII

The effect of starvation on ablated lobsters was studied in this experiment. In order to prevent cannibalism, the experimental lobsters were reared individually in rectangular plastic tanks (60 cm x 30 cm x 30 cm). Water was changed completely once a day with fresh filtered seawater.

At the end of each experiment the lobsters were dissected and the hepatopancreas, gonads and muscle were removed, weighed and dried to a constant weight at 60° in an hot-air oven. Tail weight and meat weight of all the lobsters were also noted. Tail weight, meat weight and hepatopancreas weight of lobsters of experiments I-V were grouped into 10 mm-carapace-length intervals, and the mean values are presented.

REMARKS

Moulting frequency

Eyestalk ablation accelerated moulting frequency in all size groups, resulting in shortened intermoult period. Intermoult period increased with increasing size in both ablated and control lobsters. When ablated lobsters moulted five times in 108 days (Expt. I) control lobsters moulted only thrice in the same period. The same trend was noticed in all the experiments (Table 1). The moulting frequency and weight gain of an ablated lobster reared for 249 days (from Expt. VI) is shown in Table 2. Initially, the intermoult period showed a steady increase with size, but the period between V and VI moult was considerably lesser. The lobster died while moulting for the 7th time after ablation. The moulting frequencies of starved, ablated lobsters were higher than those of control lobsters (Table 3).

Weight gain

Compared to the normal ones, the ablated lobsters exhibited three to seven-fold increase in weight gain. (Fig. 1-4). In experiment I, the ablated juveniles recorded an average increase of 1.02 g|day, while the increase was only 0.35 g|day in the control. Weight gain in ablated lobsters increased with size and a maximum of 2.5 g|day (Expt. IV and V) was obtained in maturing

TABLE 1. *Average intermoult period* (± S.D) *for ablated and control* P. homarus (A: ablated; C: Control).

Expt. No.	Duration (days)	No. of animals		Initial weight (g)	Intermoult period (days) Up to I moult	I-II	II-III	III-IV	IV-V	No. of moults
I	108	14	A	20.4±5.1	7.2±4.1	12.5±1.1	15.5±2.8	22.1±3.7	34.2±8.0	5
		14	C	24.8±4.1	22.1±11.4	30.8±5.0	39.9±4.3	—	—	3
II	93	18	A	49.7±6.0	10.0±4.4	15.9±3.5	20.8±2.4	27.6±2.9	—	4
		12	C	46.8±7.3	15.9±10.5	33.8±7.9	40.3±5.2	—	—	3*
III	165	10	A	84.5±1.9	12.3±6.4	27.1±2.5	32.8±9.0	37.3±3.3	36.8±0.5	5
		10	C	98.6±13.4	43.0±12.2	50.0±7.3	60.0±5.6	—	—	3
IV	36	4	A	169.0±24.8	17.3±7.6	—	—	—	—	1
		4	C	169.2±27.6	23.0±17.8	—	—	—	—	1**
V	61	6	A	256.5±22.2	14.8±10.7	30.8±3.6	—	—	—	2
		6	C	250.3±30.0	13.2±7.8	51.3±18.6	—	—	—	2***
VI	63	5	A	69.4±7.4	13.2±8.9	31.4±4.0	—	—	—	2
		5	C	66.0±4.7	33.4±17.8	—	—	—	—	1
VII	42	6	A	72.6±9.1	8.0±4.9	23.0±9.9	—	—	—	2
		6	C	72.2±10.0	28.7±14.6	—	—	—	—	1

* Did not complete the third moult
** Did not complete the first moult
*** Did not complete the second moult

TABLE 2. *Moulting frequency and weight gain in an ablated lobster reared for 249 days.*

Number of moults	Carapace length (mm)	Weight (g)	Increase in weight (g)	Percentage increase in weight	Intermoult period (days)
Initial	42.1	79	—	—	—
I	48.5	117	38	38.1	23
II	55.2	164	47	40.1	22
III	60.7	214	50	30.5	37
IV	65.8	270	56	26.2	42
V	73.0	377	107	39.6	43
VI	81.8	534	157	41.6	37
VII	Died while moulting				49

and mature lobsters (Table 4). In Expt. VI, in which equal quantity of food was provided for both ablated and control, weight gain was 1.14 g|day in the ablated lobsters and 0.28 g|day in the control. In Expt. VII, wherein the lobsters were fed *ad libitum* only once a day, the increase in weight was respectively 1.22 g|day and 0.21 g|day in the ablated and control groups. A maximum weight increase of 165 g in a single moult (V moult of the animal after ablation) was recorded in a lobster weighing 300 g in Expt. III, the intermoult period being 37 days.

Average percent weight gain per moult in ablated lobsters varied from 23 to 55. In control lobsters the weight gain declined from an average of 43%

TABLE 3. *Effect of starvation on moulting and survival in ablated and control* P. homarus (CL: Carapace length).

Treatment	Sex	Initial		Final		Survival	Moulting frequency (Days)	
		CL (mm)	Weight (g)	CL (mm)	Weight (g)	(Days)	I Moult	II Moult
Ablated	Male	54.4	145	56.6	160	40	12	—
	Female	53.2	142	57.0	202*	56	7	40
Control	Male	58.2	190	58.8	176	76	15	—
	Female	63.2	225	63.2	225	85	—	—

* Weight increase was due to mere accumulation of water

in early juveniles (25 g size) to 5.4% in adults (250 g size). The ablated lobsters did not show such a decreasing trend with size in percent weight gain at moult. In ablated lobsters, increase in weight at the first moult depended on the

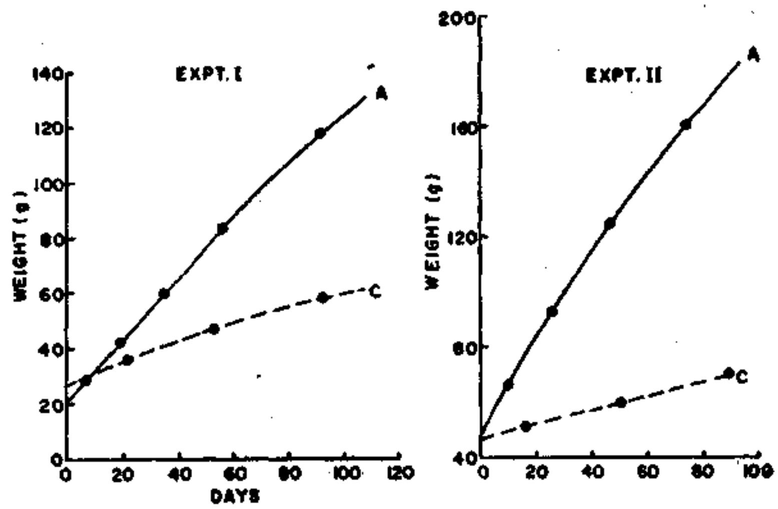

FIG. 1. Weight gain in eyestalk-ablated and control *P. homarus* in experiments I and II.

time taken for the moult after ablation or, more precisely, the moult stage at which ablation was carried out. For example, while the weight gain was 33% in lobsters moulted 10 days after ablation, it was 45.2% in those which completed the first moult after 16 days.

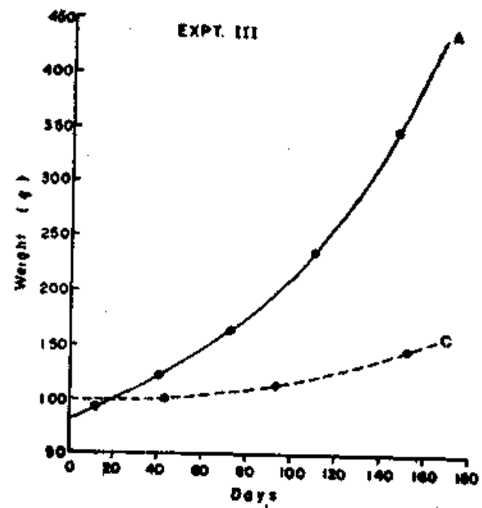

FIG. 2. Weight gain in eyestalk-ablated and control *P. homarus* in experiment III.

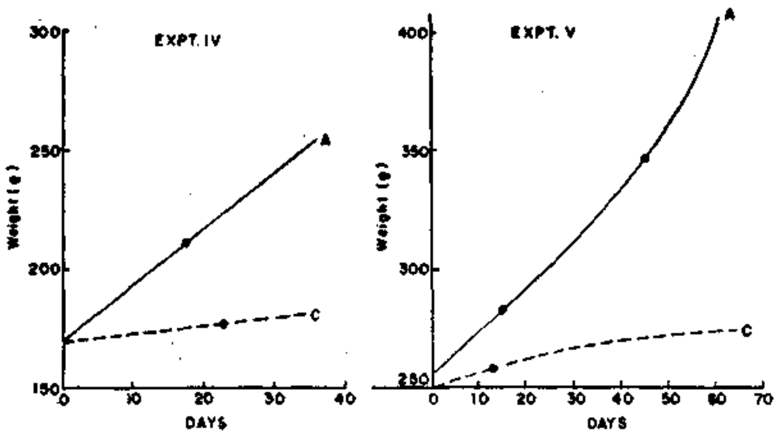

FIG. 3. Weight gain in eyestalk-ablated and control *P. homarus* in experiments IV and V.

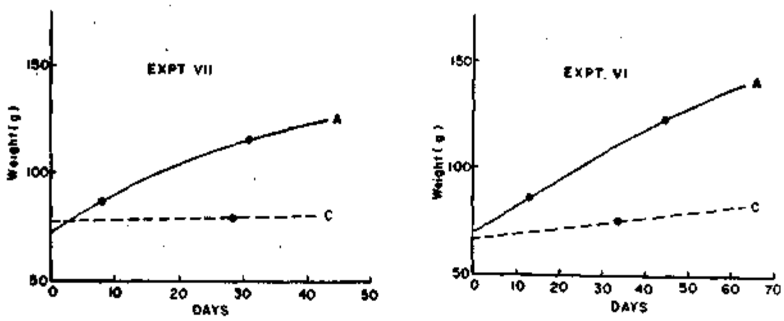

FIG. 4. Weight gain in eyestalk-ablated and control *P. homarus* in experiment VI and VII.

Increase in carapace length

The increase in carapace length of ablated and control lobsters 1 to V are given in Fig. 5. In the control group increase in carapace length per day gradually decreased with size. However, in ablated lobsters no such trend was observed and the carapace length increased by 0.2 to 0.25 mm|day in all the size groups (Table 4).

The increase in carapace length and percent increase at each moult in experiments I-III are presented in Table 5. Percent increase in carapace length at moult did not show any definite decreasing trend with size in ablated lobsters as did weight gain. In control, however, the percent increase in carapace length decreased with size. An increase of 9.9% in the III moult of the control groups in experiment III may have been due to the low temperature during December-January period (23-25°C) and consequent prolonged inter-moult period. This effect of temperature was also seen in the weight increase.

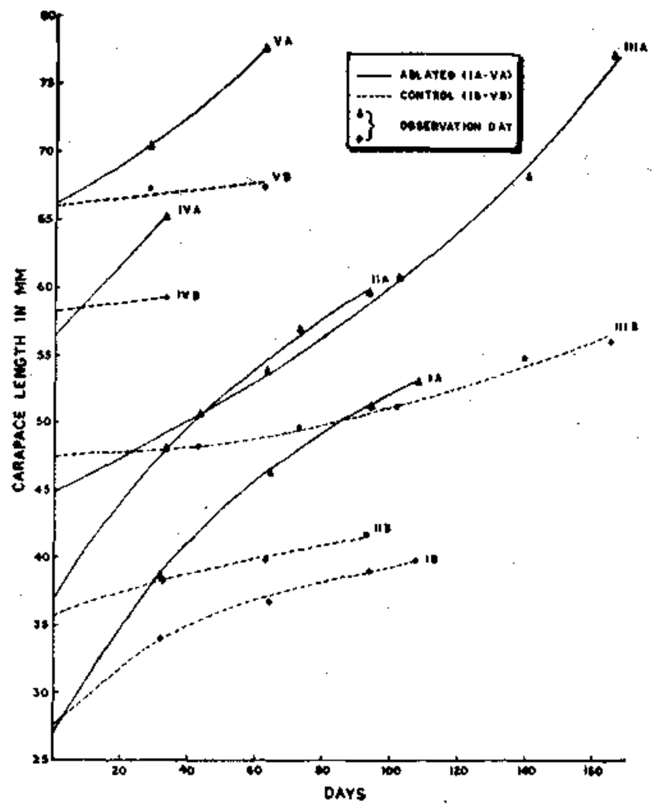

FIG. 5. Increase in carapace length in eyestalk-ablated and control *P. homarus* in experiments I-V.

Difference in growth between sexes

The total percent increase in carapace length and weight gain of male and female ablated lobsters and the control ones are given in Table 6, from which it is seen that, in the control, the males grew faster than the females. But in the ablated no such differential trend could be observed.

Effect on hepatopancreas

The percent of hepatopancreas in total body weight (hepatic index) and the percent dry matter in ablated and control lobsters are shown in Table 7. The hepatopancreas in ablated lobsters lost the normal colouration and looked like flimsy bags. While hepatic index in ablated lobsters was only 1% less than that in control lobsters, the average dry weight of the hepatopancreas of the former was about 14% less than that of control group in almost all size groups.

Tail weight and meat weight

Table 8 shows the tail weight, meat weight and the percent dry matter in the meat of ablated and control lobsters at the conclusion of the experiments.

TABLE 4. *Growth of ablated and control* P. homarus (S.D. in brackets) (A: ablated; C: Control).

Expt. No. date of start & duration (days)	Treatment	No. of lobsters	Initial		Final		Increase in wt. (total) g|days	Increase in wt.| day (g)	% increase in wt.| day	Increase in CL| day (mm)
			CL (mm)	Weight (g)	CL (mm)	Weight (g)				
I 29-3-82	A	14	27.0(2.3)	20.4(5.1)	53.1(2.8)	132.0(22.6)	110.6|108	1.02	5.00	0.24
(108)	C	14	28.7(2.0)	24.8(4.2)	39.7(3.2)	62.3(14.0)	37.5|108	0.35	1.40	0.09
II 23-4-82	A	18	36.5(1.6)	49.7(6.0)	59.7(4.2)	184.3(37.0)	134.6|93	1.45	2.90	0.25
(93)	C	12	35.8(2.1)	46.8(7.3)	41.9(3.6)	71.3(16.0)	24.5|93	0.26	0.55	0.07
III 1-9-81	A	10	44.7(3.0)	84.5(1.9)	77.4(3.1)	432.0(61.1)	347.5|165	2.10	2.48	2.20
(165)	C	10	47.3(2.4)	98.6(13.4)	56.2(2.4)	155.7(19.2)	57.1|165	0.35	0.35	0.05
IV 15-3-82	A	4	56.2(6.0)	169.0(24.8)	65.3(3.3)	255.0(25.9)	86.0|36	2.48	1.46	0.25
(36)	C	4	58.2(2.9)	169.2(27.6)	59.2(2.9)	181.0(28.3)	11.7|36	0.33	0.19	0.03
V 3-4-82	A	6	66.1(3.1)	256.5(22.2)	77.8(0.8)	408.0(10.6)	151.5|61	2.50	0.97	0.20
(61)	C	6	66.0(3.5)	250.3(30.0)	67.4(4.0)	272.5(33.7)	22.2|61	0.36	0.14	0.02
VI 19-5-82	A	5	41.2(0.6)	69.4(7.3)	53.0(1.5)	141.0(16.7)	71.6|63	1.14	1.64	0.20
(63)	C	5	41.7(2.1)	66.0(4.7)	44.2(1.6)	83.4(7.9)	17.4|63	0.28	0.42	0.07
VII 24-6-82	A	6	42.3(1.7)	72.6(9.1)	50.7(3.3)	123.8(19.4)	51.2|42	1.22	1.68	0.20
(42)	C	6	42.3(2.0)	72.2(10.0)	43.9(2.3)	81.0(11.8)	8.9|42	0.21	0.29	0.04

TABLE 5. *Increase (Inc.) in carapace length (CL) and percent increase at moult of ablated (A) and control (C)* P. homarus.

Expt. No.	Treatment	Initial CL (mm)	Moult I		Moult II		Moult III		Moult IV		Moult V	
			Inc. (mm)	%	Inc. (mm)	%	Inc. (mm)	%	Inc. (mm)	%	Inc. (mm)	%
I	A	27.0±2.3	3.4	11.8	5.0	16.9	5.6	16.2	5.0	12.5	5.9	13.1
	C	28.7±2.0	2.5	9.3	4.2	13.1	2.6	7.2				
II	A	36.5±1.6	4.1	11.2	5.2	12.8	5.3	11.6	5.7	11.1		
	C	35.8±2.1	1.3	3.6	2.2	5.9	2.0	5.1				
III	A	44.7±3.0	1.7	3.8	3.6	7.8	5.0	10.0	7.1	12.9	8.9	14.3
	C	47.3±2.4	1.0	2.1	2.2	4.6	5.0	9.9				
IV	A	56.2±6.0	4.8	8.5								
	C	58.2±2.9	0.7	1.2								
V	A	66.1±3.1	2.2	3.3	5.5	8.0						
	C	66.0±3.5	0.4	0.6								

TABLE 6. *Percentage increase in carapace length and weight in males and females of ablated* (A) *and control* (C) P. homarus.

Expt. No.	Treatment	Duration of Expt.(days)	% increase in CL		% increase in weight	
			Male	Female	Male	Female
I	A	108	103.8	89.8	600.0	486.4
	C		41.1	35.9	165.0	139.0
II	A	93	63.4	65.0	264.0	277.8
	C		19.4	14.3	60.6	43.4
III	A	165	—	74.0	—	423.0
	C		24.5	13.9	73.8	44.4
IV	A	36	17.6	13.0	51.7	41.3
	C		1.2	1.5	6.6	7.2
V	A	61	14.9	10.5	53.4	63.2
	C		1.7	2.3	11.0	6.4
VI	A	63	28.7	27.8	96.8	99.1
	C		8.0	4.0	35.8	19.9
VII	A	42	13.2	27.2	45.6	101.9
	C		5.5	2.1	14.8	7.6

The tail weight and meat weight in ablated lobsters were 1 to 2.7% less than those in normal lobsters. The percent dry matter also showed about 2% reduction in ablated lobsters. However, the total edible meat in eyestalk-ablated lobsters was far more than that usually obtained in normal lobsters. The tail weight of males was always lower than that of the females in both ablated and control lobsters; this difference being greater in ablated ones (4-5%).

Morphological and behavioural changes

Normally, *P. homarus* loses its natural colour (greenish blue) after the first moult in captivity. The pale lobsters, however, regained their natural colour one moult after eyestalk ablation. Later, this colour gradually faded after each moult and, in some cases, 'albino' lobsters were noticed after three or four moults. Some of the pale lobsters, including the 'albinos', regained their pigmentation again. Further experiments with different diets (unpublished) showed that the food plays a major role in the colouration of lobsters: lobsters fed with green mussels (*P. viridis*) maintained the natural colour in both ablated and control lobsters, while those fed with clams (*M. casta*) lost the colouration gradually.

Eyestalk ablation did not interfere with the regeneration of autotomised limbs in *P. homarus*. Regeneration of limbs lost in the intermoult stage was seen

TABLE 7. *The hepatic index and percent dry matter in hepotopancreas of ablated and control* P. homarus.

	ABLATED				CONTROL		
Carapace length (mm)	Weight (g)	Hepatic index	Per cent dry matter	Carapace length (mm)	Weight (g)	Hepatic index	Per cent dry matter
46-55.9	96-165	3.2±1.08	22.3±7.2	46-55.9	104-135	5.4±2.30	34.4±3.7
(51.8)	(130.7)			(51.6)	(120.0)		
56-65.9	153-297	2.8±0.74	22.2±8.3	56-65.9	176-315	3.4±1.20	39.2±7.7
(60.7)	(220.2)			(63.5)	(237.8)		
66-75.9	244-304	2.8±0.42	23.9±3.6	*66-75.0	270-380	3.3±0.97	37.0±11.6
(68.6)	(267.6)			(66.9)	(315.5)		
76-85.9	400-500	2.4±0.50	26.0±7.2	*76-85.9	376-470	1.9±0.70	24.7±4.8
(79.7)	(456.8)			(77.2)	(423.0)		

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

TABLE 8. *Percent tail weight, meat weight and dry matter in meat of ablated and control* P. homarus

ABLATED					CONTROL				
Carapace length (mm)	Weight(g)	Tail weight (%)	Meat (%) weight	Per cent matter dry	Carapace length (mm)	Weight (g)	Tail weight (%)	Meat weight (%)	Per cent dry matter
45-55.9 (51).8	96-165 (130.7)	30.0±3.1	23.5±3.35	22.3±2.9	46-55.9 (50.2)	104-135 (120.0)	32.7±2.0	25.8±2.7	25.1±1.3
56-65.9 (60.7)	153-297 (220.2)	28.0±4.6	26.4%3.15	22.1±4.3	56-65.9 (63.5)	176-315 (237.8)	34.2±1.5	28.5±1.3	26.0±2.5
66-75.9 (68.6)	244-304 (267.6)	32.3±1.8	26.0±1.50	22.6±1.7	*66-75.9 (69.9)	270-380 (315.5)	32.3±4.5	28.0±2.4	24.4±2.3
76-85.9 (79.7)	400-500 (456.8)	31.7±2.9	26.0±2.50	22.5±3.2	*76-85.9 (77.2)	376-470 (423.0)	32.9±1.0	26.6±3.2	21.0±3.0

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

in the first moult after ablation, but this was seen to be postponed to the next moult if autotomy happened in late-premoult. In ablated lobsters, the armature on the carapace became sharper and the walking legs stouter and, when handled, they were more aggressive than the normal ones.

In 90% of the ablated lobsters, after second or third moult, an antennule-like outgrowth developed at the site of the ablated eye, which may be either single, or bifid or trifid. With each subsequent moult this structure also increased in size. But in a very few cases (10%) such structure was not developd even after 5 moults.

The survival of ablated lobsters in the experiments was on an average 70% (43-100%) while that of the control was 97% (70-100%). The highest mortality of ablated lobsters was recorded in early juveniles (Expt. I). Death of both ablated and control lobsters was generally during moulting, or immediately after it. It was also observed that, when there was oxygen depletion due to power failure or to non-functioning of aerators, the ablated lobsters became more susceptible than the controls. Hence, the greater mortality occurred in the ablated lobsters may more probably be due to sudden fluctuations in the experimental conditions than due to any stress caused by ablation.

Discussion

Negative response of two palinurid lobsters, the tropical *P. argus* (Travis 1951, 1954) and the sub-tropical *P. cygnus* (Dall 1977), to bilateral eyestalk ablation has led to the speculation that, in palinurids, MIH is secreted by cells other than those in the eyestalk or, if it is secreted in in the eyestalk, the quantity is so insufficient as to affect moulting. Sochasky (1973) attributed Travis' failure in inducing precocious moulting in *P. argus* to gonadotropic interference, as the lobsters used by her were prepubertal or mature. Quackenbush and Herrnkind (1981) reported acceleration of gonad development in *P. argus* when ablated in spring and summer, but they did not find any significant difference in body weight or carapace length in ablated lobsters ten weeks after ablation. In their experiments, 41.6% of the ablated, mature females moulted in 48.5 ± 12.4 days, whereas 39% of the controls completed the first moult in 81.0 ± 10.7 days. In the rest of the ablated females (58.4%), which did not moult during the course of the experiment, the gonad index was high compared to that of the moulted (ablated) ones as well as of the intact controls. This led them to infer that eyestalk ablation accelerated moult cycle and gonad development in *P. argus*, but not simultaneously.

The present results of bilateral eyestalk ablation in *P. homarus* show that the acceleration of moulting frequency and gonad development is pronounced in all size groups (14-g early juveniles to 297-g adults) irrespective of the reproductive status and seasons, indicating the presence of Moult Inhibiting Hormone (MIH) and Gonad Inhibiting Hormone (GIH) in the syestalk.

In *P. homarus*, we have not considered the time taken to complete the first moult after ablation for interpreting moult acceleration, since this period is dependent on the moult stage at which ablation is performed. It is not known whether Quackenbush and Herrnkind (1981) had used lobsters in the same moult stage for ablation. It is possible that the 41.6% that moulted earlier were in the premoult stage at the time of ablation, and the rest, which did not moult, were in early intermoult stage, which makes it rather difficult to conclude whether ablation accelerated moulting frequency or not. However, the shorter duration taken for the first moult by ablated *P. argus* may be indicative of the possible presence of MIH factors in their eyestalks. This is further substantiated by isolation and partial characterization of MIH and GIH in *P. argus* (Quakenbush and Herrnkind 1983).

The accelerated growth in ablated lobsters is due to increased moulting frequency and higher percent weight gain at each moult. While faster moulting was attributed to the removal of MIH factors from the eyestalk, higher percent weight gain at moult was presumed to be due to elimination of hormone that regulates water uptake during ecdysis (Carlisle 1955), as eyestalkless lobsters became abnormally large after several moults. Koch (1952) ascribed the abnormal size increase to increased water uptake and not to tissue synthesis. In *P. homarus*, the large size attained by ablated lobsters is not due to mere accumulation of water, as was evident from the dry matter present in the meat (Table 8). However, the slightly lower percent dry matter observed in the ablated lobster meat may be due to cumulative addition of a small percentage of water retained in the tissue at each moult cycle, as ablated lobsters enter into next premoult faster, thereby all the water absorbed during ecdysis may not have been completely replaced by tissues. Mauviot and Castell (1976) also found lower percent of dry matter in the dorsal muscle of ablated *Homarus americanus* compared to intact control.

Eyestalk ablation did not incapacitate the lobsters in detecting food probably because of their well-developed chemoreceptive system (Ache and Macmillan 1980). For *P. homarus*, which inhabits the rocky coastal areas and is normally actively feeding at dusk, visual sighting may be of secondary importance for locating food. In both ablated and normal lobsters the general behavioural pattern for detecting the food was found to be the same: once the walking legs came into contact with the food, in a quick movement the object was grabbed. Antennular activity was also found to be increased on the introduction of the food.

The eyestalk factors probably regulate the storage and mobilization of organic reserves utilized for moulting and reproduction. Eyestalk ablation resulted in low hepatic index and percent dry weight of hepatopancreas, which may be indicative of the utilization of this reserve in tissue synthesis. Depletion of hepatopancreatic reserves due to eyestalk ablation was reported in *H. americanus* (Aiken

1980), as well as in crabs (Adiyodi 1969, Yamamoto 1960). A detailed study is, however, required to pinpoint the exact role of eyestalk factors in controlling hepatopancreatic metabolism.

The significance of the development of an antennule-like outgrowth in the place of the ablated eye is not fully understood. Development of such outgrowth in naturally blind (wild) *P. japonicus* was reported by Yosii (1931). Herbst (1896) had observed that the eyestalk regenerates when it is amputated at a region distal to the optic ganglia, whereas, when amputated at a level proximal to the ganglia, it produces an antenna. This he had explained as a specific morphogenetic effect of the optic ganglia on the development of the eye. However, subsequent experiment did not support this hypothesis.

The results of our study shows that further research is required to establish the hormonal role in moulting and growth in palinurid lobsters. As in many other decapods, reproduction and somatic growth are antagonistic in normal *P. homarus* and, since ablation accelerated the moult cycle and gonadal development simultaneously, this antagonistic relationship seems to be altered by bilateral eyestalk ablation. The acceleration of the moulting cycle and the higher percent weight gain at moult, irrespective of the reproductive status, lead us to believe that, under eyestalk ablation, in *P. homarus,* as in other decapods like *Eriocheir sinensis* and *Pachygrapsus marmoratus,* the relative emphasis is on somatic growth rather than on gonadal growth. The presence of MIH, as indicated here, in tropical palinurids, which are exposed to minimal seasonal environmental fluctuations, contradicts the view of Aiken (1980) that MIH exists primarily to regulate seasonal moulting and, therefore, it may not be significant in lobsters, to which this is not a requirement.

Whether MIH and GIH in *P. homarus* represent a single hormone with diverse functions or are they distinct hormones with different target tissues can only be concluded from characterisation of these hormones. However, the instances of synchronous occurrence of moulting and gonadal growth presently observed suggest the possibility that the hormonal mechanisms involved in moulting and reproduction are the same or, if they are different, they act synergistically in ablated lobsters.

In our trials with the controls, the duration taken by *P. homarus* for attaining about 200 g from an initial 25 g is about 16 months. The present study, therefore, indicates the possibility of growing *P. homarus* from 25 g to 200 g in about five months and to double that size in another two to three months more through eyestalk ablation and proper feed schedules. However, the necessity to maintain optimum environmental conditions needs to be emphasised as oxygen depletion in the culture conditions was a major cause for mortality in ablated lobsters especially during and just after moulting. It may be that the high oxygen requirement of ablated lobsters is due to the high feeding and metabolic rate.

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