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THE MOLT AND GROWTH ENHANCING EFFECT OF EYESTALK ABLATION IN JUVENILE LOBSTER (*HOMARUS AMERICANUS*)

by

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SUMMARY

The growth rate of 20 juvenile lobsters (*Homarus americanus*) at the 7th or 8th stage and 9 older juveniles (5 months old) was greatly enhanced by bilateral eyestalk ablation. The 7th and 8th stage ablated lobsters weighed an average of over 50 g 200 days after the operation, compared with the unoperated controls which weighed an average of 10 g. The increased growth was the result of both an increased molt frequency and greater percent weight gains per molt.

The dietary composition was even more critical to the survival and growth of the ablated lobsters than it was to the controls. A low protein diet resulted in reduced growth and survival of ablated lobsters but little effect on control lobsters.

Biochemical analyses of the lobsters revealed that although the fast growth of ablated lobsters resulted in a decreased lipid deposition in whole tail and chelae and hepatopancreas, the faster growth rate was the result of real tissue synthesis and protein deposition.

The ablated lobsters were different in colour, being a much paler orange-green than the controls. They also seemed at times to be uncoordinated and laid on their backs with their legs in the air. They were able to regenerate legs and antennae lost during the experiment.

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INTRODUCTION

One of the factors which is impeding the commercial aquaculture of lobsters (*Homarus americanus*) in North American is the very slow growth rate. In nature it takes 5-6 years for this species to reach the market size of approximately 450 g (Wilder, 1953). Hughes *et al.* (1972) were able to shorten this to approximately 2 years by raising lobsters at 22°C. The use of the waste heat from thermal power plants has been suggested by many as one possible way of reducing the time to produce market size lobsters. Other ways of increasing the growth rate of lobsters, however, must not be overlooked.

It has long been known that bilateral eyestalk ablation results in accelerated molt and growth rate in many decapod crustaceans (Zeleny 1905; Brown and Cunningham 1939; Smith 1940; Passano 1960; and many others). Though Flint (1972) reported that removal of both eyestalks from American lobsters seemed to lengthen rather than shorten the molt cycle, both Sochasky *et al.* (1973) and Rao *et al.* (1973) reported increased molting rate after eyestalk ablation.

In all these reports with lobsters it was found that eyestalk ablation resulted in a very greatly increased mortality rate. Thus any gains made through faster growth were offset by poor survival. High mortality in eyestalk ablated crustaceans is not uncommon. Brown & Cunningham (1939) reported 100% mortality before, during or shortly after one molt in "very lightly fed" eyestalk ablated crayfish (*Cambarus sp.*). Smith (1940) felt that the high mortality might be related to diet and found that when he fed the eyestalk ablated crayfish "liberally" some of them survived to molt three times.

We felt that the poor results with lobsters might also be related to diet. Flint (1972) fed his lobsters liver chunks. Stewart *et al.* (1967) found that this was less than a satisfactory diet and suggested it could be improved greatly by feeding (50:50) beef liver and whole herring chunks. Rao *et al.* (1973) fed their juvenile lobsters guppy food. Sochasky *et al.* (1973) do not mention what their lobsters were fed. We are now reporting the results of eyestalk ablation experiments on juvenile lobsters which were fed either frozen brine shrimp (*Artemia salina*) or diets containing many marine organisms found in the diet of lobsters in nature (Weiss 1971).

EXPERIMENTAL RESULTS

Two experiments were conducted with juveniles from the same female lobster. The ovigerous female was obtained from waters near Halifax, Nova Scotia in the summer of 1974. The eggs were hatched in late September by holding the female in 20°C filtered seawater. The larvae were fed live newly hatched brine shrimp until they reached 4th stage. At this stage they were placed in plastic trays with separate compartments to keep them apart and prevent cannibalism. All animals were held at 20°C and fed frozen brine shrimp except where stated otherwise. On December 17, 1974 one eyestalk was removed from twenty 7th or 8th stage juvenile lobsters with a pair of dissecting scissors. On the following day, the second eyestalk was removed from each lobster. As a control, thirteen unoperated lobsters were fed and held under identical conditions with the ablated test animals. For the first 83 days, these lobsters were fed *ad libitum* on frozen brine shrimp. At this point the blinded and control lobsters were subdivided into three groups for diet trials which will be discussed later. The feeding trial lasted 56 days, after which all groups were recombined and fed the same formulated diet as will be described later. As the feeding regimen was the same for both blinded and control lobsters, the growth of these animals was compared for the entire period of Experiment 1.

Regression curves for weight plotted against time were determined for both the eyestalk ablated and control lobsters as well as some of the actual weight data. The correlation coefficients for these curves were 0.975 for the ablated and 0.889 for the control lobsters. These curves predict that one year after eyestalk ablation the blind lobsters would weigh an average of about 1600 g compared with about 150 g for the controls.

On February 27th and 28th, 1975, the eyestalks were removed from 9 more juveniles from the same female as those used in Experiment 1. Eight juveniles were held as unoperated controls. These lobsters were fed brine shrimp *ad libitum* for 96 days at which time they were killed for analysis. The same type of growth enhancement was caused by eyestalk removal in this second experiment. All 9 of the operated lobsters survived for the full 96 days and molted either 3 or 4 times compared with 1-3 molts for control lobsters.

The increased growth rate of the eyestalk ablated lobsters was the result of both a shortened molt cycle and an increased weight gain after molting. The average time between the 1st and 2nd molt on the experiment was 13.5 ± 1.4 days (SE) for the eyestalk ablated lobsters on experiment 1, compared with 22.7 ± 3.4 for the controls. The average percent weight gain for the ablated lobsters for this molt was 93.1 ± 5.4 compared with 71.0 ± 9.8 for the controls. Though with each successive molt the mean percent weight gain per molt decreased and the mean intermolt period increased for both ablated and control lobsters, for each molt stage the percent gain was greater and the intermolt period shorter for ablated lobsters than controls.

Koch (1952) suggested that the increased weight gains of eyestalk ablated crabs (*Eriocheir sinensis*) was simply the result of an altered osmoregulation and did not represent any real growth process or tissue synthesis. Our results contradict this conclusion. After 96 days in experiment 2, the ablated lobsters were more than 3 times as large as the controls. There was no significant difference in the % moisture, or protein in the muscle, or the % moisture in the whole tail plus chelae.

The faster growth rate of the ablated lobsters did result in a lower deposition of lipid in tail plus chelae and hepatopancreas, but there can be no doubt that eyestalk ablation did result in faster growth in lobsters with increased tissue synthesis.

We mentioned earlier that in experiment 1 we tested the effect of diet. Eighty-three days after ablation the surviving lobsters were divided into three groups. Groups with 4 ablated and 3 control animals were fed Diet 1 a high protein feed. Group 2 also with 4 ablated and 3 controls was fed Diet 2, a low protein diet. The remaining 6 ablated and 4 control lobsters were fed frozen brine shrimp as before. The low protein Diet 2 greatly reduced the mean % gain and increased the intermolt period of the ablated lobsters. The diet had no effect on the control lobsters. Three of the 4 ablated lobsters on Diet 2 died before this phase of experiment 1 was terminated. These results clearly demonstrate the critical role diet plays in eyestalk ablation experiments and might help to explain some of the negative results and high mortalities encountered by other workers.

At this point we would like to mention a few additional points of interest. In agreement with results on other crustaceans (Smith 1940, and Abramowitz & Abramowitz 1940) we found that the ablated lobsters tended to have a much paler color than the controls.

Though Sochasky *et al.* 1973 reported that their ablated lobsters did not tend to produce limb buds and regenerate lost appendages, our lobsters showed very good regenerative powers.

Another behaviour peculiar to the blinded lobsters was also noted. They often seemed to loose their ability to coordinate their position and laid on their backs with walking legs up. This behaviour was reversible; after spending 1-3 weeks on its back, the lobster seemed to regain its balance and righted itself.

CONCLUSION

In conclusion: (1) Eyestalk ablation does result in significantly accelerated growth in lobsters *(Homarus americanus)*. (2) Diet is a more critical factor in the survival of the ablated lobsters than of controls. (3) The increased growth rate is the result of both increased % weight gains at molt and shortened intermolt periods. (4) Biochemical analysis shows that ablation results in real growth in terms of protein and tissue synthesis. (5) Ablated lobsters are paler in color than normal controls. (6) Ablated lobsters can regenerate lost limbs. (7) Eyestalk ablation may have application as a means of increasing growth rate of lobsters for commercial aquaculture.

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TABLE 1. Effect of Eyestalk Ablation on Composition of Lobsters.

Analysis	Mean Value For		Probability of Difference
	Ablated	Control	
% Dry Weight of Muscle	20.9 ± 1.5	23.3 ± 1.7	.10
% Protein in Muscle	78.3 ± 3.6	78.2 ± 2.6	.61
% Dry Weight of Tail & Chelae	31.0 ± 2.2	34.1 ± 3.9	.12
% Lipid in Tail & Chelae	2.03 ± 1.54	3.40 ± 1.20	.03
% Dry Weight of Hepatopancreas	30.2 ± 3.4	38.9 ± 7.9	.02
% Lipid in Hepatopancreas	37.3 ± 6.9	56.3 ±13.2	.007
% Glycogen in Hepatopancreas	1.06 ± 0.24	1.65 ± .72	.16
% Calcium in Shell	27.0 ± 3.2	28.2 ± 3.8	.24

TABLE 2. Composition of Diets

INGREDIENT	PERCENT IN DIET 1	2	3	BRINE SHRIMP
Mussel	10.0	8.0	33.3	
Squid	28.0	8.0	12.2	
Clams	16.6	5.0	-	
Oysters	8.0	-	-	
Crab	-	7.0	24.3	
Krill	-	12.0	-	
Brine Shrimp	-	24.0	-	
Bread	6.2	8.8	-	
Fish Meal	21.3	4.0	-	
α-Cellulose	4.0	8.0	2.7	
Gelatin	-	8.0	5.3	
Soybean Protein	-	-	6.7	
Fish Protein Conc.	-	-	4.0	
Casein(vitamin free)	-	-	5.3	
Dextrin	-	-	2.7	
Agar	4.4	7.2	-	
Mineral Mix	1.1	-	-	
Vitamin E	-	-	0.08	
Vitamin Mix	-	-	0.80	
Corn Oil	-	-	1.07	
Cod Liver Oil	-	-	1.07	
Cholesterol	-	-	0.20	
Choline	-	-	0.28	
Protein (wet wt)	25.85	15.14	26.0	4.2
Protein (dry wt)	64.46	27.53	64.0	41.7
Moisture	59.94	45.00	59.38	90.0

TABLE 3. The Effect of Diet on Growth of Eyestalk Ablated and Control Juvenile Lobsters.

DIET	GROUP	MEAN % GAIN	MEAN INTERMOLT PERIOD DAYS
1	Ablated	70.4 ± 9.3	28.8 ± 3.8
	Control	51.6 ± 6.9	44.0 ± 5.0
2	Ablated	51.0 ± 7.9	32.0 ± 3.0
	Control	55.3 ± 5.9	41.2 ± 8.4
Brine Shrimp	Ablated	78.7 ± 2.0	28.0 ± 5.0
	Control	52.1 ± 5.6	34.0 ±10.0