Recent Experiments on the Laboratory Rearing of Tropical Lobster Larvae[1]

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Abstract

Phyllosoma larvae of spiny lobsters and sand or slipper lobsters are very different morphologically from larvae of other decapod crustaceans. Associated with their morphology are ecological requirements which have been difficult to duplicate under laboratory conditions, despite the availability of techniques which have been satisfactory for the artificial rearing of many other kinds of decapods.

In very recent years some encouraging progress has been made in the artificial culture of phyllosoma larvae by several workers. Larvae of a number of species of spiny lobster have been successfully maintained for periods ranging from a few weeks to several months. Similar phyllosoma larvae of sand lobsters have been cultured with more success, at least one species having been reared to metamorphosis in the laboratory and others having survived nearly to metamorphosis.

These partial successes have pointed the way to probable eventual development of a satisfactory technique for rearing these larvae to metamorphosis under artificial conditions. A major obstacle in the past has been the nutrition of later stage larvae. Successful and unsuccessful experiments are reviewed and suggestions for further experimentation are presented.

THE SPINY LOBSTER, *Panulirus argus*, supports a very considerable fishery in Florida and the Caribbean and related species are of great economic value in other tropical seas. Since the early 1950s, biologists of the University of Miami have studied various aspects of the life history and ecology of this animal. Field studies on ecology and growth have been done also by the Florida State Board of Conservation and similar work is continuing. Investigation on the larval development of *P. argus* has been started at our laboratory and results of some preliminary experiments will be reported in detail by Robertson. My present purpose is to review some past work on larvae of the spiny lobsters and to summarize some recent findings which may be applied to future studies.

A program to study the larval development of a variety of tropical decapod crustaceans has been in effect at our institution since 1960. This continuing program has been supported with a series of grants by the National Institutes of Health and the National Science Foundation. Through laboratory rearings it has been possible to learn something about the morphology and biology of the larvae of a wide variety of crustaceans including shrimps, crabs, lobsters and related forms. Most of the more than 100 species studied have been non-

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commercial species, but some information has been produced by institute biologists for a few of the commercial species such as the pink shrimp and the stone crab. Most of the species studied have been sufficiently similar in morphology and requirements that a now widely used technique has proven at least moderately successful for laboratory rearings.

The larvae of the spiny lobsters of tropical seas and their close relatives the sand lobsters (also called bulldozers, slipper lobsters and Spanish lobsters) differ in several essential respects from all other larvae of decapod crustaceans. Because of these differences, the artificial rearing of these larvae in the laboratory has been a more difficult task than for most others. Until recent years no one had succeeded in keeping newly hatched larvae of this type alive for more than a few days despite many attempts.

The larvae of the spiny lobsters (Palinuridae) differ in a few relatively minor characters from those of the sand lobsters (Scyllaridae) and can be distinguished from them but in general the larvae of the two groups are very similar to each other. The most important characters are the extreme flatness of the body, the very long biramous legs used for swimming and feeding, and the relatively weak mouth parts. The larva usually swims in a horizontal position, dangling the legs below it, keeping its orientation and progress by action of the exopods of the legs. These larvae range in body length from just a couple of millimeters at hatching to many millimeters (less than 10 mm to more than 70 mm) before metamorphosis according to the species.

To be able to rear larvae of spiny lobsters in the laboratory would open the way for many studies on larval ecology which are not possible now. A subject of great interest to many is the question of possible artificial culture of lobsters on a large scale and obviously good information concerning the early development of these animals would be essential to any evaluation of that possibility. Almost nothing is known about the larval ecology of phyllosomas and until very recently we had few clues as to the natural foods and feeding habits.

Prior to the late 1950s, studies on phyllosomas were generally in three overlapping areas; (1) taxonomy and morphology, based on specimens from the plankton, (2) descriptive ecology, based again on plankton samples and (3) attempts, nearly always unsuccessful, to rear larvae under artificial conditions. At about this time however, an unprecedented expansion of research effort on the rearing of decapod larvae began, with brine shrimp nauplii as the single most important factor in laboratory successes.

Nonaka, Oshima and Hirano (1958) were apparently the first to succeed in getting *Panulirus* larvae to feed on *Artemia* in the laboratory and they obtained third stage larvae from reared material.

Between 1958-1961, Inoue and Nonaka (1963) succeeded in rearing larvae of *P. japonicus* up to the seventh stage (40-48 days after hatching) using *Artemia* nauplii and filtered sea water, but they reported high mortality after the first four stages. The later stages were smaller than corresponding stages taken from the plankton.

About the same time Saisho (1962) reared *P. japonicus* from hatching also with brine shrimp as their food. Larvae lived for 90 days and molted 10 times but the 11th stage larvae were not close to metamorphosis. Later the same author reported upon experiments in which *P. japonicus* larvae were reared on *Artemia* for 178 days going through 16 molts (Saisho, 1966). The

time between molts was 7-8 days early in development, but increased to 10-15 days later in development. The conclusion was made that *Artemia* is a suitable food only for the younger stages and that a new food had to be found for the later stages of phyllosoma larvae.

Ong (1967) working with *P. polyphagus* was able to get some larvae to fourth stage, again with *Artemia,* using non-aerated shallow pans.

With regard to *Artemia* as a food for phyllosomas, Inoue (1965) found that within a favorable temperature range of 22-28C for *P. japonicus* a maximum of one *Artemia* nauplius per hour was consumed by a phyllosoma larva and the optimum density of food was 4 nauplii per ml. He also showed that, after the first stage, the phyllosoma larva was able to consume more food per hour if the *Artemia* were larger than that taken by first stage phyllosomas.

Attempts to rear the scyllarid phyllosomas of *Ibacus* were reported by Dotsu, Seno and Inoue (1966). They used larval gobiid fishes and were able to get only a very small percentage (less than 1%) to molt twice in 55 days in one experiment but got better than 10% to molt twice in another experiment on a different species, with one individual molting three times within 58 days. Later Dotsu, Tanaka, Shojima & Seno (1966) demonstrated that captured late stage phyllosomas of *Ibacus* could be held alive through metamorphosis in the laboratory.

In trying to determine the number of stages in the development of *P. japonicus,* Murano (1967) emphasized that culture work on these larvae gave very abnormal results concerning not only the number of stages supposed in development, but also the rate of growth. In the development of a wide variety of decapod crustaceans including probably phyllosoma larvae, the number of stages is a variable thing and independent of growth, certainly after the first few molts. Nevertheless, Murano implied that there is a fixed number of stages (11) in the development of *P. japonicus* and that the 11th stage approximates 28 mm body length as found by Oshima, (similar to the 25-30 mm body length of the final stage of *P. interruptus.*)

The earlier work of the Japanese was not widely known in 1963 when, after several years of success in rearing other kinds of decapod larvae, we began to study phyllosoma larvae. Several attempts to rear phyllosoma larvae of various species resulted in moderate success. Only two attempts were made to rear spiny lobster larvae, most effort being placed on phyllosomas of various sand lobsters because of their availability at the time. The very extensive information obtained on larvae of the Scyllaridae has been put together in a doctoral dissertation by Robertson who is publishing the material as time permits. Two papers from this work have already appeared (Robertson, 1968a, 1968b). The first describes the results of experiments on the American sand lobster and is of special significance, in that larvae of this species were reared completely from hatching to metamorphosis, the first such successful, complete rearing of phyllosoma larvae so far as we know. Robertson obtained postlarvae in 32-40 days at 25C and suggested that complete development might require 40-50 days at 20C but less than a month at 30C. He pointed out that while some scyllarid lobsters may have a shorter development than those panulirids for which there is any information, it is probably not true of all genera of scyllarids.

Other experiments on species of scyllarid lobsters were also successful, but to a lesser degree. Results of these experiments and the descriptions of the

larvae, including those of the large shovel lobster, *Scyllarides aequinoctialis*, will be published in the near future.

During the course of these studies, a little work was done on larvae of two of our spiny lobster species, *P. argus* and *P. guttatus*. Those experiments, the results of which will be published in detail elsewhere, were essentially similar to those of the Japanese and other workers, who used different species. At temperatures higher than 20C larvae were able to pass through as many as eight or nine molts, and some individuals lived as long as 9-10 weeks, but growth slowed very markedly after the first few molts and the animals alive after 2 months were probably much less developed than would be larvae of similar age in the natural environment.

Despite its convenience as a laboratory diet, *Artemia* is not a natural food in the sense that phyllosomas encounter it in the sea, and it obviously does not satisfy the requirements of these larvae once they are past the first few stages. Unfortunately there has been little information on the natural food of phyllosoma larvae.

Both Robertson (1968 b) and Sims and Brown (1968) called attention to the observations published by Thomas (1963) and Shojima (1963) who reported phyllosomas of *Ibacus* attached to scyphozoan medusae and Williamson (*in* Thomas, 1963) reported feeding phyllosomas of *Jasus* on hydromedusae. Shojima found *Scyllarus* phyllosomas carrying hydromedusae by means of the long pereiopods. Sims and Brown (1968) examined the gut contents of several phyllosomas and found nematocysts in the gut and in fecal material extruding from at least one specimen. From this they suggest that medusae do indeed constitute a natural food for phyllosomas.

Batham (1967) working with the spiny lobster genus *Jasus* was able to rear larvae as long as 4 weeks, but only through one molt in that time, perhaps because of the very low temperatures prevailing at the season (10-19C). The duration of the first stage of the few individuals which succeeded in molting varied from 19-25 days under those conditions. However, most significant were his observations on feeding. Batham offered his phyllosomas a variety of natural foods including *Obelia* and Anthomedusae, copepods, zoeas, trochophores, a veliger larva and an ascidian tadpole. None of these foods was taken by the phyllosomas, nor were pieces of mussel (*Mytilus*) which is known to be favored food of juveniles. *Artemia* apparently were not accepted by *Jasus* larvae either, but small pieces of mullet flesh were taken. The larvae fed most successfully on pieces of dead and living polychaete worms.

Summary and conclusions, proposed work

To my knowledge there has not been as yet any successful rearing of spiny lobster larvae all the way from hatching to metamorphosis, although various workers have kept phyllosomas alive for periods up to several months. As has been already stated by others, *Artemia* nauplii, while apparently adequate for the earlier stages, are not adequate food for later stages, and even though molting may continue for a long time, growth is markedly slowed if not stopped after the first few stages. The problem of providing a different food for the later stages has long been recognized as the primary obstacle to successful complete rearing of those species with naturally long larval life.

The various clues obtained by very recent experiments such as that of Batham (1967) point the way toward possible solutions to this problem. The

food must be physically much larger than *Artemia* nauplii, of soft texture, of suitable chemical composition (and here the contrasting compositions of jellyfishes and worms or fish may give clues), must be easily produced and must not decay readily. Natural or artificial foods with these qualities will be the key to successful artificial rearing of tropical lobster larvae. Experiments along these lines will be continuing.

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