Hatchery Technology and Seed Production of Lobsters

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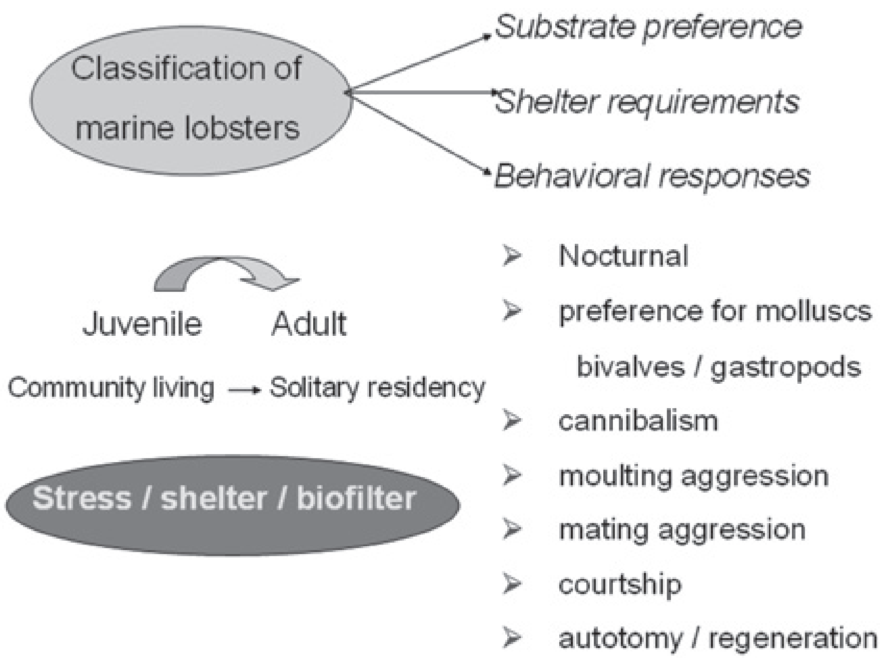
Lobsters are high-value seafood delicacies commanding high demand in international markets, with a high culinary value attached and lobster tails are always in great demand world-wide. Freshwater crayfishes, which are considered a delicacy in many parts of the world, are a favourite aquaculture candidate in North America, Europe and Australia. Crayfish and rock lobster aquaculture practices are initially capital oriented but deliver high production and income turnover in the long run. This industry has already taken off in countries like the U.S.A. and Australia. The lobster fishery in India is supported by two groups of lobsters – the spiny lobsters (*Palinurus homarus*, *P. polyphagus*, *P. ornatus* and *P. versicolor*) and the scyllarid lobster (*Thenus unimaculatus*). Lobster culture in India is still in the infancy stage. With the distinction of being perhaps, the only seafood resource in India's trade economy, which remains relatively low down the ladder in terms of quantity of production but brings in maximum foreign exchange, lobsters have been the subject of study for more than two decades now and C.M.F.R.I. has been spearheading research in the development of culture technologies for different species of lobsters.

The spiny lobster, *Panulirus homarus* has been the chief candidate for lobster aquaculture research in India. While complete larval rearing in captivity is yet to be achieved, other technologies like broodstock development, maturation and breeding in captivity and fattening of juveniles collected from the wild have been standardized. The sand lobster *Thenus unimaculatus* (earlier known as *Thenus orientalis)* which contributes to 8% of the global lobster production, and ranks next to spiny lobsters and tiger shrimp in export value, is one of the most promising candidates for lobster aquaculture in India. Increasing demand for live lobsters in the export market led the farmers and entrepreneurs to collect juvenile lobsters and crabs from the wild and grow to marketable size in ponds and tanks by feeding trash fishes and other discards. Breeding of the spiny lobsters, *Panulirus homarus* and *P. polyphagus* have been achieved in captivity and rearing of early larval stages has been done in different Research Centers of the Institute. Complete larval development of *T. unimaculatus* and *Petrarctus rugosus* was achieved for the first time in India at the Kovalam Field Laboratory of CMFRI in March 2004 (Kizhakudan et al., 2004).

As in any aquaculture system, broodstock development and hatchery management are the primary aspects to be tackled while establishing an aquaculture unit for lobsters. Sub-adult and adult lobsters are usually collected from the wild and acclimatized to captive holding. Different techniques for induced maturation and breeding in captivity involve physical handling and provision of favorable influential factors like artificial and natural diets, shelters and hiding places, pathogen-free rearing medium etc. The life history of lobsters shows a transition from a free-swimming planktonic larval phase to a benthic, crawling adult phase. We need to understand the specific requirements of the species before designing the right type of brood stock and hatchery units. The design of an indoor lobster brood stock and hatchery unit is based on the inherent nature of the animals, as depicted below –



Comparison of traits between sand and spinylobsters

	Thenus	***Panulirus***
Fecundity	10000-30000	100000-600000
Spermatophore	Mucilaginous -2-3 hours life	Stored in gelatinous matrix for repeated spawning
Egg size	bigger	Smaller
Larval stages	4	12
Post larvae	nisto	puerulus
Incubation of eggs	37 days at 27°C	25 days
Feeding	Ctenophores Accept particulate diets well from beginning.	Sagitta and live feeds in the beginning and later accept gel diets and particulates
Aggression	Cluster at feeding, surface swimming and disperse well	Dactyli very sharp, disperse less and crowd at bottom when not disturbed
Cannibalism	No	Yes
Artificial grow out diets	No	Yes
Grow out densities	30-40 lobsters per sq metre	8-10 lobsters per sq metre

BROODSTOCK DEVELOPMENT

Juvenile and adult lobsters are primarily benthic forms preferring to crawl along the bottom of the sea where light penetration is minimal. To simulate natural conditions to the extent possible, broodstock tanks are usually painted black on the insides and kept covered with dark screens. Lighting in the broodstock unit is kept minimal. The time of light exposure for each species has to be fixed based on experimental studies. Habitat preferences are marked among lobsters. Sand lobsters are seen predominantly in sandy substrates and spiny amongst rocks.

Spiny lobsters are comparatively long-lived (5-10 years), while the scyllarid genus (*Thenus*) with slightly lesser (3-5 years) longevity, lead a very stressful life owing to their periodic moulting, nocturnal feeding, sedentary habits and protracted ocean-dependent larval life cycles and complex reproductive behavior. The spiny lobsters are den/crevice loving, living in groups during the juvenile phase and are carnivorous, while the scyllarids are sediment loving, aggregate in habitats and feed on pelecypods and gastropods. Although sex ratio in the wild seems to be almost equal in both the lobsters, males are more aggressive in spiny lobsters and can even harm the female, while in scyllarids the longevity of male lobster is often reduced. The female spiny lobster retains the male sperm attachments for 2-3 repeated spawning in a single intermoult, while repeated mating is essential in scyllarids as the sperm attachments remain only for a few hours.

The spiny lobster females enter into reproductive cycle at the 3rd year cycle while the scyllarids (*Thenus*) enter much earlier (1½ -2 years). After successful mating the females spawn and the eggs, after fertilization, attaches to the pleopodal setae for incubation. The fecundity is much higher in spiny lobsters while very low in *Thenus* and *Petrarctus*, depending on the egg diameter and animal size. However the egg diameter lessens the number of days of incubation more than number of larval stages (spiny); higher the egg diameter, higher the incubation period and lesser the number of larval stages (scyllarids).

Live lobsters in general hold good out of water for at least 12-24 hours, depending on the temperature and the packaging, when in intermoult stages. Lobsters collected and kept at less stressful environment, prechilled and rolled into moist paper rolls or textile kept at 22-25°C can be transported to long distances without water at higher densities. They can be held in higher densities with good aeration and clean water for shorter intervals intermediate to longer shipments.

Broodstock tanks for sand lobsters are provided with a layer of sand at the bottom, in which the lobsters remain buried for a major part of the time. Spiny lobster broodstock tanks require no bottom substratum but need to be provided with structures that provide surfaces or crevices for attachment and sheltering. Water quality and photoperiod were found to play a major role and animals reared in larger tanks with increased water depth show more amenability to captive maturation. Broodstock maintenance and development in sand lobsters are done in a Closed Recirculatory System with fluidized bed filter and minimum light exposure (LD 1:23). Juvenile (<30 mm CL) and sub-adult (30 – 40 mm CL) lobsters collected from the wild and reared in recirculatory systems developed into mature adult lobsters (65 - 70 mm CL) in a period of about 6 – 8 months. Regulation of light exposure and feeding @ 5% of body weight in two divided doses daily give good results.

Like all crustaceans growth in lobsters occurs in stages combined with a molt. Molting is controlled by hormones. Growth is faster in the juveniles and slows down as the adult phase progresses. Beyond maturation, growth, particularly in females tends to be slower. Lobsters, like other crustaceans, prepare well in advance to

Lobster broodstock tanks at CMFRI's Kovalam Field Laboratory (Chennai)

molt and have a short phase of starvation at during and immediately after molting, when they are soft shelled and vulnerable to attack by other lobsters in the brood stock tank. This is particularly seen in the case of spiny lobsters which exhibit tendencies for cannibalism. Therefore, it is necessary to provide shelters and hiding places for these animals in the tank, for seclusion during molting. PVC pipes, asbestos tiles, vertical net screens are some of the commonly used structures for this purpose. Juvenile lobsters coexist in a community living structure while adult lobsters prefer a solitary existence. This also necessitates providing shelters to aid in this transition phase in broodstock development.

Food is a major factor determining the performance of the animals in captivity. Lobsters show a preference for shellfish, particularly mussels. Sand lobsters show good reception to fresh clam meat. Broodstock diets should be combination of natural diet preferred by the species and artificial diets prepared to meet the protein requirements of the broodstock, with additives to promote growth and maturation.

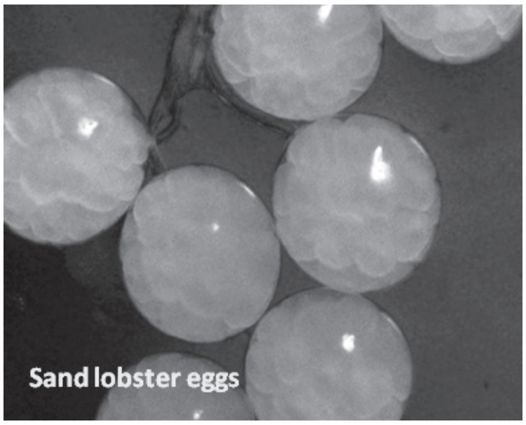
Collection of lobsters from the wild entails the possibility of the animals harboring pathogenic microbes. Quarantine measures and prophylactic treatments form an integral part of the broodstock management unit. This, combined with a strict regime for seawater treatment and disinfection of tanks between stockings, should be good enough to ensure a healthy environment for the lobsters. One of the major problems seen in lobsters, particularly spiny lobsters, is tail injury caused due to aggressive behavior among themselves. Attacks on soft shelled lobsters also induce injuries which tend to get infected. As mentioned earlier, shelters and crevices are essential to avoid such occurrences.

Broodstock handling and quality assessment

Generally live lobster freshly caught in trap nets are healthy, and are to be checked for any injury on the appendages or body or excessive bleeding. Ectocommensals like goose barnacles, polychaete worms, nemerteans, sponges and ascidians are to be cleaned off and the lobster should be given a dip in 10 ppm formalin to remove planarian larval forms and protistans, particularly ciliates. Lobsters with tail rot and necrotic lesions on the uropod and telson are to be avoided. The water pumping rates through the gill chamber when held by hand suspending the animal by holding on the antenna indicates the animal energy levels. The branchiostegal lines and decalcification indicates the moult status of the animal and the flipping strength of the lobster tails is essentially a tool to identify a healthy lobster.

HATCHERY REARING AND SEED PRODUCTION

The larval phase in most lobsters is usually complicated, extended and highly dependent on external factors. Like other crustaceans, lobsters begin life as a developing embryo inside an egg which is carried by the female along with hundreds or thousands of other eggs, on the pleopods. These egg-bearing females are called "ovigerous". Fertilized eggs are dark yellow or orange in color and turn dark brown at the time of hatching. Unfertilized eggs remain cream or pink in colour and are shed off in 3-5 days. After a rigorous incubation phase (early embryo development inside the eggs) when the eggs are fanned with the help of the pleopods, small, transparent, flattened larvae called "phyllosoma" hatch out. The incubation period varies from 26-30 days in tropical spiny lobsters to 30-37 days in sand lobsters. Hatching takes place in batches only during the early morning hours and is usually completed in 1-3 days. Water quality, tank bottom quality and handling stress, particularly during the incubation period, greatly influence the success rate of hatching.



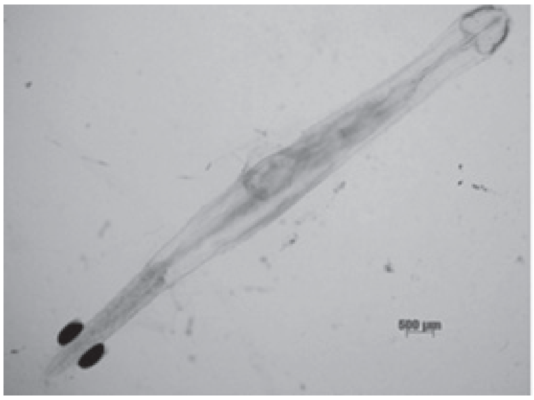
Larvae are usually small when compared to the adult except in clawed lobsters. These larval stages (phyllososma) undergo progressive molts to complete metamorphosis before settling as the post larval stage, called "puerulus" in spiny lobsters and "nisto" in sand lobsters. The hatchery phase is often the crucial stage in lobster aquaculture, since handling of the delicate phyllosoma is very difficult, and renders the hatchery phase labour intensive. The number of larval stages varies greatly among species, ranging from about 12 stages in spiny lobsters to 4 stages in sand lobsters. Compared to the spiny lobsters, the hatchery phase is of shorter duration in sand lobsters. While larval metamorphoses can extend up to 300 days in spiny lobsters, it is usually completed in 25-30 days in sand lobsters.

The rearing system should accommodate only minimum numbers per litre, as most of the species are aggressive and cannibalistic; while 10 phyllosoma per litre in tropical spiny lobsters in the initial stages is fine, as stages progress beyond fourth the density has to be thinned further to 5 and 1-2 per litre towards the final stages. The equivalent stages of most species follow almost the same stocking density limits. Larval rearing tanks are usually of shallow depth with upwelling and flow through designs ensuring very less water agitation and reduced photoperiod intensity. Light source is used to pool the larvae to facilitate collection and shifting.

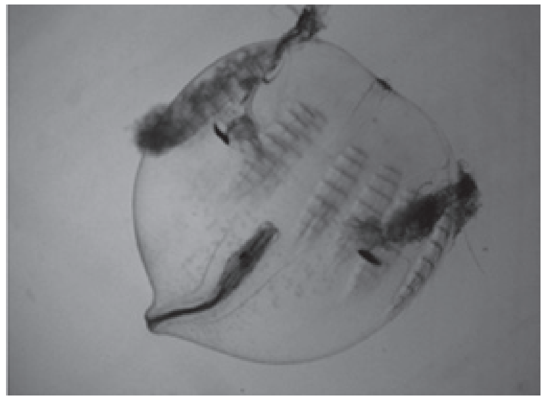
The phyllosoma are mostly phototactic and prefer specific zooplankters as live feed. Spiny lobster larvae ingest arrow worms and other live feeds in the early stages. Sand lobster larvae show a preference for ctenophores. Suitable artificial, preferably gel texture, supplementary diets are also essential in lobster hatchery feeding regimes. These diets should be floating and stable in water. Water quality in phyllosoma rearing is of utmost importance as delay in molting attracts too fouling microbes on the shell which render the larvae immobile and obstruct their feeding activity. Organic load and ammonia load should be minimal in the system and tank surfaces should be devoid of biofilm formation to reduce bacterial invasions. Proper feed and health management can improve larval survival and growth to a great extent.

Improvisations in sand lobster larval rearing

Seawater treatment: The primary source of microbial load in crustacean hatcheries being the incoming



Chaetognath



Ctenophore

seawater, different seawater treatment modes are of utmost importance to rule out the chances of pathogen infection through this source. The seawater treatment course includes heating to 45^0 C, ozone treatment and neutralizing with oxygenation. The seawater thus treated has to be subjected to UV + cartridge filtration and charcoal treatment before being released into the rearing tanks for efficient control on bacterial populations.

System designs & environmental manipulations: Slow upwelling or trickling flow regulated shallow water basins and tanks with mild aerated water influx is ideal for the phyllosomal rearing. High density rearing systems using clear water with water exchange at each feeding is labour intensive and delicate and the larvae is quite sensitive to handling. Modifications in the LRT for management of water flow rate and pattern is essential at each moulted stage as the density and feed size requirements changes. Trials were also carried out to see the viability to culture juveniles without substrates. Rearing systems without soil substrate and provided with net base instead will also gives good results. Shallow tanks with longer holding area and regulated light provide uniform distribution of larvae in the rearing volume, and thus improve feeding efficiency.

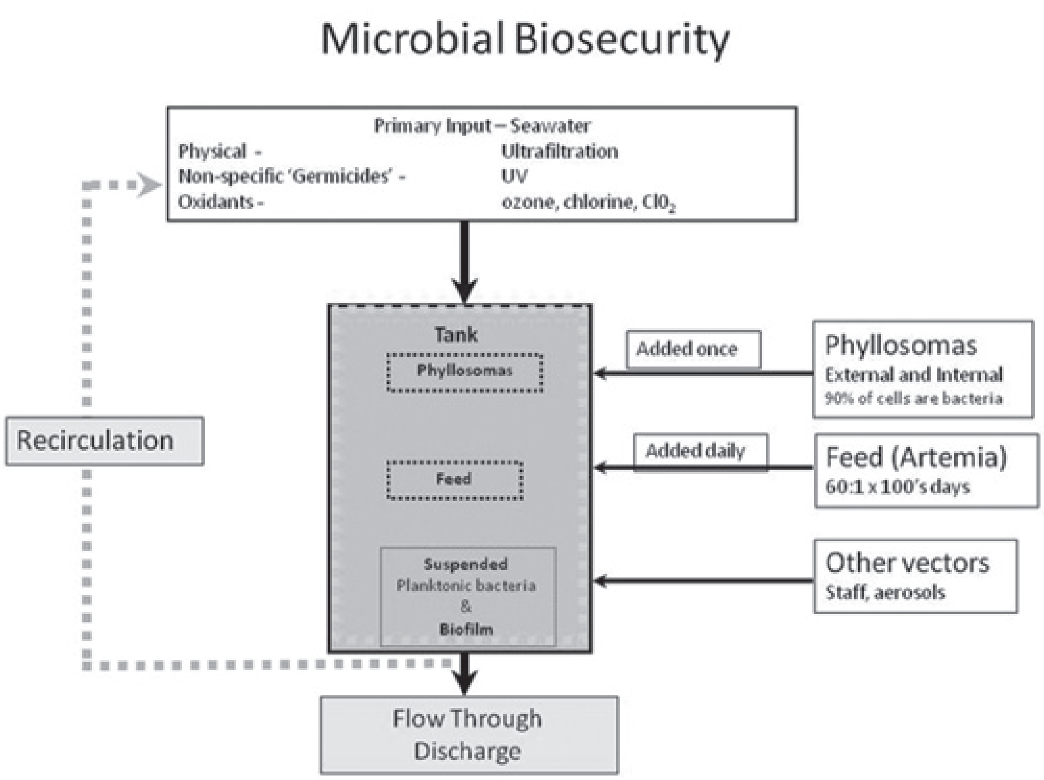
Feed interventions: Spiny and scyllarid lobster larvae are known to prey upon and consume live zooplankton and fleshy objects, and hence the use of pellets and MEDs in lobster larval rearing systems is a drawback. Therefore, soft feeds incorporating necessary nutrients will be ideal. The formulated diets are to be mixed at different concentrations separately and then added with the gelatinized binder, then gelatinized and loaded to a sterile syringe. The pellets are to be extruded through needles and the warm pellets/noodles immersed in various concentrations of cold $CaCl_2$ to solidify the noodle threads and cut to necessary size. The process is based on transformation from a sodium alginate solution to gelled calcium alginate (external gelation). Here the gelation reaction occurs from the surface inwards producing noodles with a shell entrapping the core material (inner sponge-like matrix).The composition of externally gelled micropellets incorporating live feed and other nutritive supplements was formulated and tested successfully for floatation, stability, colour, sizes and suitability to trimming at CMFRI's Kovalam Field Laboratory (Chennai). *Artemia* and algal concentrate were used in artificial diets formulations. The efficiency of the feeds with respect to larval acceptance and deliverance was worked out for sand lobster larvae.

Microbial interventions: Phage therapy has been found to develop autoimmunity in the larval mass against luminescent bacterial invasions. Bacteriophages developed against LB forms in shrimp hatcheries have also been found to show encouraging results in lobster broodstock and larvae.

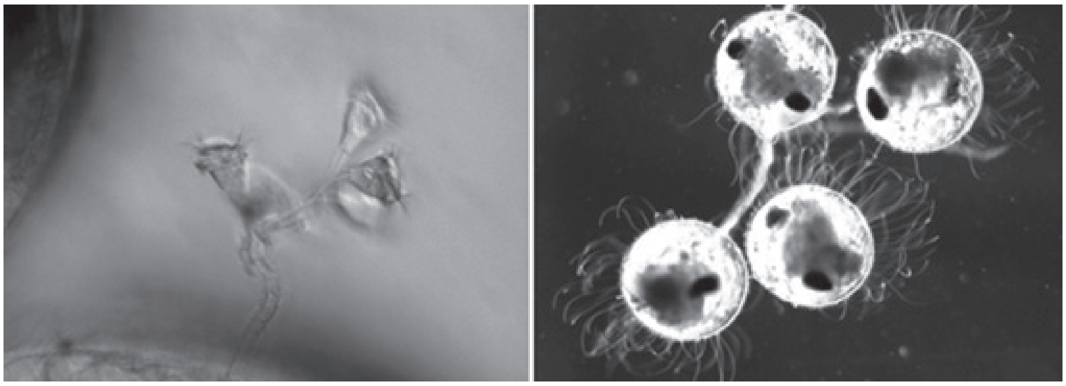
The success of any aquaculture enterprise depends on the efficiency of the rearing system design and its management. Simulation of conditions as close as possible to the lobster's natural environment must be attempted at every stage of its progress from juvenile to adult in the broodstock unit and from egg to juvenile in the hatchery unit. The first hurdle being the steady supply of brooders, the primary aim of the enterprise should be to turn out a good number of adult lobsters developed from wild collected juveniles, and to induce repeated maturation and breeding in captivity. The next hurdle would then be to effect successive larval metamorphosis with high survival rates and post-larval settlement to produce healthy juveniles which would then be ready for generation of a new batch of brooders. Both these aspects can be achieved through a rigid and structured set of management practices as described in this note, but perfected best through practical handling and knowledge gained through experience.

Length of larval period for different species of domesticated lobsters

Species	Larval length
Panulirus homarus	5 months
Panulirus ornatus	6 months
Thenus orientalis	30 days
Thenus unimaculatus	30 days
Petrarctus rugosus	2 months
Scyllarides spp.	8-9 months



Schematic representation of the microbial biosecurity system in lobster hatcher at AIMS, Australia



Vorticella and filamentous bacterial infestation in sand lobster hatchery