CMFRI

Course Manual

Winter School on

Recent Advances in Breeding and Larviculture of Marine Finfish and Shellfish

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OVERVIEW OF LOBSTER FARMING

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Introduction

Lobsters are high valued seafood with well established export markets around the world and form extremely important fisheries in many countries. World's production of palinurid lobsters mostly originate from Australia, New Zealand, Cuba, Brazil, South Africa, USA and Mexico. The annual world catch of lobsters is 2, 33,825 t (2005) valued at US $ 2108 million. Total landing of spiny lobsters is 71925 t (2004).

Most world fisheries are either fully exploited, or overexploited. Annual landing of lobsters in India was 1539 t (2007), which averaged about 2200 t in 1990's. Lobsters have excellent market demand and price and especially live lobsters are the most preferred. Annual export was to the tune of Rs.53 crores during 2003-04. Lobsters are exported in different forms; frozen tails, whole frozen, whole-chilled, whole-cooked and frozen, lobster meat and as in live form. Overseas customers are ready to pay more for fresh seafood. Live lobster export increased from 1.3% during 1993-94 to 12.7% during 2003-04 periods. The high export demand has been a major economic benefit to the country. However, increased demand in the export market and high price led to over-harvesting employing destructive fishing practices. Degradation of natural habitats from pollution and human activities has contributed to a precipitous decline in the wild populations threatening the current market's long-term sustainability.

Conservation measures are not actively enforced by maritime states to prohibit harvesting of egg bearing females and juvenile lobsters. Government of India has implemented Minimum Legal Size (MLS) for export. Non-enforcement of regulations has led to illegal export of juveniles and undersize lobsters. Undersize lobsters fetch very low price and if fattened to commercial grade can fetch higher price and can be exported legally. Therefore, fattening of low value lobsters with a view to value addition is a possibility. CMFRI has developed technology for semi-commercial scale culture of lobsters in land-based tanks. There were also attempts to culture lobsters in small nearshore fixed cages. Attempts are now in progress to farm lobsters in large marine cages by CMFRI.

A major stumbling block, however, in realizing the aquaculture potential has been the difficulties of rearing the larvae through their long and complex larval stages. Although some species have been successfully reared to settlement, large scale production of seed lobsters has not yet been possible. Successful application of the hatchery technologies seems to be far away due to obvious reasons. Rearing lobsters from the postlarvae is relatively easier and various authors have reported on the potential for their ongrowing to marketable size (Tholasilingam and Rangarajan, 1986; Kittaka, 2000; Radhakrishnan and Devarajan, 1986). Southeast Asian and Japanese markets prefer smaller lobsters and farmers venturing into culture can target these markets. The problems, constraints and global scenario in lobster farming is discussed in this paper.

Taxonomy

Systematic position of spiny lobsters

Order	:	Decapoda
Sub order	:	Macrura Reptantia
Infra order	:	Palinuridea
Super family	:	Palinuroidea, Eryonoidea,Glypheoidea,
Family	:	Palinuridae, Polychelidae, Glypheidae, Synaxidae
Genera	:	*Justitia,Jasus(Sagmariasus),Stereomastis, Panulirus,Puerulus, Linuparus, Palinustu,s Jasus,Palinurus*

Species of palinurid lobsters in Indian waters

Genus		Species reported
Panulirus	:	*P. homarus homarus*, *P. ornatus*, *P. polyphagus*, *P. versicolor*, *P. longipes*, *P. penicillatus*
Puerulus	:	P. sewelli
Linuparus	:	*L. somniosus*
Palinustus	:	P. waguiensis
Stereomastis	:	*S. sculpta*

Species under: Systematic position of Slipper lobsters

Order	:	Decapoda
Sub order	:	Macrura Reptantia
Infra order	:	Palinuridea
Superfamily	:	Palinuroidea
Family	:	Scyllaridae
Sub-family	:	Theninae, Arctidinae, Ibacinae ,Scyllarinae
Genera	:	*Thenus, Petrarctus, Scyllarides, Parribacus, Biarctus, Scammarctus, Eduarctus*

Species of slipper lobsters in Indian waters

Genus	**:**	**Species Reported**
Thenus	:	*T. indicus, T. parindicus, T. unimaculeatus* (under revision)
Petrarctus	:	*P. rugosus*
Parribacus	:	*Parribacus antarcticus*
Scyllarides	:	*S. elisabathae, S. tridacnophaga*
Biarctus, Eduarctus and *Scammarctus*	:	(under revision)

Systematic position of Nephropid lobsters

Order	:	Decapoda
Sub order	:	Macrura Reptantia
Infra order	:	Astacidea
Super family	:	Nephropoidea
Family	:	Nephropidae
Sub-family	:	Neophoberinae, Thymopinae, Nephropinae
Genera	:	Nephropsis, Acanthacaris

Genus	**:**	**Species Reported**
Acanthacaris		*A. tenuimana,*
Nephrosis		*N. stewarti, N. sulcata, N. suhmi, N. ensirostris, N. carpenteri*

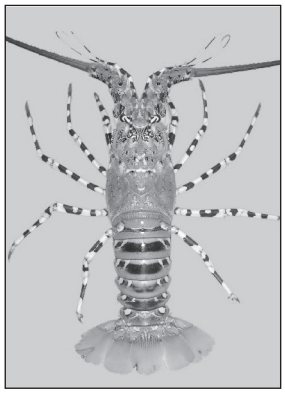
Species of aquaculture importance : *Panulirus homarus homarus, P. ornatus, P. polyphagus, Thenus* spp.

Distribution of spiny lobsters along the Indian coast

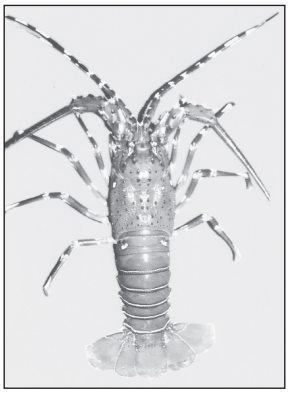
Although the lobster fauna of India comprises 25 species (Radhakrishnan *et al.*,2007), only four littoral and one deep sea form contribute to commercial fishery. The northwest coast fishery is mainly constituted by the spiny lobster *Panulirus polyphagus* (mud spiny lobster) (fig.1) and the slipper lobster *Thenus* sp. (shovel-nosed lobster) (fig.2) which inhabit at 20-50 m depth. The shallow water *P. homarus* homarus (scalloped spiny lobster) (fig.3) occupying 1-20 m depth range is the most dominant species along the southwest coast, whereas *P. ornatus* (ornate spiny lobster) (fig.4) *P. homarus homarus* and *Thenus* spp. contribute to the fishery on the southeast coast. Small quantities of *P. versicolor* are also landed along the Trivandrum and Chennai coasts. *P. penicillatus* and *P. longipes* are the two other species, which are not important from the fishery point of view. Adult *P.ornatus* inhabits relatively deeper areas (40-50 m). The spiny lobster *Puerulus sewelli* occupy the upper continental slope between 175-200 m depth

off the southwest and southeast coasts from where they are fished along with deepsea shrimps by trawlers *Linupurus somniosus* is another species of spiny lobster recorded from the Andaman waters. *P. polyphagus* is called *Titan* in Gujarathi, *Shevand* in Marathi, *Chittakonju/Kadal konchu* in Malayalam and *Katearatioroyya* in Telugu, *P. homarus* is called *Thala eral* in Tamil and *Bama reya* in Telugu. The vernacular name of *P. ornatus* is *Mani eral* in Tamil. In the export trade *P. ornatus* is commonly known as *tiger* and others as *Greens.*

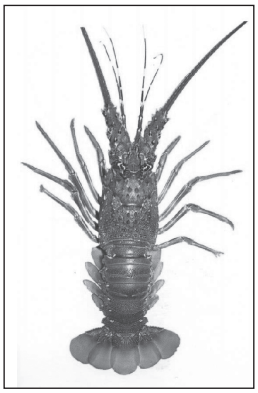
Panulirus ornatus



Panulirus polyphagus

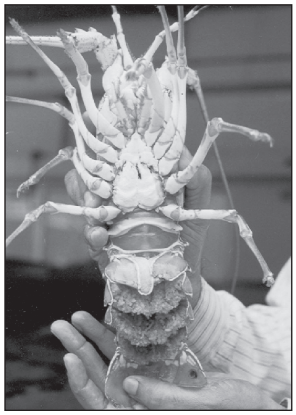


P. homarus homarus



Thenus sp.

Berried lobster



Fattened lobsters

Lobster grow out system

Farming potential of spiny lobsters

Limited availability, high consumer demand and high market value has driven interest in both experimental and commercial farming of spiny lobsters worldwide. There has been considerable interest in developing culture technologies for the 47 species (Lipicus and Eggleston, 2000) in this family. Previous studies have shown that tropical species are more promising for commercial production due to fast growth rate and good consumer demand. In India three species are most suitable for farming: *P. homarus homarus* of southwest and southeast coast, *P. polyphagus* of north west coast and *P. ornatus* of southeast coast.

Hatchery based farming of spiny lobsters is technically possible but not economically feasible due to difficulties in producing large numbers of puerulii through larval rearing techniques. Though some species have been successfully reared through their larval life (Kittaka, 2000), due to prolonged larval phase and difficulties in rearing large numbers, successful commercial application seems to be far away. The recent advances in larval rearing and the management strategies required for procurement and transportation of incidental catches of juveniles lobsters, which could form a good seed base for lobster farming is discussed.

Hatchery technology

The greatest hurdle in commercial culture of spiny lobster is lack of a proven hatchery technology for commercial seed production. Prolonged larval phase (> 300 days for cold water and semi-tropical species) and consequently, problems in food and water management are the major constraints for successful development of hatchery technology for many tropical species. Inspite of recent advances in larval culture, commercial seed production technology is a distant reality.

First success in larval culture of spiny lobster was achieved by Prof. Jiro Kittaka of Japan in 1986-87 and the Japanese successfully completed the larval phase of *Jasus lalandii*. Larvae were cultured in a medium of the microalgae *Nannochloropsis* sp. and fed on mussel (*Mytilus edulis*). Later four more species were reared to settlement. Countries like Australia, New Zealand and South Africa also succeeded in rearing the phyllosoma larvae to the postlarva (puerulus). However, all the species took more than 300 days to complete the larval phase and therefore the economical viability of hatchery for lobsters in doubtful.

Broodstock and breeding

Egg bearing females from the wild or from captive broodstock are the two sources from which healthy larvae can be obtained for larval rearing. Egg bearing lobsters with eggs in different stages of development are available throughout the year. Peak breeding of *P. homarus homarus* in India is from December-March along the southwest and east coast of India and for *P. polyphagus* the period is from September-October. Handling, transportation and maintenance in captivity until hatching have to be done carefully to avoid any stress to the egg bearing female. Exposure of egg bearing lobsters outside water shall be minimized as these eggs are prematurely shed by the mother.

P. homarus homarus has been reared to maturity in captivity (fig.5) and the females are capable of breeding repetitively through out the year (Radhakrishnan, 1977; Vijayakumaran et al. 2005). Healthy larvae can be obtained from repetitive spawning.

Culture of spiny lobster larvae by Japanese

Species	No. of days	No. of instars	Survival
Palinurus elephas	132 (62)	9	< 1%
Jasus verreauxi	189-359	17	10%
J. edwardsii	303-319	17	< 1%
J. lalandii	306	15	< 1%
Panulirus japonicus	340-391	25	< 1%

Egg bearing lobsters procured from holding tank owners are unsuitable as poor water conditions lead to microbial infection and premature egg shedding. Egg bearing lobster is to be procured directly from gillnet fishermen and transported to the hatchery without stress. The lobster is to be transferred carefully to the hatchery tank containing microfiltered and sterilised seawater (1000-1500 l). Newly deposited eggs are orange in colour. The eggs change in colour during embryonic development and become dark brown just before hatching. Incubation period is normally 20-30 days for newly deposited eggs depending on water temperature. The egg mass may attract filamentous bacteria, fungus and protozoans and therefore breeders from both wild and from brodstock holding tanks are to be transferred to the hatching tank after exposing to 50 ppm fprmalin for 30 minutes.

Larval culture protocol (Japanese culture system)

Prof. Kittaka and his team reared five species of spiny lobsters (Kittaka, 1994). 'U' shaped polycarbonate or glass tanks were used by the Japanese investigators. The tank designed by Massachusetts Institute of Technology and used for rearing American lobster larvae was modified and used. Series of tanks are connected to a reservoir containing microalga. The upwelling movement of water keep the larvae and food in suspension. Excess water entering into the tank is drained out through a central pipe. The mesh around the drainage prevents escape of larvae and feed. A disadvantage is gradual fouling of mesh which blocks the waste removal. Microalgae has to be renewed periodically. Damage to larvae due to entangling on the mesh screen has to be prevented by adjusting the flow rate. The central pipes are periodically removed and cleaned and replaced. Later clear water systems with recirculation were used.

Food and feeding

Phyllosoma larvae are carnivorous. Food is captured by the third pereiopod initially; soft food (*Artemia, Sagitta, Ctenophore medusae* etc) alone can be fed. Most suitable food for early stage larvae is freshly hatched *Artemia* nauplii. For later stages, preference is for larger food items. Mussel gonad, *Sagitta sp.,* cultured *Artemia* juveniles, *Ctenophore medusae* and newly hatched fish larvae are the potential food items were used for different stages. Suggested food for larval rearing of *Jasus* sp. are: upto fifth stage, *Sagitta,* fish larvae for middle stages and cultured fish fry of 4.5-7.5 mm for final stages. However, complete larval culture was successfully carried out on feeding with mussel. *Artemia* enriched with PUFA or microalgae, showed high food value. Marine bivalves contain essential amino acids and fattyacids and have high food value. Mussel gonads should be kept in suspension to facilitate feeding by the larva.

Culture of microalgae

Nannochloropsis sp. is the most suitable species for maintaining water quality in larval culture systems. Culture with 60-70 million cells/ml is added at about 5-10% of the total tank water. Other algae like *Tetraselmis* sp. and *Nitzschia* sp. were not very successful.

Water quality

In clear water, larvae were infected with stalked protozoans (*Vorticella, Zoothamnium)*. Treatment with formalin (30 ppm, 24 hr) and streptomycin at 10 ppm is effective but not recommended as repeat treatments are injurious. Water temperature is maintained at 20-25°C for different species; salinity varied between 33.5 to 35.5 ppt and pH ranges from 8.0-8.6. The median lethal limit (LD_{50}) of ammonia-N for a 72 h period was 8 mg/l for 13-15th instars of *P. japonicus*. COD is an index of dissolved organic matter. The upper limit of COD was set at1.2 mg/l. The median lethal limit of heavy metals, copper and zinc was determined at 0.3 mg/l and 6 mg/l, respectively for *P. japonicus*. In green water microflora was significantly lower. *Pseudomonas* prominent in green water. *Vibrio* and *Aeromonas* more in clear water. Japanese prefer 'instars' to arbitrary 'stage' to sequence development of larvae. For rearing *Jasus* sp. mussel is the most successful food for complete development.

Larval culture attempts in India

Phyllosoma larvae of *P. homarus*, *P. polyphagus*, *P. ornatus* and *P. versicolor* were reared through early stages by different laboratories. CMFRI succeeded in rearing the larvae of *P. homarus* to six stages in 60 days (Radhakrishnan

and Vijayakumaran, 1994) and then to stage 7 in 60 days. Larvae were reared to stage 8 in 42 days on a diet of *Artemia* and fresh *Sagitta* sp. Stage 8 was also achieved by exclusively feeding with different sizes of *Artemia* and by adopting enrichment techniques.

Larval culture success by other countries

New Zealand and Australia also succeeded in completing the larval phase of J. verreauxi and P.cygnus, respectively. Completion took 212-300 days.

Farming technologies

Spiny lobster grown in captivity could fetch high price through production of suitable size animals. Live spiny lobsters are sought especially in Japan and Southeast Asian countries. Japanese prefer live lobsters of 200-300 g with deep red external colour. No countries except India could supply as the legal size of most species is above this size. The puerulus after moulting to juvenile takes many months to reach marketable size. Australia, New Zealand, Taiwan and Vietnam harvest puerulii for commercial on growing. Technologies to harvest puerulii have been developed. Unlike the American lobster, *Homarus americanus,* cannibalism is much less in spiny lobsters and they can be cultured communally. There are currently no land-based lobster grow out facilities in India. Smallscale experimental grow out of lobsters has been attempted with some level of success in various marine culture systems including flow through, semi circulation and full circulation (Ting, 1973; Witham, 1973; Lellis, 1991; Sjoken, 1999; Sharp et al.2000; Radhakrishnan and Vijayakumaran, 2000; Radhakrishnan, 2004).

On-growing of puerulii and post-puerulii

Newly settled puerulus is a non-feeding stage and they start feeding after the first moult. A biomass production of 4.7 kg/m^2 was attained in *P. ornatus* juveniles stocked at 43/m^2 and fed on natural and artificial feed and estimated that production of 1 kg can be achieved in 18 months. Early studies in Australia (Chittleborough, 1974) reported 2 years for puerulii to reach a marketable size of 60 mm CL at 25° C. *P. homarus* juveniles was reported to take 12-15 months to reach marketable size of 250 g in laboratory (Tholasilingam and Rangarajan, 1986). *P. polyphagus* puerulii took 2.5 years to reach 200 g (Radhakrishnan and Devarajan, 1986). *P. ornatus* has been grown to 300 g in 10 months in Hawaii. In Taiwan, wild caught animals stocked at 25 g mean weight reached 330 g in 16 months in 200 m^2 ponds.

Fattening of low value and undersize lobsters for product enhancement

Ongrowing wild caught seed lobsters are widely practiced in Vietnam, the Philippines and Indonesia. Farming is typically on a subsistence scale (limited by the availability of seed) although the magnitude of production in Vietnam is collectively very large (1000 tonnes annualaly). In Australia and New Zealand, lobser seed cannot be taken for aquaculture except under strict and limited pilot license conditions. However, there is some in sea and on land holding of legal size lobsters for weight gain and/or more favourable (niche) marketing. In India there being no restriction on fishing, large quantities of juveniles and undersize lobsters are caught and marketed. Though there is good potential for fattening to legal size, there is very little attempt. While some entrepreneurs have shown interest, availability of healthy, quality seed is a major constraint. Ongrowing involves holding undersized lobsters, which fetch low price or not accepted legally for export, for short period until they attain legal size These lobsters could be held in tanks, ponds or cages fed with natural or artificial feed. Growth could be further enhanced remarkably through eyestalk ablation and by proper feed and water management. Since live lobsters fetch high market value, these can be marketed to targeted markets in Southeast Asian countries.

Seed availability

For the present, capture-based culture of spiny lobsters is only possible. Collection of wild-caught peurulii and collection techniques have been developed and standardized and it could become an economically viable approach by refining the techniques further. Studies in Australia and USA show that nearly 95% mortality of puerulii occur between settlement and entry into the commercial fishery and this is believed to have minimal effect on recruitment

rates of juvenile lobsters, except if collected in extremely large numbers from a particular area (Butler and Herrnkind, 1989; Phillips et al., 2003). An efficient puerulus collector , *sandwich collector*, was developed by Fisheries Western Australia and tested its efficiency. Catches of individual collectors set in areas along the Western Australian coast where settlement of *Panulirus cygnus* is high, was an average 100 animals per collector per month. Jeffs and Davis (2003) estimated that, commercial scale collection by Witham collectors is possible at an estimated cost of $0.05 to 0.30 per seed lobster. This estimated cost is dependent upon the number of puerulii available at a given time and region and thus may vary greatly. Studies along the Chennai coast show only low settlement of puerulii. Collection by collectors developed locally was not economical and therefore not recommended. New type of collectors need to be developed and standardized and sites of collection identified. However, commercial fishing using gill nets and trammel nets bring large number of juvenile lobsters as incidental catch, which fetches low price and this resource can be the source for lobster farming if collection , holding and transportation protocols are properly developed and executed.

Collection and transportation

In India, in spite of Minimum Legal Size for export is notified by Government of India, undersize lobsters were brought and sold by fishermen and are exported by various means. There is no restriction on fishing of undersize lobsters unlike other lobster fishing nations, and therefore, fishermen bring these animals to the shore. These undersize lobsters are held in small holding tanks in high densities by middlemen until purchased by the exporters. Due to poor water quality in the holding tanks and stock management these lobsters become weak and become highly vulnerable to the bacterial disease. The seed lobsters in general are unsuitable for farming as they develop *gaffkemia*, the highly contagious bacterial disease, and die within 2-3 days. The lobster traders give little care to the undersize lobsters as they fetch low price and become highly stressed during holding and transportation. A proper collection, holding and transportation protocol needs to be developed to use these valuable seed sources for fattening programme.

Lobster fattening in indoor grow-out systems

On-growing of juveniles in indoor tanks was developed by CMFRI and Tuticorin Fisheries College. Seed lobsters can be procured from fishermen or from lobster suppliers as explained above. Juveniles are more susceptible to adverse environmental conditions. High levels of haemolymph ammonia and lactic acid have been observed in holding lobsters. Lobsters under stress are likely to be infected by opportunistic pathogens. In *P. homarus* stressed lobsters have reddish exoskeleton compared to greenish colour in healthy lobsters. Weak lobsters are further stressed during faulty transportation for long duration. If the juveniles are healthy, dry packing and transportation is safe. Safe transportation time (maximum) is 10 hours. During wet transportation high levels of ammonia in the tank water, low DO levels and high temperature can lead to mortality. The stocking density and environmental parameters in tank water recommended during transportation are:

Stocking	-	0.1 kg/l
Temperature	-	20-22°C (use synthetic ice bags)
DO (mg/l)	-	4.0 and above
Ammonia	-	< 1 mg/l

The seed lobsters are to be kept under quarantine for 48 hours. Healthy lobsters (active movement) may be treated with 50 ppm formalin for 1 hour before transferring to grow-out tanks. For on-growing in indoor systems, circular cement tanks are preferred; however, for economy, serially constructed square tanks of about 9m^2 each are ideal (Radhakrishnan, 1994). Either flow-through, stagnant or recirculation system can be used depending upon the availability of seawater Sand filtered or seawater pumped from a bore with a salinity of 30-38 ppt, pH 7.8-8.4 and hardness between 100-200 ppm can be used. Central drainage pit connected to the external drainage canal with a pipe and a stand-pipe outside will remove all wastes during flow through. A flow through system with self cleaning facility was developed at Calicut Research Centre of CMFRI (fig.6). In recirculation system, external biological filters

are preferred. pH in recirculation systems is to be regularly monitored. Juvenile lobsters of < 100 g may be stocked at @ 1.0 kg/m^2. Shelters may be provided. Ambient light inside the culture facility may be maintained at < 500 lux.

Tolerance limits for various water quality parameters for the culturable species of lobsters

Parameter	Tolerance limits
Temperature	12 to 31º C
DO (% saturation)	Minimum 70% Preferably above 80%
Salinity (ppt)	30-38
Ammonia (mg L^{-1})	< 2
Nitrite (mg L^{-1})	< 5
Nitrate (mg L^{-1})	100
PH	7.8 to 8.4
Hardness (ppm)	100-200

Food and feeding

Although accept a wide range of animal food, lobsters prefer shellfish. Mussels and soft clams (information on optimum size that can be cracked is available) can be fed as whole. Trash fish may be chopped into a suitable size. Lobsters being nocturnal, food may be supplied at dusk. Mean gross conversion ratios of 5.0 for mussel, 5.8 for clams, 6.6 for fish and 4.8 for a mixed diet was obtained from experimental studies. Better conversion (3.5-4.0 for mussel) was obtained during pilot scale farming at Calicut.

Growth in captivity

P. homarus weighing 80 g attained 330 g in 12 months on an exclusive diet of mussel (fig.7). Minimum exportable weight of 200 g was achieved in 130 days. Growth enhancement can be achieved by eyestalk ablation. Ablated *P. homarus* gained a weight increase of 3 to 7 seven times more than the normal. If initial weight is considered as 80 g ablated animals of *P. homarus* can achieve an estimated 749 g in one year (Radhakrishnan and Vijayakumaran, 2000). In *P. ornatus* 100 g lobster attained 1.5 kg in 8 months.

Lobster culture in intertidal pits in Gujarat

Juvenile *P. polyphagus* (30-50 g) stocked in intertidal pits (21 m x7 m x 1 m) at 20 nos/m^2 attained 100-125 g in 90 days. Lobsters purchased at a procurement price of Rs. 20/kg were sold at a selling price of Rs. 280/kg.

Lobster culture in cages

In Philippines, *P. ornatus*, *P. versicolor* and *P. longipes* are cultured in floating cages. Initial size preferred for stocking was 100-300 g and in 6-15 months harvest weight of 800-1300 g was achieved with 90% survival. Trash fish is the main feed, which was procured at US $ 0.13-0.22/kg. Live lobsters were sold at US $ 21-31/kg. In Vietnam, *P. ornatus* is the most preferred species. Floating cages made of nylon material were fixed at a depth of 10-20 m. The size of wooden fixed cage was 20-40 sq.m. Submerged cages were also used. Seed lobsters of 25-30 mm TL were initially stocked at 100 to 200 per submerged cage and grown to 50 g. Those lobsters were then stocked in fixed cages until a harvest weight of 800-1000 g is achieved. Lobsters were fed with chopped trash fish (lizard fish or other fishes) or shell fish. Conversion ratio was high at around 17-30 (fresh weight basis). Finfish comprise about 70% of the diet and rest by shellfish. Disease problems were erupted due to increase in number of cages, feeding with trash fish and consequently increase in total nitrogen content in water. Treatment with 100 ppm formalin for 3-5 minutes was practised. Average annual production was 1500 t. Farm-gate price of live lobster was US $ 26.75/kg. The average profit margin was estimated as 50%. Cage culture experiments were conducted by NIOT, Chennai at Tuticorin. Stocking density in the fixed cages was at 15-20 nos/m^2. Lobsters were fed with mussels and clams.

Disease

Though no major diseases were encountered, stocking highly stressed seeds can invite disease. 'Gaffkemia' - like disease was reported during fattening in indoor system. Juveniles lobsters kept in poor water quality are infected This disease is highly infectious and infected lobsters exhibit lethargy and poor intake of feed during later stages. *P. homarus homarus* lobsters loose their green colour and the shell becomes reddish. Maintaining the lobsters at lower temperature (24^{o}C) was found to reduce the severity of the infection. Isolation of infected stocks is necessary to stop spread of the disease. Tail fan necrosis and shell disease are also found in captive indoor stock. Good hygiene of the bottom of the tank and maintenance of water quality and sanitation in the culture facility are very crucial.

Future prospects

There is considerable export potential for live lobsters in southeast Asian countries. Development of a successful export market could require both continuity of supply and a reasonable volume. Attempts in Philippines in 1990s to establish large-scale farming were a failure. Greatest concern is whether aquaculture will be sustainable if recruiting seed was taken in large quantities. Australians are of the view that harvesting puerulii will not have any negative impact as more than 90% mortality was observed between settlement and first moulting. This may not be applicable to all the regions. In India, lobster fishery is restricted to northwest, southwest and southeast regions. Annual landing is drastically declining. The destructive fishing practices and non-enforcement of regulations are mainly reasons for collapse of fishery. Along the Indian coast puerulii settlement is not that heavy as in Australian waters. On the southern part of the coast nearly 50% of the catch in gill nets and trammel nets are undersize lobsters. These lobsters do not fetch good price. However, these are exported. An estimated 25 tonnes of undersize lobsters are landed along the southern part of the coast and if properly handled and managed this seed stock can be fattened to legal size, which can be exported and earn valuable foreign exchange. Lobster aquaculture cannot be promoted as a major aquaculture programme for the country. Small-scale fattening of the undersized lobsters to legal size may be practical. Culture using natural food may not be sustainable. Experiments show lobsters can be fed with dry pellets. Research on formulating a practical diet for lobsters is necessary. Low intensity aquaculture for value enhancement and export strictly adhering to legal procedures is profitable in some specific locations.

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