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AN ASSESSMENT OF THE POTENTIAL OF SPINY LOBSTER CULTURE IN INDIA

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ABSTRACT

Fluctuating catches and increasing demand in both internal and international markets for lobster tails necessitate augmentation of production through proper management strategies and possible aquaculture practices. The technical feasibility of economically viable aquaculture of few species of spiny lobsters is underway at the Field Laboratory of Central Marine Fisheries Research Institute, Kovalam, Madras. Though captive breeding of various species of spiny lobsters was achieved with ease, rearing of phyllosoma larvae to puerulii under controlled conditions was not successful. So serious attempt to cultivate spiny lobsters should begin with rearing juveniles which are caught in large numbers along with the commercial size lobsters. It has been shown that commercial size (300 g) lobsters can grow in less than half the time that is required in nature, by proper feeding schedules and environment management. A further reduction in this growing period has been achieved through bilateral eyestalk ablation. Enhancement of growth in ablated lobsters up to 20 times of normal rate has been achieved. An objective assessment of the present status of spiny lobster culture and the problems which need further attention for developing commercially feasible lobster culture are discussed.

INTRODUCTION

Lobster culture is getting increasing attention in recent times due to the heavy demand for live lobsters and lobster tails in the internal and export market. Spiny lobster catches were fluctuating widely and the quantity landed are insufficient to meet the requirements. Growing lobsters in captivity is one of the strategies to cope with the increasing demand.

At present there are no commercially viable lobster farming practices anywhere in the world. However, extensive information on the growth pattern of various species of spiny lobsters under captive conditions are available (Table 1). There are several essential requirements for the commercial farming of aquatic organisms, which include adequate consumer demand and profit potential for the species, the ability to reproduce in captivity, simple larval davelopment, high food conversion efficiency and resistant to diseases (Cobb, 1976). Spiny lobsters have some of the essential characteristics which make them prospective candidates for commercial cultivation. However, among the 163 odd species (Philipps *et al*, 1980) belonging to the four families of lobsters, Nephropidae (Clawed lobsters), Palinuridae (Spiny lobsters), Synaxidae (Coral lobsters) and Scyllaridae (Slipper lobsters), only two closely related species of family Nephropidae, *Homarus americanus* and *H. gammarus* are considered to be serious candidates for aquaculture. This is mainly due to the advantage of their simple and short larval history, hardiness and ability to grow them on a variety of natural and artificial diets. These advantages are severely handicapped by their cannibalistic tendency and elevated temperature requirements for faster growth in their temperature habitat. On the other hand, the critical problem facing spiny lobster culture is the inability to grow them from egg to puerulus stage in captivity, as a result of their complex and protracted larval development requiring a variety of feeds. In view of these facts any realistic approach towards spiny lobster culture should involve rearing juveniles caught from wild to commercial sizes. This paper has made an objective assessment of the status of spiny lobster culture, based on the existing information on growth and survival of various species under culture conditions.

BREEDING AND LARVAL REARING

Berried spiny lobsters caught from the wild release viable phyllosoma larvae under captivity. Chittleborough (1974) reported for the first time rearing of puerulii of *Panulirus longipes cygnus* in laboratory conditions to sexual maturity. Later Radhakrishnan (1977) successfully reared a group of juvenile *P. homarus* to sexual maturity and bred them in laboratory. However, rearing phyllosoma larvae through their entire life cycle was not very successful. Inoue (1978) reared the phyllosoma larvae of *P. japonicus* from egg to the final stage in 253 days. Partial success was obtanied by many research workers in rearing the larvae of some of the spiny lobsters (Table 1). The critical problem encountered in most cases were difficulty in handling the delicate larvae and in finding suitable diets in order to satisfy the requirements of the phyllosoma larvae. Most of the researchers have depended intially on *Artemia* nauplii (Inoue, 1978; Saisho, 1966; Dexter, 1972; Radhakrishnan and Vijayakumaran, 1986 and Vijayakumaran and Radhakrishnan, 1986). Some of them have fed the larvae with *Mytilus* gonads, fish larvae, adult *Sagitta* sp. and *Artemia* (Mitchell, 1971; Dexter, 1972 and Inoue, 1978). These unsuccessful attempts have caused lobster culture to depend upon the naturally available post larvae and juveniles for stocking the culture systems.

POSTLARVAE AND JUVENILES

The final (XI) stage phyllosoma larvae moults into a temporary pelagic puerulus larvae which swim towards the coastal area and assumes a benthic existance. Several investigators developed devices to trap the postlarvae settling in the coastal areas (Witham *et al*, 1968; Serfiying and Ford, 1975; Philipps, 1972 and Sweat, 1968). A semi-quatitative collector developed by Philipps was most successful in collecting large numbers of puerulii *P. longipes cygnus*. The lunar periodicity in settlement of the larvae, various ecological conditions, and the related behaviour of the puerulii and the seasonal abundance was extensively studied (Philipps, 1972). The species composition and seasonal abundance of puerulii of *P. homarus, P. polyphagus* and *P. ornatus* off Madras coast was studied by the present authors. It is not feasible to

Table 1. *Summary of data on culture of lobsters*

Species	Biological information	Reference
Panulirus japonicus	Larval rearing	Nonaka *et al*, 1958
		Inoue and Nonaka, 1953
		Inoue, 1978
	Field culture	Idyll, 1971
Panulirus argus	Laboratory growth	Lewis *et al*, 1952
		Travis, 1954
		Sweat, 1968
		Witham *et al*, 1968
	Larval rearing	Robertson, 1968
Panulirus longipes cygnus	Laboratory growth	Chittleborough, 1968,
		1974a and b, 1975, 1976
		Phillips *et al*, 1977
Panulirus interruptus	Larval rearing	Mitchell, 1971;
		Blecha, 1972; Dexter, 1972;
		Serfling and Ford, 1975
Panulirus inflatus	Larval rearing	Johnson and Knight, 1966
Panulirus polyphagus	Larval rearing	Ong, 1967
	Laboratory growth	Kathirvel, 1973;
		Silas *et al*, 1984;
		Radhakrishnan and
		Devarajan, 1986
	Oxygen consumption	Kasim, 1986
Panulirus homarus	Larval rearing	Radhakrishnan and
		Vijayakumaran, 1986;
		Vijayakumaran and
		Radhakrishnan, 1986
	Breeding in captivity	Radhakrishnan, 1977
Panulirus homarus	Laboratory growth	Nair *et al*, 1981
	Eyestalk ablation and	Silas, 1982; Silas *et al*, 1984
	growth	Radhakrishnan and
		Vijayakumaran, 1982, 1984a and b
		Vijayakumaran and
		Radhakrishnan, 1984
	Field culture	Srikrishnadhas *et al*, 1983
Panulirus ornatus	Laboratory growth	Mitchel, 1979 in Tamn, 1980
	Eyestalk ablation and	Nair *et al*, 1981
	growth	Silas *et al*, 1984
		Radhakrishnan and
		Vijayakumaran, 1987
Jasus lalandii	Larval rearing	Sheared in Robertson, 1968
	Laboratory growth	Fielder, 1964
Jasus edwardsii	Larval rearing	Bantham, 1967
		Silberbaur, 1971
Jasus verreauxi	Larval rearing	Mc Koy, 1970
Panulirus versicolor	Laboratory growth	Kuthalingam *et al*, 1980
		Silas *et al*, 1984

collect large numbers of puerulii for stocking lobster culture systems as it is highly capital intensive and labour oriented. Serfling and Ford (1975) has also opined that it would not be practical to attempt large collections of puerulii for the purposes of aquaculture. Besides, mortality of puerulus larvae is high in the first two months in captivity and little is known about their physiological requirements.

It is illegal to catch rock lobsters of less than 76 mm carapace length in Western Australia (Chittleborough, 1974). But there is no minimum legal size limit for fishing spiny lobsters in India. At Kovalam, Madras, Juvenile lobsters (20-45 mm carapace length) are caught along with commercial size lobsters and this forms almost 30% of the lobsters caught in this area. An imaginative approach will be to utilize these juveniles for stocking the culture system. But these should be done with utmost caution as indiscriminate fishing of juveniles may adversely affect the lobster fishery. Chittleborough (1974) suggested strictly selective cropping of early juveniles from overcrowded shallow reefs for culture purposes. Information on season and pattern of recruitment of juveniles should be collected and the juvenile population density in major fishing centres have to be assessed before making attempts to catch juveniles.

There is only scanty data on the availability of juveniles of *P. polyphagus* and *P. ornatus* from India. However, there is fairly good information on the availability of juveniles of *P. homarus* from some of the fishing centres. At Kovalam, Madras, trammel net is used for fishing lobsters. This net is a bottom-setgill net with three layers; two outer layers having a mesh size of 24 cm and the inner layer a mesh size of 4.5 cm. A single net catches an average of 6 lobsters in a day in the peak recruitment months of February and March. The juveniles weighing on an average 80 g cost Rs. 1.50/- per lobster and can be collected for stocking the culture system. Large numbers of juveniles of *P. homarus* can be caught from major fishing areas in this way.

ENVIRONMENTAL FACTORS FOR GROWTH AND SURVIVAL

Proper environmental conditions are required for optimum growth and survival of spiny lobsters under culture conditions.

Temperature

Palinurid lobsters live in water temperatures of approximately 15-29°C. Subtropical lobsters such as *P. longipes cygnus* exposed to a wide range of temperature conditions show marked seasonal variations in growth (Chittleborough, 1974). Lobsters inhabiting tropical waters, however, are subjected to only limited temperature fluctuations of 23-29° C, and temperature dependent growth variations are negligible. This is an advantage over their subtropical counterparts which for sustained annual growth should be grown in elevated temperatures which will considerably increase the cost of aquaculture.

Salinity

Most of the palinurids tolerate wide range of salinities (25-45‰). We have observed that *P. homarus* can endure in salinities from 15-55‰. *P. polyphagus* can tolerate even wider range of salinities (5-55‰) according to Kasim (1986). However, 30-35‰ salinity is ideal for optimum growth of lobsters. Continuous exposure to extreme salinities may adversely affect growth.

Oxygen

Most of the spiny lobsters are oxygen conformers and few are partial regulators. *P. homarus* and *P. polyphagus* are oxygen conformers and can adjust to low oxygen conditions (Radhakrishnan and Vijayakumaran, MS; Kasim, 1986). In closed intensive culture conditions, aeration by compressed air is required to maintain dissolved oxygen close to saturation. The moulting and survival of *P. cygnus* was severely affected when dissolved oxygen fell to 60-67 per cent saturation and mortality of moulting lobsters was reported in 47-55 per cent oxygen saturation levels (Chittleborough, 1974).

Ammonia

In intensive aquaculture systems, the compound that is most critical is ammonia. Knowledge of ammonia excretion rates and safe ammonia tolerance limits of spiny lobsters is restricted and this may not be a problem in culture systems where there is sufficient exchange of water. Seaweeds like *Gracilaria* sp. are useful in controlling ammonia levels in lobster culture systems (Geeta Bharathan and Radhakrishnan, 1987).

Photoperiod

Spiny lobsters are generally nocturnal feeders and always occupy shaded areas of the culture tanks during day time. Normal day length is found conducive for optimum growth of spiny lobsters.

Shelter

Spiny lobsters are gregarious in habit and hide in crevices in their natural habitat. In laboratory conditions they prefer to hide in communal shelters than in individual dens. Chittleborough (1974) found similiar behaviour in *P. longipes cygnus*. He reported high food intake and growth in lobsters provided with sufficient shelter. Tubular shelters have to be avoided as lobsters tend to crowd inside the tubes resulting in reduced growth and survival.

Handling stress

Periodic handling of lobsters, especially newly moulted ones should be avoided, as this may result in internal injuries to the animal. Handling animals within two weeks prior to a moult results in depressed growth at that moult (Chettleborough, 1974). In *P. homarus*, we found increased moulting frequency when more than three walking legs are autotomised. However, there was considerable reduction in weight increase in that moult.

Food

Spiny lobsters are selective feeders with strong preference for molluscs. In nature, they feed on mussels, barnacles, small crabs and polychaete worms. If suitable size mussels are provided, *P. homarus* can break open the shells and feed on the meat. All the three species of lobsters, namely, *P. homarus*, *P. polyphagus* and *P. ornatus* reared at Field Laboratory, Kovalam feed on backwater clams, *Meretrix casta*, though this is not their natural food. Lobsters also accept a wide variety of trash fishes. The feeding rate on mussels and clams were almost similar (a mean of 5% body weight per day). However, mussel fed lobsters had slightly better growth rate than clam fed ones. Mean gross conversion ratio is 5.0 in mussel fed lobsters, 5.8 in clam fed and 6.6 in fish fed animals (both wet weights). Under field conditions, lobsters reared in cages and fed with trash fish showed growth rates comparable to those fed with mussels in laboratory conditions (Srikrishnadhas *et al*, 1983). These lobsters also would have fed on fouling organisms (barnacles and molluscs) attached to the cages, resulting in higher growth rate.

Daily feeding is necessary for optimum growth of lobsters. Chittleborough (1974) found reduced moulting frequency in lobsters fed thrice a week. Food shortage may lead to cannibalism of newly moulted animals. Lobsters prefer fresh to stale, frozen or boiled food. Feeding always commences after dusk and it is advisable to feed lobsters during this time.

Stocking density

Stocking density of lobsters have to be decided on the basis of the floor area of the culture pond, as lobsters occupy only the bottom of the tank. A stocking density of 7 lobsters/m^2 has given fairly good growth rate of *P. homarus* under laboratory conditions. In marine cages, *P. homarus* stocked at a stocking density of 10 lobsters/m^2 gave comparable growth rates.

Growth rate under culture conditions

Growth in crustaceans is a step-wise process, length and weight increasing abruptly at each moult. Various species of lobsters

Table 2. *Estimated growth of lobsters grown in culture conditions (calculated from actual growth data)*

Species	Growth period (days)	
	Puerulii-Juvenile (0.25 g)-(80g)	Juvenile-Commercial size (80g) -(380g)
[1] *Panulirus homarus*	380	365
[2] *Panulirus polyphagus*	480	*365
[1] *Panulirus ornatus*	250	365
[3] *Panulirus longipes cygnus*	455	425

* 80g - 280g

[1] Present study

[2] Radhakrishnan and Devarajan (1986) & Present study

[3] Chittleborough (1974, 1976)

have been reared from different sizes and generally it is opined that growth of lobsters is slow under natural conditions. An estimated growth period of 4 to 5 years was suggested for *P. argus* to grow from puerulii to legally harvestable size of 76.3 mm carapace length (Tamn, 1980). *P. cygnus* was reared from 35 mm carapace length (42g) to 76 mm carapace length (CL), that is 387 g in 68 weeks at an optimum temperature of 25°C (Chittleborough, 1974). Chittleborough (1974) and Philipps (1977) got almost similar growth rates (2.8 years) for *P. cygnus* rearing them from puerulii to 70 mm CL (300 g). Other palinurids which were successfully grown in experimental culture systems were *P. polyphagus* (Radhakrishnan and Devarajan, 1986), *P. homarus*, *P. ornatus* and *P. penicillatus* (Nair *et al*, 1981), and *P. ornatus* (Michel, 1979). *P. polyphagus* took 2.3 years to grow from puerulii to 300 g. The estimated growth calculated from actual growth data of four species of lobsters are given in Table 2. From the data it is evident that except *P. ornatus*, the other species of lobsters took nearly 400 or even more days to grow from puerulii (0.25 g) to juveniles size (80 g). Whereas weight gain of another 300g was achieved in another 400 days (Fig. 1). So, it is advantageous to grow lobsters from juvenile stage (80 g) to the commercial size (300 g) than growing them from puerulii to marketable size.

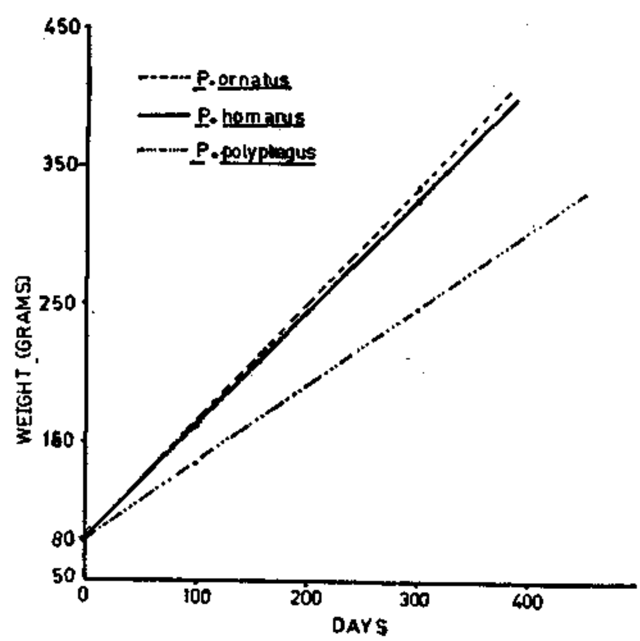

Fig. 1. Fitted regression line showing growth of *Panulirus homarus*, *P. polyphagus* and *P. ornatus* lobsters reared in the laboratory

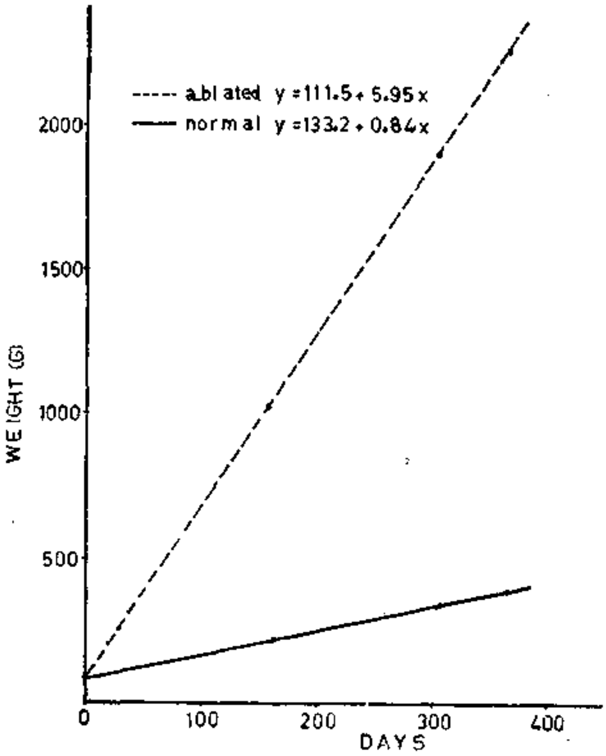

Fig. 2. Fitted regression lines showing growth of normal and bilaterally eyestalk ablated *Panulirus ornatus* in laboratory.

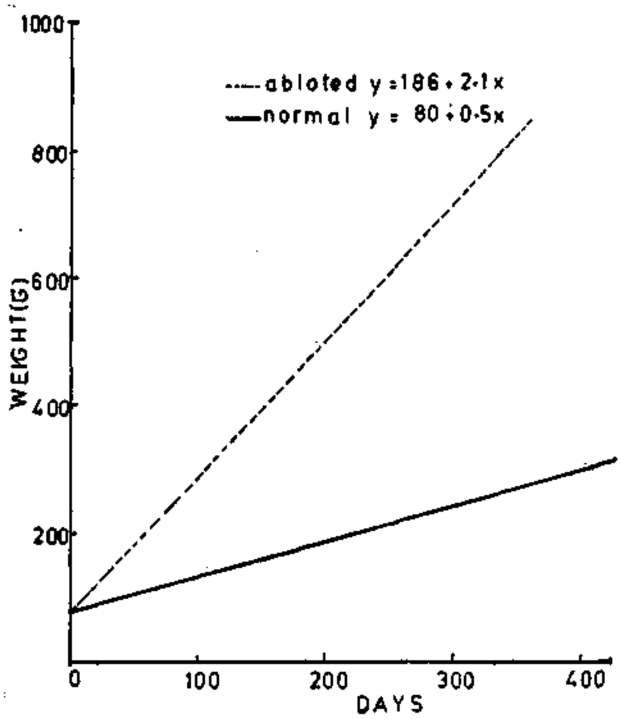

Fig. 4. Fitted regression lines showing growth of normal and bilaterally eyestalk ablated *Panulirus polyphagus* in laboratory.

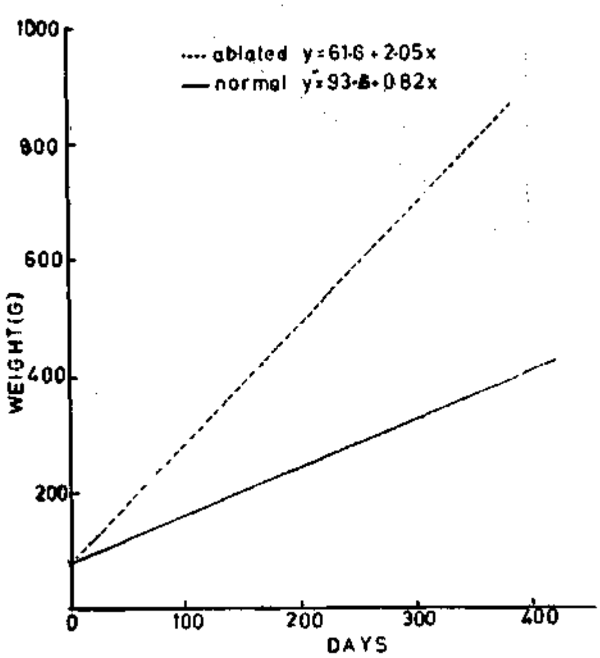

Fig. 3. Fitted regression lines showing growth of normal and bilaterally eyestalk ablated *Panulirus homarus* in laboratory.

Eyestalk ablation

For making lobster culture more feasible, it is necessary to reduce the growing period considerably. Bilateral eyestalk ablation is one way to achieve this. Our experiments show that all the three species, *P. homarus, P. ornatus* and *P. polyphagus* responded very well to eyestalk ablation. Among the three species *P. ornatus* looks most promising. The estimated growth of ablated *P. ornatus* is 2173 g/year, *P. homarus*, 749 g/ year and *P. polyphagus*, 779 g/ year if the initial weight is taken as 80 g (Fig. 2, 3 and 4). When compared to the normal lobsters, the increase is seven times in the case of *P. ornatus*, 3.8 times in *P. polyphagus* and 2.5 times in *P. homarus*.

SITE SELECTION AND CULTURE METHODS

Most of the studies on growth of spiny lobsters were indoor culture tanks involving a few hundred lobsters. However, there is one report of cage culture of *P homarus* from India (Srikrishnadhas *et al*, 1983). According to Idyll (1971), extensive culture of *P. japonicus* is being practised along the Southern coast of Kyushu. Intensive culture of lobsters in cement cisterns also may be practicable, but needs higher energy inputs. The high stocking density in such systems and the consequent high production may offset this difference. But for a reliable assessment of the culture of lobsters, pilot or demonstration scale culture programmes are necessary.

For lobster culture, sites along the east and west coast of India where lobster fishing is presently carried out may be suitable. The availability of food near the culture site and good source of clean seawater are also essential prerequisites for considering an area suitable for culture. In many places, presently clams are exploited only for the shells and the clam meat could be used as a good source of food. Green mussels from the coastal beds, which are under exploited in many places is also another good source of food. Culture of green mussels on rafts and poles in backwaters or lagoons at low cost are now perfected and mussels which do not fetch good price in the market could be converted to the higher priced lobster. It might be more economical to move the lobster juveniles to the culture site rather than transport the food required to grow the lobster to commercial size (Chittleborough, 1974).

FUTURE PROSPECTS

It is not easy now to predict when cultured lobsters will arrive in the market. Though a great deal of information on the seed availability, growth pattern, environmental conditions,

Table 3. *Status of spiny lobster culture in India*

Characteristics	*P. homarus*	*P. polyphagus*	*P. ornatus*
BIOLOGY			
Species	XX	XX	XX
Suitability for culture	X	X	X
TECHNOLOGY			
Larval rearing	P	P	P
Juvenile availability	XX	X	X
Growth in captivity	XX	XX	XX
Growth enhancement by eyestalk ablation	XXX	XXX	XXX
Adaptability to culture conditions	XXX	XXX	XXX
DIET			
Natural diet	XX	XX	XX
Compounded diet	P	P	P
Conversion rate	X	X	X
DISEASES	X	P	P
MARKETING POTENTIAL			
Internal	XXX	XXX	XXX
External	XXX	XXX	XXX
SITE AVAILABILITY	XX	XX	XX
ECONOMIC VIABILITY	X	X	X

XXX-Excellant; XX-Good; X-Fair; P-Poor.

and other physiological requirements of lobsters are available, a number of uncertainties exist which preclude an objective assessment of viability of lobster culture. Those areas with deficient information or experience and others with adequate knowledge are listed in Table 3. The assessments are based mostly on our experience.

Atleast three spices of lobsters occurring in Indian waters, namely, *P. homarus, P. polyphagus* and *P. ornatus* which form a fairly good fishery in both east and west coast of India are promising candidates for culture. But as explained earlier, inability to produce seeds in captivity is one major constraint and solution for this problem does not seem to be imminent. The unsuccessful attempts have caused dependence upon the natural environment for postlarvae. Collection of large numbers of puerulli being difficult, the culturist has to depend upon juvenile lobsters caught along with commercial size lobsters.

A concerted effort to culture lobsters was not initiated until now, probably due to paucity of information on growth, food requirements and lack of technical information on culture systems. Though extensive experimental data on biology, physiology and ecology of lobsters are available, it is highly imperative to have information on the economics of the entire operation. The growth rates obtained in our experiments and in some subtropical lobsters indicate the potential of growing lobsters in captivity. The growth could be further enhanced by eyestalk ablation by which growth period could be further shortend by more than 50%. Though clams, mussels and trash fishes from commercial trawlers could be utilized for feeding lobsters, regular supply of food in large quantities may become a critical factor in lobster culture. Successful aquaculture definitely needs a cheap, growth efficient diet. Development of such a diet is very essential and such a feed should suit the feeding behaviour and digestive physiology of lobsters.

Though extensive culture systems of several hectares look attractive, it may not be practical as such large numbers of juveniles may not be available to stock such systems. Semi-intensive culture system involving a few thousand lobsters will be a reasonable proposition.

The shells of aquarium reared lobsters generally look paler than those caught from the wild. However, there is no significant difference in the biochemical quality of the meat of reared lobster and of wild ones. No major difference in quality of meat of normal and eyestalk ablated lobsters were also found. Cultured lobsters are not generally affected by any major diseases and survival rate is more than 90% in normal lobsters and 70% in eyestalk ablated lobsters.

Culturing lobsters may not be a viable alternative to natural stock management (Taiwn, 1980). High expectations not withstanding, small scale lobster culture has definitely good scope in India.

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