INTRODUCTION:

Penaeid Prawns in general, *Penaeus monodon* Fabricious and *Penaeus indicus* H.Milne - Edwards in particular form the major items of export of Indian Marine Products (69.88%). The total Scenario of Indian coastal aquaculture today is commonly featured as culture of Penaeid Prawns. India, once occupying the the number one position in the shrimp exporting countries in the world, has been pushed down in the recent years due to stagnation, rather decline in the production of penaeid prawns from marine capture fisheries resources. The only alternative to increase Indias shrimp production for regaining her prime position in the world export of shrimps is to utilize its vast brackish water resources (0.9 million ha) for increasing production of Penaeid shrimps especially tiger shrimp (*Penaeus monodon*) and white shrimp(*Penaeus indicus*). Shrimp culture today is not only attracting big entrepreneurs/investors for earning big money, but also provides ample opportunity for increasing employment and income in the rural sector, particularly for the impoverished coastal villagers. Positive scope for earning the most valuable foreign exchange through shrimp export to mitigate country's economic crisis and providing significant economic benefit to large number of rural poor in the coastal region through coastal aquaculture activity, have generated awareness in the Indian fisheries sector to identify shrimp farming (culture of penaeid prawns) as the current high priority, fisheries development programme.

Rich brackishwater resources of Orissa State (31,600 ha) having very good potential for producing export quality prawns from aquaculture has hither to been unexploited. In 1983-84 the government of Orissa launched an innovative programme in the fisheries sector to involve poor coastal villagers in brackishwater Prawn/shrimp culture development as an additional tool to implement Governement Policy of poverty alleviation in rural areas. Therefore the beneficiaries/farmers were drawn from poorest of the poor, small and marginal farmers to take-up small scale brackishwater prawn culture in small ponds. This Government sponsored aquaculture, scheme was supervised/monitored by one special agency (Brackish water Fisheries Development Agency). The massive programme of small scale Prawn culture by rural poor launched by the State Government in 1983-84 was based on a limited success and experiences gained by the Department of Fisheries in a totally new system of brackishwater pond culture "Confined Pond Culture".

The "Confined Pond" culture of penaeid prawns through a simple and low cost technology for easy adoption by the small/weaker section farmers, is a unique pond culture system having no arrangements for exchange of water during the entire culture duration, being undrainable and rain-fed ponds and having sustained level of suitable salinity in the water phase due to leaching and re-charging action of salt in the soil phase.

Mono-culture of *Penaeus monodon* and *Penaeus indicus* in confined brackishwater ponds/farms became successful for the first time in Orissa, India with rapid expansion in the chilika lagoon area since 1984. There is no information available on the penaeid Prawn culture in confined brackishwater ponds from other parts of the world. About 5,000 ha brackishwater area in the Chilika lagoon was hither-to left undeveloped, since it was considered to be unsuitable in absence of tidal water. Therefore the newly developed "Confined Pond" culture system in 1983-84 brought out a break-through in developing vast brackishwater resources of Chilika lagoon for extensive culture of *Penaeus monodon* and *Penaeus indicus* to increase the production of shrimps for export and also became easily acceptable to small farmers for successful operation involving low-cost technology. Therefore culturing *Penaeus monodon* and *Penaeus indicus* in confined brackishwater pond is considered as a pioneering work.
The present study was carried out in three confined brackishwater ponds at Binchanapalli brackishwater sites (200 ha) in southern fringe area of the Chilika lagoon in Ganjam district of Orissa State (19° 28.3'-19° 29.6' N and 85° 7.6'-85° 8.2' E) from June 1984 to March 1988.

The Objectives of the work were:

1. to study the Physico-chemical characteristics of the confined brackishwater ponds both water and soil phases;
2. to study the biotic diversity and seasonal variation of the biotic components (plankton, benthic fauna, primary productivity etc.) of the confined brackishwater pond;
3. to study detailed larval development of two commercially important penaeid prawns (*Penaeus monodon* and *Penaeus indicus*) in an experimental hatchery at Paradeep in order to gain knowledge for future development of Prawn hatcheries in Orissa coast;
4. to study the biological aspect of the two important penaeid prawns (*Penaeus monodon* and *Penaeus indicus*) viz. growth rate, length weight relationship, condition factor, sex ratio, food (gut contents) at different growth phases and proximate composition of these two Prawn species reared in confined brackishwater ponds;
5. to conduct systematic studies on the technology packages (liming, manuring and Pond fertilization, water management stocking, feeding, harvesting etc) as applied for mono-culture of *Penaeus monodon* and *Penaeus indicus* in confined brackishwater ponds;
6. to study various growth parameters in *Penaeus monodon* and *Penaeus indicus* under confined pond culture in relation to stocking density, cropping seasons, different biotic and abiotic conditions of the culture ponds;
7. to study survival and production (Gross and Net Yield) of *Penaeus monodon* and *Penaeus indicus* in monoculture in confined brackishwater ponds under different densities and pond conditions;
8. to conduct systematic seed and fishery studies of *Penaeus monodon* and *Penaeus indicus* in Orissa coast in order to make potential resources estimate.

**METHOD:**

Seasonal variations in Physico-chemical Parameters like temperature, pH, transparency, dissolved oxygen, total alkalinity, salinity, free carbon dioxide, nitrate-nitrogen, Phosphorous etc. in the water phase of confined brackishwater pond were studied by collecting monthly samples (3-5 samples) following standard/suitable methods (welch, 1948; Golterman, 1969; Jhingran et al; 1970; APHA, 1980) for two years 1984-85 to 1985-86).

Soil quality of the confined brackishwater ponds (Physical composition, sodium chloride content, available Nitrogen, available Phosphorus, Organic Carbon, PH etc. was studied by analysing soil samples once before pond preparation and once after final harvesting of each Prawn crop for two years (1984-85 to 1985-86). Standard/Suitable methods (Walkley and Black, 1934; Subbiah and Asija, 1956; Jhingran et al, 1970) were followed to analyse the soil samples.
Correlation analysis of different physico-chemical parameters of pond water was also carried out as followed by Banerjee, (1971). Correlation of different parameters of soil quality with prawn yields was also studied.

Monthly variations of Primary Productivity of pond water by following "Dark and Light bottle" method (Gaarder and Gran, 1927) was studied for one year during 1985, except for two months (May and June) when the ponds become dry.

Diversity and density of both phyto and zoo-plankton with their monthly/seasonal variations in pond water were studied for two years (1984-85 and 1985-86). Correlation of phyto-plankton density and primary productivity was also studied. Diversity and biomass of bottom biota (Benthic fauna) for their seasonal variations in confined brackishwater ponds were studied as followed by Patnaik (1971) and Jones and Selgeby (1974) for one year during 1985-86.

Different biological aspects like gut contents (food) with preferred food items at different growth stages, length-weight relationship, daily growth rate during different rearing duration (Deshimaru and Shigeno, 1972) variations of condition factor during different rearing durations, variations of sex-ratios in different culture durations (Cochran, 1954) were studied for three years (1984-85 to 1986-87).

Proximate composition of pond reared (Confined Pond) *Penaeus monodon* and *Penaeus indicus* was determined by using suitable methods (Wong, 1923; AOAC, 1950; Dubois et al, 1986; Paine, 1964; Joshi and Bal, 1968.)

Studies on breeding and rearing of larvae/larval development of *Penaeus monodon* in a small pilot hatchery at Paradeep were carried out during 1984-85 following the methods adopted in India (Muthu et al, 1974; Mathu et al 1978; Silas et al, 1978; and Halder, 1978; to study the results under variations in water quality, larval feeding and biological differences in individual gravid female prawns collected from the wild (sea).

Monoculture experiments for *Penaeus monodon* under three different stocking densities (15625/ha, 20625/ha and 25,625/ha), culture seasons and pond conditions were carried out for three years (1984-85 to 1986-87) with two crops per year. Mono culture of *Penaeus indicus* with single stocking density of 15,625/ha was carried out for one year only during 1987-88. Growth, yield, survival, feed conversion ratio (FCR) etc. for *Penaeus monodon* in relation to variations in stocking density, cropping seasons and pond conditions were studied in detail, where as for *Penaeus indicus* observations were recorded for a single density culture. ANOVA and other statistical tests were carried out to arrive at conclusions. The economic evaluation of investment and returns in confined brackishwater pond culture of *Penaeus monodon* was made by computing the benefit cost ratio (BCR) as suggested by Dalvi et al (1988).

Resources studies in respect of natural seeds and fishery of two important penaeid prawns (*Penaeus monodon* and *Penaeus indicus*) in the Orissa coast were carried out. Since no informations were available on the characteristics of the juvenile population and influence of the environmental parameters on their abundance, the present seed resources studies included juvenile population characteristics, estimation of seed resources, seasonal abundance of juveniles and post larvae in relation to water salinity tidal and lunar periodicity etc. during January 1981 to December 1985 at ten selected coastal centres covering the entire 480 km. long coast of Orissa State. ANOVA and other statistical tests were carried out to derive conclusions.
Although no specific studies could be carried out in respect of fishery resources of these two penaeid prawns in Orissa coast, but the observations/informations recorded by other workers (Nagabhusanam, 1971; Annon, 1988) were reviewed and analysed to understand the fishery resources potentiality of Penaeus monodon and Penaeus indicus along Orissa Coast.

RESULTS:

The season wise mean values of air temperature were 33.94 °C ± 0.88 in monsoon, 25.45 °C ± 2.54 in winter and 29.67 °C ± 3.39 in post winter period. Steady rise in air temperature was observed after January. Water temperatures during the study period followed the similar trend of variations. Mean seasonal water temperatures were maximum (34.51 °C ± 0.59) in monsoon and minimum 25.47 °C ± 2.62 °C in winter. Water turbidity showed four peaks in July, October, December and April. The mean minimum and mean maximum values of water turbidity were 62.50 and 11.0 ppm SiO₂ during January and October 1985. All the three confined brackishwater ponds had consistently alkaline water showing pH variations from 7.0 to 8.62. Season wise variations did not show any marked difference. In general, water salinity showed a sharp rise after November. The fresh rain water accumulated in the dry ponds with the on-set of the monsoon gradually turned to saline/brackishwater due to leaching and recharging action of salt in the soil phase. The annual mean values of average monthly salinity during two years were 18.57 ± 7.79 ppt in Pond - 1, 15.69 ± 7.43 ppt in Pond-2 and 16.49 ± 8.71 ppt in Pond-3. The range of variations in the average salinity values were 22.90, 23.09 and 27.61 in Pond-I, Pond-2, and Pond-3 respectively. Annual mean values of dissolved oxygen concentration in the three ponds were 5.88 ± 1.38 ppm in Pond-I, 6.48 ± 1.11 ppm in Pond-2 and 4.61 ± 0.75 ppm in Pond-3.

Average monthly values of dissolved oxygen for three ponds were higher in winter months and showed a decreasing trend from February to April and it coincided with increase in water temperature. Monthly average values of nitrate-nitrogen in three ponds ranged from 0.01 to 0.09 ppm. Higher value of nitrate-nitrogen (0.069 ± 0.031 ppm) was recorded in Pond-2. Monthly average values of inorganic phosphates showed more or less bi-modal variations. It ranged from 0.03 to 0.14 ppm. Pond-2 showed higher phosphate concentration. Post winter season showed the highest mean value of total alkalinity (100.20 ppm). Correlation analysis indicated that water temperature had significant correlation (P < 0.01) with dissolved oxygen and negatively significant (P < 0.01) with free carbon dioxide.

Average composition of soil for three ponds showed 53.83% sand, 14.22% silt and 31.93% clay. Soil samples of all the three ponds showed alkaline nature. Maximum soil pH (8.67) and minimum (6.40) were recorded from Pond-2 and Pond-3 respectively. Average values of soil salinity (Sodium Chloride content) for three ponds was 670.59 mg/100g. The mean values of available nitrogen were 15.03 mg/100g in Pond-1, 17.07 mg/100g in Pond-2 and 13.46mg/100g in Pond-3. The annual mean maximum and mean minimum values of available phosphorus were 2.94mg/100mg in Pond-2 and 1.60 mg/100g in Pond-3. All the three ponds had organic carbon content less than 0.5%. The minimum average value was 0.186% in Pond-3 and the maximum average value was 0.399% in Pond-2. Highly significant correlation between prawn yield and available nitrogen (P < 0.01) was found.

The gross Primary Productivity values were high during October-November (803-1026 mg/C/M⁶/6-h day) and low during December-February (268-308 mg C/M⁶/6-h days). The annual mean gross Production was 565.90mg C/M⁶/6-h day. There was no marked difference in gross production at surface and bottom,
since the ponds were shallow. ANOVA of Primary Productivity showed that the variations between ponds was highly significant ($P < 0.001$) and variation between months was not significant.

In total twenty-six genera of Phyto-Plankton and thirteen genera of zooplankton were recorded from the pond waters. The density of Phyto-plankton gradually increased from July and reached peak in November. Numerical variations in both phyto and zoo Plankton between ponds and between months were significant at ($P < 0.01$) and ($P < 0.05$) level. Zoo-plankton density showed dominance over phyto-plankton throughout the study.

The benthic populations showed seasonal changes and variations between ponds. In total thirteen groups of benthic organisms were recorded from the bottom samples of the ponds. Production of benthic biomass was highest in Pond-2 and lowest in Pond-3. The monthly average benthic bio-mass were 11.08, 16.72 and 4.03 g/M² in Pond-1, Pond-2 and Pond-3 respectively, which contributed to similar trend in prawn yield from three ponds. With regard to taxonomic dominance, polychaet eggs, copepods and polychaetes were in the first second and third order respectively in the bottom samples.

Length-weight relationships for *Penaeus monodon* and *Penaeus indicus* reared in confined brackishwater ponds were computed from 703 males and 703 females of *Penaeus monodon* and 520 males and 520 females of *Penaeus indicus* as under:

*Penaeus monodon* :

- Male : $\text{Log } W = -5.3401 + (3.1102 \times \text{Log } L)$
- Female : $\text{Log } W = -4.7896 + (3.1013 \times \text{Log } L)$

*Penaeus indicus* :

- Male : $\text{Log } W = -6.0936 + (3.4123 \times \text{Log } L)$
- Female : $\text{Log } W = -5.4011 + (3.1038 \times \text{Log } L)$

The relationship between carapace length and body weight of these two Penaeid Prawns from confined ponds was established and the regression equations were found to be as follows:

*Penaeus monodon* : $W = 0.004698 \times C^{2.296}$

*Penaeus indicus* : $W = 0.0009143 \times C^{2.3012}$

Average growth rates (mm/day) for *Penaeus monodon* was higher at early juvenile and juvenile stages. In *Penaeus indicus* average growth rate, though appeared to be higher at the early juvenile stage, it decreased at late juvenile stage. Variations in the growth rate at different growth stages and among three ponds were found statistically (ANOVA) highly significant for *Penaeus monodon*. In *Penaeus indicus*, the variations in growth rate at different growth stages were found statistically not significant but variations between ponds were significant. A clear decrease in condition factor 'kn' value, Imai (1977) was noticed after 40 days rearing upto 100 days when the prawns were immature. The condition factor 'kn' for *Penaeus monodon* and *Penaeus indicus* varied between 0.70 and 1.30 during 100 days rearing in confined ponds. Sex ratios recorded from monthly samples were tested by chi-square test for distribution of equality in sexes which indicated equal distribution of both sexes in the samples. Gut content analysis of 161 specimens of...
Penaeus monodon and 282 specimens of Penaeus indicus showed that food composition varied at different growth stages and between two species. For Penaeus monodon, crustaceans dominated (48.71-62.33%) during juvenile stage (50-70 mm). Molluscan tissue, which was given as daily supplemental feed in ponds, formed the dominating food items (50.47-67.11%) worms in the food showed fluctuations in different months due to their variations in the bottom biota. Prawns did not consume any food during moulting as was evidenced from empty guts. Average food composition for Penaeus indicus indicated that molluscan tissue and debris together formed the bulk of food (79.13%). Crustaceous remains (10.10%), worms (6.69%), filamentous algae (1.69%) and diatoms (1.21%) were among other food items for Penaeus indicus.

Studies on breeding and larval rearing of Penaeus monodon in the pilot prawn hatchery at Paradeep during 1984, 1985 and 1986 (Seven experiments) showed that the spawning rate ranged from 33.33 to 100 percent and mean percentage loss of body weight in spawning prawns ranged from 2.10 to 7.29. During the experiments the average water temperature, pH, dissolved oxygen and sea water salinity in the hatchery were 24.5 - 28.5 °C, 8.0-8.4, 4.8-6.6 ppm and 30.0 - 35.2 ppt respectively. Better results of both spawning and larval rearing were achieved during February-March. Results were poor during November-January. The larvae were fed with blended tissue suspension of non-penacid shrimps (Acetes sp.) sieved through 50-160 micron-meshes. (Hameed Ali, 1980; Hameed Ali et al, 1982). The average survival rate of larvae (Eleven stages from nauplius to post larvae) was 20.27%.

Monoculture experiments for Penaeus monodon and Penaeus indicus during 1984-85 to 1987-88 in confined brackishwater ponds (18 crops for Penaeus monodon and 6 crops for Penaeus indicus) was carried out initially by draining and drying the ponds, ploughing the drybottomsoils, liming with quick-lime @ 250 kg/ha., Organic manuring with cow-dung @ 5,000 kg/ha, inorganic manuring (single-superphosphate and Urea with 1:1 proportion) @ 100 kg/ha. Stocking with natural seeds of Penaeus monodon (@ 15,625/ha., 20,625/ha. and 25,625/ha) and for Penaeus indicus @ 15,625/ha and daily feeding with snail meat (75%) and ground-nut oil cake (25%) @ 25.0-6.0% of estimated standing crop biomass. The yield results of three ponds clearly demonstrated that the average productivity of Pond-2 was the highest (557.473 kg/ha/crop) and that of pond-3 was the lowest (309.773 kg/ha/crop). The highest gross and net yield of Penaeus monodon (1283.194 kg and 1274.072 kg/ha/year) were recorded from Pond-2 at a stocking density of 25,625/ha. The average gross and net yield per year (with two crops) for three ponds under three densities all taken together were 914.129 kg/ha and 906.954 kg/ha respectively. Harvesting by using "Chilika type" traps demonstrated that highest trap catches of prawns are obtained on new and full moon days and new moon day catches were higher than full moon days.

Monoculture of Penaeus indicus with stocking density of 15,625/ha recorded average gross and net Yield of 449.908 kg and 444.655 kg/ha/year. Penaeus indicus recorded 66% less net yield than Penaeus monodon with same stocking density 15,625/ha. Average survival rate of 77.72%, 81.78% and 78.76% for three densities were recorded from Pond-1, Pond-2 and Pond-3 respectively. Average survival of Penaeus indicus for three ponds was 74.33%. Higher survival for Penaeus indicus was recorded in the second crops when the salinity was also higher. Higher yield in the first crops were recorded for Penaeus monodon. In general, higher specific growth rates (SGR) for Penaeus monodon and Penaeus indicus were recorded in the first and second crops respectively. Fast increase in specific growth rate (SGR) was observed from third fortnight of rearing for Penaeus monodon and fourth fortnight for Penaeus indicus. Average body weight of Penaeus monodon at harvest (averaged for three ponds and 18 crops) was 29.51 g and average body weight
for Penaeus indicus was 19.28 g. The relative feeding co-efficient ranged from 3.08 to 3.45 indicating positive suitability of supplemental feed (Molluscan meat + ground-nut oil cake) in prawn culture. The economic evaluation of monoculture of Penaeus monodon in small confined brackishwater ponds (0.40 ha) indicated high profitability where net annual income was worked-out to be Rs.21,106.00/Acre (0.40 ha) Pond. Benefit cost ratio (B.C.R.) and internal rate of returns (IRR) in such kind of prawn culture were worked out to be 2.85 at 15% and more than 50% respectively.

RESOURCES SURVEY:

Studies on natural seed resources of Penaeus monodon and Penaeus indicus showed that the juvenile collections from tidal creeks and estuaries constituted 32.27% Penaeus monodon and 67.73% of Penaeus indicus. Although both the prawn seeds were available round the year, two peaks of occurrence (April-June and November-December) for Penaeus monodon were noticed. Similarly maximum occurrence of Penaeus indicus seed during April-June and October-December was observed. The total annual potential for seed of two penaeid prawns was estimated at 130.09 million in Orissa Coast. It was further observed that the maximum collection of prawn seeds was made on both full-moon and new-moon day. Collection on new moon day was richer than full moon day.

From the exploratory survey conducted by the Department of Fisheries, Orissa (Annon, 1988) indicated declining trend of penaeid prawn landings in Orissa coast. This trend of coastal penaeid fishery is probably attributable to indiscriminate exploitation of post larvae and juvenile resources in their estuarine phase of life cycle. This suggests rational approach through Government legislation in exploitation of the natural seed resources in the coast, which would help recruitment into coastal prawn fishery. Orissa has tremendous resource potentiality for penaeid prawns, which should be exploited to man's benefit.

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