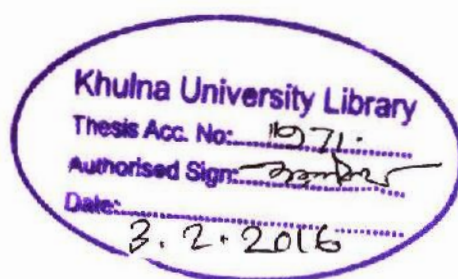


**Assessment of Supply and Marketing of Fresh
Water Giant Prawn (*Macrobrachium rosenbergii*)
from Khulna district, Bangladesh**



**Fisheries and Marine Resource Technology Discipline
Khulna University
December, 2006**

**Assessment of Supply and Marketing of Fresh
Water Giant Prawn (*Macrobrachium rosenbergii*)
from Khulna district, Bangladesh**

**A Thesis
By**

**Bishwajit Kumar Dev
Examination Roll No. MS 010612**

**The Thesis is submitted to the Fisheries and Marine Resource Technology
Discipline in partial fulfillment of the requirements for the degree of**

**Master of Science
In
Fisheries and Marine Resource Technology**

December, 2006



**Assessment of Supply and Marketing of Fresh
Water Giant Prawn (*Macrobrachium rosenbergii*)
from Khulna district, Bangladesh**

**Approved as to style and content
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Declaration

The results submitted in this thesis are entirely of the candidate's own investigations and no part of the results has been accepted for any degree, nor it is being concurrently submitted for any degree

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Bishwajit Kumar Dev

Abstract

The fresh water prawn, *Macrobrachium rosenbergii* (De Man, 1879) is commercially cultured in Khulna district of Bangladesh. Thousands of farmers in this region have converted their paddy fields to prawn farms (*ghers*) to accommodate a profitable prawn culture practice. Prawn farming become popular in this area in 1990 however, small scale prawn farming was started in Dumuria upazila back in 1984. Khulna region is godly blessed by nature interacting of brackish and fresh water environment. Availability of fry, inputs, different types of water bodies, climatic condition, market condition and marketing facilities encouraged the prawn farming. Different types of culture system adopted in Khulna district to accelerate the production and utilise the farming land. Farming area increased in 15842 ha in 2003-04 where it was 11317 ha in 1999-2000 and the production increased in 8431 MT in 2003-04 where it was 2302 MT in 1999-2000 in Khulna district. The unit production varies from upazila to upazila. The unit production of Dumuria (0.59 to/ha), Digholia (0.89 to/ha), Dacope (0.79 to/ha), Terokhada (0.95 to/ha) and Rupsha (0.62 ton/ha) is comparatively higher than other area of Khulna. The manpower involvement in prawn farming tremendously increased in 38485 in 2003-04 where it was 31075 in 2002-02. About 921 depot and 2871 persons are involved in prawn trading in 62 locality of Khulna district. Farmers directly sell their prawns to their local markets round the year but the peak period is November to February. The prawns supply system from farmers to the international markets always pass through a number of chain and group of traders: foria (field workers), prawn traders, agents and processing plants. The price of prawn differs with grade and month. The prawns demand high price in peak seasons and comparatively low price in off seasons by grade. The average local price of prawn 1050-1145, 750-820, 625-665, 350-410, 220-265 and 120-185 BDT for grade-5 (200gm), grade-10 (100gm), grade-20 (50gm), grade-30 (33.33gm), grade-50 (20gm) and grade-60 (16.66gm) respectively. The prawn is a highly valued product in the international markets. The average price of prawns in international markets varies between 4.0 and 10 per pound depending on grade. The contribution of fresh water prawn to frozen shrimps export is 43.82% (13643.03 ton) of landing and 42.82% (702.91 crore BDT) of export earnings in 2003-04 where it was 31.30% (6975.86 ton) of landing and 25.33% (338.51 crore BDT) of export earnings in 1999-2000. The present study has confined to identify and assess the level of production and marketing of fresh water giant prawn in Khulna district of Bangladesh.

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Introduction

Bangladesh is known as the land of the rivers which is endowed with very considerable marine, estuarine, and inland waters having great fisheries potential (Rahman, 1994). These vast inland water resources are suitable for growth of many species of fresh water prawns including *Macrobrachium rosenbergii* (Hussain, 1994). There are about 23 species of fresh water prawns including 10 species of *Macrobrachium* available in Bangladesh. However, only *Macrobrachium rosenbergii* (De Man, 1879) has great aquaculture potential and suitable for commercial culture (Akand and Hassan, 1992).

The giant fresh water prawn (Ling, 1963) *Macrobrachium rosenbergii* (De Man, 1879) locally known as (golda chingri) is an important species of Bangladesh. It is the biggest species of prawns (Ahmed, 1967) found in this country and very much valued for domestic consumption as well as foreign export. The species is widely distributed in both fresh and brackish water of Bangladesh. Species of the fresh water prawn genus *Macrobrachium* are distributed throughout the tropical and subtropical zones of the world. Holthuis (1980) provides useful information on the distribution, local names, habitats and maximum sizes of commercial (fished and farmed) species of *Macrobrachium*.

They are found in most inland fresh water areas including lakes, rivers, swamps, irrigation ditches, canals and ponds, as well as in estuarine areas. Most species require brackishwater in the initial stages of their life cycle (and therefore they are found in water that is directly or indirectly connected with the sea) although some complete their cycle in inland saline and fresh water lakes. Some species prefer rivers containing clear water, while others are found in extremely turbid conditions. *M. rosenbergii* is an example of the latter. *M. rosenbergii* (giant river prawn) is indigenous in the whole of the South and Southeast Asian area as well as in northern Oceania and in the western Pacific islands. *M. vollehovenii* (African river prawn) is naturally distributed in West Africa, from Senegal to Angola.

Many *Macrobrachium* species have been transferred from their natural location to other parts of the world, initially for research purposes. *M. rosenbergii* remains the species most used for commercial farming and consequently is the one which has been introduced to more countries. Following its import into Hawaii from Malaysia in 1965, where the pioneer work of Ling (1969) was translated into a method for the mass production of post larvae (PL) by Fujimura and Okamoto (1972), it has been introduced into almost every continent for farming purposes. *M. rosenbergii* is now farmed in many countries; the major producers (>200 mt) are Bangladesh, Brazil, China, Ecuador, India, Malaysia, Taiwan Province of China, and Thailand (FAO 2002). More than thirty other countries reported production of this species in the year 2000. Vietnam is also a major producer, according to New (2000b). In addition, there are also valuable capture fisheries for *M. rosenbergii*, for example in Bangladesh, India, and several countries in Southeast Asia.

Though the farming of fresh water prawns (*Macrobrachium* spp.) forms only about 6 per cent of the global aquaculture production of shrimps and prawns it is of considerable local importance particularly in Thailand and Taiwan (Michael, 1987). Farmed fresh water prawns are now entering global, as well as domestic markets, a development likely to stimulate renewed interest in *Macrobrachium* culture in other tropical countries.

The total fresh water prawn farming area is estimated about 8306.73 hectares in Bangladesh and three quarters of prawn farms are located in Khulna, Bagherhat and Satkhira districts (Rahman, 1995; Rosenberry, 1993). Now this area is increased in 15842 hectares (DoF, 2004). The most spectacular development of prawn farming has recently taken place in Khulna and Bagherhat

district where thousands of farmers have converted their paddy fields to prawn farms to accommodate a profitable prawn culture practice (Kendrick, 1994).

Bangladesh is a major exporter of fresh water prawn (*Macrobrachium rosenbergii*) caught by artisanal fishers in rivers, lakes and flooded depressions (Angell, 1992). The vast majority more than 90% of the fresh water prawn exported from Bangladesh derives from natural resources with an estimated 60% from Khulna and Bagherhat districts, 35% from Comilla and Noakhali districts and only 5 % from Cox's Bazar area (DIFTA, 1993). But in fact most of the exported prawn comes from culture fields throughout the country. Bangladesh government has declared prawn cultivation a primary industry and designed specific support program to boost the production (Datta, 1995). Over the past years there has been a notable increase in the export prices of the prawn, in particular, in USA, Japan and Europe. The European market, especially Belgium has largely accepted this prawn, because of their similarity in taste to the local coldwater *Crangon* sp. (Nierentz and Josepeit, 1988; Chauvin *et al.*, 1992). In 1995 and 1996, Japan imports 5455 and 6393 ton of fresh water prawns from Bangladesh respectively (Mc Caffrey, 1998). But now this figure is changed to increase in 7650 ton this year. Although a sound global commodity market for fresh water prawns has not yet been developed. It is anticipated that changes will come and low cost prawn production in Bangladesh is likely to benefit even more than that of today. The words 'prawn' and 'shrimp' are often used synonymously. Actual use is geographically dependent. For example, animals of the genus *Macrobrachium* are referred to as fresh water prawns in Australia and fresh water shrimp in the United States of America (USA). In its statistical data, FAO refers to the genus *Macrobrachium* as fresh water prawns but also uses the word prawn for many species of marine shrimp, including the banana prawn (*Fenneropenaeus merguensis*), the giant tiger prawn (*Penaeus monodon*) and the kuruma prawn (*Marsupenaeus japonicus*) (FAO 2001).

The introduction of *M. rosenbergii* and related species into reservoirs and the enhancement of existing capture fisheries has had some current success, notably in Brazil, India and Thailand. Further developments will require hatchery-reared post larvae (PL) and juveniles for stocking purposes. Further reading on the topic of capture fisheries and enhancement is available in New, *et al.*, (2000). Those interested in the science that supports fresh water prawn farming can find a comprehensive review in New and Valenti (2000).

M. rosenbergii has been imported into many other tropical and subtropical areas of the world and is the species most favoured for farming purposes. The use of the words 'fresh water prawns' and 'prawns' in this thesis, except where otherwise specifically qualified, refers to *M. rosenbergii*. This species remains by far the major subject of cultivation because a global market for it evolved during the 1990s and is currently being further developed. Other species of *Macrobrachium* are now also being farmed, mainly for domestic consumption, and modifications of the techniques described in this thesis can be derived to support this development. Such modifications need to take account of the different environmental requirements of the other species, especially in the larval stages. Reference to the culture of other *Macrobrachium* spp. is contained in Kutty, *et al.*, (2000). Though fresh water prawns were collected from the wild and grown up to market size in impoundments earlier, true culture systems began to be developed after 1962. Pioneer work by Shao-wen Ling in Penang, Malaysia, succeeded in closing the life cycle (Ling, 1977) of the giant long-legged prawn, *Macrobrachium rosenbergii*, stimulating widespread interest in the commercial potential of culturing this and other members of the palaemonid family of crustacea. Enthusiasm for the culture of this genus was infectious, sometimes with scant thought about the potential markets for fresh water prawns. This was spurred by the fact that, at that time, it had not been possible to close the life cycle of marine shrimp, for which there was an established global market.

In 1965-1966 *Macrobrachium rosenbergii* was imported into Hawaii, where Takuji Fujimura and his team at the Anuenue Fisheries Research Centre developed mass rearing techniques for larval production (Fujimura and Okamoto, 1972). Successful grow-out experiments in Hawaiian ponds were soon followed by early attempts to establish commercial farming of this species in many other places, including Australia and Mauritius. For several years it was Hawaii that remained principally linked with fresh water prawn culture in the columns of the aquaculture press. Meanwhile Thailand, a country with a tradition of fresh water prawn consumption, was quietly probing the possibility of *Macrobrachium rosenbergii* culture; this fact was little known outside that country at the time. The third pioneer in establishing commercial prawn culture was Taiwan. Although *M. rosenbergii* had been occasionally found naturally in southern Taiwan, it was two adults imported from Thailand in 1970 that led to the development of fresh water prawn farming (Chen, 1976).

By the middle of the 1980's global production was over 20,000 mt/yr. 73 per cent of this total was farmed in Thailand and 17 per cent in Taiwan. In 1987, Thai fresh water prawn production was estimated to be 15,000 mt/yr. *Macrobrachium* (principally *M. rosenbergii*) culture is in the experimental or low-level commercial phase in many countries. These include Australia, Bangladesh, Burma, Ecuador, Indonesia, India, Jamaica, Japan, Nepal, the Philippines, Puerto Rico, South Africa and Sri Lanka. The production, based on various sources, of 750 mt/yr and 600 mt/yr for Brazil and Mexico in 1986 may be under-estimates. In 1987, prawn production in Brazil and Mexico probably markedly exceeds.

By 1979 the pioneering research and development of the Chacheongsao Fisheries Station led by its chief, Somsak Singholka, had stimulated a national prawn aquaculture production of 80 mt/yr in Thailand. In 1976 it had been only 3 mt/yr (Boonyaratpalin and Vorasayan, 1983). By 1980, strengthened by a UNDP/ FAO project headed by the author, fresh water prawn farming had spread to 40 of the 72 Thai provinces (New, 1982). In 1980, a team studying the economic status of fresh water prawn farming in Thailand reported that it was a profitable activity for both hatchery and pond production in all sizes of farm units examined (Anonymous, 1980a). By 1982 the number of prawn farms had increased to 677 with a total area of 1,737 ha (Boonyaratpalin and Vorasayan, 1983). A further 9 of the Thai provinces contained prawn farms. Average annual pond yield was 750-1,500 kg/ha in 1982 and national production had grown to more than 1,200 mt/yr (Boonyaratpalin and Vorasayan, 1983). In 1983 Thailand was still importing 700 mt/yr of prawns, mostly from Burma. Since in 1982 prawn farming has continued to expand, with production being more than 4,000 mt in 1986 (Janssen, 1987), with an estimated farm-gate value of US\$ 16 million/yr. Cultured prawn production has not yet exceeded 800 mt/yr anywhere else except Taiwan.

Initially rapid expansion of this type of aquaculture was later overtaken by the growth of marine shrimp farming in Taiwan. The later developed in response to the global demand for the product and as a result of a break-through in rearing technology (Liao, *et al.*, 1969). However fresh water prawn culture, which was 65 mt/yr in 1979 (Liao and Chao, 1982), had increased to 3,500 mt by 1986 (Liao and Smith, 1982). Total Taiwanese production of marine shrimp exceeded 15,000 mt/yr by 1983 (New and Rabanal, 1984), while production of *Penaeus monodon* alone exceeded 18,000 tons in 1984 (Chiang and Liao, 1985) and total farmed shrimp production was estimated to be 40,000 mt in 1986 (Hopkins, 1986).

The history of fresh water prawn farming in Hawaii can be followed in the pages of a publication called *Aquaculture Digest*. There, as in Thailand, initial growth of the prawn farming industry was stimulated through the free distribution of post larvae from 1965 onwards by a government

hatchery for stocking into commercially owned ponds. However, in 1978, farmers were also turning to private hatcheries for supplies or establishing their own hatcheries. Large private hatcheries, in 1981, were claiming that irregular state hatchery production was distorting profitability figures. In 1980 there were at least 24 prawn farms in the State. One of the largest farms built in Hawaii was the Lowe Aqua farm. In 1981 this farm was reported to be harvesting at the rate of 83 mt/yr, but disappointments were being voiced about the less-than-expected growth of the industry in the State generally. By the end of 1981, total Hawaiian prawn production was only 118 mt/yr, whereas it had been predicted 3 years earlier that it would be 1,000 mt/yr by then. Economic viability, market potential and bureaucratic problems were blamed. Lowe Aquafarm (now renamed Amorient Aquafarms) was a 150-acre farm by 1983. It was then said to be making a profit on a production of 5.4–7.7 mt/month. In 1984 it produced 79 mt but in 1985 production fell to about 68 mt; then it was reported that it had 'never made a profit' and that its owners intended to convert the farm to marine shrimp culture. Since then, the farm has been for sale, its owners having decided to concentrate on marine shrimp farming in Ecuador. Though many smaller fresh water prawn farms remain in Hawaii, this account of the rise and fall of the largest farm illustrates the contrast between Hawaii and Thailand. Hawaii had neither the abundant sites, nor the cheap labour, nor the large home market accustomed to fresh water prawn consumption that Thailand had.

Elsewhere in the United States enthusiasm for fresh water prawn farming has been manifested by research and development by state governments, universities and entrepreneurs which included seasonal farming in southern states (South Carolina, southern Georgia, Mississippi, Louisiana, Tennessee, and Alabama, in mono- and polyculture), geothermal farms in Idaho, Nevada, Oregon, and California, thermal aquaculture in New Jersey, South Carolina and Oregon, and solar heated recirculating systems in Rhode Island. Despite these activities, the total commercial production of fresh water prawns in the United States remains minimal. The contribution of the continental U.S. has been principally in research, although Sandifer and Smith (1985) report the presence of at least one large commercial prawn farm.

U.S. companies are also involved in prawn farming outside the USA. These ventures include Puerto Rico, where the Sabana Grande Prawn Farm had developed 35 of its 142 hectares by 1986 and built a hatchery; harvesting rates were then nearly 4 mt/month and were expected to double shortly. Another U.S. company, General Mills, Inc. had a pilot prawn farm in Honduras. Covenant Aquaculture Corporation plans to set up an 85-ha prawn/tilapia farm in southern Georgia, USA, scheduled to produce 180 mt/yr of prawns, based on Israeli technology developed by Aquaculture Production Technology. The latter company exports prawns from Israel to Europe and has also been involved in prawn farms in Jamaica, Ecuador, the Dominican Republic and the Philippines. A Dutch-UK company, Unilever PLC began a fresh water prawn farm in Sri Lanka but is now concentrating on the development of marine shrimp farming there and elsewhere in the Indian subcontinent.

Early (pre 1976) research on *Macrobrachium* spp. indigenous to Latin America has been reviewed by New (2000a). Currently, the Dominican Republic is rapidly expanding its prawn farming industry. In 1985 248 mt/yr were produced from 32 farms totalling 65 ha; by 1987 there were said to be more than 60 farms (Aquaculture Digest, 12.9.9.). By the end of 1986, there were 76 prawn farms in Martinique, Guadeloupe and French Guyana (Anonymous, 1987). The total area in production was said to be 152 ha, producing 133 mt/yr. Some ponds, which are run under continuous cultivation (some have not been drained for 5 years), produce 2.8 mt/ha/yr (Aquaculture Digest, 12.9.11). Guadeloupe farms average 1.0 mt/ha/yr; there were 18 farmers and 48 ha of ponds in

1986 (Anonymous, 1987). Martinique produced 50 mt from 42 ha (1.2 mt/ha) and French Guyana 35 mt from 64 ha (0.5 mt/ha).

In summary, the commercial development of prawn farming is geographically broad but piecemeal and, with a few exceptions, nationally insignificant in terms of volume production. Research and development interest remains high but the large-scale expansion of fresh water prawn farming which was expected in the late 1970's has not materialized. This is due to a combination of factors which include marketing and technical difficulties. A sound global commodity market for fresh water prawns has not yet been developed. However, the increasing export of fresh water prawns from Thailand to Europe may be the early indication of global market development. On the technical front the territorial nature of prawns and their longer larval life make them less attractive compared to marine shrimp, now that the difficulties associated with the captive spawning of the later are being resolved.

Objectives and main goal of the study

- * To estimate the production of fresh water prawn from Khulna district
- * To observe the relationship and variation among production, price and manpower
- * To assess the market condition and identify the marketing channel
- * To find out year wise production trend at different upazila level in Khulna district
- * To evaluate the export status and different factors of fresh water prawn production

2. Literature and Review

2.1 Harvesting

In Thailand, some of the larger farms use the continuous management technique (New and Singholka, 1985) while some of the others use the batch technique, mainly because of seasonal shortages of water. Most Thai farmers use a combination of the two methods; cull harvesting from 5 months after stocking onwards until the pond is completely harvested after about 8 months.

In Hawaii, the seine net used for harvesting (Malecha, 1983b) retains mostly prawns over 30 g in weight; other smaller prawns may also be trapped unintentionally. Malecha (1983b), and New and Singholka (1985) describe harvesting techniques, seining, draining and pumping, in detail. Aids to improved management of prawn ponds have been suggested. Some Hawaiian farms use mechanical harvesting. A simple inexpensive prawn grader to separate prawns into the three Hawaiian marketable sizes (Arndt *et al.*, 1984) and a mechanized seine for cull-harvesting (Williamson and Wang, 1982; Losordo *et al.*, 1986) are two improvements suggested. Lam and Wang (1986) have reviewed engineering research for improving prawn yield in Hawaii. Canal type ponds (i.e. long narrow ponds not more than 30 m wide) assist seining operations. Seining operations are typically slow, labour intensive and inefficient and often exacerbate the losses of animals during harvesting.

Peterson (1982) found that either type of seining had a low efficiency in catching marketable prawns. Although the drain harvesting system was 100 per cent efficient, much labour was necessary for post-harvest hand sorting. Peterson (1982) concluded that manual seining would continue to be the methods of choice on small farms, being slightly more efficient than the modified seining technique. In terms of equipment costs per kg of marketable prawns harvested over a five-year period, drain harvesting was the most expensive at farm sizes from 4–96 ha; the manual method was the cheapest.

The composition and appearance of harvestable shrimp and prawns can be modified by dietary modification. For example, Sandifer and Joseph (1976) showed that shrimp fed a diet augmented with 3 per cent shrimp head oil had fifteen times more carotenoid content than the control. Elevating the rearing salinity several days before harvest may enhance the flavour of prawns (Fox *et al.*, 1985). Taking prawns off feed three days before harvesting is said to obviate the need for deveining (Lee, 1981).

Harvesting techniques will have to be modified for prawn-fish polyculture. Pavel *et al.*, (1985) postulated that channel catfish ponds, normally rarely drained, would need to be drained if prawns were also stocked. Methods for sorting mixed harvests of fish and prawn would also need development.

2.2 Processing

Processing yields of prawns are size and sex dependent (Smith *et al.*, 1980). Tail weight percentage decreases with increasing prawn size. Female prawns give consistently greater tail yields than males, mostly due to differences in the size and weight of their claws. In general, processing yields of de-headed prawns are less than those of penaeid shrimp but greater than those obtained from crayfish and crabs. On average, 50 per cent of the total prawn weight is lost when tails only are sold (Huner, 1980).

Many freshwater prawns are sold close to the farm site in Thailand (New and Singholka, 1985) either on ice or alive. Fresh prawns only have a shelf life of up to three days. After this they become mushy and begin to decompose. Mushiness also occurs if prawns are cooked for more than a few minutes (Lee, 1981). The quality deterioration of raw prawns under iced or refrigerated storage, characterized by softening (mushiness), may be caused by the activity of a collagenolytic enzyme released postmortem from the hepatopancreas. After 4 days storage, proteolytic and collagenolytic microflora also contribute more extensively to mushiness (Pre-maratne *et al.*, 1986). Glude (1984), commenting on the short shelf-life of fresh (chilled) prawns, postulated that this might be extended by storage under CO₂ or that bacterial decomposition might be controlled by O₃. Some farms have their own on-site restaurants. Prawns can be shipped in aerated water containers to other restaurants and to hotels if the extra value obtainable for live prawns warrants it. Freshwater prawns are particularly susceptible to enzymatic damage after harvesting and death, and some farms 'kill-chill' by dipping the prawns in iced water. This is followed by blanching them at 65°C for 15–20 seconds. The prawns are then iced and transported to market. In experiments on processing prawns in Thailand (Anonymous, 1980a), corrugated fibreboard boxes were suitable for transporting prawns for up to 14 hours with a dry ice/prawn ratio of 1:2.5. One alternative, the use of styrofoam boxes, was extremely expensive.

In Thailand, most prawns are sold whole (head and shell-on). The original quality of the prawns in terms of microbial count and hypoxanthine value is important (Passy *et al.*, 1983). The initial microbial load can be reduced significantly by heading and intensive washing. Packing in ice was found by Passy *et al.*, (1983) to prevent desiccation and to lengthen the microbial growth lag phase from 1–2 days to 5. Flushing with CO₂ and a temperature of 4°C extended shelf life by 2–3 days (to 8–9 days) without affecting flavour. Cooking tends to remove off-flavours and odours and toughens up the texture of prawns. Some information on the frozen storage stability of prawns has been published by Hale and Waters (1981). Chemical, physical, microbiological and sensory evaluations were made over a 9 month period of -20°C glazed storage on whole (raw or precooked) and deheaded (raw) prawns. Prawns can be frozen for up to six months with almost no deterioration in flavour (Anonymous, 1981).

2.3 Marketing

Values of cultured freshwater prawns are recorded high prices quoted in the USA appear to be based on the value of very large prawns rather than on average value for all the marketable animals. Farm-gate values appear to have fallen severely in Thailand between 1980 and 1986 due to a ten-fold increase in farmed production. However, while farmers complain about the prices obtainable there, this is undoubtedly because profits are not so great. That prawn farming in Thailand remains economically viable at the reduced farm-gate prices obtainable is demonstrated by its continuing expansion Glude (1984).

Marketing problems do not exist in the home market in Thailand where prawns are long established as a desirable product. Liao and Smith (1981) reported that most South Carolina consumers evaluated freshwater prawns as similar to marine shrimp but, unlike those in Thailand, preferred them heads-off. Retailers preferred a 78–110 tails/kg size category. Direct sales to consumers, as well as through seafood retailers and restaurants, were the most attractive marketing approaches there (Liao and Smith, 1982). An advertizing campaign in Hawaii in 1978 stressed heads-on prawns as the product, rather than tails, despite the fact that some residents and visitors found this unattractive; it was thought that 'heads-off' marketing might lead to "hepatopancreas contamination" (Aquaculture Digest, 6.11.51). Lee (1981) reports that Boston chefs find fresh

freshwater prawns to have more flavour than saltwater shrimp and that serving them shell-on helps retain the flavour. In north-east USA, freshwater prawns are said to be requested in preference to marine shrimp because the latter have an 'iodine taste' and an objectionable cooking odour (Aquaculture Digest, 13.3.13.). In a South Carolina marketing test, restaurateurs found good acceptability of dishes prepared either with head-on or head-off prawns. Microwaved tails stuffed with crab was the most preferred dish (Liao and Smith, 1981). A consumer survey in the same state indicated that the typical purchaser of freshwater prawns would be "a 44 year old white-collar worker with an average yearly income of US\$ 23,182 and 12 years of formal education" (Liao and Smith, 1983). This seems a little over specific and would be greeted with some amusement in Thailand.

In Thailand, different types of marketed prawns are distinguished (Sastradiwirja, 1986) and valued (Table 4). A detailed analysis of prawns population structure in various marketing categories and its relation to economic yield from a typical Thai prawn farm has been made by Lin and Boonyaratpalin (1987). About one-third of the 15,000 mt of prawns estimated to have been produced in Thailand in 1987 were exported to Europe. The possibility exists in Hawaii (Lee, 1979) for developing specialized markets for egg bearing and soft shelled forms. Soft shelled and old (terminal growth) prawns are usually separated from those to be sold. Lee (1979) found that 63.5 per cent of Hawaiian cultured prawns were ultimately used by direct consumers and the rest by restaurants. The basic farm-gate outlets for farmers were wholesalers (17.8 per cent), retailers (58.6 per cent), restaurants (18.7 per cent), and consumers (4.9 per cent). In 1982 only 15 per cent of the prawns farmed in Hawaii were being marketed off-island, 85 per cent being sold live in Hawaii. The rest went to mainland U.S., chilled on ice (Lee Ure, reported in Aquaculture Digest, 8.8.2.). The major consumer in Hawaii was the Filipino community. It would be necessary to 'educate Caucasians' to consume this product. The Hawaiian market for prawns was reported to be stable, at 117 tons/year (Lee, 1984). Only about 21 tons/year was being shipped to continental U.S. Demand, both there and Hawaii, was said to exist but no firm estimates of potential had been made. One of the problems experienced by the expanding Hawaiian prawn farming industry was being economically able to supply the quantities needed on a regular basis to continental U.S. restaurateurs interested in featuring them. One marketing agent in New York in 1985 appealed for suppliers of prawns; 45 kg was required on a regular weekly basis (Shnider, 1985).

In early 1982 the Amfac Food Group was telling its stockholders that it predicted that the U.S. 'heads-on' market for prawns was over 4,500 tons/yr with a value of US\$ 50 million (Anonymous, 1982); their Hawaiian cultured prawns were being test marketed in a frozen, whole, size-graded form in Los Angeles and Chicago. However, later in the same year, Amfac were reported to be abandoning their two-year pilot project in Hawaii and returning the land to sugar production. This was because test marketing showed "weak consumer support for the product at cost-effective prices" (Amfac news release dated 10 September 1982, quoted by Aquaculture Digest 7.11.8.). General Mills, Inc., which owned the Red Lobster Inn seafood restaurant chain began a pilot prawn farm in Honduras in 1972 to supply at least part of its need for more than 4,500 tons/year of shrimp tails in 1981 (Wulff, 1982b). General Mills sold their Honduran farm in 1983 to a local company in order to concentrate on its retailing activities and to develop a technology transfer business in prawn culture (Aquaculture Digest, 8.12.11.).

The Weyerhaeuser Company, starting its own pilot prawn farm in Brazil in 1981, intended to test market them on the East Coast of the United States and in Europe and were expecting them to end up in "the white table cloth class of restaurants" (Kadera, 1981). In 1986, Israeli-produced prawns were reported as being exported head-on to Europe and the U.S.A. (Aquaculture Digest,

11.2.53.). The Israeli export potential for prawns was, in 1978–1979, thought to be for 30 g head-on animals (Arieli *et al.*, 1981). Initial quantities were culled from monoculture and were 35–40 g in average weight. When the major supply became available in October from poly culture, they were marketed at 45–90 g. Again regularity of supply, if marketed fresh on ice in styrofoam boxes with a covering of dry ice as they were, would be a problem. Prawns originating from Jamaican aquaculture were being marketed in the U.S. head-off in small quantities but the Israeli company concerned believed they should be marketed head-on (Anonymous, 1986b). Jamaica and Puerto Rico are now said to be exporting large quantities of freshwater prawn to the US (Aquaculture Digest, 13.3.13.).

In 1980, restaurants and processing firms in Japan were reported to be buying prawns being cultured in rice paddies as a response to rice surpluses (Anonymous, 1980). In 1986 freshwater prawns, of which 20 tons/year were exported to Japan in 1983, were said to be in high local demand in Taiwan (Aquaculture Digest, 12.9.5.). Restaurant and fish buyers come to the farm-gate to buy the prawns.

2.4 Economics

Few economic studies of freshwater prawn farming have been published and many of these were feasibility studies rather than case studies of existing farms. By 1986, US\$ 3 million had been invested in a Puerto Rican prawns farm (Anonymous, 1986a). A study of the feasibility of farming prawns in Jamaica examined the projected economics of a 4-acre farm (8 ponds $\times$ $\frac{1}{2}$ acre) buying in its postlarvae and marketing its product fresh on ice in Jamaica after 9 months batch culture (ADCP, 1983a). The annual return, after interest and depreciation was about US\$ 2,580. A similar, unpublished, economic appraisal of the potential of freshwater prawns farming in the Dominican Republic (ADCP, 1983b) calculated that the annual return on a 4-acre farm would be US\$ 15,000. A feasibility report on freshwater prawn farming in Dominica in 1977 concluded that 2.5 or 10-acre farms would be economically viable as an alternative land use for existing private or government land owners, assuming certain site characteristics (New and Rabanal, 1987). Based on a mixture of projected farm sizes and types with a total annual national output of 50 tons of prawns per year a positive cash flow would have appeared in year 5 and cumulative cash flow would have turned positive in year 9.

A study of the economic status of prawn farming in Thailand in 1980 (Anonymous, 1980a) found that both hatcheries and grow-out units of all sizes were highly profitable. In most cases the initial investment could be paid off within the second year of operation. The initial investment for hatcheries ranged from US\$ 1,000 for 'backyard' operations, to more than US\$ 50,000 for large units. Annual hatchery operating costs were 5.6 times the initial investment for small hatcheries but only 1.8 times for medium and large hatcheries. (In the study, the small hatcheries were defined as having an annual production of < 2 million post larvae and most were inland.) Feed and water costs accounted for 42–67 per cent of operating costs. Annual hatchery profits ranged from US\$ 2,200 for small hatcheries to about US\$ 37,200 for large ones. The rates of return on investment were 236 per cent for 'backyard' hatcheries, 154 per cent for medium and 62 per cent for large hatcheries. Costs of production were US\$ 11.5, US\$ 9.0 and US\$ 10.0 for 1,000 post larvae for small, medium and large hatcheries respectively. Hatcheries integrated with grow out units produced post larvae at lower cost (US\$ 6.0/1,000) and coastal hatcheries produced at lower costs than inland hatcheries trucking sea water or brine. Labour is said to constitute 52 per cent (Shang, 1974) to 77 per cent (Fujimura and Okamoto, 1972) of the costs of post larval prawn production.

Investment in Thai grow-out farms ranged from US\$ 3,125–6,250/ha (Anonymous 1980a). Land costs were US\$ 3,125–5,000/ha. Annual operating costs were US\$ 4,396, US\$ 3,319 and US\$ 4,225 for small, medium and large farms respectively. (In the study the small grow-out farms were defined as < 1.6 ha, medium were 2.4–6.4 ha and large were > 8 ha.). All of the farms studied were profitable. The annual profit averaged US\$ 2,754, US\$ 5,431 and US\$ 3,275/ha for small, medium and large farms respectively. Corresponding rates of return on investment were 51 per cent, 108 per cent and 58 per cent. For medium size farms the initial investment could be paid off within one year: for others it took two years. Generally speaking, at the average market value of prawns in 1980 in Thailand (US\$ 7.50/kg) the report gave a break-even annual productivity of 588 kg/ha, 444 kg/ha and 563 kg/ha (small, medium and large farms). If 1986 prices had prevailed then the breakeven annual productivities would have been about 1,100, 831 and 1,056 kg/ha respectively. It is interesting to note that prawn farming in Thailand was still rapidly expanding in 1987, despite the drop in the market value of the crop. A recent study by Shang and Lin (1988) confirmed that all sizes of grow-out farms in Thailand were profitable but that those in the medium range were the most successful.

The author of the economic study of grow-out production of prawns in Thailand included in Anonymous (1980a) later compared this with the situation in Hawaii (Shang, 1982). In this study the investment required to start a farm in Hawaii was shown to be much higher than in Thailand, mainly due to the 2.5–8.9 times higher cost of pond construction (US\$ 20,500–43,000/ha). In Hawaii, pond construction costs decreased with increasing farm size due to economics of scale, whereas the converse was true in Thailand where the larger farms spent more on construction and equipment per unit area. Hawaiian labour costs per unit area averaged 5–6 times those in Thailand. On average, the cost of land, interest, feed and depreciation were much higher in Hawaii. Average annual productivity at 2,273 kg/ha was also higher than in Thailand (1,068 kg/ha). The lower productivity in Thailand was attributed to lower stocking rates and the shortage of water in certain seasons. The cost of labour and feed per unit of prawns produced was 6.8 and 2.1 times higher, respectively, in Hawaii than Thailand but the cost of post larvae per unit of marketable weight was lower due to the lower cost of government hatchery supplied post larvae at that time in Hawaii and to better survival rates. Total production costs per kg of marketable prawn were US\$ 8.61–10.50 in Hawaii, compared to US\$ 3.00–4.50 in Thailand. Farm-gate prices for prawns in Hawaii averaged a little higher (US\$ 8.80/kg) than in Thailand (US\$ 7.30/kg) but the low production costs in Thailand generated profits. While small (0.4 ha), medium (4 ha) and large (8 ha) Thai farms made average profits of US\$ 1,113, US\$ 2,297 and US\$ 1,139 in 1980, corresponding farms in Hawaii made an average loss of US\$ 1,543 for small farms, and US\$ 1,344 for medium farms, and only just broke even at a profit of US\$ 170 for large farms. Clearly, in Hawaii prawn farms would need to be considerably larger than 8 ha to be profitable, whereas profitability in Thailand was achievable at all farm sizes studied. 4 ha farms were the most profitable size in Thailand. Shang (1982) saw clear competitive advantages, should prawns become a global commodity for production locations with low production and marketing costs. By 1987, accelerating Thai exports to Europe were demonstrating the truth of this forecast.

Samples and Leung (1985), during conceptual modeling of Hawaiian prawn production, showed that at a wholesale price of US\$ 11/kg there is a 50 per cent possibility that a representative 8 ha farm utilizing ponds greater than 0.8 ha in surface area will incur a financial loss in any given year. The probability falls to 30 per cent if ponds smaller than 0.4 ha are utilized.

Taiwanese fresh water prawn farmers estimate that total production cost is US\$4.16/kg (Aquaculture Digest, 12.9.5.), while revenue is US\$ 8.00–9.60/kg. However, farms are small and,

like those in marine shrimp farming there, utilize family labour. The production cost does not include rent or pond construction and maintenance. Rent for a freshwater pond in Taiwan, at US\$ 3,200/ha/yr, is one quarter that of ponds for marine shrimp culture. Ponds are, after several culling harvests, totally harvested after a growing season of about 5½–6 months. Production is high, varying from 2.5–7 mt/ha per crop, reflecting the use of paddlewheel aeration, intensive feeding, heavy stocking rates (in excess of 20/m²) and careful water quality management. The unit feed cost is about US\$ 640/mt and the FCR ranges from 1.4:1 to 2.2:1, averaging 2:1. Compounded feed costs therefore represent about 31 per cent of total costs. However, Taiwanese farmers also use yellow bean cake, wheat and trash fish as dietary supplements when available; they also use fertilization.

Many other reports on the economic feasibility of the hatchery and grow-out phases of prawn farming in various locations exist but are not reviewed here. These include studies in Martinique (Elizabeth-Mesnager, 1981), Samoa (Popper, 1982), Malaysia (Tien songrusmee, 1983), the Indian sub-continent (Karim, 1982), a geothermal farm in Oregon, U.S.A. (Oregon Institute of Technology, 1981), and in South Carolina, U.S.A. (Smith *et al.*, 1983). Bauer *et al.*, (1983), investigating the costs and returns for prawn farming as a supplemental enterprise in South Carolina, reported that potential profitability was particularly likely if existing pond facilities, already discounted into the value of the land or having been constructed during a period of lower investment costs, were available. Pashen (1984), examining the feasibility of prawn farming in Queensland, Australia, estimated that an 8-ha prawn farm would require an initial investment of US\$ 210,000. After two or three years' operation the break-even price of prawns would be US\$ 8.13/kg. Prawns would not have completed favourably with marine shrimp in Australia at this price. In Israel, six month seasonal prawn monoculture was said (Aquaculture Digest, 10.11.9.) to raise a gross revenue of US\$ 14,250/ha. After postlarval costs of US\$ 5,500/ha and feed costs of US\$ 1,250, US\$ 7,500/ha was left to cover other costs and profit.

Not everybody makes money growing prawns. Some of the hazards that attend all aquaculture ventures have befallen prawn farming. Wulff (1982b) recorded that all ponds were flooded and the prawns escaped from a farm in Honduras, following hurricane Fifi. Cook (1980) noted that a farmer in Louisiana, who stocked 252,000 young prawns costing US\$ 10,000 harvested only 28,000 harvest-sized prawns which were sold to Antoine's Restaurant in New Orleans for US\$ 5,100. This brave farmer tried again, only to lose his second crop in an unexpected cold front.

3. Materials and methods

3.1 Study area (Khulna district)

The survey was conducted in 10 upazila (Koyra, Paikgacha, Dumuria, Fultala, Digholia, Terokhada, Rupsha, Batiaghata, Dacope and Metro) in Khulna district. The main prawn production areas among 10 upazila of Khulna district are Dumuria, Fultala, Terokhada and Digholia. Khulna district is a coastal area of the Bay of Bengal, which is situated at the south-western part of Bangladesh. Khulna is the most important and promising area for fresh water prawn (*Macrobrachium rosenbergii*) farming, because the availability of wild post larvae (Haroon, 1990). Prawn post larvae require brackish water in the initial stages of their life cycle and therefore, they are found in water that is directly or indirectly connected with the sea (New and Singholka, 1985). Thus post larvae were collected from coastal areas of Khulna district and also from other districts such as Noakhali, Satkhira, Bagherhat, Patuakhali and Borguna which are very close to Khulna district (Angell, 1990). Therefore Khulna district becomes one of the most suitable sites for prawn farming.

3.2 Data collection

The survey was conducted the period of one year between January to December in 2004. The data was collected by using questionnaire interviews with prawn traders and participatory rapid appraisal (PRA) tools like Focus Group Discussion (FGD) with prawn farmers. Prawn traders for face to face questionnaire interviews were selected randomly. Interviews were conducted in the market places. PRA tools were used to get an overview of some particular issues like prawn harvesting and marketing. Data also have collected from three fish processing industries that export prawn to the international markets. Data were also collected from the Bureau of statistics and Export promotion bureau, Bangladesh. Cross check interviews were conducted with many respondents of different categories as possible.

3.2.1 Primary data collection

Primary data were collected by field survey through structured questionnaires. The query was involved in exist production and marketing system of fresh water prawn as well as distribution channel of prawn from harvesting to export.

3.2.2 Secondary data collection

Data about the information of prawn production, marketing and export were collected from relevant government and non-government organizations such as Department of Fisheries (DoF), Bangladesh Bureau of statistics (BBS), Bangladesh Export Promotion Bureau (BEPB), Bangladesh Frozen Foods Exporters Association and Upazila Fisheries Office and District Fisheries Office.

3.2.3 Instruction criteria for data collection

Data collection (Level-1)

- a) Name and No. of upazila

- b) No. of farm in each upazila
- c) Manpower/farmers involved in each upazila
- d) Upazila wise production
- e) Existing culture system in each upazila.

Data collection (Level-2)

- f) Name and No. of depots
- g) No. of manpower
- h) No. of locality
- i) Amount of approximate production
- j) Grading system
- k) Marketing system
- l) Transportation system
- m) Problems.

Data collection (Level-3)

- n) Processing and preservation procedures
- o) HACCP audits
- p) Traceability
- q) Exporting grade (international grade)
- r) Quality management system.

Data analysis

Computer software support

- i) MS Word ii) MS Excel and iii) SPSS

Production counting

Production of Upazila = Average production from 3 to 15 depots in 1 locality X
total depots of each market in the upazila.

Test

- i) t-test: paired two samples for means
- ii) Linear regression analysis
 - $y = a + bx$ (Hosmand, 1998)
 - y = co-ordinate value along the vertical axis (dependant variables)
 - x = co-ordinate value along the horizontal axis (independent variables)
 - a = intercept of the curve
 - b = slope of the curve.
- iii) Co-relation co-efficient 'r'

$$r = \frac{\sum xy}{N \sigma_x \sigma_y}$$

Where,

$$x = x_i - \bar{x}$$

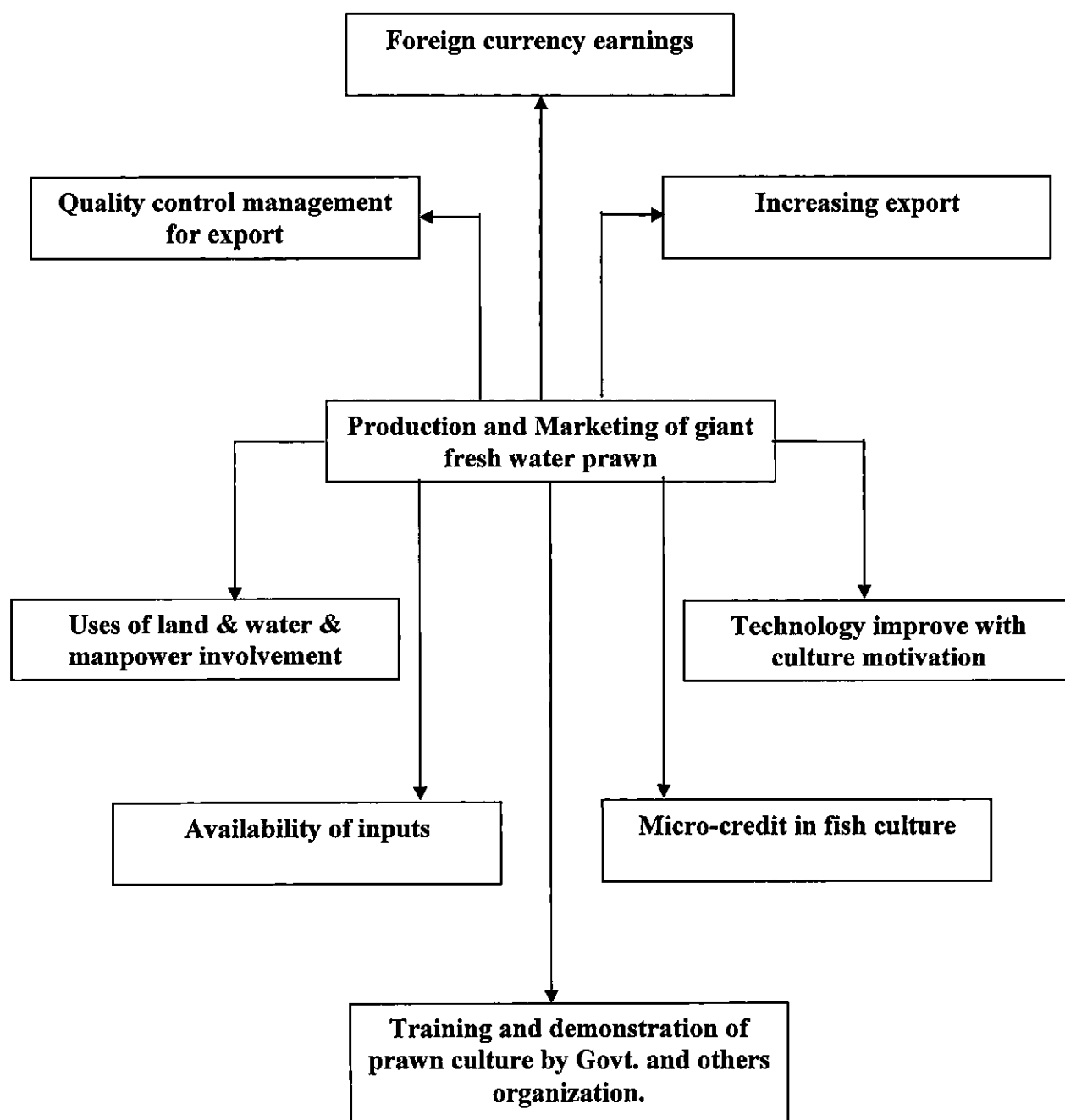
$$y = y_i - \bar{y}$$

σ_x = Standard deviation of series x

σ_y = Standard deviation of series y

N = Number of pair of observation

Objective Tree Analysis and Projection of the Work



4. Results and discussion

4.1 Fresh water prawn trading

4.1.1 Fresh water prawn harvesting and local market

The fresh water prawn, *Macrobrachium rosenbergii* (De Man, 1879) is commercially cultured in Khulna district of Bangladesh. Thousands of farmers in this area have converted their paddy fields to prawn farms to accommodate a profitable prawn culture practices. Ten upazilas of Khulna district are more or less involved in prawn farming and trading. Out of ten upazilas Dumuria is the most productive place in Khulna district. Major production is estimated from here. Comparatively, there was noticed a poor production in Dacope, Koyra, Paikgacha and Batiaghata causes of suitable for brackish water shrimp culture. Terokhada, Fultala, Rupsha, Digholia and Metro upazila are favor for prawn culture as suitable water quality and climatic support.

In Khulna district, the peak season of prawn harvesting is from November to February. Farmers harvest their prawns by using cast net (locally called 'Khepla jal') and barrier net (locally called 'goga jal'). Cast nets are generally used for small gher (prawn farms are locally called 'gher') and barrier nets are used for large sized gher. Harvested prawns are kept in Aluminium containers. Farmers commonly use vans to transport the prawns from gher to the local markets. Farmers directly sell their all head-on prawns to their local markets traders or via *foria* to the prawn traders. Prawn traders are small businessmen in prawn markets who are locally called 'depot malik'.

Their premises are modest, they might have a small rented tin-shed warehouse-cum-office in the market places equipped with a portable ice chest and weighing machine for grading. The depot malik are normally based in local markets near to the prawn farming areas. *Foria* are the field workers of prawn trading business. Their jobs are to carry head-on prawns from remote villages to the prawn traders in market centers. The prawn supply chain from farmers to the international markets always pass through a number of middle men, *foria*, prawn traders, agents and companies.

4.1.2 Distribution and manpower of trading depots

Fresh water prawn trading depots were found in 10 upazilas namely Koyra, Paikgacha, Dumuria, Fultala, Digholia, Terokhada, Rupsha, Batiaghata, Dacope and Metro in Khulna. The total number of fresh water prawn depots and manpower involved in Khulna district was 921 and 2871 respectively in 2004. The distribution of fresh water prawn depots with number of person involved in each depot are shown in Table-1.

Table-1: Distribution of fresh water prawn trading depots at Khulna district in 2004.

<i>Upazila</i>	<i>Locality no.</i>	<i>Depot No.</i>	<i>Manpower</i>
Koyra	4	10	17
Paikgacha	3	11	36
Dumuria	26	280	661
Fultala	4	49	108
Digholia	4	52	124
Terokhada	5	51	122
Rupsha	4	411	1668
Batiaghata	6	40	106
Dacope	3	7	11
Metro	3	10	18
Total	62	921	2871

(Source: Field survey, 2004.)

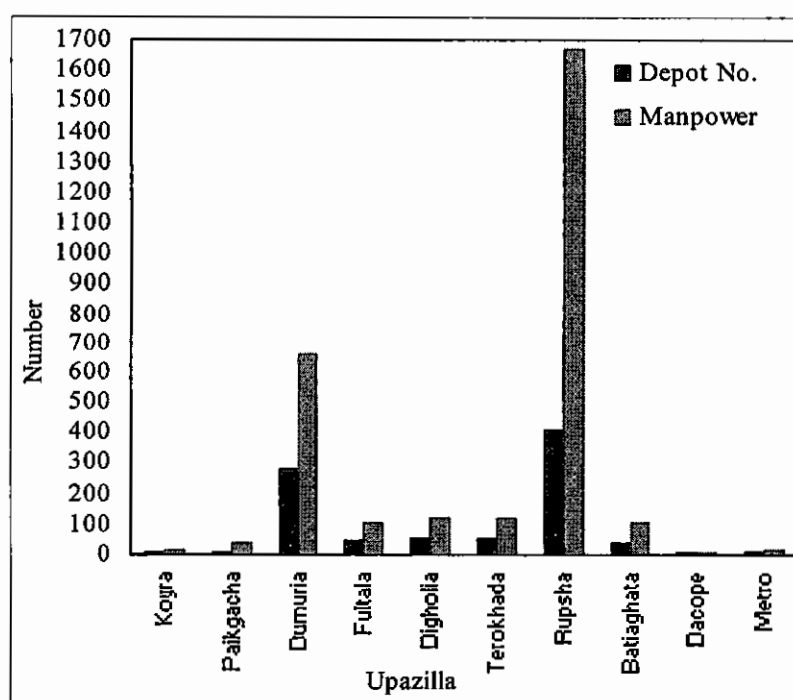


Figure-1: Manpower distribution of fresh water prawn trading depots at Khulna dist. in 2004.

The number of fresh water prawn depots and manpower in Koyra, Paikgacha, Dumuria, Fultala, Digholia, Terokhada, Rupsha, Batiaghata, Dacope and Metro were counted to be 10 and 17; 11 and 36; 280 and 661; 49 and 108; 52 and 124; 51 and 122; 411 and 1668; 40 and 106; 7 and 11 and 10 and 18 respectively. Persons involved in fresh water prawn business were maximum in Rupsha (1668) and the minimum in Dacope (11) Upazila. The total numbers of depots involved in fresh water prawn business in Khulna district were estimated to be maximum in Rupsha (411) and minimum in Dacope (7) respectively. The number of locality, where depots available, was counted to be 26 at Dumuria Upazila in Khulna District in 2004 (Table-1).

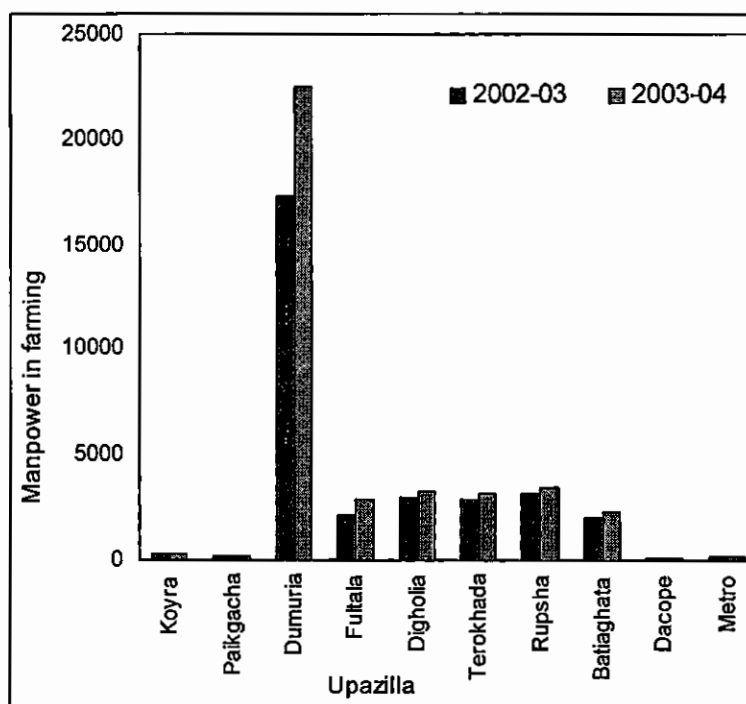


Figure-2: Manpower distribution of fresh water prawn farming at Khulna dist. in 2004.

4.1.3 Physical condition of fresh water prawn trading depots

Most of the fresh water prawn depots were located nearby the river and/or road and easily connected with the high ways. The location of the depots depends on supply of fresh water prawn from various sources. Physical condition of depots in Khulna district of Bangladesh are shown in Table-2. Out of 921 depots in the Khulna district, 5.32%, 42.02% and 52.66% were 'Katcha', 'Semi-pacca' and 'Pacca' respectively (Table-2).

In terms of construction materials, the depots were categorized into 'Katcha' (made of bamboo, bamboo-fence, and by Nypa-leaves with earthen floor), 'Semi-pacca' (made of bamboo, wood and tin roof with concrete floor), and 'Pacca' (made of bricks, RCC and concrete).

The upazila wise distribution of 'Katcha', 'Semi-pacca' and 'Pacca' type depots in Khulna district are shown in Table-2. The total numbers of percentage of 'Katcha', 'Semi-pacca' and 'Pacca' depots in Koyra, Paikgacha, Dumuria, Fultala, Digholia, Terokhada, Rupsha, Batiaghata, Dacope and Metro were 1.09, 1.19, 30.40, 5.32, 5.65, 5.54, 44.63, 4.34, 0.76 and 1.09% respectively (Table-2). The highest and lowest percentage of 'Katcha' 'Semi-pacca' and 'Pacca' depots were in Koyra (40%) and Rupsha (2.19%); Paikgacha (63.64%) and Rupsha (26.03%); Rupsha (71.78%) and Koyra (10%) respectively (Table-3).

Table-2: Physical condition of fresh water prawn depots in Khulna district of Bangladesh in 2004.

Upazila	Katcha	Semi-pacca	Pacca	Total	%
Koyra	4	5	1	10	1.09
Paikgacha	2	7	2	11	1.19
Dumuria	14	156	110	280	30.40
Fultala	4	25	20	49	5.32
Digholia	5	32	15	52	5.65
Terokhada	3	28	20	51	5.54
Rupsha	9	107	295	411	44.63
Batiaghata	6	22	12	40	4.34
Dacope	1	3	3	7	0.76
Metro	1	2	7	10	1.09
Total	49	387	485	921	100.00
%	5.32	42.02	52.66		100.00

(Source: Field survey, 2004.)

Table-3: Percentage distribution of fresh water prawn trading depots of different upazila at Khulna dist. in 2004.

Upazila	Katcha %	Semi-pacca %	Pacca %
Koyra	40.00	50.00	10.00
Paikgacha	18.18	63.64	18.18
Dumuria	5.00	55.71	39.29
Fultala	8.16	51.02	40.82
Digholia	9.62	61.54	28.85
Terokhada	5.88	54.90	39.22
Rupsha	2.19	26.03	71.78
Batiaghata	15.00	55.00	30.00
Dacope	14.29	42.86	42.86
Metro	10.00	20.00	70.00



4.1.4 Grading system

Fresh water prawns are sold at various ranges of price depending on size condition (i.e. Shell on-Head on and Shell on-Headless). Therefore, there are different categories of the fresh water prawn in both local and foreign market.

4.1.4.1 Local grading system

The price of the fresh water prawn depends on size and condition (i.e. Shell on-Head on and Shell on-Headless). Therefore, fresh water prawn traders use several types of grading regions on the basis of body weight, hardness and the presence of the head on or headless of the fresh water prawn. The grading system is different for fresh water prawn in the condition of Shell on-Head on and Shell on-Headless. Generally, both condition the Shell on-Head on and Shell on-Headless fresh water prawn were graded into some fixed categories in all districts of the south-western

region even in our country and foreign markets. The grading system of fresh water prawn is more or less same for locations in the south-western region. Fresh water prawn having body weight over 200 gm (Grade-5), 125 gm (Grade-8), 83.33 gm (Grade-12), 50 gm (Grade-20), 33.33 gm (Grade-30), 20.00 gm (Grade-50) and 14.30 gm (Grade-70) with hard shell are the purchase specification for headless-shell on prawn respectively and prawn having body weight over 200 gm (Grade-5), 100 gm (Grade-10), 50 gm (Grade-20), 33.33 gm (Grade-30), 20.00 gm (Grade-50) and 16.66 gm (Grade-60) with hard shell are the purchase specification for head on-shell on prawn respectively (Table-4). Sometimes PD is categorized the prawn with having soft shell or deviate from weight scale. Most of the PD graded prawn goes to local market for local consuming of the people at low rate.

Table-4: Grading system of fresh water prawn (*Macrobrachium rosenbergii*) by no. and weight in local market.

Purchase specification							
Head less-Shell on							
Grade	G-5	G-8	G-12	G-20	G-30	G-50	G-70
Weight (gm)	200.00	125.00	83.33	50.00	33.33	20.00	14.30
No. of The Prawn (pcs)	1--5	6--8	9--12	13--20	21--30	31--50	51--60
Head on-Shell on							
Grade	G-5	G-10	G-20	G-30	G-50	G-60	PD
Weight (gm)	200.00	100.00	50.00	33.33	20.00	16.66	-
No. of The Prawn (pcs)	1--5	6--10	11--20	21--30	31--50	51--60	-

(Source: Field survey, 2004.)

4.1.4.2 International grading system

The international grading system varies from local grading system and buyers demand or requirements. Fresh water prawn having over 200 gm (Grade-5), 100 gm (Grade-10), 50 gm (Grade-20), 33.33 gm (Grade-30), 20.00 gm (Grade-50) and 16.66 gm (Grade-60) is the main specification for purchasing. A weighing procedure and standard is maintained according to the specification. Therefore, weighing must be entrusted to a responsible person. Weighing is done in a normal balance. Normally the shell on prawn is packed with 1.2 kg, 1 kg, 0.8 kg or as per buyer choice. Weight extra 2% for shell on and 5% for peeled should be allowed to prevent weight shortage. Semi IQF is packed according to the buyer specification. A team of 5 to 6 persons are engaged to specify for grading by hand on the grading table. All of team are skilled and efficient. Out of them one is selected as team leader whose main responsibility is to check the grade whether any deviation is occurred. Grading is dependent on buyer's requirements. The company normally follows the under stated (Table-5) grading procedure and the tolerance limits. But it is changed according to the buyers and sellers contact. Around 100 companies are involved in exporting of fresh water prawns from Mongla port or Chittagong port to the international markets. Most of the companies are located in Khulna, some 30 km far from Bagherhat district. Generally three types of processing methods are followed by companies which are 1) block package 2) Intrusion Quick Frozen (IQF) and 3) cooked (ready for eat). About 120 to 150 permanent labors work in a single company for prawn processing. After processing, companies supply their prawns through Mongla port or Chittagong port by using their own refrigerator van. Shipping agents load the prawns into the ships. Containers are used for carrying the prawns in the ships. In general the size of containers is 20 ft x 40 ft. Each container contains about 16000 to

18000 kg of prawns. Each company daily exports average 8 to 10 ton of prawns during the season (November to February). The average price of prawns depends on grade.

Table-5a: Grading system of fresh water prawn (*Macrobrachium rosenbergii*) for 1.2 kg packing (Headless-Shell on) in international markets.

Size	Total Pcs	Tolerance	Weight of each shrimps (gm.)	
			Large	Small
U/5	13	12--13		90.8
6/8	21	20--21	75.66	56.75
8/12	31	30--31	56.75	37.83
13/15	39	38--39	34.92	30.26
16/20	52	51--52	28.37	22.7
21/25	66	65--66	21.61	18.16
26/30	79	78--79	17.46	15.13
31/40	105	104--105	14.64	11.35
41/50	132	131--132	11.07	9.08

(Source: Survey in processing industries, 2004.)

Table-5b: Grading system of fresh water prawn (*Macrobrachium rosenbergii*) for 1 kg packing (Headless-Shell on) in international markets.

Size	Total Pcs	Tolerance	Weight of each shrimps (gm.)	
			Large	Small
U/5	11	10--11		90.8
6/8	17	16--17	75.66	56.75
8/12	26	25--26	56.75	37.83
13/15	33	32--33	34.92	30.26
16/20	44	43--44	28.37	22.7
21/25	55	54--55	21.61	18.16
26/30	66	65--66	17.46	15.13
31/40	88	87--88	14.64	11.35
41/50	110	109--110	11.07	9.08

(Source: Survey in processing industries, 2004.)

Table-5c: Grading system of fresh water prawn (*Macrobrachium rosenbergii*) for 800 gm packing (Headless-Shell on) in international markets.

Size	Total Pcs	Tolerance	Weight of each shrimps (gm.)	
			Large	Small
U/5	9	8--9		90.8
6/8	14	13--14	75.66	56.75
8/12	21	20--21	56.75	37.83
13/15	26	25--26	34.92	30.26
16/20	35	34--35	28.37	22.7
21/25	44	43--44	21.61	18.16
26/30	52	51--52	17.46	15.13
31/40	70	69--70	14.64	11.35
41/50	88	87--88	11.07	9.08

(Source: Survey in processing industries, 2004.)

4.2 Production of fresh water prawns from the Khulna district of Bangladesh

4.2.1 Annual production of different upazilas of Khulna district

The approximate annual production of fresh water prawn was estimated from the Khulna district of Bangladesh through regular field survey at monthly interval from randomly selected fresh water prawn depots of Koyra, Paikgacha, Dumuria, Fultala, Digholia, Terokhada, Rupsha, Batiaghata, Dacope and Metro upazila in Khulna district and gross production from the farms of that upazilas for a period of one year from January to December, 2004. In addition, the annual expected production of fresh water prawn was calculated from upazila based monthly counted data. The total expected and observed production in Khulna district was 8431.86 and 13229.37 ton respectively.

The annual observed production was 46.06, 21.46, 4065.32, 344.34, 555.36, 488.02, 7292.19, 368.03, 18.40 and 30.19 ton and the annual expected production was 59.20, 29.39, 5465.20, 361.96, 623.42, 679.34, 756.54, 403.68, 21.73 and 31.40 ton in Koyra, Paikgacha, Dumuria, Fultala, Digholia, Terokhada, Rupsha, Batiaghata, Dacope and Metro upazila in Khulna district respectively (Table-6). Both the maximum observed (7292.19 ton) and expected (5465.20 ton) production was found in Rupsha and Dumuria Upazila respectively and the minimum was 18.40 ton and 21.73 ton in Dacope (Table-6). A monthly/seasonal variation of the production of fresh water prawn showed in Khulna district. The observed production was maximum 2262.42 ton in February but the expected production was maximum 1368.31 ton in the same time in Khulna district (Table-7). While the observed and expected production was found to be minimum 252.89 ton and 159.05 ton respectively in July in Khulna district (Table-7). Patra (1980) reported that *Macrobrachium rosenbergii* was less available during months from May to August. The variation of observed and expected production in Khulna district is shown in Figure-3 and 4.

Table-6: Upazila wise total observed and expected production (ton) of fresh water prawns (*Macrobrachium rosenbergii*) from 10 upazilas in Khulna district of Bangladesh in 2004.

	Koyra	Paikgacha	Dumuria	Fultala	Digholia	Terokhada	Rupsha	Batiaghata	Dacope	Metro	Total
Observed Production	46.06	21.46	4065.32	344.34	555.36	488.02	7292.19	368.03	18.40	30.19	13229.37
Expected Production	59.20	29.39	5465.20	361.96	623.42	679.34	756.54	403.68	21.73	31.40	8431.86

Table-7: Month wise total observed and expected production (ton) of fresh water prawns (*Macrobrachium rosenbergii*) from 10 upazilas in Khulna district of Bangladesh in 2004.

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
Observed Production	2015.78	2262.42	1332.91	807.91	529.07	263.74	252.89	533.79	1045.36	1205.73	1350.27	1629.50	13229.37
Expected Production	1183.79	1368.31	845.14	504.90	326.94	174.50	159.05	356.75	736.02	776.05	921.17	1079.24	8431.86

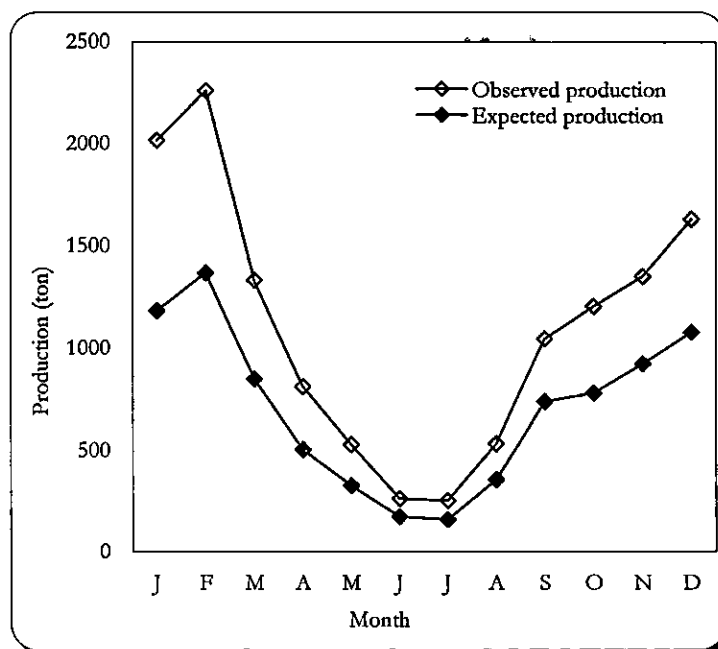


Figure-3: Month wise relationship between observed and expected production (ton) of fresh water prawns (*Macrobrachium rosenbergii*) from 10 upazilas in Khulna district of Bangladesh in 2004.

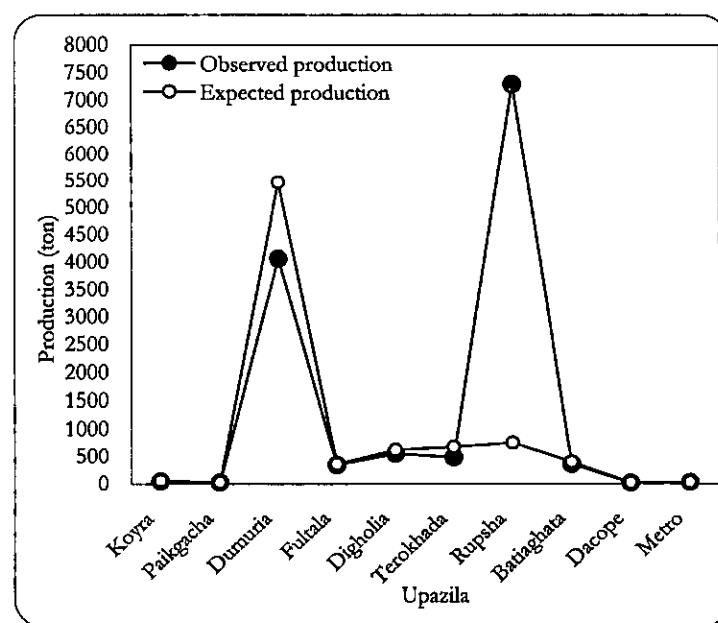


Figure-4: Upazila wise relationship between observed and expected production (ton) of fresh water prawns (*Macrobrachium rosenbergii*) from 10 upazilas in Khulna district of Bangladesh in 2004.

4.2.2 Relationship between Manpower in Depots and Production of Fresh water prawn

The total manpower involved in depots is rationally correlated with the production of fresh water prawn business in the Khulna district of Bangladesh. The regression analysis of the equation that mentioned below deliberately declared the functional correspondence of correlation of the two major units like production and manpower. The value of correlation coefficient 'r' shows the positively correlation between manpower involved in depots and production of fresh water prawns.

Out of 10 upazilas in khulna district the relationship between manpower involved in depots and production of fresh water prawns in Koyra and Dumuria upazila was significant at 1% level (the regression y on x is $y=1.287+2.407x$, $y=14.048+5.598x$ respectively) and in Digholia, Terokhada and Batiaghata upazila was significant at 5% level (the regression y on x is $y=12.338+4.081x$, $y=6.466+3.735x$, $y=15.938+2.570x$ respectively).

Table-8: Relationship between manpower and production of fresh water prawn (*Macrobrachium rosenbergii*) in all upazila in Khulna district in 2004.

Upazila	Regression equation (y on x) $y=a+bx$	Correlation coefficient "r"	Value of 't'	't' crit. Value (5% level)	't' crit. Value (1% level)
Koyra	$y=1.287+2.407x$	0.91931	*11.834904	4.3026557	9.9249883
Paikgacha	$y=1.224+0.494x$	0.99634	1.30392157	12.706150	63.655898
Dumuria	$y=14.048+5.598x$	0.88104	*4.9910512	2.0638981	2.7969509
Fultala	$y=1.359+3.138x$	0.99656	1.68025171	4.3026557	9.9249883
Digholia	$y=12.338+4.081x$	0.96731	**5.0794505	4.3026557	9.9249883
Terokhada	$y=6.466+3.735x$	0.91171	**3.4764227	3.1824493	5.8408477
Rupsha	$y=96.393+4.141x$	0.98020	1.96185476	4.3026557	9.9249883
Batiaghata	$y=15.938+2.570x$	0.87267	**2.9743360	2.7764508	4.6040804
Dacope	$y=1.398+1.292x$	0.95805	3.17322834	12.706150	63.655897
Metro	$y=2.076+1.331x$	0.99764	9.55072464	12.706150	63.655898

* = Significant at 1% level, ** = Significant at 5% level

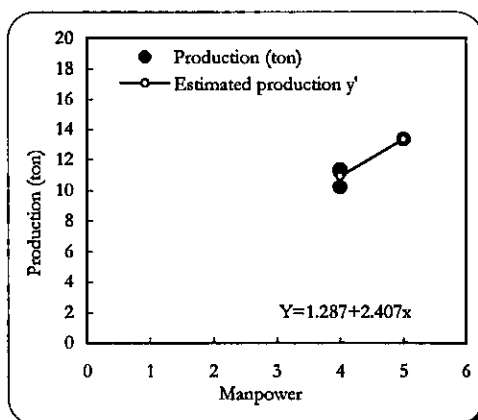


Fig-5a: Regression of y between manpower and production of fresh water prawn (*Macrobrachium rosenbergii*) at Koyra upazila in 2004.

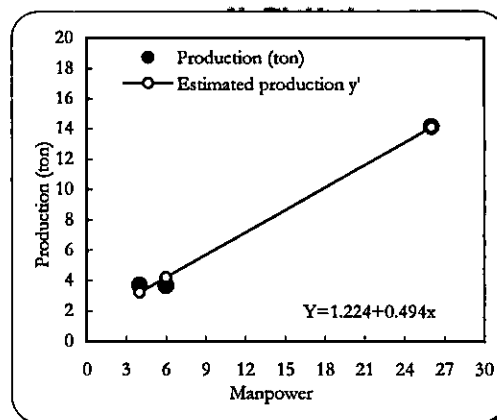


Fig-5b: Regression of y between manpower and production of fresh water prawn (*Macrobrachium rosenbergii*) at Paikgacha upazila in 2004.

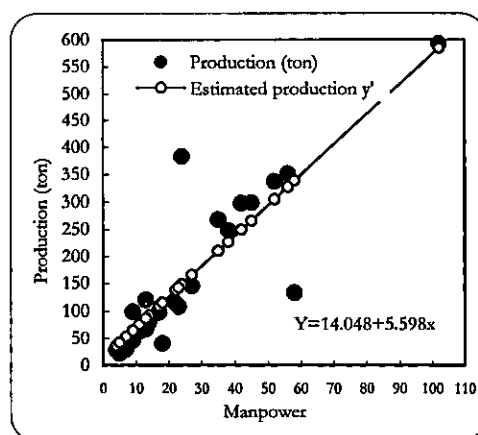


Fig-5c: Regression of y between manpower and production of fresh water prawn (*Macrobrachium rosenbergii*) at Dumuria upazila in 2004.

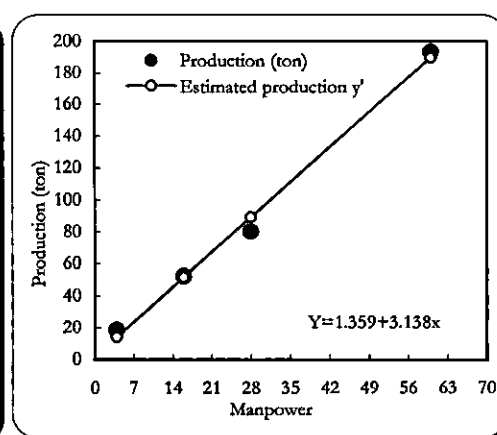


Fig-5d: Regression of y between manpower and production of fresh water prawn (*Macrobrachium rosenbergii*) at Fultala upazila in 2004.

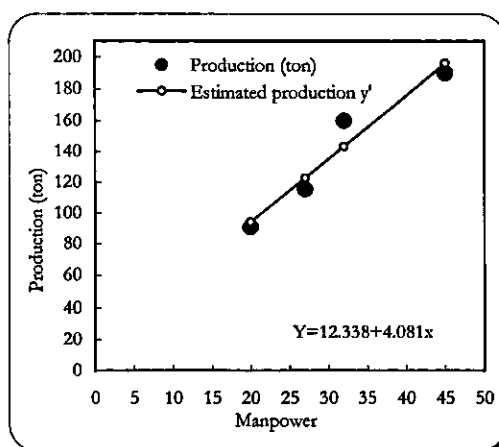


Fig-5e: Regression of y between manpower and production of fresh water prawn (*Macrobrachium rosenbergii*) at Digholia upazila in 2004.

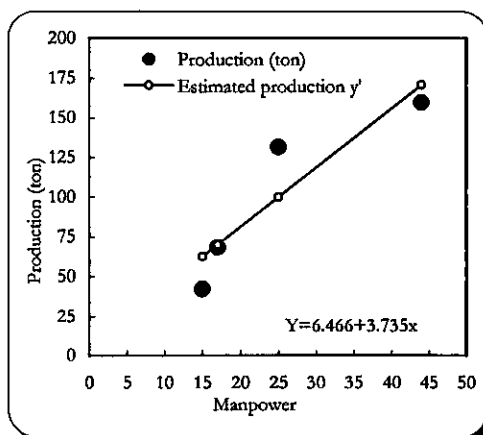


Fig-5f: Regression of y between manpower and production of fresh water prawn (*Macrobrachium rosenbergii*) at Terokhada upazila in 2004.

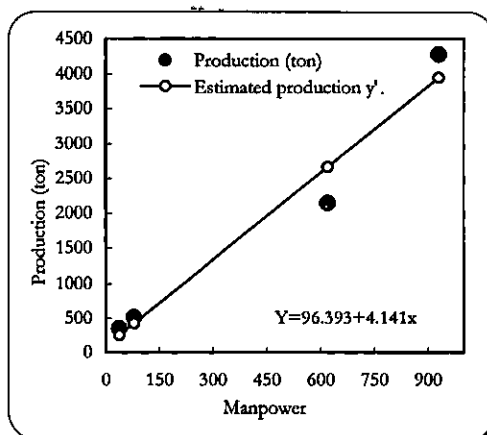


Fig-5g: Regression of y between manpower and production of fresh water prawn (*Macrobrachium rosenbergii*) at Rupsha upazila in 2004.

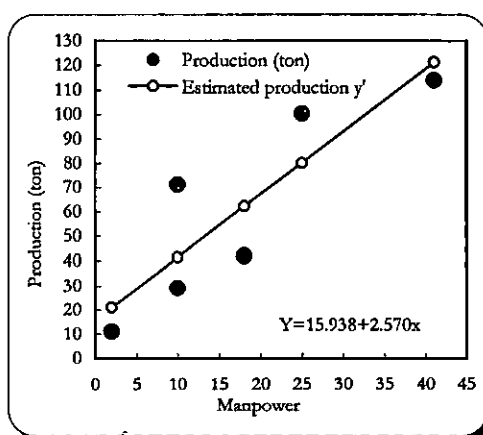


Fig-5h: Regression of y between manpower and production of fresh water prawn (*Macrobrachium rosenbergii*) at Batiaghata upazila in 2004.

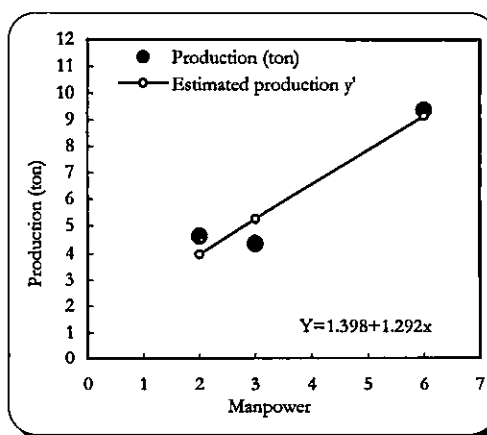


Fig-5i: Regression of y between manpower and production of fresh water prawn (*Macrobrachium rosenbergii*) at Dacope upazila in 2004.

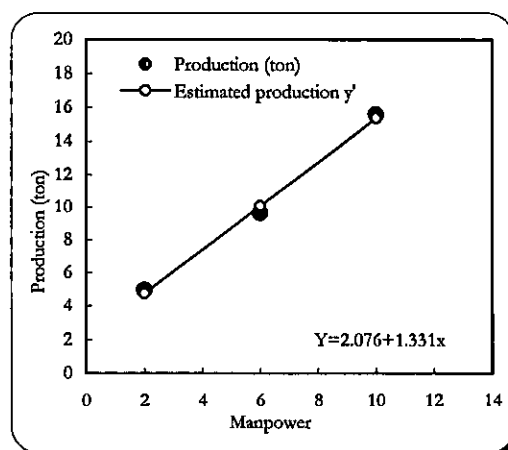


Fig-5j: Regression of y between manpower and production of fresh water prawn (*Macrobrachium rosenbergii*) at Metro upazila in 2004.

4.2.3 Relationship between Manpower and Production of fresh water prawn from depots and farms

The relationship between manpower involved in depots and production of fresh water prawns in all upazilas grossly in khulna district is positively correlated ($r = 0.98801$) and the regression analysis of y on x is $y = 3.569 + 4.596x$.

Table-9: Relationship between manpower and production of fresh water prawn at the depots (*Macrobrachium rosenbergii*) in Khulna district in 2004.

District	Regression equation (y on x) $y = a + bx$	Correlation coefficient " r "	Value of ' t '	' t ' crit. Value (5% level)	' t ' crit. Value (1% level)
Khulna	$y = 3.569 + 4.596x$	0.98801	1.72666	2.306006	3.355381

Significant at 5% level, ** = Significant at 1% level, *** = Insignificant at 5% level

The relationship between manpower involved in farms and production of fresh water prawns in all upazilas grossly in khulna district is positively correlated ($r = 0.99857$) and the regression analysis of y on x is $y = 4.345 + 0.209x$.

Table-10: Relationship between manpower and production of fresh water prawn (*Macrobrachium rosenbergii*) in the farms in Khulna district in 2004.

District	Regression equation (y on x) $y = a + bx$	Correlation coefficient " r "	Value of ' t '	' t ' crit. Value (5% level)	' t ' crit. Value (1% level)
Khulna	$y = 4.345 + 0.209x$	0.99857	1.6702241	2.306006	3.355381

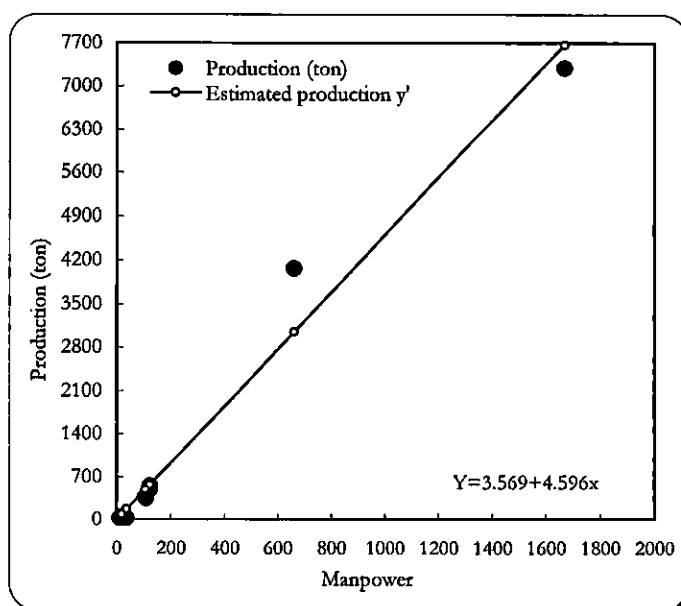


Fig-6a: Regression of y between Manpower and production at depots of fresh water prawn (*Macrobrachium rosenbergii*) at Khulna district.

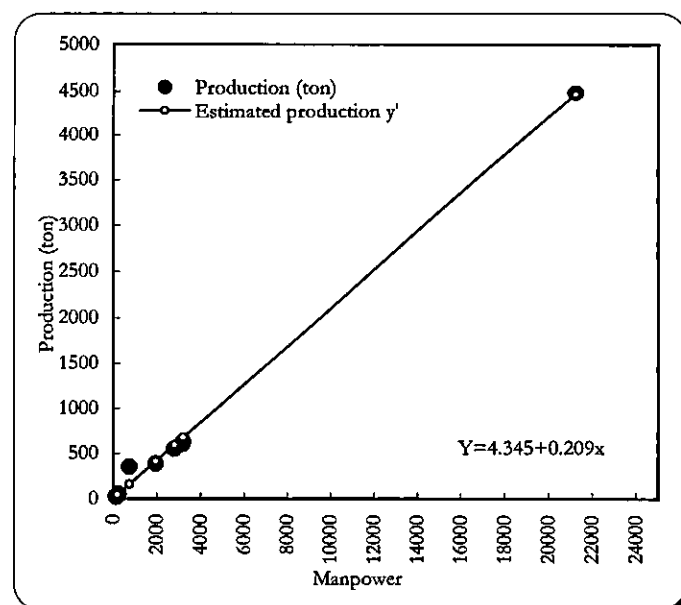


Fig-6b: Regression of y between Manpower and production at farms of fresh water prawn (*Macrobrachium rosenbergii*) at Khulna district.

4.2.4 Relationship between the price and production at different grade of fresh water prawn in Khulna district

The production at different grade of prawns in depots and the price per grade are rationally correlated on both in the Khulna district of Bangladesh. The regression analysis of the equation that mentioned below deliberately declared the functional correspondence of correlation of the two major units like production and price at different grade of fresh water prawns. The value of correlation coefficient 'r' showed that production at different grade of prawns in depots and the price every grade are positively correlated. The relationship between production at different grade of prawns in depots and the price per every grade G-5 (200 gm), G-10 (100 gm), G-20 (50 gm), G-30 (33.33 gm), G-50 (20 gm) and G-60 (16.67 gm) in Khulna district were significant at 1% level. The regression y on x is $y=1065.163+0.365x$, $y=725.6552+0.2895x$, $y=610.9354+0.1238x$, $y=351.4493+0.1206x$, $y=206.5064+0.1896x$, $y=121.3023+0.3331x$ for the grade G-5 (200 gm), G-10 (100 gm), G-20 (50 gm), G-30 (33.33 gm), G-50 (20 gm) and G-60 (16.67 gm) respectively in Khulna district.

Table-11: Relationship between the price and production at different grade of Fresh water prawn (*Macrobrachium rosenbergii*) in Khulna district in 2004.

Grade	Regression equation (y on x)	Correlation coefficient "r"	Value of 't'	't' crit. Value (5% level)	't' crit. Value (1% level)
G-5 (200 gm)	$y=1065.163+0.365x$	0.93009	* 75.511814	2.228139	3.1692616
G-10 (100 gm)	$y=725.6552+0.2895x$	0.94484	* 29.557944		
G-20 (50 gm)	$y=610.9354+0.1238x$	0.85727	* 13.736361		
G-30 (33.33 gm)	$y=351.4493+0.1206x$	0.83819	* 4.0031968		
G-50 (20 gm)	$y=206.5064+0.1896x$	0.93148	* 3.1836076		
G-60 (16.67 gm)	$y=121.3023+0.3331x$	0.92338	* 5.0425096		

* = Significant at 1% level at 10 degree of freedom, ** = Insignificant at 5% level at 10 degree of freedom.

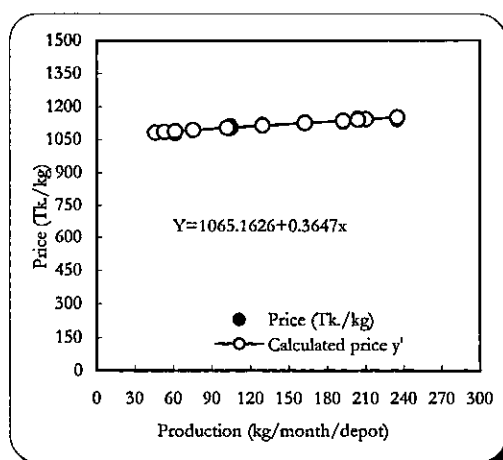


Figure-7a: Regression of y between production and price for Grade-5 (200 gm) of fresh water prawn in Khulna district

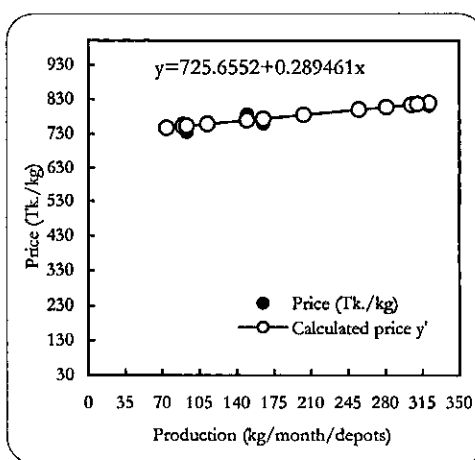


Figure-7b: Regression of y between production and price for Grade-10 (100 gm) of fresh water prawn in Khulna district

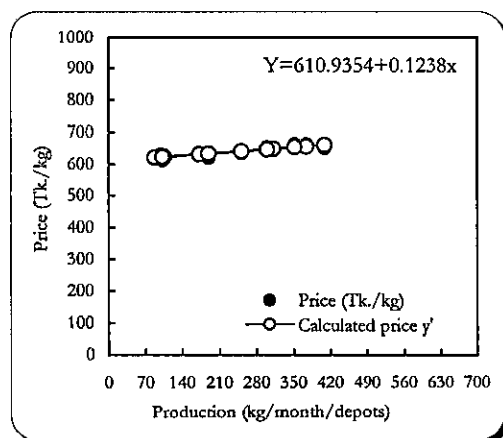


Figure-7c: Regression of y between production and price for Grade-20 (50 gm) of fresh water prawn in Khulna district

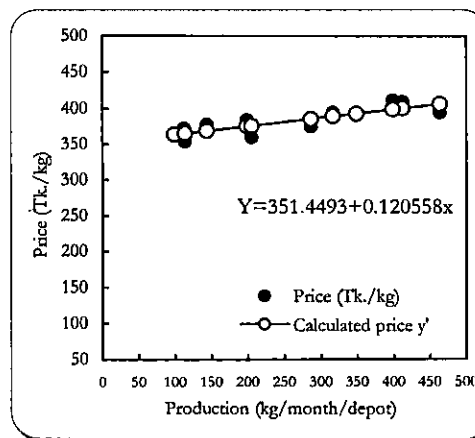


Figure-7d: Regression of y between production and price for Grade-30 (33.33 gm) of fresh water prawn in Khulna district

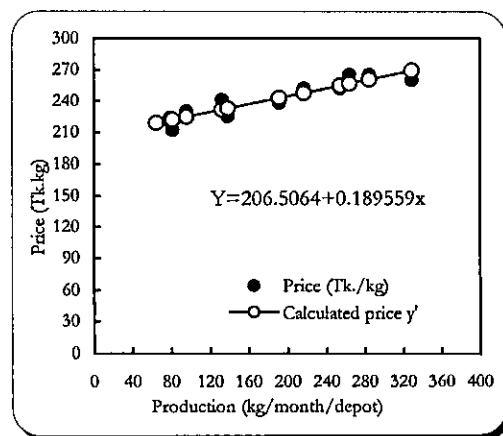


Figure-7e: Regression of y between production and price for Grade-50 (20 gm) of fresh water prawn in Khulna district

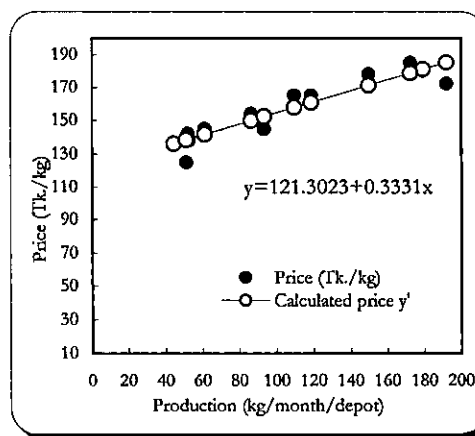


Figure-7f: Regression of y between production and price for Grade-60 (16.67 gm) of fresh water prawn in Khulna district

4.2.5 Relationship between the price and production of fresh water prawn at different upazila in Khulna district

The value of correlation coefficient 'r' showed that production of fresh water prawns in depots and the price are positively correlated in all observed upazilas in Khulna district. Price and production relationship in Paikgacha, Dumuria, Fultala, Digholia, Rupsha, Dacope and Metro upazila covered 1% significant level and Terokhada upazila covered 5% significant level. The regression equation y on x were $y=339.7884+0.266306x$, $y=458.6398+0.0277x$, $y=353.2912+0.05951x$, $y=370.3688+0.03176x$, $y=375.381+0.0474x$, $y=449.866+0.030554x$, $y=382.7746+0.224219x$ and $y=402.7018+0.21777x$ in Paikgacha, Dumuria, Fultala, Digholia, Terokhada, Rupsha, Dacope and Metro upazila in Khulna district.

Table-12: Relationship between the price and production of Fresh water prawn (*Macrobrachium rosenbergii*) at different upazila in Khulna district in 2004.

Name of Upazila	Regression equation (y on x)	Correlation coefficient "r"	Value of 't'	't' crit. Value (5% level)	't' crit. Value (1% level)
Koyra	$y=374.2854+0.1016x$	0.86900	0.9149026	2.228139238	3.16926162
Paikgacha	$y=339.7884+0.266306x$	0.865764	* 11.36001		
Dumuria	$y=458.6398+0.0277x$	0.81140	* 3.205171		
Fultala	$y=353.2912+0.05951x$	0.81747	* 1.694907		
Digholia	$y=370.3688+0.03176x$	0.94348	* 2.914201		
Terokhada	$y=375.381+0.0474x$	0.90170	** 2.36865		
Rupsha	$y=449.866+0.030554x$	0.88695	* 3.585838		
Batiaghata	$y=443.1434+0.0389x$	0.63093	1.9133722		
Dacope	$y=382.7746+0.224219x$	0.83912	* 7.091405		
Metro	$y=402.7018+0.21777x$	0.93456	* 5.790646		

* = Significant at 1% level at 10 degree of freedom, ** = Insignificant at 5% level at 10 degree of freedom.

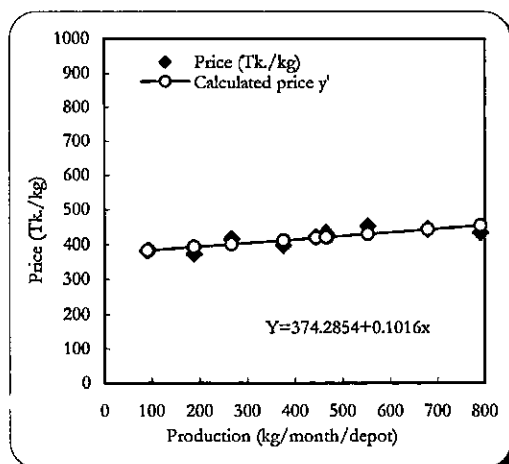


Figure-8a: Regression of y between production and price of fresh water prawn in Koyra upazila in Khulna district

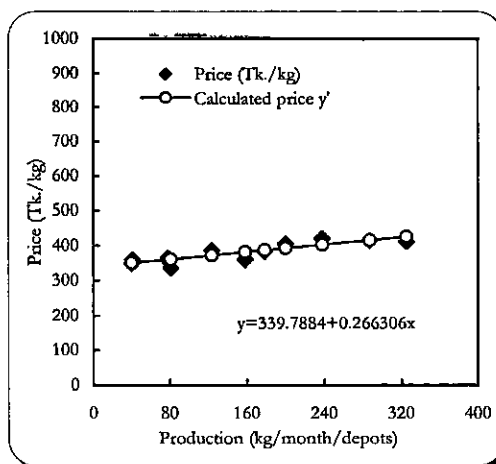


Figure-8b: Regression of y between production and price of fresh water prawn in Paikgacha upazila in Khulna district

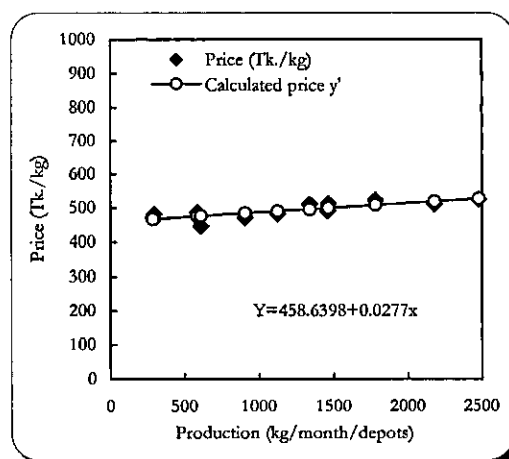


Figure-8c: Regression of y between production and price of fresh water prawn in Dumuria upazila in Khulna district

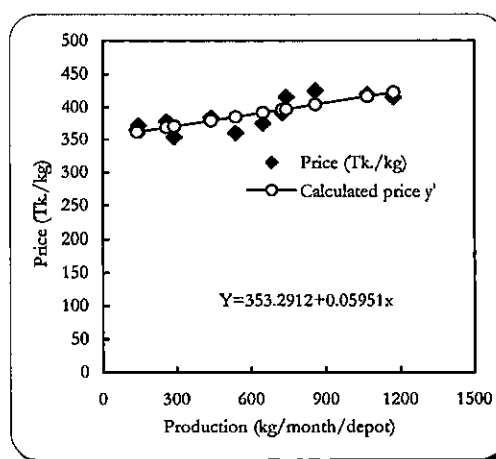


Figure-8d: Regression of y between production and price of fresh water prawn in Fultala upazila in Khulna district

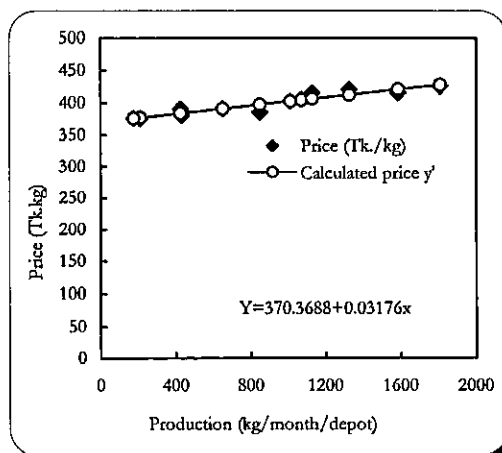


Figure-8e: Regression of y between production and price of fresh water prawn in Digholia upazila in Khulna district

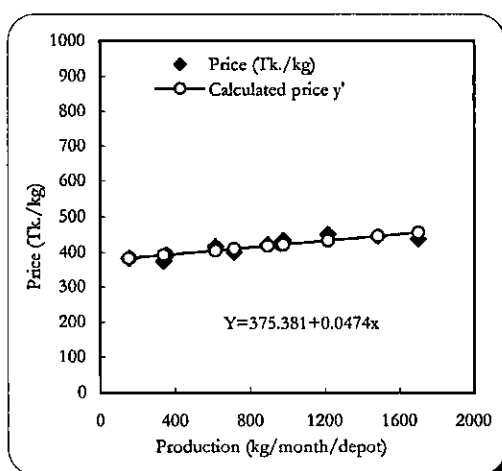


Figure-8f: Regression of y between production and price of fresh water prawn in Terokhada upazila in Khulna district

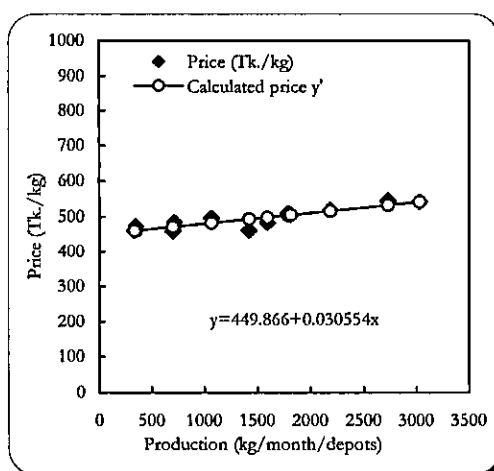


Figure-8g: Regression of y between production and price of fresh water prawn in Rupsha upazila in Khulna district

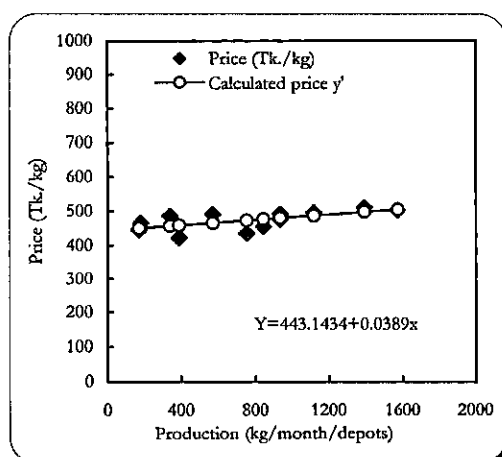


Figure-8h: Regression of y between production and price of fresh water prawn in Batiaghata upazila in Khulna district

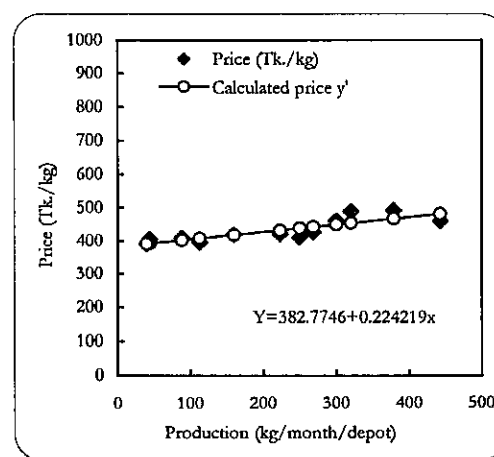


Figure-8i: Regression of y between production and price of fresh water prawn in Dacope upazila in Khulna district

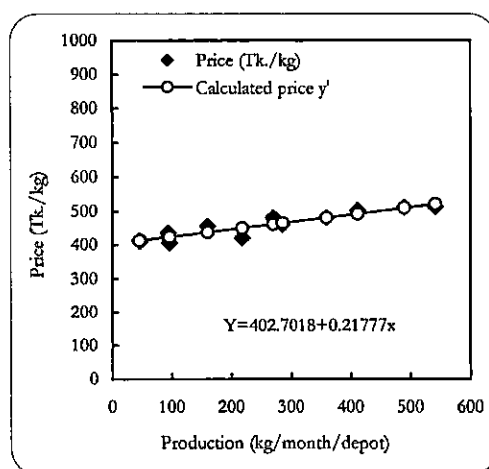


Figure-8j: Regression of y between production and price of fresh water prawn in Metro upazila in Khulna district

4.2.6 Variation of production and price of fresh water prawn in Khulna district

4.2.6.1 Monthly variation in price of fresh water prawn by grade

The grade wise average monthly variations in price in the Khulna district during January to December, 2004 are shown in Figure-9a, 9b, 9c, 9d, 9e and 9f.

The average maximum price was found to be 1150.00 ± 3.54 for Grade-5 (200 gm) prawn in December, 822.00 ± 2.74 for Grade-10 (100 gm) in December, 665.00 ± 5.00 for Grade-20 (50 gm) in December, 412.00 ± 5.70 for Grade-30 (33.33 gm) in December, 265.00 ± 8.66 for Grade-50 (20 gm) in January and 185.00 ± 5.00 for Grade-60 (16.66 gm) in December respectively in Khulna district. The average minimum price was found to be 1073 ± 2.74 for Grade-5 (200 gm) prawn in August, 736.00 ± 8.22 for Grade-10 (100 gm) in August, 613.00 ± 8.37 for Grade-20 (50 gm) in August, 360.00 ± 5.00 for Grade-30 (33.33 gm) in September, 212.00 ± 7.58 for Grade-50 (20 gm) in August and 125.00 ± 4.36 for Grade-60 (16.66 gm) in August respectively in Khulna district.

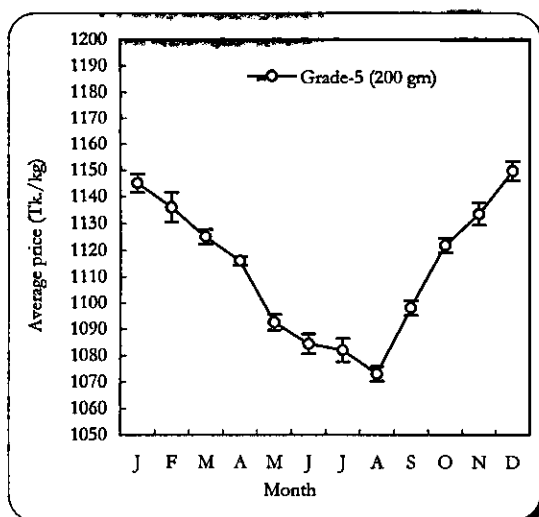


Fig-9a: Monthly variation in price of Grade-5 fresh water prawn in Khulna district in 2004

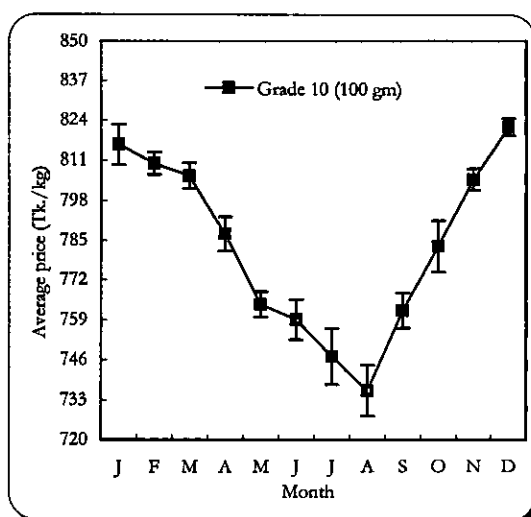


Fig-9b: Monthly variation in price of Grade-10 fresh water prawn in Khulna district in 2004

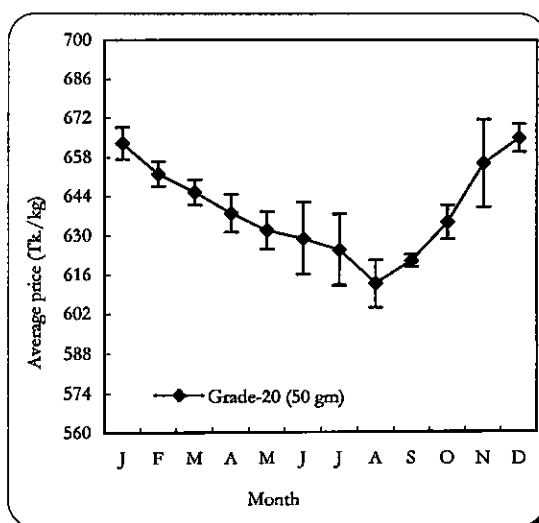


Fig-9c: Monthly variation in price of Grade-20 fresh water prawn in Khulna district in 2004

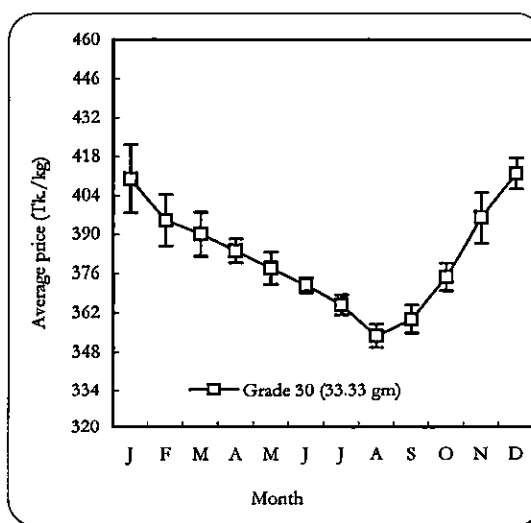


Fig-9d: Monthly variation in price of Grade-30 fresh water prawn in Khulna district in 2004

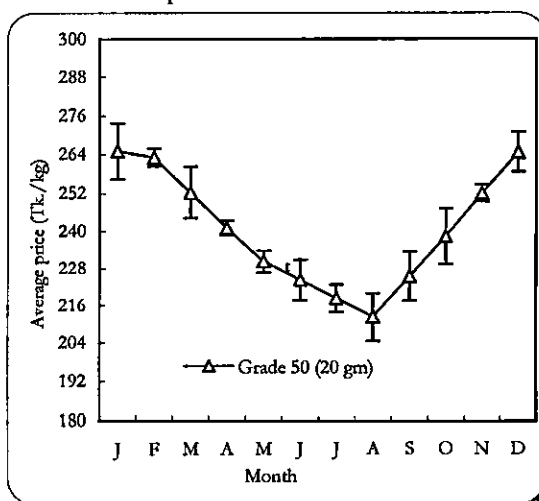


Fig-9e: Monthly variation in price of Grade-50 fresh water prawn in Khulna district in 2004

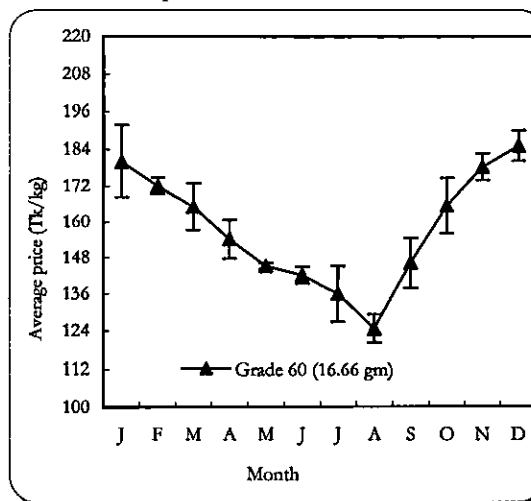


Fig-9f: Monthly variation in price of Grade-60 fresh water prawn in Khulna district in 2004

4.2.6.2 Monthly variation in production of fresh water prawn by grade

The grade wise average monthly variations in production in the Khulna district during January to December, 2004 are shown in Figure-10a, 10b, 10c, 10d, 10e and 10f.

The average maximum production was found to be 234.87 ± 13.07 ton for Grade-5 (200 gm) prawn in February, 321.42 ± 7.23 ton for Grade-10 (100 gm) in February, 408.56 ± 9.81 for Grade-20 (50 gm) in February, 463.38 ± 31.90 ton for Grade-30 (33.33 gm) in February, 328.87 ± 18.70 ton for Grade-50 (20 gm) in February and 192.00 ± 18.23 ton for Grade-60 (16.66 gm) in January respectively in Khulna district. The average minimum production was found to be 46.25 ± 5.02 ton for Grade-5 (200 gm) prawn in June, 74.33 ± 10.09 ton for Grade-10 (100 gm) in July, 87.25 ± 13.10 ton for Grade-20 (50 gm) in July, 99.15 ± 21.16 ton for Grade-30 (33.33 gm) in July, 64.48 ± 12.58 ton for Grade-50 (20 gm) in July and 44.51 ± 7.13 ton for Grade-60 (16.66 gm) in July respectively in Khulna district.

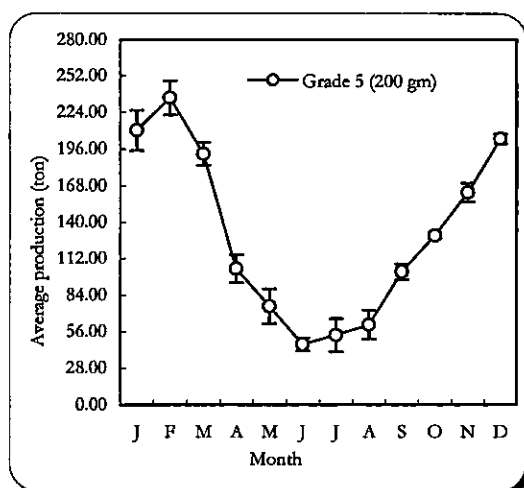


Fig-10a: Monthly variation in production of Grade-5 fresh water prawn in Khulna district in 2004

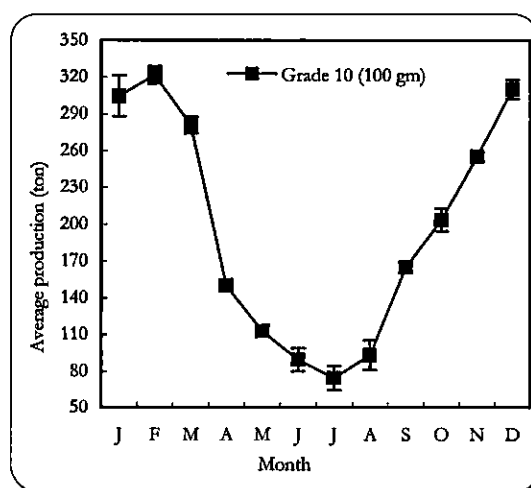


Fig-10b: Monthly variation in production of Grade-10 fresh water prawn in Khulna district in 2004

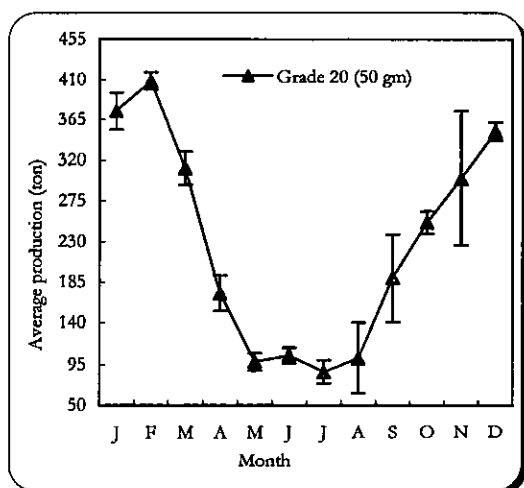


Fig-10c: Monthly variation in production of Grade-20 fresh water prawn in Khulna district in 2004

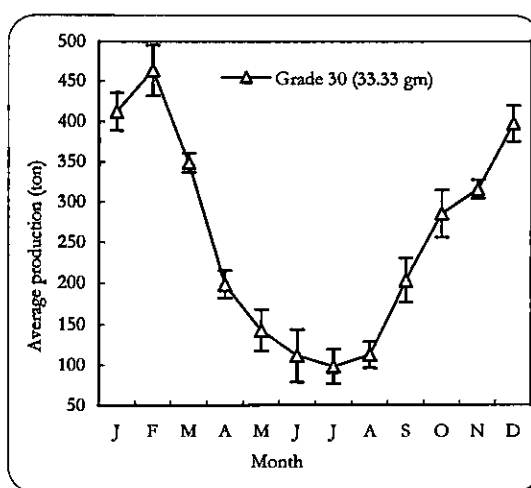


Fig-10d: Monthly variation in production of Grade-30 fresh water prawn in Khulna district in 2004

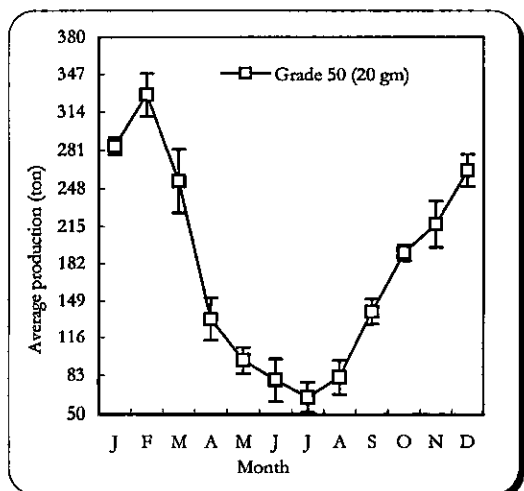


Fig-10e: Monthly variation in production of Grade-50 fresh water prawn in Khulna district in 2004

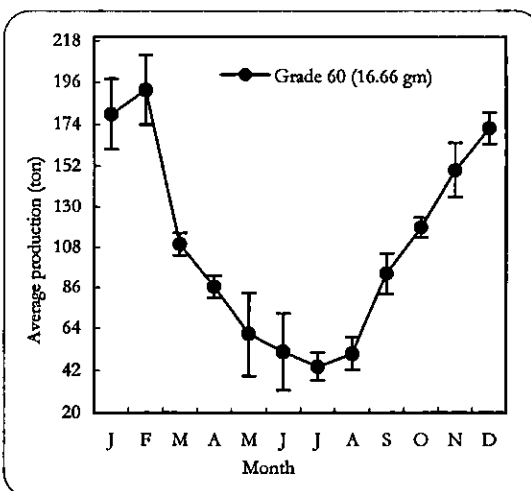


Fig-10f: Monthly variation in production of Grade-60 fresh water prawn in Khulna district in 2004

4.2.7 Production trend

4.2.7.1 Water area and land used for fresh water prawn culture

Fresh water prawn production increased around the country becoming high of its market demand and price in international market. The total area of farming land and water body and number of farms for fresh water prawn increased in potential areas. Prawn farming is not restricted to the coastal regions and expanding at the rate of 10-15% per annum (Jahangir and Alam, 2003). The number of prawn farms and area in Khulna district in 2002-2003, 2003-2004 and 2004-(till December) has to be counted of 33282, 12761ha; 36731, 14510 ha; and 38340, 15842 ha respectively. About 105000 farms are culturing fresh water giant prawn in Khulna region (Jahangir and Alam, 2003).

The major area of prawn farming was estimated to be 8500 ha, 8560 ha and 9340 ha in 2002-2003, 2003-2004 and 2004 (till December) in Dumuria upazila in Khulna district. The minor area was 22 ha, 21 ha and 28 ha in Dacope upazila (Table-13).

The total shrimp and prawn cultured area in Khulna district were counted to be 39690 ha and 15842 ha in 2004 that means prawn are cultured about 39.91% of the total shrimp farming area. About 30000 ha area are being used in prawn farming in Bangladesh (Jahangir and Alam, 2003). Although the total inland water area in Bangladesh is estimated to be about 4.3 millions hectares (Akand and Hasan, 1992).

Table-13: Uses of the total land and water area (ha) of fresh water prawn (*Macrobrachium rosenbergii*) farming in Khulna district.

Upazila	2003-04	2002-03	2001-02	2000-01	1999-00
Koyra	120	78	101	92	87
Paikgacha	150	109	25	23	19
Dumuria	9340	8560	8500	8150	7470
Fultala	2410	2324	650	590	577
Digholia	702	680	624	590	559
Terokhada	714	698	796	750	710
Rupsha	1222	1047	1010	966	929
Batiaghata	1089	949	998	975	922
Dacope	28	21	22	20	17
Metro	67	44	35	32	27
Total	15842	14510	12761	12188	11317

(Source: Bishwas, 2002 and DoF, 2004)

4.2.7.2 Year wise production of fresh water prawn from Khulna region

The contribution to export of fresh water prawn from upazila level of Khulna district showed a calculative phenomenon as increasing in significant level sequentially year by year. The cumulative production is always showed in higher having 2302, 3470, 4748, 5017 and 8431 ton in 1999-2000, 2000-01, 2001-02, 2002-03 and 2003-04 respectively. Of total production Dumuria significantly raised in higher having 1430, 2250, 3250, 2762 and 5465 ton in 1999-2000, 2000-01, 2001-02, 2002-03 and 2003-04 respectively and the lower was to be counted in Dacope as 11, 9, 16, 14 and 22 ton in 1999-2000, 2000-01, 2001-02, 2002-03 and 2003-04 respectively (Table-14).

The total contribution to export in last five years was estimated to be 138, 97, 15157, 967, 1294, 1915, 2891, 1352, 72 and 85 ton in Koyra, Paikgacha, Dumuria, Fultala, Digholia, Terokhada,

Rupsha, Batiaghata, Dacope and Metro upazila respectively in Khulna district (Table-14). There was an estimation that about 30,000 ha of land was under fresh water giant prawn cultivation in 2000-2001, producing about 11,942 ton of prawn (Jahangir and Alam, 2003).

Table-14: Year wise contribution of fresh water prawn in different upazila in Khulna district of Bangladesh.

Upazila	Production (ton)					Total
	2003-04	2002-03	2001-02	2000-01	1999-00	
Koyra	59	22	26	18	13	138
Paikgacha	30	18	22	17	10	97
Dumuria	5465	2762	3250	2250	1430	15157
Fultala	362	320	110	105	70	967
Digholia	623	341	140	125	65	1294
Terokhada	679	266	410	350	210	1915
Rupsha	756	535	650	500	450	2891
Batiaghata	404	718	110	85	35	1352
Dacope	22	14	16	9	11	72
Metro	31	21	14	11	8	85
Total	8431	5017	4748	3470	2302	23968

(Bangladesh frozen foods association of Khulna, 2004)

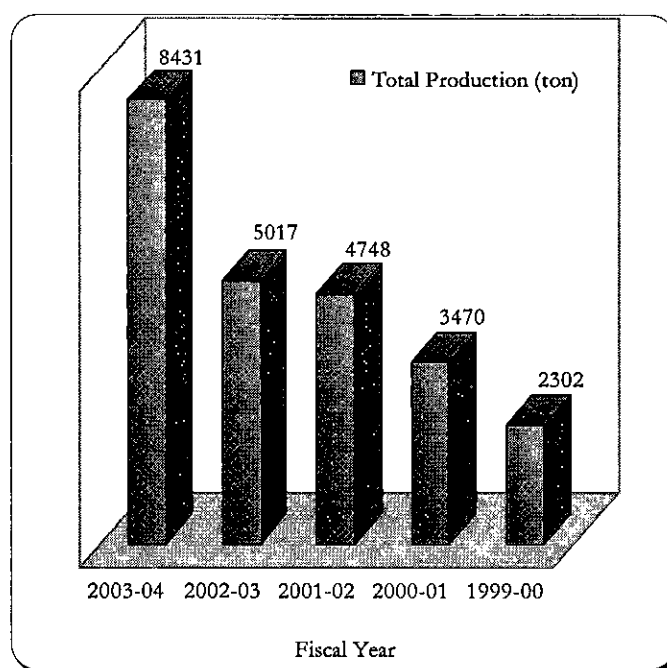


Figure-11: Year wise total production (ton) of fresh water prawn in Khulna district

4.2.7.3 Upazila wise production trend analysis

The production and cultivating area is gradually increased in Khulna district because the production and price potentiality of fresh water prawn encouraged the prawn farmers to cultivate. It was found that the production of fresh water prawn increased in every upazila with the increasing of the culture area. But the unit production increased in some upazilas due to technological support, management inputs and availability of healthy PL.

The production trend analysis in Koyra it was found that the unit production increased gradually (Fig-12a). In Paikgacha unit production increased during 1999 to 2002 but in 2002-03 unit production decreased tremendously and it was slightly recovered in 2004 (Fig-12b). In Dumuria unit production increased during 1999 to 2002 but in 2002-03 unit production decreased slightly and it was remarkably increased in 2004 (Fig-12c). Unit production in Fultala increased remarkably in 2001 but gradually decreased to 2003 and slightly recovered in 2004 (Fig-12d). In Digholia unit production increased gradually from 1999 to 2002 and it increased vertically in 2003 to 2004 (Fig-12e). Unit production in Terokhada gradually increased 1999-2002 but slightly decreased in 2003 and highly increased in 2004 (Fig-12f). In Rupsha the yearly fluctuation of unit production was not too much remarkable (Fig-12g). In Batiaghata the unit production increased tremendously in 2003 but decreased mentionable in 2004 (Fig-12h). Interestingly the unit production decreased at Dacope in 2001 but it was found no change in other years with 1999 (Fig-12i). The unit production in Metro it was found to be increased gradually (Fig-12j).

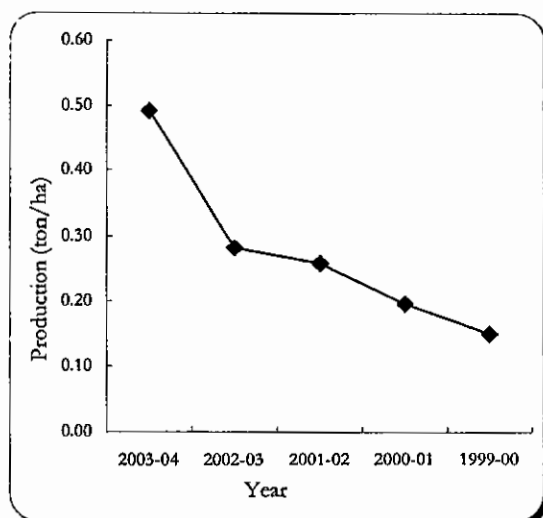


Fig-12a: Year wise production (ton/ha) trend in Koyra

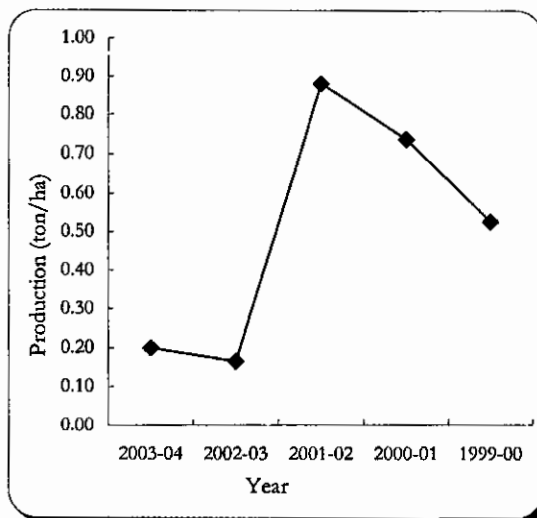


Fig-12b: Year wise production (ton/ha) trend in Paikgacha

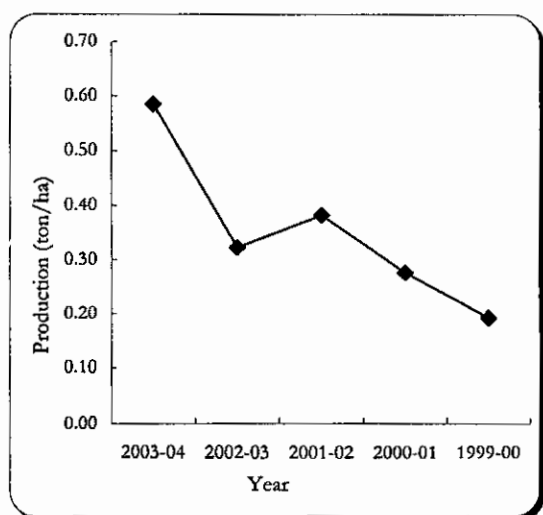


Fig-12c: Year wise production (ton/ha) trend in Dumuria

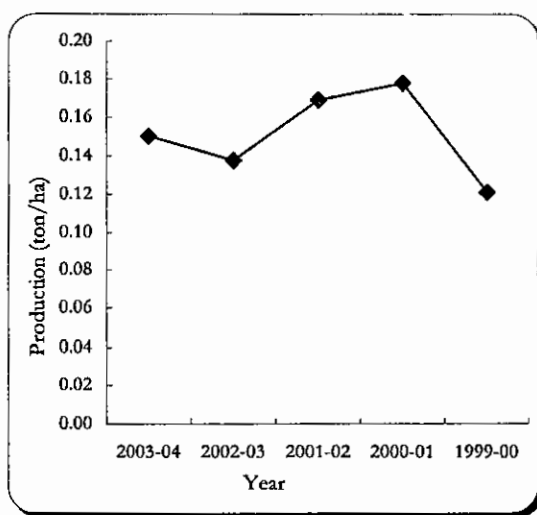


Fig-12d: Year wise production (ton/ha) trend in Fultala

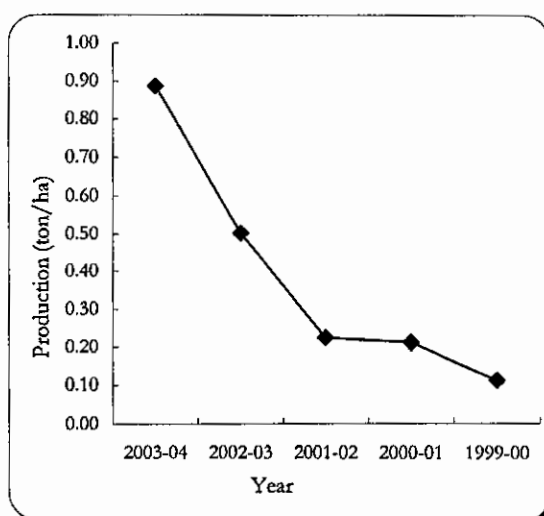


Fig-12e: Year wise production (ton/ha) trend in Digholia

4.2.7.4 Factors effecting production and farming in Khulna region

Different kinds of activities and inputs are always relating among the production, farming and marketing of prawn. These activities and inputs made both a long term and a short term effect on production and farming.

Training and skill development for farmers

Training and facilitation for fish farmers is essential for better production. Target to production of government agency, private agency, donor agency and others NGOs conducted different types of training on fish culture for culture methods and pond based cultured demonstration etc. Bangladesh govt. has already implemented training and facilitation for fish culture through different revenue program and annual development program and some program is being conducted. The program is conducted by the government project, different NGOs and private organization. At the last five years, the total of 1058796 farmers is to be trained for fish farming shown in Table-15.

Table-15: Last 5 years training activities of farmers/fishers/NGOs workers

Fiscal year	Farmers/Fishers/NGOs workers
2003-2004	207050
2002-2003	425553
2001-2002	325468
2000-2001	65400
1999-2000	35325
Total	1058796

(Sources DoF, 2004)

Besides this DANIDA project trained total 45337 households on the integrated rice fish cum prawn culture management (during 1999-2004) and also managed 34250 farmers for on-hand training during 1998-2004 (DoF, 2004). Around the country 10 prawn hatcheries cum nursery and 10 nurseries were established through 'prawn hatchery establishment and culture technology extension project (1998-2004)' to produce prawn fry for distribution among the real prawn farmers at reducing cost. Through these project 1300 farmers was taken on-hand training on prawn culture (MoFL, 2004).

About 29500 shrimp and prawn fry suppliers were trained to accelerate coastal shrimp and prawn culture activities under Fourth Fisheries Project (MoFL, 2004). Department of Fisheries (DoF) trained 2000 private staff and divisional workers of fish processing industries during 1999-2005 through Shrimp Culture Development Program conducted by DoF and funded by France. Department of Fisheries (DoF) also trained 126256 farmers and innovators for fish culture during 1997-2003 through Fisheries Training and Extension Project (phase II) funded by DFID.

Micro credit program in fisheries sector

To get the better production of fish and shrimp from the farming land more investment will be introduced. Comparatively existing land and water area is significant but the production is not high on the lack of proper utilization and investment of capital basically for promoter and pond owners. To resolve this problems Bangladesh govt. introduced micro credit program with less interest rate for the poor farmers. Bangladesh government distributed Tk. 2,47,61,000 (12% in

Khulna division) in 2003-2004 and Tk. 2,00,00,000 (13% in Khulna division) in 2004-2005 in the country (Table-16).

Table-16: Distribution of credit in the country by govt. in 2003-04 and 2004-05

Fiscal year	Total (Tk.)	Khulna div. (Tk.)	Khulna dist. (Tk.)
2004-2005	20000000	2583000	284000
2003-2004	24761000	2876000	432000
Total	44761000	5459000	716000

Besides this different govt. program/projects, NGOs, private sector and others donor agencies are prompted for giving credit to the poor fish farmers. In 2004 the project of poverty alleviation through integrated fisheries activities distributed the credit fund for prawn culture in Khulna region having about Tk.995025 in first installation and Tk.1378250 in second installation (MoFL, 2004).

Ministry of Fisheries and Livestock have already met in agreement (Memorandum of Unity) with the different govt. commercial bank like Bangladesh Krishi bank, Sonali bank, Agroni bank and Janata bank to give loan or credit for fish culture with pursuing the instruction of Bangladesh bank (MoFL, 2005). Fish farmers/beneficiaries can take the money with simple installation at the less interest rate. Some of the instructions for getting the credit from bank are listed in the Table-17.

Table-17: Bank loan for fish/shrimp/prawn culture in a certain area of water body

Bank	Sector	Credit range	Rate of interest
Bangladesh Krishi bank	Prawn culture in improved Extensive system	60,000-1,50,000/- per 205 acre	8%
Sonali bank	Shrimp/prawn culture	Traditional system-24,700/- per acre And 1,69,200/- per 10 acre Improved extensive system-1,31,298/- per acre	8%
Agroni bank	Fish/shrimp/prawn/integrated fish cum prawn culture	2,200-17,200/- per bigha	9-10%
Janata bank	Fish/shrimp/prawn/integrated fish cum prawn culture	10,000-50,000/- per acre	9-10%

(Sources: DoF, 2005)

Present status of availability of fish feed, fry and others inputs

In recent years some hatcheries and fish feed industries have been developed which are contributing effectively to reduce scarcity of prawn fry and the unavailability of the peeled diet. But the pelleted rations are quite expensive. As a result most of the farmers of Bangladesh are not interested to culture fresh water prawn in their ponds, though the economic value and the market demand of fresh water prawn, *Macrobrachium rosenbergii* is much higher than that of carp. However, the present trend shows that fresh water prawn farming is becoming a significant and expanding industry (New, 1991). There is a great potential or successful monoculture of fresh water prawn in

numerous ponds of Bangladesh. Now a days the production of prawn from natural sources are decreasing day by day. So, scientific prawn culture should be introduced in fresh water ponds (Hossain *et al.*, 2000). Although some works have been done on the rearing of *Macrobrachium rosenbergii* with different supplemental feeding and stocking densities (Khan *et al.* 1984, Humayun *et al.* 1986, Mazid *et al.* 1989, Islam *et al.* 1990 and Hoq *et al.* 1996); most of them are on polyculture. Law *et al.* (1990) suggested that copra cake, soyabean meal and wheat flour (which are low cost ingredients in Malaysia) were good sources of nutrients for prawn having examined their digestibility in 30% or 40% protein feeds with juveniles and adults. Durairaj *et al.* (1992) noted an improved growth rate when prawns in manured ponds were fed a pelleted feed containing shrimp head meal (20%) and fish meal (10%) rather than a conventional feed ratio 1:2:1 ground nut oil cake, rice bran and trash fish but the trial was un-replicated.

The prawns are self limiting in respect to total production due to antagonistic interactions increasing the need for poly-culture to maximize total pond efficiency. Prawn poly-culture has a potentially higher net return than prawn monoculture. Culture of prawn with fish also improves the ecological balance of the pond water, preventing the formation of massive algal blooms (Cohen *et al.*, 1983). A major advantage of prawn poly-culture for developing nations like Bangladesh is that low cost high quality protein (fish) is produced for local consumption simultaneously with a high value luxury protein product (prawns) that may be exported to generate foreign exchange. This development model has worked remarkably well in Israel, which produces some 50% of its total fish consumed and exports prawns to the high priced European market to generate foreign income (Cohen & Ra'anani 1983).

Hoq *et al.* (1996) reported that the survival rate of prawn ranged from 32.2 to 75.7% (mean 51.1%) in a polyculture with finfish. And he also found that the highest prawn production of 428.4 kg/ ha in a poly-culture system of prawn and other fin fishes in the same region.

4.3 Marketing and transportation system

4.3.1 Marketing system of alive fresh water prawns

Marketing of alive prawns will usually generate a better price but, of course, increases costs. Marketing of it successfully in this way depends on ability to keep them alive during transport and display, and to present undamaged, healthy prawns in an attractive way. Good survival of adult fresh water prawns can be achieved during journeys of up to at least 24 hours at a density of 600 g/L with good aeration, without any visible deterioration in their quality. It is best to transport the prawns on shelves stacked vertically within the water column; this helps to avoid mortalities caused by crowding, as well as maintaining better localized water quality. Cool transport (20-22°C) minimizes water quality problems and reduces the microbial activity of the prawns. The use of hard water tends to stabilize the pH, thus reducing the toxicity of any ammonia that builds up during transport.

Once the prawns arrive at the point of sale (e.g. restaurant, market) they can be maintained fairly densely packed in aquariums with a good biofilter. In some places, specialist firms collect live prawns from various farms, using small pickups with tanks and aeration devices. They may also buy, at a lower price, fresh (chilled) prawns. The key to success is to adapt to the needs of the local market in order to secure the highest income. In some places, small prawns can be sold as bait to fishermen; in others there is a recreational fee fishing (angling) market for live prawns themselves. In yet others there is an opportunity to sell live animals for home aquaria and for instructional use in schools. Caution must be used in areas where *Macrobrachium rosenbergii* is not indigenous, however, to ensure that they do not escape and endanger local fauna.

4.3.2 Marketing system of fresh water prawns (fresh or frozen)

Fresh (chilled) prawns can be sold if they are going to be consumed within 5 (preferably 3) days. The way to ensure that the chilled prawns are of the best quality has been explained earlier.

Prawns which are not expected to be sold within 3 days should immediately be frozen. Freezing should take place when they are fresh, not after they have been on ice for several days. Frozen tails have a longer shelf life than whole prawns. Whole frozen fresh water prawns will turn 'mushy' if they are frozen and held above -20°C , or if they are thawed and refrozen. It is recommended that prawns to be stored for long periods be held at -30 to -35°C . Tails which are frozen in ice blocks may be stored for over a year and still be very satisfactory, although a maximum of six months is recommended. Glazing or vacuum packing significantly prolongs the useful life of frozen prawns. While vacuum packing requires elaborate processing facilities, not available to small farms, glazing is quite simple: a very thin mixture of syrup and water prevents oxidation. During marketing frozen prawns, whether they are sold whole or as tails, the ideal is to sell them within a three month period. This can be achieved, if the farm is geared properly to its market (when and where will the product be required, and in what quantity). Good record keeping will help to develop an efficient farm management system, based on past experience. During selling prawns to restaurants, may find it useful to provide them with advice on how to ensure that they are consumed at their best quality.

A high quality image can be established if stakeholders begin by selling at high prices to expensive and well-respected restaurants. These tend to demand high quality, which can help them to develop good products. Selling prawns to high-quality restaurants requires more effort for a new farm but it will pay off in the long term. Going for this market and establishing the quality image first enables to obtain higher price levels when start selling larger quantities of prawns.

General recommendations to restaurants and consumers for handling and storing fresh water prawns

- Store fresh prawns in a refrigerator, covered with ice, for not more than 5 (preferably 3) days; change the ice daily and, while doing so, rinse the prawns with clean cold water
- Store frozen prawns in a freezer immediately get it; keep it at -20°C or below until you need them
- Cook and serve prawns immediately after removing them from ice or thawing them
- Cooked prawns can be frozen

4.3.3 International opportunities and general marketing strategy

The international marketing of fresh water prawns, which (except in the case of the largest farms) would be made through intermediary seafood processing plants, is outside the scope of this thesis. When the first FAO manual on fresh water prawn farming was written there were very few opportunities for export; now, fresh water prawns are beginning to become a global commodity. *Macrobrachium rosenbergii* is a routine product in the supermarkets of Europe and the USA and is widely used in the restaurant trade. It is therefore important to realize that there are now significant opportunities for exporting the product, if it is of export quality.

The development of marketing strategies and plans for fresh water prawns is covered in Phillips and Lacroix (2000) and a number of case studies are presented. That publication also contains many recipes for preparing meals containing *Macrobrachium rosenbergii*; good knowledge about the proper preparation of this species before consumption is thought to be very important to generate a good consumer image of the product. This is especially important in countries where *Macrobrachium rosenbergii* is not indigenous and there is no tradition in its cooking. A range of farm-gate and retail prices for fresh water prawns in several countries is provided in New (2000b).

4.3.4 Marketing channel in fresh water prawn trading

The trading pattern of fresh water prawn business involves a series of intermediaries between the producers, suppliers, exporters and the consumers. The final price of the product depends on the marketing network.

Generally the present supply chain for the fresh water prawn was found to be similar at all Upazilas in Khulna district. The farmers harvest their prawns by using cast net and barrier net. In the local markets, farmers directly sell their all head on prawns from gher to the local markets or to the prawn traders or via foria to the prawn traders. Prawns traders collect head on prawns from foria or prawns farmers and supply them to the fish processing plants after 1 to 2 days preservation. Some people always work with the traders. Their jobs are to carry ice from ice factory, breaking of ice, mixing of ice with prawns and loading prawns in the vehicles. Truck, pick-up and microbus are used for prawn transport from traders to the fish processing plants. Bamboo made containers with polythene cover is used for keeping the prawns. Some agents work between prawns traders and fish processing plants. Fish processing plants are the warehouse factories for processing of prawns. Finally fish processing plants export headless prawns to the international markets through Mongla/Chittagong port. The head and leg of prawns are sold by fish processing plants to the local markets through suppliers for human consumption. Farmers harvest fresh water prawns from the ponds/gher/various sources and sell to the small depots or to brokers or directly to the agents. The marketable fresh water prawns from the small depot owners are sold to big depots. The agents employed by the company purchase fresh water prawn directly from the farmers and local small depots located at the Upazila level. A big chunk of the profit goes to middleman or brokers. Broker act as a middleman between the harvesters and the exporters. Sometimes, the exporters directly purchase fresh water prawns in cash from the local depots by employing agents. The rejected fresh water prawns (under grade and broken legs or soft shell or discolored prawns) are transferred to the local market for domestic consumption at low price.

In the whole South-Western region, three types of marketing channels were observed as follows:

Marketing Channel-1

In this type of marketing channel, the farmers/fishers would collect prawn from the ponds/gher and sold it to small depots at the local market. Sometimes depots owner would employ some *foria* to collect the prawn from farmer's *gher*. This type of marketing channel was found in most of the Upazila of Khulna district except Metro and Rupsha Upazila (Diagram-1)

Marketing Channel-2

This type of marketing channel was found at all Upazilas in Khulna districts. The farmers/fishers would harvest fresh water prawns from the various pond and gher and sold to the small depots or to brokers or directly to the agents of the company. The marketable fresh water prawns from the small depot owner would be sold to large sized depots and agents of the processing plants (Diagram-1).

Marketing Channel-3

In this type of marketing channel, large depot owners purchase the fresh water prawns from the large depot of another locality. This type of marketing channel was found in Dumuria, Paikgacha, Rupsha and Metro Upazila in Khulna district (Diagram-1).

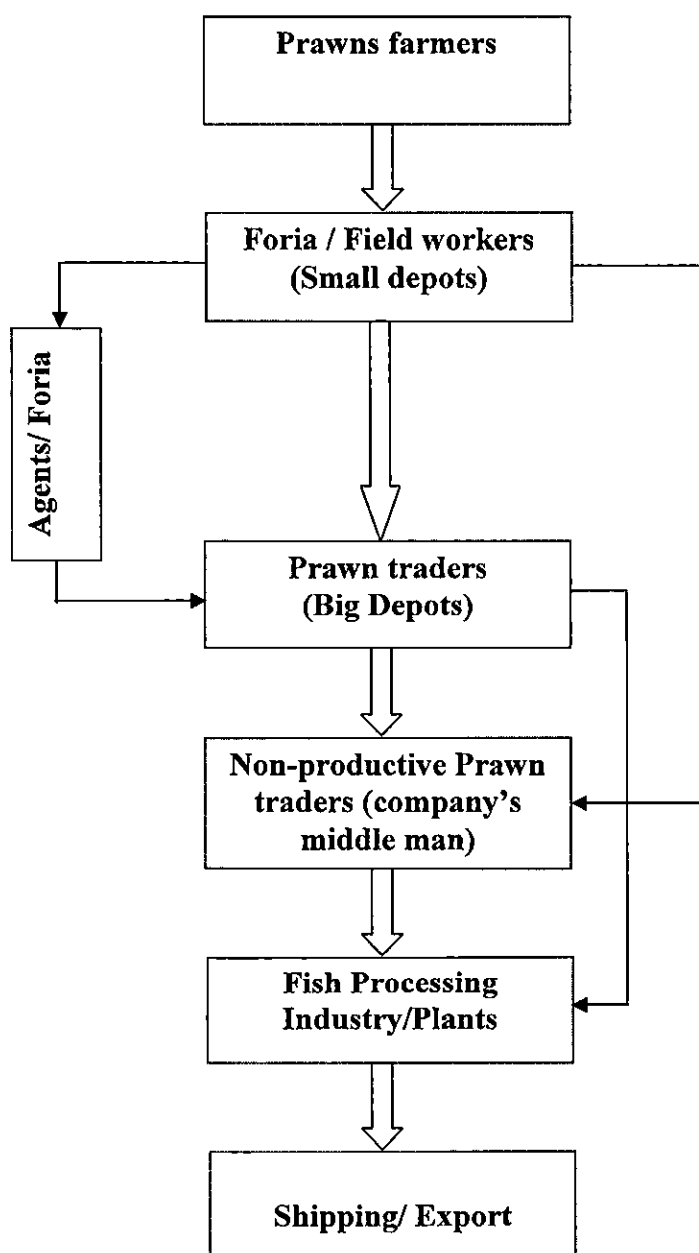


Diagram-1: The pathway of prawn distribution channel from harvesting to export

4.3.5 Fresh water prawn transportation in the Khulna region

Transport to Depots

Harvested fresh water prawns are transported to the depots from *ghers* carried in bamboo baskets, plastic pots by bi-cycle or rickshaw sometimes by small wooden boats or by mechanized trawler from local and most remote area. Basically from remote area where there was no means of transportation the farmers felt in trouble to carry the prawns to nearest market. Some times from some places farmers carried their prawns by foot/by cycle. In koyra, Dacope, Paikgacha, the mostly remote places carrying system is too much problematic. It took 5-7 hrs to carry the products to the nearest market.

Transport to processing plants

Basically the agents regulated by processing plants were involved in marketing. Shrimp and prawns which were exported carried by the agent's own transportation that was well decorated and reach in plants in well manner covering in all sorts of condition friendly for the shrimp and prawn products being well in quality.

Transport to Dhaka

Among 10 Upazila of Khulna fresh water prawns would be transported to Dhaka from processing industries located in Khulna sadar and Rupsha. Different freezer system pick-up is used to transport fresh water prawn from processing industries to Dhaka.

4.3.6 Product information

Types of Product

A description of the finished product must be developed in order to prepare a systematic evaluation of the hazards and also associated risk in specific food and its ingredients or components. The overall product categories have been described as follows

1. Raw Block Frozen Headless Shell-on Fresh water Prawns
2. Raw Block Tiger Fresh water Head-on Shell-on, Semi IQF Prawns
3. Raw Fresh water Headless Shell-on IQF Prawns
4. Raw Fresh water Skewer PDO or PUD IQF Prawns
5. Raw Fresh water Butterfly PDO IQF Prawns
6. Raw Fresh water Easy Peel Headless Shell-on IQF Prawns

Packing

6 X 4 lbs, 6 X 2 kgs, 1.5 kgs, 6 X 0.8 kgs, 10 X 1 kgs (Including 10-20% glaze for IQF or as per buyer requirements).

Verification procedure

Verification consists of a periodic review to determine the overall effectiveness of the HACCP plan. The purpose of verification is to provide a level of confidence that the HACCP plan is based on solid scientific principles is adequate to control the hazards associated with the product and process and is being followed.

Verification is conducted by the HACCP team and also by the regulatory agency. The HACCP team will verify the following on every day, weekly and year basis.

- Validation of HACCP plan
- Calibration of monitoring devices
- CCP record review
- Auditing
- Microbiological raw and end product testing

Recall procedure

To develop a process line recall or consumer complain recall, the products are produced in the facility are labeled with such code, which is easy to find out the product as quick as possible. The following code are used in the products

- Country of origin

- Brand name
- Date of production
- Best before use
- Batch no.
- Shift code
- Count
- Type of processing
- Weight.



Quality control manager will recall the product to check and also in case of consumer complaint. If the recall is a serious nature, i.e. illness, death or injury, the preoduct will be destroyed by the company.

Procedure for audit

Every food processing industries have an effect in house system of verification of the implementation of HACCP plan. The verifications have also been entrusted with qualified external auditors. The verification is done every year irrespective of absence of non compliance. The initial HACCP plan is verified after the trial run of three months for validation. The verification includes HACCP work sheets, hazard analysis, plan and monitoring procedures, corrective actions taken, customer complaints, details of traceability sampling and testing to ensure the adequacy of the HACCP plan. All the related records of audits are available with the quality control manager along with corrective actions taken. The corrective actions taken are all verified by the quality control manager.

Labels/ specification

Labels and specification indicate the detail in information of the product. The products are being marketed in a brand name which is exclusively belongs to the company. The nature of the products will appear on the label as raw, fresh etc. A list of complete ingredients of the product will also declare in its inner carton. Name and address of the processor and packer also declared. The net contents are also mentioned in the inner carton box. These are out labels / specification which already discussed elaborately earlier in the labeling procedure. It is also specified that the products are produced under approved HACCP plan.

Procedure for corrective actions

Any non conformance or product quality beyond critical limit is rectified through immediate corrective actions. The following procedures are being adopted in the processing industries for initiating corrective actions. At the receiving, thawing, processing and soaking, dipping stages, the corrective actions are taken by the quality control manager in case of any defects noticed. At the freezer and processing line during production the deficiencies are identified and the corrective actions are taken by the operator. All corrective actions involving rejection of products is done only in consultation with the production manager and the general manager. All corrective actions taken are entered in the respective documents.

Procedure for consumer complaint

The food processing industries have already developed a consumer complaint file for handling of complaints. All types of complaints reach to the consumer complaint handling department in written through Chief of the company after receipt any kind of complain from our valued customer/consumer, and it is investigated the cause of complaint. Action is taken to correct the

cause of the complaint, it is a legitimate complaint and it is recorded on the complaint form. All of the consumer / complaints form and memos are kept on the file in the quality control department.

Identification and traceability

The fish processing plants have recall procedure in case of out of control situation when the raw materials received is identified by a lot number, date of receipt of raw materials, details of origin etc. from the shipment record. Finished products can be identified by product size, type, day codes, batch number and shift code. The type, size, day code, batch number etc. are given to enable traceability of the day's production. The raw materials used for the day's production can be easily retrieved. The samples for the quality checks are also drawn from each lot as per sampling plan. In case of details the code and batch number enable to ensure traceability of the end product back to the raw materials used. The process criteria are maintained throughout the production, recorded in on line quality control log and packing register, which are also useful in initiating recall.

Procedure for control HACCP plan

The HACCP plan and the manual is authorized by the industry chief issued and maintained by the directing authority. Product quality, customer complaint etc. is received by the directing authority who is the HACCP team leader. Based on the review results of the complaint by the HACCP amendments so done is recorded in the amendment sheet provided in all the copies of the manuals. It is the duty of the directing authority to issue the amendment sheets to all the holders' manuals. The obsolete copies of the amended sheets are maintained by the Quality control chief. The HACCP plan is updated once in a year and the updated version is authorized by the managing chief.

Quality policy

The policy of the frozen foods industries are to ensure and sustainability of quality and safety of the products. These fish processing plants always consider the buyers requirements as well as buying locally requirements. To satisfy the buyers the fish processing plants process very fresh sea foods and maintain the products quality as per US FDA CFR 123 and HACCP regulation, EU directives and county FIQC regulation.

4.4 Export of fresh water prawn

4.4.1 The export contribution of fresh water prawn from Khulna district

The values of return is obviously increased in Khulna district rationally rather than the total production of shrimp. The increasing rate of prawn production comparatively with the total production of shrimp is 31.30%, 34.21%, 37.24%, 40.20% and 43.82% in the fiscal year of 1999-2000, 2000-01, 2001-02, 2002-03 and 2003-04 respectively (Table-18). And the foreign earnings increased in 25.33%, 26.46%, 40.03%, 40.13 % and 42.82% in 1999-2000, 2000-01, 2001-02, 2002-03 and 2003-04 respectively.

Table-18: Year wise % of production and earnings of prawn in Khulna district of Bangladesh.

Year	Production (ton) of frozen Shrimps from Khulna	Production (ton) of frozen FWP* from Khulna	Total Earnings from Shrimps (Tk. crore)	Total Earnings from FWP* (Tk. crore)	% of FWP* of total production of Shrimps	% of FWP* of total export earnings of Shrimps
2003-04	31136.74	13643.03	1641.60	702.91	43.82	42.82
2002-03	27332.03	10986.65	1087.77	436.55	40.20	40.13
2001-02	22383.61	8335.29	1004.79	402.22	37.24	40.03
2000-01	23878.71	8167.72	1424.50	376.89	34.21	26.46
1999-00	22286.45	6975.86	1336.28	338.51	31.30	25.33

* FWP – Fresh water prawn

(Bangladesh frozen foods association of Khulna, 2004)

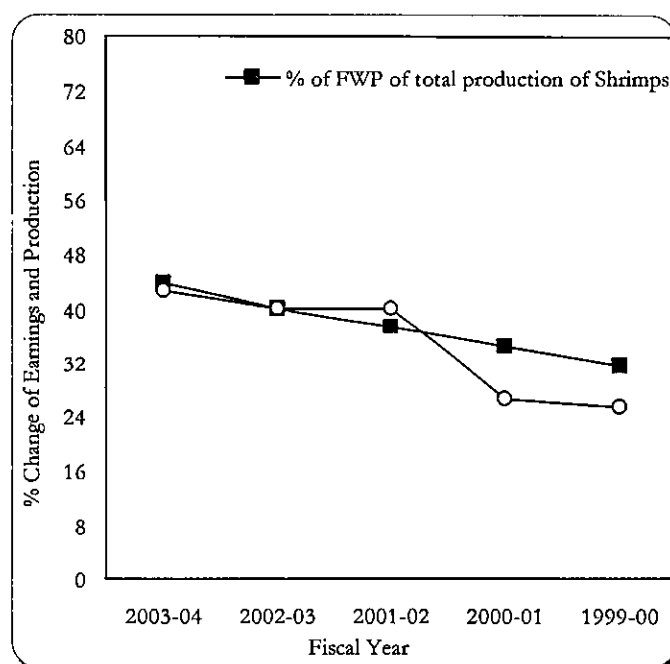


Figure-13: Year wise % of total production and earnings of fresh water prawn in Khulna district of Bangladesh

4.4.2 Export of Shrimps and prawns to international market

In the era of free trade economy world wide competition make the challenge for export trading. The restless effort of private entrepreneurship, instruction and facilitation of govt. and patronization of different organization, fisheries sector is the second largest exporting sector in Bangladesh.

Approximately 60 frozen foods processing industries approved by government are involved in shrimp and fish export. Above these 58 industries are approved in Europe for exporting frozen shrimp and fish. Approximately 130 frozen foods processing industries yet exists including sealed industries in the country (Rahman, 2005). Frozen shrimps and fish from Bangladesh are exported

to 40 different foreign countries in America, Europe, Australia and Asia. USA is the largest buyer for importing our frozen shrimps approximately one-third of our total exporting. Frozen shrimps and fish exporting to the international markets gradually increased. International market demand for exporting of fish and shrimp product was 17.94 billion dollar in 1982 but in 2002 it increased in 61.00 billion dollar. Shrimp production, price and demand play an important role in the international markets among the fisheries products.

Only shrimps contribute 92% earnings of the total exporting frozen foods in Bangladesh (Rahman, 2005). Frozen shrimps are also exporting in interregional country in Asia significantly other than USA and Europe especially Japan, Vietnam, Thailand and China. Besides this UK, Germany, Italy, Netherlands, Belgium, France, Canada, Denmark and Russia are also the renowned importer of frozen shrimps.

In present situation frozen ready to eat food products are exported mostly in Europe, USA, Japan and Canada. Last five years the demand of frozen ready to eat products is eventually increased in international markets. For that reasons frozen foods exporting industries established most modern instrument and tools for producing ready to eat food products in respect of buyers demand. About 50% industries are involved in producing ready to eat food products for exporting (Rahman, 2005). The export earnings was 383.32 million US\$ in 2004-05 (report till October) and it was 390.25 million US\$ in 2003-04. Last three years the foreign earnings significantly increased from the export of shrimp and prawn. Asian, European and American countries are buying our products for high consuming demand in foreign countries. In Asian countries Japan import the highest amount of shrimp products. In European countries United Kingdom and Belgium import the highest volume of products. But over the world United States of America is the top importer of our shrimp products. We earn the highest foreign currency from USA.

4.5 Major problem in the production and marketing in Khulna Region

Fresh water prawn business still rising venture as increasing various diseases over prawn culture in Khulna region to be involved in it. There is poor governance of Govt. or other agency to look after or manage the whole system which comprised of harvesters to exporters. Despite the great economic potential of fresh water prawns in Bangladesh, the successful commercial prawn marketing is hindered due to the existing many problems. The most crucial problems exist in fresh water prawn marketing and transportation is categorized in the following way:

- Lack of knowledge of proper marketing system and facilities.
- Poor infrastructure facilities especially transport, ice factory, electricity etc.
- Lack of consciousness/awareness about technology of fresh water prawn culture.
- The socio-economic status of the fishermen is so lower that they cannot afford even can't make the bigger investment.
- Prawn farmers are not well understood about grading system. Therefore, they are losing money during grading as well as prawn marketing.
- Lack of technical knowledge about prawn grading, icing and processing.
- Prawn traders do not maintain proper ratio of ice during icing.
- Prawn traders do not use proper weighing machine during grading.
- Farmers are not getting actual value due to presence of number of middleman in the marketing channel.
- Breakdowns in electrical supplies which are very common in our country, labor unrest and political disturbances also affect Mongla port during prawn exporting.

- Most of the traders have no Govt. registration/business license.
- Implementation of rules and regulation improperly in water transportation system.
- Mismanagement of roads and highways in communication system.
- Lack of proper transportation system of fresh water prawn from remote area to depot even in riverine way.
- Robbery/subscribing problems in rural and sub-city area.
- Violence and corruption.
- Lack of buyer and market information.
- Social and religious custom.
- Presence of middleman.
- Supply of fresh water prawn depends on foreign demand.
- Grading fraudulence by the exporter.
- The roads are not well constructed in locality.
- Implementation of rules and regulation improperly in water transportation system.
- Aricha ferryghut is a great obstacle to the transportation of fresh water prawn from southwestern region to Dhaka.
- Debt and Debt return problem.
- Presence of invidious person and extortion or muscle power by local leader
- The fresh water prawns are brought from the catching area such as the remote area through rivers to the near local market by simply boat not well mechanized having no facility to carry the sufficient ice. As a result, the products are reached too much late to the local market.
- Besides these the following problems are very susceptible for transporting directly or indirectly.
- Mismanagement of roads and highways in communication system.
- Bank credit problem.

4.6 Recommendations

- The Govt. may formulate a realistic Policy and strategy to strengthen and modernize the existing domestic and Export marketing systems of marine products.
- Un-exploited and untapped potential fishery resources need to be identified through survey and fully exploited.
- Establishment of a number of prawn/prawn hatcheries in this area.
- Farmers need training and extension work on prawn cultivation with the help of Government's Fisheries Offices.
- Establishment of a number of low-price fishmeal industries in this area.
- Avoiding middlemen during marketing.
- Sound and strong infrastructure facility should be developed to improve the marketing of prawn in this area.
- Proper management and high dike are essential to protect diseases and flood.
- Farmers need co-operative society to protect robbery and social conflicts.
- Existing fish landing and marketing centers to be modernized/ renovated to suit the EU and HACCP standard.

- Set-up new modern fish landing and marketing network having all the required facilities for easy landing, handling, auctioning, preservation, transportation etc.
- All necessary measures to be taken to keep the post harvest loss to a minimum level. Awareness building & training programs are too implemented widely at grass root level.
- In order to penetrate new markets and also to enhance the volume of fish sale, both Govt. and private sector may carry out continuous market research, technology development, quality control and packaging development activities.
- Adequate Bank credits without interest are to be ensured to the prawn farmers.
- Since market research is apparently non-profit making activity in the eye of private entrepreneurs, it may be undertaken and funded by Govt. /Donors /NGOs'.
- More frequent participation is needed in International Seafood Fairs in order to interact directly with potential foreign buyers.
- Arranging Food Fairs locally to popularize new products and also publicize improved product quality and standard.
- The Export Promotion Bureau may provide up-to-date online market information and help develop new potential markets.
- A modern centre for market research, data collection and information dissemination may be established.

4.7 Key factors for sustainable prawn farming

Although semi-intensive prawn farming may be less detrimental to the environment than intensive systems of prawn production, and less wasteful of land area than extensive farming, there are a number of factors on which the long-term sustainability of semi-intensive farming depends. The continuing high resource demands of such systems and their links to ecological degradation must be taken into consideration. The factors that should be considered to develop sustainable prawn farming are given below:

- Availability of brood stock and efficient hatchery system to ensure predictable and steady supply of prawn seed for grow-out operations.
- Suitable sites with quality water source, efficient drainage system and good infrastructure.
- Suitable farm design: construction and preparation for optimal water circulation treatment and storage of intake water, reconditioning and disinfecting of pond bottom, etc.
- Proper water management: pre-intake and discharge treatment, periodic exchange and aeration.
- Suitable stocking density considering the carrying capacity of the coastal culture environment.
- Nutrition: development of low-cost balanced feed, feeding management to avoid water pollution by feed waste accumulation.
- Prawn health management: so far the best treatment and preventive measure against diseases is to maintain good water and pond bottom conditions.
- Farmer experience: consider new ideas from farmer's self-observation for development.

5. Conclusion

Prawn farming in the country is still following traditional methods, except artificial stocking of prawn post larvae. Though the term 'Improved extensive' is being used in some cases, but it is not really so. Rather the culture system is in a transitional state between extensive and improved extensive. We could not do much to increase production level up to expectation, because the culture techniques could not be appropriately applied in most of the existing farms. Most of the prawn farms are unmanageably large having hardly exceeding 45 cm depth as against the required 1 meter, irregular shapes, uneven bottom, inadequate water supply and drainage system. Although Bangladesh is a significant exporter of prawn and thus well placed to develop and export market for farmed output. But substantial expansion of prawn farming expecting the highest efforts and wants of demand. Since there is a big gap between the supply and demand situation, prawn marketing or in other words selling of prawn domestically very easy. All types of prawn –high or low cost are easily marketed due to the presence of heterogeneous mixtures of buyers. High cost prawns are sold for rich class people or processed for exports. Mixed types low cost prawn are usually sold to the vast majority of the people of the low income group of the society who do not have enough purchasing capacity for the better species. Due to high domestic and international demand the prices of prawn or other exportable species have increased few folds.

The fish market and the marketing of fish and prawn is generally conducted by fish traders either individual or by the fishermen's cooperation. Almost all fish markets operated by such people, associations or cooperatives are very ill managed, unhygienic and unscientific. There is no proper handling, washing, cleaning, icing or re-icing of the fish and prawn. They care very little for post harvest management of the resources, but are more interested in earning more revenues at the cost of the fishermen and the final user of the consumers. Most of the fish market in the cities, district towns and in the villages managed by fish traders have no modern infrastructural facilities. City Markets built by the municipal corporations/ municipalities offer better facilities, but are not managed up to the standards requirement. Now a days, the Local Govt. Ministry are constructing small fish markets in the rural areas.

Before the liberation of the country practically no remarkable fish/ prawn processing factory was in existence. Bangladesh Fisheries Development Corporation with the objective to demonstrate the hygienic processing of prawn and fish product established fish processing plants at Chittagong, Cox's Bazar, Mongla and Dhaka. Exporters of private sector utilized the service of these plants and their interest and initiative for setting of such plants of their own developed. During independence (1971) Bangladesh had only 15 processing plants. The number of processing plants increased to 123 by 1997. The unplanned growth of such plants has resulted in loss of quality and international market goodwill. At present 58 processing plants have been issued license by Department of Fisheries (DoF) after modernization.

Since prawn is highly valued and demanding product in international markets, almost all prawns are exported to the international markets. It earns large amount of foreign currency. However, a sound global commodity market has not yet been established in Bangladesh. Government should take proper and advanced actions in prawn exporting to international market. Infrastructure development such as road, transport, ice factory and banking system and quality control must be developed in prawn farming and marketing areas.

Reference

- ADCP, 1983a. A policy for development of aquaculture in Jamaica. Report No. ADCP/MR/83/22. Aquaculture Development and Co-ordination Programme, FAO, Rome, 115 pp.
- ADCP, 1983b. A plan for aquaculture development in the Dominican Republic. Unpublished report. Aquaculture Development and Co-ordination Programme, FAO, Rome, 236 pp.
- Ahmed, N., 1967. Prawn fishery of East Pakistan. Directorate of Fisheries, East Pakistan Government press, Dhaka. 43p.
- Akand. A.M. and M.R. Hasan, 1992. Status of fresh water prawn (*Macrobrachium rosenbergii*) culture in Bangladesh. In: E. G. Silas (Editor), Fresh water prawns. Proceedings of the National Symposium, Kerala Agriculture University, India pp. 33-41.
- Angell, C. L. 1992. Inland fresh water prawn hatcheries: Introducing a new technology in Bangladesh. Bay of Bengal News, 48: 15-18.
- Anonymous, 1980a. Thai freshwater prawn and brine shrimp farming. Report on a study of economics, marketing and processing requirements. FAO, Rome, Report No. THA/75/008/80/WP/17, 124 pp.
- Anonymous, 1981. Frozen prawns tasty. Star-Bulletin (Honolulu, Hawaii), 27 August 1981.
- Anonymous, 1982. Predicting prawn success at mana. The Garden Isle (Lihue, Hawaii), 19 April 1982.
- Anonymous, 1986a. Sabana Grande Prawn Farm Ltd: An Investment Proposal, April 1, 1986 (Sabana Grande Prawn Farm Ltd.), P.O. Box 1218, Sabana Grande, PR 00747, U.S.A.
- Anonymous, 1986b. Aquabusiness: an interview with Michael Pascal. Development Business, 201:2.
- Anonymous, 1987. Special Bilan 86. Info-Macro Note d'information No. 12, IFREMER/FA-Guyana, 5 pp (in French).
- Arieli, Y., S. Sarig and Y. Bejerana, 1981. Observations on pond growth of *Macrobrachium rosenbergii* at the Ginosar Fish Culture Station in 1978 and 1979. Bamidgeh, 33(2): 57-68.
- Arndt, G., L. Gautz and J-K. Wang, 1984. Mechanical size grading of postharvest prawns. Journal of the World Mariculture Society, 15: 61-72.
- Bauer, L.L., P.A. Sandifer, T.I.J. Smith, and W.E. Jenkins, 1983. Economic feasibility of prawn *Macrobrachium rosenbergii* in South Carolina, U.S.A. Aquacultural Engineering, 2(3): 181-201.
- BBS, 2004. Bangladesh Bureau of Statistics.
- Boonyaratpalin, M. and P. Vorasayan, 1983. Brief note on the state of the art of *Macrobrachium* culture in Thailand. Network of Aquaculture Centres in Asia, Bangkok, Thailand. Working Paper NACA/WP/83/7: 10 pp.

- Chauvin, W. D., H. De-Saram and T. Singh, 1992. Traditional Shrim Harvest: supply overview. In: H. De-Saram and T. Singh. (Editors), proceedings of the Third Global Conferences on Shrimp Industry, Hong Kong, 14-16 September 1992. Infofish, Kuala-Lumpur, Malaysia, pp. 19-29.
- Chen, T.P., 1976. Aquaculture Practices in Taiwan. Farnham, England, Fishing News Books Limited, 163 pp.
- Chiang, P. and I.C. Liao, 1985. The practice of grass prawn (*Penaeus monodon*) culture in Taiwan. Journal of the World Mariculture Society, 16: 297-315.
- Cohen, D. and Z. Ra'anan, 1983. The production of the freshwater prawn *Macrobrachium rosenbergii* in Israel. 3: Density effect of all-male Tilapia hybrids on prawn yield characteristics in polyculture. Aquaculture, 35:57-71.
- Cohen, D., Z. Ra'anan, U. Rappaport and Y. Arielli, 1983. The production of the freshwater prawn *Macrobrachium rosenbergii* in Israel: Improved conditions for intensive monoculture. Bamidgeh, 35(2):31-37.
- Cook, M., 1980. There's no pot of gold in a prawn pond. State Times (Baton Rouge, Louisiana), 16 October 1980.
- Datta, A., 1995. Expanding farms, shrinking lives. Samudra Rep., 13: 24-28.
- DIFTA., 1993. Subsector study on the fresh water prawn *Macrobrachium rosenbergii* in Bangladesh. Danish Institute for Fisheries Technology and Aquaculture (DIFTA), Hirtshals, Denmark. 3 pp.
- DoF, 2004. Matshya Pacca' 2004, Department of Fisheries, Bangladesh.
- DoF, 2005. Matshya Pacca' 2005, Department of Fisheries, Bangladesh.
- Durairaj, S., G. Chandrasekharan, and R. Umamaheswary, 1992. Experimental culture of giant fresh water prawn in Tamil Nadu. In: Fresh water prawns (ed. E.G. Silal). Kerala Agricultural University, Thrissur, India. pp. 176-179.
- Elizabeth-Mesnager, D., 1981. Induced growth of *Macrobrachium rosenbergii* in Martinique: the reality (In French). Paper given at the Caribbean Aquaculture Symposium, 14-17 December 1981, pp 1-8.
- FAO, 2001. Fishery statistics: aquaculture production (1999). FAO Fisheries Series No. 58/FAO Statistics Series No. 160. Rome.
- FAO, 2002. Fishstat Plus (v.2.30), 15.03.2002. Rome, FAO.
- Fox, J.M., G.D. Treece, and G. Finne, 1985. The effect of environmental salinity on moisture content, free amino acid composition and chloride content in the tail-muscle of *Macrobrachium rosenbergii*. Manuscript from Texas A & M. University Extension Service, summarized in Aquaculture Digest, 10.11.35 and 10.11.36.
- Fujimura, T. and H. Okamoto, 1972. Notes on progress made in developing a mass culturing technique for *Macrobrachium rosenbergii* in Hawaii. In T.V.R. Pillay, ed. Coastal

- aquaculture in the Indo-Pacific region, pp. 313-327. West Byfleet, England, Fishing News Books.
- Glude, J., 1984. The development of commercial giant prawn farming in Puerto Rico. Presented at a seminar co-sponsored by the Division of Marine Resources, South Carolina, and the South Carolina Sea Grant Consortium, Charleston, South Carolina, 18 January 1984.
- Hale, M.B. and M.E. Waters, 1981. Frozen storage stability of whole and headless freshwater prawns, *Macrobrachium rosenbergii*. Marine Fisheries Review, 43(12):18-21.
- Holthuis, L.B. 1980. FAO species catalogue. Vol. I. Shrimps and prawns of the world (an annotated catalogue of species of interest to fisheries). FAO Fisheries Synopses No. 125 Vol. 1. Rome.
- Hopkins, S., 1986. Various aspects of the aquaculture industry in Taiwan with special reference to commercial cultivation of the grass prawn (*Penaeus monodon*). (Manuscript summarized in Aquaculture Digest 11.11.1.), 26 pp.
- Hoq, M.E., M.M. Islam and M.M. Hossain, 1996. Polyculture of fresh water prawn (*Macrobrachium rosenbergii*) with Chinese and Indian carps in farmers pond. J. Aqua. Trop., 11: 135-141.
- Hosmand, A.R., 1988. Statistical Methods for Agricultural Science, p 127-170 and p 251-278.
- Hossain M.A., M.A.L. Siddique and M.A.H. Miaje, 2000. Development of low cost feed for culture of giant fresh water prawn (*Macrobrachium rosenbergii*, De Man) in ponds.
- Humayun, N.M., A.K.M.N. Alam, and M.A. Ialam, 1986. Culture and production of *Macrobrachium rosenbergii* in a fresh water pond with catla catla. Bangladesh J. of Fisheries, 9(1-2): 1-7.
- Huner, J.V., 1980. Prawn culture in the continental United States. Paper presented at the Wildlife Disease Conference, Louisiana, August, 1980. Reported in Aquaculture Digest, 6.3.63.
- Hussain, M. M., 1994. Status of Development of Fisheries and Sea Food Processing Industry in Bangladesh. In: M. A. Mazid, V.R.P. Sinha and M. Kamal (Editors), Sustainable Development Marine Fisheries Resources in Bangladesh. Proceeding of a workshop, Fisheries Research Institute, Cox's Bazar, Bangladesh. pp. 65-85.
- Islam, S.K., Y.S.A. Khan and M.J.U. Chowdhury, 1990. Semi intensive culture of giant fresh water prawn, *Macrobrachium rosenbergii* (de Man). J. Asiat. Soc. Bangladesh Sci. 16 (2): 81-85.
- Jahangir Dr. Md. and Md. Alam, 2003. Culture potential of Coastal Resources.
- Janssen, J.A.J., 1987. The sex differentiation of the giant freshwater prawn *Macrobrachium rosenbergii*. Network of Aquaculture Centres in Asia, Bangkok, Thailand, Working Paper NACA/WP/87/54, P. 35.
- Kadera, J., 1981. At Weyerhaeuser: oysters, shrimp joint venture. Oregonian (Portland, Oregon), 3 September 1981.

- Karim, M., 1982. Status of shrimp/prawn culture in India, Bangladesh and Sri Lanka. Working Party on Small-Scale Shrimp/Prawn Hatcheries in Southeast Asia, Semarang, Central Java, Indonesia, 16–21 November 1981. FAO/ UNDP South China Sea Fisheries Development and Co-ordinating Programme, Manila. Report No. WP/81/SPH/CP-22, pp. 123–125.
- Kendrick, A., 1994. The Gher Revolution: The Social Impact of Technological Changes in Fresh water Prawn Cultivation in Southern Bangladesh. The report of a social impact assessment prepared for CARE International in Bangladesh with support from the Bangladesh Aquaculture and Fisheries resources Unit (BAFRU), P. 67.
- Khan, Y.S.A., A.K. Bhuiyan, S.I. Begum and M.A. Islam, 1984. Effect of different foods on the survival of growth of the juvenile *Macrobrachium rosenbergii* (de Man 1987) in indoor aquarium. Ctg. Univ. Studies, Pt. II, 81 (1): 55-60.
- Kutty, M.N., F. Herman and H. Le Menn, 2000. Culture of other prawn species. In M.B. New & W.C. Valenti, eds. Freshwater prawn culture: the farming of *Macrobrachium rosenbergii*, pp. 393-410. Oxford, England, Blackwell Science.
- Lam, C.Y. and J.K. Wang, 1986. Engineering research for improvement of freshwater prawn harvest yield in Hawaii. *Aquacultural Engineering*, 5: 313–323.
- Law A.T., K.S. Chin, K.J. Ang and M.S.Kamruddin, 1990. Digetibility of low cost ingredients in pelleted feeds by *Macrobrachium rosenbergii*. In: Proceedings of the second Asian Fisheries Forum, 17-22 April 1989, Tokyo, Japan (eds R. Hirano and I. Hanyo). Asian Fisheries Society, Manila, Philippines. pp. 333-336.
- Lee, S.R., 1979. The Hawaiian Prawn Industry: A Profile. Department of Planning and Economic Development, Honolulu, Hawaii.
- Lee, D., 1981. Turns greenhouse into a prawn shop. *Boston Herald American*, 29 May 1981.
- Lee, K.K.F., 1984. Promotion of a new aquaculture product - Hawaiian prawns. *Journal of the World Mariculture Society*, 14 : 339–40.
- Liao, I.-C., T.L. Huang, and K. Katsutani, 1969. A preliminary report on the artificial reproduction of *Penaeus monodon*. *JCCR Fisheries Series* 8:67–71 (in Chinese).
- Liao, D.S. and T.I.J. Smith, 1981. Test marketing of freshwater shrimp, *Macrobrachium rosenbergii* in South Carolina. *Aquaculture*, 23:373–79.
- Liao, D.S. and T.I.J. Smith, 1982. Marketing of cultured prawns, *Macrobrachium rosenbergii* in South Carolina. *Journal of the World Mariculture Society*, 13:56–62.
- Liao, I.-C. and N.-H. Chao, 1982. Progress of *Macrobrachium* farming and its extension in Taiwan. In: M.B. New (Editor), *Giant Prawn Farming, Developments in Aquaculture and Fisheries Science*, 10:357–79. Amsterdam, Elsevier Scientific Publishing Company.
- Liao, D. and T. Smith, 1983. Economic analysis of small-scale prawn farming in South Carolina. *Journal of the World Mariculture Society*, 14:441–450.

- Lin, C.K. and M. Boonyaratpalin, 1987. Biological characteristics of *Macrobrachium rosenbergii* in relation to pond production and marketing. Network of Aquaculture Centres in Asia, Bangkok, Thailand. Working Paper NACA/ WP/87/57, P. 16.
- Ling, S-W., 1963. Aquaculture in Southeast Asia: A Historical Overview. Seattle, University of Washington Press, P. 108.
- Ling, S.W., 1969. Methods of rearing and culturing *Macrobrachium rosenbergii*. FAO Fisheries Reports No. 57 Vol. 3:607-619.
- Ling, S-W., 1977. Aquaculture in Southeast Asia: A Historical Overview. Seattle, University of Washington Press, P. 108.
- Losordo, T.M., J-K. Wang, M.J. Brooks and C.Y. Lam, 1986. A mechanized seine harvesting system for freshwater prawns. Aquacultural Engineering, 5:1-16.
- Malecha, S., 1983b. Commercial Pond Production of the Freshwater Prawn *Macrobrachium rosenbergii*, in Hawaii. In: J.P. McVey (Editor), CRC Handbook of Mariculture, Volume I, Crustacean Aquaculture. Boca Raton, Florida, CRC Press Inc., pp 231-59.
- Mazid, M.A., Y. Mahmud, J.U. Miah and S.U. Ahamed, 1989. Effect of different stocking densities on the growth and survival of *Macrobrachium rosenbergii* with supplementary feed. Bang. J. Fish. (in press).
- McCaffrey, K., 1998. Japan's market for shrimp and prawns. Fish Farm. Int., 25(4): 16-17.
- Michael, B., 1987. New Freshwater prawns: Status of global aquaculture.
- MoFL, 2004. Annual Report, 2004. Ministry of Fisheries and Livestock.
- MoFL, 2005. Annual Report, 2005. Ministry of Fisheries and Livestock.
- New, M.B., (Editor), 1982. Giant Prawn Farming. Developments in Aquaculture and Fisheries Science, 10. Amsterdam, Elsevier Scientific Publishing Company, 532 pp.
- New, M.B. and S. Singholka, 1985. Freshwater prawn farming: a manual for the culture of *Macrobrachium rosenbergii*. FAO Fisheries Technical Paper No. 225 Rev. 1. Rome. [also published in Farsi, French, Hindi, Spanish, and Vietnamese]
- New, M.B. and A.G.J. Rabanal, 1987. Farm-made aquafeeds. FAO Fisheries Technical Paper No. 343. Rome.
- New, M.B., 1987. Feed and feeding of fish and shrimp - a manual on the preparation and presentation of compound feeds for shrimp and fish in aquaculture. Report No. ADCP/REP/87/26. Rome, FAO. [Also published in Mandarin and Farsi]
- New, M.B., 1991. Turnof the millennium aquaculture: navigating troubled waters of riding the crest of waves. World Aquacult. 22: 28-49.
- New, M.B. and W.C. Valenti, 2000. *Freshwater prawn culture: the farming of Macrobrachium rosenbergii*. Oxford, England, Blackwell Science.

- New, M.B., S. Singholka and M.N. Kutty, 2000. Prawn capture fisheries and enhancement. In M.B. New & W.C. Valenti, eds. *Freshwater prawn culture: the farming of Macrobrachium rosenbergii*, pp. 411-428. Oxford, England, Blackwell Science.
- New, M.B., 2000a. History and global status of freshwater prawn farming. In M.B. New & W.C. Valenti, eds. *Freshwater prawn culture: the farming of Macrobrachium rosenbergii*. pp. 1-11. Oxford, England, Blackwell Science.
- New, M.B., 2000b. Commercial freshwater prawn farming around the world. In M.B. New & W.C. Valenti, eds. *Freshwater prawn culture: the farming of Macrobrachium rosenbergii*, pp. 290-325. Oxford, England, Blackwell Science.
- Nierentz, J. H. and H. Josepeit, 1988. The European Shrimp market. *Infofish Int.*, 5: 36.
- Oregon Institute of Technology, 1981. Geothermal aquaculture project: Real Property Systems, Inc., Harvey Basin, Oregon, U.S.A. P. 33.
- Pashen, A.J., 1984. The economics of an aquaculture project (*Macrobrachium rosenbergii*) in Queensland. *Proceedings of the Seminar on the Potential of Aquaculture in Queensland, Brisbane, 24-25 March 1983*, pp. 187-198.
- Passy, N., Mannheim, C.H. and D. Cohen, 1983. Effect of modified atmosphere and pretreatments on quality of chilled freshwater prawns (*Macrobrachium rosenbergii*). *Lebensmittel-Wissenschaft & Technologie*, 16(4):224-29.
- Patra, R. W., 1980. Some observation on the biology and fishery of Caridean prawns of the river Bhairab and Bagherhat. *Bangladesh J. Zoo.*, 8(2): 75-80.
- Pavel, D.L., S.W. Cange and J.W. Avault, 1985. Polyculture of channel catfish, *Ictalurus punctatus*, with postlarval and juvenile prawns, *Macrobrachium rosenbergii*. *Journal of the World Mariculture Society*, 16:464-70.
- Peterson, J.J., 1982. Freshwater prawn harvesting: a comparison of three methods. *Journal of the World Mariculture Society*, 13:104-12.
- Popper, D.M., 1982. Baitfish and prawn culture in Samoa. (Report prepared for Baitfish Culture Project), FAO, Rome, Italy. P. 21.
- Premaratne, R.J., W.K. Nip and J.H. May, 1986. Characterization of proteolytic and collagenolytic psychotropic bacteria of ice-stored freshwater prawn, *Macrobrachium rosenbergii*. *Marine Fisheries Review*, 48(2): 44-47.
- Rahman, A.K.A., 1994. The small scale marine fisheries of Bangladesh. In: socio economic issues in coastal fisheries management. *Proceedings of the IPFC Symposium, Bangkok, Thailand. 8: 295-314.*
- Rahman M.M., 1995. Shrimp Resources Statistics. Department of Fisheries, Central Shrimp cell, Matshya Bhaban, Dhaka, Bangladesh, P. 16.
- Rahman, M., 2005. Present status and future prospects of export of frozen shrimps and fish of Bangladesh.

- Rosenberry, B., 1993. Shrimp farmers ravage the environment and people in Bangladesh. Ann. Rep. World Shrimp Farming, May/June, pp. 8-9.
- Samples, K.C. and P.S. Leung, 1985. The effect of production variability on financial risks of freshwater prawn farming in Hawaii. Canadian Journal of Fisheries and Aquatic Sciences, 42(2):307-11.
- Sandifer, P.A. and J.D. Joseph, 1976. Growth response and fatty acid composition of juvenile prawn (*Macrobrachium rosenbergii*) fed a prepared ration augmented with shrimp head oil. Aquaculture, 8:129-39.
- Sandifer, P.A. and T.I.J. Smith, 1985. Freshwater Prawns. In: J.V. Huner and E.E. Brown (Editors), Crustacean and Mollusk Aquaculture in the United States. Westport, Connecticut, USA, Avi Publishing, pp. 66-126.
- Sastradiwirja, F., 1986. Production, yield characteristics and economics of polyculture of *Macrobrachium rosenbergii* and various fish species under pond conditions. Network of Aquaculture Centres in Asia, Bangkok, Thailand, Working Paper NACA/WP/86/43, 66 pp.
- Shang, Y.C., 1974. Sea Grant Advisory Report. U.N.I.H.I., SEAGRANT-AR-74-05, 49 pp.
- Shang, Y.C., 1982. Comparison of freshwater prawn farming in Hawaii and in Thailand: culture practices and economics. Proceedings of the World Mariculture Society, 13:113-19.
- Shang, Y.C. and C.K. Lin, 1988. Economics of commercial production of freshwater prawn in Thailand. Paper presented at the 19th Annual Meeting of the World Aquaculture Society, Honolulu, Hawaii, January 1988.
- Shnider, M., 1985. News release, Sweet-Water Prawns Ltd., 21 November 1985, quoted in Aquaculture Digest, 11.2.33.
- Singholka, S. and C. Sukapunt, 1982. Use of a simple recirculation system for larval culture of *Macrobrachium rosenbergii*. In: M.B. New (Editor), Giant Prawn Farming, Developments in Aquaculture and Fisheries Science, 10:291-293. Amsterdam, Elsevier Scientific Publishing Company.
- Smith, T.I.J., W. Waltz and P.A. Sandifer, 1980. Processing yields for Malaysian prawns and the implications. Proceedings of the World Mariculture Society, 11:557-69.
- Smith, T.I.J., W. Jenkins, and P. Sandifer, 1983. Enclosed nursery systems for rearing juvenile Malaysian prawns, *Macrobrachium rosenbergii*. Journal of the World Mariculture Society, 14: 111-125.
- Tiensongrusmee, B., 1983. Freshwater prawn culture in Malaysia shows promise for farm venture. INFOFISH Marketing Digest, Vol. 2/83: 14-15.
- Williamson, M.R. and J-K. Wang, 1982. An improved harvesting net for freshwater prawns. Aquacultural Engineering, 1(2):81-91.
- Wulff, R.E., 1982b. General Mills' experiences in fresh-water shrimp farming in Latin America. In: J. Higman (Editor), Proceedings of the Gulf and Caribbean Fisheries Institute, 34:88-89.

Appendix - I

Table-A1: Manpower distribution of fresh water prawn farming at Khulna district in 2004.

Upazila	Manpower involvement in farm	
	2002-03	2003-04
Koyra	250	280
Paikgacha	165	210
Dumuria	17250	22530
Fultala	2100	2875
Digholia	3000	3260
Terokhada	2850	3150
Rupsha	3200	3480
Batiaghata	2000	2350
Dacope	110	135
Metro	150	215
Total	31075	38485

Table-A2: The monthly expected production (ton) of fresh water prawns (*Macrobrachium rosenbergii*) from 10 upazilas in Khulna district of Bangladesh in 2004.

Month	Upazila										Total
	Koyra	Paikgacha	Dumuria	Fultala	Digholia	Terokhada	Rupsha	Batiaghata	Dacope	Metro	
Jan	9.25	4.75	765.15	53.50	92.45	91.25	98.50	61.12	3.30	4.52	1183.79
Feb	10.35	5.25	875.30	60.34	108.03	113.35	118.24	68.15	4.10	5.20	1368.31
Mar	5.30	2.40	560.80	35.45	62.56	64.48	69.45	39.65	1.95	3.10	845.14
Apr	3.15	1.45	330.55	22.12	38.19	36.50	46.66	23.22	1.16	1.90	504.90
May	2.11	1.10	210.40	14.64	24.50	26.62	31.10	14.45	0.72	1.30	326.94
Jun	0.98	0.40	108.06	7.13	12.40	16.63	19.60	8.10	0.65	0.55	174.50
July	0.91	0.35	101.25	6.90	11.37	13.28	15.50	8.60	0.41	0.48	159.05
Aug	2.25	1.24	225.35	16.67	26.38	30.36	34.65	17.75	0.85	1.25	356.75
Sep	4.85	2.10	487.17	29.22	48.80	59.92	68.83	31.16	1.52	2.45	736.02
Oct	5.95	2.85	490.64	32.16	56.65	67.74	77.40	37.89	1.87	2.90	776.05
Nov	6.50	3.50	610.13	35.15	63.14	72.52	82.30	42.23	2.10	3.60	921.17
Dec	7.60	4.00	700.40	48.68	78.95	86.69	94.31	51.36	3.10	4.15	1079.24
Total	59.20	29.39	5465.20	361.96	623.42	679.34	756.54	403.68	21.73	31.40	8431.86

Table-A3: The monthly observed production (ton) of fresh water prawns (*Macrobrachium rosenbergii*) from 10 upazilas in Khulna district of Bangladesh in 2004.

Month	Upazila										Total
	Koyra	Paikgacha	Dumuria	Fulata	Digholia	Terokhada	Rupsha	Batiaghata	Dacope	Metro	
Jan	6.80	3.16	610.55	52.30	82.52	75.58	1121.72	55.60	2.65	4.90	2015.78
Feb	7.91	3.58	694.62	57.45	94.15	86.65	1246.66	62.88	3.10	5.42	2262.42
Mar	4.68	2.20	408.70	35.60	55.80	49.15	735.12	37.40	1.56	2.70	1332.91
Apr	2.67	1.36	253.44	21.53	33.84	31.35	438.16	22.84	1.12	1.60	807.91
May	1.88	0.86	164.50	12.69	22.45	18.13	293.44	13.56	0.62	0.94	529.07
Jun	0.94	0.45	83.34	7.15	10.94	8.11	144.72	7.32	0.31	0.46	263.74
July	0.91	0.44	80.60	6.85	9.12	7.85	139.52	6.87	0.28	0.45	252.89
Aug	1.89	0.89	170.90	14.25	22.08	17.35	289.12	15.56	0.79	0.96	533.79
Sep	3.76	1.74	314.94	26.36	44.16	36.47	583.88	30.12	1.75	2.18	1045.36
Oct	4.44	1.96	375.13	31.75	52.65	45.55	655.75	33.76	1.88	2.86	1205.73
Nov	4.65	2.20	409.75	36.35	58.68	49.85	745.65	37.44	2.10	3.60	1350.27
Dec	5.53	2.62	498.85	42.06	68.97	61.98	898.45	44.68	2.24	4.12	1629.50
Total	46.06	21.46	4065.32	344.34	555.36	488.02	7292.19	368.03	18.40	30.19	13229.37

Table-A4: Grade wise average monthly variation in price of fresh water prawn (*Macrobrachium rosenbergii*) in Khulna district in 2004.

Month	Grade-5 (200 gm)		Grade 10 (100 gm)		Grade-20 (50 gm)		Grade 30 (33.33 gm)		Grade 50 (20 gm)		Grade 60 (16.66 gm)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Jan	1145	± 3.54	816	± 6.52	663	± 5.70	410	± 12.25	265	± 8.66	180	± 11.73
Feb	1136	± 5.48	810	± 3.54	652	± .47	395	± 9.35	263	± 2.74	172	± 2.74
Mar	1125	± 2.77	806	± 4.18	645	± 4.56	390	± 7.91	252	± 8.07	165	± 7.91
Apr	1116	± 1.58	787	± 5.70	638	± 6.71	384	± 4.18	241	± 2.24	154	± 6.52
May	1093	± 2.88	764	± 4.18	632	± 6.71	378	± 5.70	230	± 3.54	145	± 1.00
Jun	1084	± 3.78	759	± 6.52	629	± 12.94	372	± 2.74	224	± 6.52	142	± 2.74
July	1082	± 4.47	747	± 9.08	625	± 12.75	365	± 3.54	218	± 4.47	136	± 8.94
Aug	1073	± 2.74	736	± 8.22	613	± 8.37	354	± 4.18	212	± 7.58	125	± 4.36
Sep	1098	± 2.74	762	± 5.70	621	± 2.24	360	± 5.00	225	± 7.91	146	± 8.22
Oct	1122	± 2.74	783	± 8.37	635	± 6.12	375	± 5.00	238	± 9.08	165	± 9.35
Nov	1134	± .18	805	± 3.54	656	± 15.57	396	± 8.94	252	± 2.74	178	± 4.47

Dec	1150 ± 3.54	822 ± 2.74	665 ± 5.00	412 ± 5.70	265 ± 6.12	185 ± 5.00
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Table-A₅: Grade wise average monthly variation in production of fresh water prawn (*Macrobrachium rosenbergii*) in South-Western region in 2004.

Month	Grade 5 (200 gm)		Grade 10 (100 gm)		Grade 20 (50 gm)		Grade 30 (33.33 gm)		Grade 50 (20 gm)		Grade 60 (16.66 gm)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Jan	210.14	± 15.27	304.45	± 16.56	374.78	± 20.68	412.24	± 23.22	284.55	± 7.30	179.22	± 18.46
Feb	234.87	± 13.07	321.42	± 7.23	408.56	± 9.81	463.38	± 31.90	328.87	± 18.70	192.00	± 18.23
Mar	192.37	± 8.91	280.96	± 6.76	311.24	± 18.36	348.88	± 11.92	254.45	± 27.33	109.59	± 6.11
Apr	104.23	± 10.64	149.96	± 4.69	172.25	± 19.54	198.87	± 16.42	132.36	± 19.01	86.28	± 6.11
May	75.52	± 13.43	112.80	± 4.67	98.44	± 9.63	143.69	± 25.54	95.65	± 11.33	61.11	± 21.62
Jun	46.25	± 5.02	89.56	± 9.53	105.58	± 8.62	112.38	± 32.42	78.89	± 18.01	51.91	± 19.87
July	53.33	± 12.84	74.33	± 10.09	87.25	± 13.10	99.15	± 21.16	64.48	± 12.58	44.51	± 7.13
Aug	61.50	± 11.19	93.25	± 12.30	102.37	± 8.55	113.65	± 16.09	81.18	± 14.18	51.12	± 8.20
Sep	102.00	± 6.02	164.99	± 3.54	189.57	± 48.10	205.06	± 26.40	138.47	± 11.19	93.33	± 10.97
Oct	129.65	± 2.41	203.31	± 9.21	251.05	± 12.47	286.34	± 29.53	191.20	± 7.12	118.64	± 5.46
Nov	162.66	± 7.16	254.85	± 3.78	299.86	± 74.50	316.82	± 11.56	216.60	± 20.68	149.85	± 14.75
Dec	204.06	± 3.81	310.15	± 7.92	352.10	± 9.83	398.55	± 22.45	264.16	± 13.95	172.28	± 8.35

Table-A₆: Upazila wise unit production (ton/ha) in Khulna district

Upazila	2003-04	2002-03	2001-02	2000-01	1999-00
Koyra	0.49	0.28	0.26	0.20	0.15
Paikgacha	0.20	0.17	0.88	0.74	0.53
Dumuria	0.59	0.32	0.38	0.28	0.19
Fultala	0.15	0.14	0.17	0.18	0.12
Digholia	0.89	0.50	0.22	0.21	0.12
Terokhada	0.95	0.38	0.52	0.47	0.30
Rupsha	0.62	0.51	0.64	0.52	0.48
Batiaghata	0.37	0.76	0.11	0.09	0.04
Dacope	0.79	0.67	0.73	0.45	0.65
Metro	0.46	0.48	0.40	0.34	0.30

Appendix-2

Questionnaire-1:

Date:	Locality:	Upazila:	Dist.:
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A)

⇒ Name of the depot:.....

⇒ Year of establishment:.....

⇒ Physical infrastructure of the depot:

a) Kaccha b) Semi-pacca c) Pacca

⇒ Size of the depot:.....

⇒ No. of partners in business:.....

⇒ No. of manpower in depot:.....

⇒ No. of customers:.....

a) Fixed:..... b) Temporary:.....

⇒ Peak period:.....

⇒ Lean period:.....

B) Grading system of fresh water prawn

In depot							Comments
In processing plants							

C) How do you preserve prawns in depot?

i)

ii)

iii)

iv)

v)

D) Transportation process from farm to depot

i) how take times?

.....



ii) which types of instruments is used for carrying?

.....

iii) is any extra activities?

.....

E) Transportation process from farm to depot

i) how take times?

.....

ii) which types of instruments is used for carrying?

.....

iii) is any extra activities?

.....

F) Did you take any loan to start your business?

Yes/No

If yes then

When :

From whom :

How much :

Was it sufficient :

Can you expand your business if financial assistance is given:

Yes/No

If yes, please tell what are the blueprints you can execute.....

G) Have given any dadon to your customers?

Yes/NO

If yes

How much?

.....

How many customers took?

.....

H) Prawn trading and business of the depots

From where prawn comes		where you supply	
customers	places	customers	places

I) Production and average price (Monthly) of fresh water prawn at upazila in Khulna district.

Month	Amount of production (kg)	Price of prawn (grade-wise) in Tk.					
		G-	G-	G-	G-	G-	G-

J) Major problems in fresh water prawn trading

a) Capital

.....

b) Law and order

.....

c) Marketing

.....

d) Transportation

.....

e) License

.....

f) Taxation

.....

g) Irregular supply

.....

i) Others

.....

Questionnaire-2:

Date:	Upazila:	Dist.:
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Survey from TFO/DFO office

A) How many/much gher are used in prawn culture? How many people are directly or indirectly involved in prawn farming?

No. of gher :

Total volume of gher :

No. of farmers :

Average production :

Total production :

B) How many licensed gher are in your upazila?

.....

.....

.....

C) How much money is taken for licensed according to the size of gher?

.....

.....

.....

D) Is any training given to farmers from TFO office/Govt. organization/Non-Govt. organization?

.....

.....

.....

E) Have any data about yearly production?

2004	2003	2002	2001	2000	Total production

F) How many types of culture system are done in your upazila?

.....

.....

.....

G) Have any plants in your upazila?

.....

.....

.....

H) I wanna ask you some information about jolmahal

Types of jolmahal :

No. of jolmahal :

Total volume :

Prawn production (%) :

Total production :

I) I wanna ask you to know some information about closed water body (pond, reservior)

Types of pond :

No. of ponds :

Total volume :

Prawn production (%) :

Total production :