

**AQUATIC ANIMAL HEALTH MANAGEMENT  
ISSUES IN FRESHWATER AQUACULTURE  
DEVELOPMENT IN ANDHRA PRADESH**

*A Thesis*

*Submitted to the*

*West Bengal University of Animal and Fishery Sciences,*

*In partial fulfillment of the requirements for the Degree of*

**MASTER OF FISHERY SCIENCE**

*in*

***Fishery Pathology and Microbiology***

*By*

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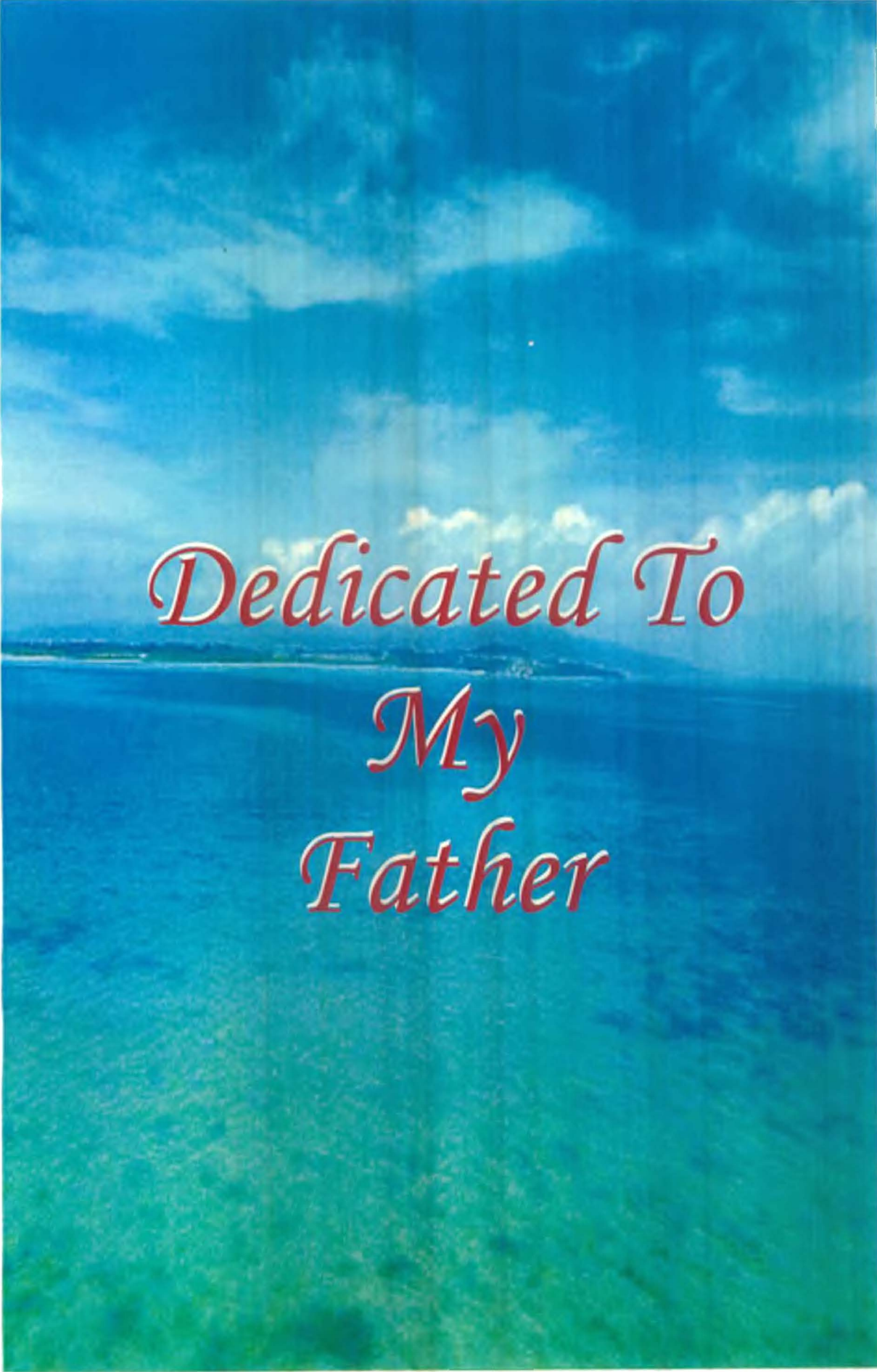
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**5 - Budherhat Road, Chakgaria, P.O. Panchasayar, Kolkata-94**

**2006**



*Dedicated To  
My  
Father*

WEST BENGAL UNIVERSITY OF ANIMAL AND FISHERY SCIENCES



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**CERTIFICATE**

This is to certify that the work recorded in the thesis entitled "*Aquatic Animal Health Management Issues in Freshwater Aquaculture Development in Andhra Pradesh*" submitted by Miss. P.Vineetha in partial fulfillment of requirement for the **Degree of Master of Fishery Science (Fishery Pathology and Microbiology)** in the Faculty of Fishery Sciences, West Bengal University of Animal and Fishery Sciences, is the faithful and bonafide research work carried out under my supervision and guidance. The results of the investigation reported in this thesis have not so far been submitted for any other Degree or Diploma. The assistance and help received during the course of investigation have been duly acknowledged.

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# *Introduction*

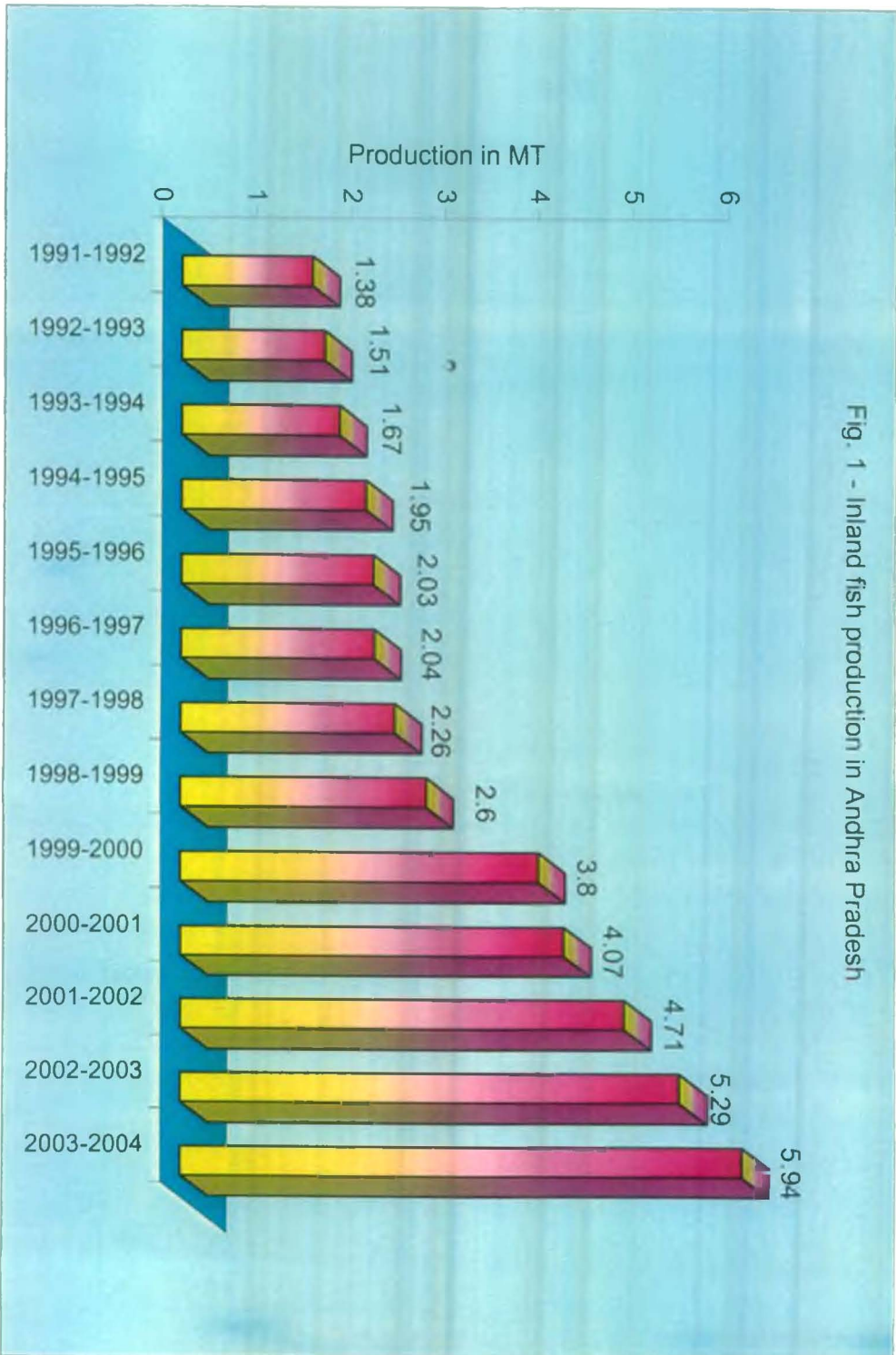


Fig. 1 - Inland fish production in Andhra Pradesh

# 1. INTRODUCTION

Fishery sector in India has come a long way since independence, contributing immensely to the country's protein requirement and also foreign exchange earning. Fishery is an industry of low investment rate, large development potential and attracting a lot of workers. Inland fish farming is an important way toward fishery development. The productive potential of water body and different foods can be utilized fully and rationally through farming the different species with different living and feeding habits in one pond. Needless to say that fish contains cheapest and highest protein content than any other products such as meat, milk etc. Like crops and pulses produced by agriculture, fish produced from ponds by practicing aquaculture is a daily food for a large section of society all over the country. Aquaculture has become the world's fastest growing food-producing sector, with a growth rate of 10% annually since 1984. Asia produces about 91% of the world's total aquaculture production with China, India, Japan, the Republic of Korea, the Philippines, Indonesia and Thailand as top producers within Asia.

In India, freshwater aquaculture has made notable progress in recent years. Freshwater aquaculture depends mainly on carp culture practices that account for around 80% of the total inland fish production and have proved sustainable at different levels of production over the years. Production comes from over 2.25 million ha of tanks or ponds, 1.3 million ha of oxbow lakes, 3 million ha of reservoirs and 1.2 million ha of coastal brackishwater area. India is the 4<sup>th</sup> largest producer of fish in the world and is 2<sup>nd</sup> in inland fish production. India's share in the world fish production has increased from 3.2% in 1981 to 4.5% at present. Fish production increased from a level of 0.75 million tonnes in 1950-51 to 6.4 million tonnes in 2003-04 against harvestable potential of 8.4 million tonnes registering an average growth of 4.29% over the same period. Fish production in 2003-04 consisted of 3.5 million tonnes from inland and 2.9 million tonnes from marine resources against the harvestable potential of 4.5 million tonnes and 3.9 million tonnes respectively. Growth rate in inland sector has been higher than the marine sector (Anon, 2004).

Andhra Pradesh is the 3<sup>rd</sup> largest state, both demographically and geographically. It has 23 districts with an area of 2,75,068 sq km. These districts fall under three distinct

regions: (i) The coastal region consisting of nine districts (Coastal Andhra), (ii) The interior region consisting of four districts (Rayalaseema area) and (iii) The Telangana region, which includes the capital city Hyderabad and ten adjoining districts. Andhra Pradesh is endowed with rich aquatic and agriculture resources with fertile soils and crisscrossing rivers and is called the 'granary' of the country. It was primarily an 'agrarian' state and now has become a prominent aquaculture state, exporting annually more than Rs. 1500 crores of marine production. The state ranks first in the country in coastal aquaculture and second in freshwater fish production (SIFT, 2004).

Andhra Pradesh has a long coastline of 974 km, 3,324 sq. km of continental shelf, and perennial Krishna – Godavari river system. All the rivers in the coastal districts of the state are east flowing and are harnessed for irrigation and power generation. The state has various types of waters (Table 1) and all these water bodies hold good fisheries wealth. There is a phenomenal development of aquaculture with 80,000 ha of freshwater fish culture in the coastal districts of the state. The state is also endowed with 6.33 lakh ha of irrigation tanks with good potential for fish production. The estimated production potential is 8 lakh tonnes from inland fishery resources. Keeping in view the vast potential for the development of fishery in the state and its contribution to the state's economy, the fishery sector is identified as a growth engine under vision-2020 and is one of the six growth engines identified under agriculture and allied sectors (SIFT, 2004).

**Table 1 - Freshwater fishery resources of Andhra Pradesh**

<b>Resources</b>	<b>Water spread area</b>
Rivers, canals and tributaries	13,891 km
Reservoirs	2,34,000 ha
Perennial fish culture tanks	1,83,000 ha
Long seasonal fish culture tanks	1,90,000 ha
Ponds	90,000 ha
Irrigation tanks	6,33,000 ha

On the inland fisheries front, West Bengal occupies the first position and Andhra Pradesh occupies second position in fish production (Fig. 1). In order to improve the inland fish production, new approaches in stocking with fingerlings are planned to be

adopted. Major carps contribute to about 85 - 90% of the total freshwater aquaculture production of Andhra Pradesh. Murrels (*Channa spp*) and catfishes (*Pangassius spp*) are the second most important group of fishes of commercial importance. The murrel landings in the state are next to major carps, mainly in Telangana and Rayalaseema regions. Where as major carps culture is mainly seen in east and west Godavari districts of Andhra Pradesh. Most of the kolleru lake region is mainly accompanied with fish culture such as catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) based on the consumer's preference. Freshwater prawn popularly known as scampi (*Macrobrachium rosenbergii*) has high potential for culture as an alternate culture species for *Penaeus monodon* in all freshwater tanks and ponds. In Andhra Pradesh, scampi culture is concentrated in Nellore district and this state is the highest producer of scampi in India. The total area of scampi culture in Andhra Pradesh is 35,000 ha.

Freshwater aquaculture in Andhra Pradesh depends mainly on carp culture practices that have proved sustainable at different levels of production over the years. With the intensification of culture, fish health problems have become very common in Andhra Pradesh carp culture systems. Several bacterial, parasitic and fungal diseases have been documented in freshwater aquaculture. In the carp-culture systems of Andhra Pradesh, much of the chronic mortality can be attributed to primary damage caused by ectoparasites and secondary infection by bacteria and fungi (Gopal Rao, 1988). Assessing the impacts of disease, even in aquaculture systems, is not easy, as only acute losses are recognized and quantified. Chronic mortalities and poor growth caused by diseases are not recognized. Though EUS appeared in the natural waters of Andhra Pradesh, reports of the disease in the well developed, semi-intensive aquaculture ponds are unknown. Several studies suggested that Indian major carps are either less susceptible or refractory to infection (Mohan and Shankar 1994). Retrospective analysis of Indian major carp culture in Andhra Pradesh during earlier EUS outbreaks suggested that EUS was not that significant in producing crop losses in culture ponds. Several surveys carried out since the occurrence of EUS in the carp-farming belt of Andhra Pradesh have identified only parasitic and bacterial diseases as major causes of crop loss.

Much of the problems associated with disease and its treatment that have surfaced now in Andhra Pradesh are a direct result of unplanned and hasty intensification of

culture practices. Compared to culture-based capture fisheries, health management in pond aquaculture is feasible and easy to implement. The major problem, however, is the lack of a holistic health management approach, as health management is often equated with chemotherapy. For better aquaculture management, the farmers must be well versed in farm-level diagnostics and health management strategies. Surprisingly, only a small percentage of farmers are able to diagnose health problems and rectify them (Rao *et al.*, 1992). Lack of diagnostic capability, coupled with misuse of chemicals, can have serious repercussions.

Many health problems originate in the seed-rearing farms but manifest themselves clinically, producing mortality under farm conditions (Mohan and Shankar, 1995; Mohan *et al.*, 1999a). Identifying health management strategies and defining health management costs to reduce or prevent disease losses relevant to Andhra Pradesh are very important. It is essential that fish farmers should be made aware that simple husbandry practices significantly reduce disease related losses. There are some areas where interventions can be attempted. These include the stocking of advanced fingerlings instead of spawn, fry or early fingerlings; stocking of resistant varieties; development of stocking policies to encourage the development of sustainable multi-species fisheries; and application of measures to avoid using these water bodies for sewage and industrial effluent discharge, pond drying, liming, assuring periodic sampling, good pond productivity, good feed and regular monitoring of fish health and water quality for a sustainable fish production. In order to quantify disease losses, fishers and farmers should be able to identify disease as the reason for crop loss, slow growth or poor harvest. The primary task should be to train farmers to carry out field level diagnosis and assess the likely impact of diseases. The present study was, therefore, undertaken with the following objectives:

- i) To understand the aquatic animal health management issues and assess systematically the impacts of diseases in freshwater aquaculture in Andhra Pradesh through interview based survey.
- ii) To develop appropriate interventions which can assist farmers to practice preventative management, and
- iii) To systematically study the diseases and pathogens that can cause significant impacts on freshwater aquaculture and affect the livelihoods of farmers.

# *Review of Literature*

## 2. REVIEW OF LITERATURE

The term health management is very broad and encompasses wider areas like water quality maintenance, providing proper nutrition, selection of good quality seed and brood stock, prophylaxis, timely disease diagnosis and chemotherapy, preventing the entry of pathogen or any stress factor, excluding more susceptible species from pond environment. It is now well established that disease development is the result of interrelationship between host pathogen and environment. Although pathogen is always present in aquatic environment, but it is not the sole cause for the disease development rather it gets a chance to cause disease when there is any imbalance between host-pathogen-environment relationships. Thus disease develops when fishes are in stressed condition due to environmental quality degradation, handling stress or nutritionally imbalanced condition, reducing the host immunity. Thus, minimizing the stress factor is the key to successful health management.

So far the research activities regarding fish health management is concentrated on use of chemicals for prophylaxis or therapy and it is characterized by lack of holistic approach. But as the aquaculture is a rural based activity socioeconomic condition of the farmers are also to be considered (Mohan and Bhatta, 2002). Considering this, appropriate approach towards health management should not only be scientifically sound but also be practical, community based, farmers needs oriented, well suited for a particular geographic location. After all, it should be socially acceptable and economically viable for the rural fish farmers (Subasinghe *et al.*, 2002). Considering this there is an urgent need to systematically assess the issues raised by several farmers to impart proper interventions at farmers level thus implementing health management practice more effectively.

### **The impacts of aquatic animal diseases**

The threat of disease has now become a primary constraint and risk to the growth of the aquaculture sector, significantly impeding both economic and socio-economic development in regions dependant on aquaculture and fisheries. Global production from aquaculture is presently estimated to be increasing at approximately 13% per year. If this rate is sustained, productions will double every six years (Baldock, 2002). In simple

terms, this phenomenon of rapid growth means more susceptible hosts will be available for pathogens to infect because of increased stocking density, excess use of feeds and fertilizers, as well as more farms with less distance between them. It follows that there are likely to be more disease problems, and the spread of epidemic diseases will be much more rapid, with potentially more devastating impacts, both on commercial and small-scale farmers. It would be, therefore, wise to plan for this situation rather than respond once it happens (Baldock, 2002).

**a) Several instances of economic loss due to disease**

Freshwater aquaculture in Asia is generally not a major foreign exchange earner, and production is mainly for local or domestic consumption. Therefore, the more significant impacts of disease on local micro-economies are probably not reflected within economic loss data (Lilly *et al.*, 2002). Economic losses due to disease outbreak in aquaculture systems are reported time to time from several countries by several authors. The annual economic loss in Chinese aquaculture due to disease is more than US\$1.2 billion (Qi, 2002).

In recent years epizootic ulcerative syndrome (EUS) has emerged as a cause of devastating loss in fresh water aquaculture system. Losses due to EUS in several Asian countries before 1990 exceeded US\$10 million (Chinabut, 1994) and In Bangladesh, the economic loss due to EUS was estimated at US\$3.4 million and US\$2.2 million during 1988-89 and 1989-90 (Mazid and Banu, 2002). The average economic loss from diseases on hatcheries and nurseries of Bangladesh was recorded Taka 8062/ha/yr (Hasan and Ahmed, 2002). Das (1994) gave an account of economic loss due to EUS in fresh water farms of three states of India causing a loss. Bhaumik *et al.* (1991) reported that 73% of the culture ponds in West Bengal were affected with EUS, most ponds having lost 30-40% of their stock. In contrast, Mohan and Bhatta (2002) reported ectoparasitic diseases are the main problem in fresh water farms of Andhra Pradesh, which cause annual losses of US\$1 million due to disease-induced mortality and impaired growth. A survey in Andhra Pradesh in the early 1990s combined the effects of disease-induced growth loss with mortality, in an estimated annual loss due to disease of 40 million Indian rupees (US\$ 860,000) (Gopal Rao *et al.* 1992).

Losses due to the outbreak of jaundice in catfish in 1992 in Thailand, was 20-100% causing an economic loss of US\$ 360-1,800/farm or US\$ 4.3-21.3 million for the whole country (Chinabut, 2002). In farms of the Vietnam where red spot disease (RSD) occurred, it caused an average loss of 45.2% of production resulting in economic losses estimated at more than US\$ 0.5 million (RIA 1 1998) and farmers expended US\$ 187.5 per farm as an additional input to control the disease (Jeney *et al.*, 2002). On average, farmers spend 10% of production costs on disease treatment (Mohan and Bhatta, 2002).

**Table 2. Economic losses due to EUS outbreak in India Source: Das (1994)**

State	Year	Economic loss (Rs million)
Bihar	1990	4.8
Orissa	1989-1991	3
Kerala	1991-1992	20

**b) Chronic losses due to disease**

Different aquaculture systems will experience different types of health problems, the majority of which will produce chronic mortalities. Unlike the acute losses associated with disease epizootics, chronic mortalities often go unnoticed. Acute losses attract the attention of fishers, fish farmers, socio-economic analysts, planners and administrators, and it is usually only these losses that are analyzed for their impact on rural aquaculture. The socio-economic impact associated with chronic losses may be many times higher than that resulting from the routinely assessed acute losses (Mohan and Bhatta, 2002). Ulcerative bacterial diseases, myxozoans, monogeneans, digeneans, larval cestods and ectoparasitic crustaceans have been regularly reported in Indian condition. Reports of mortalities associated with these pathogens are few; however, an absence of recognizable acute mortalities does not mean that these pathogens do not have an impact. Some of these pathogens are certainly responsible for significant chronic mortalities and poor growth that will be reflected in low survival and poor yield. Some of the larva digeneans and cestodes present in the body cavity and muscle of large fish can affect marketability (Mohan and Bhatta 2002).

### c) Problem of reduced marketability

There are reports of reduced marketability of the diseased fish as well as healthy fish from affected area in Bangladesh and India. A price fall of 54% and 75% was recorded in slightly ulcerated fish and healthy fish fry from affected area of Bangladesh (Khan and Lilly, 2002; Mohan and Bhatta, 2002.). Apart from acute loss and chronic loss in terms of fish production and use of additional input to combat the disease fish farmers may also be affected by reduced price in the local market. Thus, disease has a multidimensional impact on the socio-economy of fisher folk affecting the livelihoods of people involved in aquaculture and the communities in which they occur through reduced food availability and loss of income and employment, as well as other associated social consequences (Subasinghe *et al.*, 2002). Diseases can result in critical shortfalls in production which can lead to food shortages and market destabilization, and in some cases, can trigger trade problems. So there is an urgent need for incorporating basic health management programme into aquaculture practices. For that, systematic analysis of the issues raised by the fish farmer is urgently needed.

### Issues in freshwater aquaculture

#### Presence of wild fishes in the pond

There is over 10 times more chance of EUS occurring in culture ponds containing wild fish (Khan and Lilly, 2002). This was the highest relative risk (RR) measured by the author out of the variables examined. EUS commonly affects small wild fishes e.g., *Channa* spp., *Puntius* spp., *Anabas* sp., *Mastacembelus* spp, *Colisa* spp., *Mystus* spp., *Nandus* sp., *Heteropneustes* sp., *Clarias* sp. and *Ambassis* spp. These wild fishes not only acts as carrier of several pathogen but also compete for feed with the cultured fishes leaving them nutritionally poor thus prone them to increased susceptibility to disease. Study by Funge-Smith and Dubeu (2002) in Lao PDR showed that wild fishes like *Rasbora* besides being carrier of the EUS, also compete for rice-bran, especially if it is floated on the surface of the pond thus leaving the stocked fishes nutritionally poor condition which eventually increase the susceptibility of the cultured fishes to disease outbreak. Farmers of Bangladesh often consider that the additional catch of wild fish that enter fishponds may actually increase the overall production but ultimately come out with

a severe disease problem. Subasinghe and Hossain (1997) showed that prevalence was generally lower in artificially stocked fish sampled from natural waters than in wild fish.

### **Susceptibility of species**

Das (2002) showed that the fish species most severely affected by EUS were predominantly bottom dwelling fishes, like murrels and air-breathing catfishes; other miscellaneous fishes (*Puntius* sp., *Nandus* sp. etc.) were also affected. It was interesting to note that in all ponds under a traditional system of culture where both desirable and undesirable varieties of fish occur, murrels were affected at the first stage of the outbreak, followed by miscellaneous fishes and finally by the carps. In scientifically and semi-scientifically managed ponds where piscicides were used to control predatory fish, the carps were affected at the start of outbreak, since no other fishes were present (Bhaumik *et al.*, 1991).

Now, much new information has emerged on the susceptibility of different freshwater fishes to EUS. Several studies suggest that Indian major carps are either less susceptible or refractory to infection (Mohan and Shankar, 1994). Of the three Indian major carps, mrigal is considered more susceptible than catla and rohu. Histopathological studies of natural outbreaks have clearly shown that Indian major carps are able to mount a better inflammatory response and resist the fungal invasion better than the more susceptible *Channa* and *Puntius*. However common carp and Chinese carps are reported to be EUS-resistant Chinabut *et al.* (2002). Experimental infections have also shown that the typical clinical and pathological features of EUS can be induced in snakehead in seven to ten days following co-habitation or injection, while it is not possible to reproduce the disease in the same time period in major carps (Mohan *et al.*, 1999b). Grass carp was the species most frequently affected by red spot disease in North Vietnam, although in some farms mrigal and rohu were also infected (Phan *et al.*, 2002).

### **Pond connections**

Khan and Lilly (2002) showed that there was a significantly lower RR (0.39) of EUS occurring on farmed fish when pond embankments were high enough to prevent incoming waters. Similarly, ponds that had been flooded that year showed a significantly higher RR (2.33). Fish farms directly connected to water bodies that allowed the entry of wild fishes also showed a significantly higher RR (2.63) of EUS. Each type of connecting

water body (i.e., rice-field, ditch and beel) provided a similar level of risk. Ponds containing water sourced from underground wells or only from rain were at much lower risk of EUS (RR=0.91, 0.52), compared to ponds with water sourced from rice-fields (RR=2.36).

Hossain *et al.* (1992) showed a significantly lower risk of EUS-type lesions occurring on fish from rain-fed ponds (0.65) than from flooded or irrigated ponds. Floodwater and entry of wild fish are risk factors probably because they are routes of entry for pathogens (Kabata, 1985). Roberts *et al.* (1989) described floodwater as a powerful means for spreading EUS throughout Bangladesh. Changes in water quality and agricultural run-off due to floods may cause stress for the farmed fish, and may be a component cause for EUS. There is an absence of parasites and microbial flora in underground water, and the exclusive use of rainwater and underground water would reduce the risks of disease outbreak (Munro and Roberts, 1989).

#### **Pond preparation**

Khan and Lilly (2002) reported complete draining of pond water, drying, bottom mud removal and liming during pond preparation were found to result in low relative risks of 0.55, 0.41, 0.17 and 0.42, respectively in EUS outbreak. Fertilization during pond preparation also resulted in a low, but non-significant, RR (0.50). Pond preparation techniques described above will exclude *A. invadans*, and many other pathogens, from the pond environment. It is interesting that the “removal of bottom mud” resulted in a very low RR. Unlike other oomycete fungi, *A. invadans* does not appear to show strong negative geotaxis, and may possibly accumulate on the pond bottom, (although soil assays have not succeeded in isolating *A. invadans*) (Willoughby 1999). *Aphanomyces invadans* can feasibly survive the warmer months of summer in the thick bottom mud of older or derelict ponds, which generally possess a temperature below 31°C, and with declining temperature or rainfall disturbance, the fungus might be activated to grow. This theory is supported by Ahmed and Rab's (1995) study, which showed that fish cultured in previously derelict ponds had a significantly increased probability of EUS. Funge-Smith and Dubeau (2002) showed a positive health management feature of rain fed ponds in Lao PDR is that they dry completely for some period of the year, and therefore,

transmission of disease may be limited. This may currently be the most significant form of health management in this type of system.

#### **Post-stocking management**

Islam (2002) reported degradation of water quality of ponds due to poor pond management are common in Bangladesh. Overuse of fertilizers, manures and feed in pond culture are also common in Bangladesh, which causes degradation of water quality, and finally fish become stressed and prone to disease. Post-stocking liming also gave a significantly low RR of 0.46, and again, fertilization after stocking did not significantly affect RR rather over fertilization causes many stress related diseases (Funge-Smith and Dubeau, 2002). They showed that stress in shallow seasonal ponds, or over-fertilization, may lead to haemorrhages on the fish, and this may lead to reports of “red spots, spots and red scale.” In cooler, upland areas of Lao PDR, fish may eat less over winter, but farmers do not *reduce inputs*, which adversely affect water quality and fish health. Khan and Lilly (2002) also showed that pond-water colour indicating high levels of phytoplankton or zooplankton had low, but not significant RRs of EUS. However, ponds black with high levels of organic waste showed significantly higher RR (2.21).

Liming increases pH, hardness, alkalinity and the buffering system of pond water and also reduce *stress for fish*, thereby reducing the risk of disease outbreak. Exposure of fish to low pH might be one of the causes of skin damage, necessary for fungal entry to cause EUS. Callinan *et al.*, (1996) suggested that besides the germicidal effects of liming the increase in calcium and magnesium in the pond will also have a more direct effect by benefiting fish skin and inducing encystment (non infective stage) in fungal zoospores (infective stage), *thereby making* them fall out of suspension and accumulate in the pond bottom. Some farmers of Bangladesh reported that their unaffected pond became affected after they spread duckweed from a wild water body (Khan and Lilly, 2002).

#### **Hygiene / other diseases**

Islam (2002) reported accumulation of toxic gases due to decomposition of organic matter in the thick bottom sediments of old/derelict ponds and transfer of fish pathogens through water, carrier birds, and aquatic animals and insects in the ponds of Bangladesh. Khan and Lilly (2002) reported that allowing cattle to wash and drink in the pond after ploughing or grazing in other areas gave a high RR (2.90) to EUS, possibly

due to the transport of pathogens with the cattle. Netting with dried or disinfected nets, and requiring buyers to do the same, contributed much lower RR values (0.59 and 0.14, respectively). A high RR (2.65) of EUS was also demonstrated in ponds where the farmer said fish were affected by parasites. A number of parasites have been isolated from EUS-affected fish (Tonguthai, 1986) and may either be possible vectors for the pathogen, or a stress-inducing factor in EUS outbreaks. Subhasinghe (1993) demonstrated such an association between the level of infection by *Trichodina* sp. and the susceptibility of *Channa striata* to EUS infection. The mechanism of attachment of these parasites can cause skin rupture, and might facilitate infection by the EUS fungus. Funge-Smith and Dubeau (2002) reported in Lao PDR, lack of latrines and proper sanitary measure contributed to increased occurrence of trematodosis that are transmitted between humans, snails and fish.

#### **Climate / seasonality**

Khan and Lilly (2002) reported ponds with EUS in the previous season were shown to be at higher risk of EUS. EUS outbreak is prevalent during unusually low temperature or heavy rainfall 3-15 days before EUS occurrences in Bangladesh and in monsoon season in brackish water systems (Khan and Lilly, 2002, Mohan and Bhatta, 2002) where as Lilly *et al.* (2002) have shown that EUS is not always seasonal. Phillips and Keddie (1990) observed from data from 1988-89 that EUS outbreaks occurred during months when the mean daily temperature was below the annual mean temperature in Bangladesh, China, India and Lao-PDR. However, EUS outbreaks in the Philippines and Thailand were also recorded in warmer months. Chinabut *et al.* (1995) challenged striped snakehead (*Channa striata*) by injecting with zoospores of *A. invadans* and found a weaker inflammatory response, higher mortality rate and more extensive fungal invasion in fish held at 19 °C compared to fish held at 26° and 31°C. MacRae *et al.* (2002) reported that disease occurrence in fish and prawn farms of Bangladesh was most during rainy season followed by dry season where as fish and prawn mortality just before the harvesting was ranked third.

Phan *et al.*, (2002) reported RSD appeared to have a seasonal pattern, occurring mainly in March-April and October-November. In both the hatcheries and nurseries in both Mymensing and Jessor district of Bangladesh, diseases occurred more frequently

during the hot season (April-May), followed by the rainy season (June- July) and then the winter (December-January) (Hasan and Ahmed 2002). Jeney *et al.* (2002) reported in Tien Giang province of Vietnam, most of the diseases occurred after stocking, as well as in the cold and rainy seasons.

#### **Type of habitat**

Among the different types of fish habitat sampled, *haors* (biggest natural depression between two or more rivers, and is lower than the adjacent floodplains) showed the highest RR (1.33) and rivers showed the lowest RR (0.54) for EUS. Chemicals, waste and pathogens may enter the *haor* through the river systems. At the onset of the dry season, the water level of the *haors* decrease and the aquatic animals and plants are concentrated, often resulting in stressful conditions for fishes. The presence of a wide range of EUS-susceptible fishes under these circumstances make *haors* susceptible areas for EUS outbreaks. The active movement of the water in rivers may lessen the chances of the fungal pathogen attaching to fish, thereby resulting in the lower RR recorded for EUS in rivers. Phan *et al.* (2002) reported in Thai Nguyen Province, a mountain province of North Vietnam, with fishponds located in the valley and where tea is grown on the sides of the mountain red spot disease was very common just after rain as insecticides are washed into the ponds, causing the death of the fish. Similarly the pond located in rice field are also more prone to EUS out break because of the washed out pesticide enters into the pond during rainy season if proper embankment is not raised around the pond (Khan and Lilly 2002).

#### **Seed quality and low survival in nursery pond**

Sustainable rural aquaculture requires timely delivered, high-quality seed. The performance of food fish is related to both the quality of seed and their management post-stocking. Most seed used by smallholders is produced and delivered by the private sector, conservatively more than 90% in countries such as Bangladesh and Vietnam (Little *et al.*, 2002). The modern hatchery sector in both Vietnam and Bangladesh is less than 30 years old, but is characterized by increasing levels of competition, declining prices and increasing diversification and specialization. While an increased choice of species for rural farmers is beneficial, these production trends can negatively affect the quality of seed (Little *et al.*, 2002). Increasingly, as the quantity and availability of fish seed have

improved, the quality has been questioned. Funge-Smith and Dubeau (2002) reported that in Lao-PDR poor pond management results in low survival from nursery ponds, which is where greatest mortality occurs in the system. Estimated survival from egg to fingerling is below 5% and can be attributed to poor brood stock quality, poor hygiene, poor water quality, underfeeding and predation. Brood stock management is often poor, since fish need to be held at the hatchery for a minimum of one year before they mature.

A significant feature of the hatcheries is that they have perennial water, and brood stock ponds are rarely dried out and cleaned. This inevitably leads, at some stage, to health problems in fry or brood stock. This problem is compounded in some hatcheries where water reservoirs are stocked with grow-out fish. A further consideration with respect to the provincial hatcheries is that they are likely to be the source of fish that will ultimately be used as brood stock by small hatchery producers which is increasingly creating the problem of inbreeding depression resulting in genetically poor quality seed (Funge-Smith and Dubeau, 2002). The open nature of brood fish supply generally results in frequent transfers and mixing of different batches of fish and different age group of fish with consequences for genetic quality and the transfer of pathogens.

The nature of fish-seed supply networks predisposes fish to disease. Handling of both brood and seed fish typically occurs frequently and in environments prone to change and extremes. This increases stress on fish and the likelihood of infection and disease. Moreover, declining profit margins encourage practices that increase seed output for a given level of resources (space, water, feed, labour) that exacerbate these problems. These trends towards more intensive practices, if not accompanied by improved management, may further affect the pathogen-fish balance, increasing the prevalence of disease (Little *et al.*, 2002).

#### **Seed production: Hatcheries**

Management of brood stock has critical impacts on the health status and subsequent performance of seed. A trend towards commercial hatcheries outsourcing brood fish has consequences for both genetic quality and the movement of pathogens. Brood fish management of this type entails little risk of inbreeding occurring provided that the genetic variation of initial stocks is sufficiently high. The following are some points described by Little *et al.* (2002) that may adversely affect the seed quality.

Husbandry of brood stock, particularly during maturation of the gonads, is also likely to affect seed quality.

Transportation and immediate induced ovulation of female *Clarias macrocephalus* have been shown to reduce the quality of hatchlings when compared to seed from brood fish maintained and matured in the hatchery (Ingthamjitr, 1997). A trend in northern Vietnam and elsewhere in the region, towards increasing carp brood stock density, for economic reasons, prior to induced spawning could also negatively affect seed quality (RIA 1/AIT, 1999). Other factors identified by hatchery operators that might affect seed quality include increased frequency of spawning and out-of-season production, both of which may increase stress on brood fish and/or result in production of seed from immature gametes.

Induced spawning techniques themselves have also been associated with variable quality seed. Food-fish farmers in northern Vietnam believe that seed produced using pituitary glands are less susceptible to disease than seed produced using LH-RH analogues and dopamine antagonists and are prepared to pay more for the pituitary glands. A field trial indicated that different hormone types can impact on the numbers and quality of seed produced (Phan *et al.*, 1999). Handling stress associated with stripping gametes is known to reduce survival of brood fish, and natural spawning, where possible, is often preferred for this reason. Collection and incubation of seed can result in high losses through poor design and management.

Mixed batches of seed produced from multiple and small-batch spawners, such as tilapia and gourami, increase problems of cross infection by pathogens and competition/cannibalism between fish of different age classes. Poor design of spawning and incubation systems, such as catfish (*Clarias*) egg collecting trays that do not allow efficient separation of hatchlings from eggs, and tilapia incubators that mechanically traumatize eggs, increasing the chance of infection ultimately resulting in poor survival. Secondary fungal infections that follow primary bacterial disease or direct injury-related mortality is common in such systems.

Maintaining good water quality throughout the spawning and incubation cycle is critical if hatcheries are to reduce losses due to pathogens, however, water shortages and costs have forced hatcheries to use surface water with some treatment. Carp hatcheries in

Bangladesh have increased the efficiency of hatchling production / volume of water by using antiseptics during incubation. This is partly because reduced profit margins over the last decade have stimulated operators to use more surface water rather than ground water, which is costlier to pump. In Bangladesh and Vietnam, where use of surface water is the norm, hatcheries use floating aquatic macrophytes to moderate water temperatures and reduce the level of suspended solids in hatchery water (Little *et al.*, 2002). But disease outbreak in this type of system is more than those exclusively use the ground water.

Fish-seed health can also be negatively affected in clusters of nursing operations through reduction in local water quality and greater likelihood of pathogen transfer caused by pond effluents. Nursery ponds have shorter production cycles and are typically emptied and refilled more often than food fish-producing units. The greater competition among neighbouring nursery operations can also lead to reduced profitability and investment, especially in terms of pond preparation and feeding. Perhaps most importantly, clusters of nursing enterprises inevitably result in long-distance marketing of fry and concomitant risks of transport stress and damage (Little *et al.*, 2002). In Bangladesh Hossain and Mazid (1997) and reported reduced growth rate, physical deformities, diseases and high mortality in hatchery-produced carp seed, and they identified improper broodstock management, unconscious negative selection of broodstock, unplanned hybridization and inbreeding as the probable reasons behind this reduced performance.

#### **Trading of seeds**

There are many practical difficulties in maintaining fish seed in good condition before they finally reach to the farmers. High ambient temperatures, long marketing chains and basic physical facilities are important constraints. Traders selling fish seed from fixed outlets at the same location have many advantages in maintaining fish-seed quality, as electricity and clean water may be accessed more easily. Closed transportation, based on polythene bags inflated with oxygen, can improve quality, but will also impose limitations. Generally, motorized vehicles are required, and the amounts that can be transported are reduced; this increases the costs of seed transportation compared to open systems using aeration/oxygenation (Little *et al.*, 2002). Long

transportation times and poor handling will affect the quality of imported fish. The sale of poor quality fish that cannot be marketed in the country of origin is another consideration.

#### **Sudden mass mortality**

Mohan and Bhatta (2002) reported another serious problem observed in some of culture based capture systems of India is acute mass mortalities associated with domestic sewage and industrial effluent discharge. Sudden unseasonal rains bringing large quantities of silt or pesticides from the catchment areas into these water bodies can cause sudden mass mortalities. Fish health problems in culture-based capture fisheries may thus have serious socio-economic impacts. Little can be done in terms of management, in this multiple-user common resource. Hasan and Ahmed (2002) reported that in Mymensingh of Bangladesh, 40% of the farms reported sudden large-scale mortality of spawn. The reason for this sudden spawn mortality was unknown. Some of the farmers thought that a sudden sharp rise of water temperature in hatcheries and nurseries might be the cause. However, many of the farmers observed that sudden spawn mortality and the occurrence of deformed larvae are more common for spawn produced late in the breeding season. Hatchery owners often produce spawn three to four times using the same broodstock. Presumably, this practice deteriorates the larval quality and eventually results in deformed larvae and sudden mortality.

#### **Selection of healthy seeds and its movements and importation**

Funge-Smith and Dubeau (2002) reported in Vietnam one of the principal complaints from the farmers that they have very few of the stocked species in their ponds, but plenty of the small *Rasbora* spp. Their conclusion is that the fry traders are mixing the *Rasbora* (which look rather like carp fry) in with the Chinese or Indian major carps that they are selling. However, the majority of farmers (almost 95%) of Bangladesh as surveyed by MacRae *et al.* (2002) said that they were able to choose the healthy fry. However, during the peak season for stocking fish, they may have to take whatever is available because of the higher demand. Half of the farmers of Tien Giang province of Vietnam said that they were able to choose fry (53%), while the other half (47%) must take what is available. The same tendency was observed in the question about the physical condition of the fry: 54 % said the fry were healthy, while the remainder (46%)

did not know (Jeney *et al.*, 2002). About 60% of the farmers in northern Vietnam, said that they could choose the fry they purchased. Of course 92.7% said that they had access to healthy fry and only 7.3% said that they received unhealthy fry (Phan *et al.*, 2002).

#### **Stocking of water bodies**

Mohan and Bhatta (2002) reported there are definite impacts of stocking density on EUS outbreak. Smith and Dubeau (2002) reported due to constraints on fingerling supply, provincial government stocking activities are largely ceremonial, and significant numbers are not released. However, planned stocking was carried out by 98% of farmers during April in Bangladesh (Brown and Brook, 2002). Always it should keep in our mind only the uninfected fish lots should be stocked. Because, stocking of infected fish will negate any advantage gained from pond dry out as was observed in Lao-PDR, highlighting the critical value of good quality fingerlings (Funge-Smith and Dubaeu, 2002). Islam (2002) reported overstocking of fingerlings in unprepared and poorly prepared ponds and stocking of stressed and unhealthy fingerlings in the ponds of Bangladesh were quite common. Khan and Lilley (2001) also showed that sites that were artificially stocked showed no significant association with occurrence of EUS.

#### **Knowledge in aquaculture**

There are several reports that farmers gain their knowledge in aquaculture mainly from other farmers rather than any technical officer. This practice may invariably result in several problems like addition of input like feeds, fertilizer or treatment in their pond exactly in same dose like the neighbour farmer, irrespective of considering soil and water condition and cultural status of his own pond. One of the main constraints to aquaculture development in Nepal is an ongoing fear of disease, largely a result of previous EUS outbreaks. People are reluctant to start aquaculture activities due to the perceived high risk of disease and a lack of knowledge of how to deal with fish disease (Callinan *et al.*, 1999). Brown and Brooks (2002) reported in Bangladesh, in the farmers' opinion, it was their lack of understanding of fish culture and their inability to access credit that were the main constraints to their fish production. He also reported farmers in Bangladesh are interested in better basic training in aquaculture, rather than specific information regarding fish diseases.

Chinabut *et al.* (2002) reported in Thailand, farmers initially coming into aquaculture would try to learn how to grow fish by themselves. Later, they may get more information from *their neighbours*, friends or other farmers. The government is involved in transfer of knowledge about aquaculture through the organization of training courses or workshops once or twice each year. MacRae *et al.* (2002) reported the majority of the farmers of Bangladesh learned aquaculture from other farmers, followed by from friends and neighbours, learnt by self taught was ranked third where as learning from Government Extension Officers and non-governmental organizations (NGOs) was ranked last. When the farmers who own hatchery and nursery in Bangladesh were interviewed about the sources or the agencies from which they learned about aquaculture, the majority responded that they learned the techniques from other farmers (28.6%) and neighbours (24.5%), followed by government training courses (21%). About a fifth of the farmers (19.7%) responded that they were self-taught. Government training courses appeared to have a much better extension effect in comparison to non-governmental agency (NGO) training courses (2.1%) (Hasan and Ahmed, 2002). Among the 99 farmers surveyed in Tien Giang of Vietnam, the greatest number (39) contacted other farmers for information. Thirty-six farmers contacted government extension officers, 31 contacted drug and chemical salespersons, 25 contacted hatchery owners, 20 contacted fry traders, and only one contacted non-governmental organizations (NGOs) (Jeney *et al.*, 2002).

### **Disease Recognition**

MacRae *et al.* (2002) reported the ability of the farmers of Bangladesh to recognize the disease was based on a number of factors, the most frequently cited being reduced growth, *although mortalities*, abnormal behavior and abnormal appearance were all only slightly less significant. Phan *et al.* (2002) reported farmers in Vietnam check fry by visual examination, making a judgement about their health based on personal understanding of the movement and colour of the fry. Hasan and Ahmed (2002) in Bangladesh reported most of the farmers have a good understanding of the diseases problems, and *apparently*, most (87.7%) have the ability to recognize some of the diseases of their pond, while only 9.9% reported that they were able to recognize most of the diseases. Farmers of Tien Giang of Vietnam were asked about their ability to recognize disease. Thirty-one farmers said that they could recognize some diseases, while

28 said that they could not recognize any disease. No farmer said that he/she could recognise all or most diseases. The ability to recognise disease was based on a number of factors; the most frequently cited were mortality, abnormal behaviour, abnormal appearance and reduced growth (Jeney *et al.*, 2002).

### **Response to Disease**

On encountering a disease problem, most of the farmers of Bangladesh (54%) attempted to treat the animals. Some of farmers sought help or conducted emergency harvesting and *marketing*. (Khan and Lilly, 2002). MacRae *et al.* (2002) reported that majority of the farmers of Bangladesh would attempt treatment, an emergency harvest is the second most tendency among the farmers followed by “would do nothing”, and “would seek help”. Changing water, stop fertilizing and stop feeding was found to be very rare practice. Hasan and Ahamed (2002) reported nearly all (97%) farmers who operate nursery and hatchery in Bangladesh replied that they had used some form of treatment. Most of the farmers of both the study areas attempted preventive and curative treatment measures, and only a negligible percentage of farmers (1.2%) harvested and marketed their products. A few farmers (1.8%) did nothing during disease outbreaks in hatcheries and nurseries. Jeney *et al.* (2002) reported Forty-eight farmers Tien Giang province of Vietnam said that they sought help, 47 attempted treatment and 21 did something else (not specified). Ten farmers said that they carried out emergency harvest, while 11 farmers did nothing. If treatment was attempted, it generally involved the use of chemicals (36) or antibiotics (35); 29 farmers changed water, 16 stopped feeding and 12 stopped fertilizing.

### **Advice for fish disease**

Most farmers of Bangladesh contacted local government extension officers when they face a disease problem. Some of them will discuss problems with their neighbour, fry trader, feed salesperson, hatchery owner or drug salesperson. Farmers feel that information from government extension officers is useful and reliable. (Khan and Lilly, 2002). MacRae *et al.* (2002) reported that the majority of farmers (28) of Bangladesh learned about the treatment that they used from other farmers. Feed salespersons (7) and NGOs (5) were also a source of information, while chemical salespersons (4) and government extension services (3) were less frequently consulted. Five farmers reported

that they learned the treatments themselves. Phan *et al.*, (2002) also reported that government extension officers work closely with fish farmers of Vietnam to assist in controlling the disease, as 63.2% of farmers asked for help from government extension staff, while 33.7% sought help from other farmers. Farmers often establish aquaculture groups with a nominated leader, so that they can help each other with problems, as well as share experience. When farmers of Thailand have problems, they contact local fisheries officers, nearby diagnostic laboratories, or the salespersons who supply them feed or chemicals. For simple cases, the problem can be solved at the site or through a telephone discussion with a disease expert.

#### **Cost and success of the treatment**

The most common types of treatment used by farmers of Bangladesh are chemicals and antibiotics. The average cost of treatment is US\$46, and only three farmers said that the treatment was “always successful.” (Khan and Lilly, 2002). Nursery owners in Bangladesh used different treatments such as chemicals and antibiotics, water exchange and manipulation of feeding and fertilization. Use of chemicals ranked highest (98.1%, n=158), followed by stopping of fertilization (31.7%, n=51) and feeding (28.6%, n=46), water exchange (27.3%, n=44) and use of antibiotics (15.5%, n=25). Insecticides and pesticides are often used for chemical treatment e.g., sumithion and malathion are commonly used to treat against fish lice on brood stock. 15% of the farmers had complete recovery from diseases as a result of treatment, whereas 31% had usually had recovery, 59% sometimes had recovery, and 4% never had recovery. Phan *et al.*, (2002) reported antibiotics and lime were the most popular treatments applied when fish were affected by RSD in Vietnam. However, effectiveness was not high, as most farmers reported that treatment was rarely or never successful. Of the farmers surveyed, 4.9% applied more fertilizer when their pond was affected by RSD; such advice (though never successful) came from other farmers. The average cost of the treatments applied was US\$5.30, the maximum was \$20.60, and the minimum was \$0.22. In terms of treatment efficacy, only 21% of farmers reported success, while 49% reported partial success and 11% reported failure (MacRae *et al.*, 2002). Hasan and Ahmed (2002) reported the cost of treatment in hatcheries and nurseries of Bangladesh was Taka 1669/ha/yr.

The average cost of treatment was 132,414 VND (US\$101) in northern Vietnam (Phan *et al.*, 2002). The average cost of the treatments applied in Tien Giang province of Vietnam, was 64,400 VND (US\$4.60), the maximum was 200,000 VND (US\$14.30), and the minimum was 5,000 VND (US\$0.35). Only six farmers said that the treatment was “always” successful; 23 farmers said that it was “sometimes” successful, 21 said that it was “usually” successful and four said that it was “never” successful (Jeney *et al.*, 2002).

#### **Importance of fish diseases to farmers**

Farmers often considered that factors like own knowledge in fish farming, finance shortage, poaching and flooding are more important than fish disease. Flooding and poaching is one of the major concerns in several underdeveloped and developing countries. Phan *et al.* (2002) reported that the most important issues affecting farmers of North Vietnam were disease (65.8% of the farmers surveyed mentioned disease as the most important problem), insufficient water (15%), theft (8.6%), and flooding (5.7%). Other responses (predation, water temperature too hot or too cold, unidentified) made up the remaining 4.9%. When ranking problems, by hatchery and nursery owners of Bangladesh 29.3% mentioned the occurrence of disease as their major problem, while 27.6% ranked shortage of water was their major problem. Other problems faced by the farmers were flooding, theft and extremes of temperature (too hot or too cold). In addition, some of the farmers mentioned lack of finance, frequent hartals (general strikes) and bad road communication as their major problems.

Farmers of Tien Giang of Vietnam were asked to rank, in order of significance, the problems that they encountered (Table 5). The major problem was flooding, followed by theft. Disease was ranked fourth, and too little water was ranked sixth. Predation figured highly in the second and third ranking (Jeney *et al.*, 2002). Chinabut *et al.* (2002) reported that flooding is an uncontrollable problem that causes serious loss in aquaculture and was ranked first followed by disease by the farmers in Thailand.

#### **Prevalence of fish diseases in India**

Das and Das (1995) reviewed and recorded the fish diseases of economic importance those occur in various parts of India. They recorded as well as identified the causative agents of ulcerative dropsy, columnaris diseases, trichodiniasis, white gill spot, white scale spot, dactylogyrosis and gyrodactylosis, back spot disease, ligulosis, lerniasis,

ergasiliasis, argulosis, gill rot and saprolegniasis in traditional pond fishes of both indigenous and exotic origin of India. Whereas, Gas bubble diseases, white scale spot and trichodiniasis were reported from sewage fed wetlands of India. They also recorded fresh water prawn diseases like soft shell syndrome, cramped tail condition, external fouling and back spot syndrome.

In eye disease most affected species is *Catla catla*, both advanced fingerlings and adults. Gopalakrishnan (1960) reported that eye disease is very common in *Catla catla*, both advanced fingerlings and adults. He also reported *Aeromonas liquefaciens* as the causative agent of eye disease. Eyeball becomes putrified in this disease, which finally leads to death of the fish.

Dropsy affects juvenile and adults of Indian major carps (IMC). Gopalakrishnan (1961) could not develop the disease in fingerlings of *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* after inoculating the causative bacterium, a species of *Aeromonas* isolated from the dropsy infected fish. Das and Halder (1986) reported a myxozoan, *Neothelohanellus catlae* to infect and cause damage to the kidney of *Catla catla* affected by dropsy along with the bacterial pathogen. Columnaris disease is generally reported in *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*, *Ctenopharyngodon idella* and *Hypophthalmichthys molitrix*. Kumar *et al.* (1986) reported *Flexibacter columnaris*, causative agent of columnaris disease in stressed *Labeo rohita*.

Ulcer disease is very frequently encountered in Indian major carps, *Hypophthalmichthys molitrix*, *Ctenopharyngodon idella*, *Clarias batrachus*, *Channa spp.*, *Heteropneustes fossilis*. This disease initially appears as small reddish areas, gradually the lesions become prominent and in advanced cases large cutaneous haemorrhages occur. Species of *Aeromonas* and *Pseudomonas* were isolated by several workers in India from ulcer affected freshwater fishes and catfishes stressed by high stocking density and bad water quality (Manohar *et al.*, 1976; Karunasagar *et al.*, 1988; Sahoo *et al.*, 1996).

In India Chidambaram (1947), Gopalakrishnan (1968), Srivastava (1977), Srivastava (1980; 1987), Khulbe and Sati (1981) and Sati and Khulbe (1982) studied fungi associated with freshwater fishes. *Saprolegnia*, *Achlya*, *Branchiomyces* and *Aphanomyces* are the important genera of fungi associated to fish diseases. Saprolegniasis

is one of the most commonly occurring fungal diseases in India. Many workers reported the disease in eggs, fry and fingerlings of cultured Indian and exotic carps (Gopalakrishnan, 1968; Srivastava, 1976; Jha *et al.*, 1981). Banik, Chakraborty and Som (1997) reported occurrence of *Saprolegnia parasitica* on the epidermis of a freshwater fish *Mystus tengra* (Ham.) collected from a wetland of Tripura. They also studied important abiotic and biotic features during the abundance of this fungal parasite. Chauhan and Qureshi (1994) isolated *Saprolegnia ferox* and *S. hypogyana* several times from *Trichogaster fasciatus*, thus taken as natural host for those fungi and then they carried out host range experiments of those fungi on several other fishes viz., *Chanda ranga*, *Channa punctatus*, *Puntius sarana*, *P. ticto*, *Macrogathus aculeatus*, *Mystus cavasius* and *Xenentodon concila* from lower lake of Bhopal.

Fishes affected from ichthyophthiasis show irritation, erratic movement and restlessness with tendency to rub on the sides (Gopalakrishnan, 1964, Srivastava, 1975). In 1955, Tripathi experimentally infected fingerlings of Indian major carps with ichthyophthiasis. The urceolariid ciliates are important among the most common protozoans living on the surface of fishes (Lom and Halder, 1977). Most frequently encountered genera of this group are *Trichodina* and *Tripartiella*. Tripathi (1954) reported *Trichodina indica* from *Labeo rohita*, *Labeo calbasu*, *Cirrhinus mrigala*, *C. reba*, *Catla catla*, *Amblyp-haryngodon mola*, *Chela bacaila*. Later in 1971, Devaraj endorsed the findings of Tripathi. In 1979, Hagargi and Amoji reported *Trichodina pediculus* from the fishes of Karnataka region of India and in 1982 Mukherjee and Halder reported *Trichodina nigra* from *Nandus nandus* and *Oreochromis mossambicus*. Das and Halder (1987) investigated *Tripartiella bulbosa*, *Tripartiella copiosa* and *Tripartiella obtusa* parasitising the gills of some cultured Indian and exotic carps.

In recent years, myxozoan parasites causing diseases in intensive fish culture ponds have evoked great interest. Among the myxozoa two genera *Thelohanellus* (Kudo, 1993) and *Myxobolus* (Butschli, 1982) are important so far fish disease is concerned. A number of researchers reported different species of the genera *Thelohanellus* and *Myxobolus* from the freshwater fishes all over India (Southwell and Prashad, 1918; Tripathi, 1952; Lalitha Kumari, 1969; Seenappa and Manohar, 1981; Lom and Molnar, 1983; Halder *et al.*, 1983; Sarkar *et al.*, 1990). Monogenetic and digenetic trematodes are

important parasites, parasitising both freshwater and marine fishes. Tripathi (1957), Hora and Pillay (1962), Gopalakrishnan (1964), Das and Pal (1987) reported *Dactylogyrus* spp. and *Gyrodactylus* spp. from fry and fingerlings of *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* in nursery and rearing ponds in different parts of India.

#### **Epizootic Ulcerative Syndrome (EUS)**

Epizootic Ulcerative Syndrome was first reported in 1988 from the north-eastern states of India. Then the epizootic gradually spread throughout India in both freshwater and brackishwater fishes. In India, thirty species of freshwater and brackishwater fishes has been recorded (Das and Das, 1993; Das, 1994, 1997). Data collected in India revealed increased intensity of EUS in water areas with low alkalinity and hardness (Das, 1992; Das *et al.*, 1993; Das, 1994). Though recently, *Aphanomyces invadans* is reported as the causative agent of EUS, different workers from India have reported a variety of fish pathogens. Several workers viz., Sharma *et al.* 1988; Sitdhi, 1989; Das *et al.*, 1990; Kumar *et al.*, 1991; Bright Singh, 1991; Chakraborty, 1991; Das and Das, 1993; Mukherjee, 1996) could able to isolate a wide variety of bacterial fish pathogens from EUS affected fishes in different parts of India. Predominant bacterial forms isolated from EUS affected fishes in India are *Aeromonas hydrophila*, *Pseudomonas mottophila*, *Staphylococcus* sp., *Shigella* sp., *Salmonella* sp., *Klebsiella* sp., *Bacillus* sp., *Streptococcus* sp., *Vibrio* sp., Acid fast nocardiform (CAN) etc. Kumar *et al.* (1991) and Das and Das (1993) reported different fungal species like *Aspergillus* sp., *Saprolegnia* sp. as secondary invader in EUS affected fishes. Das and Das (1993) also reported different animal parasites but not sufficient to cause disease outbreak.

Paria and Konar (1999) reported the prevalence of fish disease in West Bengal. According to the survey, the percentage of pond affected by EUS ranged from 32.68% to 72.72%, argulosis 0.81% to 9.80%, malnutrition 9.69% to 32.30%, gill rot 9.10% to 34.37%, dropsy 3.33% to 14.40%, tail and fin rot 2.43% to 6.52%, tumour 0.85% to 7.28% and fungal diseases 1.12% to 2.19% from different districts of West Bengal. Biswas (2002) reported incidence of EUS from Nadia, 24 Parganas North and South districts of West Bengal as 13.6%, 23.0% and 50.0% on percentage basis in culture pond, public ponds and beels respectively.

Mishra and Das (1993) reported *Trichodina reticulata* from the gills of *Catla catla* at sheoraphuli locality of West Bengal. Pagarkar and Das (1993) reported *Thelohanellus caudatus* and *Myxobolus serrata* from caudal and anal fins of *Labeo rohita* and gill arch of *Cyprinus carpio* in West Bengal. Ghosh, Dutta and Laha (1987) reported *Dactylogyrus* spp in *Catla catla* from Hoogly. Das (2003) found five different types of helminth groups such as monogeneans (*Gyrodactylus* sp. and *Dactylogyrus* sp.), digeneans (*Diplostomum* sp.), cestodes (*Caryophyllaeus* sp.) nematodes (*Anisakis* sp and *Spirocamallanus* sp) and acanthocephalans (*Hypoechinorhynchus* sp.) as dominant helminth parasites in the catfishes of beels from Nadia district of West Bengal. Ghag (2004) and Saha (2005) reported five different types of helminth groups such as monogeneans (*Gyrodactylus* sp. and *Dactylogyrus* sp.), Digenians (*Heterophyes heterophyes*, *Clonorchis* sp.), cestodes (*caryophyllaeus* sp.), nematodes (*Camallanus* sp. *Indocucuiianus* sp. *Rhabdochona* sp.) and Acanthocephalans (*Pallisentis* sp.) were dominant helminth parasites in the carps from freshwater ponds, hatcheries and retail markets. They also showed the species specificity, site of infestation as well as seasonal pattern of helminth infestation in carps. Abraham *et al.* (2004) studied the bacterial flora associated with tail rot or fin rot of *Carassius auratus*, *Xiphophorus helleri* and haemorrhagic ulcers of *Clarias* spp. and isolated *Pseudomonas* spp. and gram-positive rods. Sensitivity pattern of 33 isolates were screened against six broad-spectrum antibiotics viz. ciprofloxacin, chloramphenicol, co-trimoxazole, gentamycin, nitrofurantoin and oxytetracycline. Ciprofloxacin was the most effective in inhibiting bacteria at 0.05-0.10 µg/ml levels.

#### **Disease prevalence in Andhra Pradesh**

With rapid intensification, serious fish disease problems have surfaced and became very common in Andhra Pradesh carp culture systems. Poor husbandry, increased Stocking densities, unsuitable water quality and dietary imbalances are the major causes of diseases in aquaculture. The major diseases encountered in carp culture are protozoan, crustacean, helminthic, fungal and bacterial in origin. Ectoparasitic crustaceans (*Argulus* spp.) and bacterial disease (*Aeromonas hydrophila*) account for significant proportion of the mortality (Gopal Rao, 1988). Mohan and Bhatta (2002) reported ectoparasitic diseases are the main problem in fresh water farms of Andhra Pradesh, which cause annual losses of US\$1 million due to disease-induced mortality and

impaired growth. A survey in Andhra Pradesh in the early 1990s combined the effects of disease-induced growth loss with mortality, in an estimated annual loss due to disease of 40 million Indian rupees (US\$ 860,000) (Gopal Rao *et al.* 1992). Information collated from the literature and from 200 case studies of farm ponds in Andhra Pradesh, among the major disease problems encountered in the farm ponds, parasitic infections account for 70%, while the bacterial and fungal disease problems account for 27.5% and 2.5%, respectively. On average farmers in Andhra Pradesh spend around 10% of the production cost on prophylaxis and therapy. Fish farmers now feel the need to familiarize themselves with simple diagnostic and therapeutic techniques. Commonly occurring infectious diseases, the fish species and the size range affected are presented in Table 3.

**Table 3 - Fish diseases reported in Andhra Pradesh farms**

<b>Bacteria</b>		
<i>Aeromonas hydrophila</i>	<i>C. catla</i> , <i>L. rohita</i> , <i>C. mrigala</i>	Juveniles – market size; 10 -3000 g
<b>Fungi</b>		
Saprolegniaceae	<i>L. rohita</i> , <i>C.catla</i>	Juveniles - market size; 100-2500 g
<i>Branchiomysis</i> spp.	<i>L. rohita</i>	Juveniles – market size; 100-1500 g
<b>Protozoa</b>		
<i>Myxobolus</i> spp.	<i>C. catla</i>	Juveniles (10 – 500 g)
<i>Trichodina</i> spp.	<i>L. rohita</i>	Juveniles (10 – 400 g)
<i>Epistylis</i> spp.	<i>L. rohita</i>	Juveniles (5 – 200 g)
<i>Zoothamnium</i> spp.	<i>L. rohita</i>	Juveniles (5 – 200 g)
<b>Helminthes</b>		
<i>Dactylogyrus</i> spp.	<i>L. rohita</i> , <i>C. catla</i>	Juveniles - market size; 100 – 4500 g
<i>Gyrodactylus</i> spp.	<i>C. catla</i>	Juveniles (50 – 250 g)
<b>Crustacea</b>		
<i>Argulus</i> spp.	<i>L. rohita</i>	Juveniles - market size; 100 – 3500 g
<i>Lernaea</i> spp.	<i>C. catla</i>	Juveniles (5 - 250g)
<i>Ergasilus</i> spp.	<i>L. rohita</i>	Juveniles (100 - 500g)

# *Materials & Methods*

**Figure 2: State map of Andhra Pradesh showing the surveyed districts**



### 3. MATERIALS AND METHODS

A cross-sectional, interview-based survey was conducted in seven districts of Andhra Pradesh for about nine months between May 2005 and January 2006. Fish farmers and fishers were randomly interviewed in each district and simultaneously the fishes were also examined for diseases.

#### 3.1. Survey areas

In each of the selected districts namely Anantapur, East Godavari, Guntur, Krishna, Nellore, Prakasam and West Godavari (Fig. 2) one to several blocks known to have adequate fisheries resources were randomly selected. The Fishery Extension Officers (F.E.O) of the Department of Fisheries, Government of Andhra Pradesh and the officials of Krishi Vigyan Kendra were requested to provide a list of categorized fish farm (both registered and unregistered) areas in their respective blocks. From these lists, fish farms were randomly selected.

The randomly picked fishponds of this study had a mean depth of 5.60 ft. The water spread area ranged between 3 and 206 acre (1 ha=2.5 acre), the mean value being 31.11 acre. Fish production in these ponds varied from 0.10 to 6.50 tons/acre with an average of 3.75 tons/acre. Average stocking density was 4614 fingerlings/acre (Table 4).

**Table 4 - Characteristics of surveyed Andhra Pradesh fishponds**

Characteristics	Mean $\pm$ SD	Minimum	Maximum
Depth (feet)	5.60 $\pm$ 1.07	3.50	07
Area (acre)	31.11 $\pm$ 36.58	03	206
Production (tons/acre)	3.76 $\pm$ 1.50	0.10	6.50
Stocking density (numbers/acre)	4614.28 $\pm$ 1633.88	1000	8000

#### 3.2. Development of questionnaire

The methods described by Thrusfield (1995) were followed for the development of questionnaire. Questionnaire for fish farmer and fisher (Annexure-I) was designed to record information in a standard format with in-built error checks. Closed questions were used, wherever possible, to give data in a yes/no or categorical format to facilitate ease of coding and analysis. Attempts were made to make wording unambiguous, brief, polite

and non-technical. Questionnaires were prepared in English and the respondents were interviewed in local language 'Telugu'. Before starting the survey, questionnaire was pre-tested at least two times by interviewing target people to identify ambiguous and irrelevant questions.

### **3.3. Interviewing**

During interviewing, required numbers of questionnaires, fish sampling sheets, photographs of diseased fish or pathogens, 10% buffered formalin, vials, marking pen, scalpels, scissors, forceps, transport medium, spirit lamp, alcohol, cotton, inoculation loop and cast net were carried. The management systems were also photographed for documentation.

### **3.4. Sampling**

After completion of the interview, fish from each farms or farming site were examined for diseases irrespective of species. Information like behavioural abnormalities, gross and clinical signs was recorded on the sampling sheet. Few fishes with typical disease symptoms were sampled for bacteriology and histopathology. Normal healthy fishes were also sampled for histology. Tissue samples of affected fish as well as normal healthy fish were fixed in 10% buffered formalin for histopathology.

### **3.5. Bacteriology**

#### **3.5.1. Bacteriological media**

The most common bacteriological media used in this study include nutrient agar (NA), nutrient broth (NB), phenol red agar base, Pseudomonas isolation agar (PIA) supplemented with 2% (w/v) glycerin, MacConkey agar (MA) and Mueller Hinton agar. The above-mentioned dehydrated media were procured from HiMedia, Mumbai (India). The compositions of these media are given in Annexure-II. Various other media for biochemical identification of bacteria were prepared with required ingredients as per the standard procedures (Collins *et al.*, 1989; Austin and Austin, 1999). The pH of the media was adjusted to the required level using 1N sodium hydroxide solution or 0.1 N hydrochloric acid solution before sterilization.

#### **3.5.2. Sterilization**

Bacteriological media, autoclavable labwares and glassware's were sterilized in an autoclave at 121°C for 15 min unless otherwise specified. Media for certain

biochemical tests were sterilized by steaming for an hour or at 110°C for 15 min as applicable.

### **3.5.3. Bacteriological analyses**

Tissues / inocula from external affected parts were transferred to tubes containing sterile transport medium (half strength nutrient broth + 0.70% (w/v) agar) and brought to the laboratory in insulated container. About 2 ml sterile nutrient broth was added aseptically into each of the transport medium tubes containing tissues from affected parts and incubated at 30 ±2°C for 12-16h. Inocula from each tube were then streaked onto NA, MA, PIA and starch ampicillin agar (SAA: phenol red agar base + starch 10% + ampicillin 10µg/ml; Palumbo *et al.*, 1985) plates following aseptic techniques and all plates were incubated at 30±2°C for 24 h.

### **3.5.4. Isolation and identification of bacteria**

Representative colonies, based on dominance and distinct colony morphology, were picked up randomly from NA, SAA, PIA and MA plates, purified by repeated streaking on NA plates and maintained on NA slants. A series of biochemical reactions as described by Lechevallier *et al.* (1980) were performed to identify bacteria upto genus level.

### **3.5.5. Antibiogram**

#### **3.5.5.1. Antibiotic sensitivity testing by agar-disc diffusion assay**

A total of 18 bacterial isolates, identified upto genus level comprising *Pseudomonas spp* (14), *Aeromonas hydrophila* (2), *Acinetobacter* (1) and Enterobacteriaceae (1) were screened for their sensitivity to six potential antibiotics by agar disc diffusion method (NCCLS, 1984). The antibiotic impregnated discs (HiMedia, Mumbai) and their concentration used in the present study include chloramphenicol, C (30µg), ciprofloxacin, F (5µg), gentamycin, G (10µg), nitrofurantoin, N (300µg), oxytetracycline, O (30µg) and trimethoprim, T (5µg).

Young cultures of bacteria (20 h old) from NA slants were inoculated individually into NB and incubated for 10-12 h at 30 ±2°C. Inocula from these 10-12 h grown cultures were taken separately using sterile cotton swabs and spread onto Mueller Hinton agar. Antibiotic impregnated discs were placed aseptically onto the inoculated agar plates at least 15 mm away from the edge, at equal distance and sufficiently separated from each

other to avoid overlapping of the zone of inhibition. The plates were then incubated for 24 h at  $30\pm 2^{\circ}\text{C}$  and the diameter of zone of inhibition in mm were measured. Interpretation of sensitivity was based on the zone size interpretation chart (Annexure-III) provided by the manufacturer of the antibiotic impregnated discs.

#### **3.5.5.2. Determination of resistance profile and resistance pattern**

The resistance profiles and resistance patterns for six potentially valuable antibiotics, viz., chloramphenicol (C), ciprofloxacin (F), gentamycin (G), nitrofurantoin (N), oxytetracycline (O) and trimethoprim (T) were determined from antibiogram data.

### **3.6. Histopathology**

#### **3.6.1. Tissue cutting and cleaning**

The tissues fixed in 10% buffered formalin for more than 24 h were cut into small pieces and washed overnight in clean flowing tap water until the formaldehyde odour vanished.

#### **3.6.2. Processing of the tissue**

Muscle and gill tissues were decalcified using 5% sodium sulphate as described by Das and Das (1997) and then dehydrated by a series of ethyl alcohol with a gradually increasing concentration. The tissues after dehydration were transferred to xylene to make them transparent as described by Roberts (2001) (Annexure-IV).

#### **3.6.3. Tissue embedding**

Properly filtered paraffin (melting point  $58-60^{\circ}\text{C}$ ) was used for this purpose. The affected parts were kept in molten paraffin contained in L-mould to form a block.

#### **3.6.4. Preparation of blocks for sectioning**

The solid paraffin embedded the tissues was trimmed into small square blocks and the tissues were exposed for proper sectioning.

#### **3.6.5. Sectioning**

The trimmed blocks were then fixed to the block holder of the microtome (Spencer type) and cut into thin sections or ribbons of  $5\text{-}\mu\text{m}$  thickness.

#### **3.6.6. Stretching of tissues**

The ribbons of required length were transferred to water bath with warm water maintained at  $50-55^{\circ}\text{C}$  to render the wrinkled tissues stretched and flat.

### **3.6.7. Preparation of slides**

Good sections were carefully transferred to clean, grease free glass slides and placed on “Electro thermal slide drying bench”, maintained at 50-55°C to heat-fix the tissues on the slides. The grease free slides were laid with Mayer’s (egg) albumin for better attachment of the tissues to the slides.

### **3.6.8. Staining**

The dried slides were stained with haematoxyline and eosin (H&E) (Annexure-V) according to the methods described by Roberts (2001) (Annexure-VI). The stained slides were permanently mounted using D.P.X. mountant.

### **3.6.9. Microscopy and photomicrography**

The sections were screened with the help of closed circuit television (CCTV) and monitor attached microscope. Colour microphotographs were taken from the selected slides at different magnification with advanced Trinocular Research microscope (Olympus: model BX51 Japan).

### **3.7. Database preparation for epidemiology and statistical analyses**

MS Excel™ spreadsheets were used to enter the information collected through interview of fish farmer and fisher. From the collected data 32 variables were selected for evaluating their association with infectious disease outbreak.

The term “infectious disease” (ID) in this study describes the diseased or abnormal conditions caused by the infectious biological agents. Included under these categories for the present studies are ulcers, red spots/scales, tail or fin rot, eroded jaws and mouth, gill rot, dropsy, bacterial septicemia, hemorrhage and ulcerative disease syndrome. The descriptions of the variables are given in Table 5.

**Table 5 - List of variables selected for evaluating their association with infectious diseases**

<b>Name of the variable</b>	<b>Description of the variable</b>
<b>Farm connection / Establishment details</b>	
Type of habitat	The type of habitat was categorized into farms adjacent to rice fields and adjacent to other water resources like river, flood plain, lakes, etc.
Source of water	The farms drew water either from canal and/or ground

	water or from other sources such as sewage, ponds, lakes, rainwater, etc.
Type of farming	The farming practice was categorized based on the stocking densities, management practices followed like feed inputs, use of fertilizers and health management practices, as intensive /semi intensive and modified extensive /extensive types.
Age of the farm	Age of the farm was calculated based on the total years of operation, which varied from 1 to >20 years. The farms were categorized into farms with less than five years and more than five years of age.
Number of grow out ponds	The farms were grouped as those having less than three grow-out ponds and those having more than three grow-out ponds irrespective of size.
Type of farms	The farms were categorized as perennial and seasonal types.
Presence of nursery ponds	Presence of nursery ponds was recorded for individual farm.
Total farm area	The size of the farm was recorded based on water spread area in acres and grouped into those with less than ten acres and those more than ten acres.
Training in aquaculture	Whether or not the farmer trained in aquaculture was recorded.
<b>Pre-stocking management</b>	
Draining of pond	Draining of pond water was recorded as complete and partial draining before the pond preparation for every culture operation.
Pond drying period	The period of pond drying was recorded and grouped into farms that dried the ponds for <20 days and >20 days.
Sludge removal	The removal of pond bottom deposits (sludge) was recorded.

Ploughing	The farms that ploughed the ponds were recorded.
Soil colour while ploughing	The colour of pond bottom soil was categorized as black / brownish black and brown.
Sludge disposal place	The sludge disposal place, i.e., on the dykes of the same pond and outside the pond was noted.
Water treatment	The use of chemicals such as bleaching powder, zeolite and others for pond water treatment was recorded.
Pond bottom treatment	The application of lime for pond bottom was noted
<b>Stocking management</b>	
Type of fish seeds	The fish seeds stocked were grouped as fingerlings and fry.
Source of fish seeds	The fish seeds were grouped as those bought directly from hatchery and from other sources like fish seed market, agents, etc.
Distance of fish seed transportation	The fish seeds were grouped on the basis of distance transported from the production /marketing center to the farm site, i.e., as <50 km and >50 km.
Mortality during fish seed transportation	The percentage of mortality during transportation of fish seeds was recorded as < 1% and >1%.
Treatment before stocking	The treatment of fish seeds with disinfectants like potassium permanganate, salt, antibiotics, etc before stocking was recorded
Acclimatization of fish seeds	Acclimatization of fish seeds before stocking was recorded.
Mortality during acclimatization	Mortality during acclimatization was recorded as nil to traces and 1% - 5%.
Stocking density	The stocking densities of different farms were recorded and categorized into >5000 / acre and <5000 / acre.
Species cultured	The species cultured in each farm was recorded and grouped into farms, which stocked bottom dwelling fishes such as <i>C. mrigala</i> , <i>L. bata</i> , <i>C. carpio</i> etc., and those did not stock the said species.

Type of culture	The farms that followed polyculture and monoculture of fish species were recorded.
<b>Post stocking management</b>	
Use of fertilizers	Use of organic and inorganic fertilizers like urea, single super phosphate, and potash, di-ammonium phosphate was recorded.
Regular monitoring of water quality	Whether or not the monitoring of water quality parameters done was recorded.
Regular monitoring of fish health	Whether or not the monitoring of fish health status done was recorded.
Presence of weedy fish	Whether or not the weedy fish present during culture operation was noted.
Pond bottom colour	The colour of pond bottom as black or brown during culture period was recorded.

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### **3.7.1. Epidemiology of infectious diseases**

Attributable risk (AR), Relative risk (RR), Odds ratio (OR) of the selected variables under pond connection/ establishment, pre-stocking management, stocking management, and post-stocking management were calculated using 'Win Episcopo 2.0' package. (<http://www.clive.ed.ac.uk/winepiscopo/>).

Incidence rate (IR) is the number of new cases of disease in a population during a certain period divided by the total number of animal-time-units at risk for all animals in the population at risk.

Relative risk (RR) or risk ratio or relative incidence rate ratio is the ratio of the incidence rate in the exposed group to the incidence rate in the unexposed group. The null value (no association or no increase in risk) is 1, which is equivalent to equal incidence rates. The RR can vary from zero to infinity and has no units.

Odds ratio (OR) is a ratio of the odds of exposure: non-exposure in disease specific groups or the ratio of the odds of disease: no disease in exposure-specific groups. Just like RR, the null value of OR is 1 and the OR has no units.

Attributable risk (AR) is the absolute difference between the two incidence rates from a 2 x 2 table. The AR tells the rate of disease in the exposed group that is attributable to being exposed. It implies the rate of disease that could be prevented if the exposures are removed completely from the population. A negative AR value tells the rate of disease that is prevented by the exposure. The AR has the same units as the IR and can theoretically vary from -1 to +1; the null value is zero. The AR/IR x100 value indicates the proportion of disease in the exposed that would have been prevented if exposure not occurred. The details of the epidemiological analyses are explained below:

	Frequency	
	Affected by infectious diseases	Not affected by infectious diseases
Exposed	a	b
Unexposed	c	d

$$IR_{\text{exposed}} = a/(a+b) \quad IR_{\text{unexposed}} = c/(c+d)$$

$$RR = IR_{\text{exposed}} \div IR_{\text{unexposed}} = a/(a+b) \div c/(c+d)$$

$$OR = a/b \div c/d = ad/bc \text{ or } a/c \div b/d = ad/bc$$

$$AR = IR_{\text{exposed}} - IR_{\text{unexposed}} = a/(a+b) - c/(c+d)$$

### 3.7.2. Statistical Analyses

Chi-square ( $\chi^2$ ) test with Yates correction using 2 x 2 table was carried out to know the association / independence of variables and infectious disease incidence (Snedecor and Cochran, 1974). Further, the extent of association was assessed by calculating Co-efficient of contingency (C) by using the formula:

$$C = \sqrt{[\chi^2/\chi^2 + N]}$$

Where, C = Coefficient of contingency

$\chi^2$  = Calculated  $\chi^2$  value

N = Total number of farms

Plate 1. *Labeo rohita* showing red spots on the ventral side of the body

Plate 2. *Argulus spp.* infested carp.

Plate 3. Fish with pale discoloured gills and hemorrhaging around the operculum

Plate 4. Fish with red discoloured gills

Plate 5. Fish with tail deformity

Plate 6. Dropsy condition in carp

Plate 7. A haul of dead fishes with ulcers carried on the boat.

Plate 8. Dead fishes floating on the water surface

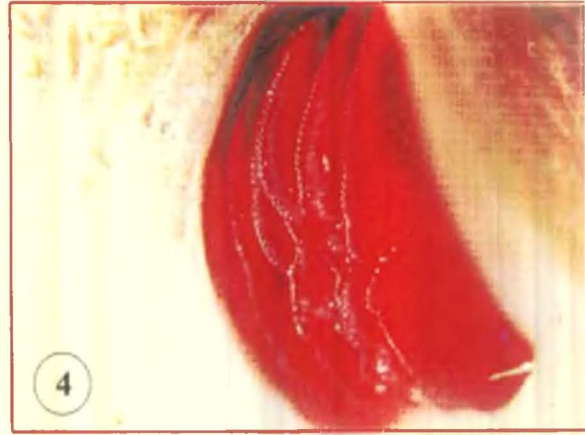
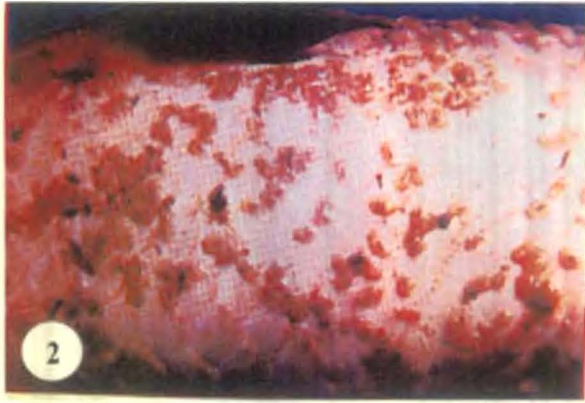


Plate 9. A freshwater fish farm showing bag feeding in Gudivada, Krishna district

Plate 10. Fish feed stored on the pond embankment covered with polythene sheets

Plate 11. Integrated fish farm (Duckery) in Ponnur, Krishna district

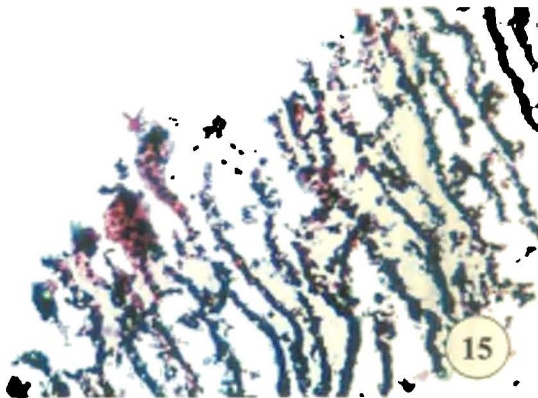
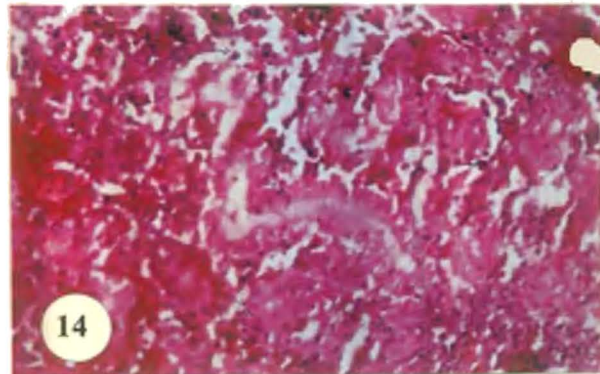
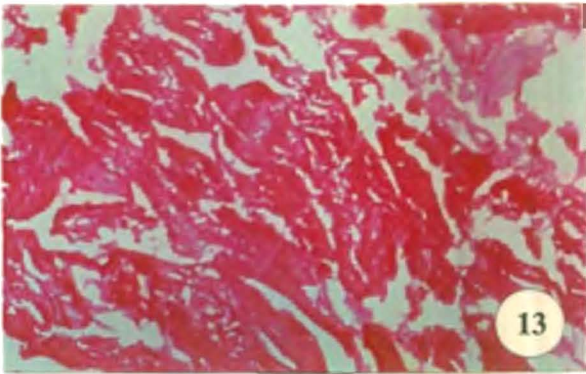
Plate 12. A farmer examining the health status of fish

Plate 13. Histological section of normal muscle of *Labeo rohita* with distinct muscle fibers (H&E, 400X)

Plate 14. Histological section of muscle showing granular degeneration with haemocytic infiltration in *Catla catla* (H&E, 400X)

Plate 15. Irregular arrangement of gill lamellae and haemocytic infiltration with lamellar hypertrophoid condition in *Labeo rohita* (H&E, 100X)

Plate 16. *Dactylogyrus* attached to the gills of *Catla catla* (Wet mount 40X).



# *Results*

## 4. RESULTS

A farm level survey was conducted for a period of six months between December 2005 and May 2006 in seven districts of Andhra Pradesh. A total of 75 freshwater fish farmers were interviewed using a pre-tested 'Questionnaire' and the information gathered were segregated as per coding / ranking and tabulated in Tables 6 - 41 and in Figs. 3 - 7. The results of the survey are described below:

### **4.1. Fish farm practices and management**

#### **4.1.1 Household size, educational qualification, experience and financial status of fish farmers of Andhra Pradesh**

Tables 6 and 7 present the general picture of household size, educational qualification, experience, financial status, farmers training in aquaculture and ranking of source of finance, respectively. The interviewed Andhra Pradesh fish farmers had family size in the range of 3 to >6 members. About 29% and 15% of the farmers had family size of 5 members and >6 members, respectively.

The educational qualifications of the farmers varied from primary to post-graduate levels. About 37% each of the farmers interviewed had education up to primary and 12<sup>th</sup> standard levels. Two farmers had post-graduate qualification. Most of the farmers (80%) had aquaculture experience ranging from 5 to >25 years. Only 20% of the farmers experience was <5 years. About 5% of the farmer's experience in aquaculture was >20 years. Among the respondents, 41% had undergone training in aquaculture before or after venturing into the aquaculture profession.

The major financial support for aquaculture to the respondent farmers was personal savings (43%), followed by bank loan (39%). The other respondent's financial source was the combination of above (Table 6). Bank loan ranked first among the financial sources (29 respondents) and 25 respondents ranked personal savings as first ranked financial source (Table 7).

#### **4.1.2 Main activity and time spent for aquaculture by the fish farmers and ownership pattern of fish farms of Andhra Pradesh**

The main activity and time spent for aquaculture activity by the farmers, and ownership pattern of fish farms in Andhra Pradesh are presented in Table 8. The two major activities that supported the respondent farmers family were aquaculture

**Table 6 - Household size, educational qualification, experience and financial status of fish farmers of Andhra Pradesh**

Variable	Description	Number of respondents	Percentage
Family size (members)	<3	5	06.67
	3	17	22.67
	4	15	20.00
	5	22	29.33
	6	5	06.67
	>6	11	14.67
Educational qualification	Primary	28	37.33
	8 <sup>th</sup> standard	09	12.00
	10 <sup>th</sup> standard	08	10.67
	12 <sup>th</sup> standard	28	37.33
	Post-graduate	02	02.67
Experience in aquaculture (years)	1-5	15	20.00
	6-10	26	34.67
	11-15	22	29.33
	16-20	08	10.67
	21-25	02	02.67
	> 25	02	02.67
Financial source	Bank loan	29	38.67
	Private loan	03	04.00
	Personal savings	32	42.67
	Personal + Bank	07	09.33
	Private + Personal + Bank	04	05.33
Training in aquaculture	Yes	31	41.33
	No	44	58.67

**Table 7 - Ranking of source of finance**

Finance	Rank	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>
	Number of respondents			
Bank loan		29	-	-
Private loan		-	03	-
Personal savings		25	06	01
Personal and bank		07	07	-
Private, personal and bank		01	03	-

**Table 8 - Main activity and time spent for aquaculture by the fish farmers and ownership pattern of fish farms in Andhra Pradesh**

Variable	Description	Number of respondents	Percentage
Main activity	Agriculture	70	93.33
	Dairy and poultry	08	10.67
	Aquaculture	75	100.00
	Mixed farming	05	06.67
	Service	06	08.00
	Business	14	18.67
Time spent for aquaculture activity (hours / day)	2-4	14	18.67
	4-6	18	24.00
	6-8	15	20.00
	> 8	28	37.33
Ownership pattern	Own land	63	84.00
	Own land with joint management	02	02.67
	Leased land	15	20.00
	Government undertaking	03	04.00
	Owned land and leased	03	04.00

**Table 9 - The main reason for fish culture and farmer's perception on aquaculture in Andhra Pradesh**

Variable	Description	Number of respondents	Percentage
Why aquaculture?	Income	74	98.67
	Food	36	48.00
	Status	03	04.00
Farmer's perception on aquaculture	Aquaculture is a risky business	66	88.00
	Aquaculture is profitable	61	81.33
	Aquaculture is profitable only for large scale farmers	19	25.39
	Aquaculture has high status	14	18.67
	Disease is an important issue	56	74.67

(100%) and agriculture (93%). Other activities of Andhra Pradesh fish farmers were business (19%), dairy and poultry (11%), service (8%) and mixed farming (7%). Around 37% of the farmers reported that they used to spend more than 8 hours / day in farms. The land used by the respondent farmers for aquaculture practices are either of own land,

leased land, own and leased land, government undertaking and own land with joint management. Around 84% of the farmers practiced aquaculture in their own land.

#### **4.1.3 The main reason for fish culture and farmers perception on aquaculture in Andhra Pradesh**

The main reasons for fish culture and Andhra Pradesh farmer's perception on aquaculture are shown in Table 9. The majority of the interviewed farmers (98.67%) reported that they have taken up aquaculture business for income only. Also majority of farmers (88%) opined that aquaculture is a risky but profitable business (81%). The farmers considered disease as an important issue (74.67%) in aquaculture development. Few farmers responded that aquaculture is profitable only for large-scale farmers.

#### **4.1.4 Source of information on aquaculture, fish seeds and disease treatment to the respondent Andhra Pradesh fish farmers**

The source of information on aquaculture, fish seeds and disease treatment to the respondent Andhra Pradesh farmers are presented in Table 10. Majority of the interviewed farmers (48%) learnt aquaculture themselves (self taught) through day-by-day experience in aquaculture. About 44% of the farmers got motivation from other farmers; whereas 41% got motivated from friends and neighbours. About 32% each of the farmers got aquaculture information from government extension workers and educational institution. Few farmers got information from non-governmental organizations (NGO's) and other sources such as consultants or feed technicians.

Majority of the farmers got information on fish seed from other farmers (49.33%), followed by self taught (38.67%), friends and neighbours (34.67%), government extension workers (26.67%), educational institution (25.33%) and from other sources like consultants. The farmers sought help for treating fish diseases mainly from feed sales persons (60%) and other fish farmers (54.67%). Around 35% of the farmers treated fish diseases in their own way. Few farmers got help from government extension workers (24%). The role of drug sales person (12%), fish traders (4%) and consultants (13%) was rare regarding the knowledge input on diseases treatment. The ranking of source of information on fish seeds and aquaculture are presented in Table 11. Knowledge input from other farmers ranked first on fish seeds (26 respondents). Likewise, input from government extension workers (17 respondents) ranked first on aquaculture information.

**Table 10 - Source of information on aquaculture, fish seeds and disease treatment to the respondent Andhra Pradesh fish farmers**

Variable	Description	Number of respondents	Percentage
Source of information on aquaculture	Government extension workers	24	32.00
	Educational institution	24	32.00
	NGO's	01	01.33
	Other fish farmers	33	44.00
	Self taught	36	48.00
	Friends and neighbours	31	41.33
	Others	02	02.67
Source of information on fish seeds	Government extension workers	20	26.67
	Educational institution	19	25.33
	NGO's	01	01.33
	Other fish farmers	37	49.33
	Self taught	29	38.67
	Friends and neighbours	26	34.67
	Others	07	09.33
Source of information on disease treatment	Other fish farmers	41	54.67
	Feed sales person	45	60.00
	Drug sales person	09	12.00
	Government extension workers	18	24.00
	Fish traders	03	04.00
	Self	26	34.67
	Others	10	13.33

**Table 11 - Ranking of source of information on fish seeds and aquaculture by the farmers of Andhra Pradesh**

Source	Fish seed				Aquaculture			
	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>
	Number of respondents							
Government extension workers	18	-	-	01	17	-	02	03
Educational institution	09	05	03	-	13	06	05	-
NGO's	01	-	-	-	02	-	-	-
Other fish farmers	26	08	01	-	14	18	02	01
Self taught	19	10	04	-	14	15	01	02
Friends and neighbours	02	19	05	01	09	10	05	04
Others	01	-	02	-	-	04	01	-

NGO's: Non-Governmental Organizations

#### 4.1.5 Particulars on the number of grow-out and nursery ponds held by the respondent Andhra Pradesh farmers

The number of grow-out and nursery ponds held by the respondent Andhra Pradesh farmers is shown in Table 12. Majority of the interviewed farmers possessed two grow-out ponds (41.33%). About 33% and 13% of the farmers possessed 3 and 4 grow-out ponds, respectively. Nine percent of the respondents had more than 5 ponds. About 91% of the farmers had atleast one nursery pond, with possession of one nursery pond being the most common (52%).

**Table 12 - Particulars on the number of grow-out and nursery ponds held by the respondent Andhra Pradesh farmers**

Variable	Description	Number of respondents	Percentage
Number of grow-out pond(s)	1	02	02.67
	2	31	41.33
	3	25	33.33
	4	10	13.33
	≥ 5	07	09.33
Number of nursery pond(s)	0	07	09.33
	1	39	52.00
	2 – 4	24	32.00
	5	05	06.67

#### 4.1.6 The details on fish farming practices and species cultured in Andhra Pradesh

The details of fish farming practices and species cultured in Andhra Pradesh are tabulated in Table 13. The intensive and semi-intensive type (66.67%) of farming was the major aqua farming practice in Andhra Pradesh. Other farming practices adopted by the Andhra Pradesh farmers were modified extensive (14.67%) and extensive types (18.67%). Polyculture with *Catla catla* and *Labeo rohita* was the most common among the Andhra Pradesh fish farmers (84%). Monoculture of *Macrobrachium rosenbergii* was done by 16% of the respondent farmers. Three respondent farmers integrated fish farming with other farming practices. Besides *C. catla*, and *L. rohita*, mrigal *Cirrhinus mrigala* (21.33%), common carp *Cyprinus carpio* (6.67%), grass carp *Ctenopharyngodon idella* (2.67%), cat fishes *Pangassius spp*, *Clarias batrachus* (9.33%) and freshwater prawn *M. rosenbergii* (41.33%) were also cultured by the Andhra Pradesh fish farmers. Other

stocked species included *Tilapia spp*, *Oreochromis mosambicus*, *Channa spp* and shrimp *Penaeus monodon* (Table 13).

**Table 13 - The details of farming practices and species cultured in Andhra Pradesh**

Variable	Description	Number of respondents	Percentage
Type of aqua farming	Intensive / Semi-intensive	50	66.67
	Modified extensive	11	14.67
	Extensive	14	18.67
Type of culture	Monoculture	12	16.00
	Polyculture	63	84.00
	Integrated farming	03	04.00
Species cultured	<i>Catla catla</i>	63	84.00
	<i>Labeo rohita</i>	63	84.00
	<i>Cirrhinus mrigala</i>	16	21.33
	<i>Cyprinus carpio</i>	05	06.67
	<i>Ctenopharyngodon idella</i>	02	02.67
	<i>Pangassius spp, Clarius spp</i>	07	09.33
	<i>Macrobrachium rosenbergii</i>	31	41.33
	<i>M. rosenbergii</i> alone	12	04.00
	Others	03	16.00

Other species cultured include *Oreochromis mossambicus*, *Channa striatus*, *Penaeus monodon*.

#### 4.1.7. Details on area, type, age and habitat of fish farms of the respondent farmers of Andhra Pradesh

The details on area, type, age and habitat of fish farms of respondent Andhra Pradesh farmers are depicted in Table 14. Around 36% of the farmers responded that the age of their farms was between 6 and 10 years. About 24% and 19% of the responded farmers farm age was in the range of 11-15 years and 1-5 years, respectively. The total farm area of the Andhra Pradesh fish farmers was in the range of 1 to >50 acres with farm area of 11-25 acres being the most common (37.33%), followed by 1-10 acres (26.67%) and 26-50 acres (22.67%). Thirteen percent of the respondent farmers had farm area more than 50 acres. As regards the habitat, 39% and 59% of the farms were located in riverine and rice field areas, respectively. Around 95% of the responded farmers farms were of perennial type and the rest were seasonal type (Table 14).

**Table 14 - Details on area, type, age and habitat of fish farms of the respondent farmers of Andhra Pradesh**

Variable	Description	Number of respondents	Percentage
Age of the farm (years)	1-5	14	18.67
	6-10	27	36.00
	11-15	18	24.00
	16-20	10	13.33
	>20	06	08.00
Type of farm or pond	Perennial	71	94.67
	Seasonal	04	05.33
Total farm or pond area (acre)	1-10	20	26.67
	11-25	28	37.33
	26-50	17	22.67
	>50	10	13.33
Type of habitat	Riverine	29	38.67
	Rice field	44	58.67
	Others	02	02.67

**Table 15 - The background information on labours of fish farms of respondent Andhra Pradesh farmers**

Variable	Description	Number of respondents	Percentage
Type of labours	Casual	38	50.67
	Permanent	25	33.33
	Both	12	16.00
Nature of work of the labours	Fishermen	34	72.00
	Transport	23	33.33
	Guard	55	73.33
	Weeding hands	18	24.00
Age of the labours (years)	<20	17	22.65
	20-40	28	37.35
	>40	30	40.00
Educational qualification of the labours	Illiterate	47	62.67
	Primary	16	21.33
	8 <sup>th</sup> standard	02	02.67
	10 <sup>th</sup> standard	05	06.67
	12 <sup>th</sup> standard	03	04.00
	Graduate	02	02.67

#### **4.1.8 The background information on labours of fish farms of respondent Andhra Pradesh farmers**

Table 15 presents the background information on fish farm labours like type of labours, nature of work, age and educational qualification of the labours. The labours employed in fish farming were either casual (50.67%) or permanent (33.33%). Sixteen percent of the farms had both casual and permanent labours. The labours were engaged in different types of works like fishermen (72%), as guard (73%), for transportation of fish (33.33%) and as weeding hands (24.00%). Most of the labours were of age >40 years (40%), followed by 20 - 40 years (37.35%) and <20 years (22.65%). Majority of the labours were illiterate (62.67%). Other labours had educational qualification of primary level (21.33%), 8<sup>th</sup> (2.67%), 10<sup>th</sup> (6.67%), 12<sup>th</sup> (4%) standard levels. Two farmers employed graduates as labours in their farms (Table 15).

#### **4.1.9 The main pre-stocking management practices followed by the respondent Andhra Pradesh farmers**

The main pre-stocking management practices followed by the respondent Andhra Pradesh farmers are listed in Table 16. After every culture period, 45% of the farmers drained their ponds completely, while the others have done only partially (55%). The farmers allowed the pond to dry after draining for a period of about  $\leq 10$  days to >30 days. Among those farmers, 41% dried the ponds for >30 days, 38% for 10-20 days, 15% for 21-30 days and 6% for about  $\leq 10$  days. Around 59% of the responded farmers did not remove the pond bottom sludge. About 24% of the farmers removed sludge up to a depth of <5 cm and 17% to a depth of 5-10 cm. Most of the farmers dumped the sludge outside the pond (59%) and the rest (41%) used the sludge for the repair or strengthening of dykes of the same pond.

About 87% of the farmers ploughed their ponds at least once even when the ponds were still wet or after drying. Few farmers did not plough their ponds (13.33%). Majority of the farmers (61.54%) reported that the colour of soil during ploughing was brown; while others observed as black (38.46%). The farmers mostly used inorganic chemicals (90.67%) and a very few used organic compounds (6.67%) for the treatment of soil. Two farmers have never attempted soil treatment. Among the inorganic compounds, the most commonly used was lime and the dose range was <100 kg to 1000 kg/acre. About 79% of

the farmer used a lime dose of <100 kg/acre, 12% used 100-500 kg lime/acre, 7% used 500-1000 kg lime/acre (Table 16).

**Table 16 - The main pre-stocking management practices followed by the respondent Andhra Pradesh farmers**

Variable	Description	Number of respondents	Percentage
Draining of pond water	Partial draining	41	54.67
	Complete draining	34	45.33
Pond drying period (days)	< 10	02	05.88
	10-20	13	38.23
	21-30	05	14.71
	> 30	14	41.18
Depth of sludge removal (cm)	< 5	18	24.00
	5-10	13	17.33
	Nil	44	58.67
Sludge disposal place	On the dykes	31	41.33
	Outside the pond	44	58.67
Number of ploughs	Nil	10	13.33
	Once or twice	65	86.67
Soil condition while ploughing	Wet	31	41.33
	Dry	33	44.00
	Neither wet nor dry	06	08.00
	Don't remember	05	06.67
Colour of pond bottom (soil)	Black	25	38.46
	Brown	40	61.54
Soil treatment	Organic	05	06.67
	In-organic	68	90.67
	None	02	02.67
Liming (kg/acre)	Nil	02	02.67
	< 100	59	78.67
	100-500	09	12.00
	500-1000	05	06.67

#### 4.1.10 Water source, water treatment and irrigation methods followed by the Andhra Pradesh farmers

The water source, water treatment and irrigation methods followed by the Andhra Pradesh farmers are presented in Table 17. The majority of the farmers (72%) reported that the main source of water for culture was from canal and bore-well, followed by the lake water (25.33%) and rainwater (2.67%). Gravity and pump was the major irrigation method (61.33%) followed by pump (33.33%). Around 95% of the interviewed farmers used chemicals for treating pond water; while others (5%) used none (Table 17).

**Table 17 - Water source, water treatment and irrigation methods followed by the Andhra Pradesh farmers**

Variable	Description	Number of respondents	Percentage
Water source	Canal and ground water	54	72.00
	Rain water	02	02.67
	Lake water	19	25.33
Irrigation methods	Gravity without using pump	01	01.33
	Pump	25	33.33
	Gravity and pump	46	61.33
	Others	03	04.00
Water treatment	Chemicals	71	94.67
	None	04	05.33

#### 4.1.11 The source and type of fish seeds, and details of fish seed transportation in Andhra Pradesh

The source and type of fish seeds and the details of fish seed transportation in Andhra Pradesh are presented in Table 18. Majority of the farmers procured fish seeds from hatchery (84%); while others used to get seeds through agents (5.33%) or other resources (8.00%). Two farmers used fish seeds of their own hatchery. The types of seeds stocked were mainly fingerlings (54.67%) followed by fry (16.00%), hatchlings (13.00%) and combination of above (16.00%). The fish seeds were transported mainly through motor vehicles (99%). The fish seed mortality of during transportation was in the range of nil to >10%. Eleven (14.67%) respondents reported no mortality during transportation;

while others reported <1% mortality (8%), 1% mortality (18.67%), 1-5% mortality (36%), 5-10% mortality (14.67%) and >10% mortality (8.00%). All the farmers used oxygen packing (100%) for the transportation of fish seeds.

**Table 18 - The source and type of fish seeds, and details of fish seed transportation in Andhra Pradesh**

Variable	Description	Number of respondents	Percentage
Source of fish seeds	Own	02	02.67
	Bought from agents	04	05.33
	Bought from hatchery	63	84.00
	Others	06	08.00
Type of fish seeds	Hatchlings	10	13.33
	Fry	12	16.00
	Fingerlings	41	54.67
	Mixed / combination	12	16.00
Mode of transportation	Bicycle	01	01.33
	Motor vehicles	74	98.67
Mortality during transport	Nil	11	14.67
	< 1 %	06	08.00
	1 %	14	18.67
	>1-5 %	27	36.00
	5-10 %	11	14.67
	> 10 %	06	08.00
Use of chemicals during transportation	Oxygen packing	75	100.00
Distance transported (km)	<50	36	48.00
	>50	39	52.00

#### 4.1.12 The main stocking management practices followed by the respondent Andhra Pradesh farmers

The main stocking management practices followed by the respondent Andhra Pradesh farmers are presented in Table 19. Majority of the farmer's (68%) pond stocking density was within the range of 2000 - 5000 numbers/acre followed by >10,000 numbers/acre (18.67%), 5000 - 10,000 numbers/acre (10.67%). The farmers of Andhra

Pradesh preferred mostly single stocking (80%); while about 20% reported repeated stocking. Around 88% of the farmers opined that the stocked fish seeds were of good quality, while the others reported as average quality. The fish seeds were acclimatized for about  $\leq 1$  hour by 77% of the respondents. During acclimatization, most of the farmers faced mild mortalities, i.e., 1-5% (45.33%) and from nil to traces (54.00%). Seventeen farmers responded that they did not acclimatize the seeds before releasing into the ponds. Majority of the farmers (84%) did not treat the fish seeds before stocking. Treatment of fish seeds with disinfectants was attempted by 16% of the farmers.

**Table 19 - The main stocking management practices followed by the respondent Andhra Pradesh farmers**

Variable	Description	Number of respondents	Percentage
Stocking	Single	54	72.00
	Repeated	15	20.00
	Not responded	06	08.00
Number of fish seeds stocked / acre	<2000	02	02.67
	2000-5000	51	68.00
	5000-10000	08	10.67
	>10000	14	18.67
Overall quality of seeds	Good	66	88.00
	Average	09	12.00
Acclimatization of fish seeds	No	17	22.67
	$\leq 1$ hour	58	77.33
Mortality during acclimatization	1-5%	34	45.33
	Nil to traces	41	54.67
Treatment before stocking	None	63	84.00
	Disinfectants	12	16.00

#### **4.1.13 The colour of pond water and pond bottom as reported by the respondent farmers of Andhra Pradesh**

The colour of pond water and pond bottom as reported by the respondent Andhra Pradesh fish farmers are presented in Table 20. The respondent farmers noticed pond water colour as transparent, light green, green and brownish green and most of the

farmers recorded green colour (57.33%). Among the pond bottom colours observed by the farmers, brownish black (48.00%) was the most common followed by black (26.67%), brown (17.33%), black with H<sub>2</sub>S smell (5.33%) and black with high organic wastes (2.67%).

**Table 20 - The colour of pond water and pond bottom as reported by the respondent farmers of Andhra Pradesh**

Variable	Description	Number of respondents	Percentage
Pond water colour	Transparent	12	16.00
	Light green	11	14.67
	Green	43	57.33
	Brownish green	09	12.00
Pond bottom colour	Brown	13	17.33
	Black	20	26.67
	Brownish black	36	48.00
	Black with high organic	02	02.67
	Black with H <sub>2</sub> S smell	04	05.33

#### **4.1.14 The main post-stocking management practices adopted by the respondent Andhra Pradesh farmers**

The main post-stocking management practices adopted by the respondent Andhra Pradesh farmers are listed in Table 21. The Andhra Pradesh fish farmers used a wide variety of feeds, out of which a mixture of groundnut oil cake / sunflower oil cake / cotton seed oil cake and rice / wheat bran (97.33%) was the most commonly used feed. Around 43% of the farmers used pelletized feed as they stocked scampi (*M. rosenbergii*) along with fishes. Two farmers did not feed their fish because of the abundant availability of natural foods in ponds.

Besides the use of different types of feeds, farmers also applied fertilizers for plankton production. Majority of the farmers used both organic (90.67%) and in-organic (85.33%) fertilizers like cowdung, poultry litter, lime, urea, single super phosphate, diammonium phosphate, etc. About 44 - 47% of the farmers monitored the water quality or fish health status regularly. Presence of weedy fish was noticed in 68% of the respondent farmers ponds during culture operation (Table 21).

**Table 21 - The main post-stocking management practices adopted by the respondent Andhra Pradesh farmers**

Variable	Description	Number of respondents	Percent age
Monitoring of water quality	Yes	33	44.00
	No	42	56.00
Monitoring of fish health status	Yes	35	46.67
	No	40	53.33
Fish feed	Ground nut, sunflower and cotton seed oil cakes	73	97.33
	Rice or wheat bran	73	97.33
	Pellet feed	32	42.67
	No feed	02	02.67
	Others	05	06.67
Type of fertilizers	Organic	68	90.67
	In-organic	64	85.33
	Both	68	90.67
	No fertilizers	07	09.33
	Others	05	06.67
Presence of weedy fish	Yes	51	68.00
	No	24	32.00

**Table 22 - Details on fish harvest, survival rate and marketing in Andhra Pradesh**

Variable	Description	Number of respondents	Percentage
Survival rate at harvest	<60 %	10	13.33
	60 -80 %	34	45.33
	>80 %	27	36.00
	Not responded	04	05.33
Mode of marketing	Local	16	21.33
	Middle man or agency	25	33.33
	Direct sale	34	45.33
Harvesting frequency	Weekly	03	04.00
	Fortnightly	03	04.00
	Monthly	25	33.33
	Quarterly and above	44	58.67

#### 4.1.15 Details of fish harvest, survival rate and marketing in Andhra Pradesh

The details on fish harvest, survival rate and marketing in Andhra Pradesh are presented in Table 22. Majority of the respondent farmers harvested table-sized fish at a time (58.67%), while 33% of the farmers harvested the fish stocks monthly. Fortnightly or weekly fish harvest was rare (4%). The observed survival rate was in the range of <60% - >80%. More than 80% survival was reported by 36% of the farmers. About 45% of the farmers reported 60 - 80% survival rate. After harvesting, the fishes were sold locally (21.33%) or through middleman or agency (33.33%) or sold directly to wholesaler (45.33%), who used to come to the farm site with ice, packing materials, etc for packing and transportation in lorries to different States.

**Table 23 - Problems encountered by the Andhra Pradesh fish farmers**

Description of problem	Number of respondents	Percentage
Uncertain water	24	32.00
Poor seed quality	23	30.67
Electricity	52	69.33
Transport	11	14.67
Draught	12	16.00
Poaching	43	57.33
Siltation	05	06.67
Diseases	68	90.67
Finance	15	20.00
Land security	02	02.67
Declining production	36	48.00
Price fluctuation	56	74.67
Management problem	34	45.33
Inundation due to floods	29	38.67
Workers health problem	08	10.67
Bad roads	16	21.33
No problem	3	04.00
Others	04	05.33

#### 4.1.16 Problems encountered by the fish farmers of Andhra Pradesh

The various problems encountered by the fish farmers of Andhra Pradesh are listed in Table 23 and also depicted in Figure 3 and, that of ranking in Table 24. Diseases were the major problem to about 91% of the Andhra Pradesh fish farmers. The other major problems of the respondent farmers were price fluctuation (74.67%), electricity (69.33%), poaching (57.33%), decline in production (48%), management problems (45.33%), flooding (38.67%), poor seed quality (30.67%) and uncertain water (32%) (Fig. 3). A few farmers encountered minor problems like transportation (14.67%), bad roads (21.33%), draught conditions (16%), siltation (6.67%), land security (2.67%), financial support (20%), health problems of the workers (10.67%), etc. Three farmers reported that they have not faced any of the problems listed in Table 23. Disease and electricity were the first and second ranked problems (27 respondents each) of the Andhra Pradesh farmers. Management problem (13 respondents) and price fluctuation (14 respondents) were the 3<sup>rd</sup> and 4<sup>th</sup> ranked problems (Table 24).

**Table 24 - Ranking of problems of Andhra Pradesh fish farmers**

Problems	Ranks					
	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	6 <sup>th</sup>
Uncertain water	05	10	04	02	-	1
Poor seed quality	03	09	03	-	-	-
Electricity	08	27	7	03	03	01
Transport	03	01	-	-	-	-
Drought	03	-	03	02	-	-
Poaching	-	-	06	04	02	01
Siltation	-	-	03	-	-	-
Disease	27	06	06	02	-	01
Declining production	01	02	01	04	03	-
Price fluctuation	02	02	04	14	08	05
Management problems	01	02	13	05	03	04
Inundation due to floods	01	05	05	04	-	04
Bad roads	-	01	02	02	-	-
Others	-	-	01	-	-	-

Fig. 3 - Major problems encountered by the Andhra Pradesh fish farmers

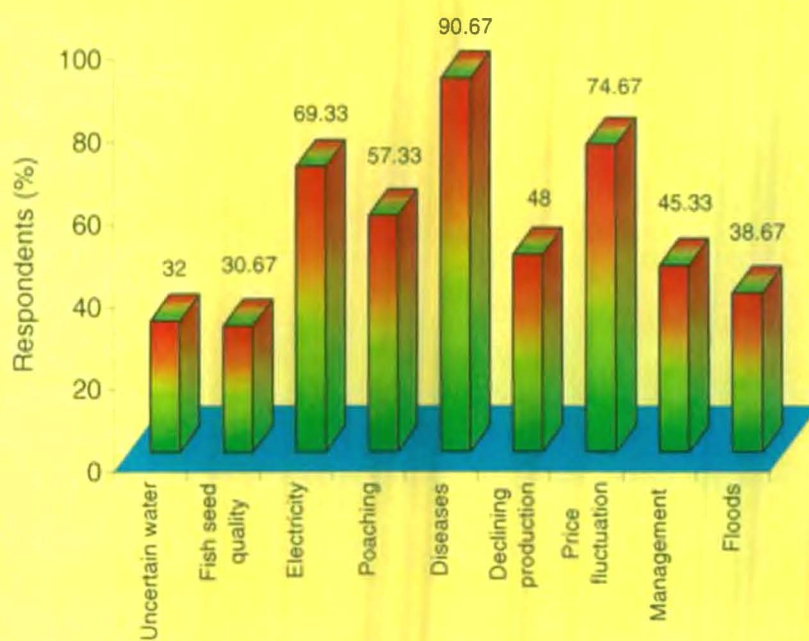
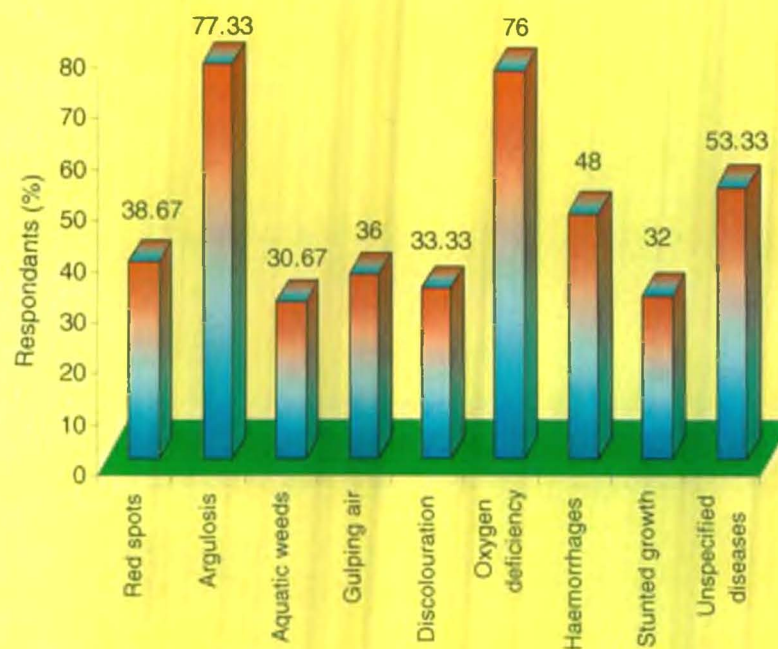


Fig. 4 - Major diseases / abnormalities that caused fish production loss in Andhra Pradesh



#### 4.1.17 The bodies or agencies who came forward to solve the problems of Andhra Pradesh farmers

The local government and non-governmental bodies who came forward to solve the problems of farmers are shown in Table 25. Majority of the farmers preferred Department of Fisheries (56%) to solve their problems followed by educational institutions (28%), government (9.33%), corporation / municipality (6.67%), panchayat (4%) and non-governmental organizations (4%). The farmers also got help from other sources (33.33%) such as from feed sales persons, other farmers, consultants, etc. Most of the farmers did not respond to the question on the role of local bodies (54.67%). About 41% of the farmers reported that the local bodies solved their problems related to aquaculture development (Table 25).

**Table 25 - The bodies or agencies that came forward to solve the problems of Andhra Pradesh farmers**

Variable	Description	Number of respondents	Percentage
Role of local bodies	Aquaculture development	31	41.33
	Not responded	41	54.67
	No idea	03	04.00
The bodies came forward to solve problems	Government	07	09.33
	Department of Fisheries	42	56.00
	Corporation / Municipality	05	06.67
	Panchayat	03	04.00
	Educational institutions	21	28.00
	NGO's	03	04.00
	Others	25	33.33

NGO's: Non-Governmental Organizations

#### 4.1.18 Frequency of diseases/abnormalities that cause production loss in Andhra Pradesh

The frequency of diseases and abnormalities causing production loss in Andhra Pradesh fish farms are listed in Table 26 and Fig. 4 and that of ranking in Table 27. The respondent farmers reported *Argulus* infection (77.33%), hemorrhages (48%), red spots (38.67%), parasitic infestation (24%), gill rot (22.67%), *Lernea* infection (21.33%) as major diseases that have been induced by biological agents. Among the environmental diseases, the most common was oxygen deficiency (76%) followed by gulping air (36%),

weed infestation (30.67%) and over crowding (22.67%). Besides these, other symptoms or abnormalities observed were discolouration (33.33%), stunted growth (32%) and anorexia (22.67%). Genetic disorder was noticed by 12% of the respondent farmers. Hemorrhage was most commonly seen on surface / skin (48%) followed by gills (25.33%), around the vent (25.33%), mouth (24%) and fin base or on fins (18.67%). *Argulus* infection was the first ranked disease (33 respondents). Twenty-nine respondents ranked red spots as the first ranked disease. Thirteen respondents ranked stunted growth as the first ranked disease (Table 27).

**Table 26 - Frequency of diseases / abnormalities that cause production loss in Andhra Pradesh**

Diseases / Abnormalities	Number of respondents	Percentage
Ulcers	10	13.33
Red spots / Red scales	29	38.67
Tail / fin rot	11	14.67
Erosion on jaw / mouth	05	06.67
Gill rot	17	22.67
Cotton fungus	02	02.67
Dropsy	07	09.33
Bacterial septicemia	05	06.67
Intestinal infection	02	02.67
<i>Argulus</i> infection	58	77.33
<i>Lernea</i> infection	16	21.33
White spots on the skin / gills	02	02.67
Parasitic protozoan infestation (external)	18	24.00
Aquatic weeds	23	30.67
Swollen eye / gills	03	04.00
Whirling movement	12	16.00
Poisoning	04	05.33
Anorexia	17	22.67
Overstocking	17	22.67
Genetic disorder	09	12.00
Gulping of air	27	36.00
Excess mucus	09	12.00
Swollen belly	01	01.33
Discolouration	25	33.33
Predation	09	12.00
Sloughing of scales	05	06.67
Oxygen deficiency	57	76.00
Water too hot	06	08.00
Polluted water	03	04.00
Hemorrhages	36	48.00
Insufficient water	11	14.67
Stunted growth	24	32.00
Unspecified disease	40	53.33

Hemorrhaging area		
Eye	06	08.00
Mouth	18	24.00
Operculum	11	14.67
Gills	19	25.33
Surface / skin	36	48.00
Fin base / fins	14	18.67
Around the vent	19	25.33
Internal organs	09	12.00

**Table 27 - Ranking of diseases or abnormalities that cause production loss in Andhra Pradesh fish farms**

Diseases / Abnormalities	Rank				
	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>
	Number of respondents				
Red spot / scales	29	-	-	-	-
Gill rot	-	06	08	03	-
Argulus infection	33	16	-	-	12
Parasitic protozoan infection	-	-	-	12	-
Gulping air	-	09	16	-	-
Oxygen deficiency	-	12	21	04	-
Stunted growth	13	05	-	03	-
Unspecified disease	-	18	06	11	04

**Table 28 - Pattern and recognition of fish diseases by the respondent Andhra Pradesh fish farmers**

Variable	Description	Number of respondents	Percentage
Pattern associated with diseases	During dry season	1	1.33
	During rainy season	42	56.00
	During hot season	7	9.33
	During cold season	56	74.67
	Just after stocking	16	21.33
	Before harvesting	1	1.33
	Just after draught	6	8.00
	Run off of domestic waste	4	5.33
	Others	3	4.00

#### **4.1.19 Pattern and recognition of fish diseases by the respondent Andhra Pradesh farmers**

The pattern associated with diseases and recognition of fish diseases by the respondent farmers are depicted in Table 28 and Fig. 5. Majority of the farmers noticed fish diseases during cold season (75%) followed by rainy season (56.00%). Sixteen farmers faced disease problems just after stocking. Incidence of diseases during hot seasons (9.33) and dry seasons (1.33%) was rare. Four percent of the farmers faced diseases because of poor water quality (Table 28).

The farmers recognized diseases on the basis of symptoms as shown in Fig 5. These included reduced growth (66.67%), anorexia (58.67%), discolouration (53.33%), sluggish behaviour (42.67%), erratic movement (38.67%), mortality (34.67%), haemorrhaging (16%), ulcers (14.67%) and others.

#### **4.1.20 Details on size group affected and pattern of fish mortality due to disease, action taken and responses of Andhra Pradesh fish farmers**

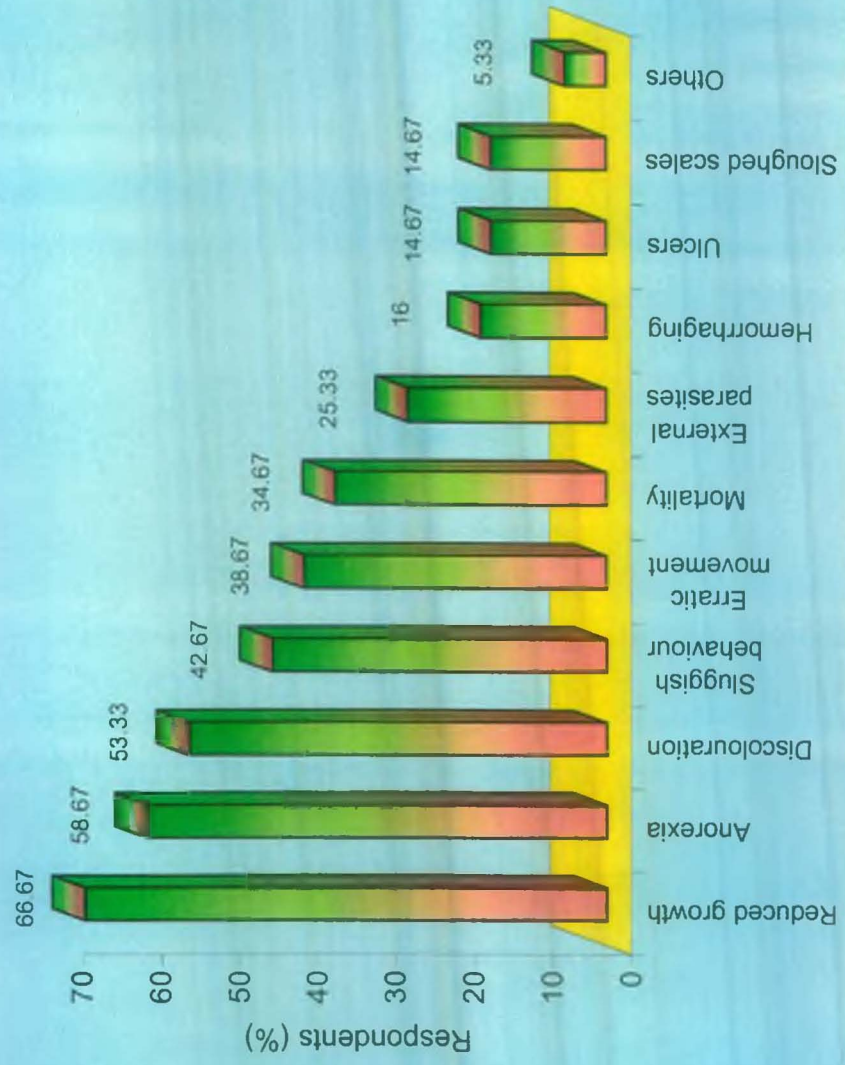
The details on size group affected and pattern of fish mortality due to diseases, action taken and responses of Andhra Pradesh fish farmers are presented in Table 29. The farmers reported that the sub-adult stage fishes were more prone to diseases (64%) followed by juvenile stage (36%). As regards the pattern of fish mortality, 55% of the farmers noticed few fish mortality in a week. Fish mortality due to diseases was normally low in Andhra Pradesh fish farms.

In respect of response to diseases, 95% attempted treatment, 72% stopped feeding, 52% stopped fertilization, 48% changed water and 49% sought help from others. About 23% of the respondents harvested the fish immediately on noticing the diseases. About 79% of the farmers used disinfectants to treat fish diseases. The use of antibiotics (5.33%), herbal products (8%) were meager. Though 95% of the farmers attempted treatment, only 77% of the farmers were successful in containing the diseases. Treatment measures were partially successful among 21% of the respondents farmers (Table 29).

#### **4.1.21 Summary of health problems encountered in Andhra Pradesh fish farms**

Table 30 summarizes the health problems encountered in freshwater fish culture in Andhra Pradesh. The freshwater fish farmers of Andhra Pradesh were often put to trouble due to the prevalence of diseases as listed in Table 26. As *Catla catla* and *Labeo*

Fig. 5 - Recognition of fish diseases by Andhra Pradesh fish farmers



**Table 29 - Details on size group affected and pattern of fish mortality due to diseases, action taken and responses of Andhra Pradesh fish farmers**

Variable	Description	Number of respondents	Percentage
Size group affected	Juveniles	27	36.00
	Sub adults	48	64.00
Pattern of fish mortality	Few fish daily	06	08.00
	Few fish weekly	41	54.67
	No mortality	15	20.00
	Don't remember	13	17.33
Response to diseases	Attempt treatment	71	94.67
	Change water	36	48.00
	Stop feeding	54	72.00
	Stop fertilization	39	52.00
	Emergency harvest	17	22.67
	Seek help	37	49.33
	Others	03	04.00
Treatment of diseases	No treatment	02	02.67
	Disinfectants	59	78.67
	Antibiotics	04	05.33
	Disinfectants and antibiotics	04	05.33
	Herbal and others	06	08.00
Perceived merits of treatment	Successful	58	77.33
	Partially successful	16	21.33
	Unsuccessful	01	01.33

*rohita* were the predominant culturable species they were more prone to diseases. 'Red disease'/ Hemorrhages', locally called as 'summer disease' was common in summer season affecting mostly the sub-adult rohu (*Labeo rohita*) which resulted only mild mortality. The second major disease was winter disease locally called as columnaris affecting the juveniles and sub-adult *L. rohita*. It was more prevalent in winter season. The mortality rate was meager. Whenever the pond management was poor, the presence and multiplication of external parasites like *Argulus*, *Lernea*, *Gyrodactylus* was observed. The stage susceptible to the argulosis was fingerlings and sub-adults of *C. catla* and *L. rohita*. Juveniles of *C. catla* and *L. rohita* were susceptible to *Lernea* and *Gyrodactylus* infection. However, no mortality was noticed due to these external parasites.

The other health problems faced by the farmers were scale loss, tail rot, gill swelling and stunted growth due to poor water quality and stress. No mortality was observed in these cases. Dropsy was common in adult and sub-adult *C. catla* and *L. rohita* during all seasons. But the severity was more during the summer season. Mortality was reported to be low. Stunted growth was noticed among all Indian major carps at all stages (Table 30).

**Table 30 - Summary of health problems encountered in Andhra Pradesh fish farms**

Health Problem	Species most affected	Stage affected	Season	Mortality rate
Red disease/ summer disease/ Haemorrhages	Mostly <i>L. rohita</i>	Sub- adults	Summer	Few fish daily
Columnaris/ winter disease	<i>L. rohita</i>	Juveniles and sub- adults	Winter and rainy days	Few fish daily
<i>Argulus</i>	<i>C. catla</i> and <i>L. rohita</i>	Fingerling and sub- adults	Rainy days and during stress	No mortality
<i>Myxobolus</i>	<i>C. catla</i> and <i>L. rohita</i>	Juveniles	Poor water quality and during winter	No mortality
Gas bubble	All cultured species	All stages	O <sub>2</sub> problem, rainy days	Few fish weekly
<i>Gyrodactylus</i>	<i>C. catla</i> and <i>L. rohita</i>	Fingerlings and juvenile	Poor pond management	No mortality
Dropsy	<i>C. catla</i> and <i>L. rohita</i>	Sub adult and adult.	All seasons. Mostly in summer and winter.	Few fish weekly
<i>Lernea</i>	<i>C. catla</i> and <i>L. rohita</i>	Fingerlings and juveniles	Rainy days	No mortality
Scale loss	<i>C. catla</i> and <i>L. rohita</i>	Adults	Deteriorated waters	No mortality
Tail rot	<i>C. catla</i>	Sub adult	Deteriorated water	No mortality
Gill swelling and stunted growth	<i>C. catla</i> , <i>L. rohita</i> and <i>C. carpio</i>	All stages	Unidentified conditions	No mortality

#### 4.1.22 Use of fertilizers, feeds, chemicals and aqua drugs in Andhra Pradesh freshwater aquaculture

The different types of fertilizers, feeds, chemicals and aqua drugs used in Andhra Pradesh fish farms and their dose rate are presented in Table 31. Majority of the farmers

used organic fertilizers for plankton production in the initial stages of culture, which served as a natural food for the growth of young ones. The farmers preferred cow dung whose dose ranged from 75 to 1000 kg/ha with an average dose of  $485.60 \pm 277.57$  kg/ha

**Table 31 - Use of fertilizers, feeds, chemicals and aquadrugs in Andhra Pradesh freshwater aquaculture**

	Dose Rate		
	Minimum	Maximum	Mean $\pm$ SD
<b>Fertilizers (kg / ha)</b>			
Cow dung	75	1000	485.00 $\pm$ 277.57
Poultry litter	100	2000	767.50 $\pm$ 399.43
Lime	100	600	217.00 $\pm$ 142.72
Urea	10	350	138.00 $\pm$ 115.97
Single super phosphate	20	550	157.00 $\pm$ 146.05
Diammonium phosphate	25	200	87.50 $\pm$ 49.00
<b>Feed (kg / ha)</b>			
De-oiled rice bran	450	1000	708.33 $\pm$ 203.51
Ground nut oil cake	100	300	200.00 $\pm$ 70.71
Sunflower oil cake	50	150	79.16 $\pm$ 40.05
<b>Chemicals</b>			
Formalin (lit / acre)	01	06	03.36 $\pm$ 1.67
Bleaching powder (kg / acre)	03	25	10.71 $\pm$ 6.76
Nuvan (lit / acre)	0.5	25	01.16 $\pm$ 0.68
Sodium chloride (kg / acre)	5	30	16.42 $\pm$ 9.88
<b>Antibiotics</b>			
Oxytetracycline	50 - 75 mg / kg feed for 10 - 15 days		
Streptomycin	50 - 135 mg / kg feed for 4 - 7 days		
Furazone and Nitrofurazone	50 - 75 mg / kg feed for 4 - 7 days		
Cyproflaxacin and enroflaxacin	5 mg / kg body weight		
Ivermectin	1 $\mu$ g / kg body weight		
Erythromycin	25 - 50 mg / kg feed for 4 - 7 days		

*Note: Depending on the farmer's choice sodium hypochloride (1 lit / acre), and / or formalin: benzal konium chloride (BKC): acetic acid mixture (2:1:1) were also applied. Water sanitizers, herbal products such as Piccoriza extract, Boerhaevia extract and Thymox extract and probiotics were also used at an unspecified ration during the periods of crisis.*

and poultry litter was used at a rate of 100-2000 kg/ha (average  $767.5 \pm 399.43$  kg/ha). Lime was mainly used in pond preparation stage (pre-stocking management) ranging from 100 to 600 kg/ha with an average of  $217.00 \pm 142.72$  kg/ha. The in-organic

fertilisers like urea (10-350 kg/ha) single super phosphate (20-550 kg/ha) and diammonium phosphate (25-200 kg/ha) were used before seed stocking for colour development as well as for plankton production along with organic fertilizers. As feed, deoiled rice bran (450-1000 kg/ha), groundnut oil cake (100-300 kg/ha) and sunflower oil cake (50-150 kg/ha) were used in bag feeding with an average dose of  $708.33 \pm 203.51$ ,  $200.00 \pm 70.71$  and  $79.16 \pm 40.05$  kg/ha, respectively.

A number of disease treatment measures were reported by farmers using chemicals during the initial stage of diseases. Most of the farmers applied water sanitizers such as formalin, iodine, chlorine and bromine compounds. Antibiotics such as ciprofloxacin, oxytetracycline, streptomycin, ivermectin, furazone, and erythromycin as listed in Table 31 were used in advance stage of fish diseases or in chronic stages. Extracts from plant source and probiotics were also used at an unspecified ration during the crisis period.

#### **4.1.23 Socio-economic impact and change in farmer's attitude to aquaculture caused by diseases in Andhra Pradesh**

The socio-economic impacts and change in farmer's attitude to aquaculture after disease outbreak are presented in Table 32. Majority of the farmers who experienced fish diseases changed the cultured species (55%) in the next culture operation. However, 45% of the farmers acknowledged that diseases caused resistance to continue aquaculture, and 33% of the farmers showed less or reduced importance towards aquaculture. Some farmers stopped aquaculture (27%) and shifted to agriculture. Three farmers reported that they stopped promoting aquaculture. The diseases have prolonged the culture operation of 80% of the respondent farmers. Reduction in income was noticed by 71% of the farmers, which ultimately increased the debt of 19% of the farmers (Table 32).

#### **4.1.24 Views of farmers on when in the growing cycle the diseases occur? and when disease was last seen?**

The views of farmers on when in the growing cycle the diseases occur? and when disease was last seen are presented in the Table 33. Majority of the interviewed farmers reported that diseases occur mostly between the 6<sup>th</sup> and 9<sup>th</sup> months of culture period. About 27% of the farmers noticed diseases during the periods between 4<sup>th</sup> and 6<sup>th</sup> and, 9<sup>th</sup> and 12<sup>th</sup> months. Diseases within the first quarter of stocking were noticed by 23% of the

respondent farmers. Few farmers (9%) noticed diseases within a month of stocking. The interviewed farmers faced disease problems within the last 2 months (56%), eight months (15%) and the last four months (11%) of culture period.

**Table 32 - Socio economic impact and change in farmer's attitude to aquaculture caused by diseases in Andhra Pradesh**

Variable	Description	Number of respondents	Percentage
Farmers attitude to Aquaculture after disease	Resistance to continuing aquaculture	34	45.33
	Stopped aquaculture	20	26.67
	Changed species	41	54.67
	Reduced importance	25	33.33
	Stopped promoting aquaculture	03	4.00
	Others	04	5.33
Socio-economic impacts on disease	Reduction in income	53	70.67
	Increased the debt	14	18.67
	Prolonged culture operations	60	80.00
	Reduction in household income	24	32.00

**Table 33 - Views of farmers on when in the growing cycle the diseases occur? and when diseases were last seen?**

Variable and description	Number of respondents	Percentage
<b>When in growing cycle disease is likely to occur?</b>		
Within a month	07	09.33
Within first quarter	17	22.67
4-6 months	20	26.67
6-9 months	43	57.33
9-12 months	20	26.67
Don't know	04	05.33
<b>When disease was last seen?</b>		
Within last two months	42	56.00
Within last four months	08	10.67
Within last eight months	11	14.67
Last year	08	10.67
Don't know	06	08.00

#### 4.1.25 Effect of diseases on fish consumption

Table 34 represents the effect of diseases on fish consumption. The farmers of Andhra Pradesh reported that they used to consume fishes most often or often (36%) and

sometimes (28%) before the outbreak of diseases. Around 64% of the farmers consumed fishes sometimes only depending upon the situation after disease outbreak. The frequency of consumption of fish often and most often was reduced to 24% and 12%, respectively after disease outbreak. About 41% of the farmers responded that they never consumed or did not consume disease fish and 30% of the farmer reported that they consume fish sometimes only. The reasons for not consuming diseased fishes were due to the fear of disease transmission (61.33%), unknown fear (42.67%) and hatred (26.67%).

**Table 34 - Effect of diseases on fish consumption**

Variable	Description	Number of respondents	Percentage
Fish consumption habit before disease outbreak	Most often	27	36.00
	Often	27	36.00
	Sometimes	21	28.00
Fish consumption habit after disease outbreak	Most often	9	12.00
	Often	18	24.00
	Sometimes	48	64.00
Consumption of diseased fish	Most often	3	4.00
	Often	11	14.67
	Sometimes	30	40.00
	Never	31	41.33
Reason for not consuming	Unknown fear	32	42.67
	Fear of disease transmission	46	61.33
	Hatred	20	26.67

#### 4.1.26 Expected and actual production and average expenses in the surveyed fish farms of Andhra Pradesh

The expected and actual fish productions of respondent farmers in Andhra Pradesh are depicted in Figs. 6 and 7 and the average expenses are shown in Table 35. The production expected by the farmers and actually achieved were categorized as 1-2 tons/acre, 3-4 tons/acre, 5-6 tons/acre and >6 tons/acre. Around 21% each of the farmers expected a production of 5-6 tons/acre and >6 tons/acre. But only a few farmers achieved a production of 5-6 tons/acre (13.33%) and >6 tons/acre (6.67%) target. Twenty percent of the farmers expected a production of 3 - 4 tons / acre. But, majority of the respondent

Fig. 6 - Expected and actual fish production of the respondent Andhra Pradesh farmers

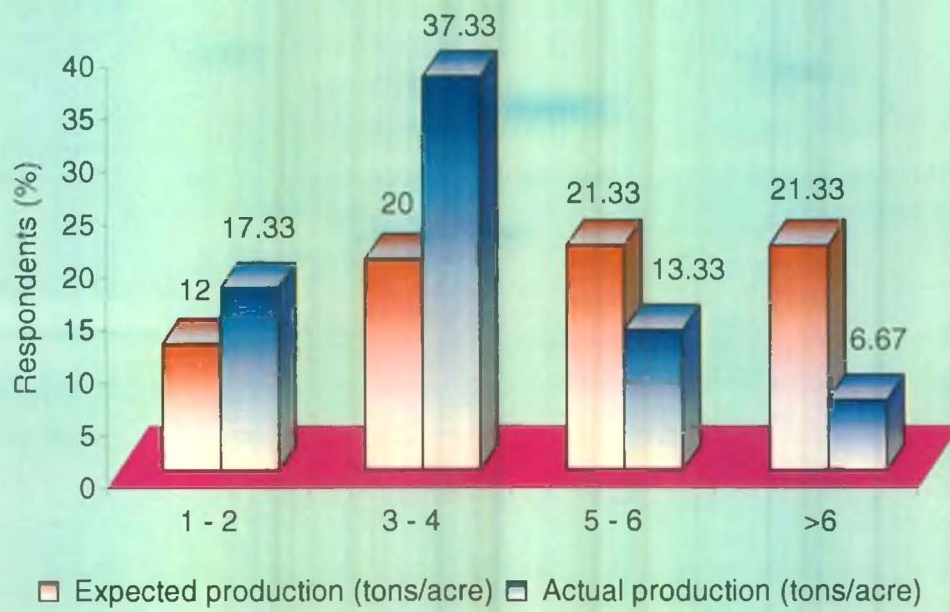
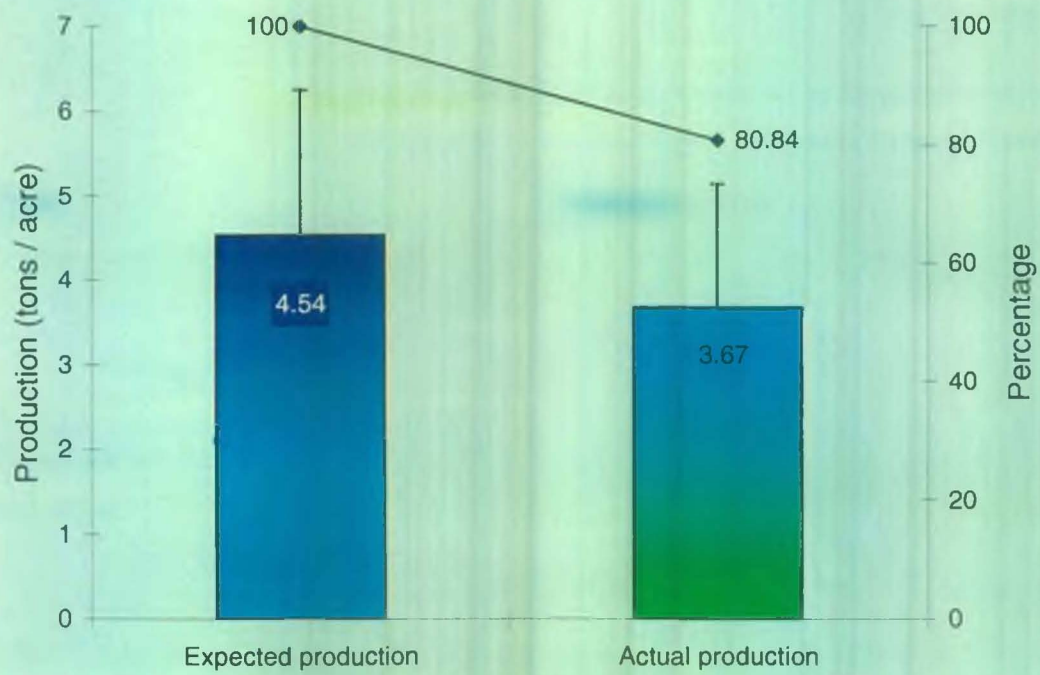


Fig. 7 - Average expected and actual fish production of the respondent Andhra Pradesh farmers



farmers (37.33%) achieved the production of 3-4 tons/acre. Although only 12% of the farmers expected a production of 1-2 tons / acre, 17.33% of the farmers actually produced 1-2 tons/acre (Fig. 6). About 57% of the farmers average expenses were in the range of Rs.5, 001 - to 10, 000 / year / acre. The expenses were less than Rs. 5, 000 / year / acre for 28% of the farmers. Others reported expenses over Rs.10, 000/ year / acre.

**Table 35 - Average expenses in the surveyed fish farms of Andhra Pradesh**

Variable	Description	Number of respondents	Percentage
Average expenses (Rs / year / acre)	≤ 5, 000	21	28.00
	5, 001 – 10, 000	43	57.33
	10,001 - 15, 000	3	04.00
	> 15,000	3	04.00
	Don't know	5	06.67

## 4.2 Epidemiology of infectious diseases and development of interventions

### 4.2.1 Details of variables that influence the infectious disease, their attributable risk and incident rate

The incidence rate (IR), attributable risk (AR) of infectious disease and the ratio between AR and IR for each of the variable regarding pond connection / establishment, pre-stocking management, stocking management and post-stocking management are presented in Table 36. The IR, AR and AR / IR ratio of variables related to pond establishment, viz. type of habitat, water source, type of farming, age of the farm, number of grow-out ponds, type of farms, total farm area, presence / absence of nursery ponds positive AR / IR (x100) values were observed with intensive and semi-intensive type of farming system (41.86%), number of grow-out ponds (41.67%) and farmers training in aquaculture (52.63%). High negative AR / IR (x100) values were observed in case of type of habitat (-103.70), water sources (-25.64) and age of the farms (-37.02). Among the variables pertaining to pre-stocking management, variables such as sludge disposal on the dykes of the same pond, sludge removal and soil colour while ploughing exhibited and training in aquaculture were observed. Among the pond connection variables, high highly negative AR / IR (x100) values and the corresponding values were -193.57, -152.94 and -92.22, respectively. Positive values were observed with variables such as draining of pond water (74.35) and water treatment (21.05).

**Table 36 - Details of variables that influence the infectious diseases (ID), their incidence rate (IR) and attributable risk (AR)**

Variable	Number of farms	Number of farms affected (%) by ID	Number of farms not affected (%) by ID	Incidence rate (IR)	Attributable risk (AR)	AR / IR X100
<b>Pond connection / Establishment</b>						
1. Type of habitat						
Rice field	75	20 (26.67)	24 (32.00)	0.27	-0.28	-103.70
Others		23 (30.67)	8 (10.67)			
2. Water source						
Canal and ground water	75	29 (38.67)	25 (33.33)	0.39	-0.10	-25.64
Rain and lake waters		14 (18.67)	07 (9.33)			
3. Type of farming						
Intensive / semi-intensive	75	32 (42.67)	18 (24.00)	0.43	0.18	41.86
Extensive, modified extensive, etc		11 (14.67)	14 (18.67)			
4. Age of the farm						
>5 years	75	32 (42.67)	29 (38.67)	0.43	-0.16	-37.02
≤5 years		11 (14.67)	03 (4.00)			
5. Number of grow-out ponds						
>3 ponds	75	27 (36.00)	15 (20.00)	0.36	0.15	41.67
<3 ponds		16 (21.33)	17 (22.67)			
6. Type of farms						
Perennial	75	42 (56.00)	29 (38.67)	0.56	0.07	12.5
Seasonal		01 (1.33)	03 (4.00)			
7. Total farm area						
> 10 acres	75	33 (44.00)	22 (29.33)	0.44	0.08	18.18
≤ 10 acres		10 (13.33)	10 (13.33)			
8. Presence of nursery ponds						
Yes	75	39 (52.00)	29 (38.67)	0.52	0.001	1.92
No		04 (5.33)	03 (4.00)			
9. Training in aquaculture						
Yes	75	14 (18.67)	07 (9.33)	0.19	0.10	52.63
No		29 (38.67)	25 (33.33)			
<b>Pre-stocking management</b>						
1. Draining of pond water						
Partial draining	75	29 (38.67)	12 (16.00)	0.39	0.29	74.35
Complete draining		14 (18.67)	20 (26.67)			
2. Pond drying period						
>20 days	34	11 (32.35)	08 (23.52)	0.32	-0.02	-6.25
<20 days		09 (26.47)	06 (17.65)			
3. Sludge removal						
Yes	75	13 (17.33)	18 (24.00)	0.17	-0.26	-152.94
No		30 (40.00)	14 (18.67)			

<b>4. Ploughing</b>						
Yes	75	38 (50.67)	27 (36.00)	0.51	0.04	7.84
No		05 (6.77)	05 (6.67)			
<b>5. Soil colour while ploughing</b>						
Brown	65	12 (18.46)	13 (20.00)	0.18	-0.16	-92.22
Black		26 (40.00)	14 (21.54)			
<b>6. Sludge disposal place</b>						
On the dykes	75	12 (16.00)	19 (25.33)	0.16	-0.31	-193.75
Outside the pond		31 (41.33)	13 (17.33)			
<b>7. Pond bottom treatment</b>						
Liming	75	42 (56.00)	31 (41.33)	0.56	0.008	1.428
No liming		01 (1.33)	01 (1.33)			
<b>8. Water treatment</b>						
Chemicals	75	43 (57.33)	28 (37.33)	0.57	0.12	21.05
Others		0 (0)	04 (5.33)			
<b>Stocking management</b>						
<b>1. Type of fish seed</b>						
Fingerlings	75	28 (37.33)	13 (17.33)	0.37	0.24	64.86
Others		15 (20.00)	19 (25.33)			
<b>2. Source of fish seed</b>						
Directly from hatchery	75	36 (48.00)	27 (36.00)	0.48	-0.007	-1.46
Other sources		07 (9.33)	05 (6.67)			
<b>3. Distance of fish seed transported</b>						
<50 km	75	23 (30.67)	13 (17.33)	0.31	0.12	38.71
>50 km		20 (26.67)	19 (25.33)			
<b>4. Mortality during fish seed transportation</b>						
<1%	75	16 (21.33)	09 (12.00)	0.21	-0.09	-42.86
>1%		27 (36.00)	23 (30.67)			
<b>5. Treatment before stocking</b>						
Yes	75	09 (12.00)	03 (4.00)	0.12	0.11	91.67
No		34 (45.33)	29 (38.67)			
<b>7. Acclimatization of fish seeds</b>						
Yes	75	36 (48.00)	22 (29.33)	0.48	0.15	31.25
No		07 (9.33)	10 (13.33)			
<b>8. Mortality during acclimatization</b>						
1-5%	75	20 (26.67)	14 (18.67)	0.27	0.02	7.41
Nil to traces		23 (30.67)	18 (24.00)			
<b>9. Stocking density</b>						
>5000 numbers / acre	75	33 (44.00)	20 (26.67)	0.44	0.14	31.81
<5000 numbers / acre		10 (13.33)	12 (16.00)			
<b>10. Species cultured</b>						
<i>C. mrigala</i> , <i>C. carpio</i> , catfishes	75	18 (24.00)	10 (13.33)	0.24	0.10	41.67
Other species		25 (33.33)	22 (29.33)			
<b>11. Type of culture</b>						
Polyculture	75	34 (45.33)	29 (38.67)	0.45	-0.11	-24.44
Monoculture		09 (12.00)	03 (4.00)			

Post stocking management						
1. Use of fertilizers						
Yes	75	41 (54.67)	27 (36.00)	0.53	0.11	20.75
No		02 (2.67)	05 (6.67)			
2. Monitoring of water quality						
Yes	75	16 (21.33)	17 (22.67)	0.21	-0.15	-71.43
No		27 (36.00)	15 (20.00)			
3. Monitoring of fish health						
Yes	75	18 (24.00)	17 (22.67)	0.24	-0.08	-33.33
No		25 (33.33)	15 (20.00)			
4. Presence of weedy fish						
Yes	75	31 (41.33)	20 (26.93)	0.41	0.09	21.95
No		12 (16.00)	12 (16.00)			
5. Pond bottom colour						
Black	75	37 (49.33)	25 (33.33)	0.49	-0.07	-14.28
Brown		06 (8.00)	07 (9.33)			

Among the variables on stocking management practices, high negative AR / IR (x100) values were noted for mortality during fish seed transportation (-42.86) and type of culture (-24.44). The variables, which showed positive values, were type of fish seed (64.86), distance of fish seed transportation (38.71), treatment before stocking (91.67), acclimatization of fish seeds (31.25), stocking density (31.81) and species cultured (41.67). Among post-stocking management the variable that had negative impact on diseases i.e. negative AR / IR ratio were regular monitoring of water quality (-71.43), regular monitoring of fish health (-33.33) and pond bottom colour (-14.28). The variables such as use of fertilizers and presence of weedy fish showed positive AR / IR (x100) values, and the corresponding values were 20.75 and 21.95, respectively (Table 36).

#### 4.2.2 Variables effecting relative risk (RR) and odds ratio (OR) of infectious diseases in fresh water aquaculture in Andhra Pradesh

The list of variables related to pond connection or establishment, pre-stocking management, stocking management and post-stocking management that affect relative risk (RR) and odds ratio (OR) of infectious diseases in freshwater aquaculture of Andhra Pradesh are tabulated in Table 37. Among the variables related to pond establishment, variables such as grow-out ponds > 3 numbers (RR=1.34), and the farmers training in aquaculture (RR=1.48) and adoption of intensive and semi-intensive type of farming (RR=1.32) were observed to be putative casual factors of infectious diseases. Other variables exhibited either no association or as sparing factor for infectious diseases.

**Table 37 - Variables affecting relative risk (RR) and odds ratio (OR) of infectious diseases (ID) in freshwater aquaculture in Andhra Pradesh, giving 95% confidence limits (lower<RR<upper). RR>1 indicates the factor is a putative casual factor of infectious diseases; RR=1 indicates no association exists between the factor and ID; and RR<1 indicates the factor as a sparing factor for ID. Just like RR, the null value of the OR is 1 and the OR has no units.**

Variable	Relative Risk	Lower Limit	Upper limit	Odds Ratio	Lower Limit	Upper Limit
<b>Pond connection / Establishment</b>						
Type of habitat: rice field	0.620	0.425	0.905	0.290	0.107	0.788
Source of water: canal and ground water	0.863	0.654	1.139	0.580	0.202	1.663
Adoption of intensive / semi-intensive farming system	1.32	0.93	1.88	2.26	0.85	6.01
Age of the farm: >5 years	0.821	0.667	1.011	0.301	0.076	1.187
Grow-out ponds: $\geq 3$	1.340	0.867	2.069	1.913	0.755	4.846
Perennial farm	1.078	0.955	1.216	4.345	0.430	43.866
Total farm area: >10 acre	1.116	0.839	1.485	1.500	0.536	4.198
Presence / absence of nursery ponds	1.001	0.864	1.159	1.009	0.209	4.859
Farmer's training in aquaculture	1.488	0.680	3.258	2.080	0.757	5.715
<b>Pre-Stocking Management</b>						
Partial draining of pond water	1.798	1.098	2.945	3.452	1.324	9.005
Pond drying period: >20 days	0.963	0.527	1.758	0.917	0.231	3.633
Removal of bottom sludge	0.537	0.311	0.929	0.337	0.130	0.876
Pond ploughing	1.047	0.871	1.259	1.407	0.371	5.344
Colour of soil: black or brown	0.656	0.356	1.207	0.497	0.179	1.377
Disposal of sludge on the dykes of same pond	0.470	0.269	0.822	0.265	0.100	0.699

Liming of pond bottom	1.008	0.933	1.089	1.355	0.082	22.514
Chemical treatment of water	1.143	1.003	1.303	62.890	0.117	3.394
<b>Stocking management</b>						
Type of seed stocked: fingerling	1.603	0.999	2.571	2.728	1.062	7.012
Source of seed: hatchery	0.992	0.813	1.211	0.952	0.272	3.329
Distance of fish seed transportation: > 50 km	1.317	0.796	2.178	1.681	0.666	4.241
Fish seed mortality during transport >1%	1.323	0.673	2.602	1.514	0.564	4.068
Treatment before stocking	2.233	0.657	7.592	2.559	0.633	10.35
Acclimatization of fish seed	1.218	0.931	1.592	2.338	0.777	7.036
Mortality during acclimatization: 1-5%	1.063	0.640	1.765	1.118	0.445	2.806
Stocking density of fingerling: >5000 / acre.	1.228	0.896	1.682	1.980	0.724	5.417
Stocking of bottom dwelling fishes, <i>C.mrigala</i> , <i>C. carpio</i> , <i>Pangassius</i> sp and <i>Clarius</i> sp	1.340	0.718	2.498	1.584	0.605	4.146
Type of culture: Polyculture	0.872	0.722	1.055	0.391	0.097	1.543
<b>Post-stocking Management</b>						
Use of fertilizers	1.130	0.960	1.330	3.796	0.686	20.96
Monitoring water quality	0.700	0.422	1.162	0.523	0.206	1.325
Monitoring of fish health status	0.832	0.514	1.346	0.706	0.282	1.765
Presence of wild fish in ponds	1.153	0.832	1.599	1.550	0.583	4.121
Black pond bottom	0.638	0.237	1.716	0.579	0.174	1.928

Among pre-stocking management practices, the variable partial draining of pond water (RR=1.798) was observed to be a putative casual factor of infectious diseases. Other variables showed either no association (RR=1.0) or as sparing factor for infectious diseases.

The variables such as type of fish seeds (RR=1.603), distance of fish seed transportation (RR=1.317), treatment before stocking (RR=2.233), acclimatization of fish seed (RR=1.218), stocking density (RR=1.278) and stocking with bottom dwelling fishes (RR=1.34) were found to be moderate putative casual factors of infectious diseases. Other variables showed no association in initiating infectious diseases and the RR values were observed to be around 1.0. The results of odds ratio (OR) obtained were similar to that of relative risk (RR). However the observed values were slightly higher than the relative risk values (Table 37).

#### 4.2.3 Chi-square values and co-efficient of contingency values of the selected variables

Chi-square values and co-efficient of contingency values of the selected variables are tabulated in Table 38. Of the 32 variables tested, only four variables exhibited significant association with diseases on the basis of chi-square analysis. These were (i) type of habitat ( $\chi^2=5.03$ ;  $c=0.25$ ;  $p<0.03$ ), (ii) removal of pond bottom sludge ( $\chi^2=4.10$ ;  $c=0.22$ ;  $p<0.05$ ), (iii) partial draining of pond water ( $\chi^2=5.48$ ;  $c=0.26$ ;  $p<0.02$ ) and (iv) sludge disposal on the dykes of the same pond ( $\chi^2=6.39$ ;  $c=0.27$ ;  $p<0.01$ ). The other variables exhibited insignificant ( $p>0.05$ ) association with infectious diseases.

**Table 38 - Chi-square analysis and co-efficient of contingency tested for the association / independence of variables and infectious disease incidence in freshwater fish culture system of Andhra Pradesh**

Variable	Total number of farms selected	Chi-square value with 'Yates' correction	Co-efficient of contingency (C)	Level of significance
<b>Pond connection/Establishment</b>				
Type of habitat: rice field	75	5.03	0.25	P<0.03
Source water: canal and ground water	75	0.58	-	*
Adoption of intensive / semi-intensive farming	75	1.96	-	*

Age of the farm: >5 years	75	2.19	-	*
Grow-out ponds: $\geq 3$	75	1.29	-	*
Perennial farm	75	0.68	-	*
Total farm area: >10 acre	75	0.26	-	*
Presence / absence of nursery ponds	75	0.006	-	*
Farmer's training in aquaculture	75	0.57	-	*
<b>Pre-Stocking Management</b>				
Partial draining of pond water	75	5.48	0.26	P<0.02
Pond drying period: >20 days	34	0.93	-	*
Removal of pond bottom sludge	75	4.10	0.22	P<0.05
Pond ploughing: once or twice	75	0.02	-	*
Colour of pond bottom: black or brown	65	1.28	-	*
Sludge disposal on the dykes	75	6.39	0.27	P<0.01
Liming of pond bottom	75	0.26	-	*
Chemical treatment of water	75	3.47	-	*
<b>Stocking management</b>				
Type of seed stocked: fingerlings	75	3.50	-	*
Source of seed: hatchery	75	0.13	-	*
Distance of fish seed transportation: >50 km	75	0.75	-	*
Fish seed mortality during transport: <1%	75	0.33	-	*
Treatment of seeds before stocking	75	1.06	-	*
Acclimatization of fish seeds	75	1.56	-	*
Mortality during acclimatization: 1 - 5%	75	0.000009	-	*
Stocking density: >5000 / acre	75	1.17	-	*
Stocking of bottom dwelling fishes, <i>C. mrigala</i> , <i>C. carpio</i> , <i>Pangassius</i> sp and <i>Clarias</i> sp	75	0.48	-	*
Type of culture: Polyculture	75	1.06	-	*
<b>Post-stocking Management</b>				
Use of fertilizers	75	1.49	-	*
Monitoring of water quality	75	1.29	-	*
Monitoring of fish health status	75	0.53	-	*
Presence of wild fish in ponds	75	0.39	-	*
Black pond bottom	75	0.34	-	*

\*: P > 0.05; - : Not calculated

### 4.3 Systematic pathology

The histopathological and wet mount observations are presented in Plates 13 - 16.

### 4.4. Bacteriology

#### 4.4.1. Bacterial flora associated with diseased fish.

The bacterial floras associated with diseased fish are presented in Table 39. *Pseudomonas spp* was the major bacterial flora associated with the affected parts of diseased fishes of the present study. The other bacterial flora isolated were *Aeromonas hydrophila*, *Acinetobacter* and *Enterobacteriaceae* group. *Pseudomonas spp* was isolated from *C. catla* with gill necrosis and gill discolouration, while in *Labeo rohita* the condition was hemorrhages around vent and opercular region and, discoloured gills. *Aeromonas hydrophilla* was isolated from *C. catla* and *L. rohita* with gill and body discolouration. *Acinetobacter* and *Enterobacteriaceae* were isolated from *L. rohita* (Cases 3 and 4) with discoloured gills.

#### 4.4.2. Antibiotic resistance in bacterial flora of diseased fishes

A total of 18 isolates comprising of *Aeromonas hydrophila*, *Pseudomonas spp*, *Acinetobacter* and *Enterobacteriaceae* from diseased fish (Table 39) were subjected to antibiogram against six antibiotics, i.e., chloramphenicol, C (30 mg), ciprofloxacin, F (5 mg), gentamycin, G (10 mg), nitrofurantoin, N (300 mg), trimethoprim, T (5 mg) and oxytetracycline, O (30 mg) and the results are presented in Table 40. Thirteen isolates (72%) were resistant to trimethoprim. All the isolates were sensitive to chloramphenicol and gentamycin. Resistance to chloramphenicol and oxytetracycline was seen among 22.20% and 27.78% of the bacterial isolates, respectively. Out of 14 isolates of *Pseudomonas spp*, 12 isolates (85.5%) developed resistance to at least one antibiotic. Two *Aeromonas hydrophila* isolates were sensitive to all antibiotics. *Enterobacteriaceae* and *Acinetobacter* were also resistant to antibiotics.

#### 4.4.3 Antibiotic resistance profile / multiple antibiotic resistance (MAR) of bacterial flora from diseased fishes

The antibiotic resistance profile and MAR of the bacterial flora of diseased fish are presented in Table 41. Four isolates from diseased fish were sensitive to all the antibiotics. The common resistance profile was NT (38.89%) followed by FOT (16.67%). Other observed resistance profiles were FONT, ONT, N and T. Multiple antibiotic

resistance, i.e., resistance to at least two antibiotics was observed in 66.67% of the bacterial isolates. Maximum 'MAR' was observed in *L. rohita* with pale to slight red gill discolouration (Case 2).

**Table 39 - Bacterial flora associated with diseased fishes of Andhra Pradesh**

Case	Species affected	Diagnosis /diseased condition	Associated bacterial flora
1	<i>Catla catla</i> Weight - 2.5 kg	Gill necrosis	<i>Pseudomonas</i> spp (n =4)
2	<i>Labeo rohita</i> Weight – 450 g	Gill discolouration (Pale to slightly red gills)	<i>Acinetobacter</i> (n=1) <i>Pseudomonas</i> (n=7)
3	<i>Labeo rohita</i> Weight – 750 g	Hemorrhages around vent and opercular region; Gill discolouration	<i>Pseudomonas</i> (n=2)
4	<i>Catla catla</i> Weight - 2 kg	Gill discoloration	<i>Aeromonas hydrophila</i> (n=1), <i>Pseudomonas</i> (n=1)
5	<i>Labeo rohita</i> Weight – 500 g	Gills and body discolouration	<i>A. hydrophila</i> (n=1), Enterobacteriaceae (n=1)

**Table 40 - Antibiotic resistance (%) in bacterial flora of diseased fishes from Andhra Pradesh**

Antibiotic / Bacteria	Number of resistance stain(s)	Percentage
Chloramphenicol, 30 µg	0	0
Ciprofloxacin, 5 µg	4	22.2
Gentamycin, 10 µg	0	0
Nitrofurantoin, 300 µg	10	55.55
Oxytetracycline, 30 µg	5	27.78
Trimethoprim, 5 µg	13	72.22
<i>Acinetobacter</i>	1	100
<i>Aeromonas hydrophila</i>	0	0
<i>Enterobacteriaceae</i>	1	100
<i>Pseudomonas</i> spp	12	85.71

**Table 41 - Antibiotic resistance profile of bacterial flora from diseased fishes of Andhra Pradesh**

Resistance profile	Source of isolates	Number of isolate(s)	Percentage
FONT	<i>Catla catla</i> (Case - 3)	1	5.55
FOT	<i>C. catla</i> , <i>Labeo rohita</i> (Cases - 2 and 3)	3	16.67
ONT	<i>L rohita</i> (Case - 2)	1	5.55
NT	<i>C. catla</i> , <i>L. rohita</i> (Cases - 1, 2 and 3)	7	38.89
N	<i>C. catla</i> (Case - 4)	1	5.55
T	<i>L. rohita</i> (Case - 2)	1	5.55
None	<i>C. catla</i> , <i>L. rohita</i> (Case - 5)	4	22.22

*F: Ciprofloxacin; O: Oxytetracycline; N: Nitrofurantoin; T: Trimethoprim*

# *Discussion*

## **5. DISCUSSION**

### **5.1.1 Household size, educational qualification, experience and financial status of fish farmers of Andhra Pradesh**

The farmers of Andhra Pradesh are mainly from large sized family, i.e., >50% of the respondents had about 5 family members. All the farmers are literate and few farmers (2.67%) had post-graduate qualification (Table 6). As the fish culture is an age old practice in Andhra Pradesh, many of the farmers acquired the farms from their ancestors. The farmers experience in aquaculture was in the range of 6 to more than 25 years. Fifteen respondents had less than 5 years experience in aquaculture. As the farmers of Andhra Pradesh are landlords, they used their personal savings (42.67%) for aquacultural activities and this was the 1<sup>st</sup> ranked source of finance. Bank (38.67%) and private loans (4%) were also used for aquacultural development activities. Many of them (41.33%) had undergone training in aquaculture (Tables 6 and 7).

### **5.1.2 Main activity and time spent for aquaculture by the fish farmers and ownership pattern of fish farms in Andhra Pradesh**

As seen in Table 8, the farmers of Andhra Pradesh practiced aquaculture mostly in their own land (84%). They were mainly engaged in aquaculture (100%) and agriculture (93.33%). They have taken up fish culture as a profession and converted their agricultural land into fishponds. Majority of the farmers (57.33%) used to spend more than 6 hours / day in farms.

### **5.1.3 The main reason for fish culture and farmers perception on aquaculture**

As fish farming is one of the major occupations of the farmers of Andhra Pradesh, they have taken up aquaculture mainly for income generation (98.67%) and raising food production (48%). The farmers perceived that the freshwater aquaculture practice is a risky business, but it yields high profits. Many opined that disease was an important issue in aquaculture development (Table 9).

### **5.1.4. Source of information on aquaculture, fish seeds and disease treatment**

As shown in Table 10, majority of the Andhra Pradesh farmers (48%) learnt aquaculture themselves through day-to-day experience. Information was sought from other farmers (44%), friends and neighbours (41%), Government extension workers

(32%) and educational institution (32%). As regards the information on fish seeds, the Andhra farmers dependent on other farmers, self-knowledge, friends and neighbours, Government extension workers and educational institution in order.

However, for the information on disease treatment, the farmers of Andhra Pradesh sought help from feed sales person (60%) who visit the farms regularly to promote the company products. They also got information from other fish farmers, Government extension workers and drug sales person. The involvement of non-governmental organizations (NGO's) in imparting knowledge on aquaculture and related activities to the farmers was negligible (Table 10).

Knowledge input from other farmers was the major first ranked information on fish seeds. Likewise, input from government extension workers ranked first on aquaculture information. The results, in general, revealed that the government, non-governmental organizations and other agencies failed to impress the Andhra Pradesh fish farmers on aquaculture development. The results also reflected the lack of coordination between government extension officers and farmers in implementing the scientific advancements in aquaculture. Over dependence on other local farmers, friends and neighbours for knowledge on aquaculture and the government extension officer was among the last source of information was also a common trend in Bangladesh, Vietnam and Thailand (MacRae et al., 2002; Chinabut et al., 2002; Kaschalchan, 2002).

#### **5.1.5 Particulars on the number of grow-out and nursery ponds held by the respondent Andhra Pradesh farmers**

The farmers of Andhra Pradesh used to culture fish in vast areas. Majority of the respondents had two or three (33.33%) grow-out ponds. Seventeen respondents owned 4 or above grow-out ponds. Almost all the farmers (91%) had at least one nursery pond (Table 12). The farmers of Andhra Pradesh used to stock fish seeds at high densities in nursery ponds for rearing different stages like hatchlings to fry, fry to fingerlings, fingerlings to advanced fingerlings or stocking size. This enabled the farmers to stock these stages in different ponds with different stocking densities.

#### **5.1.6 The details of fish farming practices and species cultured in Andhra Pradesh**

The commercial freshwater aquaculture in Andhra Pradesh is of intensive and semi-intensive type of farming. The farmers also adopted modified extensive (14.67%)

and extensive (18.67%) types of farming systems. Polyculture (84%) of Indian major carps, especially catla (*Catla catla*) and rohu (*Labeo rohita*) was the most common. Due to EUS outbreak, the three to six species (Indian major carps and Exotic carps) combination used in traditional polyculture systems, have been replaced by two species (catla and rohu) combination, which occupy the column and surface niches of the aquatic system. This practice has become well established in larger areas of Andhra Pradesh for more than 15 years and the farmers were successful in controlling the EUS outbreak, as it is more severe in bottom dwelling fishes (Mohan and Shankar, 2002).

Farmers from Nellore region practiced monoculture (12%) of *Macrobrachium rosenbergii*, as it fetched high price in the international market. Only 4% of the farmers practiced integrated farming with horticulture or duckery. Besides *C. catla* and *L. rohita*, the farmers also cultured *Cirrhinus mrigala*, *Cyprinus carpio*, *Ctenopharyngodon idella*, *Pangassius spp* and *Clarias spp*. Other species like *Oreochromis mossambicus*, *Channa striatus* and *Penaeus monodon* were also cultured for sale in local markets (Table 13).

#### **5.1.7 Details on area, type, age and habitat of fish farms of the respondent farmers of Andhra Pradesh**

The state of Andhra Pradesh has vast freshwater resources. All the rivers in this state are east flowing, and the freshwater fish culture is mainly concentrated in coastal districts (east) especially in the low lying lands of Kolleru lake which are fertile for agriculture and aquaculture productions. Only few farms were rain dependent and seasonal in nature. The perennial farms were located mainly in agricultural (59%) and riverine belts (39%). As the returns from freshwater fish culture was high compared to agriculture, the farmers of Andhra Pradesh slowly converted their agricultural land into fish farms. This has resulted in the emergence of large scale, commercial, semi-intensive carp culture in the state. About 36% of the farmers responded that the age of their farms were between 6 and 10 years. About 45% of the farmers' farms were more than 11 years old, among which 8% were more than 20 years old.

The total farm area of the Andhra Pradesh fish farmers was in the range of 1 - >50 acres. Majority of the fish farmers are large-scale commercial farmers. Few farmers (9%) had farm area more than 50 acres, inherited from their ancestors (Table 14). This is in contrast with Nandeesh et al. (2002) and Sil (2006), who recorded large number of

small-scale farmers in Bangladesh and West Bengal, respectively. In an International Development Research Center (IDRC) sponsored survey of carp farming practice, information was collected from 189 farms from four districts of Andhra Pradesh in 1991-93 (Veerina et al., 1993). According to them, about 50,000 ha were under scientific carp farming in the Kolleru basin. The average farm size was 10.5 ha, while that of culture pond was 3.9 ha and that of rearing pond was 0.6 ha.

#### **5.1.8 The background information on labours of fish farms of respondent Andhra Pradesh farmers**

Table 15 revealed that the labours of Andhra Pradesh freshwater fish farms were employed mainly on casual basis (50.67%). In some farms they are engaged on permanent basis (33.33%). In all the farms these labours were engaged as fishermen mostly at the time of harvesting and intermittent netting. Labours were also engaged for transportation of fish seeds, guard and watch and feeding fish. Most of the labours engaged in different works were of different age groups with the dominance of >40 (40%) years age group followed by 20-40 years (37.35%) and <20 years (22.65%).

#### **5.1.9 The main pre-stocking management practices followed by the respondent Andhra Pradesh farmers**

The results presented in Table 16 revealed that the Andhra Pradesh fish farmers drained the pond water either partially or completely. Most of the farmers from Kolleru lake region reported that they did not drain (54.67%) the ponds completely as the water spread area was too big to drain and/or fill. However, the ponds were drained only partially after every culture operation. On the other hand, 45% of the farmers drained the ponds completely after every culture. These fish farms situated near the coastal districts (Krishna and Nellore districts) were comparatively smaller and drew water from canals and bore-wells. The completely drained ponds were allowed to dry for a period of about  $\leq 10$  days to >30 days. Among those farms, 41% dried the ponds for >30 days followed by 38% for 10-20 days, 15% for 21-30 days and 6% for about  $\leq 10$  days.

Among the 34 farmers who drained their ponds, 18 respondents removed sludge to a depth of <5 cm (24%) and 13 to a depth of 5-10 cm (17%). However, majority of the farmers (59%) did not remove the bottom sludge due to partial draining of water. Those farmers opined that unlike shrimp culture sludge removal is not important in freshwater

Almost all the farmers of Andhra Pradesh transported fish seeds through motor vehicles (99%). Fish seed mortality was negligible during transportation as cent percent of the farmers used *oxygen packing* irrespective of distance. However, considerable numbers of farmers encountered 5 - >10% fish seed mortality during transportation despite *oxygen packing*. This may be because of selection of poor quality of fish seeds or transportation induced stress, as they were not treated with chemicals to reduce physiological activities.

#### **5.1.12 The main stocking management practices followed by the respondent Andhra Pradesh farmers**

As shown in Table 19, the fish farmers of Andhra Pradesh preferred single stocking of fish seeds (72%). Repeated stocking was also practiced by certain farmers (20%), who owned more number of nursery and grow-out ponds. The stocking densities varied from <2,000 to >10,000/acre to suit to the management practices followed, i.e., extensive, modified extensive and semi-intensive / intensive type of farming. The large-scale farmers of Kolleru lake region used stunted yearlings for stocking. The scampi were stocked at the rate of above 10, 000/acre.

Though majority of the farmers (88%) opined that the stocked fish seeds were of good quality, only few have checked or assessed the quality of fish seeds before packing. The farmers did not reveal the details of the tests performed. Majority of the farmers (77%) acclimatized the fish seeds before releasing into the ponds for about an hour and the recorded mortality during acclimatization was 1-5%. Use of disinfectants for treating fish seeds before stocking into the ponds was not a regular practice in Andhra Pradesh.

#### **5.1.13 The colour of pond water and pond bottom as reported by the respondent farmers of Andhra Pradesh**

The respondent farmers noticed different pond water colours like transparent, light green, green and brownish green. The farmers who stocked scampi along with fishes reported brownish green (12%) water colour, while those stocked scampi alone (16%) noticed transparent water. Majority of the farmers reported that they always maintained green colour to facilitate the growth of natural food (plankton) to the stocked animals through periodic application of different manures or fertilizers till harvest.

The fish farmers of Andhra Pradesh recorded different pond bottom colours such as brown, black, brownish black, black with high H<sub>2</sub>S smell. The most common condition observed by the *respondent* farmers was brownish black (48%) and black coloured (26.67%) pond bottom. It was observed that such conditions were common in those ponds where the sludge was not removed or only the top layer was removed. The farmers who desilted the ponds regularly noted brown pond bottom, thus emphasizing the importance of bottom sludge removal. Few farmers recorded black pond bottom with high organic waste (2.67%) and even H<sub>2</sub>S smell (5.33%) (Table 20), indicating anaerobic condition probably a result of non-compliance to pre-stocking management practices.

#### **5.1.14 The main post-stocking management practices adopted by the respondent Andhra Pradesh farmers**

The farmers of Andhra Pradesh used wide variety feed ingredients of both plant and animal origin. The two important feedstuffs used as a combination are rice bran and groundnut oil cake (97%). Sunflower oil cake was also preferred as a feed ingredient by the farmers of Andhra Pradesh. Like rice bran, wheat bran is another important feed ingredient available for the formulation of aqua feed (Rajesh et al., 2004).

The farmers of Andhra Pradesh developed a unique technique for feeding carps and is called “Bag feeding” method. In this, empty polythene or plastic gunny bags are usually trimmed to hold nearly 15 - 20 kg feed. At the lower portion of these bags, 2 - 3 rows of holes or perforations are made (Veerina et al., 1993). The feed mixture is placed into these bags and the bags of about 20 - 25 numbers / ha are suspended from bamboo poles erected in various locations of the pond. Through the bag feeding method, the farmers were able to avoid feed wastage and to know the quantum of feed consumed. Besides oilcake and rice bran mixture, 43% of the respondent farmers used pelleted feeds, especially those farmers who stocked scampi and shrimp (Table 22).

The farmers used different types of organic and inorganic fertilizers. Majority of the farmers preferred fertilizers or manures to facilitate the growth of natural food organisms. Application of organic fertilizers (91%) like cow dung, poultry manure, etc was the most common in nursery ponds (Table 21). The farmers used different doses of cow dung or poultry manure as shown in Table 31 after one week of stocking. The inorganic fertilizers (85.33%) used by the farmers were lime, urea, single super phosphate,

diammonium phosphate etc (Table 31). The results corroborate Haribabu and Reddy (2000) who used inorganic fertilizers for the supply of nitrogen and phosphorus to augment primary *productivity*. Regular monitoring of water and fish health status was not a common practice in freshwater fish culture. About 45% of the farmers of Andhra Pradesh monitored water quality and fish health status every fortnight along with biomass estimation. Presence of weedy fishes was noticed by about 68% of the respondent farmers, and this observation indicated poor pond management practices.

#### **5.1.15 Details on fish harvest, survival rate and marketing in Andhra Pradesh**

Majority of the farmers of Andhra Pradesh harvested their ponds when the fishes attained table size (58.67%). The farmers recorded a survival rate of 60 - >80% at the time of harvest (Table 22). The harvesting frequency was normally in accordance with the growth or size of the fish, market prices to different sized fishes. As the farmers of Andhra Pradesh operate large-scale farms, the fishes are usually harvested at a time in bulk, segregated into different size groups and dispatched to different states. Most of the harvested fish from Kolleru area are dispatched to far off states such as Orissa, West Bengal, Assam, Tripura and other North Eastern states, besides Bangladesh and Gulf countries (Murthy, 1999). Every day not less than 15 - 20 loaded trucks containing approximately about 100 tonnes of major carps are dispatched to Kolkata market. Few farmers reported that they used to harvest the fish on monthly (33%) or weekly/fortnightly (4%) basis for retail marketing. Direct sale (45.33%) to the wholesalers who used to come to the farm site was the preferred means of marketing of harvested fish. Just before harvest the farmers inform the transport company over telephone the time of harvest and the *estimate of catch*. Based on this information the transporting agency sends the trucks to the pond site with ice and packing materials along with labours. As soon as the weighment is over the fishes are handed over to the transporting agency, who pack the fish along with ice in the baskets or in crates, put identification marks and load them in trucks for transportation to the destination places.

#### **5.1.16 Problems encountered by the fish farmers of Andhra Pradesh**

As seen in Table 23 and Fig. 3, Andhra Pradesh fish farmers faced different problems. The major problems faced by them were disease (90.67%), price fluctuation (74.67%), electricity (69.33%), poaching (57.33%), declining production (48%) and

management problems (45.33%). Diseases and electricity were the first and second ranked problems of the Andhra Pradesh farmers (Table 24). The increased incidence of diseases in Andhra Pradesh fish farms according to Gopal Rao et al (1992) was due to intensification in culture practices. Due to load shedding in rural areas, the farmers also faced electricity problems (69.33%). Price fluctuation (74.67%) and declining production (48 %) were also reported to be a major problem due to reduced fish growth rate. Farms situated in low-lying areas of East and West Godavari districts were prone to floods during rainy seasons. Farmers also reported bird poaching (57.33%) during larval rearing period. The problems encountered by the fish farmers of Andhra Pradesh are more or less similar to those reported in several undeveloped and developed countries (Brown and Brooks, 2002; Phan et al., 2002; Hasan and Ahmed, 2002; Jeney et al., 2002; Chinabut et al., 2002). Some farmers expressed that the quality of the fish seeds from hatchery were poor. Likewise, Singh et al. (2002) recorded lack of quality fish seed was the major problem in aquaculture development in Punjab.

#### **5.1.17 The bodies or agencies that came forward to solve the problems of Andhra Pradesh farmers**

The farmers of Andhra Pradesh mainly preferred Department of Fisheries (56%) to solve their problems followed by educational institutions (28%). The role of municipality, panchayat and non-governmental organizations was negligible. Only minor percentage of farmers preferred other government agencies (9.33%), municipality (6.67%), panchayat and non-governmental organizations (4%). The farmers also sought help from other sources (33.33%) like feed sales persons or drug sales persons or consultants who used to visit the farms regularly and from other farmers. Most of the farmers did not respond to the question when asked on the role of local bodies (54.67%). Likewise, the freshwater fish farmers of many countries sought help from Government extension officers, as they were closely associated with the farmers (Chinabut et al., 2002; MacRae et al., 2002; Hasan and Ahmed, 2002).

#### **5.1.18 Frequency of diseases / abnormalities that cause production loss in Andhra Pradesh**

As seen in Table 26 and Fig. 4, the biological agents induced the major diseases or abnormalities and these included *Argulus* infection (77.33%), hemorrhages (48%), red

spots (38.67%), discolouration (33.33%), unspecified diseases (53.33%). The most common environmental diseases that caused production loss were oxygen deficiency (76%), gulping air (36%), weeds infestation as a result of eutrophication (30.67%), etc.

The *Argulus* infection has been a major cause of production loss in Andhra Pradesh fish farms. According to Gopal Rao (1988,) ectoparasitic crustaceans (*Argulus spp*) and bacterial diseases (*Aeromonas hydrophila*) accounted for a significant proportion of the mortality. Farmers noticed Argulosis problem throughout the culture period. The incidence and symptoms were common during the periods of excessive manuring and supplementary feeding. The infections were noticed on gills, fins and scales, which caused irritation and lesions in the infected parts of fish. In earlier reports also Argulosis caused extensive damage in wild and cultured fish populations (Singh et al., 1981; Chopra et al., 1985,1989,1993). Argulosis damage fish tissues by extracting haemolymph and other tissues, resulting in lesions on fish body, which cause further secondary infection by other pathogens (Dinesan et al., 2002).

The second major problem that caused production loss was oxygen deficiency (76%). Excessive stocking, feeding and accumulation of organic wastes normally lead to decrease in dissolved oxygen level and build up of toxic waste products and ultimately stress induced diseases. Such conditions and production losses were reported earlier in Andhra Pradesh (Gnaneswar and Gopal Rao, 1990). The parasitic infection was increased especially during the periods of oxygen deficiency and they resided inside the body cavity and, therefore, adapted to an environment poor in oxygen (Singh and Das, 2001).

Besides these abnormalities, the farmers observed discolouration (33.33%), stunted growth (32%), anorexia (22.67%) and genetic disorder (12%). Hemorrhaging was commonly seen on surface/skin (48%), gills (25%), around vent region (25%), mouth (24%) and on fin base or fins (19%). Although many abnormalities were identified, *Argulus* infection ranked first followed by red spots and stunted growth (Table 27).

#### **5.1.19 Pattern and recognition of fish diseases by the respondent Andhra Pradesh farmers**

The fish farmers of Andhra observed a number of diseases or abnormalities during the culture period. Most of the farmers noticed fish diseases during cold season (75%) followed by rainy season (56%). During these periods the water temperature

### 5.1.21 Summary of health problems encountered in Andhra Pradesh fish farms

With intensification, fish health problems have become very common in Andhra Pradesh carp culture systems. In intensive culture, the fishes are affected continuously by environmental fluctuations and varied management practices, which make them susceptible to various diseases (Wedemeyer and Wood, 1974; Subasinghe, and Phillips, 2002). As in other parts of the world, the freshwater fish farmers of Andhra Pradesh are often put to trouble due to the prevalence of diseases summarized in Table 30.

Since catla and rohu are the major cultivable species, many of the health problems were encountered in such species. Sub-adult *L. rohita* was more prone to red disease, characterized by hemorrhages, during summer months, and as a result this condition is often referred locally as 'summer disease'. Likewise, juveniles and sub-adult stages of *L. rohita* were prone to winter disease, locally known as *Columnaris* disease. As this disease was common during winter and rainy seasons, the condition was referred as winter disease. *Columnaris* disease usually associated with some kind of stress conditions such as temperature and low oxygen concentrations. The mortality rate in this case was meager. Other major health problems encountered by the Andhra Pradesh fish farmers were Argulosis, *Myxobolus* infection, gas bubble disease, *Gyrodactylus* infection, dropsy, *Lernea* infection, tail rot and stunted growth often due to poor pond management practices (Table 30). Argulosis has been reported to cause extensive damage in wild and cultured fish populations (Singh et al., 1981; Chopra et al., 1985, 1989, 1993). According to Mohan and Bhatta (2002) parasitic diseases are the most common in Andhra Pradesh fish farms.

### 5.1.22 Use of fertilizers, feeds, chemicals and aquadrugs in Andhra Pradesh

The list of feed ingredients, fertilizers and aquadrugs used by the freshwater fish farmers of Andhra Pradesh are presented in Table 31. The listed items were used in the pre-stocking, stocking and post-stocking management practices as suggested in Jhingaran (1991) for maximizing fish production. The results of the present study corroborate the observations of Gopal Rao et al. (1992) and Haribabu and Reddy (2000).

### **5.1.23 Socio-economic impact and change in farmers' attitude to aquaculture caused by diseases in Andhra Pradesh**

The results of socio economic impact and change in farmers' attitude to aquaculture due to diseases as shown in Table 32 revealed change in culturable species in next culture operation, resistance to continue aquaculture, suspension of aquaculture activities and shifting to agriculture and extended culture operation. The outbreak of diseases also caused loss in income through aquaculture and increased the debt. In Thailand, disease led the farmers to change the species (Chinabut et al., 2002). There was also a report of no significant increase in household debt (about 4.5%) due to red spot disease in Vietnam (Phan et al., 2002). Hasan and Ahmed (2002) reported no change of attitude among the Bangladesh farmers due to disease outbreak.

### **5.1.24 Views of farmers on when in the growing cycle the disease occurs? and when disease was last seen?**

Most of the disease outbreak was noticed at the later phase of the growing cycle mostly between the 6<sup>th</sup> and 9<sup>th</sup> months of culture period (57.33%), which happened to be the monsoon season in Andhra Pradesh. Further, the role of increasing load of organics on pond bottom with increase in culture period and their possible effect on cultured species could not be ruled out. MacRae et al. (2002) found that black gill disease of *Macrobrachium rosenbergii* was towards the end of the culture period when the concentration of ammonia and nitrite was maximum and when the water quality was deteriorated. However, Jeney et al. (2002) did not find any distinct pattern of disease outbreak in any growing cycle in Tien Giang province, Vietnam.

### **5.1.25 Effect of diseases on fish consumption**

As seen in Table 34, the disease outbreak in freshwater fish culture markedly affected the fish consumption habit in Andhra Pradesh. Only 12% of the farmers ate fish most often after disease outbreak as against a high percentage of (36%) often, and most often after disease outbreak. About 41% of the farmers never consumed a diseased fish and only about 40% of the farmers sometimes consumed diseased fish. The farmers did not consume diseased fish because of unknown fear (42.67%), hatred (26.67%) and mostly because of transmission of diseases (61.33%). Brown and Brooks (2002) reported that about 17% of the Bangladesh farmers consumed diseased fishes; whereas 8%

consumed as well as sold the diseased fishes. The farmers of Tien Giang province of Vietnam (71%) were reportedly ate fish from pond with sick fish. Bhowmick et al. (1991) reported reduction in fish consumption rate by 28.7%; 23.3% and 20.3% in urban, sub urban and rural sectors respectively during EUS outbreak in West Bengal.

#### **5.1.26 Expected and Actual fish production in the surveyed fish farms of Andhra Pradesh**

The results presented in Figs. 6 and 7 revealed a wide gap between production expected and production actually achieved by the farmers of Andhra Pradesh. About 13.33% and 6.67% of the farmers achieved a production of 5-6 tons/acre and >6 tons/acre though 21% each of the farmers expected this production on the basis of the management practices they adopted. This gap on production was mainly attributable to several management problems along with diseases as revealed in Tables 37 and 38. Calculating individual loss or gain in production based on difference in expected and actual production, it was found that about 49.363 tonnes production loss was observed in 1911.92 acre water spread area of 56 respondents. At this rate of production loss, there is a chance of loosing about 17, 621 tonnes or Rs. 52.86 crores annually (@ Rs30/ kg fish) considering total freshwater culturable area (Fish culture in tanks – 6, 82,500 acres). Therefore, if the management and disease problems are rectified, Andhra Pradesh freshwater fish farming sector can gain about Rs 52.86 crores annually.

A survey in Andhra Pradesh by Gopal Rao et al. (1992) in the early 1990s, which combined the effects of disease-induced growth loss with mortality, estimated the annual loss due to disease to the tune of 40 million Indian rupees (US\$ 860,000). In contrast, Mohan and Batta (2002) reported ectoparasitic diseases are the main problem in freshwater fish farms of Andhra Pradesh, which caused an annual loss of US\$ 1 million due to disease-induced mortality and impaired growth. MacRae et al. (2002) reported that prawn farmers of Bangladesh achieved an average of 119 kg/ha although they expected an average production of 831 kg/ha. They also expected an average production of carps of 676 kg/ha, but only 93 kg/ha was actually produced. The observations of Nandeasha et al. (2002) revealed that about 29.3%-39.4% farmers of Bangladesh were not happy with the production so also the results of the present study.

## **5.2 Epidemiology: Relationship between management practices and infectious diseases of freshwater fishes**

A total of 32 variables related to the management practices were associated with the occurrence of infectious diseases of freshwater fish. The results presented in Tables 36 - 38 are discussed below:

### **5.2.1 Pond Connection / Establishment details**

#### **5.2.1.1 Type of habitat**

Among the different habitats, the farms situated near rice field area had comparatively low infectious disease incidence rate (27%; Table 36). The relative risk was 0.62, which indicated that this factor served as a sparing factor for infectious diseases in Andhra Pradesh (Table 37). However, the chi-square value revealed a significant association between this type of habitat and infectious disease outbreak (Table 38;  $\chi^2=5.03$ ;  $C=0.25$ ;  $P<0.03$ ). The extent of association was low. Khan and Lilly, (2002) observed a RR value of 2.36 when the farms are situated near rice fields in Bangladesh in which EUS outbreak was observed. They attributed the hike in RR value to the use of pesticides in agricultural fields and their entry in to the fish ponds through run off.

#### **5.2.1.2 Water Source**

Among the different sources of water intake to the aquacultural activities, canals and ground water showed 39% infectious disease incidence rate as against 19% for rain and lake water. The relative risk was 0.663 and this variable was served as a sparing factor for infectious diseases (Table 37). There was no significant association between source water and infectious diseases ( $\chi^2=0.58$ ;  $P>0.05$ ; Table 38). The results presented in Table 36 further revealed that about 25% of infectious diseases were prevented in farms which used canal and ground water.

#### **5.2.1.3 Types of farming**

As majority of the freshwater fish farms of Andhra Pradesh are of intensive and semi-intensive type, a high rate of infectious disease incidence (43%) was noticed as against 15% in extensive type of farming (Table 36). The relative risk was 1.32, (Table 37) indicating that there was about 1.32 times more chance of infectious disease outbreak in such farms. The odds of developing infectious diseases were 2.26 times greater for those farms, which adopted intensive/semi-intensive culture practices. No significant

association existed between semi-intensive/intensive systems with infectious diseases. ( $\chi^2 = 1.96$ ;  $P > 0.05$ ; Table 38). The results presented in Table 36 revealed that 41.86% of infectious diseases could have been prevented if the farmers avoided the semi-intensive / intensive type of farming. The disease in productivity of aquaculture sites was imputed to over intensification, leading to deterioration of the surrounding environment (Kungvankij *et al.*, 1986; Folke and Koutsky, 1992) if ponds are not properly managed. Further, simply increasing stocking density without proper supplementary feeding measures may create nutritionally poor condition or excess feeding may create nutrient rich condition, both of which cause fish to become more susceptible to disease. Leung *et al.* (2000) associated excess feeding with increased disease occurrence in shrimps.

#### 5.2.1.4 Age of the farm

The infectious disease incidence was 43% in farms of >5 years of age as against 15% in farms of <5 years age (Table 36). The relative risk was 0.821 which indicated that no association between this factor and infectious diseases. The odds of developing infectious diseases were only 0.30 times greater for the farm whose age was above 5 years. Statistically, the age of the farms was insignificantly associated with the outbreak of infectious diseases ( $\chi^2 = 2.19$ ;  $P > 0.05$ ; Table 38). The results corroborate the observations of Nagesh (2005) who found no significant association between disease incidence and age of the shrimp farms of West Bengal. The results presented in Table 36, revealed that about 37% of infectious diseases were prevented in farms with less than 5 years of age.

#### 5.2.1.5 Number of grow-out ponds

The more the number of grow out ponds, the higher the incidence of infectious diseases. The incidence of infectious diseases was 36% in farms having >3 ponds (Table 36). The RR was 1.34 indicating that the chance of getting infectious diseases was 1.34 times more in such farms. The odds of developing infectious diseases were slightly higher than the RR value (OR=1.913; Table 37). There was no significant association between this factor and the infectious diseases ( $\chi^2 = 1.29$ ;  $P > 0.05$ ; Table 38). The results presented in Table 36 revealed that 41.67% of infectious diseases could have been prevented if the numbers of ponds was less than 3. The results of the present study

corroborate the observations of Nagesh (2005) who observed increased incidence of shrimp diseases with increase in number of grow-out ponds.

#### **5.2.1.6 Type of farms**

The incidence rate of infectious diseases was 56% in perennial type of farms compared to 1% in seasonal farms (Table 36). The RR was found to be 1.07 (Table 37) that indicated no association between this factor and infectious diseases. The odds of developing infectious diseases were, however, 4.34 times greater in perennial farms (Table 37). The results presented in Table 36 revealed that 12% of infectious diseases could have been prevented if fish culture was not done in perennial farms.

#### **5.2.1.7 Total farm area**

The incidence rate of infectious diseases was 44% in farms of >10 acre area as against 13% in farms of <10 acre area (Table 36). The RR value was 1.11 and the odd ratio was 1.50 (Table 37). The results indicated that this factor to some extents served as a putative casual factor of infectious diseases. However, the association between this factor and infectious diseases was insignificant ( $\chi^2=0.26$ ;  $P>0.05$ ; Table 38). The results presented in Table 36 revealed that about 18% of infectious diseases could have been prevented if the total farm area was <10 acre.

#### **5.2.1.8 Presence / absence of nursery ponds**

The incidence rate of infectious diseases in farms that had nursery ponds was observed to be 52% (Table 36). The relative risk was 1.00 (Table 37) and this indicated no association between this factor and infectious diseases ( $\chi^2=0.06$ ;  $P>0.05$ ; Table 38). Contrarily, Sil (2006) recorded high incidence of infectious diseases in farms that had nurseries in West Bengal. According to him, poor management practices led to increased incidence of infectious diseases in grow-out ponds.

#### **5.2.1.9 Training in Aquaculture**

The farms of the farmers of Andhra Pradesh who had undergone training in aquaculture, recorded low incidence of infectious diseases. The incidence rate of infectious diseases was only 19% as against 39% in the farms of untrained farmers (Table 36). The relative risk was 1.48 (Table 37), which indicated 1.48 times more chance of infectious diseases in untrained farmers ponds. This factor was identified as one of the putative factors for infectious diseases and the odds ratio was 2.08 (Table 37). There was

no significant association between this factor and infectious diseases ( $\chi^2=0.57$ ;  $P>0.05$ , Table 38). The results presented in Table 36 further revealed that about 53% of infectious diseases could have been prevented if the farmers were trained in aquaculture.

## **5.2.2 Pre-stoking management**

### **5.2.2.1 Draining of pond water**

Majority of Andhra Pradesh fish farmers drained the pond only partially due to the larger farm area and operational difficulties. The incidence rate of infectious diseases in such farms was 39%; while in completely drained ponds, it was only 19% (Table 36). The RR was observed to be 1.79 (Table 37) indicating that this factor served as a putative factor for infectious diseases. The odds of developing infectious diseases were 3.45 times greater in farms which drained only partially (Table 37). A statistically significant association between this factor and infectious diseases was observed ( $\chi^2=5.48$ ;  $C=0.2$ ;  $P<0.02$ ; Table 38). The results presented in Table 36 further revealed that 74% of infectious diseases could have been prevented if the farmers drained the ponds completely. Similarly Nagesh (2005) found a significant reduction in shrimp diseases by draining of pond water in West Bengal.

### **5.2.2.2 Pond drying period**

Drying the pond bottom for more than 20 days was found to be quite helpful in eliminating the chance of infectious diseases. The incidence rate of infectious diseases was observed to be 32% in the ponds which were dried for  $>20$  days as against 26% in other ponds wherein the drying period was  $<20$  days (Table 36). The RR of 0.96 (Table 37) indicated that there was no association between this factor and infectious diseases ( $\chi^2=0.93$ ;  $P>0.05$ ; Table 38). The odds of developing infectious diseases were 0.91 times greater in such farms (Table 37). The results presented in Table 36 revealed that about 6% of infectious diseases were prevented in farms, which were dried for more than 20 days. The study by Khan and Lilly (2002) also showed that pond drying gave a significantly lower relative risk ( $RR=0.14$ ) in Bangladesh freshwater fish farms.

Drying the pond bottom facilitates exposing the surface sediments, oxidizing reduced compounds, decomposition and mineralization of organic matter, disinfection of pond bottom and elimination of toxic gases entrapped in bottom sediment. Akiyama (1992) and Boyd (1995) suggested pond preparation period of 15-45 days. The pond

preparation duration should be sufficient enough to facilitate solar oxidation by allowing the pond bottom to dry and crack to a depth of 2-5 cm. Villalon (1991) and Kengkeo (1995) suggested a minimum period of 30 days for the pond preparation. This perhaps provides an explanation for the higher incidence of infectious diseases in farms that took less than 20 days for drying. *Aphanomyces invadens* which is known to have a strong negative geotaxis (Ahmed and Rab's, 1995) and it can feasibly survive in the warmer months of summer in the thick bottom mud of older and derelict ponds having generally a temperature below 31°C (Willoughby, 1999). Drying of pond bottom for more than 20 days is, therefore, recommended to avoid the risk of spread of infectious diseases more particularly Epizootic ulcerative syndrome (EUS).

### 5.2.2.3 Removal of pond bottom sludge

The incident rate of infectious diseases was observed to be 17% in sludge removed farms as against 40% where there was no sludge removal (Table 36). The relative risk value of 0.53 (Table 37) indicated that the practice of removing sludge served as a sparing factor for infectious diseases. There existed a statistically significant association between this factor and infectious diseases ( $\chi^2=4.10$ ;  $C=0.22$ ;  $P<0.05$ ; Table 38). The results presented in Table 36 revealed that about 153% of infectious diseases were prevented in farm where sludge removal was a regular practice.

Sedimentation of pond bottom occurs as a result of heavy organic matter inputs (feeds, fertilizers, dead plankton) and suspended materials introduced through surface run off during raining season, which favours the growth of microorganisms. Removal of bottom sludge is necessary to remove the foul layer of pond bottom. It can be done either manually or mechanically. If the sludge is removed properly then management of the pond become easier during high pH periods (MPEDA/NACA, 2003). Nagesh (2005) also found a significant reduction of shrimp diseases in farms of Midnapur district of West Bengal, which were desilted. Kongkea (1995) also found the similar results. Leung et al. (2000) found no significant association between desilting and disease occurrence in shrimp. The results of the present study corroborate Khan and Lilly (2002), who recorded a very low RR (0.17) in Bangladesh fish farms, which removed the bottom sludge.

#### 5.2.2.4 Sludge disposal place

The incidence of infectious diseases was 16% in farms where the pond bottom sludge was used for the repair of dykes or strengthening as against 41% in farms where sludge was placed outside the pond (Table 36). The relative risk (RR=0.47) value indicated that this factor was a sparing factor for infectious diseases. The odds of developing infectious diseases were found to be 0.26 times more for those farms where the sludge was disposed on the dykes of the same pond. The association between the infectious disease outbreak and disposal of the sludge on the same pond dyke was statistically significant ( $\chi^2=6.39$ ;  $P<0.01$ ) and the degree of association was moderate with the coefficient of contingency ('C') value 0.27 (Table 38). The results as shown in the Table 36 revealed that about 194% of the infectious diseases were prevented because of the disposal of sludge outside the pond periphery. Although the farmers disposed the sludge on the same pond dykes to strengthen and resist floods during rainy seasons, the soil was washed off and ultimately drained into the same pond, thus, neutralizing the effect of removal of pond bottom sludge.

#### 5.2.2.5 Liming of pond bottom

The incidence of infectious diseases was 56% in farms where liming of pond bottom was carried out during the pond preparation (Table 36). The RR was 1.00 (Table 37), thus revealed that no association existed between this factor and infectious diseases. The odds of developing infectious diseases were noticed to be 1.35 times more for those farms, which limed pond bed. Chi-square analysis also revealed no association between liming of pond bottom and the infectious disease outbreak ( $\chi^2=0.26$ ;  $P>0.05$ ; Table 38).

#### 5.2.2.6 Chemical treatment of water

Different types of chemicals were used in freshwater fish farms of Andhra Pradesh for the treatment of water. The chemicals like formalin, alum, zeolite, water sanitizers, iodine, salt, potassium permanganate etc. were used. This somewhat resulted in low incidence rate (0.56%) of infectious diseases (Table 36). The relative risk was 1.14 and this indicated that a slight association between this factor and infectious diseases (Table 37). The odds of developed infectious diseases were found to be 62.89 times high for those farms where no chemical treatment was done. No significant association between chemical treatment of water and infectious diseases was observed ( $\chi^2=3.47$ ;

$P > 0.05$ ; Table 38). The results of Table 36 revealed that about 21% of infectious diseases outbreak could have prevented if the farmers attempted water treatment.

#### **5.2.2.7 Pond ploughing**

The variable pond ploughing showed a RR value 1.04, which indicated no association between this factor and infectious diseases, so also the pond bottom colour (RR=0.65; Table 37). There existed no significant association between this factor and infectious diseases ( $\chi^2 = 1.28$ ;  $P > 0.05$ ; Table 38). The results of Table 36 revealed that about 92% of infectious diseases could have been prevented if the farmers maintained brown pond bottom.

### **5.2.3 Stocking management**

#### **5.2.3.1 Type of fish seeds**

The farmers of Andhra Pradesh used different types of fish seeds like hatchlings (13%), fry (16%), fingerlings (55%) and combination of above (16%) (Table 18). The incidence of infectious diseases in ponds that stocked fingerlings was 37% (Table 36). The relative risk was 1.60 and the odds of developing infectious diseases were 2.72 times more in such ponds (Table 37). The results suggested that this factor served as a putative factor of infectious diseases, may be because of poor quality fish seeds or high stocking densities. The results contradict with Sil (2006), who reported low diseases incidence rate in fingerlings stocked ponds of West Bengal. The results of Table 36 revealed that about 64.86% of infectious diseases could have been prevented if the farmers stocked good quality fingerlings at right stocking density. The association between this factor and incidence of infectious diseases was, however, statistically insignificant ( $\chi^2 = 3.50$ ;  $P < 0.1$ ; Table 38).

#### **5.2.3.2 Distance of fish seed transportation**

As seen in Tables 36 and 37, the variable on distance of fish seed transportation was identified as a putative factor of infectious diseases, although only slightly (RR=1.31). However, there existed no significant association between this factor and infectious disease outbreak ( $\chi^2 = 0.75$ ;  $P > 0.05$ ; Table 38). The results presented in Table 36 revealed that about 39% of infectious diseases could have been prevented if the distance transported was less than 50 km.

### **5.2.3.3 Mortality during fish seed transportation**

Mortality of fish seeds during transportation was observed to have a moderate impact on infectious disease outbreak in freshwater fish farming systems of Andhra Pradesh. Farmers who reported less than 1% fish seed mortality experienced low infectious disease incidence (21%) as against 36% who recorded >1% fish seed mortality (Table 36). The relative risk was 1.32 and this indicated that the factor was a casual putative factor of infectious diseases although moderately. The odds of developing infectious diseases were 1.51 times more in farms that used seeds which experienced >1% mortality during transportation (Table 37). However, there was no significant association between this factor and infectious disease outbreak ( $\chi^2=0.33$ ;  $P>0.05$ ; Table 38). The results presented in Table 36 revealed that about 43% of infectious diseases were prevented in the farms through the use of seeds that experienced low mortality during transportation.

### **5.2.3.4 Treatment before stocking**

Treatment of fish seeds before stocking showed a positive effect on infectious disease outbreak. The infectious disease incidence was 12% in farms that treated the fish seeds before stocking; while it was 45.33% in other farms (Table 36). The relative risk was 2.23, indicating that 2.23 times more chance of infectious disease outbreak in farms that did not treat the fish seeds before stocking (Table 37). However, the association between this factor and infectious disease outbreak was statistically insignificant ( $\chi^2=1.06$ ;  $P>0.05$ ; Table 38). The results presented in Table 36 revealed that about 92% of infectious diseases could have been prevented if the farmers treated the fish seeds before stocking in ponds.

### **5.2.3.5 Acclimatization of fish seeds**

The infectious disease incidence was 48% in farms that acclimatized the fish seeds before stocking (Table 36). The relative risk of this variable was observed to be 1.21 (Table 37) which indicated that this factor served as a putative casual factor of infectious diseases although slightly. There was no significant association between infectious disease outbreak and acclimatization of fish seeds ( $\chi^2=1.56$ ;  $P>0.05$ ; Table 38). The result presented in Table 36 revealed that about 31% of infectious disease could have been prevented if the farmers had gone for acclimatization practice in freshwater carp

culture systems. However, Nagesh (2005) recorded a significant association ( $P < 0.05$ ) between the disease incidence and acclimatization of shrimp larvae in West Bengal condition.

#### 5.2.3.6 Stoking densities

In Andhra Pradesh freshwater fish culture system, the fish farmers maintained a particular range of stocking densities for fry and fingerlings. The incidence of infectious diseases was 44% in farms where stocking density was more than 5,000 numbers/acre as against of 13.33% (Table 36) with lesser stocking densities. The relative risk was 1.22, which indicated that this factor was a moderate putative casual factor of infectious diseases. (Table 37). There existed no significant association between infectious disease outbreak and higher stocking densities ( $\chi^2 = 1.17$ ;  $P > 0.05$ ; Table 38). The results presented in Table 36 revealed that about 32% of infectious disease could have been prevented if the farmers avoided stocking the seeds at higher densities. The study by Paria and Konar (1999) also showed no significant correlation between stocking density and fish disease.

#### 5.2.3.7 Species cultured

Stocking of bottom dwelling fishes like mrigal, *Cirrhinus mrigala*, common carp *Cyprinus carpio*, catfishes like *Pangassius spp.*, *Clarias spp* were evaluated for their association with infectious disease outbreak. The incidence of infectious diseases was 24% in farms that stocked with bottom dwelling fishes as against 33.33% (Table 36) that stocked other fishes including miscellaneous varieties. The relative risk was 1.34 which indicated that this factor served as a putative casual factor of infectious diseases although slightly. The odds of developing infectious diseases were 1.58 times more (Table 37). There existed no significant association between infectious disease outbreak and bottom dwelling fishes ( $\chi^2 = 0.48$ ;  $P > 0.05$ ; Table 38). The results presented in Table 36 revealed that about 42% of infectious disease outbreak could have been prevented if the farmers avoided stocking of bottom dwelling fishes (Table 36). Das (2002) showed bottom dwelling fishes are more prone to EUS outbreak. However, studies by Mohan and Shankar. (1994) showed that IMC are either less susceptible or refractory to EUS infection and among three IMCs, mrigal is more susceptible to EUS than catla and rohu. Histopathological studies of natural outbreak of EUS clearly showed that IMC are able to mount a better inflammatory response and resist the fungal invasion better than the more

susceptible *Channa* and *Puntius* (Mohan and Shankar, 1994). Grass carp was reported to be the most affected species by red spot disease in North Vietnam, although mrigal and rohu were also affected in some farms (Phan et al., 2002). Chinabut et al. (2002) reported that common carp is EUS resistant.

#### **5.2.4 Post-stocking management**

##### **5.2.4.1 Use of fertilizers**

Use of fertilizers did not have any significant impact on infectious diseases. The incidence of infectious diseases was observed as 55% in farms, which used fertilizers (Table 36). Relative risk was 1.13 and the odds of developing infectious disease were 3.79 times for those farms, which used fertilizers (Table 37). Statistically, no significant association ( $\chi^2=1.49$ ;  $P>0.05$ ; Table 38) was noticed. The results of Table 36 revealed that about 20.75% of infectious diseases could have been prevented if the use of fertilizers was avoided. Likewise, Khan and Lilly (2002) also found that fertilization after stocking did not significantly affect EUS (RR=0.93) outbreak in freshwater pond culture of Bangladesh.

##### **5.2.4.2 Regular monitoring of water quality and fish health**

The infectious disease incidence for regular monitoring of water quality and fish health status were observed to be 21% and 24%, respectively (Table 36). The respective relative risks were 0.70 and 0.83 (Table 37), which indicated that these practices served as sparing factors for infectious disease outbreak. No significant association was observed for regular monitoring of water ( $\chi^2=1.29$ ;  $P>0.05$ ) and fish health status ( $\chi^2=0.53$ ;  $P>0.05$ ; Table 38). Nagesh (2005), however, observed a significant association between water quality management and diseases outbreak in shrimp farms of Midnapur district of West Bengal. The results presented in Table 36 revealed that these practices helped to prevent 33.71% of infectious diseases in Andhra Pradesh fish farming practices.

##### **5.2.4.3 Presence of weed fish**

Presence of weed fish was observed to have an impact on infectious disease outbreak. The infectious disease incidence was 41% in farms recorded the presence of weed fishes (Table 36). The relative risk was 1.15, which indicated that there was a slight chance of infectious diseases outbreak. The odds of developing infectious diseases were 1.55 times more for ponds with weed fishes (Table 37). No significant association was

noticed between infectious disease outbreak and wild fish presence ( $\chi^2=0.39$ ;  $P>0.05$ ; Table 38). Wild fishes are described as risk factor (Wabata, 1985) because they are route of entry of pathogens.

#### 5.2.4.4. Pond bottom colour

The colour of the pond bottom had some impact on infectious disease outbreak. The incidence of infectious diseases in farms, which had black colour pond bottom, was 49% as against 8% in brown coloured pond bottom (Table 36). The relative risk was 0.63 (Table 37) and there existed no association between the factor and infectious diseases ( $\chi^2=0.34$ ;  $P>0.05$ ; Table 38). The results presented in Table 36 revealed that about 14% of infectious diseases were prevented in farms that avoided black pond bottom.

## 5.2 Systematic pathology

### 5.3.1 Disease diagnosis

In the normal muscle structure of *Labeo rohita* (Plate13) no clear muscle fibers (actin and myosin) striations was seen (H&E 400X). The Plate 14 showed the deviation from the normal structure of the muscle fibers. There were granular degenerations affecting the distribution of entire striations of muscle fibers. The appearance of the fibers varied with the progress of the disease. Haemocytic infiltration into the damaged portion of the fibre was the noticeable change (H&E 400X). The Plate 15 revealed irregular arrangement of gill lamellae and haemocytic infiltration with lamellar hypertrophied condition at the tip of the lamellae. Hypotrophy of the gill lamellae was the characteristic feature (H&E 200X). The wet mount preparation of gills of *Catla catla* revealed *Dactylogyrus* infection. It was attached to the adjacent secondary lamellae principally on the middle of the primary lamellae located in the ventral region of the arch. The epic of the gill lamellae was deformed undergoing hyperplasia of the epithelium and mucus cells (Plate 16, 40X).

### 5.3.2 Bacterial flora associated with diseased fish

The results presented in Table 39 revealed that *Pseudomonas spp.* and *Aeromonas spp.* were the frequently encountered species and were isolated from each of the five diseased samples. Abraham et al. (2004) and Sil (2006) also isolated *Aeromonas spp.* and *Pseudomonas spp.* from diseased fishes of *Carassius auratus*, *Xiphophorus helleri*, *Clarias spp.* and Indian major carps from West Bengal. *Pseudomonas spp.* were isolated

from gill necrosis of *Catla catla*, discoloured gills of *Labeo rohita* and hemorrhages near vent and opercular region of rohu. Enterobacteriaceae and *Aeromonas spp* were isolated from discoloured gills of *Labeo rohita* and *Catla catla*. *Acinetobacter* were also isolated from discoloured gills of *Labeo rohita* with pale to slight red-gilled condition (Table 39).

### **5.3.3 Antibiotic resistance (%) in bacterial flora of diseased fishes from Andhra Pradesh**

The results presented in Table 40 revealed that 72% of isolates developed resistant towards trimethoprim. All the isolates were sensitive to chloramphenicol and gentamycin. Resistance to ciproflaxacin and oxytetracycline was seen among 22% and 27.78% of the bacterial isolates, respectively. Abraham et al. (2004) and Sil (2006) recorded that both *Aeromonas* and *Pseudomonas spp* from freshwater fish culture systems of West Bengal were highly sensitive to broad-spectrum antibiotics. In the present study about 22% of the bacterial isolates were highly susceptible to all tested antibiotics and MAR was seen in 67% of the bacterial isolates screened (Table 41). This high incidence of MAR probably revealed the regular use of antibiotics in freshwater aquaculture in Andhra Pradesh. On the other hand, MAR was recorded in only 18% bacterial isolates in freshwater aquaculture systems of West Bengal (Sil, 2006).

In general, the present study identified several management issues along with diseases for the production loss to the tune of Rs. 52 crores annually in freshwater carp culture and, therefore, calls for effective health management strategies and participation of all agencies involved in freshwater aquaculture development to reduce economic loss.

# *Recommendations*

## 6. RECOMMENDATIONS

Based on the management practices followed by the Andhra Pradesh fish farmers and their association with infectious disease outbreak, the following interventions can be drawn.

1. The farmers adopting intensive / semi-intensive culture practices should intensify the management practices suitable for the type of farming. The farmers should also apply the feeds as per biomass judiciously.
2. Farmers should not enlarge their farms without proper technical support. Total farm area should be ideally below 10 acres and number of ponds should not exceed 3.
3. Farmers' training on aquaculture and fish health management is highly essential. Training imparted by fisheries department should emphasize the scientific fish culture practice specific to the type of farming and region. Involvement of non-governmental organizations (NGO's) and educational institutions in imparting training is also needed.
4. Farmers should drain the ponds ideally once a year after the fish harvest. Complete draining should be done instead of mere reduction of the water level.
5. After complete draining, pond bottom should be removed at least up to a depth of 5 cm after every culture period. The removed sludge should be placed outside the pond. The sludge should never be used for pond dyke construction or strengthening.
6. Periodic liming after stocking at appropriate doses should be done which will reduce the chance of infectious disease outbreak significantly.
7. Stocking with stunted yearlings should be encouraged in the place of the present practice of stocking with fry and fingerlings.
8. Care should be taken to reduce the transport stress and mortality during fish seed transportation.
9. Before stocking, fish seeds should be given a dip treatment in 1-2% common salt solution and acclimatization of fish seeds to the pond environment at least for an hour is recommended.

10. Stocking density of fingerlings should be lower than 5000 / acre.
11. Stocking of bottom dwelling fishes (*Cirrhinus mrigala*, *Cyprinus carpio*, *Pangasius spp* and *Clarias spp*) as culturable species should be excluded, as they are highly susceptible to diseases.
12. Farmers should be advised to apply correct dose of organic manures and inorganic fertilizers during the pre and post-stocking management.
13. Entry of wild fishes into intensive / semi-intensive aquaculture systems should be avoided as they compete with stocked fish for feed and space besides the route of pathogen entry in to the ponds.
14. Since infectious disease outbreak was more common in winter, proper measures should, therefore, be taken. Fish farmers are advised to monitor the pond and fish health status regularly and to consult appropriate agencies to reduce fish loss.
15. Farmers must be educated on pond management and disease preventive measures and they must also be trained to assess the fish health by simple visual checks.
16. The communication between the farmers, scientists, NGO's, extension officers and State authorities should be improved for effective adoption of scientific advancements in freshwater fish culture.

# *Summary*

## 7. SUMMARY

Aquaculture in Andhra Pradesh started as an extensive activity and developed into an organized sector. There has been phenomenal growth in this sector. Due to intensification in culture the freshwater fish farming sector is experiencing several problems leading to production loss. Infectious disease outbreak in Andhra Pradesh fish farms is one of the major problems particularly in winter season. The present study was, therefore, carried out to understand the health management issues and assess systematically the impacts of diseases in freshwater aquaculture and to develop appropriate interventions for preventive management practices. Systematic study of diseases was also carried out.

The survey yielded a general socio-economic profile of the Andhra Pradesh freshwater fish farmers. Among different fish diseases and abnormalities in freshwater fish farming systems of Andhra Pradesh Argulosis (77.33%), oxygen deficiency (76%), hemorrhages (48%), red spots/scales (38.67%), gulping air (36%), stunted growth (32%), anorexia (22.67%), *Lernea* infection (21.33%) were the most common. The farmer's rated *Argulus* and red spots as the first and second ranked diseases. Price fluctuation (74.67%) and electricity (69.33%) were also marked as major problems by the respondent farmers. Poaching (57.33%), decline in production (48%), management problems (45.33%), flooding (38.67%) and poor seed quality (30.67%) were among the problems encountered by the fish farmers of Andhra Pradesh.

Different management practices followed by the farmers were evaluated for their association with infectious disease outbreak. Hemorrhages, red spots/scales, ulcers, tail rot /fin rot, eroded jaws and mouth, dropsy, bacterial septicemia were considered as infectious diseases to establish the association.

Among the pond connection / establishment details, variables such as  $\geq 3$  number of grow-out ponds (RR=1.34), and the farmers training in aquaculture (RR=1.48) and adoption of intensive and semi-intensive farming (RR=1.32) were observed to be putative casual factors of infectious diseases. Other variables like rice field habitat (RR=0.62), water source from canal and ground water (RR=0.86), age of the farm (RR=1.07) were observed as sparing factors for infectious diseases.

Among the pre-stocking management variables, partial draining of pond water was observed as a putative casual factor of infectious diseases. Variables such as pond drying for >20 days (RR=0.96), removal of pond bottom sludge (RR=0.53), brown colour of soil while ploughing (RR=0.65) were observed as sparing factors. Other variables showed no association with infectious diseases.

The stocking management variables such as type of fish seeds (RR=1.60), distance of fish seed transportation (RR=1.31), treatment before stocking (RR=2.23), acclimatization of fish seeds (RR=1.21), stocking density (RR=1.27) and stocking with bottom dwelling fishes (RR=1.34) were found to be moderate putative casual factors of infectious diseases. Other variables showed no association with infectious diseases.

None of the post-stocking management practices was found to have significant impact on infectious disease outbreak.

*Pseudomonas spp* was the major bacterial flora of diseased fishes and 72% of the isolates were resistant to trimethoprim. All the isolates were sensitive to chloramphenicol and gentamycin. The multiple antibiotic resistance was seen in 66.67% of the bacterial isolates.

Based on the management practices followed by the Andhra Pradesh fish farmers and their association with infectious diseases several interventions for preventive management practices were drawn for adoption by the farmers.

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# *Annexures*

## ANNEXURE - I

### QUESTIONNAIRE: AQUATIC ANIMAL HEALTH MANAGEMENT ISSUES IN FRESHWATER AQUACULTURE DEVELOPMENT

1. Date \_\_\_\_\_

2. Farm's Name \_\_\_\_\_

3. Police Station / Block \_\_\_\_\_

4. Village \_\_\_\_\_ District: \_\_\_\_\_

5. Owner's Name: \_\_\_\_\_ Educational Qualification: \_\_\_\_\_

Family size: ----- Male ----- Female Total -----

5a. Main activity that supports the family

Activity	Yes / No	Activity	Yes / No
i. Agriculture - Paddy	_____	v. Mixed farming	_____
ii. Agriculture – Fruits & vegetables	_____	vi. Service	_____
iii. Dairying and Poultry	_____	vii. Business	_____
iv. Aquaculture	_____	viii. Other activity, specify	_____

5b. Household income Rs. ----- / year

5c. Why aquaculture?

Reason	Yes / No	Reason	Yes / No
i. Income	_____	iii. Status	_____
ii. Food	_____	iv. Others, specify	_____

5d. Time spent for aquaculture activity

Hours /day		Hours / day
i. Husband	_____	iii. Children
ii. Wife	_____	iv. Other labours

5e. Experience in aquaculture ----- years

5f. Income from aquaculture Rs ----- / annum

6. Type of aqua farming: Semi-intensive / Modified extensive / Traditional

Type	Yes / No	Type	Yes / No
i. Monoculture	_____	iv. Sewage fed	_____
ii. Polyculture	_____	v. Others, specify	_____
iii. Integrated farming	_____		_____

7. Species cultured

Type	Yes / No	Type	Yes / No
i. Catla	_____	vii. Big head carp	_____
ii. Rohu	_____	viii. Kalpasu	_____
iii. Mrigal	_____	ix. Pata	_____
iv. Common carp	_____	x. Cat fish	_____
v. Silver carp	_____	xi. Scampi (Prawn)	_____

vi. Grass carp	_____	xii. Others, specify	_____
8. Ownership Pattern			
Pattern	Yes / No	Pattern	Yes / No
i. Own land	_____	vii. Vested / CMC land	_____
ii. Own land with joint managment.	_____	viii. Leased land with joint mangmt.	_____
iii. Owner – worker participatory	_____	ix. Sublets vested / CMC land	_____
iv. Co-operative - Registered	_____	x. Incorporated company	_____
v. Co-operative – Not Registered	_____	ix. Govt. undertaking	_____
vi. Leased land	_____	x. Own and leased (vested)	_____
9. Age of the farm	----- years		
10. Type of farm / pond	Perennial / Seasonal		
11. Total farm / pond area	----- bigha		
Water spread area	----- bigha		
a. Grow-out ponds	----- bigha,		Numbers: -----
Water depth	Summer: ----- m	Monsoon: ----- m	Winter: ----- m
b. Nursery ponds	----- bigha,		Numbers: -----
12. Type of Habitat:			
Habitat	Yes / No	Habitat	Yes / No
i. Riverine	_____	iv. Beel	_____
ii. Floodplain	_____	v. Bhery	_____
iii. Rice field	_____	vi. Others, specify	_____
13a. Pre-stocking management: Pond preparation details:			
i. Complete draining of water	Yes / No		
ii. Drying	Yes / No	How long? (in days) _____	
iii. Sludge removal	Yes / No	How deep? (in _____ cm)	
iv. Sludge disposal place	Inside the pond / Outside the pond _____		
v. Ploughing	Yes / No	Number of ploughs? _____	
vi. Soil condition while ploughing	Wet / Dry	Brown /	Black _____
13b. Soil treatment:			
Name of substance	Quantity / bigha	Name of substance	Quantity / bigha
_____	_____	_____	_____

i.	_____	iii.	_____
ii.	_____	iv.	_____

## 13c. Water treatment / fertilization / disinfection:

Name of substance	Quantity / bigha	Name of substance	Quantity / bigha
i.	_____	iii.	_____
ii.	_____	iv.	_____

## 14. Water source

Water source	Yes / No	Irrigation methods	Yes / No
i. Sewage canal	_____	i. Gravity without using pump	_____
ii. Jheels and ponds	_____	ii. Pump	_____
iii. Sewage canal and ground water	_____	iii. Gravity and pump	_____
iv. Rain water	_____	iv. Others, specify	_____
v. Rain water and groundwater	_____		_____
vi. Others, specify	_____		_____

## 15. Fish feed

Type	Yes / No	Amount / bigha
i. Mustard oil cake, Mohua oil cake, etc	_____	_____
ii. Rice / wheat bran and husk	_____	_____
iii. Leather milk, and others	_____	_____
iv. Hotel waste, dust and others	_____	_____
v. Garbage	_____	_____
vi. Weeds, Duckweed	_____	_____
vii. No feed	_____	_____
viii. Others, specify	_____	_____

## 16. Type of fertilizers:

Type	Yes / No	Type	Yes / No
i. Organic	_____	vi. Green manure	_____
ii. Inorganic	_____	v. No fertilizer	_____
iii. Organic and inorganic	_____	vi. Others, specify	_____
Name of fertilizer	Amount / bigha	Name of fertilizer	Amount / bigha
i.	_____	iv.	_____
ii.	_____	v.	_____
iii.	_____	vi.	_____

## 17. Fish Seed:

Type	Yes / No	Type	Yes / No
i. Own	_____	iv. Bought from agents	_____
ii. Bought from market	_____	v. Bought directly	_____
iii. Both	_____	vi. Others	_____

Type	Name and place of hatchery / nursery	Mode of transportation
i. Spawn / Hatchlings	_____	_____
ii. Fry	_____	_____
iii. Fingerlings	_____	_____
iv. Mixed / combination	_____	_____
v. Others	_____	_____
18. Fish seed stocking details:		
i. Mortality during transportation	Yes / No;	Mortality ----- %
ii. Use of chemicals during transportation	Yes / No	
iii. Name of chemical and dose	_____	
iv. Distance transported	----- km	
v. Stocking	Single (once) / Repeated	
vi. Acclimatization of fish seeds	Yes / No	
vii. Mortality during acclimatization	Yes / No	Mortality ----- %
viii. Chemical* treatment before stocking	Yes / No	
ix. Number of seed stocked / bigha	_____	
x. Auto stocking	Yes / No, If yes, name(s) of wild species	
xi. Seed testing / Quarantine	Yes / No	
xii. Overall quality of seed	Good	Average
	Bad	
xiii. Was the fish seed size uniform?	Yes / No	
xiv. Involvement of middlemen, if any	Yes / No	
*Name of chemical	Concentration	Name of chemical
i.	_____	iv.
ii.	_____	v.
iii.	_____	vi.
19. Post stocking management and hygiene of habitat		
Liming	Yes / No	Fertilization
Amount / bigha	_____	Amount / bigha
20. Pond watercolour:		
Type	Yes / No	Type
i. Transparent	_____	iv. Brown
ii. Light green	_____	v. Black
iii. Green	_____	vi. Red
21. Pond bottom colour	_____	_____

Type	Yes / No	Type	Yes / No
i. Brown	_____	iv. Black + high organic waste	_____
ii. Black	_____	v. Black + H <sub>2</sub> S smell	_____
iii. Brownish black	_____	vi. Others, specify	_____

## 22. Type of labours and numbers

Type and numbers	Yes / No	Type and numbers	Yes / No
i. Fishermen	_____	iv. Weeding hands	_____
ii. Transport	_____	v. Others, specify	_____
iii. Guard	_____		_____

## 23. Labourers who have been benefited – M: Male; F: Female; T: Total

Type of work	Age in years									Educational qualification	Total man days
	< 20			20 – 40			> 40				
	M	F	T	M	F	T	M	F	T		
i.	_____										
ii.	_____										
iii.	_____										
iv.	_____										

## 24. Finance: Rank importance wise, if possible

Source of finance	Yes / No	Rank	Interest %
i. Bank loan/ loan from co-operatives/ Government	_____	_____	_____
ii. Private loan/credit	_____	_____	_____
iii. Dadan or advance	_____	_____	_____
iv. Personal savings	_____	_____	_____
v. Private loan/credit and Dadan or advance	_____	_____	_____
vi. Private loan/credit and Personal savings	_____	_____	_____
vii. Personal savings and Dadan or advance	_____	_____	_____
viii. Private loan/credit and Dadan or advance and Personal savings	_____	_____	_____

## 25. Source of information on aquaculture, Rank if possible

Source	Yes / No	Rank	Source	Yes / No	Rank
i. Govt Extension workers	_____	_____	v. Self taught	_____	_____
ii. Educational institution	_____	_____	vi. Friends & neighbours	_____	_____
iii. NGO's	_____	_____	vii. Others, specify	_____	_____
iv. From other farmers	_____	_____		_____	_____

## 26. Are you trained in aquaculture?

	Yes / No
i. Details of training, if any	_____

## 27. Production:

i. Survival rate	_____ %	ia. Average body weight	_____ kg
------------------	---------	-------------------------	----------

- ii. Expected production ----- kg / bigha (Growth rate)  
 iii. Actual production ----- kg / bigha  
 iv. Mode of transportation \_\_\_\_\_  
 v. Mode of marketing \_\_\_\_\_  
 vi. Harvesting frequency      Weekly                      Fortnightly                      Monthly

28. How are you linked to the market sellers / paikars?

29. Regarding seeds and other inputs whose help do you take and how?

Source	Yes / No	Rank	Source	Yes / No	Rank
i. Govt Extension workers	_____	_____	v. Self taught	_____	_____
ii. Educational institution	_____	_____	vi. Friends & neighbours	_____	_____
iii. NGO's	_____	_____	vii. Others, specify	_____	_____
iv. From other farmers	_____	_____			

30. Problems, rank if possible

Problems	Yes/No	Rank		Yes / No	Rank
i. Uncertain water	_____	_____	xii. Declining production	_____	_____
ii. Poor seed quality	_____	_____	xiii. Price (Market) fluctuation	_____	_____
iii. Electricity	_____	_____	xiv. Management problems	_____	_____
iv. Transport	_____	_____	xv. Risk of land developers	_____	_____
v. Drought	_____	_____	xvi. Inundation due to floods	_____	_____
vi. Poaching	_____	_____	xvii. Workers health problem	_____	_____
vii. Siltation	_____	_____	xviii. Bad roads	_____	_____
viii. Disease	_____	_____	xix. Labour union problem	_____	_____
ix. Financial	_____	_____	xx. No problem	_____	_____
x. Law and order	_____	_____	xxii. Lease period and policy	_____	_____
xi. Land security	_____	_____	xxi. Others, specify	_____	_____

31. Are you associated with any of the bodies that fight for aquaculture development?

Yes/No

32. What did the local bodies do regarding your occupation?

- i. Aquaculture development \_\_\_\_\_  
 ii. Labour related \_\_\_\_\_  
 iii. Union related \_\_\_\_\_  
 iv. Any other, specify \_\_\_\_\_

33. The bodies, which have come forward to solve your problems?

Name of Organization	Part it plays
i. Government	_____
ii. Dept of Fisheries	_____
iii. Corporation / Municipality	_____
iv. Panchayat	_____

- v. Educational Institutions \_\_\_\_\_  
 vi. NGOs \_\_\_\_\_  
 vii. Others, specify \_\_\_\_\_

## 34. Fish Diseases:

Local name or symptoms	When it usually occurs?	Prevention / treatment (Did you receive help?)
i. <i>Khata</i>	_____	_____
ii. <i>Gaye Poka</i>	_____	_____
iii. <i>Lege Ghosha</i>	_____	_____
iv. <i>Pakhna pocha</i>	_____	_____
v. <i>Kankote slesha</i>	_____	_____
vi. <i>Ras pandu</i>	_____	_____
vii. <i>Jok laga</i>	_____	_____
viii. Others, specify	_____	_____

## 35. Farmers' perception on aquaculture

Perception	Yes / No	Perception	Yes / No
i. Aquaculture is a risky business	_____	iv. Aquaculture has high status	_____
ii. Aquaculture is profitable	_____	v. Disease is an important issue	_____
iii. Aquaculture is only profitable for large-scale farmers	_____	vi. Disease doesn't occur in small-scale farms	_____

## 36. Pattern associated with disease / Frequency of disease

Period	Yes / No	Period	Yes / No
i. During dry season	_____	vi. Just before harvesting	_____
ii. During rainy season	_____	vii. Just after drought	_____
iii. During hot season	_____	viii. Run-off of domestic waste	_____
iv. During cold season	_____	ix. Run-off of industrial waste	_____
v. Just after stocking	_____	ix. Others, specify	_____

## 37. Disease recognition

Signs	Yes / No	Signs	Yes / No
i. Sluggish behaviour	_____	vii. Ulcers	_____
ii. Erratic movement	_____	viii. Sloughing off of scales	_____
iii. Hemorrhaging	_____	ix. Reduced growth	_____
iv. Body discolouration	_____	x. Infection / infestation	_____
v. Anorexia (Loss of appetite)	_____	xi. Others, specify	_____
vi. Mortality	_____		_____

## 38. Response to disease

Response	Yes / No	Response	Yes / No
i. Attempt treatment	_____	v. Emergency harvest	_____
ii. Change water	_____	vi. Seek help	_____
ii. Stop feeding	_____	vii. Do nothing	_____

iv. Stop fertilization	_____	viii. Others, specify	_____
39. Where did you learn treatment?			
Source	Yes / No	Source	Yes / No
i. Other farmers	_____	v. Extension workers of NGOs	_____
ii. Feed sales person	_____	vi. Fish traders	_____
iii. Drug sales person	_____	vii. Self	_____
iv. Extension workers of Govt.	_____	viii. Others, specify	_____
40. Treatment:			
i. Chemicals used		i. _____	iii. _____
		ii. _____	iv. _____
ii. Application rate	_____		
iii. Frequency of use	_____		
iv. Cost / unit	_____		
v. Perceived merits	Successful / Partly successful / Unsuccessful		
vi. Average expenses / year / bigha	_____		
41. Loss of production and additional inputs due to diseases			
i. Was regular monitoring of water quality done?	Yes / No		
ii. Was regular monitoring of fish health done?	Yes / No		
iii. Was there any loss of production?	Yes / No		
iv. Were additional inputs required?	Yes / No		
v. Cost of additional input	Rs. _____		
42. Farmers attitude to aquaculture after disease			
Attitude	Yes / No	Attitude	Yes / No
i. Resistance to continuing aquaculture	_____	v. Eat fish from a pond with sick fish	_____
ii. Stopped aquaculture	_____	vi. Stopped promoting aquaculture	_____
iii. Changed species	_____	vii. Others, specify	_____
iv. Reduced importance	_____		_____
43. When in the growing cycle disease is likely to occur?			
1	2	3	4
5	6	7	8
9	10	and	11 months
44. Size group affected			
Size group	Yes / No	Size group	Yes / No
i. Spawn / hatchlings	_____	iv. Juveniles	_____
ii. Fry	_____	v. Sub-adults	_____
iii. Fingerlings	_____	vi. Adults	_____
45. When disease was last seen?			
Period	Yes / No	Period	Yes / No
i. Don't know	_____	iv. Within last 8 months	_____
ii. Within last 2 months	_____	v. Last year	_____
iii. Within last 4 months	_____	vi. Others, specify	_____

46. Pattern of fish death due to diseases:

i. Few fish daily	Yes / No
ii. Few fish weekly	Yes / No
iii. No mortality	Yes / No

47. Socio-economic impacts of health and disease problems

Impact	Yes / No	Impact	Yes / No
i. Reduction in income	_____	iii. Prolonged culture operations	_____
ii. Increased the debt	_____	iv. Reduction in household income	_____

48. Disease problems, Rank if possible

Diseased condition	Yes / No	Rank	Diseased condition	Yes / No	Rank
Ulcers (EUS)	_____	_____	Over stocking	_____	_____
Red spots / Red scales	_____	_____	Genetic disorder	_____	_____
Tail / fin rot	_____	_____	Gulping air	_____	_____
Erosion: jaws / mouth	_____	_____	Big / Deformed head	_____	_____
Gill rot	_____	_____	Loss of mucus	_____	_____
Cotton fungus	_____	_____	Excess mucus	_____	_____
Dropsy	_____	_____	Distended /Swollen belly	_____	_____
Bacterial septicemia	_____	_____	Discolorations	_____	_____
Intestinal inflammation	_____	_____	Predation	_____	_____
<i>Argulus</i> infestation	_____	_____	Sloughing off of scales	_____	_____
<i>Lerneae</i> infestation	_____	_____	Oxygen deficiency	_____	_____
White spots on skin/ gill	_____	_____	Water too hot	_____	_____
Parasitic protozoan infestation (External)	_____	_____	Polluted water	_____	_____
Aquatic weeds	_____	_____	Predation	_____	_____
Swollen eye	_____	_____	Insufficient water	_____	_____
Whirling movement	_____	_____	Hemorrhaging	_____	_____
Anorexia	_____	_____	Stunted growth	_____	_____
Poisoning	_____	_____	Unspecified mortality	_____	_____
Unspecified disease	_____	_____		_____	_____

49. Hemorrhaging area

Area	Yes / No	Area	Yes / No
i. Eye	_____	v. Surface / skin	_____
ii. Mouth	_____	vi. Fin base / fins	_____
iii. Operculum	_____	vii. Around the vent	_____
iv. Gills	_____	viii. Internal organs	_____

50. Fish consumption behaviour

Fish consumption habit before disease outbreak	_____	Most often / Often / Sometimes
Fish consumption habit after disease outbreak	_____	Most often / Often / Sometimes
Consumption of diseased fish	_____	Most often / Often / Sometimes / Never

Reason for not consuming	Unknown fear / Fear of disease transmission / Hatred
51. Other observations in diseased farms / ponds	
Observations	Yes / No
i. Rain unusually heavy prior to disease	_____
ii. Temperature unusually low prior to disease	_____
iii. Allowing cattle to wash and drink in the pond after ploughing / grazing	_____
iv. Netting with dried / disinfected nets	_____
v. Presence of wild fish in fishponds	_____
vi. Connection to rice fields through drainage	_____
vii. Bird poaching	_____
viii. Animal poaching	_____
ix. Use of affected pond water for domestic purpose	_____
x. Fall of price in disease affected area	_____
xi. Fall of healthy fish fry in disease affected area	_____
xii. Fry source water released in pond	_____
xiii. Others, specify	_____
52. Any information other than the ones discussed which you would want to tell	

## ANNEXURE - II

**Transport medium, Half strength nutrient agar**

Ingredients	Grams / litre
Nutrient broth, dehydrated	6.50
Sodium chloride	5.0
Agar	7.00
Distilled water	1000ml
Final pH (at 25°C)	7.4 ± 0.2

Sterilized at 121°C (15 pascal) for 15 min.

**Nutrient agar (Hi Media, 1991)**

Ingredients	Grams / litre
Peptone digest of animal tissue	5.00
Sodium chloride	5.00
Beef extract	1.50
Yeast extract	1.50

Agar 15.00

Final pH (at 25°C) 7.4±0.2

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Sterilized at 121°C (15 pascal) for 15 min.

**Starch ampicillin agar (Palumbo *et al.*, 1985)**

**a) Phenol red agar base (Hi-Media, Mumbai)**

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Ingredients	Grams / litre
Beef extract	1.00
Protease peptone	10.00
Sodium chloride	5.00
Agar	15.00
Phenol red	0.025
Final pH (at 25°C)	7.4 ± 0.2

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**b) Starch soluble 10% (w/v)**

**c) Ampicillin 10 µg/ml**

Dehydrated phenol red agar base (31.0g) was weighed for 1000 ml and dissolved in 800 ml distilled water and sterilized at 121°C (15 pascal) for 15 min. Two hundred millilitre of 10% (w/v) (steam sterilized) starch solution was then mixed with the phenol red agar base. Ampicillin was added to the medium at 10 µg/ml after temperature of the medium was brought down to 45 - 50°C.

**Pseudomonas isolation agar (Hi-Media, Mumbai)**

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Ingredients	Grams / litre
Peptone	20.00
Magnesium chloride	1.40
Potassium sulphate	10.00
Irgasan	0.025
Agar	13.60
Final pH (at 25°C)	7.2 ± 0.2

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Glycerol was added at 2% (v/v) and sterilized at 121°C (15 pascal) for 15 min.

**MacConkey agar (Hi-Media, Mumbai)**

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Ingredients	Grams / litre
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Peptic digest of animal tissue	20.00
Lactose	10.00
Bile salts	5.00
Sodium chloride	5.00
Neutral red	0.07
Agar	15.00
Final pH (at 25°C)	7.5 ± 0.2

Sterilized at 121°C (15pascal ) for 15 min.

**Mueller Hinton agar (Hi-Media, Mumbai)**

Ingredients	Grams / litre
Beef, infusion from	300.0
Casein acid hydrolysate	17.5
Starch	1.5
Agar	17.0
Final pH (25°C)	7.3 ± 0.2

**ANNEXURE - III****Antibiogram: Zone size interpretative chart**

Antibacterial agents	Concentration (µg / disc)	Zone of inhibition (mm)		
		Resistant ≤	Intermediate	Sensitive ≥
Chloramphenicol, C	30	12	13-17	18
Ciprofloxacin, F	5	15	16-20	21
Gentamycin, G	10	12	13-14	15
Nitrofurantoin, N	300	14	15-16	17
Oxytetracycline, O	30	14	15-18	19
Trimethoprim, T	5	10	11-15	16

**ANNEXURE - IV**  
**Tissue processing schedule**

Steps	Time duration (hr)
30 % alcohol	1
50% alcohol (2-3 changes)	1
70% alcohol (2-3 changes)	1
80% alcohol	1
90% alcohol	1
95% alcohol	1
100% alcohol (3 changes)	2
Xylene (3 changes)	½
Melted paraffin (3 changes)	1

**ANNEXURE - V**  
**Haematoxylin**

Haematoxylin	1 g
Absolute alcohol	10 ml
Potassium alum	20 g
Distilled water	200 ml
Mercuric oxide	0.5 g
Glacial acetic acid	0.8 ml
<b>Eosine</b>	
Eosine-Y	1 g
90% alcohol	100 ml

**ANNEXURE - VI**  
**Double staining (Haematoxylin and Eosine) schedule**

Steps	Time duration (min)
Xylene I	15 min
Xylene II	15 min
100% alcohol	5 min
90% alcohol	5 min
80% alcohol	5 min
70% alcohol	5 min
50% alcohol	10 min
30% alcohol	10 min
Distilled water	5 min
Haematoxylin	15 min
Distilled water	5 min
50% alcohol	1 min
70% alcohol	1 min
80% alcohol	1 min
90% alcohol	1 min
100% alcohol	1-3 min
Eosin	2-4 min
90% alcohol	1 min
100% alcohol (3 changes)	4-5 min
Xylene I	5 min
Xylene II	5 min