

**A STUDY ON THE NON INFECTIOUS DISORDERS ASSOCIATED
WITH INDIAN MAJOR CARP AQUACULTURE IN ANDHRA
PRADESH**

BY

A.SUKEERTHI, B.F.Sc.

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DEPARTMENT OF AQUACULTURE
COLLEGE OF FISHERY SCIENCE, MUTHUKUR - 524 344
SRI VENKATESWARA VETERINARY UNIVERSITY
TIRUPATI - 517 502, Andhra Pradesh

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CERTIFICATE

This is to certify that **Mrs. A.SUKEERTHI**, I.D.No.MFM/2009-04 has satisfactorily persecuted the course of research and that the thesis entitled “**A STUDY ON THE NON INFECTIOUS DISORDERS ASSOCIATED WITH INDIAN MAJOR CARP AQUACULTURE IN ANDHRA PRADESH**” submitted is the result of her original research work and so sufficiency high in standard enabling its presentation to the evaluation. I also certify that this thesis or part thereof has not been previously submitted by her for a degree or diploma of any University.

Date:

Dr. P. HARIBABU

Place: Muthukur

(Major Advisor)

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This is to certify that the thesis entitled “**A STUDY ON THE NON INFECTIOUS DISORDERS ASSOCIATED WITH INDIAN MAJOR CARP AQUACULTURE IN ANDHRA PRADESH**” submitted in partial fulfillment of the requirements for the award of the degree of **MASTER OF FISHERY SCIENCE** in **AQUACULTURE** in the **Faculty of Fishery Science** of Sri Venkateswara Veterinary University, Tirupati is a record of the bonafide research work carried out by **Mrs. A.SUKEERTHI**, ID.No.MFM/2009-04 under our guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee.

No part of the thesis has been submitted for the award of any other degree or diploma. All assistance and help received during the course of investigations have been duly acknowledged by the author of the thesis.

(Dr. P. HARIBABU)

Chairman of the Advisory Committee

Thesis approved by the Student’s Advisory Committee

Chairman : **Dr. P. HARIBABU**

Professor & Univ. Head
Dept. of Aquatic Animal Health Management
College of Fishery Science
Muthukur – 524 344

Member : **Dr. D. RAVINDRA KUMAR REDDY**

Professor & Head
Dept. of Aquaculture
College of Fishery Science
Muthukur – 524 344

Member : **Dr. G. VIDYA SAGAR REDDY**

Principle Scientist & Head
Fisheries Research Station
Paleru.

*To my Beloved
Husband...*



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Date:

Place: Muthukur

(A.SUKEERTHI)

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ABSTRACT

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Author : **Mrs. A. Sukeerthi**

Title of the thesis : **A STUDY ON THE NON INFECTIOUS DISORDERS
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Research work has been carried out on the topic “A Study On The Non Infectious Disorders Associated With Indian Major Carp Aquaculture In Andhra Pradesh” to develop better management practices. The specific objectives are to study the relationship between Indian Major Carp farming practices and non-infectious disease status of growing fish from commercial fish culture ponds which can lead to production losses.

Kolleru region located in Krishna Godavari zone and SPSR Nellore district are the two significant freshwater fish culture areas and were selected to study the impact of Non Infectious Disorders from commercial Indian Major Carp culture ponds.

The samples (*Labeo rohita* and *Catla catla*) collected from four places in Kolleru area and four places in Nellore area covering farmer's ponds and commercial fish seed trader's ponds. The sampled fish were examined grossly for their morphological abnormalities and those fish with notable morphological deformities were photographed in the field and preserved in 15% neutral buffered formalin. Fish suspected to have skeletal abnormalities were placed in ice and taken to laboratory for radiographic records. X-rays were taken and skeletal abnormalities were evident in all those fish that were suspected. Out of total pond harvested fish biomass of nearly 44 tons, 0.086% showed the deformities. Of these, 5.6% had semi-operculum, 84.21% had spinal deformity, 2.63% had fin deformity, 2.63% had mouth hyperplasia and 7.89% had stump body. Growth of deformed fish was substantially slower than that of the normal fish under the same management conditions. The study was carried out based on the evidences that the physical deformities in fish have been associated with exposure to physical, chemical and environmental variables. But the factors for the analysis could not provide any significant difference for the deformation in fish in either of the locations viz. Kolleru region and Nellore region. The reason for deformities could not be determined, but possible causes were discussed.

INTRODUCTION

1. INTRODUCTION

Aquaculture is relatively recent development and contributor to global food security, having expanded at an average annual growth of 8.9% since 1970. During the time, aquaculture has increased from representing just 3.9 percent of global fisheries production volume up to almost 50% in 2004. It is inevitable that aquaculture production will overtake capture fisheries production within the next 10-20 years. In this context, the supply of quality fish seed has increased, and must continue to increase dramatically to sustain growth in aquaculture (FAO, 2006). In a sustainable biological production, we expect the fish that are produced should be healthy and normal. In aquaculture, at times far too many deformed fish are produced, which is both a welfare problem and a source of financial losses.

The rapid expansion of fish culture operations in recent times makes fish culturists to solely depend on hatcheries for their seed requirements, whereas in the past a major portion of the seed was collected from rivers. There is every possibility in these hatcheries, where female and male breeders are chosen from a finite (small) population for mating, with a greater chance of crossing sib (brother-sister) or closely related fish. Moav and Wohlfarth (1976) stated that a single full sib mating of a particular fish might result in 10-20% depression in growth and a considerable proportion of individuals might show physiological abnormalities. Because of generation of inbreeding and accumulation of unfavorable alleles from close mating, genetic deterioration of existing cultured

farmed stocks might make them less suitable for culture. An inbred or homozygous population normally loses its genetic vigor.

Artificial breeding and rearing of early stages of economically important animals in hatchery followed by their use for ranching is becoming increasingly popular. Genetic constitution of cultured stocks is generally modified by selective breeding and inbreeding (Allendorf and Ryman, 1987; Gjedrem *et al.*, 1988). Reproductive mixing of the natural and hatchery produced stocks can potentially modify the genetic composition of wild populations. Results can be serious if hatchery releases are large and outnumber the natural population of geographically confined species. Because genetic factors determine the fitness and adaptability of the organisms, preservation of genetic capital of brood-stock is important in production of high quality seed for aquaculture and for ranching purposes. Even if founder specimens of brood-stock are genetically intact, lack of a proper management strategy can lead to inbreeding and rapid decline in diversity at gene level.

Artificial culture systems can expose developing fish to a variety of suboptimal environmental conditions, many of which are associated with the induction of deformities. Most hatchery culture systems are designed to duplicate natural temperature, lighting and water chemistry, although the degree to which these are accomplished is debatable. In many cases, hatchery rearing parameters are based on trial and error or on assumptions about the physical requirements of a particular species.

Deformities or malformations in commercially raised fish are a common source of downgrading of product value (Yves Verhaegen *et al.* 2007). Deformities in fish have deserved the attention of several investigators since the 16th century (Berra and Au 1981) and since then, a great number of studies document the appearance of various types of abnormalities in wild (Browder *et al.* 1993, Lemly 2002; Jawad 2005; Al-Jufaily *et al.* 2005; Boglione *et al.* 2006; Jawad & Hosie 2007; Jawad and Oktoner 2007; Jawad *et al.* 2007; Koumoundouros 2008). The development of the skeletal deformities occurs during the early life stages due to unfavorable environmental conditions (Sfakianakis *et al.* 2004, 2006) and pollutants (Bengtsson 1988; Lemly 1993), as well as due to inbreeding and mutations (Tave *et al.* 1983, Gjerde *et al.* 2005). Thus, skeletal anomalies have been considered as an important indicator of environmentally induced stress of fish in the wild (Bengtsson 1988; Lemly 1993; Boglione *et al.* 2006; Koumoundouros 2008).

Malformations are one of the most representative factors of the quality of fingerlings, although only some of the malformed fish are either poor growers or difficult to sell. Since carps are highly fecund, hatchery operators tend to maintain a low effective population size (number of brood stock that contributes genetic material to the next progeny) and do not exchange brood fish between hatcheries. Poor performance of resultant seed had been linked to inbreeding of carps in India (Eknath and Doyle, 1985). A communal or mixed spawning system for major carps in West Bengal is being practiced and is known to produce approximately 10% hybrids (Padhi and Mandal, 1997). This technique may lead to loss of important major carps. Fish farmers often

complain about poor growth of fish procured from particular hatcheries (Seed Farms) and feel that such fish do not reach marketable size within the stipulated period. This is also attributed to inbreeding. Thus, to summarize the findings of Eknath and Doyle (1990) and Basavaraju *et al.* (1997), it is evident that the hatchery practices indicated inbreeding depression and negative selection for growth in domesticated stocks of Indian major carps.

However, in the absence of proper breeding plans, this has led to a gradual decline in the genetic quality of the seed. Consequently the negative effect of inbreeding started appearing gradually with the characteristic poor survival and slow growth, besides disease susceptibility of the hatchery produced seed (Ibrahim *et al.*, 1982). All this suggests that it is an appropriate time to act seriously about the genetic improvements of the carps.

Pathological spinal curvatures can also result from environment factors including lighting, temperature and salinity (Langdon, 1988; Liu *et al.*, 1994) and thermal shock can increase the incidence of spinal deformities. A sudden and brief increase or decrease in water temperature, if occurring during a critical phase of early development can cause 100% incidence of scoliosis in exposed embryos. Thermal pollution or raised water temperature is considered to be one of the causes of the vertebral abnormalities as sudden change in water temperature may lead to abnormal muscle growth and spinal anomaly (Al- Hassan, 1982). A wide range of physical, chemical and biological factors may cause morphological deformities of fins in natural and reared conditions (Tutman *et al.*, 2000).

Other problems arise in pond scale culture; although ponds are used primarily for grow out in temperate aquaculture, nursery ponds are often used for the culture of larval and juvenile fishes in the tropics (Pillay, 1990). Pond management strategies differ depending on pond sizes, often involving extensive treatment with assorted organic and inorganic fertilizers and other chemical compounds (Boyd, 1995). Such practices may increase the risk of developmental deformities. The frequencies of certain developmental deformities may be useful indicators of an impaired environment (Langdon, 1988), and can provide a scientific basis for improvement of culture conditions. Even in a well balanced and presumably ‘optimized’ culture system, deformities can emerge after generations of successful culture if genotypic diversity becomes compromised. Because of the high rate of fecundity of most fish species, breeding practices often rely on a small number of brood stock fish with attractive characteristics. This results in inbreeding depression (Liao *et al.*, 1993).

In most cases it can be difficult to relate observed developmental deformities to a specific causative factor, because so many physical defects have been associated with more than one potential cause. Opercular deformities are especially prevalent in cultured fishes, and has been ascribed to infectious disease, inbreeding, environmental disturbances, etc., (Tave and Handwerker, 1994). Quite often multiple deformities are found in the same fish (Takashima *et al.*, 1976; Daoulas *et al.*, 1991). When such deformities are encountered, diagnosis and corrective action may depend not only on observation on the nature of the deformities, but also on their frequency and their pattern

of heritability. Changes in severity and in frequency over time can be valuable diagnostic clues leading to corrective processes (Tave and Handwerker, 1994). Also, a detailed understanding of the physical and chemical environment is an essential component of good hatchery management.

Hence, there is an immense need to study the sensitivity of deformities in Fish and to reduce the loss incurred to the farmers during harvest. Keeping this in view the study was undertaken with the following objectives.

Objectives of this study:

1. To explore the relationship between Indian major carp farming practices and non infectious diseases status of growing fish from commercial fish culture ponds.
2. To identify the non infectious disorders from the commercial fish culture ponds which lead to production losses and to interpret the results with appropriate management practices.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Fisheries are an important sector in India. It provides employment to millions of people and contributes to food security of the country. With a coastline of over 8,000 km, an Exclusive Economic Zone (EEZ) of over 2 million sq km, and with an extensive fresh water resource, fisheries can play a vital role. Fisheries and aquaculture contributed 1.07 per cent to the national GDP and 5.30 per cent to agriculture and allied activities, while the average annual value of output during the X Five Year Plan (2002-2007) was 3,6182,50 crores. During the fiscal year 2010–11, annual fish production has reached to the level of 8.30 million tonnes. Annual export earning has also touched record US\$2.9 billion mark contributing about 17 per cent to national agricultural export. About 14.5 million people are engaged in fishing, aquaculture and other allied activities of which about 75 per cent are in inland fisheries and the remaining in marine fisheries (Planning commission, 2012-17 Vol -2).

Aquaculture is one of the fastest growing food-producing sectors, providing an acceptable supplement to and substitute for wild fish. During the past three decades the total production of cultured finfish and shellfish has increased in production quantity and value. Global aquaculture production is estimated at nearly 10 million metric tons annually, and it contributes 12% of the total consumed fish and shellfish (Pérez and Rodríguez, 1997).

In a sustainable biological production, we expect that fish that are produced will be healthy and normal. In aquaculture, at times far too many deformed fish are produced, which is both a welfare problem and a source of financial losses to the fish farmers.

Certain commonly observed physical deformities in fish have been associated with exposure to physical, chemical and environmental variables and to infectious organisms. Some have also been attributed to inbreeding and to nutritional deficiencies. In general, the effects of exposure to harmful or suboptimal conditions tend to be much more profound in early development than later on life. Relatively subtle changes can have an enormous impact on an entire cohort of delicate embryos or larvae during critical phases of differentiation, often resulting in mortality or severe disfiguration.

Fish that have not yet undergone skeletal ossification are particularly for fish culturists, since most fish with visible deformities are essentially unmarketable, regardless of whether they are intended for the food or ornamental trade.

Deformities are common in both wild and cultured fish populations, but their frequencies are greater in hatchery populations. Available evidence suggests that abnormalities are induced during the embryonic and post-embryonic periods of life (Al-Harbi, 2001).

Morphological deformity in fishes has been reported in various species and was attributed to various factors viz, nutritional deficiency, stressed conditions in the ecosystem and genetic factors. Deformities include Spinal, Opercular, Gill, Eye, Multiple, Head and Jaw, Fin, Behavioral Responses etc, are discussed below.

2.1 SPINAL DEFORMITIES

Spinal deformities in natural and reared fish populations are relatively well described and many reports have been published on different fish species (Endo and Iwatsuki, 1998, and Fagbuaro *et al.*, 2006). Vertebral deformities may affect the biology of the affected fish indirectly through inhibiting its free movement (Jawad, 2004).

Cyprinus carpio with spinal deformities either swim upside down or sideward, or the growth was slow compared to a normal fish were reported (Al-Harbi, 2001). Similar behavior has been observed in a pike, *Esox lucius* with abnormal spinal cord (Wunder, 1978). Average length and weight of abnormal fish have been found to be substantially lower than that of normal fish, probably due to their inability to feed normally and to compete with the normal ones for food and other adequate resources (Al – Harbi 2001).

Spinal deformities were reported in *Cyprinus carpio* and strong water current was found to be responsible for such (Backiel *et al.*, 1984). On the other hand,

Dabrowski *et al.* (1988) and Frischknecht *et al.* (1994) suggested that vitamin C deficiency in the diet was responsible for the spinal column deformity.

Though the inland fishing industry is mainly based on carps, records of morphologically deformed carps are scantier and limited to sporadically caught specimen only (Raj *et al.*, 2004). A hump back *Catla catla* has been described by Hora (1942) and Law (1944).

An abnormal specimen of *Labeo boja* with bent posterior vertebral column resulting in deformed urostyle and a change in caudal fin structure was reported by Jayaram *et al* (1974). An abnormal specimen of Indian Major Carp (*Cirrhinus mrigala*) with vertebral deformities was also recorded.

Several researchers have identified various factors for the different types of vertebral abnormalities. Pollutants have been considered to be responsible for deformities of different parts of the body of fish (Subba, 2004). Parasitic infestations and mechanical trauma, contamination, oxygen deficiency, water current, salinity, sudden change in temperature, toxic chemicals, hereditary (Jawad and Oktener 2007). Also skeletal disorder which is as a result of complex mixture of vertebral and spinal malformations in larvae and juvenile fish have been linked to a poorly understood relationship between nutrition, environment and genetic factors (Lall and Lewis – Mc Crea, 2007).

Other factors such as waste water from households was found to be responsible for curvature of spine in pike – perch (*Lucioperca sandra* L.), inadequacy of the key nutrients such as calcium, phosphorous in the pathogenesis of skeletal deformities, vitamins, lipids and nutrient interaction were implicated in the vertebral deformation in fish species (Lall and Lewis – McCrea 2007, Agrawal and Mahajan 1980). Experimental avitaminosis C causes retarded growth and high mortality associated with vertebra deformations, lordosis, scoliosis, and haematopathological changes in *Cirrhinus mrigala* (Agrawal and Mahajan, 1980).

Amitabh and Firoz Ahmed (2010) reported that poor lateral muscle moving the 4 precaudal trunk vertebrae caused the Indian Carp, *Cirrhinus mrigala* to bend towards left when the muscles immediately posterior to these developed to compensate for the bending and the process resulted in a loop formation on the right side of the caudal vertebrae. Although, this type of vertebral anomaly in *Labeo rohita*, an Indian carp that was attributed to have mechanical injury at an early stage of the development caused by some violence followed by irregular calcification (Kapoor and Sarkar 1955).

Pathological spinal curvatures can also result from environment factors including lighting, temperature and salinity (Langdon, 1988; Liu *et al.*, 1991) and thermal shock can increase the incidence of spinal deformities. Temperature variations can lead to spinal abnormalities in at least two ways. Rearing fish larvae at temperatures above or below the optimal temperature for the species (Polo *et al.*,

1991) and thermal shock can increase the incidence of spinal deformities. A sudden and brief increase or decrease in water temperature, if occurring during a critical phase of early development can cause 100% incidence of scoliosis in exposed embryos.

Thermal pollution or raised water temperature is considered to be one of the causes of the vertebral abnormalities as sudden change in water temperature may lead to abnormal muscle growth and spinal anomaly (Al- Hassan, 1982). Dissolved oxygen content of the water during spawning seasons and developmental stages may be responsible for production of vertebral abnormality. Absence and inability to inflate the swim bladder during post larval growth has been associated with spinal curvature in sea bream (*Sparus aurata*) and sea bass (Chaitan, B., 1994; Andrades, J.A., *et al.*, 1996) and mugil, *Liza abu*. (Jawad, L.A. and Oktener, A., 2007).

Malachite green, once commonly used in fish culture, has been found to include a range of spinal and skull anomalies when embryos are exposed to it during a critical stage of development (Meyers and Jorgenson, 1983). Malachite green is currently restricted for application in food fishes but is still commonly used in ornamental fishes.

Geurden *et al.*, (1997, 1998) reported that the different phospholipid classes highly affect growth and development in a freshwater carp *Cyprinus carpio*. In particular, they concluded that phosphatidylcholine has a growth promoting effect, and phosphatidylinositol prevents skeletal deformities.

It has been reported that a deficiency of the amino acid tryptophan induces scoliosis in salmonids, such as sockeye salmon, rainbow trout and Coho salmon, and Chum salmon (Akiyama *et al.*, 1986). The teratogenic effect of retinoic acid, a compound related to vitamin A is now well documented in vertebrates (Ross *et al.*, 2000). Retinoic acid acts on the expression of the genes of *Hox* family, which are involved in the formation process of antero-posterior axis (Conlon, 1995).

A role of vitamin A in skeletal malformation of larvae produced in hatchery is suspected since some years (Takeuchi *et al.*, 1998). Dedi *et al.* (1995) conducted an experiment by feeding six groups of Japanese flounder larvae, *Paralichthys olivaceus*, with *Artemia* enriched with increasing vitamin A levels. High vitamin A level resulted in higher incidence of bone deformities, such as vertebral curvature, central fusion and compression of vertebra. Almost all the fish in the group fed the highest vitamin A levels showed bone deformities, and almost all the 37 vertebrae were abnormal in these fish.

Haga *et al.* (1999) examined the effect of Retinoic Acid (RA) on the occurrence of vertebral deformity by feeding *Artemia* enriched three different levels of RA (10×10^3 , 50×10^3 $100 \times 10^3 \mu\text{g}$ RA). They observed that vertebral deformity in flounder occurred in a dose-dependent manner. RA induced vertebral deformities in a similar pattern as induced by various retinoids, suggesting that RA is a critical factor causing vertebral deformity in juvenile flounder.

Kitamura *et al.*, (1965) reported that rainbow trout *Salmo gairdneri* and carp *Cyprinus carpio* developed spinal curvatures when fed diets low in ascorbic acid. Similar observations have been reported in brook trout *Salvelinus fontinalis* following a 34-week feeding period (Poston, 1967).

Halver *et al.*, (1969) observed acute lordosis and scoliosis in Coho salmon *Oncorhynchus kymathch* and rainbow trout after 24 weeks fed on ascorbic acid-deficient diet. Halver *et al.*, (1969) observed distorted and twisted cartilage upon histological examination of the spinal columns and gills of the ascorbic acid deficient fish after 12 to 14 weeks fed the test diet.

Infectious agents have also been implicated in some cases of spinal curvatures (Lom *et al.*, 1991). Viral, Fungal, Protozoan and Bacterial pathogens have all been found to cause spinal curvature (Langdon, 1988). Prophylactic treatment of halibut eggs with antibacterial disinfectants results in a reduction in

skeletal deformities (Bergh and Jelmert, 1990). Scoliosis of cultured yellowtail caused by parasitic *Myxobolus buri* cyst lumps was ameliorated to some extent by intensive and frequent feeding (Sakaguchi *et al.*, 1987).

Curvature of spine in pike perch *Lucioperca Sandra* has been linked to waste water from households (Wunder, 1976). Experimental avitaminosis C causes retarded growth and high mortality associated with vertebrae deformation, lordosis, scoliosis, and haematopathological changes in *Cirrhinus mrigala* (Al-Harbi, A. H., 2001).

In newly hatched larvae of *Clarius batracus* exposed to toxic levels of malathion, deformed notochord results from uncontrolled contraction of body musculature that causes vertebral deformity (Hong Lien, *et al.*, 1997).

Lordosis in sea bass and sea bream, mainly affecting vertebrae 14-15, has been related to the hydrodynamic in tanks, particularly the water current intensity (Chatain, 1994). Inadequate light intensity as well as temperature and salinity in rearing water have been reported as sources of skeletal malformations (Johnson and Katavic, 1984).

The causes of lordosis in *Cyprinus carpio* could not be established but in a number of marine fish lordotic deformation is noted to occur only in fish that had no gas in their swim bladder (Kitajima *et al.* 1994).

Marine fish larvae undergo major functional and morphological changes during the developmental stages. Several factors can interfere with the normal development of larvae and affect larvae quality (Chantal *et al.*, 2003).

In a recent study, Boglione *et al.*, (2001) showed that only 4% of wild caught animals are affected by body deformations. This percentage can reach very high values in hatchery reared larvae (Divanach *et al.*, 1996). Malformations are often associated with growth depression and high mortality rate.

Andrades *et al.*, (1996) showed that only a few percent of larvae affected by skeletal (lordotic) malformation can survive after larval development. This leads to significant loss of money for the hatchery. In addition, fish growing with malformations are sold at a depressed price.

In round fish, such as sea bass, sea bream or milkfish, a lot of skeletal malformations have been observed in hatchery reared larvae. Spinal malformation as scoliosis, lordosis, coiled vertebral column, missing or additional fin rays, and also bending opercle or jaw malformations have been described (Divanach *et al.*,

1996). Beside morphological malformations, quality can also be negatively affected by a low stress resistance in fish larvae reared in hatchery (Koven *et al.*, 2001; Fushimi, 2001). Kanazawa *et al.*, (1981) also showed that dietary incorporation of phospholipids reduced malformation, especially, twist of jaw and scoliosis in Ayu larvae *Plecoglossus altivelis*.

Pathology in very young larvae and especially development of some pathogenic bacteria can induce high rates of malformations (Madsen and Dalsgaard, 1999). Moreover, it has been shown that prevalence of skeletal malformations, including jaw deformities, is significantly higher in triploid farmed fry of Atlantic salmon (Sadler *et al.*, 2001).

Spinal deformities can be heritable (Lodi, 1978; McKay and Gjerde, 1986) although they are often caused by acute nutritional deficiencies have been associated frequently with scoliosis in fishes (Zitzow and Millard, 1988; Harris and Hulsman, 1991). One cause is a dietary insufficiency of essential amino acids, such as tryptophan (Akiyama *et al.*, 1986; Post, 1993b) although inadequate levels of dietary vitamin C are more commonly associated with this problem (Koenig, 1984). Vitamin C contributes to spinal development as well as to the effective maintenance and repair of spinal tissues, and its deficiency has been implicated in a range of vertebral deformities (Halver *et al.*, 1969; Post, 1993b).

A 45% incidence of spinal curvature (scoliosis and lordosis) was reported in channel catfish fed an experimental vitamin C deficient diet, as opposed to 3.9% in controls (Lovell, 1973). Among other problems, vitamin-deficient diets can lead to osteoporosis and consequently to brittleness in the vertebral column and distortion of the supporting cartilage (Halver, 1971).

Intermediate levels of dietary vitamin C (30 mg/ kg of food) were sufficient to prevent clinical signs of spinal deformity in channel catfish, although gill damage persisted in these fish; consequently higher dietary levels of vitamins C are typically used for channel catfish (Lim and Lovell, 1978).

Increased appearance of vertebral column as a sort of malfunctions was reported by Wunder (1971) in cod fishes due to the action which was originally considered to be exclusively hereditary.

Spinal curvatures can be caused by exposure to relatively low concentrations of certain toxic materials. Roberts (1989) reviewed pollutants including zinc, organochlorine, organophosphates and carbamates associated with vertebral anomalies.

Fourhorn sculpins (*Myoxocephalus quadricornis*) displayed increasing frequencies of vertebral defects with increasing proximity to discharged pulp mill effluent, which included bleach (Bengtsson, 1991).

The deformities concerned with decoloration, egg weight loss, pigmentation of the egg, twin fry, kyphosis, lordosis, and the evidences in most of the fry (Hora and Pillai, 1962; Biswas, 1992).

Abnormality can be caused by various factors like infectious agents (Hoffman, 1990), no proper husbandry or rearing, hypoxia, nutritional imbalance and genetic factors (Bruno, 1997), which ultimately lead into permanent ailment. Disrupted osteogenesis has been reported by infectious agents, such as *Myxobolus cerebralis* that cause deformities especially in cranium (Hoffman, 1990).

2.2 OPERCULAR DEFORMITY

Dabrowski *et al.* (1988) reported operculum deformity in *C. carpio*, and found it to be associated with vitamin C deficiency in the flaked diet. In *Oncorhynchus mykiss* vitamin C deficiency related operculum deformity has also been reported (Frischknecht *et al.* 1994). Operculum deformity has also been reported in hatchery raised *Oreochromis niloticus* (Mair 1992, Tave and Handwerker 1994) and *Tilapia mossambica* (Handwerker and Tave 1994).

The operculum deformity was found to be non heritable (Handwerker and Tave 1994, Tave and Handwerker 1994). A recent study also evidenced that dietary incorporation of DHA induces a decrease of opercular deformities in milkfish *Chanos chanos* (Gapasin and Duray, 2001). Gapasin *et al.*, (2001), reported that the incidence of opercular abnormalities was 50% lower in milkfish

larvae fed rotifer and Artemia enriched with highly unsaturated fatty acid and ascorbic acid, compared to fish fed rotifers and Artemia enriched only with highly unsaturated fatty acids. These opercular abnormalities, associated with distortion of gill filament cartilages, are characteristic of scorbutic fish (Lim and Lowell, 1978; Soliman *et al.*, 1986) and are the result of a decalcification (Dabrowski *et al.*, 1990).

A scorbutic condition was induced in channel catfish reared in floating cages fed a commercially available floating catfish ration devoid of ascorbic acid. The major pathological conditions observed were altered pigmentation, lordosis, scoliosis, and ultimately, a broken back were due to impaired collagen biosynthesis due to the absence of dietary ascorbic acid (Robert P.W., 1973). Ascorbic acid deficiency in the channel catfish *Ictalurus punctatus* was demonstrated by Lovell (1973).

During the intensive rearing of gilthead sea bream (*Sparus aurata*) opercular deformities were the most commonly observed type of deformation (affecting up to 80% of the fisheries stock), sometimes showing a severe inward folding of the operculum. In order to exploratory quantify and qualify the deformities, geometric morphometric analyses were performed on the external morphology from larvae with an age ranging from 50 to 69 days post-hatching (dph), and on the cranial skeleton of 110 dph old juveniles. The results showed several osteological cranial shifts and a striking left – right independency

associated with deoperculation. Even though a significant size difference was observed at 65 dph between normal and deoperculated specimens, allometries during the examined growth stages still appear to be very similar in normal and deoperculated specimens (Yves *et al.* 2007).

2.3 GILL DEFORMITY

Poorly or incompletely formed gill opercula have been observed in a wide variety of teleosts. In some cases of deformities, a genetic predisposition to their inheritance is suggested (Chandrasekaran and Rao, 1981). Tave and Handwerker (1994) described a semi- operculum in tilapia, and concluded that this was a ‘non-heritable birth defect’, and not the result of exposure to an environmental disturbance.

In other cases nutritional and environmental problems are found to be responsible for developmental gill deformities. Vitamin C deficient diet causes weakening of the cartilage in gills, and this leads to distortion of gill filaments (Halver, 1972).

Dabrowski *et al.*, (1988) reported a deficiency in dietary ascorbic acid induced gill arch pathology and caudal fin erosion in carp larvae. Ascorbic acid supplied by diet is crucial for fish larvae development, since most of the species

are unable to synthesize this vitamin. Chicken manure added to ponds has been identified as one cause of gill deformities in Tilapia (Liu and Wong, 1987).

2.4 EYE DEFORMITY

Chaitan and Dewavrin (1989) found that vitamin C deficient diets resulted in disruptions of normal eye geometry. This evidently is caused by abnormal deposition of cartilage in and around the orbit. Riboflavin deficiency can result in cataracts and corneal vascularisation (Post, 1993b). Hughes (1985) identified dietary deficiencies that were associated with specific ocular disruptions in salmonids. Exposure to chlorinated water has been found to result in eye deformities in a high percentage of shiner perch *Cymatogaster aggregata* (Thatcher, 1979)

2.5 MULTIPLE DRFORMITIES

Amitabh Hore and M. Firoz Ahmad (2009) studied mutiple spinal abnormalities, an adult specimen of *Cirrhinus mrigala* showing signs of multiple spinal abnormalities was netted in a mixed catch of carps- *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala* and *Labeo calbasu*, from Chutia pond, Ranchi, Jharkhand.

The fish affected with multiple deformities swam upside down or sideward, and growth was slow compared to a normal fish were reported in *S. aureus* (Tave *et al.*, 1982), *C. carpio* (Dabrowski *et al.*, 1988), *Carassius auratus* L. (Wiegand *et al.*, 1989) and *O. mykiss* (Frischknecht *et a.*, 1994).

2.6 HEAD AND JAW MALFORMATION

Head deformities have been reported in many species of freshwater and marine fish (Riehl and Schmitt 1985, Quigley 1995). The frequency of head and jaw deformities increases in intensive aquaculture and in inbred populations. Atlantic halibut *Hippoglossus hippoglossus* larvae display increased frequency of head, jaw and fin deformities at supra-optimal rearing temperatures (Pittman *et al.*, 1990), and jaw deformities are also related to lighting conditions (Bolla and Holmefjord, 1988).

The fish affected with head deformity swam normally, but growth was slow compared to normal fish that appeared to be due to ossification and compression of bones. Jaw deformity could be caused by many factors such as mechanical injury, nutritional deficiencies, parasitism, teratogenic substances, and adverse environmental conditions or genetic aberration (Quigley 1995).

Stumpbody is caused by an abnormal ossification of the trunk vertebrae and x-ray radiography revealed that the fish with stumpbodies also had semi-operculum and lordosis (Al-harbi, 2001). Stumpbody has been reported in *Sarotherodan aureus* (Steindachner) (*Tilapia aurea*) (Tave *et al.* 1982) and in channel catfish *Ictalurus punctatus* (Dunham *et al.* 1991) and found to be non-heritable.

2.7 FIN DEFORMITIES

A wide range of physical, chemical and biological factors may cause morphological deformities of fins in natural and reared conditions (Tutman *et al.*, 2000). One specimen of *Liza abu* showing partial loss of the caudal fin was caught by cast net from waters of Karkhe River branches near Sūsangerd, South west of Iran (Jawad *et al.*, 2010). This is the first report of caudal fin anomaly in Iran and the second abnormal report about the species in Iran.

In fishes, the caudal fin has an important role in maneuvering and steering functions; therefore it must be constructed so as to cope with hydrodynamic stresses with the least possible expenditure of energy (Boglione *et al.* 1993). Any anomaly in the caudal fin will impair the flexibility of the tail, so hindering the performance of the fish (including the capacity to get food and to avoid predators). Among the xenobiotic substances, heavy metals such as Cadmium, Zinc and

Copper are suspected to cause reduction or absence of fins (Sloof, 1982). Vitamin C deficiency has been associated with caudal fin degeneration (Halver, 1972).

Fins which have developed normally may also degenerate as a result of infection or injury. Thermal shock as experienced by striped bass *Morone saxatilis* developing near a power plant cooling system has been associated with both fin and spinal deformities (Koo and Johnston, 1978).

Fin deformities caused by bent or misshapen rays commonly appear in conjunction with spinal curvatures and/or head deformities (Sindermann, 1988). A population of larval pacific herring (*Clupea harengus pallasii*) with high incidences of fin, head, jaw and spinal deformities which apparently resulted from atypically high water temperature is described (Purcell *et al.*, 1990).

The dorsal and anal fins and their support deformities in particular are scarcely reported and deserved less attention (Hussein,1979).The only skeletal deformity case in (*Pampus argenteus*) reported so far from the Arabian Gulf area (Al-Hassan,1982). Euphrasen, (1788) for the first time documented the absence of the pterygiophores supporting the dorsal and anal fins in wild-caught silver pomfrets *Pampus argenteus* was collected from the Omani coasts of the Arabian Gulf.

The deformed individuals were characterized externally by a substantial shorter profile at the dorsal and anal fins area and complete deformity of the dorsal

and anal fin rays. The lack of dorsal fin rays whether it is partial or complete is known as the "saddleback syndrome" (SBS) (Tave *et al.*, 1983). The absence of pterygiophores and the presence of complete fin rays intact might be a result of interference of external unfavorable conditions with the development of both pterygiophores and fin rays. The normal specimen presents the typical anal fin structure and support. Such phenomenon for silver pomfrets and family 'Stromatidae' was not observed, but the case of dorsal fin loss of pterygiophores was reported for the parrotfish *Sparisoma cretense*. (Koumoundouros, 2008). Such deformity can hinder the movement of fishes and thus they became less capable to catch prey or avoid predator, but may not significantly affect fish survival (Koumoundouros, 2008). It may, however, affect to a certain limit other aspects of performance such as reproduction success in species using fin display in courtship or intraspecific competition (De Giro-lamo *et al.*, 1999; Koumoundouros, 2008). The loss of pterygiophores from the dorsal and anal fins is an ontogenetic continuation of abnormalities of the primordial marginal fin fold during the early larval stage (Koumoundouros *et al.*, 2001).

2.8 BEHAVIOURAL RESPONSES

Halappa and David (2009) studied the behavioral responses of the freshwater fish *Cyprinus carpio* in the experimental periods. Acute toxicity (96 h LC50) of chlorpyrifos for the freshwater fish *Cyprinus carpio* was found to be

0.160 mg/L. Fish in toxic media exhibited irregular, erratic and darting swimming movements, hyper excitability, loss of equilibrium and sinking to the bottom. The carp were found under stress, but mortality was insignificant in both the sub lethal concentrations. Caudal bending was the main morphological alteration during the exposure periods. The behavioral and morphological changes may be due to the inhibition of acetyl cholinesterase (AChE) activity. Inactivation of AChE activity results in excess accumulation of acetylcholine (ACh) in cholinergic synapses leading to hyper stimulation and cessation of neuronal transmission (paralysis). Impaired behavioral responses and morphological deformities were observed even under recovery periods. This may be a consequence due to the inhibition of brain and muscular AChE activity by chlorpyrifos-oxon via biotransformation of bioaccumulated chlorpyrifos in the tissues. Chawanrat *et al.*, (2007) reported that inhibition of brain AChE activity is an early process of sub lethal exposure to chlorpyrifos in hybrid catfish and hence support the above observed behavioral changes in the exposed fish.

Johnson and Finley (1980) and Clark *et al.*, (1985) reported 96 h LC50 of chlorpyrifos to channel catfish, *Ictalurus punctatus* and sheepshead minnow, *Cyprinodon variegatus* as 0.280 mg/L and 0.136 mg/L, respectively. Chlorpyrifos toxicity reported by Rao *et al.*, (2003 and 2005) to euryhaline and mosquito fish, *Oreochromis mossambicus* (Tilapia) and *Gambusia affinis* by semi-static method is 0.0259 mg/L and 0.297 mg/L, respectively.

Fish embryos exposed to complex mixtures of polycyclic aromatic hydrocarbons (PAHs) from petrogenic sources show a characteristic suite of abnormalities, including cardiac dysfunction, edema, spinal curvature, and reduction in the size of the jaw and other craniofacial structures. To elucidate the toxic mechanisms underlying these different defects, zebrafish (*Danio rerio*) embryos were exposed to seven non-alkylated PAHs, including five two- to four-ring compounds that are abundant in crude oil and two compounds less abundant in oil but informative for structure – activity relationships (John P. Incardona *et al.*). The primary etiology of defects induced by dibenzothiophene or phenanthrene appears to be direct effects on cardiac conduction, which have secondary consequences for late stages of cardiac morphogenesis, kidney development, neural tube structure, and formation of the craniofacial skeleton. The relative toxicity of the different mixtures was directly proportional to the amount of phenanthrene, or the dibenzothiophene – phenanthrene total in the mixture. Pyrene, a four-ring PAH, induced a different syndrome of anemia, peripheral vascular defects, and neuronal cell death, similar to the effects previously described for potent aryl hydrocarbon receptor ligands. Therefore, different PAH compounds have distinct and specific effects on fish at early life history stages. Gross malformations resulting from PAH exposure included pericardial and yolk sac edema, jaw reductions, and presumptive skeletal defects described as lordosis or scoliosis (dorsal curvature).

The vertebral column is the defining character of vertebrates providing the organism with a unique ability of movement, form and function. Spinal disorders are a major cause of disability for humans and an important health problem for intensively farmed animals. The fundamental aspects of bone metabolism and pathogenesis of vertebral fusions in Atlantic salmon *Salmo salar* examined by Ytteborg *et al.*, (2010). Experimentally, juvenile salmon were subjected to hyperthermic conditions where more than 28% developed fused vertebral bodies. To characterize the fusion process an intermediate and a terminal stage of the pathology by using x-ray, histology, immunohistochemistry, real-time quantitative PCR and in situ hybridization analysed. At early stage in the fusion process, disorganized and proliferating osteoblasts were prominent at the growth zones of the vertebral body endplates. Loss of cell integrity through cell proliferation and metaplastic shifts seem to be key events in the fusion process. In teleosts, hyperthermia can induce vertebral deformities both during the embryonic development and after the vertebral column has been established (Ytteborg *et al.*, 2010). Spinal fusions involves transformation of intervertebral notochord tissue into cartilage, shape alterations of vertebral body end-plates, mineralization of the intervertebral cartilage and replacement of intervertebral cartilage by bone (Witten P.E., *et al.*, 2006).

The use of exogenous hormones has become standard in aquaculture, although a variety of physical deformities has been associated with these treatments. Some have been ascribed to the use of excessive doses, or to inappropriately timed treatments (Brown and Nunez, 1994). Eggs of sea bream (*Sparus aurata*) obtained by spawning induction with gonadotropin releasing hormone (LHRH) analogues show increased incidence of oil globule detachment and buoyancy problems (Barbaro *et al.*, 1991). Anabolic steroids given in high dosages to tilapia accelerate both the rate of growth and the frequency of physical deformities (Guerrero, 1975, 1976).

Applications of exogenous anabolic steroids cause abnormalities in epidermal thickness and pigmentation in the short term, followed by morphological changes after prolonged exposure (Higgs *et al.*, 1982).

Other problems arise in pond scale culture; although ponds are used primarily for grow-out in temperate aquaculture, nursery ponds are often used for the culture of larval and juvenile fishes in the tropics (Pillay, 1990). Pond management strategies differ depending on pond sizes, often involving extensive treatment with assorted organic and inorganic fertilizers and other chemical compounds (Boyd, 1995). Such practices may increase the risk of developmental deformities. Animal manures are commonly used throughout the third world to promote pond productivity; in Eastern Europe manures are typically applied to

fresh water ponds at a rate of more than eight metric tons per hectare (Marcel, 1990).

In cohorts exhibiting very high incidence of physical anomalies (>33%), a number of hatchery procedures including pre-spawning conditions, incubation procedures and handling of eggs and fry must be considered in addition to the usual range of possible genetic, toxicity and environmental causes (Post, 1993a).

Breeding of same broods more than one time in a season is another common practice in many hatcheries that presumably deteriorates the larval quality and increases the occurrence of deformed larvae and death. Hussain and Mazid (1997) reported reduced growth, physical deformities, diseases and high mortality in hatchery produced carp seed and they have identified improper management of brood stock, unconscious negative selection of broods, unplanned hybridization and inbreeding as the probable reasons behind these reduced performances.

Hassan and Ahmed (2002) conducted a survey on disease problems in 180 carp hatcheries and nurseries in southern and eastern regions of Bangladesh and reportedly found disease as big problem for hatcheries and nurseries. They listed a number of disease found in hatcheries and nurseries with white spot, tail and fin rot, EUS (Epizootic Ulcerative Syndrome), sudden spawn death, fish louse, gill rot, dropsy, malnutrition, air gulping and deformities.

2.9 Inbreeding

Since carps are highly fecund, hatchery operators tend to maintain a low effective population size (number of brood stock that contributes genetic material to the next progeny) and do not exchange brood fish between hatcheries. Poor performance of resultant seed had been linked to inbreeding of carps in India (Eknath and Doyle, 1985).

A survey of carp hatcheries in the state of Karnataka in South India was made (Eknath and Doyle 1990) because of the growing concern that hatchery stock may be inbred, as suggested by rapid deterioration of their performance. Eknath and Doyle (1990) found the rate of the accumulation of inbreeding (F) was particularly high for the three most desirable carp species in the country, Catla, Rohu and Mrigala.

The survey of Basavaraju *et al.*(1997) conducted particularly for catla in the three major seed producing hatcheries in the state of Karnataka, namely Tunga Badra Dam (TBD), Bhadra Reservoir Project (BRP) and Kabiri Reservoir Project (KRP), also indicated that the practices followed by these hatcheries are likely to result in both inbreeding and negative selection. Thus, to summarize the findings of Eknath and Doyle (1990) and Basavaraju *et al.* (1997), it is evident that the hatchery practices indicated inbreeding depression and negative selection for growth in domesticated stocks of Indian major carps.

A communal or mixed spawning system for major carps in West Bengal is being practiced and is known to produce approximately 10% hybrids (Padhi and Mandal, 1997). This technique may lead to loss of important major carps. Fish farmers often complain about poor growth of fish procured from particular hatcheries (Seed Farms) and feel that such fish do not reach marketable size within the stipulated period. This is also attributed to inbreeding.

However, in the absence of proper breeding plans; this has led to a gradual decline in the genetic quality of the seed. Consequently the negative effect of inbreeding started appearing gradually with the characteristic poor survival and slow growth, besides disease susceptibility of the hatchery produced seed (Ibrahim *et al.*, 1982). The vertebral shortening and ankylosis characterize a race of carp (*Cyprinus carpio*) is determined to be hereditary (Wunder 1949) while the vertebral ankyloses in 'medaka' is known to be hereditary and non- hereditary (Yamamoto *et al.*, 1963).

Few studies have been carried out to observe the roles of hereditary and strain differences on the skeletal abnormality in cultured population of freshwater and marine fishes: European sea bass *Dicentrarchus labrax* (Bardon *et al.*, 2009), *Oryzias latipes* Yamamoto *et.al.* (1963), *Cyprinus carpio* L. (Al – Harbi, 2001), *Solea senegalensis* (Gavia *et al.* 2001). Vertebral abnormalities are known to occur in *Cirrhinus mrigala* and *Hypothalmichthyp motitrix* due to inbreeding depression

(Raj *et al.*, 2004). Studies on lordotic anomalies indicated that lordosis has been reported in the guppy *Lebistes reticulatus*, in Sword tail, *Xiphophorus helleri* (Rosenthal and Rosenthal 1950).

Another aspect, which may also pose a problem, is the growing trend of replenishing the rivers, lakes and reservoirs with the hatchery produced fish seed in many states in India (Mishra and Raman, 1993) and even in the neighboring countries like Bangladesh. This should be given proper thought as most of the hatcheries produce seed without following any genetic resource management (Eknath and Doyle, 1985) and as such it may be disastrous from a genetic view point. Deviations brought about in the gene pool of survivors to that of the original populations effected by pollution will ultimately be reflected in future populations (FAO, 1980). There is likely hood of genetic detoriation in populations which suffer drastic depletions. Population size is the single most important factor in sustaining a high level of genetic variation with in a population (Frankel and Soule, 1981).

Das and Barat (1990) have dealt with fish conservation methods that are necessary following habitat degradation. Obviously, the various causative factors inducing stresses on fishes need to be eliminated or reduced as a first step. However, it appears very little or nothing can be done with regard to alternations of river systems and increased water abstraction when the greater interest of nation

is put ahead of interest of fish or local groups of fishers or farmers (Das and Barat, 1990).

MATERIAL and METHODS

3. Material and Methods

3.1. Material

3.1.1. Location:

On the basis of the condition, rainfall and temperature the twenty five districts of Andhra Pradesh were divided into seven agro climatic zones.

1. Krishna- Godavari zone,
2. North- Coastal Zone,
3. Southern Zone,
4. North-Telangana Zone,
5. South Telangana Zone,
6. Scarce Rainfall Zone and
7. Hill-Tribal Zone

The study has been carried out during a period of six months i.e. from March to August 2011 from the two significant Freshwater Fish Culture areas of Andhra Pradesh state as detailed below

1. Kolleru area – Krishna Godavari Zone
2. Nellore area – Southern Zone

The five districts viz., Guntur, Krishna, West Godavari, East Godavari and Nellore, in which the present study was conducted, constitute the Krishna-Godavari (KG zone) and Nellore (Southern Zone).

Lake Kolleru is one of the largest natural freshwater lakes in India situated in KG zone between latitudes 16° 32' and 16° 47'N and longitudes 81° 4 and 81° 22'E. The lake has an area of 901sqkm. and receives water from a catchment area spreading over 4760 km of which 3400 km is upland dry area and 1360 km is deltaic. One third of the Kolleru lake area is in Krishna district and the remaining area is in the West Godavari district of Andhra Pradesh. Almost 80% of the carp culture in the state developed in and around the largest fresh water lake in India, the Lake Kolleru and this influenced the southern coastal district Sri Potti Sri Ramulu (SPSR) Nellore district of Andhra Pradesh to follow accordingly. The Fresh water fish culture consisting of Indian Major Carps has been in practice in SPSR Nellore district from late 1980s. Though the same pond production management strategies of Kolleru area are being followed by the SPSR Nellore area fish farmers, the agro-climatic conditions of these two places differ significantly in terms of soil type, water quality and weather in particular.

3.1.2 Sample collection:

a. Fish Samples

Indian Major Carp samples (*Labeo rohita* and *Catla catla*) collected from four places in Lake Kolleru area and four places in Nellore area covering farmer's ponds and commercial fish seed traders' ponds. Fish samples collected once in a fortnight from each

place and details of management practices required for this work have been recorded.

b. Proforma

This study included interviews with the fish farmers using a Proforma as detailed in the annexure to cover

- Farm details to cover management aspects
- Management strategies followed by fish farmers and economic impact of deformities on fish farm profits

3.1.3 Water quality parameters:

Major water quality parameters noted are pH, Temperature, Transparency, Dissolved Oxygen, Salinity and Ammonia.

3.2 Methods

3.2.1. Physico'chemical parameters of water:

The water quality parameters were observed fort-nightly during the study period. Water quality parameters observed during the study are:

pH:

The pH of water was measured using the desk top digital pH meter having glass electrodes.

Temperature (°c):

The given pond water temperature was recorded by immersing a mercury thermometer (0°C -50 °C) at subsurface level.

Transparency (cm):

The water transparency was recorded by immersing the Secchi disc in water column at different depths of the sampled ponds. Secchi disc (20cm. diameter) was lowered vertically into the water column by holding the attached graduated tubular rod. As the disc disappears, the surface level of water (cm) on the graduated rod was noted. Then slowly lifted the disc and noted the depth (cm) at which the disc reappeared. The average of these two readings was taken as the limit of visibility or transparency of the pond water.

Ammonia:

Phenate method was followed for estimation of Ammonia. To a 25ml sample in a 50ml Erlenmeyer flask, added 1ml phenol solution, 1ml Sodium Nitroprusside solution and 2.5ml oxidizing solution with thorough mixing after each addition. Covered samples with plastic wrap or paraffin wrapper film. Let color developed at room temperature (22°C to 27°C) in subdued light for 1 h. Color was stable for 24 h. Measured absorbance at 640nm. Prepared blank and two other standards by diluting stock ammonia solution into the sample concentration range. Treated standards as same as samples.

Dissolved Oxygen (DO) ppm:

Winkler method was followed for estimation of dissolved oxygen in the fish pond water. Water samples were collected in 250 ml reagent bottles avoiding air bubbles. DO of water sample was fixed by adding (Manganous Sulphate) Winkler - A reagent followed by (Potassium Iodide) Winkler – B reagent to it. The resultant precipitate was dissolved with concentrated Sulphuric acid and titrated against the standard Sodium Thiosulphate solution (0.025 N) using starch solution as an indicator.

3.3 Hatchery operation

An examination was conducted on the deformed fish by induced breeding (Pituitary gland extract) in a commercial fish hatchery, at Kuchipudi, Tenali Revenue Division, Guntur District in the month of July 2011, coinciding with the peak breeding time. The breeding trial was conducted by using 'Hapa' method.

Body weight of the deformed female brood fish (*Labeo rohita*) used was 6 kg. First dose given was in the afternoon at 1.00pm at 4mg/kg body weight. Duration between the first and the second dose was 6 hrs. For the second dose, the dosage was increased to 10mg/kg body weight on par with normal female brood fish used on that day.

3.4 Statistical Methods

Multiple Linear Regressions (MLR): From the zero order correlation coefficients, the relationship of each one of variables could be hypothesized to have an amount of independent effect on the dependent variable. The coefficient of determination (R^2) was tested through f-value for its significance whereas partial regression coefficient (b) represents the changes in the independent variable and it was tested through t-value for its significance.

RESULTS

4. RESULTS

4.1 Farm level observations

Indian major carps (*Labeo rohita* and *Catla catla*) collected from four places in Lake Kolleru area and four places in Nellore area covering farmer's ponds and commercial fish seed traders' ponds. Out of a total pond harvested fish biomass of nearly 44 tons, 38 (0.086%) showed different types of deformities. The deformities are externally apparent and were identified as spinal deformities which include Scoliosis and Lordosis, Semi-operculum and Fin deformity.

4.1.1 Spinal deformity:

Spinal deformity was the most common (84.21%) among the examined Indian major carps (*Labeo rohita* and *Catla catla*). The predominant types of spinal deformities observed in the study were scoliosis and very low percentage of lordosis. Lordosis is characterized by the formation of a v-shaped curvature of the spinal column (Fig: 1). Fish with spinal deformities either swim upside down or sideward, and the growth was slow compared to a normal fish. During transferring of the fishes from nursery pond to rearing pond, fishes with scoliosis was recorded (Fig:.2). X-ray radiographs of the deformed fish shows abnormal

swim bladder when compared to the normal fish (Fig: 9). Spinal deformity is seen in both Nellore and Kolleru areas.

4.1.2 Semi operculum:

About 5.26% of the deformed fish had Semi opercular deformity. The deformed fish first observed in the seed tank and in this case the operculum was usually shortened with involuted edges (Fig: 3). It was also seen in grow out pond. In this study the fish had operculum deformity only on one side and the other operculum was normal. Fish with this kind of deformity swam normally, but growth was slow (Table 1). Both the specimens were found in Nellore area.

4.1.3. Fin deformity:

About 2.63% of deformed fish had Fin deformity. Dorsal fin of the fish is not completely formed; it is split into two fins (Fig: 4) and this specimen was found in Nellore area in grow out pond.

4.1.4. Stump body:

Stump body is caused by an abnormal ossification of the trunk vertebrae. About 7.89% of the deformed fish had stump body (Fig: 5) and these deformed fishes were found in both Nellore area and Kolleru area in grow out pond.

4.1.5. Mouth hyperplasia:

About 2.63% of the deformed fish had mouth hyperplasia (Fig: 6) and this deformed fish was found in Kolleru area.

Table 1: Percentage of deformity and mean size

Type of deformity	Percentage of deformed fish	Average body weight (gms)	Average body length(cms)
Fin deformity	2.63%	675	23.50
Semi operculum	5.26%	700	24.75
Spinal deformity	84.21%	550	21.50
Stump body	7.89%	600	16.50
Mouth hyperplasia	2.63%	897	26.25

4.2 Harvesting and packing

Indian Major Carps were cultured for different durations depending on the size of the seed stocked, market demand. The mean and range of culture period were 10 and 6-12 months respectively. Most of the farmed fish were cultured for a period of 10-12 months. After the completion of harvest carps are graded according to species and size. During the time of harvest deformed fish were separated and discarded from export with normal fish. Normal fish were packed in boxes with ice usually at 1:1 ratio.

Table 2: Farm pond management in Nellore and Kolleru

Management	Nellore	Kolleru
Seed Source	Kaikaluru	Kaikaluru
Pond size	5-10acres	10-20acres
Stocking Density	4000/acre	3000-4000/acre
Water Source	Irrigation /Tubewell water	Irrigation canal water/Agricultural drain
Water Depth	5feet	>5-6feet
Manures	Mostly inorganic	Organic and inorganic

4.3 Hatchery operation

An examination was conducted on the deformed fish by induced breeding (Pituitary gland extract) in the hatchery owned by K. Sri Ramulu garu, at Kuchipudi, Tenali Revenue Division, Guntur District in the month of July 2011, coinciding with the peak breeding time. The breeding trial was conducted by using 'Hapa' method.

When the male (normal and without deformities) and female (deformed fish showing typical scoliosis) was in the proper condition and hatching percentage was 95% with an egg size of 2mm diameter. For 6kg of fish 60 liters of egg is released (1kg-10lts eggs), for one liter of eggs contain 20,000 eggs. The total number of eggs released by the deformed female brooder is 12.0 lakh eggs. Hatching time was 60-72hrs. The observation for expression of deformities in the spawn has been continued for a total period of 60 days.

Nursery ponds are stocked with about 2-3days old spawn. The moderate rate of stocking was 25-35 lakh/ha. Spawn was raised to fry stage in about 14 days. Harvesting of fry (25-30mm) was done on the 14th day by fine meshed drag net (1.5mm). Fry were raised to fingerling (100-150mm) in rearing ponds in about 3 months period. There is no record for the expression of deformities during the time of observation period.

4.4 Case study

This case study is about an observation regarding the harvest in Nellore area in a grow-out pond. The cultured species was *Catla catla* and *Labeo rohita* with the culture period of 9 months. The harvest was done in the month of June, 2011. After the grading was completed, about 230 kg of fishes were deformed. The deformed fish include Scoliosis, Lordosis, and Fin deformity (Fig. 8). The pond details are given below in table.

Table 3: Pond management details

S.no.	Management	Details
1.	Pond size	0.6 ha
2.	Water depth	1.5 m
3.	Stocking density	4000/acre
4.	Water source	Bore water
5.	Seed source	Kaikaluru
6.	Avg body weight At the time of stocking	90 grms
7.	Average body weight after harvest	750 gm
8.	Seed survival	92%
9.	Disease	Argulus
10.	Chemicals	Decis and Butax
11.	Fish farm gate price	Rs 45/kg

Fig 1



Fish with scoliosis (*Labeo rohita*)

Fish with lordosis (*Labeo rohita*)

Fig 2



Deformed fish *Catla catla* and *Labeo rohita* from nursery pond respectively

Fig 3



Fish with semi operculum (*Labeo rohita*)

Fig 4



Fish with fin deformity (*Labeo rohita*)

Fig 5



Fish with stump body (*Catla catla*)

Fig 6



Fish with mouth hyperplasia

Fig 7



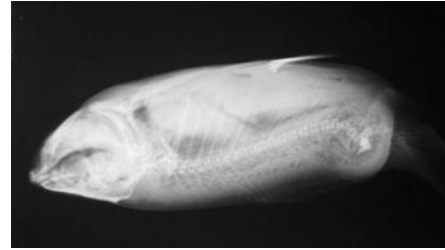
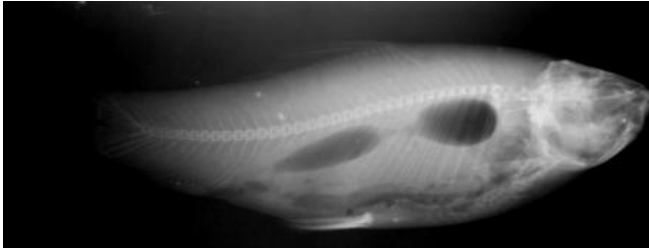
Size comparison between a Normal fish and a deformed fish collected from the same pond.

Fig 8

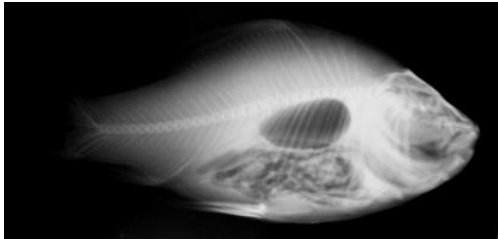


Case Study: Various deformations observed in the same pond at Nellore

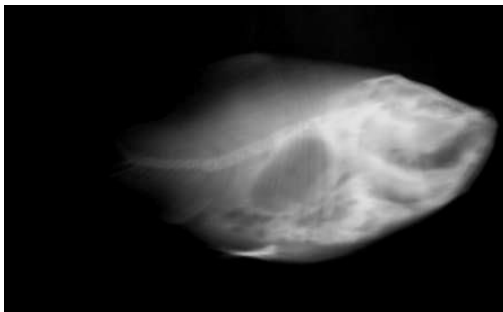
Fig. 9 X-ray radiographs of normal and deformed fishes.



Fish with a normal vertebral column (*L. rohita*) and with an abnormal vertebral column



Fish with a normal vertebral column (*Catla catla*)



Fish with an abnormal vertebral column (*C. catla*)



Deformed fishes from nursery ponds

Table 4: Water quality parameters of Kolleru area

S.no	pH X1	Temperature (0°C) X2	Dissolved oxygen (ppm) X3	Ammonia (ppm) X4	Transparency (Cm) X5	Salinity X6	Average body Weight (gms) Y
1	7.5	28	3.4	2.0	30	0	500
2	8.5	30	3.6	0.3	30	0	500
3	9.0	29	3.8	0	30	1	475
4	8.4	30	3.6	0.2	30	0	425
5	7.6	30	3.7	1.0	30	0	450
6	8.5	30	3.8	0.1	30	0	400
7	7.5	28	3.6	1.0	28	0	525
8	7.3	31	4.0	1.5	28	0	450
9	7.6	30	3.8	2.0	28	0	600
10	8.4	30	3.7	0.8	28	0	500
11	8.5	31	3.6	0	28	1	450
12	8.3	30	3.7	0.2	28	1	750
13	8.0	32	5.0	0	30	1	450
14	8.5	28	4.0	0.3	28	0	400
15	8.0	31	4.0	0.1	31	0	500

A) Temperature:

The minimum temperature recorded was 28 °c, maximum temperature recorded as 32 °c (Table 3). The Mean was 29.86, Standard deviation (S.D) was 1.18 and Co-efficient variance (C.V) was 3.97 %. The 't' value for temperature at 0.01 was non significant.

B) Transparency:

The water transparency value remained more or less than same, while the splashing levels showed insignificant change. Mean is 29.13, S.D. is 1.12 and C.V is 3.86%. The 't' value for transparency calculated as 0.55 which is non significant.

C) pH:

The minimum pH recorded was 7.3, maximum value recorded was 9.0 (Table 3). Mean 8.10, S.D. was 0.50 and C.V. was 6.21%. The 't' value for pH calculated as 0.32 which is non significant.

D) Ammonia:

The minimum Ammonia recorded was 0.1 ppm, maximum value was 2.0 ppm (Table 3). Mean 0.63, S.D. was 0.71 and C.V. was 112.86%. The 't' value for alkalinity calculated as 0.61 which is non significant.

E) Dissolved oxygen:

The minimum Dissolved oxygen recorded was 3.4 ppm, maximum Dissolved oxygen recorded was 5.0 ppm (Table 3). Mean was 3.82, S.D. was 0.36 and C.V. was 9.65%. The 't' value for Dissolved oxygen calculated as -0.62 which was non significant.

G) Salinity:

The minimum and maximum salinity value remained more or less the same (Table 3). Mean was 0.26, S.D. was 0.45 and C.V. was 171.65%. The 't' value for salinity calculated as 0.59 which was non significant.

According to MLR the relation between six independent variables and one dependent variable R-Sq (R^2 represents the proportion of total variation explained by all the independent variables taken together the regression equation) was found to be 25.9, which indicated that the variation in Y is explained by the independent variables to the extent of R-Sq ($R-Sq \times 100$ equals) is 25.9 % .

Hence, the 't' value for six independent variables (Temperature, Transparency, pH and Ammonia, dissolved oxygen, salinity) were found to be non significant.

The F value 0.46, for all independent variables and dependent variables was found to be non significant.

Table 5: Water quality parameters of SPSR Nellore area

S.no	pH	Temperature (0°C)	Dissolved oxygen (ppm)	Ammonia (ppm)	Transparency (Inches)	Salinity	Average body Weight (gms)
	X1	X2	X3	X4	X5	X6	Y
1	4.0	30	4.0	1.0	28.0	1	400
2	3.8	28	3.8	1.0	30.0	0	375
3	5.2	31	5.2	2.0	30.0	0	125
4	6.0	30	6.0	0.25	28.5	0	300
5	4.0	29	4.0	1.5	28.5	0	400
6	3.8	30	3.8	0.50	30.0	0	450
7	5.0	30	5.0	0.8	30.0	1	500
8	4.0	30	4.0	0.1	28.5	0	450
9	5.2	28	5.2	0.1	31.0	1	375
10	5.5	29	5.5	0.2	28.0	0	500
11	6.0	30	6.0	0	28.5	0	375
12	4.6	31	4.6	0.2	28.5	1	375
13	4.0	31	4.0	2.0	30.5	0	400
14	3.8	28	3.8	0	26.0	0	625
15	4.0	28	4.0	0	28.0	0	450

A) Temperature:

The minimum temperature recorded was 28 °c, maximum temperature recorded as 31 °c (Table 3). The Mean was 29.53, Standard deviation (S.D) was 1.12 and Co-efficient variance (C.V) was 3.81 % . The 't' value for temperature at -0.51% was non significant.

B) Dissolved oxygen:

The minimum Dissolved oxygen recorded was 3.8 ppm, maximum Dissolved oxygen recorded was 6.0 ppm (Table 3). Mean was 4.59, S.D. was 0.81 and C.V. was 17.77%. The 't' value for Dissolved oxygen calculated as -0.62 which was non significant.

C) Ammonia:

The minimum Ammonia recorded was 0.1 ppm, maximum value was 2.0 ppm (Table 3). Mean 0.68, S.D. was 0.71 and C.V. was 103.76%. The 't' value for calculated as -1.34 which is non significant.

D) pH:

The minimum pH recorded was 7.0 and maximum value recorded was 8.5, (Table 3). Mean was 4.59, S.D. was 0.81 and C.V. was 17.77%. The 't' value for pH calculated as -1.71 which is non significant.

E) Transparency:

The minimum transparency recorded was 28 inches, maximum recorded was 31 inches (Table 2). Mean was 29.63, S.D. was 1.35 and C.V. was 21.85%. The 't' value for transparency calculated as -0.9 which was non significant

G) Salinity:

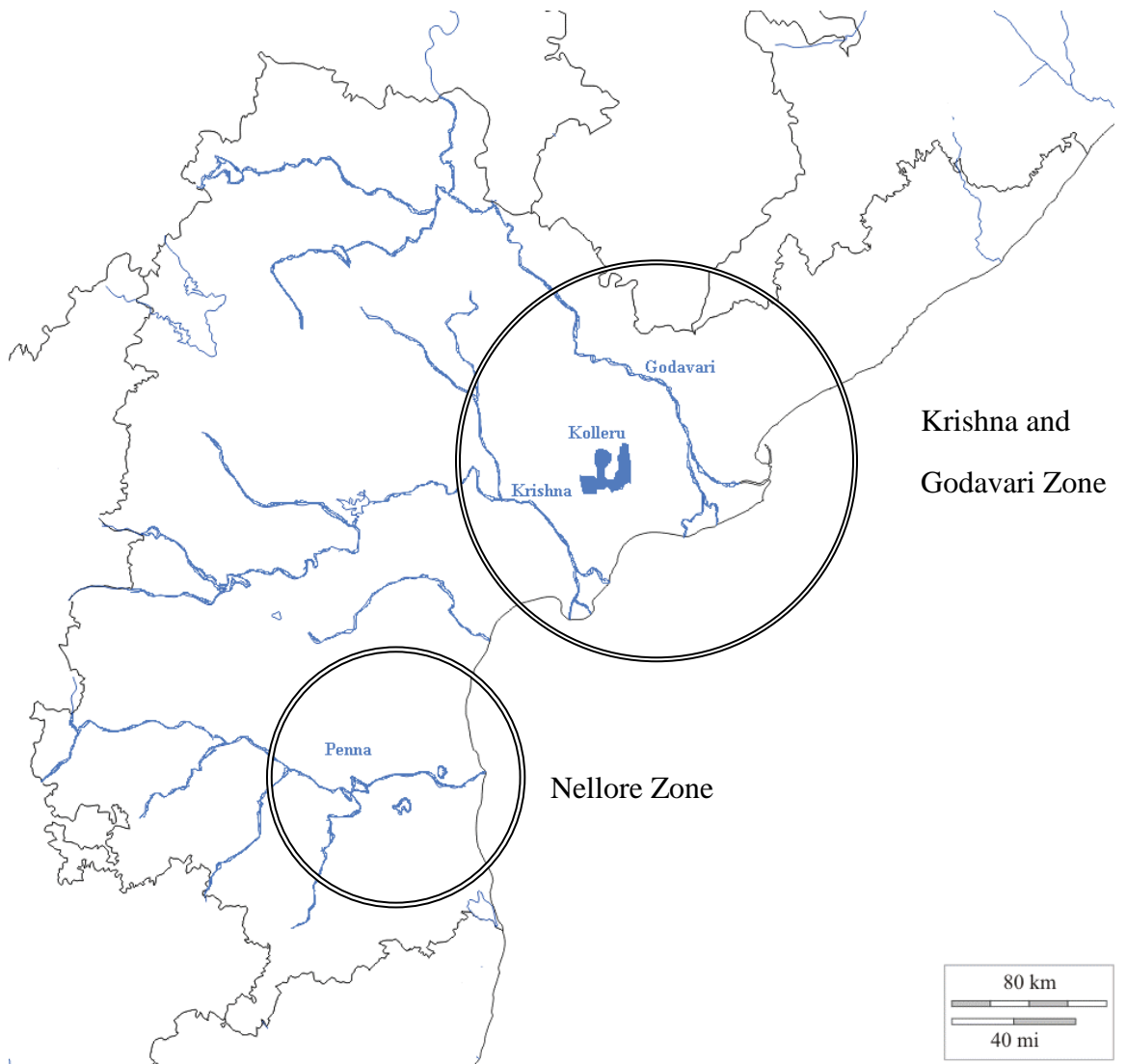
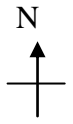
The minimum and maximum salinity value remained more or less the same (Table 3). Mean was 0.26, S.D. was 0.45 and C.V. was 171.65%. The 't' value for salinity calculated as 0.4 which was non significant.

According to MLR the relation between six independent variables and one dependent variable R-Sq (R^2 represents the proportion of total variation explained by all the independent variables taken together the regression equation) was found to be 56.3, which indicated that the variation in Y is explained by the independent variables to the extent of R-Sq ($R-Sq \times 100$ equals) is 56.3% .

Hence, the 't' value for six independent variables (Temperature, Transparency, pH, Ammonia, dissolved oxygen, salinity)) were found to be non significant.

The F value 2.32, for all independent variables and dependent variables was found to be non significant.

GEOGRAPHICAL AREA OF SAMPLING



DISCUSSION

5. Discussion

Deformities are common in both wild and cultured fish populations, but their frequencies are greater in hatchery populations. Available evidence suggests that abnormalities are induced during the embryonic and post embryonic periods of life. Morphological deformity in fishes has been reported in various species and was attributed to various factors viz. nutritional deficiency, stressed conditions in the ecosystem and genetic factors.

Certain commonly observed physical deformities in fish have been associated with exposure to physical, chemical and environmental variables and to infectious organisms. Some have also been attributed to in-breeding and to nutritional deficiencies. The fish with most visible deformities are essentially unmarketable, regardless of whether they are intended for the food or ornamental trade. Though the inland fishing industry is mainly based on carps, records of morphological deformed carps are scantier and limited to sporadically caught specimen only (Raj *et al.*, 2004).

The rapid expansion of fish culture operations in recent times makes fish culturist to solely depend on hatcheries for their seed requirement, where as in the past a major portion of the seed was collected from rivers. In India induced breeding has become the foundation for expansion of Indian major carp culture particularly in the state of Andhra Pradesh. As on 2011, two major areas of fresh water fish culture have become the nuclei for production and they are Kolleru area located in between Krishna Godavari Zone and Sri Potti Sree Ramulu Nellore District. For the entire operations of the Indian major carp culture in Andhra Pradesh, the lion's share of seed is being produced in Kolleru area being a predominant centre for carp culture is known as the 'Carp Pocket of India'. On an average, 160-170 trucks transport fish daily from

Kolleru lake area (on average 1130 t /day) (Ganesh Kumar, *et al.*2010). During the present study out of the total pond harvested fish biomass of nearly 44tonnes, 0.086% show different types of deformities at market size. The 0.086% of deformity may seem smaller as this is only for 44tonnes. But this becomes a larger share if the total output of 1130t/day is considered. The selected physical deformities that are externally identified include spinal deformities, opercular deformities and fin deformities.

Spinal Deformity:

Spinal deformity was the most predominant (84.21%) among all observed deformities in two cultured species of Indian major carps *Catla catla* and *Labeo rohita* (Fig.1). Fishes with spinal deformities were swimming either upside down or sideward, and the growth was slow compared to a normal fish (Fig.7). The vertebral column is a defining character of the vertebrates providing the organism with a unique ability of movement, form the function. Spinal disorders are the major cause of disability for intensively farmed animals. According to Ytteborg *et al* (2010) in teleosts, hyperthermia can induce vertebral deformities both during the embryonic development and after the vertebral column has been established. Spinal fusions involves transformations of inter vertebral notochord tissue into cartilage, shape alternations of vertebral body end-plates, mineralization of the intervertebral cartilage and replacement of inter vertebral cartilage by bone (Witten Pe, *et al.*, 2006).

The X-ray radio graphs of normal and deformed fishes in the study show vertebral deformities clearly in the deformed fishes compared to normal fish (Fig: 9)

During this an extreme case of observations was recorded from the SPSR Nellore region where the fish harvest from a 0.6ha pond yielded 18% of the fish as deformed category (Granamoru in Telugu). There was no value for the fishes. The fish trader did not buy the

deformed fish and left the material near the farm pond. The expected loss of revenue to the fish farmer was nearly Rs.10350 from 230kilograms of deformed fishes. This amount becomes a sizeable income to the fish farmer.

Abnormalities are reported to be caused by various factors like infectious agents (Hoffman, 1990), no proper husbandry or rearing, hypoxia, nutritional imbalance and genetic factors (Bruno, 1997), which ultimately leads into permanent ailment. Experimental avitaminosis C caused retarded growth and high mortality associated with vertebrae deformation, lordosis, scoliosis and hematological changes in *Cirrhinus mrigala* (Al-Habri, 2001). Several factors can interfere with the normal development of larvae and affect larval quality (Chantal *et al.*, 2003). Andradas *et al* (1996) reported that only a few percent of larvae affected by skeletal (lordotic) malformations can survive after larval development leads to significant loss of money to the hatchery operator.

Pond management strategies differ depending on pond sizes, often involving extensive treatment with assorted organic and inorganic fertilizers and other chemical compounds (Boyd, 1995).Marcel (1990) reported that such practices can increase the risk of developmental deformities. This study observed that the fish farmers have been using cattle dung and poultry manure at a rate of 4-10 tonnes per hectare and chemical fertilizers at a rate of 500-1000 kg per hectare during a crop period. The transparency levels recorded in this study ranged from 26-31 cm and the appearance of pond water clearly states that the Indian major culture practiced in Andhra Pradesh is highly 'plankton' based. Thus the application of these inputs may support the developmental deformities in future. This aspect needs future study. Chicken manure added to ponds has been reported by Liu and Wang (1987) as one cause of gill deformities in tilapia.

Hussain and Mazid (1997) and Sardar (1998) reported reduced growth, physical deformities, diseases and high mortality in hatchery produced carp seed and they have reported

improper brood stock management, unconscious negative selection of broods, unplanned hybridization and inbreeding as the probable reasons behind these reduced performance.

The work of Eknath and Doyle (1990) and Basavaraju *et al* (1997) clearly indicated that inbreeding depression and negative selection for growth in domesticated stocks of Indian major carps. This becomes a cause of concern and objectives of the present study to record the status of physical deformities among the Indian major carps in farming.

Among the nutritional aspects, Retinoic acid was identified as one critical factor causing vertebral deformity in Japanese flounder *Paralichthys olivaceus* (Haga *et al.*, 1999). Many studies have reported the role of vitamin A in skeletal malformations of larvae produced in hatcheries. This aspect needs further study.

Heritability:

Genetic factors also play a substantial role in the spinal deformities seen in salmon and it is recommended not to select breeders from families showing high incidences of deformed fish, to prevent the increase in the genetic susceptibility in the population (Gjerde *et al.*, 2005). Lodi (1978), McKay and Gjerde (1986) observed that spinal deformities can be heritable. Based on this observation an attempt has been made in the present study with the help of a private hatchery located in Guntur District. According to this observation the physical deformity (Scoliosis) is non-heritable at least during the observation period of 60 days. The experienced hatchery owner also is of the same opinion that he never rejected the brood fish with deformities for breeding purpose since the deformities are non-heritable.

However physical deformity is an indication of inferior quality and reflection of certain deficiency during the growth of an individual, this study recommends avoiding use of brood fish with any physical deformities.

Other Deformities:

After the spinal deformity, the identified deformities include stump body (7.89%) (Fig.5), opercular deformity (5.26%) (Fig.3), Fin deformities (2.63%) (Fig: 4) and mouth hyperplasia (2.63%) (Fig:6).

Stump body was reported by Tave *et al* (1982) in *Sarotherodon Aureus* and in *Ictalurus punctatus* by Dunham *et al* (1991) and was found to be non-heritable.

Opercular deformities have been reported by many workers as a result of Vitamin C deficiency. Handverker and Tave (1994) reported opercular deformity as non-heritable. The present study was unable to consider the nutritional aspect since the fishes were fed supplementary diet as the main diet course for the fish has been plankton only.

Tutman *et al* (2000) reported that a wide range of physical, chemical and biological factors cause morphological deformities of fins in natural and reared conditions. Koumoundouros (2008) reported that fin deformities can hinder the movement of fishes and thus they became less capable to catch prey or avoid predator, but may not significantly affect fish survival. However they can limit the sexual play during reproductive activities.

Fish farmers quite often use organophosphates to control fish ectoparasites. This toxic effect can induce behavioral and morphological changes mainly due to the inactivation of Acetylcholine esterase. Caudal bending was the main morphological alternation during the exposure period.

Since carps are highly fecund, hatchery operation tend to maintain a low affective population size (number of brood stock that contributes genetic material to the next progeny) and do not exchange brood fish between hatcheries. Poor performance of resultant seed had been linked to inbreeding of carps in India (Eknath and Doyle, 1985). In response to this, the Indian

Council of Agricultural Research (ICAR) has developed “Jayanti Rohu” to improve the genetic performance of the predominant and popular fish among the fish farmers.

To protect the felt needs of fish farmers, the Government of Andhra Pradesh introduced the Aquaculture fish seed Act, 2006.

Despite all this responsive actions by the Government, farmers are still dependent on unregulated private seed producers and traders. Padhi and Mandal (1997) reported communal or mixed spawning system in West Bengal have been producing approximately 10% hybrids which may lead to loss of important major carp genetic resources. Quality fish seed is the most critical input to enhance the productivity and production of fishes .But, there are no organized brood-stock production and management facilities in the country. Fish farmers often complain about poor growth of fish procured from particular hatcheries. Hence in the absence of proper breeding plans, this has led to a gradual decline in the genetic quality of the seed.

Another aspect, which may also pose a problem, is the growing trend of replenishing the rivers, lakes and reservoirs (Ranching) with the hatchery produced seed in many states in India (Mishra and Raman, 1993) and even in the neighboring countries like the Bangladesh. Deviations brought about in the gene pool of survivors to that of the original populations affected by pollution will ultimately be reflected in future populations (FAO, 1980). Population size is the single most important factor in sustaining a high level of genetic variation with in a population (Frankel and Soule, 1981). Therefore it is important to restore the size of populations wherever trends of decline are indicated. In this context the present study has made an attempt to gauge the impact of poor performance of the major carps particularly *Catla catla* and *Labeo rohita*. It may be difficult to understand qualitative changes in the form of deformities at the level of fry or fingerlings but the familiarity of these at harvest size can sensitize people so that the message of abnormalities go a long to make fish culture sustainable and profitable by avoiding risks.

SUMMARY

6. SUMMARY

Aquaculture is one of the fastest growing food-producing sectors, providing an acceptable supplement to and substitute for wild fish. Freshwater aquaculture in India is dominated by Indian Major Carp (IMC), contributing more than 80% of the total Inland fish production.

Non-infectious production related problems are recurrent in aquaculture and are of welfare concern. Cultured fishes and fishes in managed ecosystems seem particularly susceptible to developmental deformities. One reason is decreased survival of less fit individuals that might be subject to disease or predation under natural conditions (Sindermann, 1988; Tave And Handwerker, 1994). Developmental anomalies are not always detrimental. Many of these deformations are thought to be caused by hereditary and/or environmental factors, as they are not associated with specific infectious agents.

Fluctuation in water temperature is considered to be one of the causes of the spinal deformities (Al – Hassan, 1982, Wang and Tsai, 2000) as sudden change in water temperature may lead to abnormal muscle growth and spinal deformity. In this study, the areas where the fish were sampled are not exposed to variation in temperature, hence it is unlikely that the vertebral abnormalities been induced by a drastic change in temperature during its larvae life or thereafter. Out of 44 tonnes of fish examined, 0.086% fish were deformed. The causes of all these deformities may be, and probably almost certainly are,

complex. Some are incidental, and have little or no impact on fish or farmer, but some can be very costly in both welfare and financial terms.

This study observed that the fish farmers have been using cattle dung and poultry manure at a rate of 4-10 tonnes per hectare and chemical fertilizers at a rate of 500-1000 kg per hectare during a crop period. The transparency levels recorded in this study ranged from 26-31 cm and the appearance of pond water clearly states that the Indian major carp culture practiced in Andhra Pradesh is highly 'plankton' based. Thus the application of these inputs may support the developmental deformities in future. This aspect needs further study. Chicken manure added to ponds has been reported by Liu and Wang (1987) as one cause of gill deformities in tilapia.

In a sustainable biological production, we expect the fish that are produced will be healthy and normal. During the course of this research, an extreme case of observations was recorded from the SPSR Nellore region. Over 18% of the harvested fish were deformed (Granamoru in telugu). There was no value for the fishes. The expected loss of revenue to the fish farmer was nearly Rs.10350 from 230kilograms of deformed fishes. This amount becomes a sizeable income deficit to the fish farmer.

In the case of deformities which have an impact on welfare, whatever the level of incidence, their presence will raise the ethical question of whether or not aquaculture should continue if fish cannot be produced without significant levels of deformity occurring. However it should be remembered that many of the deformities seen in larger fish are the natural product of population which is not exposed to natural selection

pressures, resulting in many fish being kept alive in aquaculture which would normally die or be predated in the wild. This will result in an unnaturally high level of 'natural' deformities, and could support an argument in favour of continuous grading and culling of affected fish. But there are also undoubtedly factors occurring in aquaculture which can, and do, contribute to these problems, and some of these will be inevitable as production methods change within what is actually a relatively new farming venture.

However, the research effort being invested into causes of deformity in aquaculture is considerable, and the aquaculture industry has been quick to adopt corrective measures as soon as these measures have been defined, as has been demonstrated by the significant improvements seen in the incidence of vertebral deformities in fish over recent years. More work is clearly needed though and is a part of a continuing process.

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APPENDIX

APPENDIX

The Survey Data Sheet

Standard Questionnaires of Survey:

Dt:

1. Name and Address with phone no. :

2. No. of ponds :

(Nursery_____ Rearing_____ Growout_____)

3. Culture period_____ Depth of water_____

4. Stocking Details:

Stocking Date	Culture period	Species	Number (acre)	Avg. size at Stocking (kg-gr)	Avg. size at Present (Kg-gr)	Biomass

5. Seed source :

6. Water quality parameter :

i) Temperature :

ii) Dissolved oxygen:

iii) Ammonia :

iv) Water pH :

v) Transparency :

vi) Salinity :

7. Morphological deformities of carps (IMC) collected at farms

Deformity	Juvenile/nursery/rearing		Adult/grow-out/harvested	
	Number of fish sampled	Percentage of deformed fish	Number of fish sampled	Percentage of deformed fish
Split fins				
Scale disorientation				
Mouth hyperplasia				
Opercular deformity				
Gill deformity				
Lowerlip protrusion				
Jaw deformity				
Mouth protrusion				
Eye deformity				
Skeletal deformity				
Total no. of fish examined				