PRESENT STATUS OF HATCHERY OPERATION IN CHAMPARAN OF BIHAR AND POSSIBLE IMPACT ON AQUACULTURE

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In

AQUACULTURE

By

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CERTIFICATE

This is to certify that the work embodied in the thesis entitled "**PRESENT STATUS OF HATCHERY OPERATION IN CHAMPARAN OF BIHAR AND POSSIBLE IMPACT ON AQUACULTURE**" submitted by **Arpna Kumari** in partial fulfilment of requirements for the **degree of Master of Fishery Science (Aquaculture)** in the Faculty of Fishery Sciences, West Bengal University of Animal and Fishery Sciences, is the faithful and bonafied 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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Dedicated

to my

Nanajee (late Sri Baidnath Singh)

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Date:..................... **(Arpna Kumari)**

Place:...................

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LIST OF ABBREVIATIONS

CPE	Carp pituitary extract
PG	Pituitary gland
GnRH	Gonadotropic releasing hormone
LHRH	Leutenising hormone releasing hormone
Hr	Hour
IMC	Indian major carp
Max	Maximum
Min	Minimum
Ha	Hectare
Ne	Effective breeding population number
Bati	Spawn measuring cup
ANOVA	Analysis of varience
CaO	Calcium oxide
MDG	Millennium Development goal
GDP	Gross domestic product
M:F	Male: Female
$KMnO_4$	Potassium permanganate
GTH	Gonadotrophin hormone
Mg	Milligram
Fig	Figure
N/A	Not available
NPC	Nitrogen Phosphorus carbon
NPK	Nitrogen Phosphorus Potassium
HCG	Human chorionic gonadotropin
ATMA	Agricultre technology management agency

INTRODUCTION

1. INTRODUCTION

Aquaculture plays an important role in global efforts towards eliminating hunger and malnutrition by supplying fish and other aquatic products rich in protein, essential fatty acids, vitamins and minerals. Aquaculture can also make significant contributions to the development by improving incomes, providing employment opportunities and increasing the returns on resource use. According to FAO figures, aquaculture alone directly created 12 million full-time jobs in Asia in 2004. It significantly contributes to the national GDPs in many developing countries in Asia and Latin America. With appropriate management, this sector appears ready to meet the expected shortfalls in fish supplies for the coming decades and to improve global food security (FAO, 2006). Fisheries and aquaculture play an important role in the economic development of Asian countries, contributing to increased animal protein intake, household income, employment generation and foreign income earnings. Being a primary food producing sector, aquaculture's most immediate contribution to the achievement of the Millennium Development Goals (MDG) is the eradication of poverty and hunger. Reducing hunger through increased production and availability of fish either to producers or to non producers for purchase at local markets may, as outlined in the World Nutrition Report 2004, contribute indirectly to all of the MDG goals (Siriwardena, 2007). Aquaculture also makes an important contribution to national Gross Domestic Product (GDP), accounting more than 1 percent of GDP in six countries worldwide (Sugiyama *et al.*, 2004). Freshwater aquaculture contributes more than 50 percent of the total aquaculture production in majority of the leading aquaculture producing countries in Asia. A most notable feature of the aquaculture sector in South Asia is that most of the produce comes from inland waters; hence freshwater aquaculture is the primary area gaining more importance by days. As per study conducted in 2003 culture mainly restricted to species such as bighead carp, grass carp, silver carp, common carp, rohu, catla and mrigal, and accounted for 88 percent of the total freshwater aquaculture production. Freshwater fin fish alone accounts for 98.8 percent of total finfish aquaculture production. Again, aquaculture production in terms of quantity is diversified. Freshwater aquaculture production is 39 percent out of the total aquaculture production. The aquaculture sector is expected to contribute more effectively to global food security, nutritional well-being, poverty reduction and economic development by producing - with minimum impact on the environment and maximum benefit to society - 85 million tonnes of aquatic food by 2030, an increase of 37 million tonnes over the 2005 level (FAO, 2007).

As food fish is considered as the most important source of animal protein for many Asian countries, including China, so aquaculture play a critical role in countries where the population is dependent on fish. Meeting the demand resources such as water, land and fish seed and inputs such as feeds, fertilizers, etc. play an important role. Lack of quality fish seed supply is often acted as a bottleneck for freshwater aquaculture development in rural areas of many countries in the region (Siriwardena, 2007). Freshwater fin-fish culture is the most important form of aquaculture in providing nutrition to the poor in the Asia-Pacific region with India being only second to China in the scale of world inland aquaculture production (Csavas, 1993).

In the Asia-Pacific region 95% of the inland fin-fish species produced in 2000 were of the non-carnivorous 'cheap' varieties, of which 82% comprised of carps (FAO, 2002) which are the primary types of fish cultured in India. Of these, Indian Major Carps (IMC), comprising of rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhina mrigala*), are the primary species cultured in India with exotic carps, catfish and tilapias being the other main contributors.

Bihar has a span of 361 thousand hectares of water area. This constitutes around 3.9 percent of the total geographical area. There exists, therefore, an ample opportunity of providing gainful employment to rural households through pisciculture. Fish production in the state has been showing a steady growth. The contribution of fisheries sector in GSDP has doubled during the last ten years. Better management and credit inflow to fish farmers would usher in a new era of development for this sector which could contribute to the growth of GSDP. In 2004-05, the total production of fish in Bihar was 2.67 lakh tonnes. There was steady increase of fish production thereafter and it reached to a level of 3.06 lakh tonnes in 2008-09. In 2009-10, the level of production has come down to 2.97 lakh tonnes. The year wise production of fish is presented in table given below. From the (Table 1), it is estimated that the rate of growth during the period 2004-05 to2009-10 was 2.58 percent per annum.

Table 1: Annual Production of Fish in Bihar

Year	Fish Production (lakh tonnes)
2004-05	**2.67**
2005-06	**2.79**
2006-07	**2.67**
2007-08	**2.88**
2008-09	**3.06**
2009-10	**2.97**
CAGR	**2.58**

Source: Department of Animal Husbandry, GOB

The state government has taken several steps for the development of fisheries sector in general and for the betterment of fish farmers in particular. Provision of better credit facilities and extension services in the form of education and training to fish farmers has been important landmarks for the development of this sector. The state government schemes like distribution of fingerlings, training of fish farmers, distribution of loans for maintenance and renovation of private ponds and free housing for fishermen have immensely benefited the fishermen of the state. In 2009-10, a record 3307.85 lakh fish seeds were produced and distributed in the state. The district wise figures for production of fish and fish seeds for the year 2009-10 are presented in Table 2. The data reveals that districts falling in Darbhanga Division, namely Darbhanga, Madhubani and Samastipur are major producers of fish. The level of fish production in these districts and their share in total fish production in Bihar are as follows — Darbhanga (16.90 thousand tonnes, 5.68 percent), Madhubani (16.49 thousand tonnes, 5.54 percent) and Samastipur (12.40 thousand tonnes and 4.17 percent).

Table 2 : District wise production of fish and fish seeds for the year 2009-10

District	2009-10	
	Fish Production (000 tonne)	Fish Seeds (Lakh)
Patna	9.65	8.00
Nalanda	10.00	143.00
Rohtas+Kaimur	7.00	90.50
Buxar	5.20	0.00
Bhojpur	4.30	2.36
Gaya	1.65	0.00
Aurangabad	7.60	175.00
Jehanabad+Arwal	3.20	0.00
Nawada	8.09	13.00
Saran	13.90	100.00
Siwan	3.35	140.00
Gopalganj	9.80	0.00
Muzaffarpur	14.08	197.00
Sitamarhi+Sheohar	15.30	160.00
W. Champaran	14.30	232.00
E.Champaran	12.65	161.80
Vaishali	9.40	0.00
Darbhanga	16.90	270.00
Samastipur	12.40	0.00
Madhubani	16.49	221.00
Saharsa	12.00	180.00
Supaul	5.50	63.00
Madhepura	10.55	90.00
Purnea	8.50	50.00
Araria	3.92	41.00
Kishanganj	4.46	58.19
Katihar	12.30	220.00
Bhagalpur	7.96	127.00
Banka	5.00	45.00
Munger+Sheikhpura+Lakhisarai	9.30	90.00
Begusarai	9.90	255.00
Jamui	3.75	20.00
Khagaria	9.00	155.00
Bihar	**297.40**	**3307.85**

1 million=10 lakh

Source: Department of Animal Husbandry, GOB

Champaran is situated in the NW part of Bihar. The total area of Champaran is 9196 Km^2 with a total population of 62,67,302 (Census 2001). It is the border part of India with Nepal. This town is known as the **Gate way to Nepal**. It is connected by **NH28A** and is 32 km away from Chhapawa (on NH28A), 52 km from Motihari (the District Town) and 60 km from Bettiah. **Birganj** - the Second Big City of Nepal is just 3 km away from this town. About 80% of the population of this region Prefer to eat fish.

The 'Machura or Mallah community' referred to as exclusive fisherman community hails from this region in Bihar. Champaran contributes about 11% (393 lakh) and 9% (27,000 tonns) of fish seed and fish production of Bihar respectively. Among the two districts, Bettiah leads in total fish seed production. It is worth mentioning that Bettiah is third only to Darbhanga and Samastipur districts in respect of fish seed production in the state. Champaran has one of the oldest and the largest fish market in Bazar samiti, Bettiah. The enterprising fish seed producers of Bettiah and Motihari districts enjoy the monopoly of the fish seed production business in the Champaran.

The fish seed being the major input for fish farming, there is always a growing demand of quality fish seed. The uncertainty in the quality and quantity of riverine fish seed collection led to development of many eco hatcheries in the state.

The annual fish production of the State, both from aquaculture and capture fisheries, has been estimated at 261 thousand tons against a demand of approximately 456 thousand tons based on the nutritional requirement of 11 Kg per capita per annum. This has remained almost stagnant for many years. As reported by the state fisheries department, the deficiency is partially met by importing fish from other states like Uttar Pradesh, and West Bengal causing a drain out of money from the state. Evidently, there exists a wide gap between demand and supply, to the tune of 43%, which is quite paradoxical in view of the vast fisheries resources in the State. The unmet demand is partly met from supply of fish from other States. Similarly, the annual demand of fish seed in the State is over 900 million, while the production is only about 350 million from the 121 government fish seed farms, two corporate level fish hatcheries, and 26 private hatcheries (Fisheries Policy 2008, GOB). During 2008 the annual production of fish seed from 28 hatcheries and121 government fish seed farms were around 350 million and till now (2009-10) in spite of presence of around 62 hatcheries along with government fish seed farms the annual production is limited to 330 million, showing no improvement in production.

Difficulties in accessing adequate quality fish seed is therefore considered constrain in production, business and food fish supplies. Deficiencies in fish seed supply in India were anticipated in the early eighties with the level of production was not able to satisfy less than half of customer and consumer demands at the time (Pathak, 1990).

The State is endowed with rich aquatic and fisheries resources in the form of rivers, flood plains, wetlands (*chaurs*), ox-bow lakes *(mauns)*, reservoirs, tanks and ponds. The main culture fishery resources of Bihar lie in over 43,000 ponds and tanks of variable sizes covering a total area of about 65,000 ha distributed throughout the length and breadth of the State. Flood plains and other wetlands locally known as *chaurs* are other major fisheries resources covering an area of about 45,978 ha which are found mainly in the basins of Kosi-Gandak river systems of North Bihar. Estimate prepared by Irrigation Department indicate several fold higher figure. Ox-bow lakes, locally known as *mauns,* are the discarded loops of meandering rivers which got cut off from the main rivers and is estimated to be about 9,000 ha. The 29 reservoirs in the State covering total water spread area of about 11000 ha is an important resource for fisheries development. Besides, 3200 km of rivers are the main resource for capture based fisheries in the State(Fisheries Policy 2008, GOB).

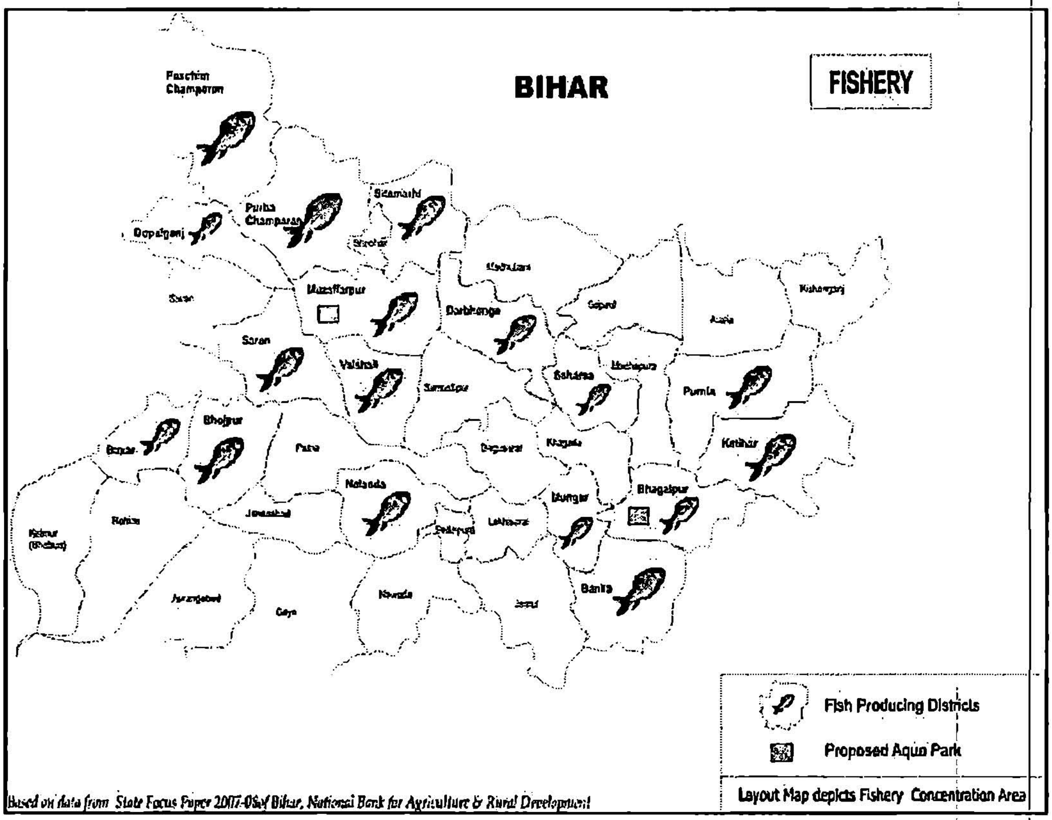

Fig 1: Fish producing districts of Bihar

On one hand the State has huge underutilized and untapped fisheries resources which offers immense potential for fish production and scope for the development of rural livelihoods, while on the other, the state still depends for supply of about half of its demand of fish from other states. The very low average productivity in all culture based fisheries sector, poor socio-economic condition of fishers and fish farmers, lack of adequate public and private investment and capital flow into fisheries sector, lack of awareness about aquaculture as a viable and profitable economic activity, non availability of adequate and professionally skilled human resource, ineffective and redundant services delivery systems, poor infrastructure facilities, etc have all been responsible for the limited growth and development of fisheries sector in Bihar. *Thus there is an urgent need to bridge the gap between demand and supply of food fish and fish seed by effective and sustainable utilisation of available resources.*

Although in India induced breeding technique of carp was developed way back in 1957, the actual momentum of hatchery seed production in Champaran of Bihar began during nineties when two progressive fish farmers established Chinese hatchery at Bettiah and Motihari districts in Champaran. Observing the success of these two hatcheries, many progressive farmers who were earlier engaged in hapa breeding and nursing, started establishing carp hatcheries in several districts of Bihar in early part of 90's. Initially, the technology of carp seed production employing Chinese hatchery was infused to Bihar from West Bengal. Technical support for establishing the eco hatchery in the state was mainly provided by the illiterate fish breeders of Bengal who are ignorant about the scientific basis of the technology. So the hatchery establishment in Bihar started with this sort of primary defect in the transfer of technology.

Realizing its profitability, many people from the private sector established similar type of hatchery and as a result most hatcheries came up with similar design and capacity. This resulted in mushroom growth of hatchery in private sector and this undoubtedly contributed significant increase in total quantity of hatchery raised fish seeds in Bihar. As the initial investment for establishing a carp hatchery is more, the fish breeders adopted the technology only for profit making proposition and as such quality never considered as a criteria. As a result the total fish production did not increase significantly although the total seed production has gone up considerably.

This study was undertaken to review the modus operandi of fish seed production technology in the farming sector of the Champaran of Bihar with a view to find out the consequences of such practices in the Aquaculture sector of the state. The study was undertaken with the following objectives:

1. To study the present status and mode of hatchery operation in Champaran of Bihar.
2. To Study the possible impact of unscientific and profit making approaches in hatchery operations on aquatic biodiversity.

REVIEW OF LITERATURE

2 REVIEW OF LITERATURE

2.1. Back ground of fish breeding and hatchery operation

According to Andersen, O., and Hayes, B., (2005), 'The aim of fish breeding is not to change individual fish, but rather fish population. 'With the introduction of induced breeding technique for fish breeding, the technology of fish breeding has revolutionized the entire fishery industry. Science its introduction the technology for fish seed production in captivity was infused to innumerable hatcheries. Fish farming started 4000 to5000 years in China. Artificial hatching of fish was already practiced in China around year 2000BC (Lin, 1940).

In fact the technique of induced breeding proposed nearly 60 years ago by Prof. B.A. Housay of the university of Buenos Aires, Argentina and Dr.R.Von Ihering of the Department of fisheries, Brazil. In India, Khan (1938) was first to successfully induced *Cirrhinus mrigala* to spawn by injecting mammalian pituitary hormone. Dr.H.Choudhary (1956) succeeded in inducing *Esomus danricus* to spawn by intra peritoneal injection from pituitary gland from *Catla catla* . Ramaswamy and Sundararaj (1956) succeeded in inducing spawning of *Heteropneustes fossilis* and *Clarius batracus*. Later, several carps *Labeo rohita, Labeo bata*, *Cirrhinus mrigala*, *Cirrhinus reba, etc.* were successfully bred by injecting pituitary extract (Choudhury and Alikunhi, 1957). Ever since 1957, carp breeding by hypophysation is an established technology in India. An epoch discovery for carp seed production in confined waters revolutionized the fish seed production in India.

Even though the induced breeding technique of carp in India was developed way back in 1957, in champaran the 1st hatchery was established during 1991 and a span of 20 years the numbers increased to 23. With the increasing number of hatcheries in the private sector, the Bettiah and Motihari district in Champaran (Bihar) soon became the one of the most important centre for hatchery produced carp seeds. Initially, the technology of carp seed production employing Chinese hatchery was brought to Bihar from neighbour state of West Bengal. In addition to the government support, successful fish seed producers of West Bengal were contacted to seek technical assistance in hatchery construction, induced breeding and hormone supply (pituitary gland) by few progressive fish farmers. These farmers also visited many successful fish seed production centre in West Bengal before venturing into this new business in Bihar.

2.2. Status Design and Mode of hatchery operation

2.2.1. Design and operational aspect of circular carp hatchery

Rath *et al*, (1997) reported that the commercial seed production has attained the status of industry in India. Advances made in the design and construction and management of hatcheries have undoubtedly contributed a lot to promote major carp seed production. A carp hatchery can be defined as 'formulated infrastructure to facilitate spawning of brood fish, incubation of fertilized egg and rearing of the hatchlings there from up to post larval stage'. Based on ecological factors responsible for carp breeding in nature and following hypophysation technique, eco hatchery was first formulated in China during late fifties and early sixties (1958-1963). The standardized technology of eco hatchery construction and operation was brought to the aquaculture sector in India during eighties. Since then the chines hatchery has been gaining popularity for carp seed production on commercial scale throughout India.

Rath, S.C., and Gupta, S.D., (1997) stated that the carp hatchery complex comprises of water source and supply units; brood spawning unit; egg incubation unit; and larval rearing unit.

Sahoo et al (2001), reported that a carp hatchery complex generally consists of the brood stock unit having ponds varying from 0.1-1.o ha; the main hatchery unit for spawn production; the nursery unit for raising fry from stocked spawn (4-5mm to 25-30mm); the rearing unit for raising fry to fingerlings (50mm and above); and the packaging and marketing unit. Of these, the main hatchery unit (eco hatchery) for spawn production comprises of spawning pool; incubation pool; spawn collection pool and water supply units.

2.2.2. Operational aspects of spawning and hatching pool

Rath, S.C., and Gupta, S.D., (1997) reported that the diameter of the spawning pool may vary from 6m-8m while depth 1-1.5m for a standard commercial carp hatchery with water depth of 0.6-1m depending on the density of the brood in the spawning pool. It is observed that the water current before or just after the hormone administration; or before one hour of calculated spawning time initiates the extrulisation (excitement of the spawners) and spawning ensue. The flow rate in the spawning pool with a velocity of 0.3-0.5 m/sec is reported. Effective spawning time noted to be $1\text{-}1^1/_2$ hr from the time of initiation of spawning. So, the breeding pool should be operated for a maximum period of 3 hrs starting from the initiation of spawning.

Similarly, in the hatching pool, the standard size of the outer chamber; depth of the pool ranges from 1-1.5m; and the mesh size of the screen used is 1/60 inches-1/80 inches. The flow rate in the pool is maintained at 0.4-0.5 m/sec for first twelve hrs; 0.1-0.2 m/sec for next six hrs; and 0.3-0.4 m/sec for rest of the operation.

2.2.3. Flow Rate in spawning pool and hatching pool

Thomas *et al.*, (2003) reported that the flow rate in the spawning pool should be between 3-5 m/sec while in the circular pole between 0.2-0.5 m/sec. Water current is not required before or just after incubation. Flow rate is allowed one hour before the calculated spawning time, which initiates the excitement to the spawners and results in spawning. The spawning is usually completed within 1-1.5 hours of initiation. Water flow can be stopped soon after the spawning is over. The recommended speed of water flow in the hatching pool is maintained at 0.4-0.5 m/sec in the first twelve hours and then at 0.1-0.2 m/sec in the next 6 hours and then again increased to 0.3-0.4 m/sec for rest of the operation.

Rath, S.C., and Gupta, S.D., (1997) also reported the same flow rate in the spawning and hatching pool as above.

Rath *et al.*, (1999) observed that the Grass carp preferred the reduced flow rate of 2-3 m/sec and less water depth(0.5-0.6 m) for spawning.

Sahoo (2001) reported a flow rate of 0.2-0.3 m/sec in both the spawning and hatching pool as the standard velocity of flow.

2.2.3. Mode of hatchery operation

2.2.3.1. Brood stock management

Little, Satapornvanit and Edwards (2002) have emphasized the importance of fresh water fish seed quality in Asia and suggested criteria for selecting good quality seed for aquaculture.

Hussain and Mazid (1997) reported reduced growth, physical deformities, diseases and high mortality in hatchery raised carp seed and they have identified improper management of brood stock, unconscious improper selection of broods, unplanned hybridization and inbreeding as probable reasons behind these reduced performance. Recent studies revealed high rate of inbreeding and inter-specific hybridization in both endemic and exotic carps (Simonsen *et al.*, 2005, Simonsen *et al.*, 2004; Alam *et al.*, 2002).

The FAO Code of Conduct for Responsible fisheries (CCRF) emphasizes that proper attention should be taken for brood stock management to avoid inbreeding; maintain stock integrity by not allowing hybridization between different stocks, strains or species. This certainly minimizes transfer of genetically different stocks and periodically assessing their genetic diversity (i.e. laboratory genetic analysis). Inbreeding, inter-specific hybridization, negative selection of broods, improper brood stock management are reported as common phenomena in hatcheries, particularly in small-scale hatcheries.

Gupta *et al.*, (1995) observed that although most carps attain first maturity in 1 to 2 years, there is an optimum age and weight at which they should be selected for induced breeding. In order to develop potential brood stock for hatchery use usually carps that are of 2-3 years and not above 5 years are collected and reared. Usually, fish that have bred at least once in the earlier year have been proved better for breeding work. Such fishes are named 'professional brood stock'. It was also stated that the stocking density is maintained at 1000 kg/ha with 25- 30% water replenishment at least once in a month (January-March). It was suggested to select the perspective spawners and rear at least 5-6 month before the breeding season in the stocking pattern 'main species': rest=60 %(each for species).

Siriwardena (2007) observed that brood stock is a prerequisite for all types of hatchery production and proper brood stock management exhibit breeding responses and increased fecundity, fertilization, hatching and larval survival rates and more viable fish seed. Small- scale hatchery owners practice multispecies brood stock in one or two ponds with high stocking densities, which are underfed or fed with low quality feed. This limit the potential of each stocked fish species in terms of maturation, fecundity, fertilization, hatching success and survival rates. It is reported that these hatcheries rarely recruit new broods from outside without any inflowing of new genetic material. The common practice of using the same brooders more than once in a breeding season results in deterioration of larval quality, mortality and larval deformity.

Siriwardena (2007) reported that selective breeding and hybridization programmes of pedigreed fish are not carried out in fish seed farms. The good practice of transferring spawners after spawning to a resting pond without mixing with ripe males and females is also ignored in many small-scale hatcheries.

Eknath (1985b) refers brood stock management to the aggregates of methods that the farmer uses to handle his animals in the farm. These methods include feeding, spawning and culling animals under aquaculture conditions. Management practices can be defined in terms of genetics as 'domestication selection'. He reviewed observations of animal breeders who had recognized the changing physiology and behavior due to domestication selection in aquaculture condition in trout (Vincent, 1960; Reinsenbichler and McIntyre, 1977; Ryman and Stahl, 1980) in carps (Wolfforth et al, 1975; Moav and Wolfforth, 1975). In Channel cat fish (Burnside et al, 1975; Broussard and Stickney, 1981) and in tropical aquarium fishes (Gordon, 1957). Appropriate estimation of genetic change by domestication selection are defined in terms of selection differential and selection intensity by Eknath (1985b). He concluded from one of his experiments that selection by domestication was very strong, and that it would lead to genetic change. Selection intensity on economic traits can be very high in the hatchery environment, but this selection intensity might be in a different direction from the artificial selection goal. Therefore, brood stock management studies should be included into the selective breeding programmes. Furthermore, the brood stock management programme should be the first genetic research priority.

Padhi, (2000) viewed that collection of brood stock in adequate number, cataloguing of their geographical origin, their genetic characterization and maintenance of their pedigree record are important pre-requisites for breeding programme. These aspects are of much genetic relevance. Further, proper feeding of brood stock and their health maintenance some important management aspects.

Dutta, (2000) reported that low survival and reduced growth potential of hatchery produced carp seed can be attributed to lack of selection of brood fish stock, no upgradation of brood stock and indiscriminate inter specific hybridization in eco-hatcheries. He opined that almost all the hatchery facilities do not have adequate number of ponds to raise brood fish species wise. The practice of breeding multi species fish available in the fish seed farms in Assam has resulted in production of interspecific hybrids and purity of strains and species in hatchery raised carps practically getting lost over the years.

Das (2000) reported that most fish breeders in Assam have tendency to select brood fish from the unsold seed of the previous year when they attain maturity. Therefore in most hatcheries crossing among parents and offspring and brothers and sisters take place. This results in inbreeding and production of poor quality fish seeds. In many private hatcheries immature fish weighing below 300-400gms are also used for egg production when matured fish are not available.

2.2.3.2. Age and size of parents

Thomos *et al.*, (2003) reported that age and size at first sexual maturity depends on the temperature and other climatic factors of the environment. In the plains of tropical countries like India, where temperature varies from 18^0C-35^0C, the females become mature within 6-8 months where as males mature about two months earlier. But in hilly areas of India it takes one year to attain sexual maturity.

Bondari *et al.*, (1987) reported that the age and size of the parents can influence certain phenotypes. Size of brood stock has been shown to affect spawning success and early growth of channel cat fish fry. They observed that brooders within 5 years of age showed negative correlations between size of the males and spawning success; female weight and egg weight; female weight and fry weight.

Thomos *et al.*, (2003) reported that the carps in the age group of 2+ years to 5 years are preferred for breeding since, after 5years senility sets in and hence are not advisable for breeding.

Ayyapan, S (2006) stated that the peak breeding efficiency of a carp female in tropical condition is recorded within 2+ to 5+ year age group.

2.2.3.3. Sex ratio

Thomas, P.C., Rath, S.C., and Mohapatra, K.D., (2003) viewed that to achieve successful induced spawning, it is advisable to maintain a ratio of one female with two male (1:2) in case of hapa breeding. But in eco hatcheries male to female ratio can be 1:1 provided males are of equal size and strength.

Milwain *et al.*, (2002) reported that within hatchery system of West Bengal, the present brood stock management practices may be acting negatively on production efficiency. The sex ratios used during breeding operation by over half of the 20 hatcheries studied fell outside of Tripathi & khan (1990)'s recommendations of 2:1 or 1:1 (male:female), while two hatcheries noted using brood stock more than the Tripathi & khan (1990)'s recommended 1-3 times per season. Half of the hatcheries studied used more than one female per male fish which can reduce genetic variability in offspring and increase the risk of inbreeding and poorer stock survival I hatcheries, particularly where offspring are further used for producing future generations within the farm of their origin.

Tave, D. (1993) explained the effect of skewed sex ratio on breeding by this formula; F (inbreed.ing) = 1/8(female) + 1/8(male).

When breeding populations are small, skewed sex ratios can lower N_e and increase inbreeding dramatically. The following example demonstrates this fact.

Population 1: 25females and 25 males

F = 1/8(25) + 1/8(25)

F = 1%/ generation

Population 2: 250 females and 10 males

F = 1/8(250) + 1/8(10)

F = 1.3%/ generation

Population 2 has over 5 times as many breeding individuals, but the Ne in population 1 is 50 while the Ne in population 2 is only 38.5. As a result, the inbreeding produced by population 2 is 30% greater because of the skewed sex ratio. The author suggested to spawn a more equal sex ratio, provided it is not already 50:50.

Bondari (1983**B**) demonstrated that cat fish farmers who use the open pond spawning technique can skew the sex ratio of the channel cat brood fish up to 4 females : 1 male and not affect fry production. The practice may be beneficial for the economics of the fingerling production but any genetic problems that exist will only get worse. There is often great temptation to use skewed sex ratios because they optimize fingerling production out of small number of brood fish needed to achieve fingerling production quotas.

2.2.3.4. Inducing agent (hormone)

2.2.3.4.1. Pituitary Gland extract

Haniffa et al., (2000) reported that hypophysation is a simple practical technique but suffers from the disadvantage regarding potency of which is unknown and difficult to standardize. In the experiment conducted by Haniffa et al., (2000), the striated murrel *Channa striatus* were injected with natural hormones (pituitary extract and human chorionic gonadotropin) and synthetic hormones (luteinzing hormone releasing hormone analogue and ovaprim). When compared to the LHRH and ovaprim, the latency period was long in pituitary (24 hr) and HCG injected (26 h) fish. In the pituitary injected *Channa striatus* the percentage of fertilization was the lowest (60-68%) but the duration of hatching was longest (39-43 h) followed by HCG – (36-38 h), LHRH – (34-36 h), and ovaprim injected (21-23 h) individuals. In terms of fertilization (95-98%) and hatching, ovaprim yielded better results. Ova reached the highest diameter (1.34 -1.45 mm) in *Channa striatus* injected with ovaprim, followed by HCG (1.22-1.27 mm). The lowest ova diameter (1.07-1.09 mm) was observed in *Channa striatus* injected with LHRH.

Chondar (1994) made an assessment and stated that of proper doses of pituitary gland for induce breeding of fish is most important. Low dose may not be at all effective, while overdose inhibits spawning or initiates premature release of ova which either do not fertilize or at best lead to deformed progeny susceptible to mortality. The greatest difficulty in standardization of fish gonadotrophin is encountered on account of various factors of which the size and sexual stage of maturity of the breeders are the most important. It is very difficult to know the exact stages of maturity of ovaries in female breeders from external characters. Breeders belonging to particular species and having the same size may differ in the stage of maturity of their gonads. The potency of glands also varies according to size and sexual development of the donor as well as the species of the donor fish, time of collection of glands and their proper preservation.

Chondar (1994) studied the dose of PG in relation to the weight of the breeder to be injected. It was noticed that the identical dose to the breeders of similar weights (and similar sex) may give contradictory results owing to difference in maturity of gonads.

Even heavy dose of hormones (12-17 mg) may not be effective if the gonads are in recession stage. It is, thus, by individual experience that one can determine the proper dose needed to induce spawning in a particular fish. By careful selection of breeders and administrating a known weight of pituitary gland per kg body weight of the breeder, successful breeding can be obtained in about 60-70% events when the weather condition is favourable.

Chondar (1994) reported that in similar environmental conditions, catla usually requires a little higher dose than Rohu and Mrigal. However, for successful breeding of fully mature female Indian and Chinese major carps in confined waters, the average total dose of pituitary gland for Catla is 9-12 mg/kg (2-4 mg and 7-8 mg in 1st and 2nd injections, respectively); for Rohu and Mrigal is 7-9 mg/kg (2-3 mg and 5-6mg in 1st and 2nd injections, respectively); for silver carp 10-14 mg/kg (2-4 mg and 8-10 mg in 1st and 2nd injections, respectively); and for Grass carp is 9-13 mg/kg (2-4 mg and 7-9 mg in 1st and 2nd injections, respectively).

Ayyappan, S (2006) recommended one priming dose of 4-6 mg/kg body weight and a decisive dose of 10-12 mg/kg body weight of carp pituitary extract to female for induced breeding of IMC. The effective spawning time reported with pituitary gland extract is 3-5 hrs.

Thomos *et al.*, (2003) stated that the initial dose for female is 2-3 mg/kg body weight and after 5-6 hours male are given PGE injection of 4-6 mg/kg and females 10-12 mg/kg. On an average female Grass carp and Silver carp require a dose of 10-14 mg/kg and male require 2-5 mg/kg body weight of pituitary gland. In case of grass carp and Silver carp artificial insemination by stripping was also carried out at about 6-8 hours after the resolving dose.

2.2.3.4.2 Ovaprim

Thomos *et al.*, (2003) reported that the ovaprim is highly successful and advantageous when compared to the traditional method of CPGE administration. Use of ovaprim increases spawning, fecundity, fertilization and hatching rate.

Nandesha *et al.*, (1990) stated that studies based on 3 year field trial with Indian Major Carps from 1988-90 have indicated that average number of eggs obtained per kg body weight of brood fish was 114000 with ovaprim as compared to 85000 with CPGE.

Average number of fry obtained per kg body weight of brooder was 72000 with ovaprim as against 43000 with CPGE. Thus 40% increase was recorded using ovaprim than CPGE.

Alok et al., (1993) and Nandesha *et al.,* (1990, 1993) achieved complete spawning for medium and high dose of ovaprim injected fish where as low dose injected fish did not respond. In terms of fertilization and hatching, ovaprim yielded better results. The highest percentage of fertilization (95-98%) was observed in ovaprim injected *Channa striatus*.

Azad and Shimery (1991) observed 90% fertilization in Mrigal injected with ovaprim. Statistical analysis confirmed that latency period of fish injected with ovaprim differs significantly ($p<0.05$) with LHRH. With regard to fertilization and incubation period, ovaprim differs significantly with other hormones.

Chondar (1994) reported that ovaprim appears to be very promising agent for spawning of carps and can be very successfully used as a substitute of fish pituitary. It induce breeding of Indian and Chinese carps with a single dose given simultaneously to both male and female in the late evening which spawn within 8-12 hrs. The effective dose for female of Catla is 0.4-0.5 ml; Rohu0.3-0.4 ml; Mrigal 0.25-0.3 ml; Silver and Grass carp 0.5-0.7 ml; big head carp, *L. fimbriatus and l. bata* 0.5 ml per kg body weight. The minimum post spawning mortality of the used spawners and non adverse effect on the growth of spawn are the merits of this drug. Large scale field trial on female Catla with single dose of ovaprim @ 0.5-0.7 ml/kg and0.2-0.3 ml/kg to male revealed that it responds extremely well in exudation of ova to the tone of 1-1.2 lakh/kg of spawners.

Ayyapan, S (2006) reported that GnRH based inducing agent expel the gametes (spermatozoa and oocytes) to the water body in 6 hr while the carp pituitary extract takes 12 hr. The effective spawning time is 1-2.5 hr with ovaprim.

2.2.3.5. Mixed spawning and hybridization

Padhi and Mandal (1994) opined that poly culture of Indian major carps like Catla, Rohu, and Mrigal, is a customary practice recommended by the fishery scientists for obtaining high production per hectare of water bodies. This naturally prompts the fish farmers to ask the fish breeders for supply of fish seeds of these species in a desired proportion. Artificial breeding of these fishes is generally done in 'breeding pools' in modern farms. These species are hormonally induced and released together in the 'breeding pool' to spawn on their own. This practice is called as 'mixed spawning'. The mixed spawning of carps leads to hybridization inadvertently because of their genetic kinship (padhi and Mandal, 1997). Inadvertent hybridization between IMC's and backcrossing of F_1 hybrids with parents would cause genetic introgression, causing contamination of gene pools. This 'genetic pollution'will obviously affect the genetic diversity and genetic integrity of these species. As a result it will be difficult to get pure stock of 'Catla' or 'Rohu', which will affect selective breeding program for genetic improvement in future (Padhi, 2000).

Tripathi (1992) observed that the hybrids of these species are not much beneficial for culture point of view. These species produce inter-generic hybrids in nature and under captive breeding condition. The identical chromosome number, identical isozyme gene expression, and ease of producing fertile hybrids on a large scale indicate their close genetic relationship. Further the synchronization of spawning time of these carp species occur due to hormone treatment, also enhances the incidence of hybridization.

Siriwardena (2007) reported that a communal or mixed spawning system for major carps in West Bengal is being practiced and is known to produce approximately 10% hybrids. This technique may lead to loss of genetic purity of important major carps.

Das (2000) conducted a study in Assam which revealed that almost all hatcheries are producing mixed carp spawn out of which 10-30% is hybrid. If such unplanned breeding of indigenous carp is allowed to continue, the resultant hybrid seeds arising out of mixed spawning may lead to ecological disaster when escaped to natural waters during monsoon. Although, the actual data on production of hybrid carps and their status is not available, the situation is very alarming as almost all the seed producers are engaged in mixed spawning. If the unplanned breeding activities are allowed to continue, it will jeopardize the seed production industry of the state. Already to some extent, the gene pools of our indigenous varieties of carps viz: Rohu, Catla, & Mrigal have been contaminated. As a result, in near future it is feared that pure seeds of these indigenous carps, endemic to this region shall gradually disappear from the culture system.

According to Padhi and Mandal (1994) the seed producers of West Bengal who contributes 70% of carp seed requirement of the country use Chinese-type hatcheries for seed production of all three major carps Catla, Rohu, and Mrigal by breeding them together in a common breeding pool with the administration of hormones.

Mishra *et al.,* (1998) has assessed the percentage of hybridization during mixed spawning practices. It was observed that the rate of spontaneous/inadvertent hybridization (inter generic) ranged from 7.24 to 9.24% in Utter Pradesh. The hybrids were identified as catla-mrigal and rohu-mrigal.The growth performance of these hybrids as observed by Mishra *et al.,* (1998), found to be significantly higher than parents. Performance of Catla-Rohu is found to be highest among all. The Rohu-Mrigal hybrids exhibits better cultural traits than parents. Performance of Catla-Mrigal hybrids were better than mrigal, but not Catla. Though all the three species bred together (mixed spawning), the incidence of hybridization (7.24 to 9.24%) is comparatively less inspite of their compability. The probable reason for this could be species specific courting behavior. It was also reported that the male coils round the abdomen of species specific female and releases milt when she releases the eggs.

The spontaneous/inadvertent hybridization which is reported to take place during mixed spawn may be due to accidental fertilization of the eggs of one species by the sperm of another species which might have been released in close proximity. Species specific courtship behavior and following species recognition keep the accidental level of hybridization low. However, the presence of even a few numbers of hybrids among the lot of other pure species (Indian major carps) may be detrimental to the genetic quality in the long run.

Padhi and Mandal (1994) and Mishra et al., (1998) stated that it is essential to prevent indiscriminate hybridization by preventing the mixed spawning of Indian carps. These carps, as been observed, are highly compatible to interbreed. Also, since almost all inter specific and inter generic hybrids are found to be fertile, care should be taken to check cross-breeding which may cause serious damage to the original gene pool through genetic introgression.

Das (2000) reported that in a mixed spawning trial resultant seeds were 75% hybrid and 25% were pure. These hybrids are mostly reported from nurseries of a particular hatchery in the locality. During random netting with a cast net at village Nankarbhoyra in Nalbari district, all the fish species harvested were found to be hybrid. The netting was conducted by the principal investigator in presence of fish pond owner, seed producer and a departmental officer. If some of the fertile hybrid fishes escape to natural water, it will certainly affect the future stock.

2.2.3.6 Hybridization

Hubbs (1955), Slastenenko (1957) and several other workers have reported hybridization in nature among fish species with Indian major carps. Slastenenko (1957) has given a list of natural hybrids of world which suggests that species belonging to the cyprinid group are more prone to interbreed than other groups of fishes and Indian major carps belonging to this group.

Tripathi *et al.*, (1992) on the basis of morphological characters and position of the pectoral and anal fins, the parental species of these putative hybrids have been identified as female Catla and male Rohu; several causes have been suggested to account for the occurance of hybrids in the nature.

Hubbs (1955) holds the view that hybridization in nature is facilitated when there is scarcity of one species and consequent dominance of an allied species in close proximity.

Zhang and Reddy (1991) reported that particularly in case of Indian major carps, with very compatible genomic structure, it is all the more easy and frequent to encounter natural hybrids when bred together in a relatively congregated condition. In 'bundh' breeding occurance of natural hybrids may be due to congestion in the spawning ground. Because of the limitation of breeding groung, there is very likelihood of ova of one species getting accidentally fertilized by the sperm of another species.

Ferguson (1990) reported that hybridization and introgression of non native genes can also result in a loss in allelic diversity, which disrupts locally adapted genotypes and effect population fitness.

2.2.3.6.1. Interspecific hybrids

Basavaraju et al., (1990) made a detailed investigation regarding the growth, food conversion ratio and protein efficiency ratio of the hybrid produced between fimbriatus (female) and rohu (male). The growth of the hybrid was evaluated in comparison to the parent species. In terms of percentage weight gain, specific growth rate and feed utilization, the hybrid performed better than both the parental species.

Choudhury (1971) reported that the percentage of fertilization of about 94% and development of egg was normal of the hybrid between *Labeo rohita* and *labeo calbasu.* The offspring of both the hybrid crosses were highly viable and their growth rate was superior to their slow growing parents. Hybrids of both the crosses were found to be fertile and attained maturity within two years.

Choudhury (1973) reported that almost all the interspecific hybrids matured within the third year of age. Almost all the hybrids either inter specific or inter generic, produced among Indian major carps in general exhibited intermediate traits to their parental species. The matured calbasu-rohu hybrid has been bred through hypophysation and the F_2 generation was produced successfully in 1960. As in the case of F_1 progeny was also recorded to be high. The hybrids possessed varying characters which were intermediate between the original parents' viz. *Labeo calbasu* and *Labeo rohita.*

2.2.3.6.2. Intergeneric hybrid

Konda Reddy and Varghese (1980b) conducted experiments on the growth performance of the rohu-catla and catla-rohu hybrids along with the parent species. They observed that the rohu-catla hybrid (female rohu and male catla) showed slightly faster growth than rohu but very much slower than catla.

Keshavanath et al., (1980) also evaluated the growth performance of the hybrids produced between L. rohita (female) x C.catla (male) and the reciprocal hybrids along with their parentel species under community rearing and also independently. These studies have shown that the growth of both the hybrids was inferior to catla and almost equal to rohu. The growth difference was insignificant between the hybrids. However, when reared separately, the growth performance of the hybrids was better than rohu but inferior to catla.

Varghese and Shantharam (1979) made a comparative study on the growth of three intergeneric hybrid of Indian major carps viz., hybrids produced by crossing female rohu x male catla (rohu-catla), catla female x male mrigal (catla-mrigal) and rohu female x mrigal male (rohu-mrigal). After 90 days of rearing, the rohu-catla hybrid showed the fastest growth among the three hybrid types, followed by the catla-mrigal hybrid. The rohu-mrigal hybrid attained the lowest growth of all the three. In terms of percentage increase in the growth the rohu-catla and catla-mrigal have respectively shown 257.6% and 110.9% more over the rohu-mrigal hybrid.

Choudhury (1973) observed that the Indian carp hybrid rohu-catla was the best as it inherited the cultural trait like quick growth of catla and small head of rohu. He reported that the growth of this hybrid was faster than rohu and nearly as fast as catla.

Konda Reddy and Varghese (1980b) however reported that rohu-catla hybrid grew slightly faster than rohu, but its growth when compared to catla was very poor.

Jana (1981) conducted a more detailed study at the fish farm of the Central Institute of Fresh Water Aquaculture (CIFA), Bhubaneswar in different combinations of the hybrid with the major carp species, i.e. catla, hybrid and mrigal; rohu, catla and hybrid; and mrigal, rohu and hybrid have shown that the rohu-catla hybrid grew better than rohu and mrigal.

Konda Reddy and Varghese (1984) produced this catla-rohu inter generic hybrid and studied the embryonic and larval developments and compared with the parental species. They reported that the developmental stages of the hybrid were quite normal and no abnormalities were noticed and were similar to the parental species.

The observation of Alikunhi et al., (1971) has shown the hybrid grew better than even catla under monoculture as well as when grown with catla. Similarly, Varghese and Sukumaran (1971) also observed the hybrid to grow better than even both the parents. This is in contrary to what was reported by Konda reddy and Varghese (1980b): these workers reported that the catla-rohu hybrid (catla female-rohu male) grew very much slower than Catla and slightly slower than rohu. Rohu registered 25.2% more than the hybrid while catla registered 108.9% more. These authors conducted that this hybrid is much inferior to catla and slightly slower than rohu.

Das (2000) reported that the hybrid between Silver carp (*Hypopthelmicthys molitrix)* and Bighead carp (*Aristhic nobilis*) has strong disadvantages. Firstly, the phytophagus habit of Silver carp is changed in the hybrid and then growth rate is decreased drastically in the second and third generation.

Ibrahim (1977), Basavaraju and Verghese (1980b) reported that out of 13 intergeneric hybrids produced only four hybrids, L. rohita, C, catla, C. mrigala, C. catla, L. rohota, C.

mrigala, L. fimbriatus, C. catla and the reciprocal hybrids have been found to possess useful traits in terms of growth.

2.3. Impact on aquaculture

2.3.1. Inbreeding

Bondari and Dunham (1987), Padhi and Mandal (1994) stated that the mating between the closely related individuals leads to inbreeding. It increases the proportion of homogenous individuals in a population. Fishes are more prone to inbreeding in hatchery environment for their high fecundity. They examined effects of inbreeding in hatchery environment for their high fecundity. They examined effects of inbreeding in several species of fishes including common carp, channel catfish, zebra fish etc. by sib-mating and concluded that inbreeding leads to reduction in growth, food conversion efficiency, survival rate and increased production of abnormal offspring. This phenomenon is called inbreeding depression. One generation of inbreeding in common carp reduced 10-20% in growth rate.

Kincaid (1983) stated that inbreeding depression is the effect of inbreeding normally measured as a reduction in the expected performance of affected trait, and is measured as the average performance difference between an inbred population and the base population.

Basavaraju et al.,(1990) conducted a survey, particularly for catla in the three major seed producing hatcheries in the state of Karnataka, namely Tunga Bhadra Dam (TBD), Bhadra Reservoir Project (BRP) and Kabiri Reservoir Project (KRP), also indicated that the practice followed by these hatcheries are likely to result in both inbreeding and negative selection. The TBD, BRP, and KRP have indicated that the common practices of brood stock replacement seems to be to retain a few fingerlings each year which are normally collected towards the end of spawning season, consisting of not more than two or three families. These practices are likely to result in inbreeding and selection for poor growth. Genetic analysis of hatchery stocks using four tetra nucleotide micro satellite loci has shown these stock to be different from each other. Results of growth trials indicated no significant differences in the performance between the stocks of the key hatcheries. However, the inter hatchery crosses produced highly significant increases in yield.

Basavaraju et al.,(1990) also reported the performance of intra and inter strain crosses between individuals of the same hatcheries viz. TBD, BRP and KRP and between two different hatcheries mentioned above. These studies have shown that crosses between the individuals of the same hatchery did not show any clear difference in growth performance suggesting that no one strain would necessarily be recommended over another. On the other hand, inter hatchery crosses between the strains at TBD and BRP and the reciprocal cross when stocked under polyculture along with rohu and mrigal at BRP and two commercial farm ponds and under monoculture in a pond at the Fisheries Research Station (Hassarghatta) have shown an apparent enhancement of culture performance in the cross bred fish over the pure intra hatchery crosses. There was considerable increase ($P<0.001$) in yield of the inter hatchery crosses compared to intra hatchery crosses ranging from 120-245%, indicating positive heterosis for growth in the inter hatchery stocks. It is evident from the findings of Basavaraju et al., (1997) that the hatchery practices indicated inbreeding depression and negative selection for growth in domesticated stocks of Indian major carps. The same was reported by Eknath and Doyle (1990).

Eknath and Doyle (1990) found the inbreeding rate between 2 to 17% in some of the Indian major carp hatcheries in Southern India, where the brood stocks remained genetically close. They found that the rate of the accumulation of inbreeding (F) was particularly high for the three most desirable carp species of catla, rohu and mrigal in the country.

2.3.2. Genetic drift

Allendorf and Phelps (1980) first addressed this problem of hatchery practices leading to genetic drift in Cutthroat trout Oncorhnchus clarki (Wallbum). They showed the loss of alleles due to genetic drift by comparing the allelic frequencies in hatchery and their wild relatives. Genetic drifts makes a population unfit for selective breeding as occurred in case of *Tilapia nilotica.*

Padhi (2000) stated that in carp hatchery few brood stocks are used for breeding at a time, which leads to genetic drift. It is a phenomenon that leads to random changes in the gene frequency in a founder population, which may not carry some alleles due to sampling error. The loss of alleles reduces genetic variance in the hatchery population

Tave (1991) reported that genetic drift led to the extinction of certain strain of channel catfish.

Jewel et al., (2006) reported that in Bangladesh, common carp is bred repeatedly in the hatchery with limited number of parents in the hatchery to keep the production cost at minimum level. As a result genetic erosion may have occurred through inbreeding, genetic drift and bottleneck effect in the hatchery populations.

A study was conducted to assess the genetic variation among the different hatchery populations of selected carps and minor carp and to compare the genetic variability between different populations using microsatellite loci developed by Croojmans et al., (1997). Three populations of scale common carp fingerlings and three populations of mirror carp fingerlings were collected from different hatcheries of Mymensingh district viz. as Sagar Matshya Khamar (SMK), Adorsho Matshya Khamar (AMK), Brahmaputra Char Fishery (BCH) and Anil Fish Farm (AFF). There was no deviations from Hardy-Weinberg expectations found in the populations SC-SMK and SC-BCH. That means these two populations had lower level of loss of heterozygosity. Only one population of selected carp and all three populations of mirror carp had deviation from Hardy Weinberg expectation at some loci. Repeatedly mirror carp populations were found to more null allele (6) than selected carp population (4). That means mirror carp strain had relatively higher level of loss of allele variations and loss of heterozygosity than scaled carp strain. The deviation of minor carp strain from equilibrium might be due to loss of heterozygosity in hatchery populations as a result of bottleneck, inbreeding and genetic drift. Higher level of loss of allelic variation in mirror carp than scaled carp may be due to the fact that scaled carp was introduced into Bengladesh in two batches while mirror carp in three batches and bred repeatedly in the hatcheries with small effective numbers of broods (Ne). As a result genetic erosion might have happened in most of the hatchery populations through inbreeding and genetic drift. The loss of heterozygosity may be increased with the increasing effect of inbreeding.

Alam and Islam (2005) in one of their study found that the population of Catla catla deviated from Hardy Weinberg equilibrium at a number of loci.

Was and Wenne (2002) reported loss of allelic variation in Polish hatchery populations of trout.

Sekino et al., (2002) found that the numbers of microsatellite alleles are markedly reduced in the hatchery strains compared with the wild populations in Japanes flounder.

2.3.3. Effect of population size on inbreeding and genetic drift

Tave (1993) stated that effective breeding number (Ne) is one of the most important concepts in the management of a population, in that it gives an indication about the genetic stability of the population because Ne is inversely related to both inbreeding and genetic drift. As Ne decreases, inbreeding and variance of changes in gene frequencies as a result of genetic drift increase. The inbreeding (F) produced by a single generation of mating in a closed population is; F=1/2Ne. The inverse relation between F and Ne in aclosed population and it occurs by 'chance encounters'. In a closed population, there is a probability that when fish are mated at random, related individual will be mated; the smaller the Ne the greater the likelihood of it occurrence. Effective breeding number depends on several factors: the most critical are total number of breeding individuals, sex ratio, mating systems and variance in family size. Unintentional inbreeding and genetic drift occur in hatchery populations because they are small and closed. This combination can quickly destroy a population's genetic variance and increase inbreeding, which will lower productivity and increase production costs. Genetically, ideal populations are infinitely large. Unfortunately (or fortunately depending on our point of view), hatchery managers cannot work with infinitely large populations. When a population is finite the best way to describe it is not by total population but by effective breeding number. The author recommended the effective breeding number (Ne) between 263 and 344 for food fish and bait fish populations and between 424 and 685 for population to be stocked in natural water bodies.

2.3.4. Deformity

Bondari and Dunham (1987), Padhi and Mandal (1994) reported that deformity could be the effects of inbreeding, it was examined in several species of fishes including common carp, channel catfish, zebra fish etc. by sib-mating. They have concluded that inbreeding leads to reduction in growth, food conversion efficiency and survival rate and increased production of abnormal offspring.

Chattopadhyay (2008) stated that the negative aspect of this genetic phenomenon (inbreeding) is fry deformity (35-40%).

Al-Harbi (2001) stated that the deformities are quite common in both wild and cultured fish populations, but their percentage is more in hatchery populations. Available evidence suggests that abnormalities are induced during the embryonic and post-embryonic periods of life. However, the etiology of these syndromes is not yet well understood. Several factors have been implicated for the appearance of deformities in fish. The deformities can possibly be caused by environmental disturbance or toxicants (Couch et al., 1979, Backiel et al., 1984, Weis and Weis, 1989, Wiegand et al., 248 1989, Grady et al., 1992), parasites (Hoffman et al., 1962, Treasurer 1992), nutritional difficiencies (Rucker et al., 1970, Lim and Lovell, 1978, Dabrowski et al., 1988, Frischknecht et al., 1994, Quigley 1995), genetic basis (Matsui 1934, Rosenthal and Rosenthal 1950, Tave et al., 1983, Mair, 1992), or may be caused by traumatic injury (Breeder, 1953, Gunter and Ward, 1961), or culture techniques (Romanov, 1984). Deformities may also be non inheritable congenital defects (Tave et al., 1982, Dunham et al., 1991, Handwerker and Tave, 1994).

Dabrowski et al., (1988) during larval rearing of common carp, skeletal deformities have been reported and found to be related to either vitamin C deficiency in the diet or to a strong water current (Backiel et al., 1984).

Chondar (1994) observed that low dose of pituitary gland may not be at all effective, while overdose inhibits spawning or initiates premature release of ova which either do not fertilize or at best lead to deformed progeny susceptible to mortality.

2.3.5. Impact on wild fish population

Ruzzante et al., (2004) and Hansen et al., (2001) stated about the scientific consensus that both intentional and unintentional release of cultivated fish poses serious risk to the genetic identity of the recipient populations.

According to Lynch and O' Hely (2001) and ford (2002) farmed fish might, for example, be genetically depauperate or maladapted due to unintended and/or artificial selection during rearing.

Kallio-Nyberg and Koljonen (1997), Fleming et al., (2000) and McGinnity et al., (2003) reported that unintentional selection in hatcheries may also cause changes in quantitative traits of the reared fish suchi as increased growth rates and earlier maturation. The stocks of farmed and native fish might also have different historical backgrounds, and thereby potentially also harbor unique and different genetic features. Mixing between released and naturally occurring fish might therefore result in alterations of the wild genetic structure and in the breakdown of locally adopted gene complexes.

Ryman (1997) stated stocking might also change the demographic characteristics of the recipient population resulting in increased rates of inbreeding.

Saisa et al., (2003) interpreted the loss of genetic diversity is dependent on the actual population size, and when population size in the wild are smaller than in the hatcheries the diversity of wild population might increase.

Hinder et al., (1991), Jonson (1997) and Naylor et al., (2005) noted that the introduced fish could also spread novel pathogens to wild populations. Populations of Atlantic salmon have, for example, been infected by the salmonid pathogen Gyrodactylus salaries via transmittance from stocked eggs from Baltic salmon that were resistant to the parasite. The lack of resistance to Gyrodactylus has in turn resulted in decimation of the Atlantic salmon populations in more than 30 Norwegian rivers.

In all the effects of stocking, wide varieties of outcomes ranging from no detectable effects to inbreeding and sometimes complete displacement of wild population are reported.

2.4. Advances in carp breeding technology

2.4.1. Multiple breeding techniques

Thomos et al., (2003) stated that multiple breeding technique by utilizing the same brood fish repeatedly in the same year to get maximum number of progeny. Special care is recommended for spawn produced through multiple breeding because yolk sac get absorbed within 60 hours after hatching instead of 72 hours in traditional spawn.

Gupta et al., (1995) reported that a given brood fish can breed four times, twice during pre-monsoon, once during monsoon and another time during late monsoon. This was achieved through careful pond management practices, selection of brood stock and scientific feeding practices. The pre-monsoon breeding commences as early as March. The spawn yield is reported between 0.5-0.6 lakh spawn/kg body weight of fish. The spent breeders are maintained for 40-45 days and used again for induced spawning when the production of spawn was 1-1.5 lakh spawn/kg body weight. After a lapse of 40-45 days of second spawning, a third crop can be obtained during June-July. As this is the natural spawning season of major carp the spawn yield has been seen to increase to 1.5-2 lakh spawn/kg body weight. Finally, late monsoon spawning during August-September is possible if maintained in a stress free environment and following proper management guidelines. The spawn yield was recorded to be 0.4-0.5 lakh spawn/kg body weight.

Ayyappan, S (2006) reported that the Indian major carps are commercially bred for multiple (3-4) times in an extended breeding season during April to September.

Rath, S.C., Gupta, S.D., and Dasgupta, S., (1999) reported induce spawning and double spawning of grass carp in hatchery system with foliage free brood diet.

2.4.2. Cryopreservation of carp milt

Thomas et al., (2003) reported that cryopreservation of milt of several species of fishes has been successfully practiced; the same was standardized for IMC till recently. Application of this technique might help in overcoming 'inbreeding depression' very often noticed in the present day aquaculture practices.

2.4.3. Synthetic compound used for spawning

Thomas et al., (2003) has stated that another breakthrough in this field was formulation of synthetic compounds and their use to induce spawning in carps and other fishes. Synthetic compounds used for induce breeding of fishes under captive conditions are of four categories (1) Gonadotropins (2) Gonadotropin releasing hormons (GnRH) or (Leutenizing hormone releasing hormone-LHRH or LRF) and their analogues (GnRH-A/LHRM-A/LRF-A), (3) Steroids, and (4) Other drugs.

2.4.4. Natural spawning of Exotic carps in eco hatchery

Tripathy, S.D., (1992) reported that stripping and artificial insemination was invariably practiced for the seed production of Grass carp and Silver carp in India and elsewhere.

Choudhury et al., (1956, 1957) reported partial natural spawning of Grass carp through hypophysation. Further hand striping was not always successful as sometimes stripping was not done in proper time. It was also reported that there was also poor survival due to striping stress.

Rath et al., (1999) in recent year has succeeded in breeding of Grass carp in eco-hatchery after hypophysation reared on 'foliage free diet'. The fish were fed on formulated diet prepared from soya bean, GOC, rice bran and fish meal (10:5:4:1) containing 36.75% crude protein, 6.8% crude fat, 14.25% crude fibre and total ash 13%. The breeding response was better than grass carp fed on foliage diet in all respect. The breeding response was88.2%, spawning fecundity $0.9 \pm 0.15 \times 10^5$ per kg body weight, the rate of fertilization was $89.6 \pm 5.33 \times 10^5$, and the spawn recovery rate was $0.76 \pm 0.13 \times 10^5$ per kg body weight.

Rath, S.C., and Sarkar, S.K., (2002) have used the Chinese circular hatchery (eco-hatchery) for the breeding of common carp. In this methods bundles of synthetic fibres peeled off from sacs used for packing cement, fertilizer etc. are provided in the spawning pool for egg collection and the same are also incubated in the incubation pool for hatching. Common carp in the sex ratio 1:1 are administered inducing agents at the recommended dose (PGE 2-3 mg/kg body weight or ovaprim @ 0.1-0.2 ml/kg body weight in a single dose only to female) and released into the spawning pool. No water current is required in the spawning pool unlike IMC. The female lays egg within 10-15 hours depending on temperature. The eggs hatch out after 30-48 hours depending on temperature. Spawn recovery has been reported to be as high as 90-92% in this system.

METHODS AND MATERIALS

3. MATERIALS AND METHODS

The study was based on field survey, interviews with actors in the fish seed production and distribution network, specimen collection and identification, and data analysis in accordance with the field investigations by Milwain *et al.*, (2002) and Chattopadhyay *et al.*, (2008) in West Bengal.

Interviews with key informants, incorporating questionnaires Champaran area of Bihar, were undertaken to get an understanding of the status and mode of operation of fish seed production in Champaran. Technical issues relating to production were investigated, where appropriate, to establish the status and efficiency of the system and the possible impact on aquaculture.

Bettiah and Motihari in North-Bihar, being an area of leading producer of fish seed and having easy access to market were chosen as the initial location for obtaining information and locations of 'actors' involved in the fish seed production and distribution network. Respondents provided variable estimates of hatchery within the areas identified.

During fieldwork a better appreciation of the significance of hatchery and nursery business was obtained and sample numbers were adjusted accordingly, as practical as possible, to account for geographical variations. As most of the hatcheries in north Bihar was found in and around Champaran and nearby fish seed market, one of the largest in the north-west Bihar and a focal point for fish seed distribution, provided further opportunities to interview the actors and obtain information relating to fish seed production and distribution through the market.

Data obtained was based on respondents' estimation as few business kept records. Cross-checking of information throughout fieldwork, however provided an appreciation of data consistency while enabling identification of 'actors' roles, significance and relationships in the network. The survey incorporated Bettiah and Motihari districts of north Bihar (Fig II).

Fig 2: Bihar showing study area, the Champaran

3.1. Locale of the study area

The study area is located in Champaran , comprising of Bettiah and Motihari districts of Bihar. All the study and field observations were concentrated in the fish seed production areas of these districts of north-west part of Bihar. Bihar is an important state in the eastern India for fish seed production because it encompasses a vast stretch of fertile plain. It is drained by the River Ganges, including its northern tributaries Gandak and Koshi, originating in the

Nepal Himalayas and Bagmati originating in the Kathmandu Valley that regularly flood parts of the Bihar plains. Bihar stands as 12th largest state in terms of geographical size (94,163 km²) and 3rd largest by population and 85% of the population lives in villages in accordance with Guruswamy **et al., (2003)**. The state is located between 21°-58'-10" N ~ 27°-31'-15" N latitude and between 83°-19'-50" E ~ 88°-17'-40" E longitude. Its average elevation above sea level is 173 feet (53 m).The Ganges divides Bihar into two unequal halves and flows almost through the middle from west to east along with its tributaries like Son River, Budhi Gandak, Chandan, Orhani and Falgu. Though the Himalayas begin at the foothills, a short distance inside Nepal and to the north of Bihar, the mountains influence Bihar's landforms, climate, hydrology and culture. Central parts of Bihar have some small hills, for example the Rajgir hills. To the south is the Chota Nagpur plateau, which was part of Bihar until 2000 but now is part of a separate state called Jharkhand. Bihar lies mid-way between West Bengal in the east and Uttar Pradesh in the west. It is bounded by the country of Nepal to the north and by Jharkhand to the south.("State Profile". GOI)

Champaran is situated in the NW part of Bihar. The total area of Champaran is 9196 Km^2 with a total population of 62, 67,302 (Census 2001). It is the border area of India with Nepal. This town is known as the **Gate way to Nepal**. It is connected by **NH28A** and is 32 km away from Chhapawa (on NH28A), 52 km from Motihari (the District Town) and 60 km from Bettiah. **Birganj** - the Second Big City of Nepal is just 3 km away from this town. About 80% of the population of this region Prefer to eat fish.

3.2. Data collection

3.2.1. Methodology

The methodology followed in this study has been designed with the following parameters:

- Identification of total number of hatcheries involved in breeding practice.
- Size of hatcheries like small, medium and large, and intensities of operation
- Educational status of the hatchery owner
- Status of brooders and their source
- Length of breeding season
- Nature of inducing agent in practice
- Variation in injection dose and time
- Breeding strategy

- Hybridization policy adopted
- Cultural traits of hybrid
- Awareness of modern technology
- Impact of existing practice on Aquaculture
- Need of the fish breeders
- Innovative technologies of the farmer
- Unauthorized introduction of species
- Suggestive measures to be adopted.

3.2.2. Detailed methodology

Comprehensive questionnaire schedule for collection of primary data through direct interview of the farmers was designed (Annexure-1). The schedule mainly incorporated the information about the farm site, ownership status, educational background of the farmers; species of fish under breeding operation, method of induce breeding adopted, manuring and nutritional aspects, disease problem, marketing detail, immediate need of the farmers along with other investigation criterion.

Eco-Carp hatcheries were categorized into marginal carp hatchery, Medium carp hatchery, and large carp hatchery based on the criteria (modified) adopted by Gupta *et al.*, (2000) for categorization of hatchery during the time of investigation in table-1.

Table 3: Criteria for categorization of Eco carp hatchery

Criteria	Category		
	Marginal	Medium	Large
Farm Area	0.70 ha	2-3 ha	3-5 ha
Actual Brood Raising Area	0.26 ha	1 ha	1.5 ha
Nursery Space	0.2 5 ha	1 ha	1.5 ha
Total Brood Requirement	130 kg	1300 kg	2600 kg
Spawn Production Level (SPL)	5 million	50 million	80 million
Number of Breeding Operations	1/week	2/week	3/week
Diameter of Spawning Pool	3 metre	3-4 metre	4-5 metre
Diameter of incubation Pool	2 metre	2.5 metre	3 metre
Number of Spawning Pool	1 no.	1 no.	1 no.
Number of incubation Pool	2 nos.	3 nos.	3-4 nos.

Source: **Gupta *et al.*, (2000)**

3.3. Breeding strategy.

The breeding practices adopted by farmers of the study area are both natural as well as stripping. Around 56% farmers practice both natural and striping practice, 12% farmers are adopt striping while 28% farmers are conducting only natural breeding practice. The method of spawning in the study area is mostly single species spawning and sometimes mixed spawning is also adopted depending on the demand of customers.

The method of multiple breeding practices in the study area depends upon the type of species and the conditions of breeders. Common carp breeding is practiced only once per season (100% single spawning) and one set of breeders are used either in the pre-monsoon or monsoon time. For Grass carp breeding practice is multiple type (around 100% of population) and the same set of brooders are used during pre-monsoon and monsoon season. Around 85% population of Silver carp is used for multiple breeding practice. Except Common carp and Grass carp in all other species (60%) are used for multiple breeding. Fish breeders of the area are mostly interested in breeding of Mrigal as the species is very much responsive to CPE as well as breeds easily, but for Catla as response is less, so the breeding and spawning is not easy. Breeding of Bighead carp, though banned, is a very popular practice among the fish breeders.

3.4. Study of the effect of Carp Pituitary Extract (CPE) on latency period, effective spawning time and incubation period.

The study indicates that the fish breeders of the areas under study use CPE as the sole inducing agent for fish seed production and this is evident in all of the 25 numbers of hatcheries under consideration. As fish breeders of the study area are not using the Ovaprim , so we are not in the position to study the comparative impact of CPE and Ovaprim. The mode of fish breeding operation was closely observed to study the latency period, incubation period and effective spawning time with the use of CPE. The weight of the fish, sex ratio and dose of CPE administration were recorded.

The study was purely based on the emperical breeding practices adopted by the farmers to raise fish seeds with profit making approaches without any scientific basis. The fish breeders are not only ignorant but are not in any way aware about the scientific basis of technology. The whole stock of pituitary gland is collected from the gland suppliers of Bengal or it is carried over by expert non-educated hired fish breeders of Bengal who use to visit the hatcheries of Bihar during breeding season. The entire breeding practice is happen to be under the total control of these hired fish breeders from Bengal. The quality and freshness of the gland is determined by observing the colour, if the colour is light brown or reddish brown then it is considered suitable while the dark brown color is not suitable. Potency of the gland is never considered as factor for breeding success as the farmers are totally unaware about this phenomenon. Males and females of IMC are selected from the brood stock just prior to breeding (own stock 70% + 30% outside stock) in most of the cases. The males and females are identified by the farmer examining external morphological characteristics and experience. The Pituitary extracts prepared just before injection from the selected glands and the same is injected intramuscularly at the caudal peduncle region above the lateral line. The females are given an initial dose and after 5-6 hrs both the male and female are given resolving dose. After injection the brooders are released into the spawning pool. The doses, as used by the farmers for IMC and exotic carps are given below:

Table: 4 Dose of CPE used by the fish breeders

Species	Female		Male
	1st dose (in mg/kg of body weight)	2nd dose(resolving dose in mg/kg of body weight)	(resolving dose) in mg/kg of body weight)
Mrigal	2.0	8.0	2.0
Rohu	2.0	8.0	2.0
Catla	3.0	8.0	2.0
Common carp	3.0	10.0	2.0
Grass carp	3.0	10.0	2.0
Silver carp	3	10.0	2.0
Bighead carp	N/A	N/A	N/A

After a short period of sex play which continue for 5-6 hrs spawning occurres which continued for another 3 hrs. The fertilized eggs either directly transferred to hatching pool or are collected to the small rectangular chamber slightly below(how much) the spawning pool. The collected spawn are then transferred to hatching pool with the help of hand net. A flow rate (initial, mid and final) is maintained in the hatching pools which help the fertilized eggs to move in a circular fashion. This facilitates the swelling and water hardening of eggs. The eggs hatched out after a period of 16-18 hrs in the hatching pool. These observations help to calculate latency period (the time between administration of hormone and initiation of spawning; effective spawning time (the actual time between initiation of spawning and completion of spawning); incubation period (the time between fertilization and hatching of egg.

3.5. Study of the flow rate in spawning pool and hatching pool

The study the flow rate in spawning pool and hatching pool a total of twenty (20) numbers of hatcheries were observed.

During breeding operation in the hatcheries of study the area the flow rate maintained in the spawning pool after introduction of hormone administered males and females in the pool was observed. No water current was used in majority of the hatcheries before or just after hormone administration. Water current is maintained just 1-2 hour before the calculated spawning time and a uniform speed is maintained till initiation of spawning and continued for $1^1/_2$-2 hr of spawning. A change in flow rate was observed and after slow initial flow a rapid flow is maintained for rest of the operation. The initial flow rate in the spawning pool was measured by dropping a float in the spawning pool and observing the time taken to complete one rotation around the circular pole of the spawning pool.

The procedure to measure initial, mid and final flow rate in the hatching pool was also same as above. The initial flow rate was measured for first 12 hours, the mid flow rate for next 6 hour and final flow rate for rest of the operation (Thomas *et al.*, 2003).

3.6. Materials

- Questionnaire
- Data recording sheet, record book, pen, pencil
- Camera, Emergency light
- Measuring tape, Scale, Float, Stop watch
- Specimen collection bottles
- Weighing Balance
- Formalin (10%)
- Bucket, Mug
- Scoop net, cast net, drag net
- Enamel tray, Petri dish

3.7. Statistical Analysis

All the recorded data and observation were processed and analyzed keeping in view the objectives of the study. The following statistical methods were used in the study:

- Percentage analysis
- Mean
- Standard deviation
- Analysis of variance (ANOVA)

3.8. Analysis of variance (ANOVA)

The data generated from the investigation were tested for significance of variance of dose of inducing agents and its effect on spawn yield, latency period, effective spawning time, incubation period and flow rate maintained in the spawning and hatching pools of hatcheries during the period of study from May to July, 2010-2011 through single factor analysis of variance. Statistical tests were performed using statistical software (MS-Excel 2003).

RESULTS

4 RESULT

4.1. Status of fish and fish seed production

The Champaran contributes about 11% (393 lakh) and 9% (27,000 tonns) of fish seed and fish production of Bihar respectively. Among the two districts, Bettiah leads in both total fish seed production and total fish production (Table 2). The total number of eco-hatcheries in Champaran is 25. This includes one in government sector (under construction) and the rest 24 in private sector (Annexure 1).

Table 5: District wise fish seed production of Champaran (2009-2010)

Sl. No.	Districts	Fish seed production (lakh)			Fish production (000 tonns)		
		Department	Private	Total	Department	Private	Total
1	Bettiah	0.00	232.00	232.00	0.00	14.30	14.30
2	Motihari	0.00	161.00	161.00	0.00	12.65	12.65
Total		0.00	393.00	393.00	0.00	26.95	26.95

Table 6: District wise number of eco-hatcheries in Champaran (2009-2010)

Sl. No	Districts	No. of eco-hatcheries		Total (A+B)
		Private (A)	Govt. (B)	
1	Bettiah	13	1	14
2	Motihari	11	-	11
Total		24	1	25

4.2. Temporal trend in hatchery establishment

Table 7 and Fig 3 indicates decade wise increasing trend of the establishment of eco-hatcheries in Champaran. It was started in the year 1990-2000 with the initial establishment of three (3) hatcheries , two in Bettia and one in Motihari district. In 2000-2010, twenty(20) numbers of hatcheries were added to the existing three making total of twenty three (23). During the current decade two (2) hatcheries were established in the area of Champaran.

Table 7: Decade wise establishment of eco-hatcheries in Champaran

Sl. No	Decade	No of hatcheries established
2	1990-2000	3
3	2000-2010	20
4	2010-	2

4.3. Categorization of eco- carp hatchery

Eco-carp hatcheries can be categorized into marginal carp hatchery, medium carp hatchery, and large carp hatchery based on criteria (modified) adopted by Gupta *et al.*, (2000) for categorization of eco-carp hatchery in Table 3. It was observed that most of the hatcheries come under marginal category, followed by medium category and big category (Table 8 and Fig 4). The majority of hatcheries are based on the Chinese design and principle.

Table 8: Categorization of eco-hatchery

Sl. No	Category	No of hatcheries
1	Marginal	12
2	Medium	9
3	Large	4

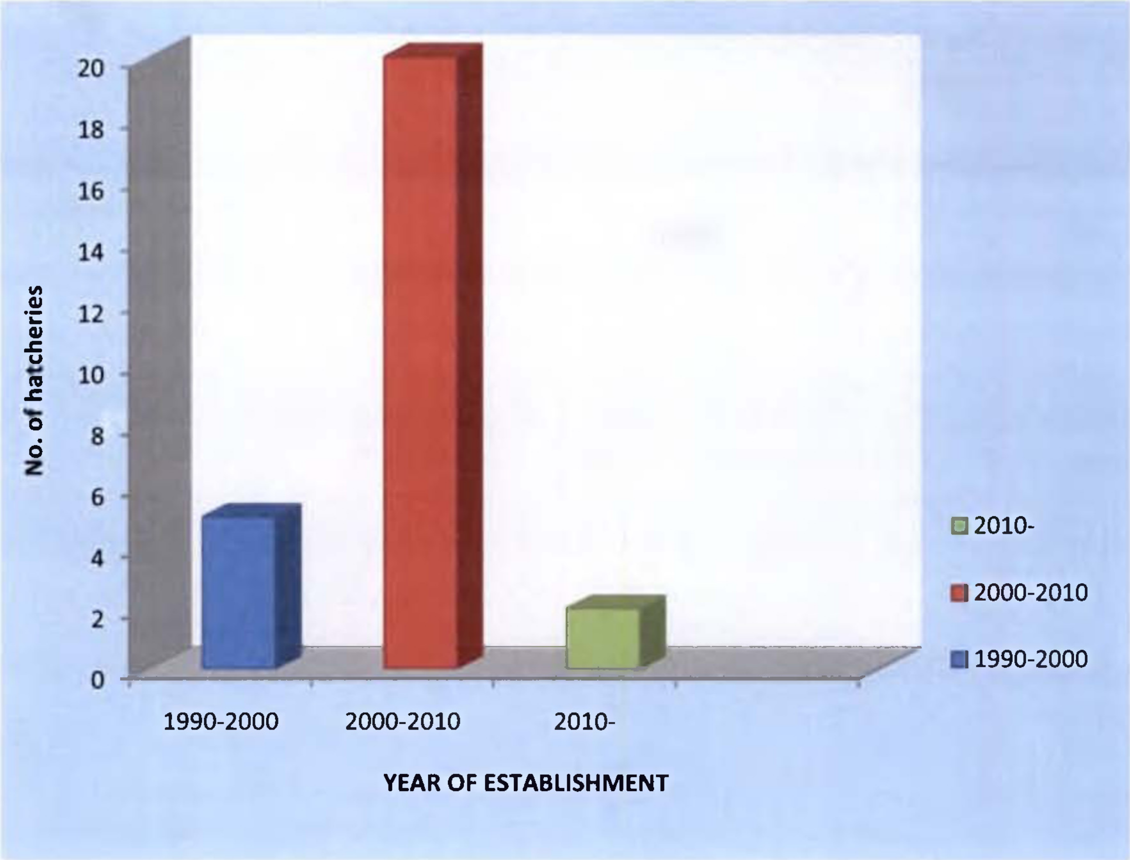

Fig 3: Decade wise establishment of eco-hatcheries in Champaran

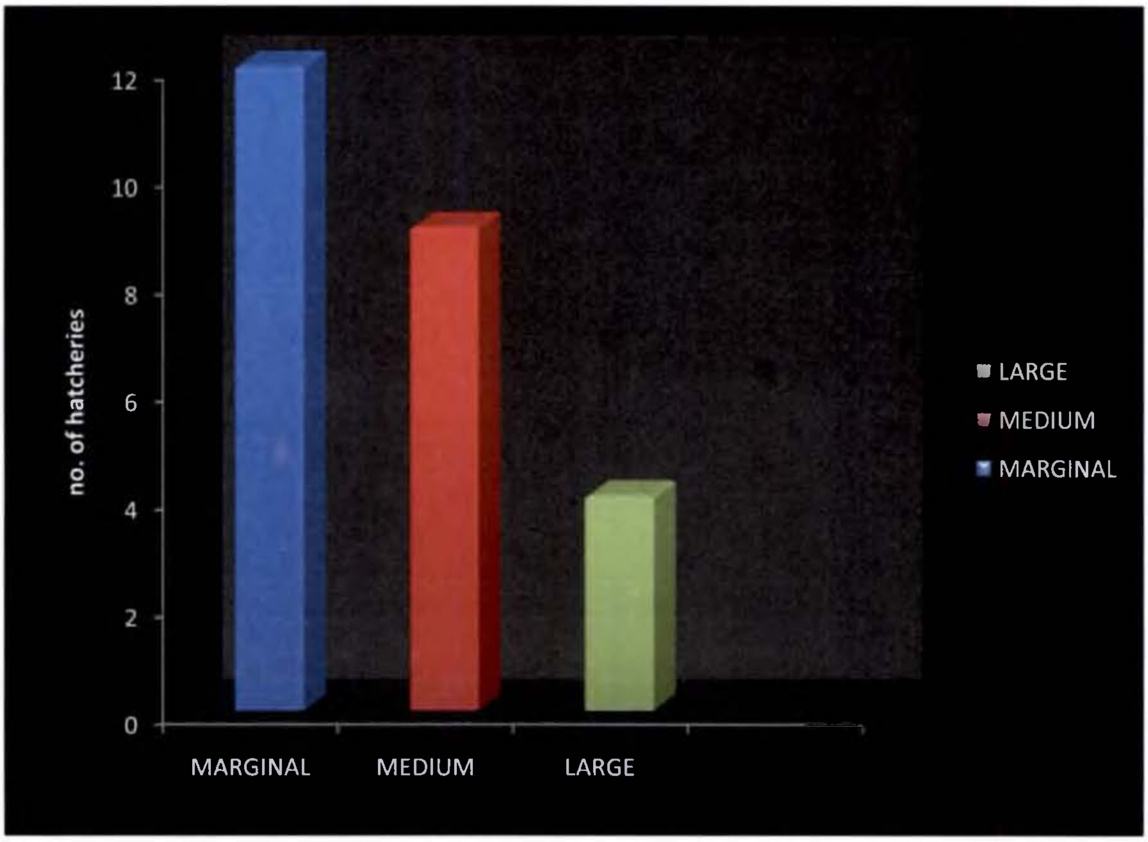

Fig: 4 : Categorization of eco-hatchery

4.4. Ownership status

The ownership status of eco-hatcheries studied in the Champaran area (Bihar) shows that 92% of the hatcheries came under single ownership, 4% hatcheries are in joint ownership category, and 4% are in government sector (Table 9 & Fig 5). This indicates that single ownership is preferred than joint venture.

Table 9: Ownership status of hatcheries

Sl.No.	Ownership	No of hatcheries
1	Single	23
2	Joint	1
3	Government	1

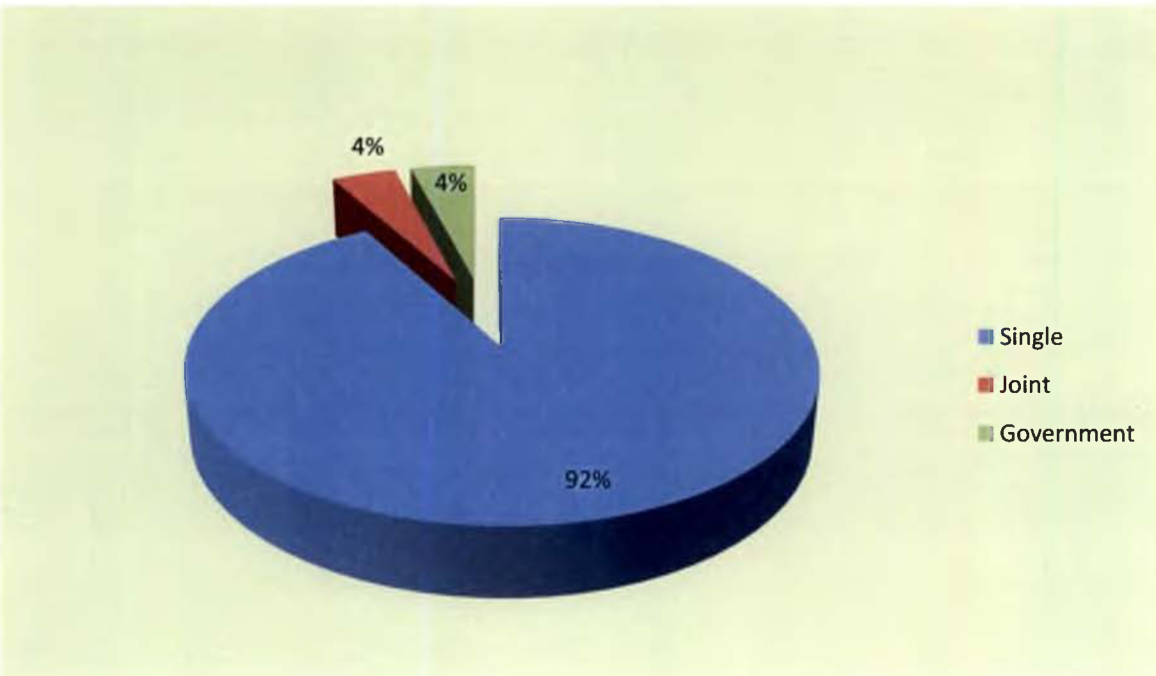

Fig 5: ownership status of hatchery

4.5. Breeding season and price variation of spawn

The season as reported by farmers begins in mid- February or first week of March depending upon the weather condition with the breeding of Common carp and continued till mid- August or September in some cases. The breeding of IMC begins from the month of April in Champaran area (Bihar). The price of spawn varies with season, during early days in February- March (pre-monsoon) the price is Rs. 400 per bati (30,000-50,000) and thereafter the price reduced to Rs. 200 per bati as the season reaches its peak during May-July (monsoon). This is because during the peak of breeding all categories of fish breeders participate in breeding as the brooders are readily available at this moment. Later part of July and up to August there is again price rise to the same level as it was during beginning of the season (Table 10 & Fig 6). This rise again due to paucity of brood fish particularly in case of small and marginal farmers.

Table 10: Breeding season and spawn price

Sl.No.	Month	Price (Rs.)
1	March-April	350-400
2	May-June	150-200
3	July-August	350-400

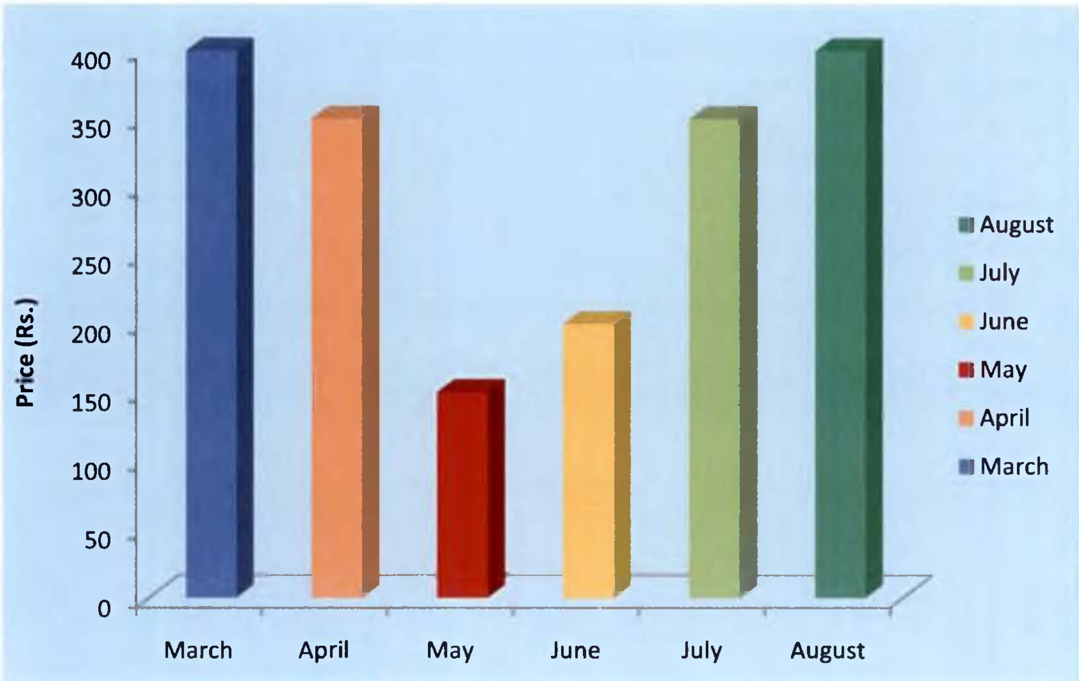

Fig 6 : price variation with month

4.6. Design of eco-carp hatcheries in Champaran

Most of the carp hatcheries in Champaran area are lacking sufficient infrastructure to skilfully facilitate spawning of brood fish, incubation of fertilized eggs and rearing of the hatchlings up to post larval stage. The carp hatchery complex comprise of water source and supply units; brood spawning unit; and larval rearing unit. While some of the newly established hatcheries in the Motor chawk area of Motihari district do not have spawning pool, they only go for artificial breeding (stripping) and transfer the fertilized egg manually to the hatching pool. Almost all the hatcheries are based on the Chinese design in the private as well as government sector and presently contributing around 11% of fish seed production of the state.

The rain water and bore water (using pump set or boring) are the two main source of water utilized for induce breeding of carps in Champaran. The average area of brood stock unit for rearing and management of carp brood stock was recorded as 1.34 ha (Annexure IV). The brood spawning unit consists of a circular cemented pool of 3.5-6.0m in diameter and 1.5-2.0m in height. The overhead tank (OHT), mostly rectangular cement tank and is found to 5.62m^3- 8.37m^3 in sizes. The egg collection chamber attached to spawning pool is a rectangular cemented tank of 1.50-6.28m^3 in size. In most of the hatcheries spawns are directly sold from the hatching pool or hapa. The average area of nursery/rearing unit for raising of spawn to fry stage and fry to fingerling stage was found to be 0.76 ha (Annexure IV).

4.7 Breeding practice

Entire breeding operations in each of the hatcheries of Champaran are conducted by some hired personal from Bengal, locally known as doctor (Plate 1). These people somehow learned the technology of induced breeding but are illiterate and completely devoid of scientific basis of the technology nor they are equipped with any institutional training. They learned the technology from fish breeders in West Bengal and use to visit Bihar during breeding season.

4.7.1. Age and size of brooders

Table 11 depicts the average age and size of the brooders used by the hatchery operators of Champaran. In 68% hatcheries the average age of brooders was 5.54-6.26 years and in 84% of hatcheries the average size was 0.26-3.41 kg. This shows extensive use of fish more than 5 years of age and size less than 0.5 kg as brood stock.

4.7.2. Sex ratio

The average sex ratio considered for breeding in the Champaran have been found to be 17:40 (M: F). The 96% Of hatchery owners in the region consider sex ratio less than 1:1=M:F (Table 11). The breeders also believe that one ripe and healthy male is sufficient to fertilize the eggs of two or more number of females. Moreover, there is always shortage of mature and sufficient number of healthy male brooders in all the hatcheries and may be the reason why the breeders use the skewed sex ratio for achieving the targeted production without even considering the future consequences.

Common carp is only species where the M:F ratio is found to be 3:2.

Table 11: Breeding practices in hatcheries of Champaran

Actors involved in fish seed production		Fish seed producers		
Hatcheries (n)= 25				
Factors	Indicators	Variables	No of respondents	Percentage
	Breeding age*	5.54-6.26**	17[#]	68%
	Size	0.26-3.41kg**	21[##]	84%
	Sex ratio (Skewed)	17:40(M:F)	24[###]	96%
	Multiple breeding	Gc,Sc, Bh,IMC	24	96%
	Mix spawning	multispecies	24	96%

*Maximum breeding age= (Minimum spawning age + No of times a fish is spawned); ** Average; # (>5yrs), ## (<0.5kg), ### (<1:1), Gc=Grass varp; Sc=Silver carp; Bh=Big head carp;

Table 12: Breeding practices and inducing hormones used in hatcheries of Champaran

Actors involved in fish seed production			Fish seed producers	
Hatcheries (n)= 25				
Factors	Indicators		No of respondents	Percentage
	Both natural breeding* & stripping		14	56%
	Only natural breeding		7	28%
	Only stripping		3	12%
	Restocking		19	76%
	Inducing Agent	CPE	24	96%
		Ovaprim	-	-

natural breeding* preferred over striping

4.7.3. Multiple breeding

Multiple breeding is a general practice followed in most of the hatcheries of Champaran (Table 11). It was found that 96% of hatcheries practice multiple breeding. As reported that fish breeders are using the males of Mrigal, G.carp and S.carp 5-6 times in a season at 30 days interval. Females of Silver carp, Big head carp and grass carps are used to spawn 3-4 times in a season. The breeders effectively spawn IMC female at least thrice in a year and in some cases four times at an interval of 35-40 days in a season. The breeding of Common carp is conducted during pre-monsoon and monsoon period, but not during post-monsoon period and common carp is never used for multiple breeding. The breeding of Grass carp is taken in the early (March- April) and last part of the breeding season (July-August) only, where as breeding of Bighead carp and Silver carp is carried out with rest of the species. As breeding response of Catla catla is not good, so its breeding is carried out during peak monsoon period only.

4.7.4. Mixed spawning

Mixed spawning is very much common in the hatcheries of Champaran. While conducting this study it is revealed that around 96% hatchery owners are involved with the practice (Table 11). The hatchery owners undertake mixed spawning to meet the demand of customers and due to lack of sufficient infrastructures. All of the hatcheries possess single spawning pool (three hatcheries without spawning pool in the Motor chauk area of Motihari, plate:2) along with insufficient infrastructure to carry out single species spawning (Annexure-2). The fish breeders generally conduct mixed spawning among three species of IMC (Indian major carps) as well as with exotic carps (Plate 3) like Silver carps, Grass carps, and Bighead carps according to the need of the time and convenience. The fish breeders reported that they conduct mixed spawning following the demand from farmers for mixed composition of seed for this polyculture or composite culture (plate 4)

Mixed spawning leads to hybridization not only among different species of IMC but also between IMC and different species of exotic carps. This has been revealed by the identification of different types of hybrids in farming condition during study. The fish breeders are not only ignorant of such consequences but doesn't care for the same. Their only concern is profit and convenience.

As demand for Big head carp is more (2^{nd} to Rohu) because of it's taste and good growth although it is banned variety, so farmers are producing hybrids of Silver carp+Big head carp in which hybrid is similar to Big head carp.

4.7.5. Natural breeding

Majority of the breeders follow the practice of natural breeding in the hatcheries of Champaran. It was observed that 84% (56% both natural+ stripping and 28% only natural breeding)of the fish breeders prefer natural breeding over stripping where as only 12% fish breeders prefer stripping over natural breeding (Table 12). In natural breeding the fishes are released into breeding pool after hormonal induction. The induced fish indulge in sex play which continues for 3-4 hours which ends in spawning and this ensures fertilization (plate 5).

4.7.6 Striping

It was observed that around 68% of breeders were found to practice stripping (56% both natural + stripping and 12% only stripping) in their hatcheries (Table 12). But the fish breeders who adopting both the breeding practices, the striping is secondary one. Stripping is generally practiced for exotic carps. For IMC it is done in case of shortage of male brooders. For IMC and exotic carps striping is generally taken after 5- 6 hours of 2nd injection. The injected brooders are kept in hapa (plate 6, Plate 7) and the stripping time is determined when the brooders, specially female rub their body against wall of hapa it indicates that fish is ready for stripping. The success of stripping with increased fertilization rate mainly depends on the milt concentration of the male. If the male is matured enough and its milt concentration is optimum (indicated by the highly concentrated whitish milt) then one male can fertilize the eggs of 2-3 females.

4.7.7. Breeding of Common carp

At the onset of breeding season breeding practice starts with breeding of Common carp as the fish mature first compare to other fishes considered for breeding. Common carp is a perennial breeder and attain maturity at mid- February and continue up to April. In the same breeding season the fish again considered for breeding in July-August.

The matured fish is indicated by bulging abdomen of female and easy oozing of single egg and whitish milt from male. Generally carp pituitary extract is used for induction. The doses for male and female are given in table 4.

The eggs are first striped into a steel tray and immediately after milts are pressed out in the same tray. Both the eggs and milts are mixed by gently moving a feather in the egg-milt mixture witli the addition of water (plate8). As the egg of C.carp posses a sticky/adhesive glue like substance, the eggs clogs to form several round and irregular structure (plate 9) as a result entry of sperm is prevented. As the fertilization is impaired so the availability of spawn or hatchling is less. The fish breeders are totally unaware about the negative aspects of such failure of fertilization and hatchling.

4.8. Selling of spawn

The fish breeders generally sell 80% of their produce, if possible 100%, on 3rd day following incubation. This is because the mortality to spawn usually occurs after third day. From hatching pool the spawns are collected into a rectangular piece of coarse cloth and from cloth the spawns are transferred into a standard steel mug or bati by using a plastic mug (plate 10). The standard steel mugs or bati provide information on the quantity of spawn delivered to the farmers. The spawns are then acked in plastic bag with oxygen and water in 3:1 ratio for selling to different distant places (plate 11).

4.9. Restocking of brooders

Restocking of brooders after spawning is a common practice adopted by most of the hatcheries of Champaran. We have observed that 76% of hatchery owners restock the brooders and kept as potential brood stock for next season (Table 12). Some of the fish breeders partially sales the brooders after breeding season, while some sales the non-performing ones, old aged ones, which are not supposed to be promising for next season (Annexure2).

4.10. Inducing agent

In the present context of breeding operations when ovaprim is gaining popularity day by day and used by most of the fish breeders of neighbouring states like West Bengal and particularly Assam (Chandan Chetri., 2009), the fish breeders of Champaran are still using carp pituitary extract (CPE) as a sole inducing agent for fish seed production. Carp pituitary extract (CPE) is the natural inducing agent containing GTH-I (Gonadotropin Hormone-I) and GTH-II (Gonadotropin Hormone-II), where as OVAPRIM is a synthetic inducing agent. Recent study indicates that the use of CPE is more in Bengal and Bihar, while the fish breeders of Assam mainly use Ovaprim.

About almost all farmers of the study area are still using CPE as the sole inducing agent (Table 12 and P-19) and opined that Ovaprim in exerts negative impact on spawning as well as health of brooders.

4.10.1. Pituitary protocol used in hatcheries of Champaran

The average pituitary protocol used by different hatcheries of Champaran during pre-monsoon, monsoon and post-monsoon are given in the Table 4. It was observed that the dose of CPE was higher during pre-monsoon and post-monsoon, while the dose in monsoon season was comparatively less. It may be due to attainment of full maturity and availability of all the congenial environmental condition during monsoon time. During post monsoon season higher dose needed as brooders are already spent and due to unavailability of congenial environment. Catla preferred slightly higher dose compare to rohu and mrigal throughout the season as reported by the farmers of the Champaran area. The dose of male did not vary much irrespective of breeding season, for all species.

4.10.2. As farmers of Champaran are not using OVAPRIM , so we are unable to give the OVAPRIM protocol used in hatcheries of Champaran area. We are also unable to do the comparative study of CPE and OVAPRIM on fish seed production, latency period, effective spawning time, and incubation time.

Table 13: Study of spawn yield with respect to season

Species	CPE(mg/kg)/(Mean±SD)						(Mean±SD) Spawn yield(lakh/kg)		
	Pre-monsoon		Monsoon		Post monsoon				
	Female	Male	Female	Male	Female	Male	Pre-monsoon	monsoon	Post monsoon
1	2	3	4	5	6	7	8	9	10
Rohu & Mrigal	11.8±0.60	3.1±0.55	10.1±0.36	2.13±0.15	13.8±0.36	3.13±0.65	0.53±0.03	0.66±0.09	0.28±0.07
	12.33±0.76	2.93±0.49	10.4±0.26	2.26±0.20	13.9±0.26	3.03±0.47	0.50±0.02	0.67±0.12	0.37±0.02
	12.16±1.04	3.03±0.20	10.3±0.43	2.16±0.20	13.6±0.1	3.26±0.40	0.49±0.02	0.75±0.11	0.40±0.02
Catla*	13.00±043	3.40±0.55	11.4±0.36	2.26±0.20	14.43±0.20	3.46±0.25	-	-	-
	13.13±0.40	3.46±0.25	11.63±0.35	2.73±0.25	14.63±0.20	3.46±0.30	-	-	-
	13.53±0.15	3.33±0.72	12.13±0.40	2.5±0.1	14.46±0.25	3.83±0.11	-	-	-
Ec (Bh,Sc)	-	-	13.36±0.15	2.76±0.30	14.46±0.25	3.4±0.26	-	0.64±0.04	0.35±0.04
	-	-	13.60±0.26	2.36±0.32	14.93±0.15	3.66±0.15	-	0.59±0.08	0.32±0.03
	-	-	13.70±0.20	2.70±0.20	14.60±0.10	3.80±0.20	-	0.64±0.06	0.31±0.33

4.10.3. Study of spawn yield with CPE during pre-monsoon, monsoon and post Monsoon period

The detailed breeding operation were observed closely to study the spawn yield for IMC and Exotic carps with respect to pre-monsoon, monsoon and post-monsoon period (Table 13). It was observed that average yield per kg body weight for IMC during monsoon season (May-July) as observed was 0.66±0.09 to 0.75±0.11 lakh per kg with the use of CPE (Table 13 and Fig 8). During pre-monsoon (March-April) the spawn yield was 0.49±0.02 to 0.53±0.03 lakh per kg with the use of CPE (Table 13 and Fig 7). Least quantity of spawn yield as observed was 0.28±0.07 to 0.40±0.02 lakh per kg with the use of CPE (Table 13 and Fig 9) during post monsoon season (August to September). Similarly the spawn yield for exotic carp (Big head and Silver carp) was 0.59±0.08 to 0.64±0.06 lakh per kg with the use of CPE during monsoon season (May-July), while it was 0.31±0.33 to 0.35±0.04 during post monsoon season (August to September). The Big head and Silver carp are bred during monsoon and post monsoon season, while the induce breeding of Grass carp and Common carp is mostly carried out during pre-monsoon season only. Significance difference exists between spawn yield per kg of body weight, with respect to season and dose of CPE.

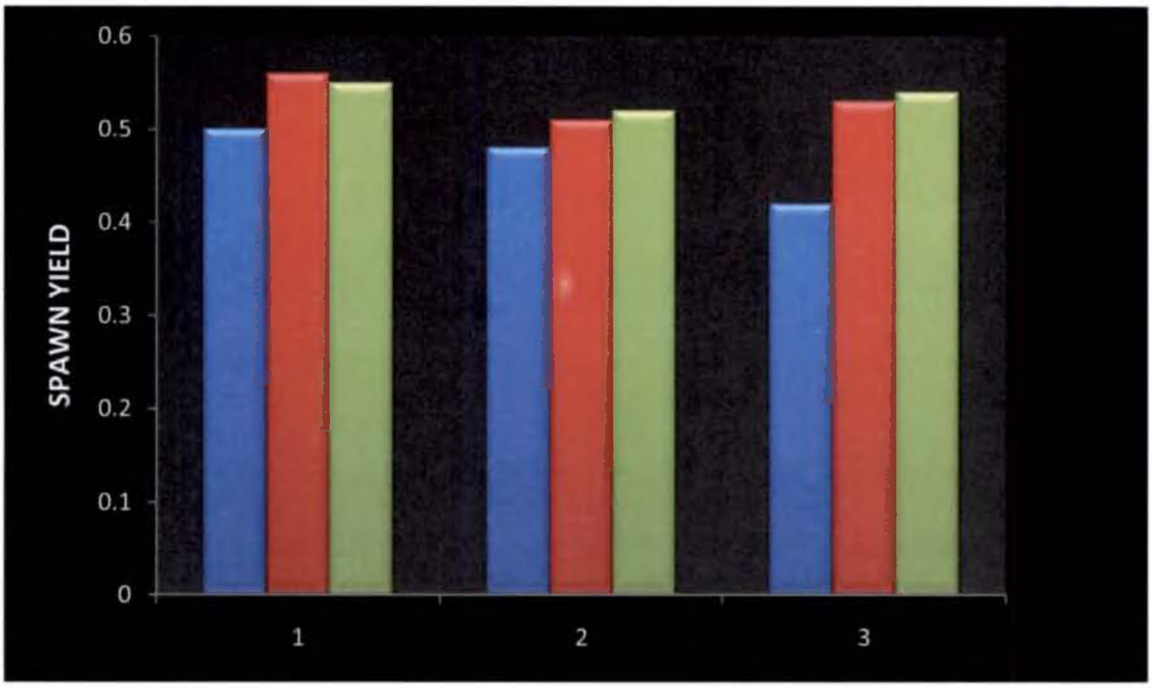

Fig 7 : Effect of CPE on Spawn Yield During Pre- Monsoon

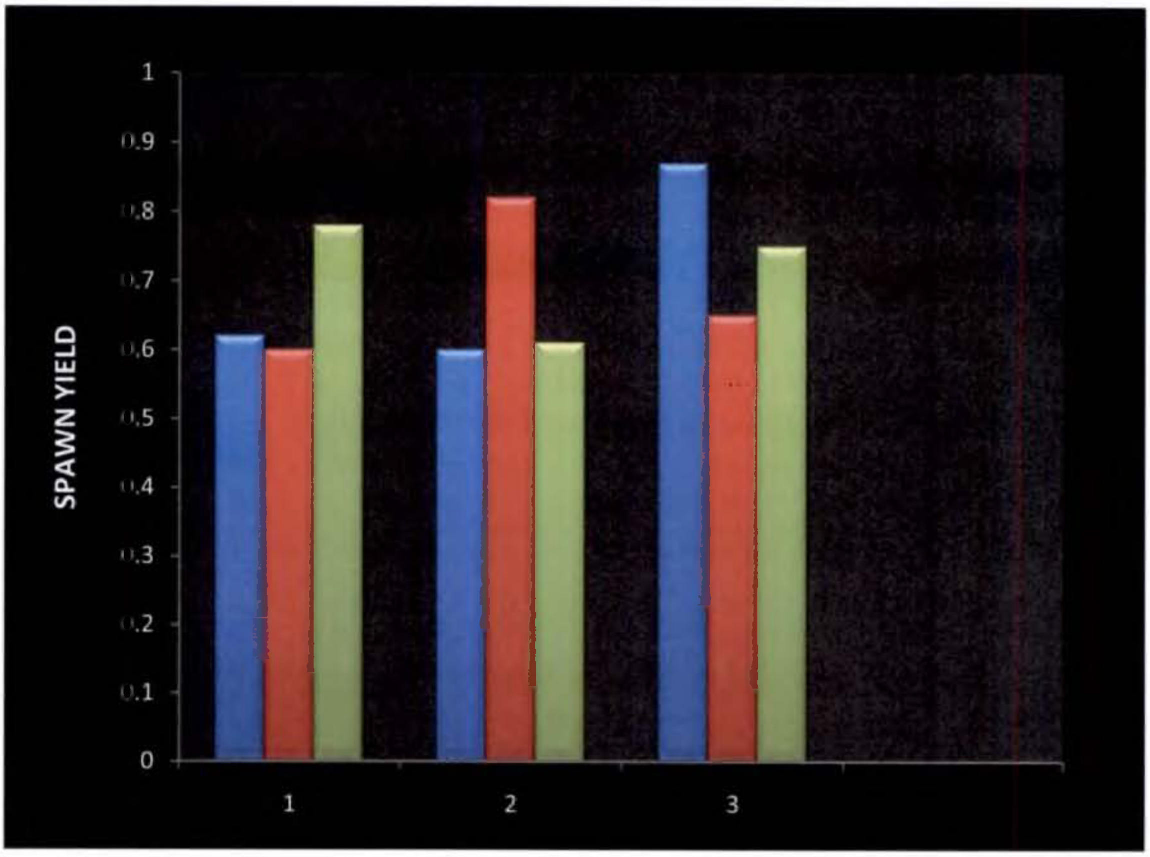

Fig 8 : Effect of CPE on Spawn Yield During Monsoon

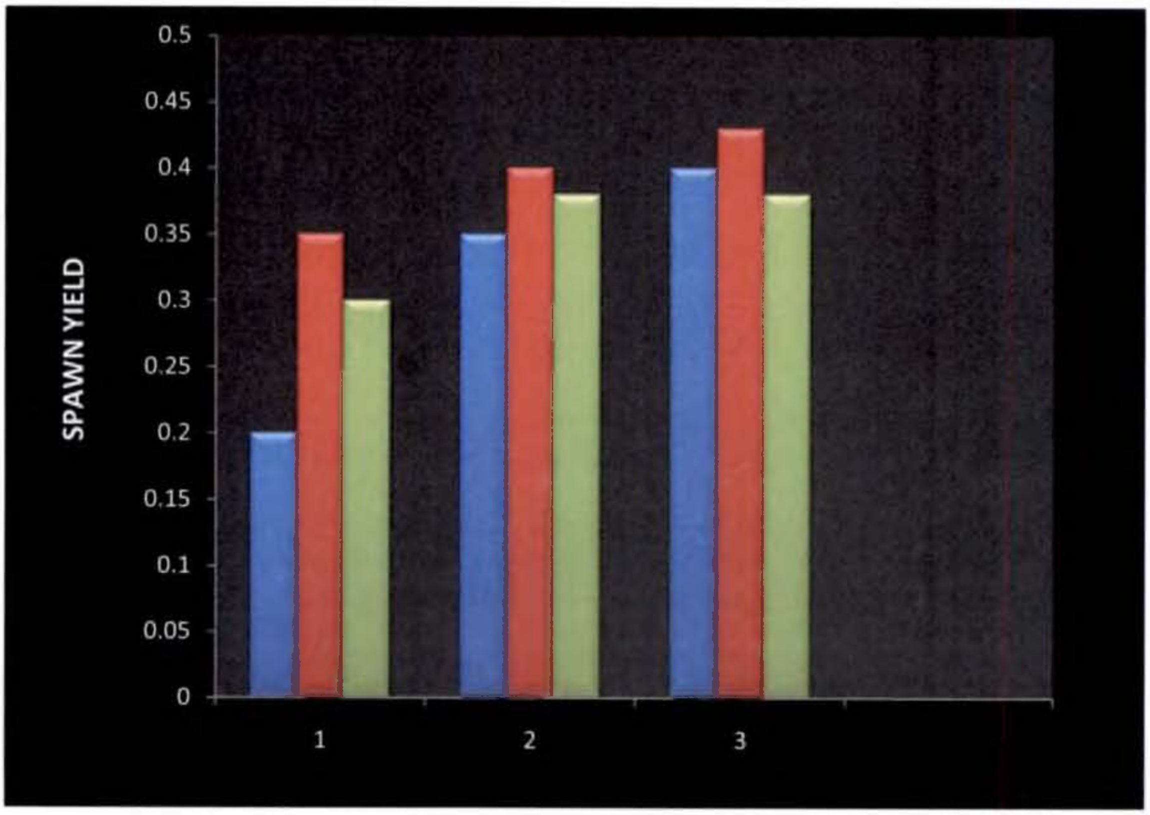

Fig 9 : Effect of CPE on Spawn Yield During Post- Monsoon

4.8.4. Flow rate in breeding pool and hatching pool

Table 14: Flow rate in breeding pool and Hatching pool

Breeding pool (m/sec)		Hatching pool (m/sec)		
Initial	Final	Initial	Mid	Final
Mean ± SD		Mean ± SD		
0.28±0.06	0.20±0.05	0.19±0.05	0.18±0.03	0.18±0.04
0.43±0.07	0.21±0.03	0.20±0.02	0.19±0.04	0.18±0.02
0.41±0.16	0.18±0.02	0.19±0.04	0.19±0.01	0.22±0.04
0.37±0.09	0.20±0.02	0.20±0.05	0.20±0.05	0.24±0.04
0.31±0.06	0.22±0.07	0.24±0.05	0.18±0.03	0.16±0.02
0.38±0.14	0.19±0.02	0.21±0.03	0.20±0.05	0.21±0.04

The flow rates maintained in the breeding and hatching pools in the hatcheries of Champaran are dipicted in Table 14. The initial flow rate which begins 2-3 hrs just before the actual spawning occurs in the spawning pool as recorded as 0.28±0.06 (min) and 0.43±0.07 (max). The final flow rates recorded during spawning was 0.18±0.02 (min) and 0.22±0.07 (max).

Similarly, the initial flow rates as observed for the first 12 hrs in the hatching pool were 0.19±0.04 (min) and 0.24±0.05 (max). The mid flow rate observed in the hatching pool for another 6 hrs were 0.18±0.03 (min) and 0.20±0.05 (max). While the final flow rate for the rest of operation were 0.16±0.02 (min) and0.24±0.04 (max).

ANOVA confirmed a highly significant difference between the initial and final flow rates maintained in the breeding pool by farmers ($F= 45.13$, $P<0.05$). A significant difference ($F=0.76$, $P<0.05$) was also noticed in the flow rates of hatching pool during initial (1st 12 hr), mid (next 6 hr) and final (rest period) phase of breeding period. The result suggests highly significant difference between the initial and final flow rates maintained in the spawning pools (Fig 10). Similarly there was also significant difference in the flow rates maintained in the hatching pools (Fig 11).

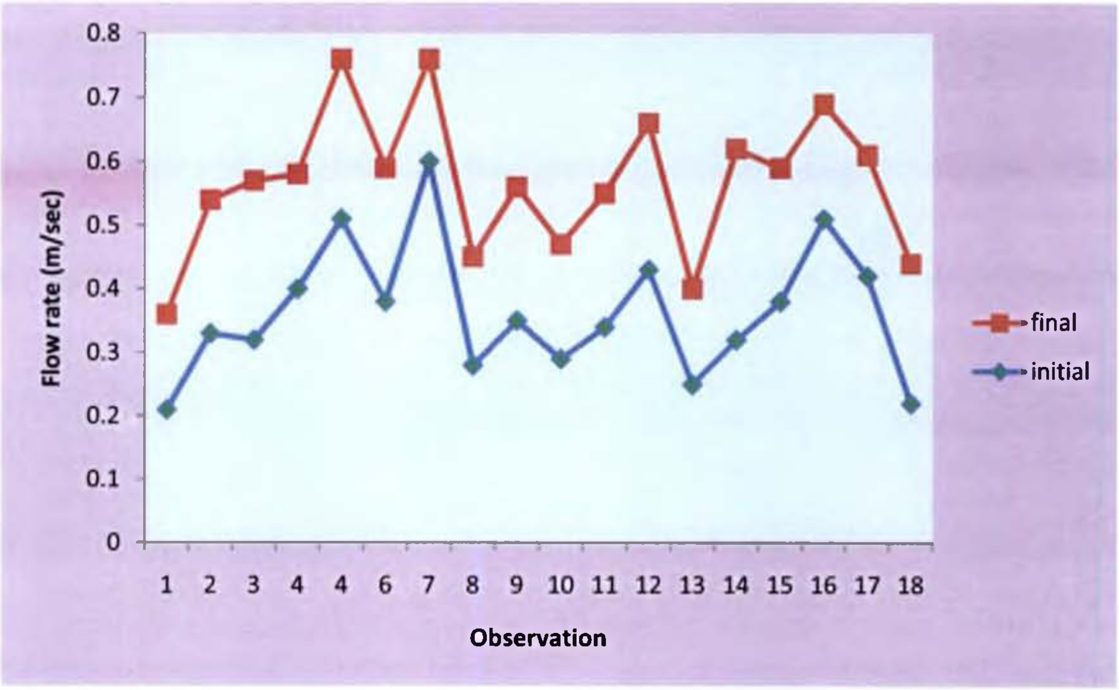

Fig 10: Flow rate in spawning pool

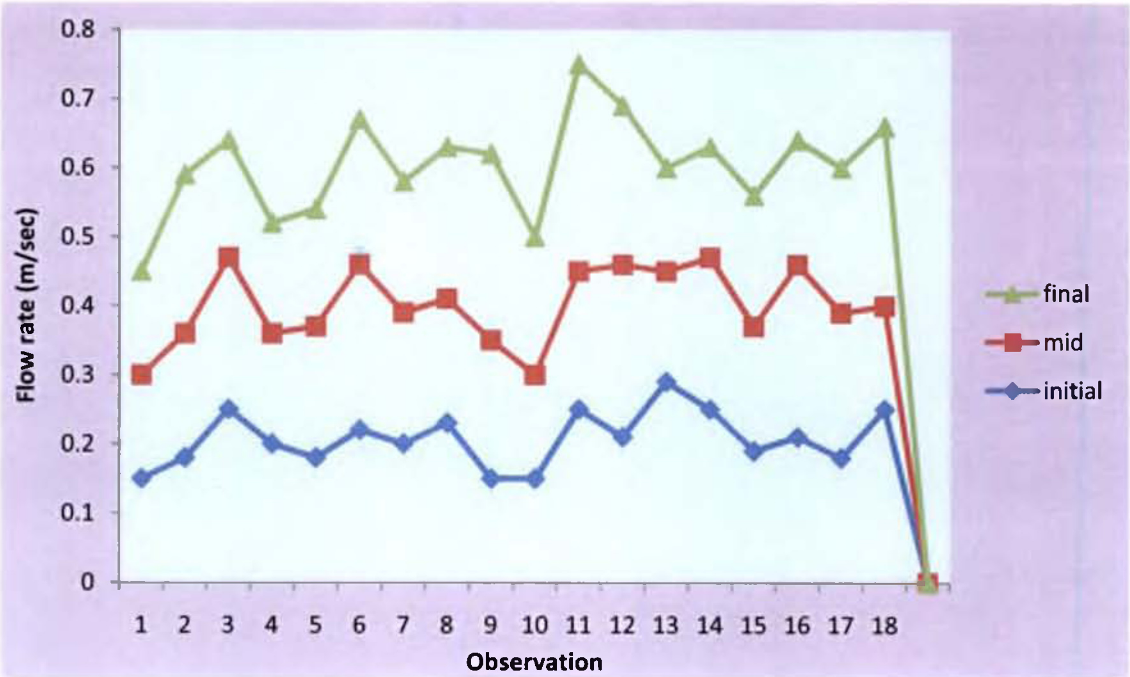

Fig11: Flow rate in hatching pool

4.11. Brood stock management

4.11.1. Species and Stocking Density

The hatcheries in Champaran maintain a multi species brood stocking pond comprising of IMC and Exotic carps of different age groups and size with very high stocking density

(Annexure 2). Though multi species carp culture is a recommended practice, but the unscientific manner in which it is carried out is the real cause of concern. It was observed that 84% of the total seed producers of the Champaran maintained more than six species brood stocking pond with no control over the species ratio and composition (Table 13). It was observed that the species composition included even the banned species like Bighead is also considered.

Though stocking density is one of the most important criteria to be taken into account for brood stock management the hatcheries of Champaran were maintaining a very high stocking density. During study work it was observed that 80% hatchery owners are maintaining a stocking density of more than 1500 kg per hectare. The average stocking density maintained by the hatchery owners of Champaran is 2194.16 kg per hectare (table 15 and Annexure 3). There are reports of considerable mortality in the brooders pond due to oxygen deficiency following eutrophication. The fish breeders are unable to use aerator due to frequent interruption in current supply throughout the study area.

Table 15: Brood stock management practice in Champaran

Actors involved in fish seed production	**Fish seed producers**			
Hatcheries (n) = 25				
Factors	**Indicators**	**Variables**	**No of Respondents**	**Percentage**
	Species	Multi species*	21	84%
	Stocking density	2194.16 kg**	20***	80%
	Feed and fertilizer	Monthly	17	68%
	Infrastructure	Insufficient	22	88%
	Source of brood fish	Own/others	24	96%
	Culling	Deformed/diseased/overage/etc.	5	20%
	Pedigree	-	18	72%

*(> 6species); ** Average; *** (>1500) kg

4.11.2. Feed and Fertilizer

Most of the hatchery owners are not using proper feed and fertilizer schedule for their brood stock or management. The 68% of hatcheries provide feed and fertilizer on monthly basis (Table 15). Just before the start of breeding season a changed feeding schedule. From February onwards the brooders are feed with mustard oil cake or Ground nut oil cake and broken rice in 1:1 ratio without considering the ratio of brood fish to fed. The spent brooders are given regular food to prepare the spent brooders for early maturation and take up multiple spawning programmes.

During pond preparation for brooders they dry the pond and apply lime at the rate of 200 kg/ha and after 7 days interval raw cow dung is applied at the rate of 1500 kg/ha. Similarly in nursery pond they are using the feed and fertilizer without any scientific basis of feeding and as a result of this improper feed and fertilizer schedule there is heavy growth of filamentous algae which frequently results in mass mortality of spawns.

4.11.3. Infrastructure and brood stock raising

The available brood stock raising area, nursery, spawning pool, hatching pool, brood stock biomasses etc. available in the hatcheries of study area have been provided in Annexure-3. 88% of the hatchery does not possess sufficient area for growing of brood stock in their farm (Table 15) and this is evident from the formula for calculation of the area required for brood fish pond as advocated by Thomas et al., (2003):

$$ABRP = BR \times 1/SD, \text{ where}$$

ABRP = Area of brood fish production pond

BR = weight of brood fish expressed in kg

SD = stocking density of brood fish per ha.

4.11.4. Source and pedigree of brood stock

The study revealed that 96% of hatchery owners do not have sufficient numbers of brooders to sustain the level of spawn production in their hatchery (Table 15). The small farmers depend entirely on outside source for collection of brood fish prior to breeding programme. The big and medium farmers depend both on farm raised and outside source. It was observed that 73% (average) of total brood fish comes from farmers own pond and the rest 27% (average) comes from outside source (Annexure 2). The breeders in the hatcheries (72%) are least bothered to know the pedigree of fish stock they have for the breeding programme to be carried out in their farms (Table 15). Some of the farm was found to have kept pedigree record of the brood stock they have been maintaining since long back. The pedigree record should be maintained to avoid the mating of closed relatives. Hatchery operator should have detailed information on pedigree of brood stock. Cultured populations should be identified by using a proper marking system. Females and males should be from two different lines.

4.11.5. Culling

The practice of culling or eliminating of fish from the breeding programme is the necessity of the modern breeding programme. The culling of fish could be based on the certain criteria based on the phenotype of the fish such as growth, age, size, disease and deformity etc. No such activity was adopted by the fish seed producers of the Champaran area, instead the breeders are found to use the deformed/tumourous/diseased fishes as brooder for seed production (plate 12, 13, 14, 15). Table 15 conforms that majority of the breeders have no idea about the importance of culling of fish from the breeding programme.

4.11.6. Fish disease

Annexure 4 depicts the most commonly occurring fish disease in the hatcheries of Champaran. Most of the hatcheries suffer from outbreak of one or other type of disease or deformity in fishes. The most commonly observed problems related to fish health in the hatcheries of Champaran are as follows:

- Fingerlings suddenly becomes thin with large head and mass mortality occurs
- Fin and tail rot (plate 14)
- Argulus and Learnea infections
- Curved tail of spawns

- Hemorrhage on body (pin point like, specially surrounding eyes and on soft parts of the body) and mass mortality, takes on the interval of every 2-3 years (plate 15).
- Gill rot (Plate 16)
- Disproportionate growth of head and body

For control of disease the farmers apply different types of medicines as per their own (Annexure 4). The dose and frequency of application is not specific as well as scientific, therefore variability results. Besides the aforesaid disease the brood fish are reported to be dead because of other reasons not identified by the farmers. There are reports of change of pond water or use of lime+ $KMnO_4$+ salt to control the disease. The curved tails of spawn are reported in both stripping and normal breeding and it may cause mortality up to 100%.

4.12. Deformity

Alltogether 20 numbers of specimens having different types of deformities were collected from the hatcheries of study area. The deformities were carefully studied and classified according to nature of deformities. The maximum number of deformities identified was spinal deformity (plate 12). Some cases of other deformity like operculum deformity here also found. Individual's vertebral bodies were found to be normal. No lesions, erosion, or sclerosis were found. It gives an impression of gross spinal dysplasia, may be congenial, hormonal, nutritional, inbreeding etc.

Table 16: Type of deformities found in hatcheries of Champaran

Sl. No	Type of Deformity	No's of deformity	Average length (cm)	Average weight (gm)
1	Spinal deformity	18	12.2	24.17
2	Head deformity	-	-	-
3	Opercular deformity	2	11.05	16.4

4.13. Inbreeding and genetic drift

Table17.Factors responsible for Inbreeding and Genetic drift

Practice	No of farmers			Percentage (%)	
	Yes	No	N/A	yes	No
Partial replacement of Brood stock (>3)	3	18	4	12	72
Brood stock raised from Same offspring (negative selection)	21	-	3	84	-
Skew sex ratio	23	1	1	92	4
Varied potency	14	6	5	56	24
Effective breeding No (<263)	-	21	4	-	84
Random mating instead Of pedigree mating	23	-	2	92	-
Brood size (>5kg)	3	21	1	12	84

It was observed that the majority of the hatcheries (72%) in the Champaran do not practice partial replacement of brood stock. Only 12% of hatcheries were found to adopt this practice. In 84% of hatcheries the effective breeding number was found to be less than 260 nos. About 84% of hatcheries practice negative selection of brood fish. In 92% of hatcheries skewed sex ratio was maintained. About 56% of farmers complained of varied potency of pituitary gland. About 92% of hatcheries practice random mating instead of pedigreed mating. As a result genetic erosion may have occurred through inbreeding, genetic drift and bottleneck effect in the hatchery populations.

4.14. Hybridization

There is no report of purposefully hybridization practice adopted by fish seed producers of Champaran. But during our study period we find that 88% (Table 15) hatcheries are having insufficient infrastructure and 96%(Table 11) hatcheries were observed to conduct mixed spawning and it is known that mixed spawning leads to hybridization due to genomic plasticity in fishes. Purposeful hybridization is completely absent in the study area.

Plate: 1 Hiered personal from Bengal with technical assistant of fishery department, Bettiah to carry out the hatchery operations in the study area.

Plate: 2 Totally unmanaged hatchery and brooders pond

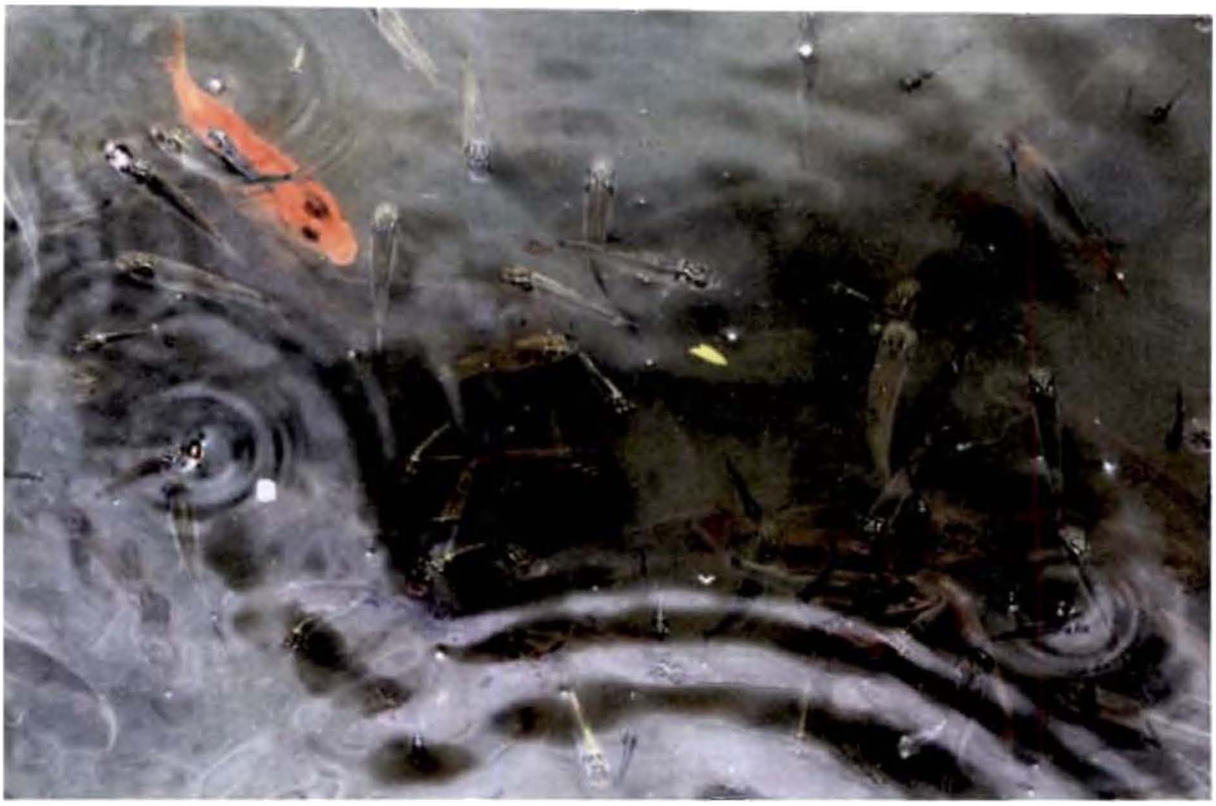

Plate:3 Mixed spawning of IMC and exotic carps

Plate: 4 Mixed spawn of IMC and exotic carps

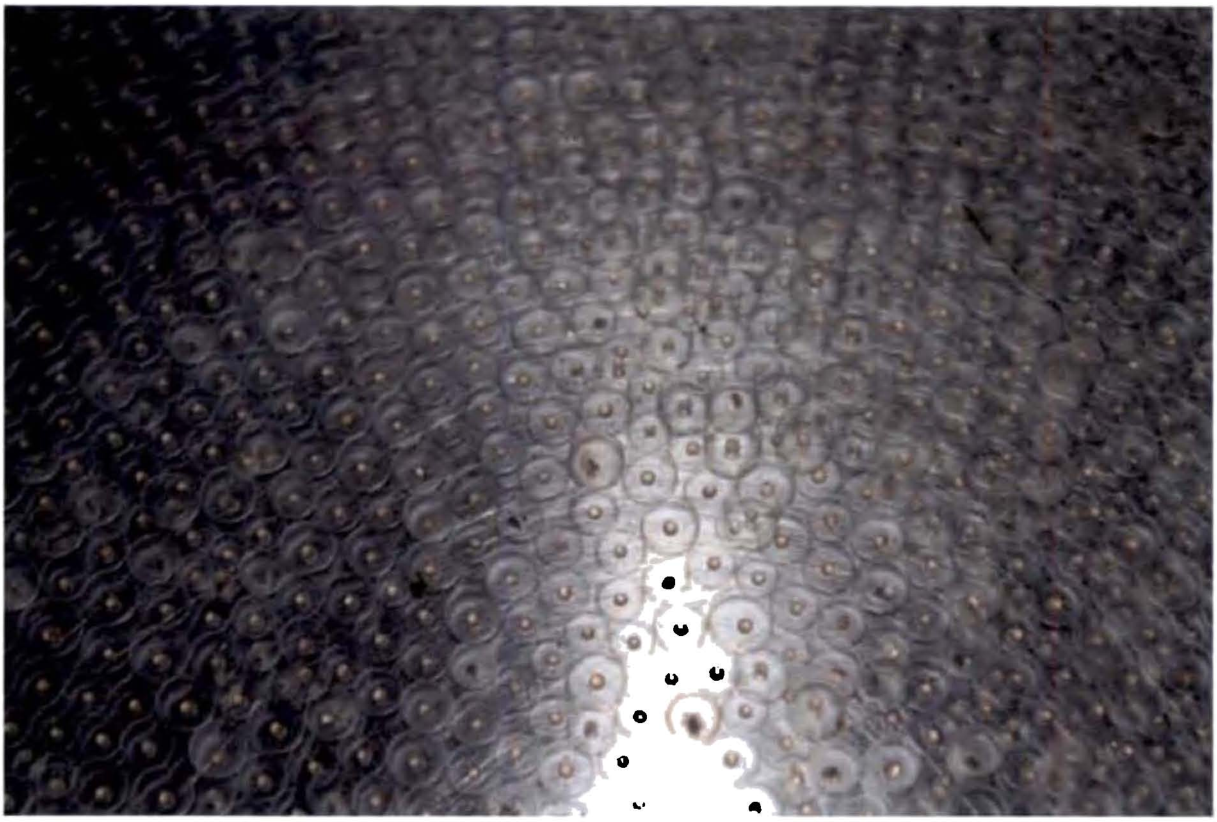

Plate: 5 fertilized eggs of IMC

Plate:6 Injection of CPE to C. Carp

Plate:7 Sexwise segregation before and after injection during stripping.

Plate:8 striped eggs of common carp

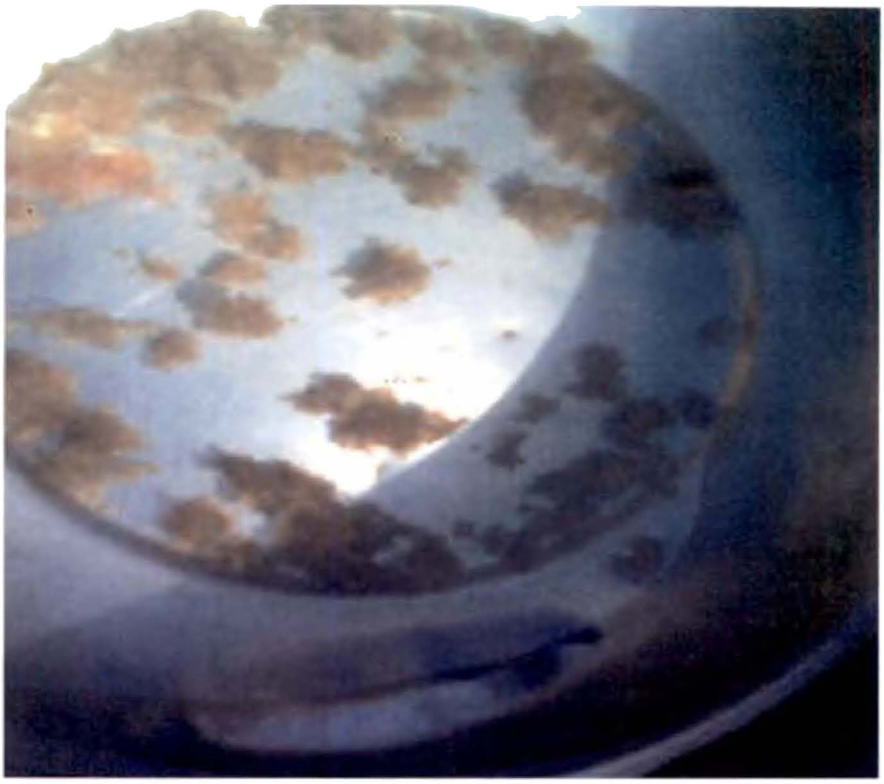

Plate:9 Aglutinated fertilized eggs of common carp in a hatching pool.

Plate:10 Spawns are poured in a standard container for measurement of quantity before selling.

Plate:11 Measured spawns are pouring in plastic container for transportation.

Plate: 12 Deformed body of Rohu collected during study

Plate: 13 Brood fish with tumour like hump in tail region.

Plate: 14 Tail rot in Catla used as brood fish

Plate: 15 Haemorrhage on body of Rohu used as brood fish

Plate: 16 Gill rot in C. Carp

Plate:17 Modified design of inlet in the hatching pool for better flow rate in a govt. Hatchery.

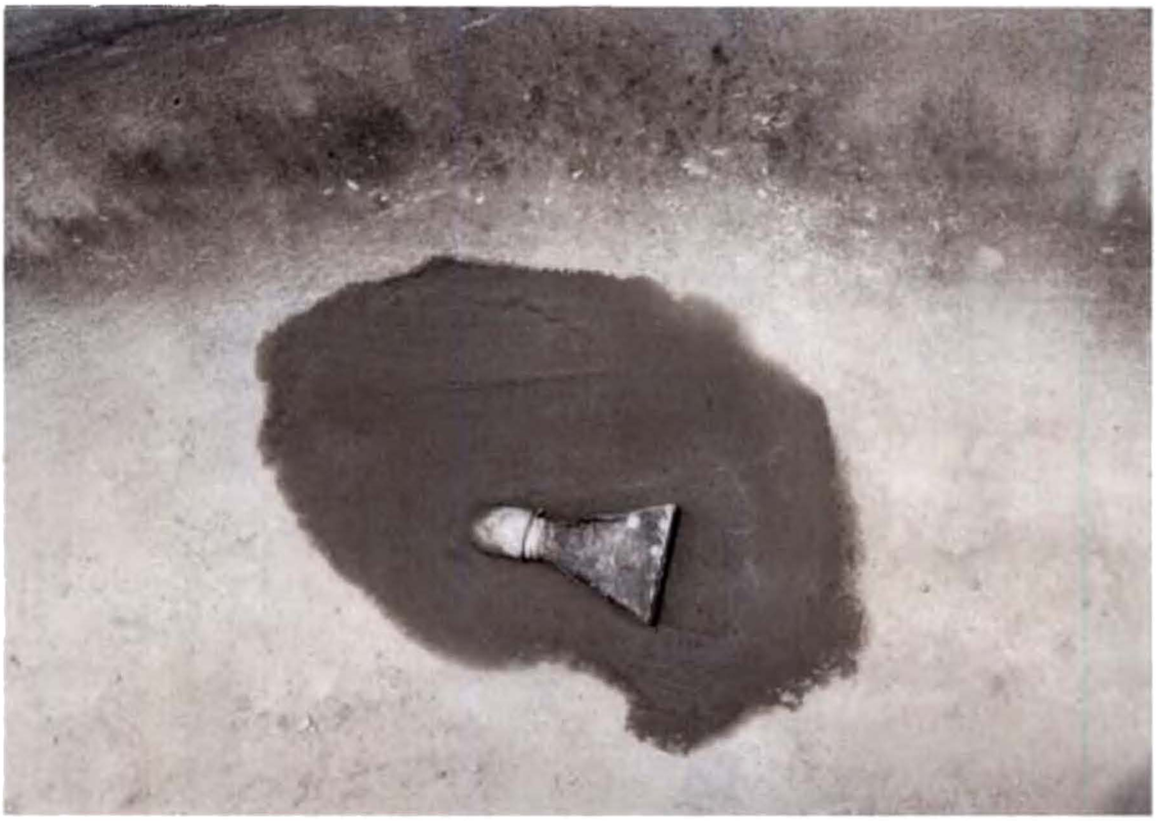

Plate:18 Close view of a single modified inlet in a hatching pool of govt. hatchery

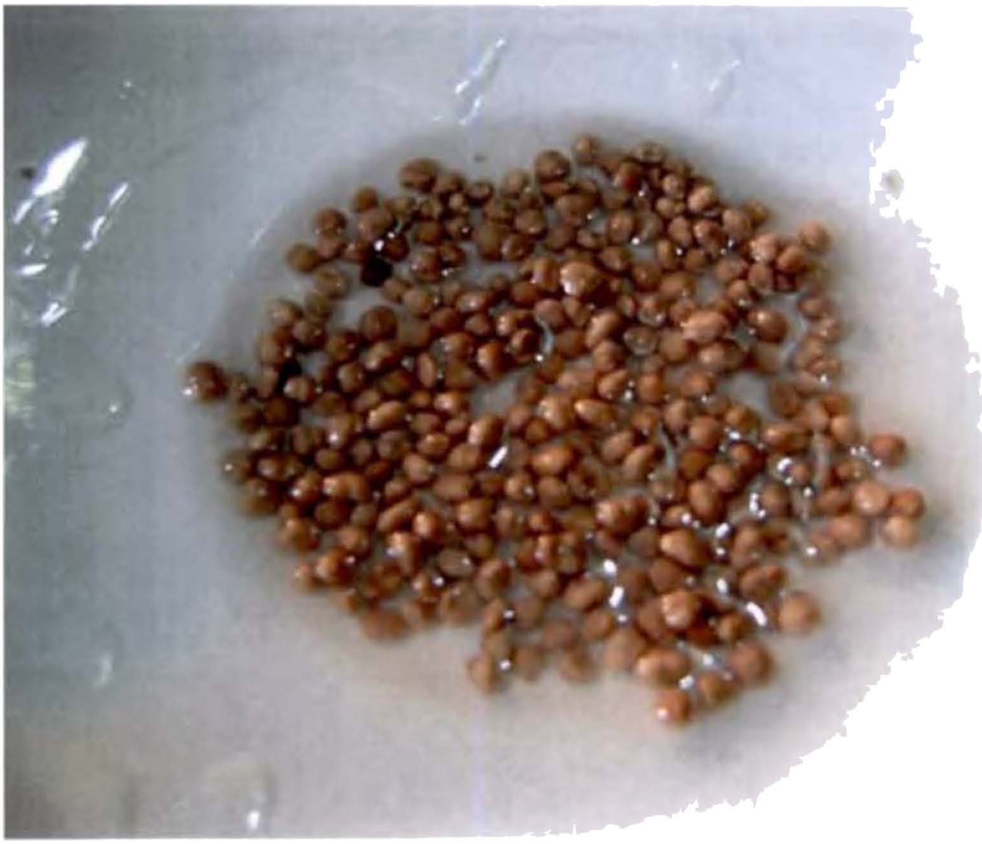

Plate:19 Pituitary gland brought from West Bengal

DISCUSSION

5. DISCUSSION

5.1 Status of fish and fish seed production

As per report of fishery department Bihar the annual fish production of Champaran during the year 2009-2010 from all sources is 2.97 lakh tonnes. During our study period we also met with District fishery officials but they have not kept any record per capita consumption of fish in the concerned districts. We also did not find the per capita consumption of fish in the state from the data of state fishery department.

The annual fish production of the State, both from aquaculture and capture fisheries, has been estimated at 2.61 lakh tons against a demand of approximately 4.56 lakh tons. Evidently, there exists a wide gap between demand and supply, to the tune of 43%, which is quite paradoxical in view of the vast fisheries resources in the State. The unmet demand is partly met from supply of fish from other States like W.B, Assam, and Utter Pradesh etc. Similarly, the annual demand of fish seed in the State is over 900 million, while the production is only about 350 million. (Draft fishery policy, GOB, 2008). From the data obtained from state fishery department the increase in fish and fish seed production is almost stagnant from several years (Table 1).

According to a report of central government, the state produces 350 million fry against its current requirement of 2000 million (A report of the special task force on Bihar, government of India new Delhi April, 2008). Both the data i.e. of state and central published in the same year but one is depicting that annual requirement of fish seed is 900 million while other is saying that annual fish seed requirement is 2000 million indicating huge gap, between the two.

According to our field visit and observation during study period the annual fish seed production in Champaran is quite different from the data given by state fishery department.

5.2. Temporal trend in hatchery establishment

The actual momentum of fish seed production through establishment of Chinese hatcheries in Champaran of Bihar started during early nineties and continues till the time of investigation (fig 3). The figure indicates decade wise increasing trend of the establishment of eco-hatcheries in Champaran of Bihar. It started in the year 1990-2000 when only three (3) numbers of hatcheries was established in Bettia and Motihari districts of Champaran. In 2000-2010 again twenty (20) new hatcheries were added in the same. During the current decade two (2) numbers of small hatcheries has came up.

All the primary fish seed producers who have established their hatcheries during 1990-2000 were initially fish farmers and use to visit the hatcheries of West Bengal for getting seed and from their farmers learned the technology. The farmers get initial training from late Mr. Nilu Ghosh

Two progressive fish farmers named Mr. Ramvilash Rai from Bettiah and Mr. Surendra Singh from Motihari established the Chinese hatchery in Champaran of Bihar. Observing the success, many progressive farmers, earlier engaged in fish farming, started establishing carp hatcheries in and around the Bettia and Motihari. Interestingly, within a span of ten years eighteen more new hatcheries came up. The technology of Carp seed production using Chinese hatchery was brought to Bihar from West Bengal and credit is going to Mr. Nilu Ghosh pioneer of hatchery for initiation of hatchery establishment and technology to hatchery operation in West Bengal. With this initial training two progressive fish farmers Mr. Ramvilash Rai of Bettiah and Mr. Surendra singh of Motihari established the first Chinese hatchery in Champaran of Bihar. Observing the success as well as profit of fish seed production many progressive farmers, earlier engaged in fish farming,started establishing carp hatcheries in and around the Bettiah and Motihari. Interestingly within a span of ten years eighteen new hatcheries has came up. It is intresting to note that the technology of carp seed production using Chinese hatchery was brought in Bihar from West Bengal and entire credit for such transfer of technology owes to some pioneer persons in this field as mentioned. During the study period it was observed that the hatchery owners of Bettiah and Motihari are still dependent on the hired personal from Bengal to carry out the entire breeding and hatchery operations.

5.3. Categorization of Eco-carp hatchery

Eco-carp hatcheries can be categorized into marginal, medium and large hatchery based on the criteria adopted by Gupta et al., (1999) for categorization of eco-hatchery as indicated in Table 3. It was observed that most of the hatcheries come under marginal (12), followed by medium (9) and large (4). All the hatcheries are based on Chinese design and principle, some maintain double row of duck beak inlet while others maintain single row.

5.4. Ownership status

The ownership status of eco- hatcheries as pointed out in figure 4 indicates that entrepreneurship with single ownership control is preferred rather than a joint approach in the Champaran of Bihar as far the fish breeding and hatchery management is concerned. Chattopadhyay (2008) in West Bengal and Das (2000) in Assam have also reported the choice single ownership over joint venture.

5.5. Design of eco-carp hatcheries in Champaran

The design of carp hatchery in Champaran is based on the ecological factors responsible for carp breeding in nature followed by hypophysation technique. All the private hatcheries are based on Chinese design in the private sector while only one govt. Hatchery in Champaran which is under construction is the latest modification of Chinese design of hatchery. Advances made in designing, construction and innovative management of hatcheries have undoubtedly contributed a lot to promote major carp seed production (Rath *et al*, 1997) in Bihar by West Bengal Assam.

We have seen a of hatchery (under construction) which is a modification of Chinese hatchery and is the single govt. hatchery in Champaran. The Government hatchery of Bettiah is a improved modification of Chinese hatchery, which contains only six(6) inlets in hatching pool and three inlets in spawning pool. The mouth of inlets in hatching pool is compressed to increase the rate of water flow (plate: 17, 18).

5.6. Breeding season and price of spawn

It was observed that spawn price per bati (40000-50000 nos) varied with breeding season during March to August (Table 10). The highest price fetched per bati spawn is Rs. 400 (four hundred) only during early and latter part of the season, the lowest being Rs. 150 (one hundred fifty) during peak of the season when the breeding intensity is highest during May-June (fig 6). During peak of the breeding all categories of hatchery owners i.e. marginal, medium and large, participate in breeding programme as the brood fish are readily available to all. But during early and late season only large hatchery owners participate in seed production but the other two categories could not as the brood fish are not available. This is because as already mentioned , the marginal and medium seed producers have little source of their own brooders and in most cases depend on large fish breeders or other source for their brooders.

The price hike of spawn during early and late season is due to less production of seed by only large hatchery owners.

5.7. Breeding practice

5.7.1. Age and size of brooders

The majority of fish breeders in Champaran are using fish more than 5 years of age as brood stock and some even consider above 5 kg (Table11 and Annexure 2). The common practice is to use the same brood stock for consecutive years and supplementation stocks with parent and offspring is common in India, where; the use of brood stock over 5 kg reduces fish fecundity and gamete viability, increases the risk of inbreeding with consequential reduced 'fitness' and survival of offspring and suitability for future reproduction. Bondari et al., (1987) reported that the age and size of parents not only influence certain phenotypes but also affect spawning success and early growth of Channel cat fish fry. They found that within 5 year old brood stock there exist negative correlations between size of the males and spawning success; female weight and egg weight; female weight and fry weight of 4 weeks.

5.7.2. Sex ratio

In hatcheries of Champaran brood stock management practices may be acting negatively on production efficiency. The sex ratio used in breeding in 96% hatcheries (Table 11) fell outside of Tipathi and Khan's (1990) recommendations of 2:1 or 1:1 (M:F), while the average sex ratio (17:20=M:F) used by fish breeders of the Champaran is also less than the recommendation of Tipathi and Khan (1990). All the hatcheries (table 11 and Annexure 2) used more than one female per male fish which can reduce genetic viability in offspring and increase the risk of inbreeding and poorer stock survival in hatcheries, particularly where offspring are further used for producing future generations within the farm of their origin.

5.7.3. Multiple breeding

Multiple breeding is practiced in all the hatcheries of Champaran of Bihar (Table 11). It not only enhances the production capacity of the hatcheries but also give price edge to the producers and judicious use of the limited resource facilities they have in their farms. It was found that 96% of the hatcheries practice multiple breeding. Due to scatcity of male brooders in nature the fish breeders generally use a single male for 5-6 times in a season at 30 days gap and female 3-4 times in a season at 30-40 days interval from March to August in a year. The breeders as reported have been found effectively spawning IMC thrice in a year with and sometimes four times in some hatcheries and exotic carps are bred twice or thrice in a year. Breeding of Grass carp is taken up in early part of the season i.e March-April and later part of the season only where as the silver and Big head carp carried out also with the rest of the species. The breeding of catla is preferred during peak season because breeding response of catla is not good as compare to other carps. The spawn yield per kg body weight for IMC is maximum during the second phase of breeding (monsoon), whereas during initial breeding season (pre-monsoon) it was less. During the third breeding programme (post-monsoon) the quantity of spawn yield is least (Table 11). Gupta *et al.*, (1995) reported similar result during multipl breeding IMC. It indicates that, the brooders are forced to breed, during the first breeding programme, though they are yet to attain complete gonadal maturity which coincides with the vernal equinox, a phenomenon occur during peak season.

On the other hand, the quantity of spawn yield is reduced during the 3rd breeding programme due to improper maturity instead of enhanced feeding, environmental attributes, physiological shock, etc. However, the farmers are unaware of the fact that survivality and growth rate of the seeds generally reduced while practicing multiple breeding of carps (Thomas *et al.,* 2003). Also repetitive hypophysation within a short breeding season had been reported to cause blindness and other abnormalities, particularly to males (Chattopadhyay., 2008)

5.7.4. Mixed spawning

Most of the fish seed producers of Champaran conduct mixed spawning of different fish species, such as Rohu, Mrigal, including Big head carp, G. Carp etc. and that results in the production of many unwanted hybrids. Polyculture of IMC, catla, rohu, mrigal, is very common practice as recommended by the fishery scientists for obtaining higher production per hectare water bodies. This naturally prompts the fish farmers to ask the fish breeders for supply for fish seeds of these species in a desired proportion suitable for composite fish farming. Artificial breeding of these fishes are generally done in a 'community breeding pool' known as 'mixed spawning'. Mixed spawning leads to the hybridization inadvertently because of their genetic kinship among the genetic flexible species of IMC and Exotic carps(Padhi and Mandal, 1997). Reports are there that these species produce inter-generic hybrids in nature and under captive breeding condition (Tripathi, 1992). The identical chromosome number, identical isozyme gene expression, and ease of producing fertile hybrids on a large scale indicate their close genetic relationship. Further the synchronization of spawning time of these carp species following hormone treatment, also enhances the incidence of hybridization. Hybrids of these species are not much beneficial from culture point of view (Tripathi, 1992).

Inadvertent hybridization between IMCs and backcrossing of F_1 hybrids with parent would cause genetic introgression, which leads to contamination of native gene pools. This 'genetic pollution' will affect the genetic diversity and genetic integrity of these species. As a result it will be difficult to get pure stock of 'Catla' or 'Rohu' which will affect selective breeding program for genetic improvement in future (Padhi, 2000). Das (2000a 2000b) reported that mixed spawning among different fish species in Assam, such as Rohu, Mrigal, Catla, Gonius, Calbasu, Bata etc. in a single operation give rise to many unknown hybrids. When these hatchery raiseds find there way into natural habitat there is every possibilities of contamination in the nature gene pool. During present study many such undesirable hybrid where encountered.

5.7.5. Natural breeding

Majority of breeders follow the practice of natural breeding in hatcheries of Champaran. It was observed that 84% of the fish breeders of Champaran preferred natural breeding over striping (Table 12), as it require less effort and expertise and produce better quality seed. Unlike Bengal and Assam where striping is a common practice as reported by Chattopadhyay (2008), the farmers in Champaran are mostly engaged in natural breeding. Striping is generally practiced for exotic carps and cat fishes, due to farmers of Champaran do not practice cat fish breeding. Although the govt. of Bihar is very much interested in initiating Pangasius breeding and culture, but farmers are still less attentive to this and realised that Pangasius breeding is not possible in Champaran.

5.7.6. Stripping

It was observed that 12% of the fish breeders practice stripping in the hatcheries of study area (Table 12). It is used mostly for exotic carps as they fail to spawn naturally because of their less responsiveness to inducing agents. Stripping is only practiced to meet the demand of cross breed hybrid fish seed from the farmers as the hybrids are comparatively hardy and can withstand transportation shock. Compare to Bengal and Assam, such a low percentage of stripping operation in the Champaran was found to be due to lack of expertise by hatchery owners as they are totally dependent on hired peoples from West Bengal for breeding practice and hatchery operations. Again as the majority farmers preferred natural spawning over stripping both the fertilization and mortality rate is high. For IMC it is done for hybridization and acute case of male brooders shortage but it is mandatory for Exotic carps. The farmers practice without considering the negative consequences like damage to internal organs, stress to the brooders, and mortality etc.

5.7.7. Restocking of brooders

Restocking of brooders after spawning is a common practice adopted by most of hatcheries in the Champaran. This practice allows the fish breeders to reap the harvest repeatedly with the same numbers of brooders for a longer period of time without replacing the stock. It is quite interesting to note that the breeders in some hatcheries reported that they continue with the breeding of same set of brooders till it sustains. We have observed that 76% of the hatchery owners restock the brooders and kept as potential brood stock for the ensuing season and preceeding years to come (Table 12). There are few who sales the brooders partially after breeding. There are also some of them who sale the non-performing ones, old aged, etc. it will block the supplementation of genetic material into the breeding population. Jewel et al., (2006) reported that in Bangladesh, Common carp are bred repeatedly in the hatchery with limited number of parents to keep the production cost at minimum level. As a result genetic erosion occurred through inbreeding, genetic drift and bottleneck effect in hatchery populations.

A study was conducted to assess the genetic variation among the different hatchery populations of scaled carp and mirror carp and to compare the genetic variability between different populations using microsatellite loci developed by Croojmans et al (1997). This indicates that in mirror carp strain there is increased loss of allelic variations and heterozygosity than scaled carp strain. The deviation of mirror carp strain from Hardy Weinberg expectation equilibrium might be due to loss of heterozygocity in hatchery population, as a result of inbreeding, genetic drift and bottleneck. Higher level of loss of allelic variation in mirror carp than scaled carp may be due to the fact that scaled carp was introduced into the Bangladesh in two batches while mirror carp in three batches and bred repeatedly in the hatcheries with small effective number of broods (Ne). As a result genetic erosion might have happened in most of the hatchery populations through inbreeding and genetic drift. The losses of heterozygosity may be increased with the increasing effect of inbreeding.

5.8. Inducing agent

The fish breeders of Champaran are using only CPE extract as inducing agent for induced breeding of fish. CPE is the natural inducing agent containing GTH-I (Gonadotropin Hormon-I) and GTH-I (Gonadotropin Hormone-II). Though it is establish that OVAPRIM has certain advantage over CPE, the farmers of Champaran are still using CPE as sole inducing agent. The farmers informed that OVAPRIM is affecting the fish health and is not useful for multiple breeding and it is not economical because of high cost. This shows that farmers are not interesting to adopt the ovaprim as inducing agent or they are not well trained about how to use the ovaprim.

The whole requirement of pituitary glands is collected from Kolkata and the glands brought from Bengal are sometimes reported to be spoiled or required higher dose. This gives unexpected results and fish breeders have to suffer loss. As all the fish breeders are dependent on the hired peoples from West Bengal, so they have to compromise with the gland quality whatever brought by the Bengali people. However, the fish breeders learn to recognise the quality gland by observing the color and spongy nature (plate 19). The cost of pituitary gland is also increasing day by day, each piece of the gland (<5 mg) cost Rs. 5.00 and the piece of gland (>5 mg) cost Rs. 7.00 and above.

Chondar (1994) made an assessment and stated that of proper doses of pituitary gland for induce breeding of fish is most important criteria for success of breeding programm. The greatest difficulty in standardization of fish gonadotropin is encountered on account of various factors of which the size and sexual stage of maturity of the breeders are the most important factor. The potency of the glands also varies according to sizes and sexual development of the donor as well as the species of donor fish, time of collection and their proper preservation.

5.8.1. Pituitary protocol used in different hatcheries during pre-monsoon, monsoon and post-monsoon

The average pituitary protocol used by different hatcheries of Champaran during pre-monsoon, monsoon and post-monsoon are given in the table 13. It was observed that the dose of CPE was higher during pre-monsoon and post-monsoon, while the dose in monsoon season was comparatively less. It may be due to several reasons such as brooders not attaining full maturity during pre-monsoon period, less congenial environment etc. And during post-monsoon period the brooders used are already spent two-three times which are now on the recession stage. Catla preferred slightly higher dose of CPE compared to Rohu and Mrigal throughout the season as reported by farmers (Table 13). This is conformity with the findings of Chondar (1994) who reported that in similar environmental conditions, Catla usually requires a little higher dose than Rohu and Mrigal. The male dose of pituitary gland did not vary much irrespective of breeding season. It remained almost similar throughout the season and species. Hence farmers use higher dose to get breeding response by any means, irrespective of quality. This shows that farmers are more concerned with only profit oriented seed quality not quantity. There was significant difference in dose for female, used by farmers during pre-monsoon, monsoon, and post-monsoon period ($F=33.84$, $F_{crit}=3.68$, $p<0.05$)

Catla preferred a slightly higher dose of pituitary gland extract compared to Rohu and Mrigal throughout the seasons as reported by the farmers.The male dose of pituitary gland did not vary much irrespective of breeding season. It remained almost similar throughout the season and species. ANOVA analysis at 5% significant level shows that no significance difference between the means of pituitary dose used for IMC was noticed during three spawning season ($F=30.05$, $F_{crit}=3.68$, $p<0.05$).

5.9. Flow rate

The initial flow rate (0.28±0.06 to 0.43±0.07 m/sec) maintained in spawning pool was within the recommended range of 0.2-0.5 m/sec Thomos et al., 2003). The final flow rate (0.18±0.02 to 0.22±0.07 m/sec) practiced by farmers of Champaran could not be compared because of paucity of literature. The initial (0.19±0.04 to 0.24±0.05 m/sec) and final (0.16±0.02 to 0.24±0.04 m/sec) flow rate observed in the hatching pool of the hatcheries of Champaran fell short of initial (0.4-0.5 m/sec) and final (0.3-0.4 m/sec) recommended range of Thomos *et al.*, (2003). But Sahoo (2001) reported the flow rate of 0.2-0.3 m/sec in both the spawning pool and hatching pool as the standard velocity of flow. The farmers are not aware of the recommended rate. They adjust the rate in such a way that it would not allow th e developing fertilized egg to settle at the bottom, instead the egg undergo a cyclic downward and upward movement until hatching. ANOVA (single factor) confirmed a highly significant difference between the initial and final flow rates maintained in the breeding pool by the farmers ($F=45.13$, $p<0.05$). A significance difference was also noticed in the flow rates of hatching pool during initial (1st 12 hr), mid (next 6 hr) and final (rest period) phase of breeding period. The slowdown of flow rate prevents excess loss of water which saves water, energy and therefore production cost. Most of the farmers reported that the water current in the spawning pool is initiated 1-2 hr before the calculated spawning time only. This initiates the excitement of spawners and spawning results. The spawning is usually completed within 2-3 hrs of initiation. This may extend up to 3-4 hrs depending upon the nature of inducing agent used, weather condition, age and quality of brooders. The farmers reported that spawning of Catla must be done with shower, while other fishes can spawn without shower. And during peak season low dose of CPE and slow water velocity is required for the spawning of IMCs and Exotic carps.

5.10. Brood stock management

5.10.1. Species and stocking density

The fish breeders of Champaran maintain a multispecies brood stock pond comprising of IMC, Minor carps, and Exotic carps of different age groups and sizes with high stocking density. Though multispecies carp culture is a recommended practice, but the unscientific manner in which it is carried out is the real cause of concern. It is observed that 84% of total seed producers of Champaran maintained more than six species in the brooder pond with no control over the species ratio and composition (Table 15). It was observed that the species composition included even the banned species Bighead carp (Annexure I).

The species composition as suggested by Thomos *et al.*, (2003) should be 3:2:2:2:1 for Catla: Rohu: Mrigal: Grass carp: Silver carp respectively. Stocking density is considered to be one of the vital criteria to be taken into account in brood stock management programme. Most of the hatcheries in Champaran seem to maintain a very high stocking density in brood stock pond. It was observed that 80% of the fish breeders maintained a stocking density of more than 1500 kg per hectare. The average stocking density maintained by the hatchery owners of Champaran was 2106.4 kg per hectare (Table 15). The stocking density of 1000 kg per hectare and the stocking pattern; 60% (main species: 10% (rest of each species) of professional brood stock do not match the criteria suggested by Gupta *et al.*, (1995).

5.10.2. Feed and fertilizer

The hatchery owners of Champaran do not have proper feeding and fertilizing schedule for the brooders and other management practices in their farms. Most of the fish breeders provide feed and fertilizer on monthly basis. It is just before the start of the breeding season there is change in feeding schedule. From February onwards the brooders are fed with mustard oil cake or Ground nut oil cake and broken rice in 1:1 ratio and there is no proper measurement about feed quantity with relation to body weight of brooders. Just after the onset of breeding season the feed is given regularly to spent brooders only for early maturation and take up multiple spawning programmes. During pond preparation for brooders they dry the pond and apply lime at the rate of 200 kg/ha and raw cow dung at the rate of 1500 kg/ha. In nursery pond they are using the feed and fertilizer without any scientific basis of feeding and as a result of this improper feed and fertilizer schedule there is heavy growth of filamentous algae which frequently results in mass mortality of spawns.

Das and Jana (1996) revealed that the concept of pond fertilization should be based on NPC rather than NPK, as availability of potassium is high in the pond sediment. For most of the phytoplankton species NPC required ratio is 16:1:106 which indicates that even in trace quantities phosphorus influences the primary productivity in the presence of other two elements sufficient concentrations. The brood fish are to be fed on formulated diet containing 30% protein (Gupta et al., 1995).

5.10.3. Infrastructure for brood stock

There are several constraints concerning the availability of brood stock raising area, nursery, spawning pool for breeding of single species in the study area (Annexure-IV). Altogether, 88% of the fish breeders has insufficient area for raising of brood stock in their farm. The total biomass (average) of the brood stock for each hatchery was 2560 kg (2.56 MT, Annexure-II) for which the fish breeders was found to maintain an average of 1.34 ha, but the recommended area for maintaining 1300 kg brood is 2.6 ha (Thomos et al., 2003). This indicates insufficient area available for proper raising and maintenance of the brood fish.

5.10.4. Source of pedigree of brood stock

It was found that 76% of fish breeders do not have sufficient numbers of brooders to sustain the level of spawn production in their hatchery (Table 9). The small farmers depend entirely on outside source for collection of brood fish prior to breeding programme. The big and medium farmers depend both on their own stock and outside source. There is recruitment of brooders from mauns and chaur as outside source. The brooders from wild source are good but are costly and difficult to procure at the right time.

The fish breeders are least bothered to know the pedigree of fish stock they have for breeding programme to be carried out in their farms. No farm was found to have kept pedigree record of their brood stock they have been maintaining since long back. Hatchery operators should have detailed information on pedigree of brood stock. Cultured populations should be identified using a proper marking system. Females & males have to be originated from two different lines. Sriwardena (2007) reported that selective breeding and hybridization programmes of pedigreed fish are not carried out in fish seed farms.

Padhi (2000) viewed collection of brood stock in adequate number, cataloguing of their geographical origin, their genetic characterization and maintaining their pedigree record are important pre-requisites for scientific breeding progremme. The pedigree record should be maintained to avoid the mating of close relatives Padhi (2000). These aspects are of much genetic relevance. Tave (1993) reported that pedigree mating differs from random mating as each female leaves one daughter and each males leaves one son to be used as brood stock in the following generation. The approach to maximize Ne is to switch from random mating to pedigreed mating for long term success in breeding programme.

5.10.5. Culling

The practice of eliminating or culling of fish from breeding programme is the necessity of the modern breeding programme. The culling of fish should be based on the criteria based on the phenotype of fish such as growth, disease, deformity, age, size etc.

Tave (1993) opined that culling should be based on most catchable fish than least catchable during harvesting. Doyle (1985) refers brood stock management to the aggregates of methods that the farmer uses to handle his animals in the farm. These methods include feeding, spawning, and culling animals under varied aquaculture conditions. No such activity was adopted by any of the fish seed producers of the study area, instead one of the breeder was seen using a Rohu for induce spawning with a tumor like lump in the fin region of the fish (plate 13) raised in his farm. Krishna and Pandey (2001) are of the view that the brooders that are senile, diseased, physically defective, disabled and without family history should be culled from the breeding programme. The fish breeders of the study area are totally unaware of such important scientific aspects of breeding programme. For successful management with a view to quality seed production, this aspect should be included in future breeding programm.

5.11. Fish disease

The most commonly occurring disease in the hatcheries of Champaran are listed in Annexure-IV. Almost all the hatcheries suffer from the outbreak of one or other type of disease. As reported by farmers Fin and tail rot, curved tail of spawns, thin body and large head of fingerlings, Argulous and Llearnea infections, haemorrhage on body are the major disease encountered by them. Again diseases like ulcer gill rot, Dropsy, Gas bubble are reported by the farmers which are considered responsible for fish seed mortality.Similar types of disease were observed by Milwain et al., (2002) and Chattopadhyay (2003) in the hatcheries of West Bengal.

For control of disease the farmers apply different types of medicine as per their own (Annexure-IV). The dose and frequency of application is not specific, therefore variable results come up. This shows the lack of expertise in identifying the causative agents and their treatment by competent authority and also due to the non-avalibility of specific aquaculture drugs in market. Sometimes brood fish are reported to be dead and floating on the surface for which specific reason is not known to the farmers. Farmers are using lime, salt, potassium per magnet to control the disease. One of the common problem reported by farmers is the heavy mortality of spawns in nursery pond due to very high growth of filamentous algae. This shows that farmers are using feed and fertilizer in more than required amount.

For control of disease they are also guided by Agriculture technology management agency (ATMA) and also by neighbouring farmers. Mainly, the farmers are using agricultural or veterinary medicine.

5.12. Deformity

In the hatcheries of Champaran so many deformed fish were found. Al-Harbi (2001) stated that the deformities are quite common in both wild and cultured fish populations, but their percentage is more in hatchery populations. Available evidence suggests that abnormalities are induced during the embryonic and post-embryonic periods of life. However, the etiology of these syndromes is not well understood.

The fish breeders in Champaran work as genetically closed units where inbreeding among the brood stocks is the usual phenomenon. The large number of private hatchery owners is in the business of fish seed production with a very limited number of founder brood stocks. The brood stock progenies are being repeatedly utilized for seed production without any replacement from outside (Wild) sources. The signs of 'inbreeding depression' as evidenced by the large frequencies of appearance of deformities in the hatcheries of study area as reported by farmers supported the existence of inbreeding.

Bondari and Dunham (1987), Padhi and Mandal (1994) reported that deformity could be the effects of inbreeding. In a study conducted by Chattopadhyay (2008) in West Bengal revealed that the negative aspects of this genetic phenomenon (inbreeding) is fry deformity (35-40%).

The optimum or standard dose of pituitary gland was never practiced in hatcheries. Sometimes brooders are forcibly bred with higher dose of hormone even when they are not mature enough. This initiates premature release of ova which either do not fertilize or at best lead to deformed progeny susceptible to mortality (Chondar, 1994).

Dabrowski et al., (1998) during larval rearing of common carp, reported skeletal deformities and found to be related to either vitamin C difficiency in the diet or to a strong water current (Backiel et al., 1984). About 5 numbers of stumped bodied cases were identified during study period. Stump body is caused by an abnormal ossification of the trunk vertebrae (Al-Harbi, 2001). Deformed fish were shortened along the anterior-posterior axis, more deep body with shortened trunk than a normal fish. Tave et al., (1982) and Dunham et al., (1991) opined that stump body to be non-inheritable.

5.13. Inbreeding

During our study we observed that the way in which fish breeders are doing the breeding practice invite both inbreeding and negative selection. The common practice of brood stock replacement by the farmers of Champaran seems to retain a few fingerlings each year which are normally collected towards the end of spawning season, consisting of not more than two or three families. These practices are likely to result in inbreeding and selection for poor growth. Inbreeding occurs when mates are more closely related by ancestry than the average relationship of all individuals in the population. Mating involving full or half sibs, offspring and parent, and even cousins can be termed inbred mating.

The hatcheries of Champaran adopt the breeding programme in which they use same broods and offspring raised from it in successive generation and therefore inbreeding is a very common practice in hatcheries of Champaran. This practice will prevent the genetic exchange between farmed stock species and wild species, thus minimizing the chance of development of superior traits. The negative aspect of this genetic phenomenon will result in decreased survival rate of fry and fingerlings, fry deformity, decreased food conversion efficiency etc. this depression is due to increased homogygosity of genes, particularly harmful one and reduce productivity. The effects of inbreeding was examined in several species of IMCs including common carp,channel catfish, zebra fish etc. by sib-mating (Bondari and Dunham, 1987; Padhi and Mandal, 1994). Fishes are more prone to inbreeding due to their high fecundity and genetic plasticity.

The hatchery environment ensures high growth and survival in absence of competition for food and challenges from predators and parasites. If the brood stocks in hatcheries are not replaced or exchanged, the fish breeder will bred the close relatives. This has happened in some Indian major caps hatcheries of southern India, where the brood stocks remain genetically close. This resulted in inbreeding rates of 2-17% (Eknath and Doley., 1990).

Now, it has been establish that inbreeding leads to reduced growth, food conversion efficiency, survival rate and increase production of abnormal offsprings. This phenomenon is known as inbreeding depression. For example one generation of reduce 10-20% in growth rate. Any fishery operation that result in limited number of fish being available to produce progeny for use as brood stock for next year may lead to a constriction in the gene pool of that population, either in hatchery or in natural fishery.

One of the genetic erosion occurring in the most hatchery of Bihar is the crossing between brother-sister and parent-offspring. In fish culture, harmful effects of inbreeding appear moderately because of the high number of offspring. Effects of inbreeding in fish population as a result of some of the recessive alleles are retarded fish growth, reduced reproductive capability, low survivality, deformities etc (Das, 2000).

5.14. Genetic drift

In hatcheries the fish breeders are using small number of brood stocks for breeding at a time, which leads to genetic drift. It is a phenomenon that leads to random changes in the gene frequency in a founder population, which may not carry some alleles due to sampling error. The loss of alleles reduces genetic variance in the hatchery population. Allendrof and Phelps (1980) first addressed this problem of hatchery practices leading to genetic drift in Cutthroat trout Oncorhynchus clarki (Wallbum). They showed the loss of alleles due to genetic drift by comparing the allelic frequencies in hatchery and their wild relatives. Genetic drift makes a population unfit for selective breeding as occurred in case of *Tilapia nilotica*. It was also found that genetic drift led to the extinction of certain strain of channel catfish (Tave, 1991). Almost all the hatcheries bred fish repeatedly with limited number of parents in the hatchery to keep the production cost at minimum level. As a result genetic erosion may have occurred through inbreeding, genetic drift and bottleneck effect in the hatchery populations.

5.15. Hybridization

As carp hatcheries of Champaran are not having sufficient infrastructure, only one spawning pool in each hatchery (Annuxere IV), and farmers are interested in polyculture, so pure breeding of IMC is seldom practiced in most of the hatcheries in study area.

Therefore, fish seed breeders are practicing mixed spawning practice. None of the hatcheries are purposefully doing hybridization practice, but they are totally unaware of the fact of genetic plasticity of IMCs. The purposefully hybridization is only practiced in case of Silver carp+ Big head carp, because hybrid is similar to Big head carp and there is good demand for Bighead carp in Champaran and its surrounding area.The fish breeders are using the combination of IMC+G. carp, among IMC, Silver carp +Big head carp, Rohu+mrigal+G.carp+Big head carp for mix spawning. Obviously there is a chance of random hybridization among the genetically flexible species of IMC. Reduction of genetic diversity can also occur because of indiscriminate hybridization. Indiscriminate hybridization among IMC and backcrossing of F1 hybrids with parents cause contamination in the gene pool of IMC through genetic introgression (Gyllensten, et al., 1985).

5.16. Impact on wild fish

As Champaran and its surrounding areas are frequently affected by flood and during that period there is chance of migration of fishes from hatcheries to natural water bodies (mauns and chaur). Besides the hatchery raised fishes are distributed to diverse geographical territories and find their way into natural system through various programmes like ranching. As it is discussed that mixed spawning is a common practice in the hatcheries of study area, so it is expected that different kinds of undesirable hybrids are produced among the genetically flexible species of carps and exotic fishes. There are reports of production of viable offspring out of reciprocal cross as well as backcrossing among different species of carps. These findings clearly indicate that when these hatchery raised hybrids are released into natural system, the native gene pool will be contaminated through hybridization among these hybrids and wild fish fauna.

SUMMARY

6. SUMMARY

The technology of breeding fish in captivity was developed by the scientists to produce quality seeds of desired species when it was understood that natural source is declining fast due to pollution, destruction of spawning ground and related anthropogenic activities. Though initially it was implemented to the farming situation to produce quality seed and meet the increasing demand of culture sector with the application of remarkable technology of composite fish farming.

The technology was primarily adapted by the Bengal farmers and relatively the notable profit, the farmers of Assam and Bihar learn the technology from the Bengal fish breeders to implement the same in their respective state. In all cases the farmers learn the technology from the neighbouring illiterate fish breeders, devoid of any institutional training and scientific appraisal of the technology.

The fish breeders of the Champaran district of Bihar are lagging behind compared to other two states and still they depend on some hired personnel from Bengal for entire hatching operation and inducing agent (carp pituitary).

The fish breeders as they are concerned only for profit and as there was no scientific appraisal programme, implement all sorts of unscientific approach to raise maximum seed during breeding season. Mixed spawning, hybridization is a common practice and nothing has been done for brood stock development and quality assurance of gland. All these activities, since implementation of technology in the state, has led the seed production far away from the very idea of quality seed production for which the technology was implemented.

Now, several misappropriations of technology, as mentioned, are putting threat to the entire aquaculture sector, especially, the native gene pool of the entire state. There is urgent need for an objective study to the extent of damage that has already done through the dissemination of farm raised undesirable hybrids into the natural system. Scientific programme from government and/or institutional level should be initiated to teach the fish breeders about the impact of their misdeeds and how these are alarming to fish seed sector and culture sector.

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ANNEXURES

Annexure 1: Species wise fish seed production in Champaran

Districts	Location of Hatchery	No. Species produced	Mrigal (%)	Rohu (%)	Catla (%)	Silver Carp(%)	Grass Carp(%)	Bighead Carp(%)	Common carp(%)	Labeo Calbasu(%)	Labeo bata(%)	Others (%)
Bettiah	Barwat sena	10	30	8	8	2	20	15	10	3	2	2
	Pipara	9	25	10	6	4	20	15	12	5	3	
	Pipara	8	20	10	7	3	25	20	12	-	3	
	Plpara	6	30	7	-	3	25	20	15	-	-	
	Kathaia chawk	8	35	7	8	2	20	15	10	-	3	
	Majhawlia	8	30	8	7	3	20	20	10	-	2	
	Majhawlia	8	25	8	7	3	25	20	10	-	2	
	Bagha	8	20	8	8	4	25	20	12	-	3	
	Bagha	7	25	7	7	3	25	20	10			
	Bankat	8	30	7	7	4	20	20	10	2	-	
	Bankat	9	40	7	5	3	15	15	10	2	3	
	Avahar	8	30	7	8	4	20	15	10	-	4	
	Avahar	8	30	8	8	2	20	20	10	-	2	
	Sadar	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Motihari	Motor chawk	8	25	8	6	4	25	20	12	-	-	
	Motor chawk	6	25	8	7	-	25	20	15	-	-	
	Motor chawk	6	30	7	8	-	20	20	15	-	-	
	Motor chawk	9	35	8	8	4	20	15	10	-	-	
	Paharpur	9	30	7	7	3	20	20	10	-	3	
	Ghorasahan	10	20	7	7	3	25	20	12	4	2	
	Dumaria	8	20	8	8	3	25	20	12	-	4	
	Lakshmipur	9	25	9	8	2	20	20	10	3	3	
	Chitouni	9	25	7	7	3	20	20	10	5	3	
	Chauradano	9	30	9	7	4	20	15	10	3	2	
	Engilsh gram	8	30	7	6	2	20	20	10	2	3	
Mean		8.12	27.70	7.79	7.17	3.09	21.66	18.54	10.81	3.22	2.76	

Annexure 2: Brood stock inventories for hatcheries

Hatchery	Species	Broodstock Management								
		Broodstock Source		Breeding						
		Own Stock (%)	Other Purchased/Share basis (%)	Minimum Age (Yrs)	Sex Ratio (M : F)	No. of Spawning /Season	Brood size (Kg)	No. of Years a fish is Spawned	Brood stock biomas (MT)	Post spawning Fate
Barwat senas	IMC,Ex, Bh, Cc,Cl	80	20 (Mauna/Chaur)	1+ to2+	30:70	3(Gc,Sc, Bh); 3(IMC)	0.5-4	3-4	6.5	Non-performing sold
Pipara	IMC, Ex, Bh	75	25 (local farm)	1+ to 3+	25:70	4(Gc,Sc, Bh); 3(IMC)	0.2-3	3-4	5.7	Non-performing Sold
Pipara	IMC, Ex, Bh	80	20 (Mauna/Chaur)	2+	10:25	4(Gc) 3(Sc Bh,); 2(IMC)	0.2-3	Till sustains	1.2	Restocking
Pipara	IMC, Ex, Bh	70	30(River)	1.5 to 2+	2:4	3(Gc,Sc Bh,); 2(IMC)	0.2-4	5-6	0.75	Restocking
Kathaia chawk	IMC,Ex, Bh	75	25 (Mauna/Chaur)	1+ to 2.5	15:20	3(Gc,Sc Bh,); 3(IMC)	0.2-4	3-5	2.2	6+ year sold
Majhawlia	IMC,Ex, Bh	80	20 (Mauna/Chaur)	1+ to 3+	40:70	4(Gc) 3(Sc, Bh); 3(IMC)	0.5-4	5-6	0.6	Restocking
Majhawlia	IMC,Ex, Bh, Cc	80	20 (Local farm)	1.5 to 2+	25:70	3(Gc, Bh Sc,); 2(IMC)	0.25-4	3-4	3.9	Restocking
Bagha	IMC,Ex, Bh,Cc	80	20 (River)	2+	20:60	4(Gc,Sc Bh,); 3(IMC)	0.25-3	3-4	0.6	Restocking
Bagha	IMC,Ex, Bh	80	20 (Mauna/Chaur)	2+	2:4	3(Gc,Sc Bh,); 3(IMC)	0.3-4	3-5	4.3	Restocking
Bankat	IMC, Ex Bh,	75	25(River)	1+ to 2+	10:15	3(Gc,Sc, Bh); 2(IMC)	0.25-4	5-6	3.5	Non-performing sold

Bankat	IMC, Ex Bh, .	80	20(River)	1+ to 2.5	3:5	3(Gc,Sc, Bh,) 3(IMC)	0.2-3	5-7	2.7	Restocking
Avahar	IMC, Ex, Bh,	80	20 (Mauna/Chaur)	3+	4:6	3(Gc,Sc, Bh), 4(IMC)	0.2-3	6-7	0.8	Restocking
Avahar	IMC, Ex , Bh, Cc	80	20 (Mauna/Chaur)	1+ to 2+	25:70	3(Gc,Sc, Bh); 2(IMC)	0.2-3.5	5-6	1.6	Restocking
Sadar	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Motor chawk	IMC, Ex, Bh, Cc	80	20 (Mauna/Chaur)	2+	10:15	3(Gc), 2(Sc Bh,), 3(IMC)	0.25-3	4-6	1.5	Restocking
Motor chawk	IMC, Ex, Cc	10	90(mauna/chaur)	1+ to 2+	20:65	3(Gc,Sc Bh,); 3(IMC)	0.2-4	5-6	0.8	Restocking
Motor chawk	IMC, , Ex, Cc	85	15 (Mauna/Chaur)	1+ to 3+	2:3	3(Gc,Sc, Bh); 3(IMC)	0.25-3	3-5	0.9	Restocking
Motor chawk	IMC, , Ex, Bh, Cc	80	20(mauna/chaur)	2+	25:65	3(Gc,Sc, Bh); 3(IMC)	0.5-3.5	Till sustains	1.7	Restocking
Paharpur	IMC, Ex, Bh	85	15 (Mauna/Chaur)	1+ to 2+	40:70	2(Gc) 3(Sc, Bh); 2(IMC)	0.2-3	3-7	3.4	7+ year sold
Ghorasahn	IMC, Ex, Bh	80	20 (Mauna/Chaur)	2+	2:3	3(Gc,Sc, Bh); 4(IMC)	0.2-3.5	3-5	4.5	Restocking
Dumaria	IMC, Ex,Bh	80	20 (mauna/chaur)	1+ to 2+	35:70	3(Gc,Sc, Bh,) 4(IMC)	0.25-3.5	4-5	3.8	Restocking
Lakshmipr	IMC,Ex,Bh	75	15 (Mauna/Chaur)	1+ to 2+	20:60	3(Gc,Sc Bh,); 3(IMC)	0.5-3	Till sustains	1.9	Restocking
Chitouni	IMC,Ex,Bh	80	20 (River)	1+ to 2.5	25:55	3(Gc,Sc Bh,); 3(IMC)	0.2-3	5-6	1.5	Restocking
Chauradano	IMC,Ex, Bh	80	20 (mauna/chaur)	3+	2:3	3(Gc,Sc, Bh); 3(IMC)	0.25-3	4-5	3.5	Restocking
Engilsh gram	IMC, Ex,Bh	85	15(mauna/chaur)	1+ to 2+	25:70	3(Gc,Sc, Bh); 4(IMC)	0.2-3	5-6	4.7	Restocking
Mean		83.33	23.95	2.17	17: 40	3(Gc,Sc, Bh); 3(IMC)	0.26-3.41	4.04-4.66	2.56	

Annexure 3: Hatchery inventory

Locaton of hatcheries	No. of fish seed produced/ season (million)	Hatchling Sales (%)	Fry Sales (%)	Fingerling Sales (%)	Food-fish Sales (%)	Kept as brood-stock (%)	Breeding strategies	Mortality (%)	Hatchling Prices (Rs/bati)
Barwat senas	600	**70**	**20**	**8**	-	**2**	A,N	30-35	200-350
Pipara	420	**80**	**15**	**4**	-	**1**	A,N	40-50	250-400
Pipara	170	**80**	**15**	**3**	-	**2**	A,N	30-50	200-350
Pipara	120	**80**	**14**	**4**	-	**2**	N	35-50	200-350
Kathaia chawk	250	**85**	**10**	**3**		**2**	A,N	40-50	250-400
Majhawlia	150	**80**	**15**	**4**	-	**1**	A,N	40-50	250-400
Majhawlia	150	**80**	**15**	**3**	-	**2**	A,N	35-40	200-400
Bagha	130	**85**	**10**	**4**	-	**1**	A,N	**45-55**	200-350
Bagha	100	**90**	**8**	-	-	**2**	N	35-50	200-400
Bankat	75	**75**	**20**	**3**	-	**2**	A,N	30-40	250-400
Bankat	82	**85**	**14**	-	-	**1**	N	35-50	200-350
Avahar	78	**80**	**15**	**4**	-	**1**	A,N	40-60	250-350
Avahar	67	**90**	**8**	-	-	**2**	A	35-40	250-400

Sadar	-	-	-	-	-	-	-	-	-
Motor chawk	25	**80**	**15**	**4**	-	**1**	A	35-50	200-350
Motor chawk	27	***85***	**14**	-	-	***1***	*A*	*50-55*	*200-400*
Motor chawk	32	**90**	**8**	-	-	**2**	A	40-50	250-400
Motor chawk	43	**80**	**15**	**4**	-	**1**	A,N	45-55	250-350
Paharpur	20	**80**	**15**	**4**	-	**1**	A,N	40-45	200-400
Ghorasahan	45	**85**	**10**	**4**	-	**1**	A	35-40	200-350
Dumaria	57	**80**	**15**	**4**	-	1	A	40-55	250-400
Lakshmipur	42	**85**	15	-	-	2	A,N	45-50	200-400
Chitouni	35	**80**	15	3	-	2	A,N	35-50	200 -350
Chauradano	65	**85**	14	-	-	1	A	40-50	250-400
Engilsh gram	300	**90**	8	-	-	2	A,N	35-55	250-400
Mean	128.45	85.83	13.45	2.62		1.5		37.91-48.95	222.91-379.16

Annexure –4: Infrastructure of Hatcheries of Champaran

Location of hatcheries	No. of brood pond	Area (in ha)	Stocking density Kg /ha	No. of Nursery pond	Area (in ha)	Total Area (in ha)	No. of breeding pools	No. of hatching pools	Diameter of BP/HP (m)
Barwat senas	5	2.67	1645	7	1.8	4.47	1	5	5/3.8
Pipara	4	1.45	2000	6	0.75	2.20	1	4	4/2.7
Pipara	3	1	1680	4	0.42	1.42	1	3	3.5/2.5
Pipara	4	1.5	1450	5	1	2.5	1	3	4.5/2.5
Kathaia chawk	4	1.2	1750	5	0.6	1.8	1	3	4/2.5
Majhawlia	4	1.7	1970	5	0.8	2.5	1	3	4.2/2.5
Majhawlia	4	1.3	2250	3	0.45	1.75	1	3	3.5/2.7
Bagha	5	2.3	2730	3	0.62	2.92	1	4	4/3
Bagha	4	1.5	2865	4	0.65	2.15	1	3	4/3
Bankat	3	1	2500	4	0.58	1.58	1	4	3.5./2.5
Bankat	4	1.2	1500	5	1.3	2.5	1	3	4/2.5
Avahar	2	1.3	2000	3	0.50	1.80	1	2	4.5/3.5
Avahar	3	1.85	1980	4	0.73	2.48	1	4	4/3
Sadar	-	-	-	-	-	-	-	-	-
Motor chawk	2	0.70	1420	4	0.86	1.56	-	2	3.7/2
Motor chawk	3	1	1300	3	0.4	1.4	-	3	4/2.5
Motor chawk	2	0.76	2000	3	0.45	1.21	-	3	3.8/2.5
Motor chawk	2	0.65	3200	4	0.67	1.32	1	3	3.8/2.6
Paharpur	3	1.2	2450	4	0.8	2	1	7	4/2.8
Ghorasahan	3	1.3	2760	3	0.35	1.65	1	3	4/3
Dumaria	4	1.85	2380	3	0.5	2.35	1	4	3.5/2.6
Lakshmipur	4	1.4	2930	5	1.3	2.7	1	3	3.7/2
Chitounl	2	1.5	3000	4	0.72	2.22	1	2	3.8/2
Chauradano	3	1.3	2500	4	0.65	1.95	1	2	4/2.5
Engilsh gram	5	2.1	2400	8	2	4.14	1	4	6/4
Mean	3.41	1.40	2194.16	4.29	0.756	2.00	0.87	3.33	3.73/2.71

Annexure 5: Most commonly occurring fish diseases in hatcheries of Champaran

Disease identified by farmer	Clinical/Behavioural signs	Possible Type of Disease	Fish affected	Seasons	No. of Farmers	Therapeutants used by farmer	Dose
Gill rot	Infiamation of gills	Bacterial	F, TF	Rainy season	9	1-2 min dip treatment of fish in 5% tutia, $KMnO_4$,	As advised by s FEO & extension worker / Advice printed on the body of substance product container.
Tail rot	Tail necrosis	Bacterial, Fungal	F, B, TF	Whole year	10	5 min dip treatment of fish in 3-5% salt + 200 kg/ha lime in pond, $KMnO_4$	
Fin rot	Erosion of fins	Bacterial, Fungal	F, B,FL, TF	Rain	13	5 min dip treatment of fish in 3-5% salt + 200 kg/ha lime in pond, $KMnO_4$	
EUS	Lesions, Haemorrhage and ulcer on skin	Bacterial, fungal	F, B, TF	Mostly winter, all season	12	CIFAX, Black lime @200 kg/ha 3 times in 3 months.	
Argulus	Parasite on the skin	Argulosis (Parasitic)	F, B	All season	5	Metacid, Cleaner, Decis, $KMnO_4$, Toximar	
None identified	Bulgy abdomen, Scales loose	Dropsy	B, TF			$KMnO_4$, Salt,	
None identified	Whirling disease	Protozoan	F, FL	Rainy season	5	$KMnO_4$, Salt,	

Key:F=Fry, FL=Fingerling, B=Brood fish, TF=Table fish. Source of information: Respondents interview, Milwain *et al.*, (2002)

ANNEXURE –6

QUESTIONNAIRE SCHEDULE

1. Date of survey :
2. Name of the farmer :
3. Address : Vill - P.O. -

Dist - State -

4. Name of the hatchery :
5. Address : Vill - P.O. -

Dist -

State -

6. Year of establishment
7. Educational status
8. Family size Male - Female-

Adult - Minor -

Total -

9. Major activity : Agriculture -

Animal Husbandry -

Fish/Fish seed production -

Service

- Business

Other activities -

10. Annual income from sale of fish seed: Spawn (Rs)-

11. Fry (Rs)

- Fingerling (Rs)

- Total (Rs)

-

a. Reason behind fish seed production :Income -

Food -

Status -

Any other reason -

12. Compare with other allied activities in terms of : Time spent -

Income -

Labour -

Food value -

13. Land ownership Own land -

Co-operative -

Leased -

Government -

Others -

14. Type of labour and numbers Family

Male - Fem -

Total -

Hired

Total -

Contractual :

Total -

Others

15. Total farm area (in ha)

16. Tank area (in ha) and numbers : Brooders tank

Nos. - Area -

Nursery tank -

Nos. - Area -

Rearing tank -

Nos. - Area -

17. Size and number of hatchery units : Over head tank :

Nos. - Capacity -

Breeding pool Nos. :

Dia - Depth -

Hatching pool Nos. :

Dia - Depth :

Egg collection chamber :

Nos. - Size -

Any other unit :

18. Egg collection chamber in use or not
19. Egg holding capacity of egg collection tank:
20. Connection of breeding pool to how many hatching pool:
21. Fertilized eggs are directly collected in hatching pool or egg collection chamber, why?
22. Production capacity
23. Present output
24. Brooders management : Source of brood fish

self	-	outside	-
Species you buy most			
Rohu	-	Catla	-
Mrigal	-	C Carp	-
G carp	-	Silver	-
Calbasu	-	Any other	-
Age of brooders/Sex ratio			
Male	-	Fem	-
Weight (gm/kg)			-
Replacement of brooders			-
Time interval			
Multiple breeding			-
Time interval			
Mixed spawning			:

25. Pre stocking management : Dewatering -
    - Drying
    - Sludge removal -
    - Ploughing -
    - Liming
    - Fertilization -
    - Use of chemicals -
    - Source of water -
    - Stocking density -
26. Post stocking management : Type of feed -
    - Rate of application -
    - Type of fertilizer :

Inorganic - Organic-

Rate of application -

Rate of application of Lime -

Monitoring of

Water colour

Pond bottom soil -

27. Nursery and Rearing management : Time

Feed -

Manuring -

Stocking density -

Disease control -

Treatment -

28. Disease

Sl.No.	Disease	Occurrence with any peak	Species affected	Medicine	Dose	Result

29. Are you a trained farmer? :

30. Mention the place and duration

31. Seek technical advice from : Govt. extension worker -

Farmer -

Self -

NGO -

Education/Research institute

Others -

32. Are you associated with any fish farmers organization

33. Mention the name of the organization:

34. Breeding activities : Inducing agent (Natural)

Source -

Collection & Preservation -

Preparation of extract -
Calculation of dose accord
-ing to species and sex
Selection of fresh pituitary
gland
Information regarding po -
-tency of the gland & if any
population decline due to this
Inducing agent (Artificial)
Source
Mention the name
Compare with pituitary -

35. Instruments and Appliances
Over head tank -
Breeding pool -
Chinese hatchery -
Glass jar hatchery -
Any other indigenous method
Water pump -
Syringe and needle number for
Specific species -
Use of hapa for breeding -

36. Natural breeding in breeding pool
Percentage -
performance -

37. Multiple breeding -

38. Rate of water flow in breeding and hatching pool(Initial/Mid/Final)-

39. Method of injection

Sl. No.	Period	Site of injection	Time interval	Dose
1	First			
2	Second			

40. Breeding activities (for specific species) -

41. Breeding time after 2nd injection -

42. Is there any practice of third injection -

43. Egg release and fertilization
44. Mortality during fertilization
45. Hatching : Hapa(%)

Hatching pool(%)

Time-

Survivality-

Any abnormality

46. Comparison of egg production during multiple breeding
47. Spawn development
48. Collection from hatching pool
49. Stripping (any characteristics for species and dose used)
50. How to identify that brooders are ready for stripping
51. Management and care of brooder after stripping
52. Report of damage due to stripping
53. Wheather any report of dose variation with temperature variation :
54. Role of soil and water quality on breeding programme
55. Culling of fish from breeding program
56. Fertilization
57. Production of hybrid
58. Length of breeding season
59. About overhead tank- Area/hight/capacity/source of water to tank. Specification of pipeline to tank and to breeding and hatching pool:
60. Location of hatching pool –apart from and how much lower than breeding pool :
61. Operation procedure used for control of water into pools :
62. Engagement in other part of the year :
63. Inducing agent used
64. Idea about the scientific basis of the technology
65. Any innovative technology developed by the farmer:
66. Suggestion from the farmers end
67. Needs of the farmer

Date:

Place: **Signature**