Evolution of Fisheries and Aquaculture in India

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Evolution of inland aquaculture and fisheries research

The researches on inland aquaculture and fisheries technologies got momentum only in the seventies at Central Inland Fisheries Research Institute (CIFRI), Barrackpore under All India Coordinated Research Projects on Composite fish culture, Air-breathing fish culture, Riverine seed prospecting and Fisheries management of freshwater reservoirs. Later, a new coordinated project on brackishwater aqauaculture was framed. Aquaculture research in India received the momentum when Freshwater Aquaculture Research and Training Centre was established at Dhauli, Bhubaneswar (Orissa). In 1986, it got the status of an independent ICAR Institute and was named Central Institute of Freshwater Aquaculture (CIFA). These two institutions are pioneers in the development of aquaculture and culture based fisheries technologies.

Freshwater Aquaculture

Carp culture

Fish culture has a long history in India and farmers were aware of the importance of the Indian major carp (IMC) in pond fish culture (Chaudhuri *et al.,* 1974). However, the production from these systems remained significantly low at 600kg ha^{-1} $year^{-1}$ (Banerjee, 1967; Jhingran, 1969) until the introduction of scientific composite carp culture technology during the seventies. Introduction of exotic species like silver carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idella*) during 1959 (Alikunhi and Sukumaran, 1964) filled two important niches of phytoplankton and macro vegetation. These species along with the indigenous carp species have contributed significantly in enhancing the yields from fish ponds. Further, the Bangkok strain of common carp (*Cyprinus carpio*) introduced during 1957 also made a mark through its presence within very short period (Ayyappan and Jena, 1998).

The technology of scientific carp culture in India developed at the Pond Culture Division of CIFRI, Cuttack, was disseminated to different agro-

climatic zones and was refined through the work carried out at different centres under All India Coordinated Research Project (AICRP) on Composite Fish Culture and Fish Seed Production, initiated in 1971 by Indian Council of Agricultural Research, New Delhi. Studies from all the six centres of AICRP revealed that the production increased from 2436 kg ha^{-1} $year^{-1}$ to 6522 kg ha^{-1} $year^{-1}$ through fertilization and supplementary feeding at the various agro-climatic zones.

The researches by Lakshmanan *et al.*, 1971; Sinha *et al.*, 1973;Chaudhuri *et al.*, 1974, 1975; Chakrabarty *et al.* 1979; Saha *et al.*, 1979; Sinha and Saha, 1980; Tripathi and Mishra, 1986; Rao and Raju, 1989; Tripathi *et al.*, 2000; Ayyappan and Jena, 2001and Jena *et al.*, 2002 a, b have led to the development, refinement and standardization of a host of technologies with varied production levels depending on the input use and finally resulted in the development of the technology for intensive carp culture.

Catfish culture

Various researchers worked for the development of technology for air breathing fish and large size catfish culture (Parameswaran and Murugesan, 1975; Dehadrai, 1980; Dehadrai *et al.*, 1985; Thakur and Das, 1986; Seth, 1997; Seth and Katiha, 2002).

Freshwater prawn

In India, freshwater prawn culture is becoming popular. The technology for its mono and polyculture with carps was developed by many researchers (Chakraborty *et al.*, 1980; Reddy *et al.*, 1985; Gopal Rao *et al.*, 1986; Anon., 1990; Jhingran, 1991; Thangadurai, 1991; Rama Rao *et al.*, 1992; Raje and Joshi, 1992; Tripathi, 1992).

Integrated fish farming

Little attention has been paid to integrated fish farming system in India, though initial trials on the integration of pig, duck and poultry with fish culture have given encouraging results (Sharma *et al.*, 1979 and 1979a Jhingran and Sharma, 1980; Sharma and Das, 1988; Jhingran, 1991; Tripathi, 1991).

Aqua feed

Regarding technologies for aqua feed and nutrition, a variety of ingredients of plant and animal origin has been screened for incorporation in supplementary feed for carps and used either singly or in combination (Lakhsmanan *et al.*, 1967; Chakraborty *et al.*, 1973). Most of these diets, however, are confined to only carp fry and fingerlings (Sen *et al.*, 1980;

Singh *et al.*, 1980; Mohanty and Swamy, 1986; Mohanty *et al.*, 1990; Jafri *et al.*, 1991; Mohanty and Das, 1995; Paul *et al.*, 1997; Jena *et al.*, 1996, 1998c, 1999). Several non-conventional feed ingredients have been evaluated for incorporation as feed supplements (Mukhopadhyay and Jena, 1999). In most cases, the grow-out supplementary feed comprises only oil cakes of mustard/groundnut and rice/wheat bran in 1:1 ratio by weight (Tripathi, 1990a). However, as the cost of oil cakes and rice bran has been increasing rapidly, the farmers of states like Andhra Pradesh are manipulatively using the combination of those two ingredients based on fish growth rate and pond productivity (Nandeesha, 1993). Researches have already been initiated with regard to amino acid and fatty acid requirements, vitamins and mineral requirements, provision of additives like growth promoters, antioxidant preservatives, and probiotics (Ravi and Devaraj, 1991a,b; Mohanty and Kaushik, 1991; Khan and Jafri, 1993; Mukhopadhyay and Rout, 1996). In the recent past research has been done on the feed at CIFA and College of Fisheries, Mangalore. The feeds CIFAPRA, CIFAMA and CIFACA have been commercialised (Tripathi, 2003).

Hatchery technologies

Breakthrough in induced breeding through hypophysation (Chaudhuri and Alikunhi, 1957) was achieved during the fifties with a thrust on mass production of quality spawn in controlled environment, thereby reducing dependence on natural seed collection. Scientists have successfully induce-bred different carp species like *Labeo rohita, Cirrhinus mrigala, C. reba, L. bata* and *Puntius sarana* by injecting carp pituitary extract. This technique has been adopted widely and forms a regular part of fish culture programme in India (Jhingran, 1991).

Chinese carps were also successfully bred in 1962 adopting similar techniques (Alikunhi *et al.*, 1963). The technique of induced breeding of carps by hypophysation has been followed in different species by several workers (Chaudhuri, 1960, 1963; Moitra and Sarkar, 1975; Varghese *et al.*, 1975; Bhowmick *et al.*, 1986). Further, the use of various synthetic formulations including Ovaprim has largely replaced the use of pituitary and the technology has become more farmer-friendly. Now Ovatide and WOVA-FH are also becoming popular.

Strain development

Several intergeneric and interspecific hybrids have been produced in the last four decades for genetic improvement (Chaudhuri, 1959, 1973; Das *et al.*, 1980, 1989; Naseem and Alikunhi, 1971; Varghese and Santaram, 1971; Chondar, 1977; Konda Reddy and Varghese, 1980a,b; Basavaraju and

Varghese, 1981, 1983a,b; Bhowmik *et al.*, 1981; Khan *et al.*, 1988; Gopal *et al.*, 1989). Monosex production by breeding six inverted broodstock in grass carp, common carp and silver carp has been reported for their production enhancement in open water system (Naggy *et al.*, 1981,1984). In India sex reversal of common carp is reported by Basavaraja and Rao (1988) and in tilapia (*Oreochromis mossambicus*) by Das *et al.* (1987), Varadaraj and Pandian (1989a) and Pandian (1991). The genetic engineering practice which is becoming popular during recent years is gynogenesis, polyploidy and transgenics (Das *et al.* 1986; Das and Ponniah, 1991). Sterile triploid hybrids have been produced by crossing common carp with IMC males (Khan *et al.*, 1988). Reddy *et al.* (1990) succeeded in producing triploidy and tetraploidy in rohu and catla by giving heat shocks to the fertilized eggs. Further, Reddy *et al.* (1998a) induced triploidy in common carp. Pandian and Varadaraj (1987) produced triploids and tetraploids in tilapia by heat shock. Varadaraj and Pandian (1989 b, c) employing judicious combination endocrine sex reversal, selective breeding and gynogenetic techniques produced super male tilapia for the first time.

In India, selective breeding work has been taken up at the Central Institute of Freshwater Aquaculture for rohu wherein growth increments of about 15 % over the parental stock for F_1 generation was successfully demonstrated (Reddy *et al.,* 1998b; Das Mahapatra *et al.,* 2000). After the F_3 generation, the genetic improvement was of the order of 50%.

Carp hatchery has been improved from the earthen pits to double-walled hapa and running water glass jar or FRP circular hatcheries (Bhowmick, 1978; Dwivedi and Rabindranathan, 1982; Dwivedi and Zaidi, 1983; Jhingran and Pullin, 1985; Gupta *et al.*, 1994 and Rath and Gupta, 1997).

Though refinements in various hatchery systems have paved the way for a large scale seed production (Alikunhi *et al.*, 1964; Bhowmick, 1978), spawn and fry rearing suffer 50-70% mortality (Lakshmanan *et al.*, 1967, Lakshmanan, 1969; Jena *et al.*, 1996, 1998b). Thus, efficient rearing of the initial stages of fish has assumed importance (Sukumaran *et al.*, 1976; Mishra and Tyagi, 1981; Mohanty, 1995). Although the need for raising fingerling in rearing pond system is fully realized, it is usually ignored by most of the fish culturists, who normally resort to stocking the ponds directly with fry (Hora and Pillay, 1962; Lakshmanan *et al.*, 1968; Natarajan *et al.*, 1979). As a result, young and delicate fry are exposed to different species of predators. This feature directly affects the survival of the seed (Tripathi, 1990b).

The first success in induced breeding of *Clarias batrachus* in India was achieved in mid fifties when Ramaswamy and Sundararaj (1957) were able

to effect spawning in the fish using homoplastic pituitary glands. Khan (1972) and Khan and Mukhopadhyay (1975) succeeded in breeding the fish using heteroplastic pituitary glands. Rao *et al.* (1991) also succeeded in advancement of ovarian maturation and multiple spawning of *C. batrachus*. Many researchers contributed towards development of breeding and seed production of air breathing fishes (Thakur and Das, 1986; Rao and Janakiram, 1991; Rao *et al.*, 1991, 1994) and catfishes (Gupta *et al.,* 1992 a,b; Gupta *et al.,* 1993,1998; Parameswaran *et al.,* 1988; Seth, 1997; Seth and Katiha, 2002).

Though traditional culture of freshwater prawn is in vouge in India for a long time by collecting the young ones from nature and stocking them in ponds and tanks, scientific culture of two important prawn species, *Macrobrachium rosenbergii* and *M. malcomsoni* is taking roots only in recent years. Researchers who have worked on this aspect include Kanaujia and Mohanty (1992,1993); Kanaujia *et al.* (1993); Soundarapandian *et al.* (1997); Kanaujia (1998) and Pillai *et al.* (1999). The pioneering attempt on hatchery seed production of *M. rosenbergii* in the country was made during 1963-65 at CIFRI, Barrackpore (Rao, 1965) after Ling's success in Malaysia (Ling, 1969a, b; Ling and Merican, 1961). The prawn-breeding unit of CIFRI at Kakinada achieved the first success in larval rearing in 1975 (Tripathi, 1992).

Our country has a rich and unique biodiversity with variety of indigenous ornamental fishes. The researchers (Menon, 1974; Datt, 1977; Ghosh and Lipton, 1982; Lipton, 1983; Barman, 1988; Choudhuri, 1992, 1995; Pandian, 2001) have so far reported 84 species of fishes inclusive of ornamental fishes from Tripura state.

In India, aquaculture witnessed an impressive transformation from a highly traditional activity to a well developed industry. With rich resource base both in terms of water bodies and fish species, the investments in this sector are following an increasing trend. The freshwater aquaculture production of 2.69 million t contributes to over one third of total fish production of India. This was made possible by following appropriate technologies, financial investments and entrepreneurial enthusiasm.

Brackishwater Aquaculture

The importance of brackishwater aquaculture technologies was recognised in the early seventies and an All India Co-ordinated Research Project was initiated in 1973 in West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Kerala and Goa (Rao and Ravichandran, 2001). Various technologies on shrimp culture developed under the project (CIFRI, 1978, 1981, 1983) generated interest among fish farmers but requirement of high initial

investment deterred its commercialisation.

CMFRI initiated research at its Narakkal Prawn Hatchery Laboratory (NPHL) in 1976 for developing a comprehensive system of producing penaeid prawn seed in hatcheries. Intensive and sustained research by a team of scientists has resulted in the successful evolution of an indigenous, low cost hatchery technology for the Indian white prawn, *Penaeus indicus* (CMFRI, 1978; Muthu, 1980). Seed production technology for other commercial shrimp species such as *P. monodon*, *P. semisulcatus*, *P. merguiensis* and *P. japonicus* were also developed later (1985) by NPHL of CMFRI (Silas *et al.*, 1985; Muthu and Pillai, 1991). Based on this technology one hatchery at Mopla Bay (Kerala) for *P. indicus* and another one for *P. monodon* at Chirala, Andhra Pradesh had been established.The CMFRI had also successfully demonstrated the proven technology of selective farming of *P. indicus, P. monodon and P. semisulcatus* under different ecological environments.(George, 1974, 1980; Nandakumar,1982; Marichamy and Motha,1986; Maheswarudu *et al.,*1997). Research on broodstock development for *P. monodon* and protocol for developing ecofriendly sustainable shrimp farms are being conducted at CIBA, Chennai. The technology on mud crab culture and fattening was developed and transferred (Kathirvel *et al.*, 1997 and Srinivasagam *et al.*, 1998; Marichemy and Rajapackiam, 2000).

Hatchery/ breeding/seed production technologies for shrimp (Laxminarayana *et al.*, 1995 and Rao *et al.*, 1995); mullets (Abraham *et al.*, 1995, 1999) ; sea bass (Thirunavukkarasu *et al.*, 1997) and mud crab (Srinivasagam *et al.*, 2000) were also developed at CIBA, Chennai. Feed processing technology for shrimp was developed by Ali *et al.* (2000).

Fisheries

CIFRI is the pioneer in inland fisheries research in India. Some of the important inland fisheries technologies developed are :

Fish seed prospecting from rivers

Riverine spawn collection nets were standardised in terms of their shape, size and mesh-size to suit different hydrological conditions. The nets developed are five times more efficient than the conventional ones. Number of researchers worked on these aspects including David (1959), Motwani (1964), Anon. (1966, 1976), Natarajan (1971), Tripathi (1976), Jhingran and Ghosh (1978), Dwivedi *et al.* (1988), Dwivedi (1999) and Dwivedi and Tyagi (1999).

Fish seed transportation

The traditional practice of transporting fish seed in earthen pots

(hundies) used to cause heavy mortalities. The development of a technique for packing and transport of spawn, fry and fingerlings in polythene bags with oxygen has enabled to minimise the mortality rate to a great extent (CIFRI, 1981a; De *et al.*, 1986; De, 1992).

Aquatic weed control

Massive proliferation of aquatic macrophytes in fish farm was a real handicap in their utilisation for getting higher fish production. Suitable eco-friendly technology was developed to tackle this menance by using different weedicides, based on type and nature of weed infestation (Ramchandran, 1963; Ramchandran and Ramaprabhu, 1968; Ramchandran *et al.*, 1975; Gupta, 1979; Mitra, 1993, 2003; Gopal, 1995).

Fishery management of reservoirs

Ecosystem oriented reservoir fisheries management technology was developed and its application in various reservoirs of the country has demonstrated the possibility of manifold increase in their average production from the present level. The application of culture-based capture fisheries technology for small reservoirs has demonstrated that the fish production from this resource can be increased to above 100 kg ha^{-1} yr^{-1} as against the present average of less than 50 kg ha^{-1} yr^{-1}. The researchers in this area include Natarajan (1976, 1979, 1979a); Sreenivasan (1976, 1984, 1993); Anon. (1977, 1980, 1983, 1984, 1997); Jhingran (1988, 1990); Mathew and Mohan (1990); Paul and Sugunan (1990); Sinha (1990); Dubey (1994); Sugunan (1990, 1995, 1997, 1997 a, 1997 b, 1999, 2000, 2000 a, 2001); Sugunan and Sinha (1997, 1997a, 2001); Sugunan and Katiha (2004).

Environmental impact assessment *vis-a-vis* fisheries

Environmental monitoring is the most important aspect of inland open water fisheries, since their yield depends directly on the health of the aquatic environment and biodiversity. The technology for assessment of such environmental perturbations would be of great help for development of remedial measures (Joshi, 1985, 1986, 1988, 1989, 1990, 1990a, 1992, 1994, 1994 a; Joshi and Sukumaran, 1987; Chandra *et al.*, 1984; Yadava, 1985; Mukhopadhyay *et al.*, 1987, 1987, 1994, 1994a; Banerjee, 1988; Ghosh, 1988; Ghosh *et al.*, 1983, 1988; Jhingran, 1989, 1990, 1990a, 1991; Jhingran and Joshi, 1987; Laal *et al.*, 1988; Mukherjee and Roy, 1989; Banerjee *et al.*, 1989; Singh *et al.*, 1993; Parmeswaran, 1995; Sugunan *et al.*, 2003).

Estimation of inland fisheries resources and production

CIFRI has evolved a standard methodology for estimation of inland

fisheries resources and their production (Gupta and Mandal, 1997).

Spawning artificial fecundation and hatchery for *Hilsa*

The depletion of fishery of *Hilsa* in middle stretch of the river Ganga due to construction of Farakka barrage necessitated mass scale seed production of the species for ranching. A technology for artificial fecundation and hatchery management for raising *Hilsa* seed has been developed (Mitra and De, 1981; Mitra *et al.*, 1988; Mitra and Karmakar, 1985; Chandra *et al.*, 1984, 1990; De *et al.*, 1986, 1988, 1994; De and Dutta, 1990, 1990a; De and Sen, 1988; De and Saigal, 1989; Choudhury *et al.*, 1990; Sen *et al.*, 1990).

Floodplain wetland fishery development

Management norms for different types of floodplain wetlands based on their carrying capacity and minimum level of interference with their ecosystem processes and natural food chain has been developed. The researchers who contributed to this field are Jha (1989, 1995); Vass (1989, 1989a, 1992); Vinci (1992); Yadava (1989, 1992, 1992 a, 1992b, 1992c); Yadava and Paul (1992); Choudhury (1992, 1992 a); De and Mukherjee (1992); Sinha (1993); Srivastava (1992); Sinha (1997); Sinha and Jha (1997); Sugunan *et al.* (2003); Sugunan and Bhattacharya (2000).

Pen culture in floodplain wetlands

Technologies for rearing of freshwater giant prawn (*Macrobrachium rosenbergii*) and carps in pen enclosures installed in ox-bow lakes have been developed. High productions are possible from this openwater fishery resource through these technologies based on extensive culture principles. The preliminary research studies are by Rajyalakshmi (1984); James *et al.* (1986); Chitranshi (1988, 1992); Mukherjee (1988, 1989); Vass (1990); Rai and Singh (1990); Vinci and Mitra (2002); Vinci *et al.* (2002); Sugunan *et al.* (2003).