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Present status of breeding and culture of catfishes in South Asia

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Abstract

The commercially important fish which contribute substantially to the total inland fish production in South Asia are*Aorichthys aor, A. seenghala, Mystus cavasius, M. gulio, Rita rita, Wallago attu, Ompok bimaculatus, Heteropneustes fossilis, Clarias batrachus, Silonia silondia* and *Pangasius pangasius.* These are widely distributed in all the South Asian countries; Pakistan, India, Bangladesh, Sri Lanka and Myanmar except Bhutan and the Maldives. In comparison to carp culture, catfish culture has just begun in the region. Techniques of seed production have been standardized in*C. batrachus, H. fossilis* and*W. attu* which can be spawned even repeatedly at short intervals of 30-40 days. Such methods are, however, in an experimental stage for other species.*C. batrachus* is the most popular and its traditional culture in rice fields is well known. It is now being incorporated in carp ponds and semi-intensive and intensive monoculture systems have also been developed. The species fetches a very high price in India and Bangladesh and has a great export potential.*C. macrocephalus* and *C. gariepinus* have been introduced in Bangladesh with considerable success but their impact on the indigenous species needs to be studied.

A vast grow-out potential exists all over the region for small catfish in carp nurseries as a second crop. Extensive culture of large catfish in derelict ponds could be an intermediate step in their improvement through control of all trash fish. With increased seed availability, semi-intensive and intensive mono-culture systems, being tried experimentally, could be developed in the view of an industrial production of catfishes as new export items from the region, if conditions for proper water quality management, aeration and partial replenishment, and availability of adequate pelleted feed could be met.

Keywords: Siluroidei, catfish, aquaculture, South Asia.

État actuel de l'élevage des poissons-chats en Asie du Sud.

Résumé

Les poissons d'eau douce d'importance commerciale qui contribuent à la production totale de poissons en Asie du Sud sont : *Aorichthys aor, A. seenghala, Mystus cavasius, M. gulio, Rita rita, Wallago attu, Ompk bimaculatus, Heteropneustes fossilis, Clarias batrachus, Silonia silondia and Pangasius pangasius.* Ils sont largement répandus au Pakistan, l'Inde, le Bangladesh, le Sri Lanka et Myanmar, à l'exception de Bhutan et des îles Maldives. Comparé à l'élevage de la carpe, l'élevage de poissons-chats débute juste dans la région. Les techniques de production d'œufs et de larves ont été standardisées chez *C. batrachus, H. fossilis* et *W. attu* qui peuvent même pondre de façon répétitive à 30 à 40 jours d'intervalles. De telles méthodes sont cependant au stade expérimental chez les autres espèces. *C. batrachus* avec son élevage traditionnel dans les rizières est le poisson le plus connu. Il est maintenant incorporé dans les étangs d'élevage de carpes et des systèmes d'élevage intensif et semi-intensif ont également été développés. En Inde et au Bangladesh, cette espèce atteint des prix élevés et a un fort potentiel pour l'exportation. *C. macrocephalus* et *C. gariepinus* ont été introduits au Bangladesh avec un succès considérable mais leur impact sur les espèces indigènes mérite d'être étudié. Un important potentiel d'élevage en écloserie

existe pour les poissons-chats de petite taille comme espèces secondaires dans les écloseries de carpes. Le développement de l'élevage extensif de poissons-chats de grande taille en étangs abandonnés pourrait être une étape intermédiaire à leur réhabilitation et permettrait le contrôle des poissons habituellement rejetés. Avec une augmentation de la disponibilité en alevins, les systèmes d'élevage mono-spécifiques intensifs et semi-intensifs expérimentés pourraient être développés en vue d'une production industrielle de poissons-chats pour l'exportation, si les conditions d'une bonne gestion de l'eau (réapprovisionnement et aération) et de disponibilité en aliments composés appropriés sont réunies.

Mots-clés : Siluroidei, poissons-chats, aquaculture, Asie.

INTRODUCTION

Fish are not only a valuable source of high-grade protein but also, as in many other parts of the world, a significant part of the socio-economic tissue of the South Asian countries, viz. Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan and Sri Lanka, located between 4-37°N latitude and 62-101°E longitude. The region is largely tropical, bounded in the north by temperate and in the south by equatorial climatic conditions. Both native and exotic carp have been the mainstay of aquaculture so far. However, in recent years, considerable interest has been evinced in seed production and culture of catfish.

The south Asian countries are inhabited by over 930 species (Talwar and Jhingran, 1991) of which Siluroidei (catfish) comprise about 142 species belonging to 13 families and 46 genera (Jayaram, 1977). Except for the Plotosidae and Ariidae, which have marine representatives, they are largely a group of freshwater fishes.

The catfishes constitute an insignificant group in terms of fisheries production as is evident from the total world fish catch of 96.93 million t during 1991, where their contribution was just 0.63%, of which 0.44% was from the freshwater and 0.19% from the marine sector (FAO Fishery Statistics, 1993) (*table* 1). An examination of the country-wise fisheries data in the FAO Yearbook further shows that India's total catfish catch comes from the marine sector alone while the freshwater sector appears to be making no contribution at all. Similar is the case with Pakistan. No statistics on the contribution of catfishes are available for other South Asian countries. It must be admitted that the data base is very poor. However, according to the Statistical Bulletin published by the Government of India (1993), catfishes constitute 15% of the total fish production in India. Catfishes contribute about 14% of the total fish production in Bangladesh too (BBS, 1989).

The catfish species actually cultured and potentially culturable in South Asia are mainly represented by the families Bagridae, Siluridae, Schilbeidae, Pangasiidae, Clariidae, Heteropneustidae and Plotosidae. The main catfishes of commercial importance in South Asia are listed of which all but those belonging to Ariidae are suitable for aquaculture (*table* 2).

Table 1. – World catches (t) of freshwater and marine catfishes 1991. Adapted from FAO 1993: (FAO Yearbook, Fishery Statistics, Vol. 72, 1991).

A. Total world catch (metric tonnes)		**96 925 900**
B. Freshwater catfishes		
Buffalofish	*Ictiobus* sp.	1 269
Wels catfish	*Silurus glanis*	16 879
Glass catfish	*Kryptoterus* sp.	17 000
	Chrysichthys nigrodigitatus	270
Black catfish	*Chrysichthys* sp.	1 170
Naked catfish	*Bagrus* sp.	13 316
Channel catfish	*Ictalurus punctatus*	177 373
Black bullhead catfishes	*I. melas*	1 800
	Ictalurus sp.	16 907
Hong Kong catfish	*Clarias fuscus*	110
African catfish	*C. gariepinus*	10
	C. anguillaris	3
Torpedo-shaped catfish	*Clarias* sp.	86 498
Freshwater Siluroids		84 524
Upside down catfish	*Synodontis* sp.	4 083
Total (FW)		**461 662**
C. Sea catfishes	Catfish eels (*Plotosus* sp.)	1 720
	Ariidae	185 173
Total (Marine)		**186 893**
Total B + C		608 555
D. Percentage of world catch B (FW)		0.44
C (Marine)		0.19
TOTAL B + C (FW & Marine)		0.63

Catfishes have a high nutritive value. Moreover, they are particularly favoured as they have fewer intramuscular spines. *Wallago attu*, *Mystus* sp., *Pangasius pangasius* and *Ompok* sp. have a special appeal for many. The air-breathing catfishes, *Clarias* and *Heteropneustes*, renowned for their ability to withstand a hypoxic environment, are marketed live and referred to as "live fishes". The live fishes in particular and the catfishes in general fetch a higher price than the carp which are presently the mainstay of aquaculture in the region. Summarized information on the bionomics of important indigenous species is given in *table* 3.

Table 2. – Catfish of commercial importance in South Asia.

Bagridae	Pangasiidae
Aorichthys aor	*Pangasius pangasius*
A. seenghala	
Mystus cavasius	Sisoridae
M. vittatus	*Bagarius yarrellii*
M. gulio	
Rita rita	Clariidae
R. pavimentata	*Clarias batrachus*
Siluridae	Heteropneustidae
Ompok bimaculatus	*Heteropneustes fossilis*
O. pabda	
O. pabo	Ariidae
Wallago attu	*Arius arius*
	A. jella
Schilbeidae	*A. sona*
Clupisoma garua	
Eutropiichthys vacha	Plotosidae
Silonia silondia	*Plotosus canius*

STATUS OF INDIGENOUS PRODUCTION

Bangladesh

The inland fisheries of Bangladesh are one among the richest in the world, next only to China and India. Of the total catch of 837000 t during 1987-88, non-airbreathing catfishes contributed about 9% and airbreathing catfishes (including the perch *Anabas*) about 4% (BBS, 1989). The Thai catfish (*C. macrocephalus*) and the African catfish (*Clarias gariepinus*) have also been introduced in Bangladesh during 1987 and 1989 respectively and they have gained great popularity owing the ease with which they can be propagated. The hybrids between the two species are particularly preferred.

India

Presently, the catfish form a lucrative capture fishery with a share of around 10-15% of the inland sector in India. However, their contribution in the total production from marine sector is rather low and ranges from 3 to 6%.

Organized catfish aquaculture has not developed as yet in India though the large non-air breathing catfishes such as *Wallago attu, Aorichthys seenghala* and *A. aor*, and the air-breathing *Pangasius pangasius* are held in high esteem in the North and North-Western states while the smaller varieties of both air-breathing (*Clarias batrachus* and *Heteropneustes fossilis*) and non-air-breathing catfish (*Rita pavimentata, Ompok bimaculatus* and *O. pabda*) are considered a delicacy in the central, eastern and north-eastern states.

Seed production techniques for *W. attu, M. seenghala, C. batrachus, H. fossilis, Ompok* sp. are available and could be utilized for their mass production for aquaculture.

Techniques of semi-intensive and intensive aquaculture are available and fish yields of up to 4.0-7.3 $t.ha^{-1}$ in six months have been obtained in a single crop from November/December to May/June (Dehadrai *et al.*, 1985). Although cage and pen culture are new systems for India, these have a tremendous potential for raising catfish.

The American channel catfish, *Ictalurus punctatus*, is now being farmed on a commercial scale in India by a private company which has established a huge farm at Needamangalam in Tanjore district in Tamil Nadu. The species shows 30% higher growth than in USA indicating the potential for its culture in India to be extremely good because of high ambient temperatures which facilitate fast growth and hence a higher production.

Myanmar

Fish farming in Myanmar started in the late 1950s. Only two South Asian catfish i.e. *Clarias batrachus* and *Pangasius* sp. are being used for aquaculture in Myanmar. Culture of *Clarias batrachus* is in an experimental stage but no information could be found on the culture of *Pangasius* sp. Experimental work on exotic catfish viz. *Clarias macrocephalus* (Thai catfish) and *Clarias gariepinus* (African catfish) and the hybrid produced by crossing female *Clarias macrocephalus* with male *Clarias gariepinus* is also in progress. *W. attu* is in great demand though not yet cultured.

Nepal

Land-locked Nepal, besides Bhutan, is the only country in the region with an exclusively freshwater fish fauna, mainly comprising the cold-water fishes, of which the mahseers (*Tor* sp.) are the most significant. The Indian and Chinese major carp are largely used for aquaculture in the Himalayan foothills but the catfish are at present unimportant.

Pakistan

Mirza (1975) has listed 156 species of freshwater fishes belonging to 68 genera from Pakistan, almost all of which are the same as those reported from India. Although catfish contribute 35% of the total catch in the Sindh province, their culture is not yet known.

Sri Lanka

Compared to other countries of the region, Sri Lanka has a less diverse ichthyofauna and production is largely based on introduced exotic species like tilapia, common carp, Indian and Chinese carp, milkfish and shrimps.

The Sri Lankan Bagridae are relatively small, none of them growing more than 25 cm (Pethiyagoda, 1991).

Table 3. – Bionomics of potentially culturable catfish of South Asia.

Species	Distribution	Habitat and rearing structures	Salient biological features
Aorichthys aor	Pakistan, India, Nepal, Bangladesh, Myanmar	Mainly riverine, also in lakes, canals, ponds and reservoirs	Giant catfish of considerable fishery value; 1.0-1.8 m in length; spawns before the onset of monsoons by building nests in the form of circular shallow depressions in pond/river about 1 m depth of water; parental care with female guarding the nest; carnivorous adults predate on fish/shrimp while the young are insectivorous.
A. seenghala	Pakistan, India, Bangladesh, Nepal, Myanmar	Rivers, reservoirs and tanks	Maximum length 1.5 m; spawns before monsoons like *A. aor* by making nests; parental care; carnivorous with marked piscivorous tendency in adults (Saigal and Motwani, 1962; Bhatt, 1970).
Mystus cavasius	Pakistan, India, Bangladesh, Nepal, Myanmar, Sri Lanka	Tidal rivers, lakes, ponds and flooded fields	Small sized (250 mm) catfish used as food in the Indian subcontinent; spawns during monsoons in ponds; feeds on insects and fish fry.
M. gulio (partly marine)	Pakistan, India, Bangladesh, Myanmar	Estuaries and tidal rivers, ascending in freshwaters	Suitable for culture both in fresh and brackish-waters; insectivorous.
M. vittatus	Pakistan, India, Bangladesh, Nepal, Sri Lanka, Myanmar	Ponds, lakes, rivers	Small sized (200 mm) catfish; spawns in monsoon in ponds and rivers; feeds on insects and fish larvae.
Rita pavimentata	India	Narmada and Krishna rivers	Attains 415 mm in Narmada; seasonal fishery during monsoons on baited longlines; bottom feeder, adults feed on molluscs while juveniles on prawns and insects; matures when 2+ y old; spawns only once during monsoons. Fecundity of a fully-grown old fish is 30000 eggs (Karamchandani *et al.*, 1967).
R. rita	Pakistan to Myanmar	Rivers and tidal waters	Large-sized (1.5 m) catfish forming a good fishery in major rivers of the Indo-gangetic plains; carnivorous and predatory; spawns during monsoons.
Ompok bimaculatus	Pakistan, India, Sri Lanka, Bangladesh, Myanmar	Rivers, tanks, reservoirs and ponds	A tasty fish, highly priced, grows well in tanks and ponds; maximum length 50 cm; spawns during monsoons; eggs brownish; fecundity 221 eggs.g^{-1} body weight; insectivorous, cannibalistic also (Parameswaran *et al.*, 1970).
O. pabda	Pakistan, India, Bangladesh, Myanmar	Rivers, reservoirs, tanks and ponds	Grows to about 17 cm; good eating with great demand and high price; insectivorous; spawns during monsoons; males with serrations on pectoral spines; fecundity 174 eggs.g^{-1} body weight; eggs dull greenish (Parameswaran *et al.*, 1971).
O. pabo	Pakistan, North-East India, Bangladesh, Myanmar	Rivers, tanks and ponds	Medium-sized catfish attaining about 24 cm in length; considered a nourishing food fish for invalids; insectivorous; spawns once during monsoons.
Silonia silondia	Pakistan, India, Bangladesh, Nepal, Myanmar	Mainly in large rivers but common in Gangetic estuary/reservoirs and tanks	Gregarious fish moving in shoals; length 90 cm; voracious feeder, predatory; provides good sport and valued as food fish too; spawns during monsoons; larval characters known (Karamchandani and Motwani, 1956).
Wallago attu	India, Sri Lanka, Nepal, Bangladesh, Myanmar	Rivers, tanks, lakes and reservoirs	Highly predatory known as freshwater shark; grows to 2 m weighing over 45 kg; prefers muddy waters, sluggish and bottom dweller; feeds on decaying animal matter, hence discarded as food in some parts but highly valued in others. Monsoon breeder, breeds in running waters; Egg sticky and laid on a hard substrate.

Species	Distribution	Habitat and rearing structures	Salient biological features
Pangasius pangasius	Pakistan, India, Bangladesh, Myanmar	Large rivers and upper reaches of estuaries	Grows to 1.5 m; good sport but not so valued as food fish owing its habit of feeding on foul, decaying animal matter; feeds on molluscs too, hence useful for their control, breeds in monsoons (David, 1963); migrates downstream in the tidal belt for spawning.
* *Heteropneustes fossilis*	Pakistan, India, Nepal Myanmar	Ponds, beels, swamps, marshes, ditches, muddy rivers	Size 300 mm, 250 g in weight; feeds on detritus and benthic organisms; spawns during monsoons in flooded paddy fields or puddles; sexual dimorphism well known even during non-breeding season, females with a short genital papilla having a cleft but males have a long and pointed papilla; fecundity 15 280-36 706 in fish weighing 220-285 g; spawning activity prolonged with intermittent mating and release of eggs in batches; incubation takes 18-20 h and larval development 12 days at 26-29°C. Esteemed food fish owing its invigorating qualities. Aggresive in nature, it inflicts painful wounds with its pectoral spines which have poison glands at their bases (Bhatt, 1968; Thakur and Das, 1986*b*).
* *Clarias batrachus*	Bangladesh, Sri Lanka, Myanmar	Ponds, swamps, derelict waters, rivers	Grows to about 380 mm (400 g); adults feed on insects, postlarvae on crustaceans; sexual dimorphism well known with a short and blunt urinogenital papilla in female, long and elongated in male; spawns during monsoons, migrating to freshly filled pools, puddles and paddy fields; fecundity 55 eggs.g body weight, matures when one year old; spawning takes 6-8 hours with intermitenst release of ova; fertilised eggs greenish, adhesive, demersal, 1.7-1.9 mm in diameter; hatching takes 21-24 h at 25-29°C; yolk-sac absorbed in 4-5 days; aerial respiration commences on day 10; adult characters by day 20 (Thakur and Das, 1986*a*).
Plotosus sp.	Sri Lanka, Bangladesh, Myanmar, India	Coastal waters, estuaries	Forms a fishery in brackishwater lakes on the east coast of India and the Hooghly estuary. Grows to 150 cm but normally fish ranging in length from 80-100 cm are common. Suitable for brackishwater fish culture.

* Air-breathing catfish.

BREEDING AND SEED PRODUCTION

Natural breeding

The accumulation of sufficient rain water in the environment is considered a triggering factor for spawning. The flood facilitates migration of mature fishes from swamps/ponds to the nearby low-lying areas, especially in inundated paddy fields, where certain species of catfishes prepare nests in the form of breeding pits in 15 to 30 cm depth of water to lay their eggs (*table* 3).

Fry of *Clarias* and *Heteropneustes* is collected from such pits in paddy or jute fields, flooded lands, swamps, ditches, margins of lakes, marshes etc. and used for aquaculture on a limited scale.

Observations on the natural breeding of air-breathing catfishes in low-lying paddy fields in Andaman and Nicobar Islands were made by Kohli (1989) who collected 4500 and 2000 fingerlings (50-120 mm in size) of *Clarias* and *Heteropneustes* respectively, besides 60 and 40 kg of adults of the two species from a 10 ha paddy field. He suggested that these should be collected for stocking the ponds as heavy rains wash them into the sea.

P. pangasius, however, shows a catadromous habit as it migrates downstream in the tidal riverine belt for spawning (Pantulu, 1962).

Induced spawning

Though natural spawning is limited to rainy season, induced spawning could be undertaken for extended periods and quality seed obtained for aquaculture. *Table* 4 summarizes the dosages of pituitary extract used along with details of hatching and larval rearing.

Table 4. Induced spawning using pituitary extract and seed production.

Fish Species	Injection doses ($mg.kg^{-1}$)	Hatching period	Remarks
O. bimaculatus	F:3–4+17–27 M:nil+3–4	21-23 h at 25-28°C	Fertilized eggs 1.7-1.9 mm in diam. and reddish in colour; newly-hatched larvae measure 4.3 mm (Parameswaran *et al.*, 1970).
O. pabda	F:2-3+8-22 M:nil+3.5 5	21-23 h at 25-28°C	Spawning occurs 6-8 h after the second dose, fertilized eggs, dull green in colour and 1.48-1.65 mm in diam. (Parameswaran *et al.*, 1971).
W. attu	F:16 (4+12 or 6+10) M:5-6 (2+3 or 3+3)	15-16 h at 29-30°C	Spawning after 5-6 h of second injection; eggs sticky, hence egg collectors provided in spawning pool. Urea and tannic acid used for degumming; degummed eggs incubated in glass jar hatchery; eggs yellowish; fertilization rate 60-70%.
A. aor	F:16 (6+10 or 8+12) M:6-8 (3+3 or 4+4)	30-32 h at 28-30°C	Female stripped after 7-8 h of second injection in dry basin; testes removed from males, macerated in 0.9% saline solution; fecundity low, 2 500-3 000 eggs.kg^{-1} body weight; hatching achieved by maintaining a mild flow of water in small plastic basins; newly hatched larvae 3.54 mm in total length; yolk absorbed in 45-50 h; larvae fed on tiny plankton and egg custard initially and on chopped shrimps and trash fish when five days' old.
P. pangasius	F:5+10 M:nil+3	20-24 h at 29-30°C	Female stripped after 8 h of second injection in dry basins and eggs fertilized; fertilisation rate 70%; fecundity 30 000 eggs.kg^{-1} body weight; eggs incubated in hatching jars.
C. batrachus	F:30 M:nil	24-26 h at 27-30°C	Female stripped after a latency period of 14 hrs; testes from males removed, macerated and preserved in 0.9% salt solution for fertilising the eggs; hatching undertaken in plastic basins provided with a mild current of water; yolk absorbed in 4 days; hatchlings reared in larger rectangular containers provided with aeration devices; finely sieved zooplankton given as initial feed for 3 days followed by boiled hen's egg for a week; survival 70-75% (Rao *et al.*, 1994).
H. fossilis	F:80-120 M:nil	24 h at 27-30°C	The fish is now bred at a much lower dose of 30 $mg.kg^{-1}$ (Rao *et al.*, 1994).

F: Female; M: Male.

Ompok bimaculatus

The techniques of broodstock development and management have not been developed so far though the species was induced to breed in captivity (Parameswaran *et al.*, 1971). Since it has a low fecundity, a large broodstock and a mini-hatchery are necessary for commercial seed production.

O. pabda

While the fish has been spawned successfully using the carp pituitary extract, use of other inducing agents such as the hCG needs to be tried to make spawning operations really economical. Techniques of broodstock development and management deserve equal attention.

Wallago attu

Spawners weighing 1.00-1.50 kg are collected from wild during February-March and reared in 0.04 to 0.1 ha ponds at a stocking biomass of 2500 to 3000 $kg.ha^{-1}$. These are fully mature by May and could be induced to breed, at least twice, till August. The broodstock is fed daily on goat/poultry viscera, molluscan meat or trash fish at 3-5% of the body weight.

Sexually mature males and females (1:1) are selected and hypophysed. The injected spawners are released in the breeding pool where fresh oxygenated water is circulated and sprinkled. Since natural spawning after hypophysation results in loss of eggs, an alternative is to strip the female 4-5 h after the second injection and to fertilize the eggs according to the dry method.

Even the 1-day-old fry of *W. attu* with yolk sac attached is highly cannibalistic. In order to obtain a high survival rate these are first thinned out and fed with filtered plankton, followed by goat liver/viscera from the third day onwards. As the fry does not survive in ponds, fibreglass tanks are used and a survival of 30-40% obtained after 15 days' rearing, when a size of 30 mm/260 mg is achieved. At this stage, the fish can be stocked in nursery ponds.

The same fish has also been spawned twice at an interval of 30 days thus doubling the quantum of seed produced from each female. Multiple spawning, at least three to four times, as in Indian major carp appears possible between April to September.

Aorichthys aor

Spawners weighing 0.5 to 0.7 kg are collected from the wild, reared in 0.04 ha ponds by feeding chopped poultry viscera mixed with rice bran and live food (*Tubifex* and *Chironomus*). Induced spawning is undertaken from May to July.

Pangasius pangasius

The broodstock of *P. pangasius* is collected during January-February and reared alone or with carp broodstock in 0.1-ha ponds. They are fed on molluscan meat, rice bran, groundnut oil cake and fish meal (1:1:1:2) at a daily rate of 5% fish biomass. Live young molluscs are also introduced into the pond.

After administering the initial dose of pituitary extract to the female, both male and female spawners are released together in the spawning pool. The female is administered the second dose 6 hours later while the male is given only a single dose. A mild current of water is provided in the pool.

Clarias batrachus

The first success in induced spawning of *Clarias batrachus* in India was achieved by Ramaswami and Sundararaj (1957) using homoplastic pituitary glands. Khan (1972) and Khan and Mukhopadhyay (1975) used heteroplastic pituitary glands of carps and found that a single dose of 135 to 150 mg.kg^{-1} to the female could effect spawning. Successful spawning was also obtained using the glands of the freshwater catfish *Wallago attu* at 50 to 260 mg.kg^{-1} with 84.6% fertilization as well as with the marine catfish pituitary extract (Devaraj *et al.*, 1972). Rao and Janakiram (1991) showed that female *Clarias batrachus* could be readily spawned even when administered a much lower dose of Indian major carp pituitary extract 30 mg.kg^{-1} body weight. The males did not require to be hypophysed at all.

Fishes weighing 150 g (1-year) are stocked during January-February in cement cisterns (3 × 1 × 1 m) provided with 15-cm soil base and a continuous flow of water at 2 l.min^{-1}. These are fed daily on trash fish and rice bran (9:1) at 10% body weight.

Ahmed and Hussain (1987) have suggested that the fish could be bred from May to October. Advanced, repeated and prolonged spawning is possible by intramuscular implantation of hormone pellets, 3 × 3 mm in size weighing 25-30 mg each containing 100 µg of LHRHa. Besides the carp pituitary, the following inducing agents have also been used successfully:

– hCG at 4000 IU.kg^{-1},

– LHRHa and Domperidone at 0.04 and 3 mg.kg^{-1} respectively in a single injection schedule,

– lyophilized, partially purified carp GnRH at 2.5 mg.kg^{-1}.

For induced breeding of *C. batrachus* specially prepared paddy fields which simulate natural conditions were also used (Thakur, 1976; Thakur and Das, 1986*a*). Effective dose of pituitary gland of Indian major carps was 100-140 mg.kg^{-1} of female body weight with fertilization and hatching rate of 94 and 86% respectively. This method is, however, not very effective as the young fry cannot be harvested easily and the recovery of fingerlings is very poor.

Heteropneustes fossilis

The first success in induced breeding of *Heteropneustes fossilis* was achieved by using homoplastic pituitary glands (Ramaswami and Sundararaj, 1956). Heteroplastic pituitary glands of Indian major carp were successfully used by Khan (1972). The All India Co-ordinated Research Project on Air-breathing Fish Culture recommended a dose of 80-120 mg.kg^{-1} of female *H. fossilis* (Kohli and Goswami, 1987). There is a growing interest in the seed production of this species for aquaculture.

CULTURE SYSTEMS

Catfish farming in South Asia is of recent origin and culture and propagation techniques for most of the species are still in infancy. However, significant developments have been made in India in evolving viable culture techniques for air-breathing catfishes, mainly *C. batrachus* and *H. fossilis*, under the All India Coordinated Research Project on Air-breathing Fish Culture. Based on this work, a manual with package of practices was also brought out for easy adoption of the techniques by the farmers (Dehadrai *et al.*, 1985). *Table* 5 gives an account of the different culture systems for these species.

DISEASES AND THEIR TREATMENT

In semi-intensive culture of *C. batrachus* and *H. fossilis* the fishes were found to suffer from dropsy and loss of barbels.

Terramycin containing oxytetracycline hydrochloride (Pfizer, India) was successfully used for their treatment lasting 10 days (Pal and Tripathi, 1978). *H. fossilis* has been shown to be affected by various bacterial diseases. Di-potassium permanganate bath at 1 mg.l^{-1} has been found to be effective in prevention of these diseases. Thakur (1977) has reported mass mortality of *H. fossilis* due to severe infection by the parasite *Diplostomum singhii*.

C. batrachus showing symptoms of ulcers, reddish lips and loss of barbels due to *Pseudomonas* infection were treated by application of sulphadiazine in the diet at 100 mg.kg^{-1} of feed for one week to control the diseases (Pal and Ghosh, 1985).

Infections, especially due to parasites, are known also from other catfish but no control methods have been used so far as cultural practices are non-existent.

Table 5. – Catfish culture systems in India.

System	Mono/ poly culture	Type of water/ area	Species cultured	Stocking rate.ha $^{-1}$	Feed used	Production (kg.ha^{-1})	Rearing period (months)	Remarks
Extensive	Polyculture	Swampy (0.04 ha)	*C. batrachus*, *H. fossilis*, *Anabas testudineus*	25 000	NIL	1 200	7	Parameswaran and Kumaraiah (1987)
Semi-intensive	"	Derelict pond (0.1 ha)	*C. batrachus*, *H. fossilis*, *A. testudineus*	80 000	Mustard oilcake ricebran, silkworm pupae (1:1:1)	1 547	12	"
	"	Farm pond (0.1 ha)	*C. batrachus*, *H. fossilis*	120 000	– do –	5 043	12	"
Intensive	"	Farm pond	*C. batrachus*		Fish meal rice bran	7 800	5	"
	Monoculture	Carp nursery pond (0.015 ha)	*H. fossilis*		Fish meal rice bran mustard oil cake (1:1:1)	6 947	5	"
Culture with carps		Farmer's pond (0.07 ha)	*Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* *C. batrachus*	5 000	Groundnut oil cake + rice bran (1:1)	1 945	9	Dehadrai *et al* (1985)
			C. batrachus	1 000	No separate feed	1 029	4.5	Stocked 135 days after initiation of carp culture, *Clarias* contributed 55% of the total sale value
		Farm pond (0.01 ha)	Left-over stock of carp *C. batrachus*	20 000	Rice vran, fish meal, groundnut oil cake and minerals (50:30:17:3)	3 300	10	Dehadrai *et al.* (1985)
Culture with aquatic cash crops	Polyculture	Makhana pond (0.03 ha)	*C. batrachus*, *H. fossilis*, *A. testudineus*	70 000	NIL	1 200	7	Makhana (*Euryale ferox*) and Singhara (*Trapa bispinosa*) are two important aquatic cash crops which are raised in shallow water bodies. Low oxygen, high carbon-dioxide and ammonia content are characteristic features of these water bodies where the airbreathing catfish can thrive (Parameswaran and Kumaraiah, 1987).
		Makhana pond (0.04 ha)	*C. batrachus*, *H. fossilis*, *A. testudineus*	55 000	Flat rice husk and fish meal	2 250 + 320 kg makhana seed	10	
Cage culture	Monoculture	Split bamboo cages (2 × 1 × 1 m) installed in large weed-choked water bodies	*C. batrachus*	2 million (200/cage)	Dried trash fish + Silk worm pupae + Mustard oilcake + Rice bran	9-12 kg.m $^{-3}$	12	Dehadrai *et al.* (1985)
	Monoculture	As above	*H. fossilis*	1.0-1.5 million (100-150/cage)	Silkworm pupae + Mustard oil cake + Rice bran	2.8-4.8 kg.m^{-3}	3	"
Paddy-cum-catfish culture	Polyculture	Paddy plots	*C. batrachus*, *H. fossilis* (1:1)	10 000	Fish meal + Rice bran	375	1	Parameswaran and Kumaraiah (1987)
	Polyculture	Paddy plots	*C. batrachus*, *H. fossilis* (1:1)	10 000	No feed	199	1	"

CONSTRAINTS

Despite the awareness and demand for certain species of catfish in the region, their aquaculture potential remains totally unexploited on account of various constraints such as the non-availability of seed, its transport and appropriate feed. Some of these constraints are discussed below:

Seed

Large-scale adoption of catfish culture needs a regular supply of seed which is one of the main constraints at present. To some extent, the seed is procured from natural sources in sufficient quantities but as there is no organized industry for its collection and marketing, this resource is unfortunately not properly utilized and just wasted. Seed production of important catfish could be increased by establishing a series of hatcheries with facilities for controlled breeding and rearing.

Feed

Lack of good quality and proper feed for catfish is also one of the major constraints. Catfish need a high protein diet with components of animal origin. No larval diet is available at present and hence rearing of post larval stages poses a serious problem. Suitable feeds are, therefore, necessary for all the different stages of growth.

Water quality

Although these fish are generally found in derelict or swampy waters and known to be very hardy, their culture in clean water results in higher yields as the absence of a stress factor on their metabolism enables a faster rate of growth. As in channel catfish, water exchange in *Clarias* ponds has already shown the possibilities of increasing the yields manifold. Aeration would further help in enhancing the yield rates.

Transport

No technology is yet known for transport of these fishes Available methods for other species need to be adapted, modified and standardized. However, spinous fins which not only damage the containers but also injure other animals during transport, and further, their cannibalistic habit, especially when young, pose the greatest menace both during transport and rearing.

POTENTIAL AND PROSPECTS

There is a great potential for increasing catfish production in South Asia in the foreseeable future through utilization of existing ponds and tanks for their culture along with carp. In addition, production could also be increased by utilizing the swamps and derelict ponds. In India alone, out of approximately 1.6 million ha of water area, 0.6 million ha, accounting for 40% of total area, are in the form of swamps and derelict waters unsuitable for carp culture. These derelict water bodies are ideally suited to air-breathing fish culture (Dehadrai and Tripathi, 1976).

Catfish fetch a very high price in India and Bangladesh and also have a good world market. *W. attu* and *Mystus* sp. are in great demand in the domestic markets of Pakistan and Western and Central India while *Clarias, Heteropneustes, M. gulio, Ompok* sp. and *P. pangasius* have lucrative markets in eastern India and Bangladesh. *W. attu* is in demand in Myanmar too. One can also easily visualize the possibilities of exporting these fishes for earning foreign exchange once their local production increases and a surplus is generated. The markets of Far-East and South east Asia as well as those of many European countries are open for catfish consumption in large quantities.

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