The diversity of cypriniforms throughout Bangladesh: Present status and conservation challenges

Article · January 2011

CITATIONS
3

READS
1,800

2 authors:

Mostafa Hossain
Bangladesh Agricultural University
189 PUBLICATIONS **2,406** CITATIONS
SEE PROFILE

Md Abdul Wahab
Bangladesh Agricultural University
339 PUBLICATIONS **8,292** CITATIONS
SEE PROFILE

In: Species Diversity and Extinction ISBN: 978-1-61668-343-6
Editor: Geraldine H. Tepper

Chapter 4

THE DIVERSITY OF CYPRINIFORMS THROUGHOUT BANGLADESH: PRESENT STATUS AND CONSERVATION CHALLENGES

Mostafa A. R. Hossain [*] ***and Md. Abdul Wahab***
Faculty of Fisheries, Bangladesh Agricultural University
Mymensingh-2202, Bangladesh

ABSTRACT

Bangladesh is endowed with a vast expanse of inland openwaters characterised by rivers, canals, natural and man-made lakes, freshwater marshes, estuaries, brackish water impoundments and floodplains. The potential fish resources resulting from these are among the richest in the world; in production, only China and India outrank Bangladesh. The inland openwater finfish fauna is an assemblage of ~267 species, the diversity of which is attributed to the habitats created by the Bengal Delta wetlands and the confluence of the Brahmaputra, Ganges and Jamuna rivers that flow from the Himalayan Mountains into the Bay of Bengal.

The indigenous fish fauna of Bangladesh's inland openwaters, however, are dominated by the cypriniforms - 87 species under 35 genera. Although representatives are rarely encountered in brackish waters, certain species have adapted to some of the country's most extreme freshwater environments.

There are, however, serious concerns surrounding the slow decline in the condition of openwater fish stocks which have been negatively impacted upon through a series of natural and anthropogenic induced changes. These include disturbances resulting from water management programmes including the large scale abstraction of water for irrigation and the construction of water barrages and dams, human activity resulting in the overexploitation of stocks, the unregulated introduction of exotic stocks and pollution from industry. Also, natural phenomena, regular flooding etc cause rivers to continually change course creating complications of soil erosion or oversiltation of waterways. As a consequence, many Bangladeshi species are either critically endangered or extinct. The

[*] Corresponding author: marhossain@yahoo.com

Hossain M. A. R., and Wahab M. A. (2010) The diversity of cypriniforms throughout Bangladesh: present status and conservation challenges. In: Species Diversity and Extinction. ISBN: 978-1-61668-343-6, 448 p. Geraldine H. Tepper (ed). Nova Science Publishers Inc., New York, USA. 143-182 pp.

biodiversity status of many of these have now changed from that listed in the IUCN Red Book almost a decade ago.

Assessment is based primarily on the study of specimens maintained in the Fish Museum and Biodiversity Center (FMBC) of Bangladesh Agricultural University and through surveys conducted over the last ten years. The threat to inland openwater biodiversity is countrywide, but that facing cypriniform species is severe. More than 15% of cypriniforms appear to have disappeared; only one or two individuals of a further 20% of species have been found in the last ten years.

The needs of Bangladesh's poor fisher community to eat what they catch and lack of a legal legislative framework means the situation can only worsen. Hope, however, is offered through several new conservation initiatives including the establishment of fish sanctuaries at strategic points in rivers and floodplains, concerted breeding programmes and the maintenance of captive stocks and cryogenically stored materials.

1. INTRODUCTION

Bangladesh is situated in the northeastern part of the South Asia and lies between 20°34' and 26°38' North longitudes and 88°01' and 92°41' East latitudes. The country is bordered by India on the West, North and North-East (2,400 kilometer land frontier) and Myanmar on the Southeastern tip (193 km land and water frontier). On the south is a highly irregular deltaic coastline of about 710 kilometers, fissured by many rivers and streams flowing into the Bay of Bengal. The territorial waters of Bangladesh extend 22 km, and the exclusive economic zone of the country is 370 km. The total landmass of the country is about 144,400 km^2 and extends 820 kilometers north to south and 600 kilometers east to west. The country stretches out at the junction of the Indian and Malayan sub-regions of the Indo-Malayan zoogeographic realm.

Formed by a deltaic plain, Bangladesh is virtually the only drainage outlet for a vast complex river basin made up of the Ganges (local name the Padma), the Brahmaputra and the Meghna rivers and their network of tributaries. The Padma unites with the Jamuna (main channel of the Brahmaputra) and later joins the Meghna to eventually empty into the Bay of Bengal. The alluvial soil deposited by these rivers every year has created some of the most fertile plains in the world. Most parts of the delta are less than 12 metres above the sea level, and it is believed that about 50% of the land would be flooded if the sea level rise by a metre. Straddling the Tropic of Cancer, Bangladesh has a tropical monsoon climate characterised by heavy seasonal rainfall, high temperatures, and high humidity. There are three broad physiographic regions in the country. The floodplains occupy about 80%, terrace about 8% and hills about 12% of the land area (Table 1). Moreover, it is a country dominated by wetland having more than 50% of its territory under true wetlands that is freshwater marshes, swamps, rivers estuaries and the world's largest contiguous mangrove forest - the Sundarbans.

Bangladesh has a total inland water area of 6.7 million ha of which 94% is used for open water capture fishery and 6% for closed water culture fishery (Table 2). The inland open water fishery resources have been playing a significant role in the economy, culture, tradition and food habit of the people of Bangladesh. Rivers and their ramified branches cover about 479,735 ha area of land. Seasonal floodplain expands over a massive 5.5 million ha for 4-6 months of the year. Inland open water also contains estuarine areas with semi-saline waters

(0-10 ppt), huge number of *beels* (natural depressions often with permanent area of water) and *haors* (bowl-shaped deeply flooded depressions) in the north and east and the manmade Kaptai lake – the largest lake of the country in the south. The country is blessed with 0.26 million of closed waters in the form of ponds, ditches, oxbow lakes (channel of dead rivers) and brackish water farms. More than 2 million people directly or indirectly depend on inland capture fisheries for their livelihood.

Fish have been an integral part of life of the people of Bangladesh from time immemorial. Many aspects of the Bangladeshi culture, economy and tradition are based around fishing and fish culture activities. The sector plays a vital role in the country's economy, employment generation, animal protein supply, foreign currency earning and poverty alleviation. Fish is a natural complement to rice in the national diet, giving rise to the adage "Maache-Bhate Bangali", literally meaning – 'fish and rice make a Bangladeshi'. Fisheries, second only to agriculture in the overall economy of Bangladesh, contribute nearly 5.0% to the gross domestic product (GDP), 23% of gross agriculture products and 5.71% to the total export earnings (DoF 2008). It accounts for about 63% of animal protein intake in the diet of the people of Bangladesh (DoF 2005). The fisheries sector provides full-time employment to an estimated 1.2 million fishermen and an estimated 10 million households or about 64% of all households are partly dependent on fishing, e.g. part time fishing for family subsistence in flooded areas. Another 10% poor and middle class people are engaged in part-time fishing, aquaculture, fish seed production and collection of shrimp and prawn seed, fish handling, processing and marketing, net making, input supply etc.

The people of Bangladesh largely depend on fish to meet their protein needs in both the rural and urban areas. Until 70s, there was an abundance of fish in the natural waters of the country to well-satisfy the demand. In recent years, however, capture fish production has declined to about 50%, with a negative trend of 1.24 % per year (Ahmed 1995). Despite the constant depletion of the natural waterbodies for years, Bangladesh still holds one of the most diverse inland fisheries in the world. However, the availability of many fish species has been drastically declined, and many are either critically endangered or extinct. On the migration journey to the floodplains, and the return to rivers, fish now face many blockage and danger, which seriously interfere with the breeding and resulting recruitment.

Table 1. Major physiographic areas of Bangladesh

Description	Area (km^2)	% of total area
Rivers, canals, streams	8,300	5.76
Estuarine, brackishwater water-bodies	1,828	1.27
Floodplains	112,010	77.76
Wetlands	2,930	2.03
Freshwater ponds and tanks	794	0.55
Artificial lakes	906	0.63
Hill areas	17,286	12.00
Total Bangladesh	144,054	100

Source: Hoq (2009)

Table 2. Extent of different type of water areas

Types of water areas	Area (ha)
a) Inland open waters	
1. Rivers (during dry season)	
The Ganges	27,165
The Padma	42,325
The Jamuna	73,666
The Meghna (upper)	33,592
The Meghna (lower	40,407
Other rivers and canals	262,580
2. Estuarine area	551,828
3. *Beels* and *haors*	114,161
4. Kaptai Lake	68,800
5. Inundated flood plains (seasonal)	5,486,609
Total	6,701,133
b) Closed waters	
1. Ponds and ditches	146,890
2. *Baors* (oxbow lakes)	5,488
3. Brackish water farms	108,000
Total	260,378

Source: FRSS-DoF 2008

2. THE KEY WATERBODIES AND THE STATUS

The inland open water fishery of Bangladesh is composed of highly diverse and unique aquatic systems. It has an extensive network comprising of floodplains, large and small rivers, *beels*, *haors* and *baors* offering tremendous scope and potential for fish production. It has also large impounded water areas in manmade ponds, ditches, borrow pits, lakes and enclosures (DoF 2005).

2.1. The Floodplain

Floodplains are relatively low laying land area, bordering rivers and seasonally over-flooded by overspill from the main river channel. There are two distinct flooding patterns, one resulting in flow direction from the floodplains to the rivers (from flush flood due to local rainfall) and the other from the rivers to the floodplains (river overspill due to the heavy rainfall in the upstream). The ecodynamics of floodplain are influenced by the river water incursion and retreat and the timing and intensity of monsoon. There are great differences in the area flooded from year to year, and this greatly influences the population dynamics of many fish species.

The seasonally flooded area is highly productive for growth of fish and other aquatic animals. During the dry season, as pasture land, the floodplain receives nutrients in the form

of animal dropping and rotting vegetation. As the monsoon approaches the accumulated nutrients rapidly enters into the solution combined with river-borne silt, led to an upsurge of productivity resulting in rapid growth of plants and other forms of aquatic biota. This productivity phase offers an ideal condition for feeding and breeding of many riverine fishes and other aquatic animals which migrate to floodplain with the rising waters. Floodplains inundated during monsoons are nutrient rich and play a significant role as nurseries for larvae and juvenile of many fish species (Junk *et al*. 1989). A large number of fresh water fish species migrate from rivers and *beels* to floodplains for breeding and grazing and are harvested by the rural professional and amateur fishers. The floodplains are essential for most of the rural people of Bangladesh for their livelihood.

The floodplains are very rich in both floral and faunal diversity and harbour a large number of finfish, crustaceans, molluscs amphibians, reptiles and a large number of aquatic vegetation. FAP-6 (1992) recorded 154 finfish and prawn in the floodplain of the northeastern region of the country. FAP-17 (1994) documented 89 finfish and prawn species in the floodplain of Tangail. Major species under the two studies reported were Indian major carps, several species of minor carps and loaches belonging to the Order Cypriniformes.

Fish production in 2006-07 was 819,446 mt in the floodplains, which was 77.29% of total inland capture fish production and 51.32% of the total inland fish production. The rate of present floodplain fish production in Bangladesh is 289 kg ha^{-1} $year^{-1}$ which is higher than the production in the floodplains of many neighbouring countries (DoF 2008).

Since 1970, the annual flooding of approximately 2-3 million ha of floodplain has been either controlled or prevented altogether by means of sluice gates or pumps positioned along earth embankments or levees (ESCAP 1998). This reduction in area is believed to be one of the major reasons for declining floodplain fisheries in Bangladesh (FAP 17 1994). Over-exploitation of inland fish stocks has also been reported (Graaf *et al*. 2001).

2.2. The Rivers

Bangldesh is a riverine country. It has numerous rivers and their tributaries (Figure 1). The Ganges, the Brahmaputra and the Meghna are the mighty rivers. The three rivers along with their innumerable tributaries form one of the richest habitats of fishes in the Indian Subcontinent. In addition to three main rivers, the other main rivers are the Karnafuli, Matamuhuri, Halda and Sangu in the southern Chittagong sub-region. The major rivers are the Surma, Kushiara, Kangsha and Someshwari in the north-east region and the Tista, Korotoa, Atrai, Bangalee, Mohananda in the north-west. The total length of the network of about 310 rivers in Bangladesh together covers more than 24,000 km with a catchment area of 1,031,563 ha. Annual flooding of the rivers inundates about 70% of the total land surface. The total annual discharge passing through the rivers system into the Bay of Bengal reaches up to 1,174 billion m^3 (Banglapedia 2004).

The rivers are not evenly distributed in the country. For instance, the numbers and size of the rivers gradually increase from the northwest of the northern region to the southeast of the southern region. All the rivers, except those of Chittagong hilly sub-region, belong to three major river systems, the Ganges, the Bhramaputra and Meghna. In the global context, the Brahmaputra is the 22nd longest (2,850 km) and the Ganges is the 30th longest (2,510 km)

river in the world. Rivers and canals roughly cover 5.8 % of the total area of the country. According to (BWDB 2005) 57 of the rivers are trans-boundary – 54 originate from India and 3 from Myanmar. The river system of Bangladesh is divided into 6 hydrological regions as shown in Table 3.

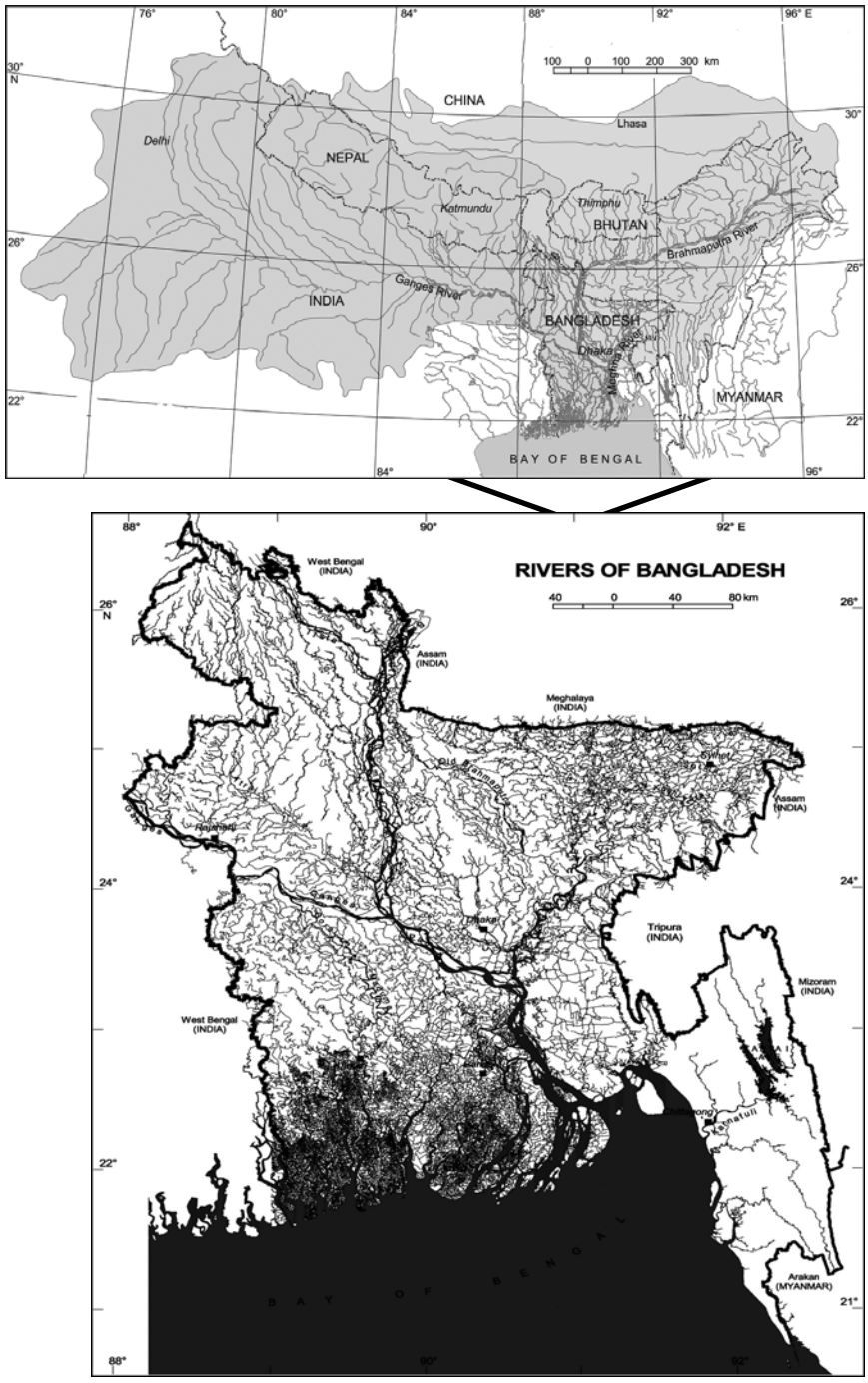


Figure 1. Map of Bangladesh showing main rivers and their tributaries (Banglapedia 2004).

Table 3. Hydrological regions of river system in Bangladesh

Hydrological region	Number of rivers	Length (km)	Catchments area (km^2)
North West Region	96	4,908	63,718
North Central Region	20	1,311	18,404
North East Region	55	3,250	47,616
South East Region	24	1,320	10,068
Eastern Hilly Region	17	1,131	6,253
South West Region	98	4,969	35,576
Total	310	16,889	1,81,635

Source: BWDB (2005)

During rainy season, the rivers carry high amount of silt which makes the water turbid. In winter, the water level decreases and water becomes clear. The depth of the coastal rivers usually ranges from 2 m to 5.5 m and reaches up to 36.5 m near the Bay of Bengal. Salinity of about 1 ppt extends nearly 56 km upstream in these rivers.

The rivers of Bangladesh have a great importance in respect of fisheries and other hydrological and navigation benefits. Rivers are the migratory routes of fishes with adjacent floodplains and vice-versa. Among the riverine fishes, Cypriniform - carps, barbs and minnows and loaches are very important. Many of the Cypriniforms migrate upstream (floodplain) in order to spawn in nutrient rich water, where they feed on plankton and grow (Rahman 2005). At the end of monsoon the adult and young fishes escape to the rivers and most likely to the adjacent deeper *beel*s to avoid harsh condition of the floodplain during dry season.

The hill-streams in the north and north-east are swift flowing with clear water. Many of the Cypriniform mainly loaches inhabiting the hill-streams usually have modified paired fins and grooved thoracic disk, which acts as adhesive apparatus. The fishes with compressed head and horizontally placed pectoral and pelvic fins can easily stick to the bottom and do not swept away in swift flowing water. Among the riverine Cypriniform that inhabit the hill-streams are the members of the genera – *Nemachilus*, *Schistura*, *Balitora* and *Psilorhynchus* under the Families of Balitoridae and Psilorhynchidae. The fish species of the Genera - *Garra*, *Barilius* and *Raiamas* under the Family Cyprinidae are also available in these streams.

2.3. The Beels

The *beel* is a Bengali term used for relatively large surface, static waterbody that accumulates surface run-off water through an internal drainage channel (Banglapedia 2004). This type of shallow, seasonal waterbody is common in low-lying floodplain areas throughout Bangladesh. The total area of *beels* in Bangladesh was estimated to be 114,161 ha, occupying 27.0% of the inland freshwater (Ahmed *et al*. 2007). The number of *beels* in the north-eastern part of the country recorded was 6,034 having an area of 69,870 ha (Bernaesek *et al*. 1992).

The most famous *beel* in the country known as the Chalan *beel* is located in the north-west. The other major *beels* in this region are Hilna, Kosba, Uthrail, Manda, Sobna and *Beel* Mansur. In central region, Arial *beel* and Balai *beel* now lost their importance as natural fish

habitat. Other important *beels* in this region are Chanda, Boro, Mollar and Tungipara *beels*. There are many *beels* in the south and south west and the notable are Chapaigachi, Garalia, Panjiapatra, Chenchuri and Dakatia *beels*.

The *beels* are parts of riverine floodplain formed due to changes in the river course or strengthening of river embankments for controlling flood (Saha *et al*. 1990). The *beel* water is very productive in terms of fertility and nutrient, full of organic debris and organic vegetation and provide food and shelter to many larvae and juvenile as well as adult fishes and other aquatic organisms (Graff 2003).

Beels are mainly of two types: a) perennial *beel* (retain water throughout the year) and b) seasonal *beel* (dried up in the dry season but during the rains expand into broad and shallow sheets of water). The perennial *beels* are the dry season refuges (over wintering ground) of many fish species. These waterbodies are very favourable natural habitat of small and large indigenous fishes to feed, grow and breed during monsoon as well. Among the various parameters that influence the *beel* ecosystem are depth, nature of catchments area or river basin, precipitation and duration of connection to river (Sugunan and Bhattacharjya 2000).

Beels are generally rich in fisheries resources in Bangladesh and provide considerable fish production of the country. Some important *beels* in greater Sylhet and Mymensingh region are known as "mother fishery". *Beels* play an important role in the fish production as well as shelter of brood fish in the country. The *beels* of Bangladesh comprise about 2.82% of total aquatic resources which supplied 77,524 mt of fish in 2007-08. *Beel* fishery of Bangladesh is being deteriorating day by day due to over fishing, uncontrolled use of chemical fertilizer and insecticide, destruction of natural breeding and feeding grounds, harvesting of wild brood fishes and for many other causes (Azher *et al*. 2007).

2.3.1. Chalan beel

Chalan *beel* is the largest and most important watershed in the North Central Bangladesh. It comprises of a series of depressions interconnected by numerous channels to form more or less one continuous sheet of water during monsoon covering an area of about 375 km^2. The watershed serves about five million people predominantly through fisheries and agriculture. Though far from its past glory, Chalan *beel* is still an abode of large variety of ichthyofauna with a huge importance in local economy and people's livelihood.

During the dry season, the water area decreases down to 52-78 km^2 and looks like a cluster of small *beels* of different sizes. Besides being a giant junction of a number of water ways, the *beel* also served a springboard where many rivers flowed further south and east to meet finally with the river Padma and the Brahmaputra (Iqbal 2006).

The Chalan *beel* comprised of 21 rivers and 93 small *beels* and their floodplains, 12,817 ponds and 214 borrow pits. There are 21 rivers streaming into the Chalan *beel* which cover a total area of about 709 ha and 3,300 ha in dry and monsoon, respectively. Most of the rivers and *beels* are at the risk of partial or total degradation due to manifold reasons like agricultural encroachment, siltation along with other anthropogenic activities. The critical dry out condition (0-5% of the monsoon size) was observed in 83% of the rivers and 68% of the *beels* in the lean season (Hossain *et al*. 2009)

Hossain *et al*. (2009) documented 114 finfish species from 29 families in the largest *beel* of Bangladesh – the Chalan *beel*. Among the thirty nine Cyprinifoms in the Chalan *beel* - thirty one species were under Cyprinidae one under Balitoridae, six under Cobitidae and one

under Psilorhynchidae. The most abundant fish species were two Cypriniform - *Puntius sophore* and *Puntius ticto*.

The number of fishers in the Chalan *beel* has been changed over time with a 58% reduction from 1982 to 2006 (Table 4). They either left their profession or migrated elsewhere in Bangladesh. Presently there are 75,000 professional and subsistence fishers in the Chalan *beel* area maintaining their livelihoods from this resource directly or indirectly.

Most of the fishermen families have been leading a sub-human life, many have been catching eggs, spawns, fry, undersized fish and broods indiscriminately which have resulted in scarcity of fish in the *beel* area. In this situation, almost all the fishermen, who used to earn their livelihood by fishing, are now facing hardships as there is virtually no fish in the waters in most of the time of the year.

It has been reported that the fish production in Chalan *beel* reduced by 31% and 52% in 1992 and 2002, respectively, as compared to the production in 1982 (Figure 2). Fish species availability and production are tightly bound to the pattern of the flooding which takes place during the monsoon in the Chalan *beel* (Ahmed 1991).

Human interferences including some development interventions such as construction of roads, dams and embankments and human settlement adversely affected the aquatic ecosystem and habitat of fish population in the Chalan *beel* by obstructing their migratory routes. Therefore, the breeding of migratory species has been interrupted which hampered natural recruitment of fish in the *beel*. Though, this is not the case for non-migratory resident fish spawners, over-exploitation and drying up of the waterbody perhaps responsible for overall low abundance of many species.

Table 4. Changes in number of fishermen over the years in Chalan *beel*

Fishermen category	Year			
	1982	1992	2002	2006
Professional	53,446	46,534	33,445	22,316
Subsistence	1,23,615	1,06,335	73,612	52,684
Total	177,061	152,869	107,057	75,000

Source: Hossain *et al*. (2009)

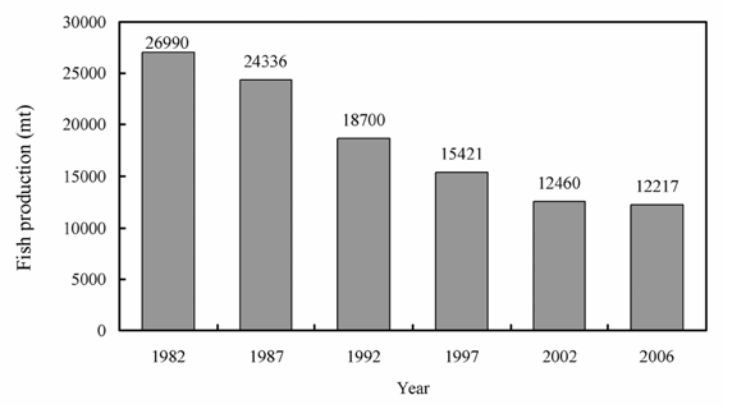


Figure 2. Fish production tends in Chalan *beel* (Hossain *et al*. 2009)

2.4. The Haors

The *haors* are back swamps or bowl-shaped depressions between the natural levees of rivers, or in some cases, much larger areas incorporating a succession of these depressions. The Bengali word *haor* basically derived from the word *sago*r (literally meaning sea) and dialectically *sagor - saior - haor* has been evolved (Khan *et al*.1990). In terms of morphology and hydrology, a *haor* can be subdivided into three major areas, the piedmont area around the hill foot, the floodplains and the deeply flooded area (Hossain and Nishat 1989). The *haors* vary in size from as little as a few hectares to thousands of hectares. The *haors* flood to a depth of as much as 6 m during the rainy season and in many cases two or more neighboring *haors* unite to form a much larger water body.

Greater part of the north east region of Bangladesh is characterized by the presence of numerous large, deeply flooded depressions, known as *haors*, between the rivers. There are altogether 411 *haors* (47 major and large sized) comprising an area of about 8,000 km^2 dispersed in the north-eastern Sylhet and Mymensingh districts. The *haor* basin is bounded by the several Indian states - hills of Meghalaya on the north, hills of Tripura and Mizoram on the south, and the highlands of Manipur on the east.

The two big rivers in the region – Surma and Kushiyara in association with several smaller hill-streams - Manu, Khowai, Jadhukata, Piyangang, Mogra and Mahadao form the dense network and supply the massive water to the *haors*. The rivers are primarily responsible for providing inputs - rainwater and sediment load to the haors. The *haors* remain flooded for about 7 to 8 months. During the rainy season, the *haors* look just like vast inland sea and the villages within appear as islands.

In greater Sylhet the most prominent *haors* are Saneer, Hail, Hakaluki, Dekar, Maker, Chayer, Tangua and Kawadighi. In consideration of the environmental importance and heritage, the government has decided to save the Tanguar *haor* (9,500 ha) by symbolizing it as an internationally critical environment area under the Environmental Protection Law of 1995 and registered as a wetland of international importance (Ramsar site, site no. 1031, declared in 10.07.2000) under Ramsar Convention. The location-wise principal *haor* systems are given in Table 5.

The *haors* are considered to be the most productive wetland resources of Bangladesh. The basin supports a large variety of aquatic biodiversity and works as natural reservoir. In past, most of the *haor* basin was covered with swamp forests and reed lands had a characteristic feature of flooded forests made the entire *haor* a suitable habitats for small and large fish and other aquatic animals. Livelihoods of the villagers living in and around the *haor* were largely dependent on the *haor* resources for food, nutrition, grazing, boating, housing, income and other forms of livelihood security.

The *haors* serve as the natural brood stocks of many indigenous fishes including large carps and catfishes. With the advent of the dry season water recedes, the relatively elevated parts of *haor* area begin to dry when paddy is raised on the dried upland areas. The relatively depressed areas, however, remain under water where fishes take shelter. The *haors* also act as important breeding and spawning ground of many fishes. There are a total of 141 finfish species found in the *haors*. The important Cypriniform fishes available in the *haors* are - *Labeo rohita, L. gonius, L. boga, L. calbasu, Catla catla, Cirrhinus mrigala, C. reba, Crossocheilus latius, Bengala elanga, Rasbora rasbora, Osteobrama cotio cotio* and *Tor tor*.

Table 5. The principal *haor* systems of Bangladesh

Location	Name of the *haors*
Eastern and lowest part of the basin, Mymensingh	Baram, Banka, Habibpur, Maka, Makalkandi and Ghulduba
Foot of the Meghalaya Hills	Tangua, Shanir, and Matian
East of the Tangua system	Dekhar, Pathar Chanli, and Jhilkar
Eastern rim of the basin	Jamaikata, Mahai, Nalua, and Parua
Central Sylhet lowlands	Hakaluki, Chatal Bar, Haila, Kawadighi, Pagla and many smaller
Tarap and Banugach hill ranges in the southeast	Hail
South of the basin	Dingapota, Ganesher, Tolar, Anganer, Bara, and Humaipur
Kishorganj	Etna and Sania
East Mymensingh	Khaliajhuri

Source: NERP (1995)

2.5. The Baors

In the southwest region of Bangladesh there are a number of meandering rivers changed their courses, part of the old course got silted up and cut-off from the main course. As a result horseshoe shaped oxbow lakes known as *baor* was created. A *baor* apparently looks like a lake, but unlike lakes, it remains connected with original river through channels during monsoon. This way, the *baors* annually receive fresh supply of riverine water carrying fry, fingerlings and adult fishes and other aquatic animals. *Baors* are very important wetlands of Bangladesh and support a wide range of aquatic flora and fauna.

There are more than 87 *baors* in Bangladesh covering an area of 5,488 ha (DoF 2008). Most of the larger *baors* are in southwestern Jessore region. The *baors* range in size from about 25 ha to a maximum of 500 ha (Bhuiyan and Choudhury 1997). The important *baors* of the country are Arial, Bahadurpur Baluhar, Bookbhara, Harina, Habullah, Rustampur, Ichhamati, Jaleshwar, Jogini Bhagini, Joydia, Kannadah, Kathgara, Khedapara, Marjat, Pathanpara, Rampur, Sagarkhali, Sirisdia and Sonadia.

The *baors* are an abode of small and large indigenous fish species. Most of the fish species breed and thrive in the *baors* throughout the year. The waterbodies are shelters and breeding grounds for fishes, amphibians, reptiles and a gamut of aquatic invertebrates. The *baors* support a continuous daily harvest of subsistence and commercial fishing round the year. About 50 species of indigenous fishes belonging to 31 genera and 20 families could be found in a *baor*. All the *baors* are now under a heavy fishing pressure. The construction of dams and other flood control structures have reduced the natural recruitment and contributed to stock depletion. The total catch area in the baors is about 5,488 ha and the annual production is about 2,460 mt (DoF 2008).

2.6. The Ponds and Ditches

There are more than 1.3 million ponds having a water surface of 0.3 million ha in the country (DoF 2008). Though in past ponds were constructed for washing, bathing and irrigation purposes, recently, many ponds are being constructed absolutely for fish culture purposes. There are two types of ponds on the basis of water retention capacity – the perennial ponds - contain water round the year and the seasonal ponds - contain water at a certain times or seasons (mainly in monsoon).

The pond culture fisheries have always been considered as being crucial for the livelihoods of the most vulnerable people of the country. In addition, it is also good for the fish diversity as it encourages the domestication of wild fishes through artificial breeding and rearing in the captivity. Selective aquaculture, however, could be detrimental for fish biodiversity as the culture technologies advice farmers to remove all small indigenous fishes from the ponds before releasing the fry of target fish. Farmers often use piscicide and insecticide to clean their ponds. The practice has been going on in Bangladesh since the carp polyculture being introduced in late 70s. As a result, though harvests from fish culture are rapidly increasing, the catches of small fishes are declining at an alarming rate.

The fish production from ponds and ditches in Bangladesh in the year 2007-08 reached to 866,049 mt with an average production of 2,839 kg ha^{-1} (DoF 2008). The major culture species are the Cypriniforms – *Labeo rohita, L. bata, Cirrhinus mrigala* and *Catla catla*. *Labeo calbasu* and *Cirrhinus reba* are also being cultured in smaller scale. The small indigenous Cypriniforms used to be abundantly available in the past in most of the homestead ponds, now-a-days seldom found are *Amblypharyngodon mola, Salmostoma phulo, Esomus danricus, Osteobrama cotio cotio, Puntius sophore* and *Puntius ticto*.

2.7. The Kaptai Lake

There are only three true natural lakes in the country. Rainkhyongkine lake and Bogakine lake are located in the Chittagong Hill Tracts, and a lake named Ashuhila *beel* at the northern end of the Barind Tract. The largest man-made lake in South Asia is Kaptai lake of 68,800 ha (surface area – 58,300 ha). The H-shaped Kaptai lake, the only major reservoir in Bangladesh was created from the construction of dam across the river Karnafuli near Kaptai town in 1961. It has drowned almost the whole of the middle-Karnafuli valley and the lower reaches of the Chengi, Kasalong and Rinkhyong rivers. Shoreline and the basin of Kaptai Lake are very irregular. The volume of the lake is 524,700 m^3 with a mean depth 9 m (maximum depth – 32 m and mean water level fluctuation - 8.14 m). Though the lake was created primarily with a vision to generate hydroelectric power, it substantially contributes to the national economy through freshwater fish production, navigation, flood control and agriculture. The lake is confined within the hill district of Rangamati and embraces sub-districts of Rangamati Sadar, Kaptai, Nannerchar, Langadu, Baghaichhari, Barkal, Juraichhari and Belaichhari

In 2007-08 fish production in Kaptai lake was 8,248 mt with an average of 120 kg ha^{-1}. At the early stage of the creation of lake, Indian major carps were the dominant species of about 60% of total catch, which is reduced to 5.69% in 2007-08. Presently the major catch in the Kaptai lake is kachki (*Corica soborna*) - 29.90% followed by chapila (*Gudusia chapra*) -

29.81%, respectively. Halder *et al.* (2002) recorded 66 species of indigenous fish in the lake. The major Cypriniforms available in the lake are *Catla catla, Cirrhinus mrigala, Lebeo rohita, L. calbasu and L. goinus* and *Puntius sarana*.

There are about 10,000 people directly or indirectly involved in fishing and fishery related activities at the reservoir. The reservoir has also provided income and employment opportunities to people, particularly in the areas of drying and retail marketing of the fish. As the local poor people remove the protective vegetation around the lake, the rocks are exposed to the monsoon rains and thus eroded easily. This results in regular landslides, and the loose rocks is washed down the slopes and carried by rivers into the lake. As a result, the lake is silting up rapidly. By early 1990s, in its 30-year existence, it had already lost 25% of its volume due to siltation.

3. AQUATIC FAUNA OF BANGLADESH

Bangladesh is a transitional zone of flora and fauna, because of its geographical settings and climatic characteristics. It is natural that the water resources of the existing extent and magnitude should harbour and support populations of a large variety of vertebrate and invertebrate aquatic living organisms. This country is rich in fish and aquatic resources, and other biodiversity (Table 6). Bangladesh's water bodies are known to be the habitat of 267 freshwater fishes, 475 marine fishes, 23 exotic fishes and a number of other vertebrates and invertebrates. Among the documented aquatic fauna, finfish tops the list, followed by the crustaceans and molluscs (Figure 3).

Table 6. Diversity of aquatic animals in Bangladesh water

Animal group	Number of Species	
	Freshwater	Marine
Finfish	267	475
Shrimp	-	41
Prawn	20	-
Mollusc	26	336
Crab	4	11
Lobster	-	6
Frog	10	-
Turtle & tortoise	24	7
Crocodiles	2	1
Snakes	18	6
Otters	3	-
Dolphin	1	8
Whale	-	3
Total	375	894

Source: Ahmed and Ali (1996), Ali (1997) and Banglapedia (2004).

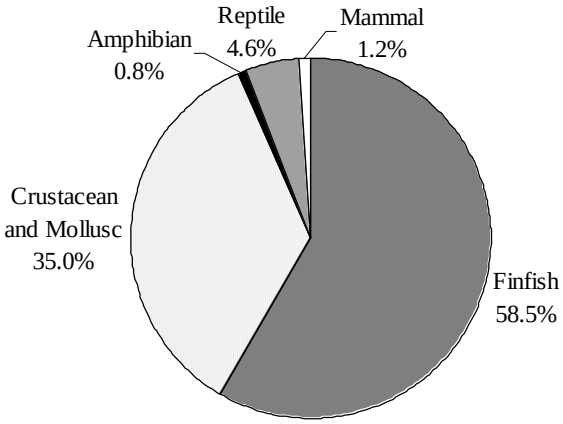
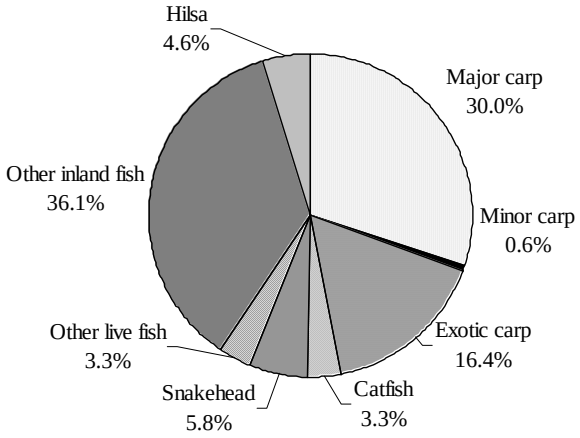


Figure.3. Percentages of major aquatic animal groups of Bangladesh.



Source: FRSS-DoF 2008.

Figure 4. Group-wise catch of freshwater fishes (2006-07).
Major carp - Rui, Catla, Mrigal and Kalibaus; Exotic carp - Silver carp, Common carp, Mirror carp and Grass carp; Minor carp – Gonia, Reba and Bata; Catfish - Rita, Boal, Pangas, Silong and Air; Snakehead - Shol, Gazar and Taki; Other live fish - Koi, Singh and Magur; and Other Fish - all other fishes

The total inland open water fish production of Bangladesh in the year of 2006-07 (July-June) was 1.783 million tons. The catch was dominated by major carps (30%) followed by exotic carps (16.4%) and snakeheads (5.8%) (Figure 4).

4. THE CYPRINIFOM FISHES

The Oriental region (i.e. monsoonal Asia, south of 30^{o}N) hosts over 3,500 species under 105 families of freshwater finfishes. Cypriniforms are the most diverse group of fishes in most of the Asian countries like Bangladesh, India, Nepal, Pakistan, Myanmar, Thailand, Vietnam, Cambodia, Indonesia and Malaysia. In terms of generic richness, the top two fish families in Asia are Cyprinidae (147 genera) and Balitoridae (38 genera) under the Order

Cypriniformes (Dudgeon 2002). Globally the Order contains 6 families (Balitoridae, Catostomidae, Cobitidae and Gyrinocheilidae under Super Family Cobitoidea and Cyprinidae and Psilorhynchidae under Super Family Cyprinoidea), 320 genera and more than 3,250 species.

In Bangladesh, there are 267 species of freshwater bony fishes under 156 genera and 52 families (Table 7). Among the freshwater fishes, the three Orders that dominate are Cypriniformes, Siluriformes and Perciformes. More than one third of the total freshwater fish belong to the three Orders – Cypriniformes (33%), Siluriformes (22%) and Perciformes (24%). The major fish groups available in the country's freshwater are major carps, large catfishes, minor carps, small catfishes, river shads, snakeheads, freshwater eels, feather backs, parches, loaches, anchovies, gobies, glass fishes, mullets, minnows, barbs and flounders.

The diversity in size, shape, colors, habitat preference, feeding and breeding of the freshwater fishes of the country is high. If one considers only the size, there are very small fish (maximum length - only a few cm. *Danio rerio*, *Oryzias dancena* etc.) and also there are large fish (maximum length – more than two meters, *Wallogo attu*, *Bagarius bagarius* etc).

The Cypriniformes is the largest order of freshwater fishes in Bangladesh and includes carps, barbs, loaches and minnows. This is usually the dominant group of freshwater fishes, very rarely entering brackish water, and adapted to the most extreme freshwater environment. Members of this order have compressed head and body and most species lack fin spines. They do not have any adipose fin. The mouth is usually more or less protractile. Cyprinifoms also have a weberian apparatus that connects the swim bladder to the auditory system (the inner air) through a chain of small bones to facilitate an acute sense of hearing. The presence of the weberian apparatus is one of the most important and phylogenetically important distinguishing characteristics of the Cypriniformes and some other fishes. Body of the Cypriniform fishes are either with cycloid scale or naked and heads are scaleless.

Table 7. Number of freshwater fish species, genera, families and orders present in Bangladesh

Order	Family	Genus	Species
Anguiliformes	5	6	8
Osteoglossiformes	1	2	2
Elopiformes	1	1	1
Clupeiformes	3	12	18
Cypriniformes	4	35	87
Siluriformes	13	36	59
Cyprinodontiformes	1	1	1
Syngnathiformes	1	2	3
Synbranchiformes	2	4	6
Perciformes	15	46	65
Beloniformes	3	5	7
Pleuronectiformes	3	4	7
Tetraodontiformes	1	2	3
Total = 13	52	156	267

Table 8. The key distinguishing characters of the four Cypriniform families available in the freshwaters of Bangladesh

Characters	Psilorhynchidae	Balitoridae	Cobitidae	Cyprinidae
Pectoral fin	Inserted horizontally		Pectoral and pelvic inserted laterally	
Pectoral fin ray	At least two unbranched rays		All rays branched or only outermost anterior ray unbranched	
Body shape	Greatly arched dorsally and flattened ventrally	Depressed	Worm-like to fusiform	Usually laterally compressed
Barbel	Absent	3 or more pairs	3 - 4 pairs	1 - 2 pairs or absent
Air bladder	Greatly reduced; free in the abdominal cavity	Large; partly enclosed in a bony capsule	-	-
Spine	-	-	Erectile spine near eyes	No suborbital or preorbital spine
Pharyngeal teeth	-	-	1 row	1-3 rows

Modified from Talwar and Jhingran (1991)

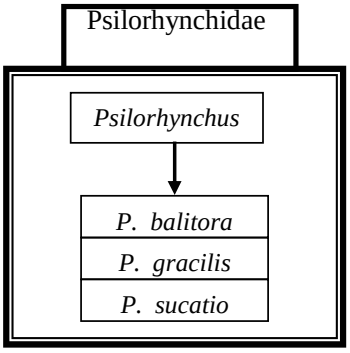
Among the six families of Cypriniformes available worldwide, fishes of four families (Balitoridae, Cobitidae, Cyprinidae and Psilorhynchidae) are available in Bangladesh. Under the four families, there are 35 genera and 87 species reported from the freshwaters of Bangladesh. The four families can be separated by a number of key characters (Table 8).

4.1. Family Psilorhynchidae

The family only has one genus – Psilorhynchus and the members are found in primarily in the Gangetic river system of Southeast Asia - Bangladesh, Nepal, Myanmar and Indian state of Assam. These fishes are found in the rapidly flowing permanent hill-streams without tidal influence.

There are about 12 species under the Genus worldwide. In Bangladesh, only three species have been documented (Box 1.) They have been found only in a few hill-streams near the Bangladesh-India border in Dinajpur, Mymensingh, Sylhet and Chittagong region.

In the Red Book published in 2000, all three fishes, - *Psilorhynchus balitora*, *P. gracilis* and *P. sucatio* have been described as data deficient (IUCN Bangladesh 2000). Through surveys conducted over the last ten years by the research team of Bangladesh Agricultural University (BAU), all three species were found in a few occasions and are maintained in the Fish Museum and Biodiversity Center (FMBC) of the BAU. They, however, were found in a very little number (one or two individuals) together with many other small fish in fishermen's net and never found in the fish markets. The biodiversity status of all three *Psilorhynchus* should be considered as critically endangered (Table 9).



Box 1. The available species under the family - Psilorhynchidae in Bangladesh

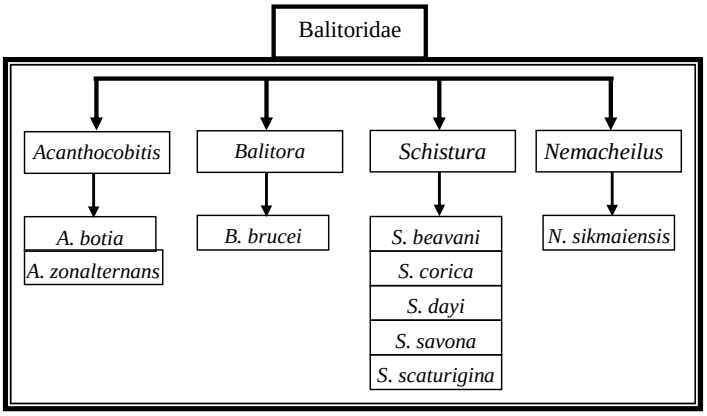
Table 9. Biodiversity status of the fishes of the family Psilorhynchidae

Fish	English name	Local name	IUCN Red Book 2000 status	Present status
Psilorhynchus balitora	Balitora minnow	Balitora	DD	CR
Psilorhynchus gracilis	Rainbow minnow	Balitora	DD	CR
Psilorhynchus sucatio	River stone carp	Titari	DD	CR

DD- Data deficient; CR – Critically endangered

4.2. Family Balitoridae

Members of the family are known as river loaches or hillstream loaches. The rheophilic fishes are found in the well-oxygenated torrential and swift streams of the south and east Asian countries, and Indo-Australian archipelago except in New Guinea. Pectoral and pelvic fins of Balitorids are usually horizontally inserted. The fishes use the modified paired fins for cleaning the rocks. The family includes more than 60 genera and over 600 species. In the waters of Bangladesh, however, only 4 genera containing 9 species have been reported (Box 2).



Box 2. The available species under the family - Balitoridae in Bangladesh.

Table 10. Biodiversity status of the fish of the family Balitoridae

Fish	English name	Local name	IUCN Red Book 2000 status	Present status
Acanthocobitis botia	Mottled loach	Bilturi	DD	NO
Acanthocobitis zonalternans	-	-	DD	NO
Balitora brucei	Stone loach	-	NE	NF
Nemacheilus sikmaiensis	-	-	DD	CR
Schistura beavani	Creek loach	-	DD	NF
Schistura corica	-	Korica	DD	CR
Schistura dayi	-	-	NE	NF
Schistura savona	-	Savon korika	NO	NO
Schistura scaturigina	-	Dari	NO	EN

NO – Not threatened; VU – Vulnerable; EN – Endangered; CR – Critically endangered; DD- Data deficient; NE – Not Evaluated; and NF – Not found.

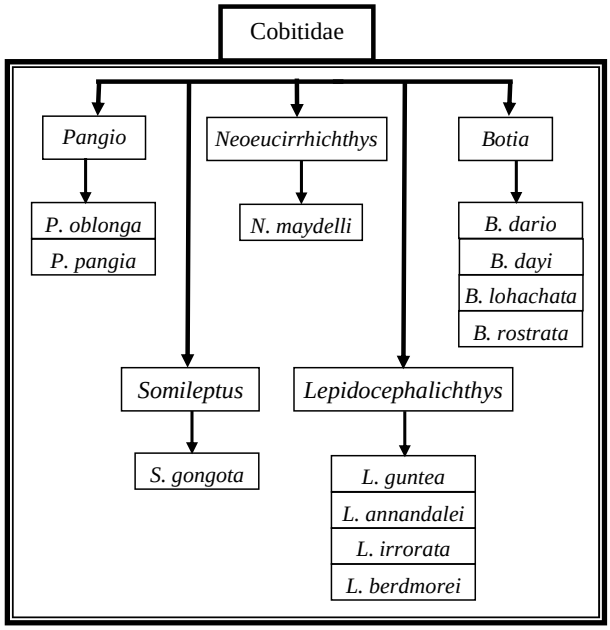
As the distribution of Balitorids goes in Bangladesh, the fishes are only available in a few hillstreams of Dinajpur, Mymensingh and Sylhet region. Presently, all the fishes under the family Balitoridae are very rare in Bangladesh. IUCN Bangladesh (2000) described five fishes as data deficient and two as not threatened. The biodiversity of the *Balitora brucei* and *Schistura dayi* were not determined. In the BAU survey, six species have been found in varying numbers, however, *Balitora brucei*, *Schistura beavani* and *S. dayi* were not found. According to the number of occurrences and number of individuals present in each occurrence, the present biodiversity status of the Balitorids is given in Table 10.

4.3. Family Cobitidae

Members of the family are known as true loaches. They are distributed in Eurasia and northern part of Africa, but the diversity is nowhere greater than in Asia. Bottom dwelling Cobitids are mostly of small size (less than 30 cm). Presently more than 200 species and nearly 30 genera are idntified under this family. New species under the family are being described regularly. Family Cobitidae in Bangladesh is represented by 5 genera and 12 species. Most of the fishes are inhibiting the hillstreams of Dinajpur, Mymensingh and Sylhet. A few of the members are also available in rivers, swamps and ditches throughout the country.

Among the 12 Cobitids, the biodiversity status of 3 were not evaluated by the IUCN Bangladesh (2000), 3 fishes described as data deficient, 2 as endangered and remaining four as not threatened. Among the twelve fishes, the BAU survey found 11 except *Neoeucirrhichthys maydelli* (Table 11). The BAU survey agrees with the biodiversity status of four Cobitids - *Lepidocephalichthys annandalei*, *L. guntea*, *Pangio oblonga* and *Somileptus gongota* as described by the IUCN Bangladesh (2000) as not threatened (NO). Although Bengal loach *Botia dario* was described as endangered by IUCN, the BAU survey found the fishes regularly in large quantities without noticing any decreasing trend in its biodiversity from most of the areas of Bangladesh. Therefore, the biodiversity status of the

fish should be changed to the category of not threatened (NO). Remaining three *Botia sp*. and *Pangio pangia* are described as critically endangered (CR), and *Lepidocephalichthys berdmorei*, *L. irrorata* as endangered (EN) based on the survey findings.



Box 3. The available species under the family - Cobitidae in Bangladesh

Table 11. Biodiversity status of the fish of the family Cobitidae

Fish	English name	Local name	IUCN Red Book 2000 status	Present status
Botia dario	Bengal loach	Bou	EN	NO
Botia dayi	Hora loach	Rani	DD	CR
Botia lohachata	Reticulate loach	Rani	EN	CR
Botia rostrata	Gangetic loach	Rani	NE	CR
Lepidocephalichthys annandalei	Annandale loach	Gutum	NO	NO
Lepidocephalichthys berdmorei	Burmese loach	Puiya	DD	EN
Lepidocephalichthys guntea	Guntea loach	Gutum	NO	NO
Lepidocephalichthys irrorata	Loktak loach	Puiya	NE	EN
Neoeucirrhichthys maydelli	Goalpara loach	-	DD	NF
Pangio oblonga	Java loach	Panga	NO	NO
Pangio pangia	-	Panga	NE	CR
Somileptus gongota	Gongota loach	Cheng gutum	NO	NO

NO – Not threatened; VU – Vulnerable; EN – Endangered; CR – Critically endangered; DD- Data deficient; NE – Not Evaluated; and NF – Not found.

4.4. Family Cyprinidae

Cyprinidae is the largest family of freshwater fish in the world with about 220 genera containing over 2,400 species. The members are known as carps, barbs, loaches and minnows. Goldfish, rasboras, danios are also included in the family. These fishes have soft finrays without true spines. In some members, however, the last unbranched ray is hardened and forms a stiff spine-like structure, and in a few species, the last anal fin ray is also hardened. Fishes have toothless jaw but strong pharyngeal teeth. The Cyprinids are egg-layers and most fishes do not guard their eggs, only a very few species build nests and/or guard the eggs.

This important family of primarily freshwater fishes is widely distributed in Asia, Africa (excluding Madagasker), Europe and North America. The family is very dominant in most areas within its distribution and is of considerable economic importance in many Asian countries. This large family has been divided into various subfamilies. Sixty three cyprinid species under four subfamilies Leuciscinae, Rasborinae, Cyprininae and Garrinae are found in Bangladesh waters (Box 4).

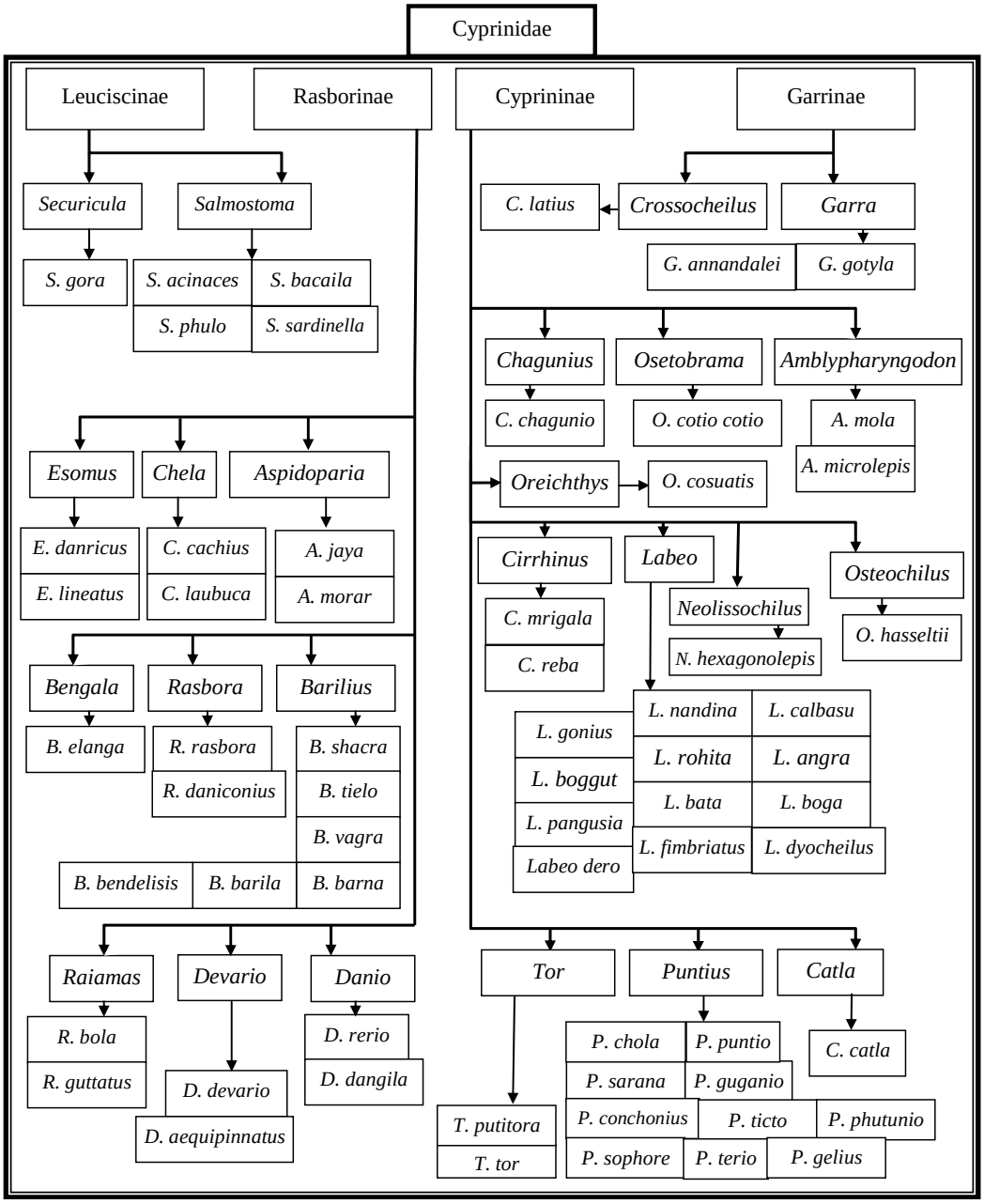
There are five species available in Bangladesh belong to the subfamily Leuciscinae. The leuciscine minnows could be differentiated from the other Cyprinids by the possessions of a sharply keeled abdominal rim and presence of highly irregular scale pattern on the dorsal side. The 5 species are placed under 2 genera *Securicula* (1 species) and *Salmostoma* (4 species). According to the status given by the IUCN, 3 species are not threatened, one data deficient and one not evaluated. In the BAU survey, all five species were found. Based on the survey findings, the biodiversity status of thee leuciscine - *Securicula gora*, *Salmostoma bacaila* and *S. phulo* remains unchanged, ie., not threatened as described by IUCN Bangladesh (2000), *S. acinaces* is vulnerable and *S. sardinella* is critically endangered (Table 12).

Subfamily Rasborinae has 9 genera containing 21 species in Bangladesh. In the BAU survey all except two rasborine - *Raiamas guttatus* and *Devario aequipinnatus* were found. The genus *Esomus* has 2 species- *E. danricus* and *E. lineatus*. *E. danricus* is abundantly available throughout the country (not threatened). *E. lineatus*, however, is rarely found and the diversity is rapidly decreasing (critically endangered). The two *Chela* species - *Chela cachius* and *C. laubuca* should now be considered as endangered. The 2 species of *Aspidoparia* was described as data deficient by the IUCN. Both the species were found in the BAU survey and the present status of two fish is endangered. According to the BAU survey, the biodiversity status of *Begala elonga*, four *Barilius sp*. *Raiamas bola* and *Danio dangila* are critically endangered. The biodiversity status of two *Rasbora sp*., two *Barilius sp*., and *Devario devario* should be considered as endangered and *Danio rerio* as vulnerable.

There are 11 genera containing 34 species under the subfamily Cyprninae found in Bangladesh. Among the 34 species, the BAU survey did not find 6 species - *Osteochilus hasseltii*, *Labeo angra*, *L. fimbriatus*, *L. dero*, *L. nandina* and *Neolissochilus hexagonolepis*. The survey found 14 fishes regularly in large quantities without any decreasing trend in their biodiversity over the years from most of the areas of their distribution (not threatened). Although *Puntius sarana* was described by IUCN as critically endangered, the stable stocks of the species in a number of rivers and floodplain were found and the fish has been successfully bred in the laboratory. *P. sarana* should be described as vulnerable. According to

the findings of the survey the number of endangered and critically endangered fishes under the subfamily Cyprninae is 3 and 10, respectively (Table 12).

The outstanding identifying character of the Subfamily Garrinae is the absence of a groove between the upper lip and snout, the upper lip is being coalescent with the skin of snout. The pectoral and pelvic fins are horizontally placed. It has two genera containing three species in Bangladesh. In our survey we did not find *Garra annandalei*. The present biodiversity status of the two Garrinae is endangered.



Box 4. The available species under the family - Cyprinidae in Bangladesh.

Table 12. Biodiversity status of the fish of the family Cyprinidae

Fish	English name	Local name	IUCN Red Book 2000 status	Present status
Securicula gora		Ghora chela	NO	NO
Salmostoma acinaces	Silver minnow	Chela	DD	VU
Salmostoma bacaila	Large minnow	Katari	NO	NO
Salmostoma phulo	Finescale minnow	Ful chela	NO	NO
Salmostoma sardinella	Sardinella minnow	Chela	NE	CR
Esomus danricus	Flying barb	Darkina	DD	NO
Esomus lineatus	Striped barb	Darkina	NE	CR
Chela cachius	Glass barb	Chhep chela	DD	EN
Chela laubuca	Glass barb	Chhep chela	EN	EN
Aspidoparia jaya	Joya	Joya	DD	EN
Aspidoparia morar	-	Morari	DD	EN
Begala elonga	Megarasbora	Elong	EN	CR
Rasbora daniconius	Slender rasbora	Darkina	DD	EN
Rasbora rasbora	Gangetic rasbora	Darkina	EN	EN
Barilius barila	-	Barali	DD	EN
Barilius barna	-	Koksa	DD	CR
Barilius bendelisis	-	Joiya	EN	EN
Barilius shacra	-	Koksa	DD	CR
Barilius tileo	-	Pathorchata	DD	CR
Barilius vagra	-	Koksa	EN	CR
Raiamas bola	Trout barb	Bhol	EN	CR
Raiamas guttatus	Burmese trout	Bhol	NE	NF
Devario aequipinnatus	Giant danio	-	EN	NF
Devario devario	Sind danio	Debari	NO	EN
Danio dangila	-	Nipati	DD	CR
Danio rerio	Zebra danio	Anju	NO	VU
Amblypharyngodon microlepis	Indian carplet	Mola	NO	NO
Amblypharyngodon mola	Mola carplet	Mola	NO	NO
Osteobrama cotio cotio	-	Dhela	EN	EN
Chagunius chagunio	Chaguni	Chaguni	DD	CR
Osteochilus hasseltii	Silver sharkminnow	-	DD	NF
Labeo angra	-	Angrot	NO	NF
Labeo bata	Bata	Bata	EN	NO
Labeo boga	-	Bhangon	CR	CR
Labeo boggut	Labeo boggut	-	DD	CR

Table 12. (Continued)

Fish	English name	Local name	IUCN Red Book 2000 status	Present status
Labeo calbasu	Orange-fin labeo	Kalibaus	EN	NO
Labeo dyocheilus	-	Ghora machh	DD	CR
Labeo fimbriatus	Fringed-lipped carp	-	NE	NF
Labeo gonius	Kuria labeo	Sada gonia	EN	NO
Labeo nandina	-	Nandil	CR	NF
Labeo pangusia	-	Baitka	CR	CR
Labeo rohita	Rohu	Rui	NO	NO
Labeo dero	Kalabans	Kursa	NO	NF
Neolissochilus hexagonolepis	Copper mahseer	-	DD	NF
Cirrhinus mrigala	Mrigal	Mrigal	NO	NO
Cirrhinus reba	Reba	Raek	VU	NO
Catla catla	Catla	Katla	NO	NO
Puntius chola	Swamp barb	Chalapunti	NO	NO
Puntius conchonius	Rosy barb	Kanchonpunti	NO	NO
Puntius gelius	Dwarf barb	Gilipunti	DD	EN
Puntius guganio	Glass barb	Molapunti	NO	CR
Puntius phutunio	Spottedsail barb	Phutanipunti	NO	EN
Puntius puntio	Puntio barb	Punti	DD	CR
Puntius sarana	Olive barb	Sarpunti	CR	VU
Puntius sophore	Pool barb	Bhadipunti	NO	NO
Puntius terio	Onespot barb	Teripunti	NO	NO
Puntius ticto	Ticto barb	Titpunti	VU	NO
Oreichthys cosuatis	-	Kosuati	NO	CR
Tor putitora	Putitor mahseer	Mohashol	NE	CR
Tor tor	Mahseer	Mohashol	CR	CR
Crossocheilus latius	-	Kalabata	EN	EN
Garra annandalei	Sucker head	Ghorpoiya	DD	NF
Garra gotyla gotyla	Sucker head	Ghorpoiya	DD	EN

NO – Not threatened; VU – Vulnerable; EN – Endangered; CR – Critically endangered; DD- Data deficient; NE – Not Evaluated; and NF – Not found.

Among the 87 Cyprinifoms reported in Bangladesh, the BAU survey observed 74 over the last ten years. The biodiversity status of many of these have now changed from that listed in the IUCN Red Book published in 2000. The changed biodiversity status proposed here is based primarily on the study of specimens maintained in the Fish Museum and Biodiversity Center (FMBC) of the BAU and through surveys conducted over the last ten years. Figure 5 shows that although the percentage of not threatened and vulnerable Cypriniform remained mostly unchanged over the last ten years, the percentage of critically endangered fish increased almost five times. Many Cypriniforms described as data deficient by IUCN were found in the BAU survey. The biodiversity of these fishes, however, remains under severe threat and most are described as either endangered or critically endangered.

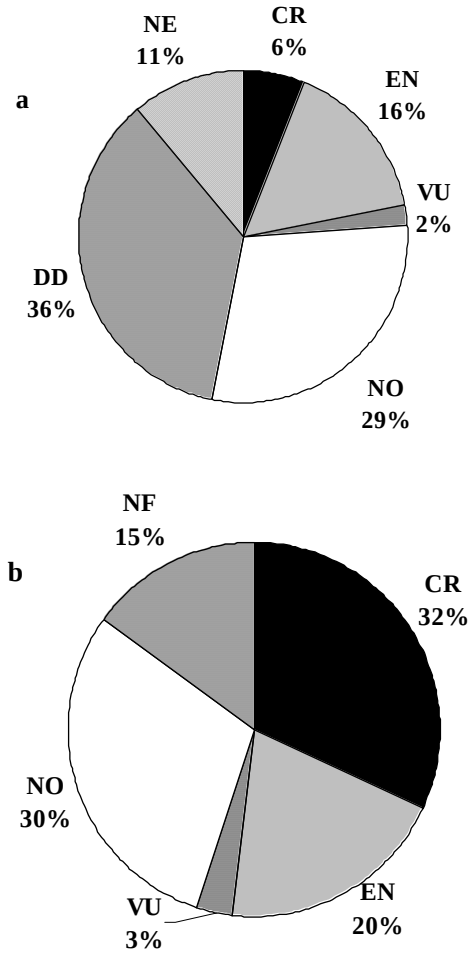


Figure 5. Comparison of percent of Cypriniform fishes under different categories – a. IUCN Bangladesh 2000 and b. Present status NO – Not threatened; VU – Vulnerable; EN – Endangered; CR – Critically endangered; DD- Data deficient; NE – Not Evaluated; and NF – Not found.

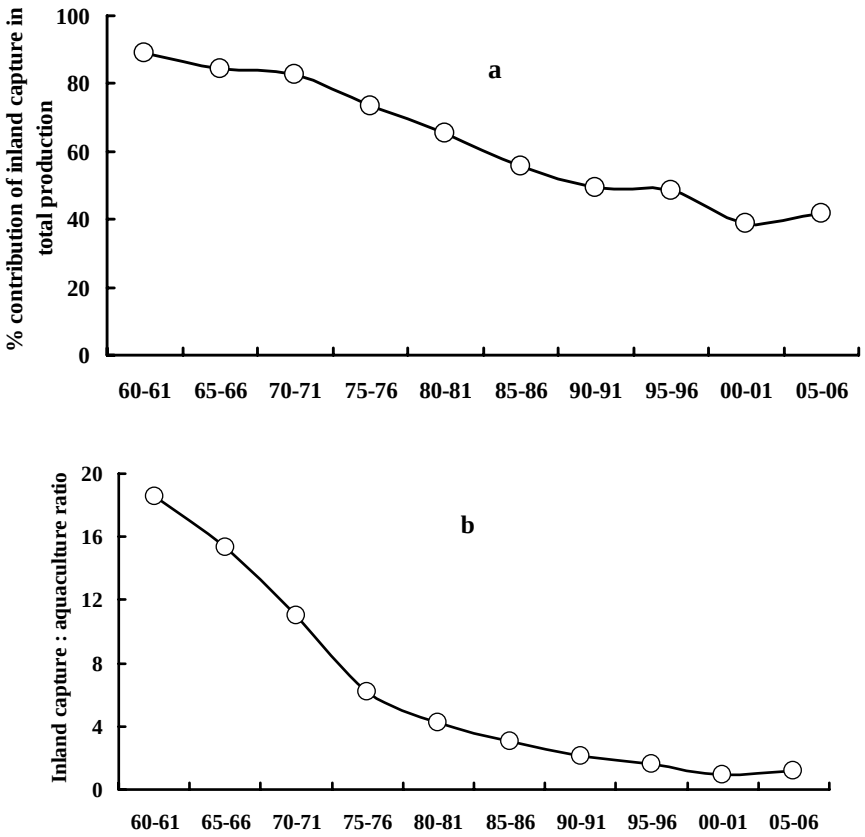
5. THE MAJOR CAUSES OF LOSS OF FISH BIODIVERSITY

In the past the major source of fish production in Bangladesh was the inland open water capture fisheries. During 1960s, it contributed about 90% of the country's total fish production. Rapid growth of population coupled with lack of proper management policy, however, created increasing pressure on fish resources and aquatic environment. Due to over exploitation of fish including use of harmful fishing gears and system (fishing by dewatering), degradation and loss of fish habitats, obstruction of fish migration routes by construction of embankment and water control structures mainly to increase agriculture production and road communication, siltation of water bodies by natural process, introduction of a number of alien invasive fish species and water pollution by industry, and agrochemicals, the natural inland fish stocks have declined significantly and fish biodiversity and poor fishers' livelihood have been affected seriously (Ali 1997).

Fish stocks in the rivers and floodplains are declining for a variety of reasons. Most of the indigenous fish are migratory and rely on seasonal flooding for spawning cues and access to larval rearing habitat (floodplain). Almost all dams and embankment interfere directly with the successful completion of the fish migration (breeding and feeding). Agriculture (excessive removal of surface water and extraction of groundwater for irrigation), pollution (domestic and industrial), and unregulated discharge of untreated industrial and farm effluents, habitat destruction also have significant impact, as does the regular overflooding and lack of flooding rain in the last few decades. Introduced species (primarily tilapia, Chinese carp and Thai pangas) are significant contributors to aquaculture production, but also threaten the biodiversity of indigenous fishes. In past, stocking of rivers and floodplain is carried out with both indigenous and introduced species by government and through different projects. The effectiveness of stocking activities has generally not been well assessed. Furthermore, the impacts of aquaculture (both commercial and small scale) have not been accurately assessed in this country.

Most of the literal and floodplains areas are cultivated with rice and other crops, providing multiple annual harvests. Thus, government policy has always prioritized cereal food production. Consequently, most development initiatives in the country have focused on crop cultivation, rather than biological management of the rich floodplain system for fish production, ignoring the needs of poorer people for access to renewable protein sources. Capture fisheries in inland waters which are based on natural productivity generally have reached the level of overexploitation. The inland open water fisheries, where the floodplains assume an important position in the livelihoods and nutrition of the rural poor have now been under serious threat of resource depletion due to various man-made and natural causes. The majority of the waters of this type have been depleted to an alarming state and warrant urgent interventions for conservation and sustenance. Ecosystem integrity has often been destabilized and aquatic systems now fail to support decent levels of aquatic life. As a result the livelihoods of fishers and rural Bangladeshis, previously supported by the inland open waters, are seriously compromised (Coates 1995). Some rivers and floodplains have been modified to a level where they are only recognized as narrow ditches and paddy fields.

During 1960s, the inland capture fisheries contributed about 90% of the country's total fish production. Production from inland capture fisheries has declined significantly over the years and in 2005-06 it accounted only about 40% (Figure 6a). During 1960s, production from inland capture fisheries was almost 20 times higher compared to the then aquaculture production of the country (Figure 6b). However, aquaculture production both in fresh water and brackish water has significantly increased during the last two and a half decades with development of technology. Due to the rapid increase of aquaculture production and sharp decrease of capture fishery production, in 2007-08, the aquaculture contributed almost equally (about 40 %) as inland capture fisheries in total fish production of the country (FRSS-DoF 2008). There has been a qualitative degradation of fish catch in terms of valued species which included cypriniforms like Indian major carps and olive barb. The Indian major carps contributed 67% of the total stock in 1967 in Sylhet-Mymensingh *haor* basin that rapidly declined to 50% in 1973 and only 4% in 1984 (Tsai and Ali 1987).



Source: Ali *et al.* (2009).

Figure 6. Trend of fish production in Bangladesh 1960-2006, a. Contribution of inland capture (%) in total fish production, and b. Inland capture to aquaculture ratios

5.1. Effects of Usage of Pesticides and Chemicals

Every year, there are thousands of tons of different pesticides (insecticides, herbicides, piscicide, miticides, fungicides, weedicides etc.) used around the globe that enter into aquatic systems from direct application and indirectly through terrestrial runoff or wind-borne drift. Pesticide affects the aquatic ecosystem by interrupting the aquatic food chain of open water fish species resulting loss of natural diversity (Parveen and Faisal 2002).

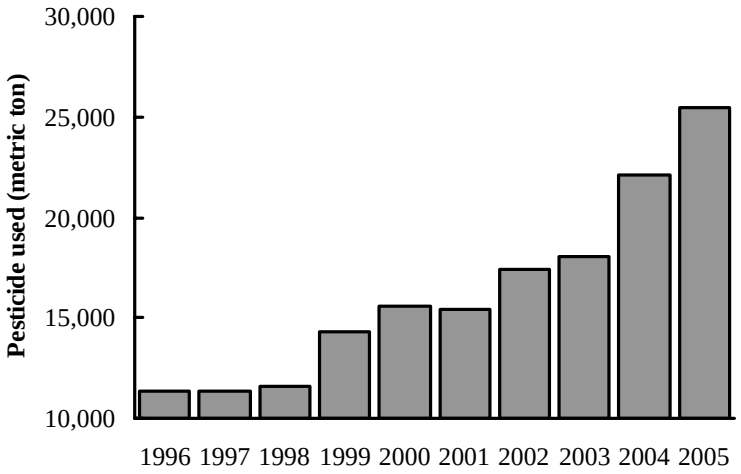
The Bangladesh Pesticides Rule clearly states that "no person shall import, manufacture, formulate, repack, sale, hold in stock, or in any other manner advertise any brand of pesticides which has not been registered." The naive and illiterate farmers are, however, convinced by glib sales talk at promotional camps, and through incentive schemes, to buy new unregistered formulations that promise to protect crops against pest attacks and disease. Suppliers continue to sell many chemicals banned by the government. The increased reliance on pesticides in rice and other crop production has, in some areas, proved to be unsuitable and unsustainable due to pesticide-induced outbreaks of insect pests, development of pesticide

resistant pests, rising cost of pesticide use and the negative effects of pesticide use on human health and the environment (Pingali and Gerpacio 1997).

The inundated floodplains of Bangladesh during monsoon are the seasonal habitat of the many indigenous fish. The residual effects of pesticides applied to these floodplains for agricultural purpose before monsoon lead to the fish mass mortality. Besides fish killing, there are also many other chronic effects of pesticides on fish including changes in their reproductive system, metabolism, growth patterns, food availability and population size and numbers (Rohar and Crumrine 2005). Lower abundance of phytoplankton and, consequently, lower abundance of zooplankton are observed as a result of pesticide use in the waterbodies. The application of a pesticide might kill all individuals and it can be substantial perturbation to the ecosystem.

The pesticides affect the aquatic biodiversity in two ways depending on the intensity: sublethal (chronic) effect and lethal (acute) effect. The sublethal concentrations of pesticides can alter a wide range of individual traits including changes in neurotransmitters, hormones, immune response, reproduction, physiology, morphology and behaviour including reduced foraging and changes in swimming ability, predator detection, learning and social interactions (Weis *et al*. 2001). At relatively high concentrations, pesticides become lethal and kill the organisms immediately. However, pesticides that are sublethal for short exposure can also be lethal to aquatic organisms when they are exposed for longer durations (chronic exposure).

The indiscriminate use of insecticides and pesticides in the crop fields by the farmers is one of the major causes of disappearance of many fish from the natural waters in Bangladesh High yielding varieties (HYV) of rice have replaced the indigenous ones resulting in substantial increase in insecticides and pesticides use and causing total disappearance of fish from many monsoon fed water bodies (Mazid 2002). Prolonged misuse of pesticides and fertilizers over the years has also halted the development of inland fisheries and aquaculture (Abdullah *et al.* 1997).



Source: Bangladesh Crop Protection Association, Aziz (2005) and www.moa.gov.bd/statistics/Table4.15CP.htm.

Figure 7. Trend in pesticide use in Bangladesh during 1996-2005.

Pesticide use in Bangladesh got started from mid 1950s and gained momentum in late 1960s with the introduction of green revolution through the use of HYV rice in the country (Rahman 2004). A total of 94 pesticides, with 299 trade names of different groups and formulations have been registered for use in the crop fields. In 1999, the total use of pesticides was about 14,340 mt (active ingredient 2,462 mt) (Banglapedia 2004). In pesticide sector, farmers have been receiving extension services and considerable subsidies from the government over the years (Hossain 1988). As a result of the expansive policy and to minimize the increasing demand of staple crops, pesticide use in Bangladesh has been more than double since 1996, rising from 11,700 mt to 25,466 mt in 2005 (Figure 6). Among the different pesticides, more than 60% are insecticides and used mainly in the paddy field.

Table 13. The exotic fishes introduced into the freshwaters of Bangladesh and the countries they imported from

Common name	Scientific Name	Source	Year of introduction
Siamese gourami	*Trichogaster pectoralis*	Singapore	1952
Goldfish	*Carassius auratus*	Pakistan	1953
Tilapia	*Oreochromis mossambicus*	Thailand	1954
Guppy	*Poecilia reticulata*	Thailand	1957
Common carp	*Cyprinus carpio*	India, Nepal	1960
Mirror carp	*Cyprinus carpio var specularis*	India, Nepal	1979
Scale carp	*Cyprinus carpio var communis*	India, Nepal	1965
Leather carp	*Cyprinus carpio var nudus*	India, Nepal	-
Grass carp	*Ctenopharyngodon idella*	Hong Kong,	1966
Silver carp	*Hypophthalmichthys molitrix*	Hong Kong	1969
Nilotica	*Oreochromis niloticus*	Thailand	1974
Thai sarpunti	*Barbonymus gonionotus*	Thailand	1977
Bighead carp	*Hypophthalmichthys nobilis*	Nepal	1981
Black carp	*Mylopharyngodon piceus*	China	1983
African magur	*Clarias gariepinus*	Thailand	1990
GIFT (genetically improved farmed tilapia)	*Oreochromis niloticus*	Philippines	1994
Genetically improved scale carp	*Cyprinus carpio var communis*	Vietnam	1995
Thai pangas	*Pangasius hypophthalmus*	Thailand	1990
Giant pangas	*Pangasius gigus*	Thailand	-
Mosquito fish	*Gambusia affinis*	India	-
Sucker mouth catfish	*Hypostomus plecostomus*	Hong Kong, Singapore	-
Red piranha	*Pygocentrus nattereri*	Hong Kong, Singapore	2003
Pirapatinga	*Piaractus brachypomus*	Hong Kong, Singapore	2003

Modified from Rahman (2005).

Table 14. The negative impacts of exotic fishes on the cyprniform fishes

Exotic fish	Impact
Tilapia	Their prolific breeding surpasses the carrying capacity of the waterbody leading to stunting of tilapia and a number of cypriniform SIS – mola, dhela, anju, darkina, chela, punti etc.
Common carp	Destroy pond embankments, make water turbid by stirring up mud. Reduce the water transparency and dissolved O_2 in water. Destroy the habitat of SIS living closed to the pond dyke and loaches in the bottom.
Grass carp	High feeding competition with many herbivorous cypriniforms.
Silver carp	Strong feeding and habitat competition with cypriniform – catla in both captive condition and in the wild
Thai sarpunti	Compete with local sarpunti for foods and space
African magur	Predation and voracity of this catfish is legendary, predate on almost all small fishes including most cypriniforms
Thai pangas	Natural diet is finfish, crustacean and insects, periphyton and benthos. This predatory fish is the major cause of disappearance of SIS from the pond system
Mosquito fish	They live in the littoral zone of the waterbody and compete with small cypriniforms for food and habitat
Suckermouth catfish	One of the dangerous catfish, now found in the floodplain allover the country, feeds on small crustaceans and cypriniforms like small loaches and freshwater eel
Red piranha	One of the most dangerous and aggressive species of piranha, feeds on insects, worms and small and large fish. The cultured fish in the pond system and escapees in the wild actively predate on the indigenous fishes including many cyprinifomrs
Pirapatinga	The natural diet is terrestrial plants, fruits, insects and crustaceans, however, in captivity where the natural food is scarce the pirapatinga predate on small cypriniforms. The fish has strong, human like teeth used to crush food items.

In the inland open waters of Bangladesh, mass mortality of fish by pesticides mainly occurs due to the use of pesticides in improper doses and use of banned chemicals. The most commonly used pesticide in the crop field is organochlorine which is highly toxic to fish and other aquatic organism. In sub-lethal doses, organochlorine affects the reproductive physiology of fish and other aquatic fauna. A few drops of endrin can kill all fish in a pond. Hossain and Halder (1996) reported that the main cause of disappearance of the fish from the inland open water of Bangladesh was the use of excessive and banned pesticide and 100% fish mortality occurred within 96 hours of the application of a number of pesticides following even recommended dose for the crop. Lethal dose and even at sub lethal dosage of chemical residues of pesticides largely attributed to cropland runoff contaminants killed fish as well as other aquatic organisms (Parveen and Faisal 2002).

5.2. Introduction of Exotic Fish

Allover the world the exotic species have been recognized as an agent of the loss of indigenous biodiversity. Alteration of species and ecosystem caused by exotic invasive animals and plants influence the functioning and overall health of the affected ecosystems (Ameen 1999).

As a country of rivers and wetlands, Bangladesh is very rich in fish diversity. Even then, over the last six decades a total of 23 fishes have been introduced (Table 13). The invasive species rapidly spread over the wetlands as biological explosives during the rainy seasons. Most of the introduced species were meant only for captive cultivation in closed pond systems but nobody succeeded to maintain the fish in captivity. During monsoon and/or flood the escapees easily found their ways to the rivers and floodplains throughout the country. This posed one of the major threats to the biodiversity of many indigenous fishes in this country.

Several introduced species are highly carnivorous and predatory and eat almost everything including the small indigenous species of fish (SIS - which grow to a maximum length of 5- 25 - Felts *et al.* 1996). Sixty fishes out of 87 cyprinids are considered as SIS. Several exotic species also compete with the SIS and gradually occupy their niches. The ecological, economic and biodiversity consequences of the introductions of exotic fish species have never been taken into consideration. It is very unfortunate that the long-term, and even short-term adverse effects were not considered while introducing the invasive species in Bangladesh. The excessive fecundity and growth rate of these species created pressure on the carrying capacity of the habitat, and the ecosystem balance itself by reducing the indigenous species diversity and population. Some of the negative impacts of exotic species on Cypriniforms are given in Table 14.

6. THE CONSERVATION MEASURES

The government of Bangladesh and a number of non government organizations (NGOs) have taken a number of regulatory and development interventions for sustainable management of the natural fisheries. In order to reverse the loosing trend and ensure sustainability of fish biodiversity and production from inland open waters various measures for protection, conservation and management of fisheries resources have been adopted time to time. Among the measures are the implementation of Fish Protection and Conservation Act 1950 and related rules including new fisheries management policy (licensing the fishing rights directly to the true fishers), community based fisheries management (CBFM), establishment of fish sanctuary in the strategic points of the rivers and floodplains, fish stock enhancement through releasing fish seed in seasonal floodplains, and fish habitat improvement through excavation of link canals (between rivers and floodplains) and *beels*.

The Fish Act 1950 provides regulations for: (i) restriction on capture size of some fish for a specific period, (ii) restriction on catch of any species for specific time or season, (iii) closure of fishing in any water body for any stipulated time period, (iv) restriction of fishing by dewatering or any other destructive method, (v) restriction on the use of any kind of gear and mesh size of net, and (vi) restriction on placing fixed engine in a water course, which may restrict fish migration.

Implementation of fisheries regulations has proved to be very difficult in this country due to institutional weakness of implementing authorities and the socio-economic conditions of the fishers. However, the Fish Act 1950 element – 'closure of fishing in specific area for specific period' as may be termed as 'fish sanctuary' is easier than applying other regulations of the Fish Act. Sanctuary has been tested and found as a powerful tool for protection and conservation of fish stock in Bangladesh.

The dry season is the critical time for the fishes, when water levels in the rivers, canals, *beels* etc. recede drastically leaving a very few refuge for the inland fishes. Fish are exposed to greater predation and increased susceptibility to fishing pressure as the water level drops due to water extraction for irrigation and evaporation due to persistent heat of the dry season. Loss of surface water in the dry season results in the reduction in the brood fish stock. The fishes become increasingly vulnerable to intensive fishing and thereby the fish stock particularly the brood stock depletes to such a level that cannot sustain the fisheries and gradually fish diversity and production decline. Therefore, the major issue for biodiversity conservation is to provide sufficient dry season refuges to maintain the population at sustainable level.

Among all measures, fish sanctuary has been apparently found most effective for fish biodiversity conservation, when other measures are difficult to implement in the present administrative and social contexts. With this notion, Bangladesh government has established fish sanctuaries under different development projects following a number of management approaches since 1960 and more intensively in last decade. The NGOs like BRAC, CARITAS, CNRS, PROSHIKA and WorldFish Centre (CBFM project) have also been involved in fish stock development by establishing traditional sanctuaries in *beels* and rivers of Bangladesh.

In addition, a number of silted up *beels*, *baors*, dead rivers and link canals have been re-excavated by the government under the food for work programs over the years. By 2000 a total of about 8,300 ha water area of borrow pit, *baors*, dead rivers, canals and *beels* had been excavated (DoF 2005). In the late 1990s the government approved a series of sectoral policies including National Fisheries Policy (1998), National Environment Policy (1995), and National Land Use Policy (2001) with a new emphasis on maintaining and protecting the moribund inland waterbodies. Under the National Fisheries Policy, government has formulated strategies for inland capture fisheries and emphasized on fisher community participation in fisheries management, along with fish sanctuaries as a key management tool (DoF 2005).

6.1. Fish Sanctuaries

The massive siltation has threatened the existence of most of the inland waterbodies – rivers, floodplains, *beels*, *haors* and *baors*. Many waterbodies once the blessings for Bangladesh providing fishing, communication and irrigation facilities are now drying up at an alarming rate. Most of the waterbodies are becoming empty of fish. The causes of reduced abundance of fish are over-fishing, reduced flooding, siltation, agricultural and industrial pollution etc. These activities have severely affected the indigenous fish diversity of the country. The complete drying up in many parts of the river and other waterbodies is a

common scenario during lean season, which is detrimental to fish populations. Where perennial waterbodies have been transformed to seasonal waters due to several manmade and natural factors, establishing a fish sanctuary (refuges where fish are protected during the dry season) can help to restore the fish habitat and fish diversity. The establishment of fish sanctuaries in the deeper parts of the waterbodies where fish reside during dry season and grow and attain maturity for spawning in the next monsoon– is particularly very important. At the onset of early monsoon rains, these fish disperse on the rivers and adjacent floodplains for breeding and feeding.

Following the provision of the Fish Act 1950, Govt. declared closed season for fishing of certain species or for all species of fish in specified water bodies under normal fisheries management programme and under different development schemes/projects of DoF. In 1952 Govt. prohibited catching of cypriniforms - rui, catla, mrigal, kalibaus and gonia of any size in rivers and canals for different time period between mid March to 31 July every year except for pisciculture purposes. Under the Development and Management Scheme of Department of Fisheries (DoF), 23 sanctuaries were established in different floodplains during 1960-1965. Upon having good results of the established sanctuaries, 25 more sanctuaries were established under the same scheme of DoF during 1965-70. Afterwards 10 more sanctuaries were established in 1987 under the Integrated Fisheries Development Project of DoF.

Most of the fish sanctuaries now focus on the need of involvement of fisher community and local govt. in the management system, long tenure of lease period and also strong monitoring and supervision. Besides, to safeguard of the fishers interest, the Govt. policy now is to establish sanctuary in part of the floodplain and the remaining part is open for fishing by the local fishers. Based on this idea, under different development projects, government has established a number of sanctuaries involving the fisher communities with support of NGOs. In a government declared fish sanctuary, catching/killing of fishes is prohibited by law and order of competent authority for all the times to come or for a specified period mainly with objective of protecting/conserving the fish.

A total of 463 permanent fish sanctuaries covering an area of 1,745 ha have been established in 98,405 ha water bodies by 2007 (Table 15). A number of the sanctuaries have been closed after the projects ended. Management has deteriorated in many sanctuaries due to the conflict of interests among the stakeholders, lack of funding and lack of coordination among the organizations.

Fish sanctuary in Bangladesh was proved to be an important and efficient tool for management in protection and conservation of fishes and other aquatic organisms (Ali *et al.* 2009). Since mid 80s, concept of the involvement/participation of local fisher community in setting up and managing sanctuaries has been the government policy. However, a major problem in managing sanctuaries in public water bodies is the policy conflict between the government ministries. Although the national fisheries policy envisages establishing fish sanctuaries, there is no clear guideline for establishment and management of fish sanctuaries. To make the fish sanctuaries more effective, the following stages should be followed - mitigation of all the conflicts among the stakeholders involved, formulation of clear guidelines of sanctuary management, selecting the strategic place and size of the sanctuary, proper awareness building among the stakeholders, ensuring proper community organization and full participation and continuous monitoring and impact assessment.

Table 15. Fish sanctuaries established in Bangladesh by 2007

Project/ Programme	Area of water body ha	Area of Sanctuary ha	Number of Sanctuary
Fourth Fisheries Project	12,233	1,022	63
Community Based Fisheries Project (CBFM-2)	9,602	93	182
Management of Aquatic Ecosystems through Community Husbandry Project (MACH)	785	76	65
New Fisheries Management Policy	1,698	77	21
Fisheries/ Fish Culture Development in *Beel* and Chharas project	1,294	18	29
Aqua Development Project (Faridpur)	454	11	14
Patuakhali Barguna Aquaculture Extension Project (PBAEP)	307	26	19
Fish Habitat Restoration Project	3,890	73	45
Fisheries Development in *Jabai Beel* project	75	4	4
Sustainable Environment Management Programme (SEMP-17)	50	17	12
Community Based Wetland Management Project(CBWM- 4)	17	4	7
Kaptai Lake	68,000	324	2
Total	98,405	1,745	463

Modified from Ali *et al.* (2009).

6.2. Fish Breeding, Domestication and Gene Banking

As more fish species of Bangladesh become threatened, there is tremendous need to preserve the disappearing genetic material as well as to conserve the existing gene pools. The ideal strategy for conservation of threatened and endangered fish species is through restoration of the native habitat of the species (*in situ* approach). Unfortunately, most habitat damages are irrevocable and where remediation is possible it is costly and requires a great deal of time, as the restoration process is slow. One alternative is to maintain *ex situ* conservation (outside the natural environment) as live populations or in a cryopreserved sperm bank (Pullin *et al*. 1991).

Domestication of wild fishes in most cases benefits both the farmer and the environment. Investments in domestication have to pay off; therefore, researches should take into account the biodiversity and production scenario and overall socioeconomic and environmental outcome at a broader scale. In Bangladesh, to date about 22 fish species have been domesticated and their breeding and rearing protocols have been developed. Around 50% of the domesticated fishes are cypriniforms and now under nation-wide aquaculture (Table 16). Though there is high possibility of working with reduced gene pool, it is optimistically believed that the biodiversity of the domesticated fish are well-preserved.

Table 16. The domesticated indigenous fishes of Bangladesh

Order	Fish	Culture status
Cypriniformes	*Catla catla*	Country-wide commercial
	Labeo rohita	Country-wide commercial
	Labeo gonius	Country-wide commercial
	Labeo bata	Country-wide commercial
	Labeo calbasu	Small scale, sporadic
	Cirrhinus mrigala	Country-wide commercial
	Cirrhinus reba	Small scale, sporadic
	Tor putitora	Breeding protocol developed
	Puntius sarana	Small scale, sporadic
	Lepidocephalichthys guntea	Breeding protocol developed
	Botia dario	Breeding protocol developed
Osteoglossiformes	*Chitala chitala*	Small scale, sporadic
Siluriformes	*Ompok bimaculatus*	Small scale, sporadic
	Ompok pabda	Small scale, sporadic
	Mystus vittatus	Small scale, sporadic
	Mystus gulio	Breeding protocol developed
	Clarias batrachus	Small scale, sporadic
	Heteropneustes fossilis	Small scale, sporadic
Synbranchiformes	*Mastacembelus armatus*	Breeding protocol developed
	Macrognathus aculeatus	Breeding protocol developed
Perciformes	*Anabas testudineus*	Breeding protocol developed
	Colisa fasciata	Breeding protocol developed

Recently there has been expanded development of cryogenic sperm banks (preservation of fish sperm in liquid N_2 at -196 ^oC) for fish in Europe and North America. These sperm banks are more cost effective than maintaining live gene banks which require wide space, maintenance and high costs. Cryogenic gene banking avoids the risk of genetic contamination and requires little space and minimal facilities.

Fish sperm cryopreservation assists conservation of fish biodiversity through gene banks of endangered species, and assists aquaculture by providing flexibility in spawning of females and selective breeding through synchronizing artificial reproduction, efficient utilization of semen, and maintaining the genetic variability of broodstocks (Lahnsteiner 2004). The technique also ensures preservation of genetic materials of the genetically superior wild fish populations and the gene transfer between wild and hatchery stocks (Tiersch *et al.* 1998).

The sperm cryopreservation protocol for different fish species seems variable and species-specific. Although fish are the main protein source in Bangladesh and other countries in the sub-continent, and the fish biodiversity and production from open water are declining, little attention has been paid to cryopreservation of fish sperm. In Bangladesh, research on fish sperm cryopreservtion was started in early 2004. The studies have focused on aquacultured or commercial species and so far none of the threatened species have been considered (Table 17).

Table 17. Cryopreservation of sperm of some fish species in Bangladesh

Fish group	Fish
Indigenous - cypriniform	*Catla catla*
	Cirrhinus mrigala
	Labeo rohita
	Labeo calbasu
	Puntius sarana
Indigenous - others	*Ompok bimaculatus*
	Mastacembelus armatus
	Channa striatus
	Rita rita
Exotic fishes	*Cyprinus carpio*
	Hypophthalmichthys molitrix
	Hypophthalmichthys nobilis
	Barbonymus gonionotus
	Oreochromis niloticus

Genetic stock conservation for wild and domesticated fishes is very important, as the genetic diversity of every species develops through a long evolutionary process over millions of years. Cryogenic techniques can assist in the conservation of biodiversity, to bring back the threatened species to natural environment with restocking programmes, as well as in improving aquaculture production. Cryogenic sperm banks for more fish need to be established as means of germplasm conservation in Bangladesh.

7. CONCLUSION

There is a crying need to adjust the existing laws and legislation of the country for integrated resource management to save the fisheries resources. Although much of the damage to the habitat and biodiversity of the inland water of Bangladesh over recent decades is likely to be irreversible, there is still time to act. From now on, Bangladesh government, the NGOs and national and international bodies should foster a social and technical environment in which the enormous richness of the fisheries resources can stabilize and eventually rebuild so as to continue to feed people of today and tomorrow. Poverty in fishing communities should be reduced in part by ensuring a stable supply of fish, something can only be achieved through improved knowledge, integration of fisheries and freshwater management, and greater public involvement. In case of fishing closure in areas or for certain time, the fishers should be provided with alternative income generating activities, credit with low interest and other sustainable means. Creating public awareness of the importance of maintenance of fish diversity in Bangladesh is extremely necessary and should be the first priority for a lasting change. Sustenance of fish diversity can only be achieved with public support. Bangladeshi fishers, fish farmers, traders, processors, and general people as a whole need - to understand the issues, to be involved in the formulation of management plans and to benefit from the whole process. A key step in building fisheries co-management and fish biodiversity

conservation with community participation is to bring all the various stakeholders in a common front with a view to sharing resource and knowledge, creating an environment for meaningful discussion on cross-cutting themes and valuing each other.

A renewable resource like fish, when under intense exploitation, needs a management regime as it is not inexhaustible. Therefore, management measures should be applied in such a way that young fish are protected to grow before capture and enough are left as breeding stock for future generations. The management measures should include – regulate fishing intensity at sustainable level, control gear selectivity, gear type and size of fish, closed season, prohibition of destructive fishing, closed fish sanctuary, and allocation of resources to different types of fisheries.

For sustainable and well-protected fish diversity for present and for future, the country should go for -

- Rational use of inorganic fertilizers and pesticides, and proper management of industrial effluents,
- Maintenance of minimum water depth (at least 1 m) during water extractions from critical waterbodies,
- Regulation of selective fishing gears, mesh sizes, and fishing by dewatering,
- Establishment of more fish sanctuaries and natural *beel* nurseries in strategic points,
- Stock enhancement programmes,
- Establishment of community-based organizations (CBO) among the fishers,
- Zero tolerance to new exotic fish introduction, and
- Strict application of existing fisheries rules and regulations.

This is the high time to care for the biodiversity of the most valuable Cypriniform and other indigenous fishes – the pride, heritage and livelihood of Bangladesh before they are lost forever. The researchers, policy makers, GOs and NGOs and national and international bodies should come forward to conserve the fish species using both *in situ* and *ex situ* approaches.

ACKNOWLEDGEMENTS

We wish to acknowledge the research fellows and students of the Laboratory of Fish Biodiversity and Conservation, Bangladesh Agricultural University for their sincere cooperation and assistance in preparing this manuscript. Thanks also are given to Dr. Andy P. Shinn, Institute of Aquaculture, University of Stirling, UK and Mr. Md. Nahiduzzaman, Professor Md. Samsul Alam and Professor A.K.M. Nowsad Alam, Bangladesh Agricultural University for improving the English, and helping to rewrite some portion of this manuscript.

REFERENCES

Abdullah, A. R., Bajet, C. M., Matin, M. A., Nhan, D. D. & Sulaiman, A. H. (1997). Ecotoxicology of pesticides in the tropical paddy field ecosystem. *Environmental Toxicological Chemistry, 16*, 59-70.

Ahmed, M. (1991). A model to determine benefits obtainable from the management of riverine fisheries of Bangladesh. *ICLARM Tech. Rep*, *28*, 133.

Ahmed, A. T. A. (1995). Impact of Other Sectoral Development on the Inland Capture Fisheries of Bangladesh. Proceeding of the Fourth Asian Fisheries Forum. *The Fourth Asian Fisheries Forum*. China Ocean Press. Beijing, China.

Ahmed, A. T. A. & Ali, M. L. (1996). Fisheries Resources Potential in Bangladesh and Manpower Development for Fisheries Activities. *In*: *Population Dimension of Fisheries Development and Management Policies of Bangladesh*. Dhaka, Bangladesh.

Ahmed, K. K. U., Ahamed, S. U., Hasan, K. R. & Mustafa, M. G. (2007). Option for formulating community based fish sanctuary and its management in beel ecosystem in Brahmanbaria. *Bangladesh J. Fish. (Special Issue)*, *30*, 1-10.

Ali, M. Y. (1997). Fish, water and people, Reflections on inland openwater fisheries resources in Bangladesh. *The University Press Limited*, Dhaka, 154.

Ali, M. L., Hossain, M. A. R. & Ahmed, M. (2009). Impact of Sanctuary on Fish Production and Biodiversity in Bangladesh. Final Project Report. *Bangladesh Fisheries Research Forum (BFRF)*, Dhaka, Bangladesh. 80.

Ameen, M. (1999). Development of guiding principles for the prevention of impacts of alien species. *Paper presented at a consultative workshop in advance of the 4th meeting of SBSTTA to the CBD*, organized by IUCN Bangladesh at Dhaka on 25 May 1999.

Azher, S. A., Dewan, S., Wahab, M. A., Habib, M. A. B. & Mustafa, M. G. (2007). Impacts of fish sanctuaries on production and biodiversity of fish and prawn in Dopi beel, Joanshahi haor, Kishoregonj. *Bangladesh J. Fish. (Special Issue), 30*, 23-36.

Aziz, M. A. (2005). Country Reports, Bangladesh. In the Proceedings of the Asia regional workshop on the implementation, monitoring and observance of the international code of conduct on the distribution and use of pesticides. *FAO Regional Office for Asia and the Pacific*, Bangkok, Thailand. 26-28 July 2005 RAP Publication - 2005/29. 258.

Banglapedia. (2004). National Encyclopedia of Bangladesh, Asiatic Society of Bangladesh, 1st edn. February 2004. Dhaka, Bangladesh. Available from URL: www.banglapedia.org.

Bernacsek, G. M. S., Nandi, S. & Paul, N. C. (1992). Draft Thematic Study: Fisheries in the North East Region of Bangladesh. North East Regional Water Managemenet Project (FAP-6). *Bangladesh Engineering and Technological Services*, Dhaka, Bangladesh, 122.

Bhuiyan, A. K. M. A. & Choudhury, S. N. (1997). Freshwater aquaculture: potentials, *constraints and management needs for sustainable development. National Workshop on Fisheries Development and Management in Bangladesh*. BOBP/REP/74. Madras, India. 77-113.

BWDB (Bangladesh Water Development Board). (2005). Bangladesher Nad Nadi, Pani biggyan, June 2005, *Bangladesh Water Development Board*, Dhaka. 621.

Coates, D. (1995). Inland capture fisheries enhancement: status, constraints and prospects for food security. *Report of the International Conference on the Sustainable Contribution of*

Fisheries to Food Security, 4-9 December, 1995. Kyoto, Japan. Government of Japan. Document # KC/ FI/95/TECH/3. 85.

DoF (Department of Fisheries) (2005). Matshya Pakkhya Saranika-2005. Department of Fisheries, Ministry of Fisheries and Livestock. *The Government of the Peoples Republic of Bangladesh*, Ramna, Dhaka. Bangladesh. 109.

DoF (Department of Fisheries). (2008). Matshya Pakkhya Saranika-2008. Department of Fisheries, Ministry of Fisheries and Livestock. *The Government of the Peoples Republic of Bangladesh*, Ramna, Dhaka. Bangladesh. 96.

Dudgeon, D. (2002). An inventory of riverine biodiversity in monsoonal Asia: present status and conservation challenges. *Water Science and Technology, 45*, 11-19.

ESCAP (Economic and Social Commission for Asia and the Pacific). (1998). Integrating Environmental Considerations into the Economic Decision Making Process.*ESCAP*, Bangkok, Thailand. www.unescap.org/drpad/pub3/integra/ modalities/ bangladesh /4bl02b01.htm.

FAP (Flood Action Plan)-6. (1992). Northeast Regional Water Management Project, Fisheries Specialist Study, Main Report (Volume-1), *Engineering and Planning Consultants Ltd*, CIDA. 67.

FAP (Flood Action Plan)-17. (1994). Fisheries Studies and Pilot Project- Final Report. ODA, UK. 185.

Felts, R. A., Rajts, F. & Akhteruzzaman, M. (1996). Small Indigenous Fish Species Culture in Bangladesh. Technical Brief, EC & DoF, *Integrated Food Assisted Development Project*, Gulshan, Dhaka, Bangladesh. 41.

FRSS-DoF. (2008). Fisheries Statistical Year Book 2006-07. Department of Fisheries, *Ministry of Fisheries and Livestock*, Bangladesh. 42 p.

Graaf, G. J., Born, A. F., Uddin, A. M. K. & Marttin, F. (2001). Floods, Fish and Fishermen. *Eight Years Experience with Floodplain Fisheries in Bangladesh*. The University Press Limited, Bangladesh. 174.

Graaf, G. J. (2003). The flood pulse and growth of floodplain fish in Bangladesh. *Fisheries Management Ecology, 10(4)*, 241-247.

Haldar, G. C., Ahmed, K. K., Alamgir, M., Akhter, J. N. & Rahman, M. K. (2002). Fish and fisheries of Kaptai Reservoir, Bangladesh. *In*: Management and Ecology of Lake and Reservoir Fisheries (ed. I.G. Cowx), 144-160. Blackwell Science Publishers, Oxford, UK.

Hoq, M. E. (2009). Fisheries Resources and Management Perspectives of a World Heritage Site- Sundarbans Mangrove, Bangladesh. In: Fisheries: Management, Economics and Perspectives (N. F. McManus, & D. S. Bellinghouse, Eds.)., *Published by Nova Science Publishers Inc*., New York, USA. (ISBN 978-1-60692-303-0). 199-227.

Hossain, M. (1988). Nature and Impact of the Green Revolution in Bangladesh. Research Report No. 67. *International Food Policy Research Institute*, Washington DC, USA. 146.

Hossain, G. M. & Nishat, A. (1989). Planning considerations for water resources development in the *haor* areas. *AIT-BUET Workshops on Development and Technology*, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh. 12.

Hossain, Z. & Halder, G. C. (1996). Impact of pesticide on environment and fisheries. In: Fisheries Fortnight publication: Technologies and management for fisheries development. (M. A. Mazid, Ed.), *Bangladesh Fisheries Research Institute*, Mymensingh, Bangladesh. 160.

Hossain, M. A. R., Nahiduzzaman, M., Sayeed, M. A., Azim, M. E., Wahab, M. A. & Olin, P. G. (2009). The Chalan beel in Bangladesh: habitat and biodiversity degradation, and implications for future management. *Lakes & Reservoirs: Research and Management, 14*, 3-19.

Iqbal, I. (2006). The railway in colonial India: Between ideas and impacts. *In*: Our Indian Railway: Themes in Indian Railway History. (R., Srinivasan, M. Tiwari, & S. Silas, Eds.), 173-186. *Foundation Books Pvt. Ltd*., Darayganj, New Delhi, India

IUCN Bangladesh. (2000). Red Book of Threatened Fishes of Bangladesh. *IUCN- The World Conservation Union*. 116.

Junk, W. B., Bayley, P. B. & Sparks, R. E. (1989). The flood pulse in river floodplain systems. *In*: Proc. International Large River Symposium (D. P. Dodge, ed.). *Canadian Special Publication Fisheries Aquatic Sciences*, 106, 110-127.

Khan, M. A., Srivastava, K. P., Dwivedi, R. K., Singh, D. N. Tyagi, R. K & Mehrotra, S. N. (1990). Significance of ecological parameters in fisheries management of a newly impounded reservoir-Bachhara reservoir. In: Contribution to the Fisheries of Inland Open Water Systems in India (Part I) (eds. A.G. Jhingran, V.K. Unnithan and A. Gosh). IFSI, *Barrackpore*, India. 100-108.

Lahnsteiner, F. (2004). Cryopreservation of semen of the Salmonidae with special reference to large-scale fertilization. *Methods in Molecular Biology*, *253*, 1-12.

Mazid, M. A. (2002). Development of Fisheries in Bangladesh: Plans and strategies for income generation and poverty alleviation. *Nasima Mazid Publications*, Dhaka, Bangladesh. *176*.

NERP. (1995). Northeast Regional Water Management Project; Wetland Resources Specialist Study, Northeast Regional Water Management Plan, Bangladesh Flood Action Plan 6 (IEE NERP FAP 6). Flood Plan Coordination Organisation, Water Development Board, *Government of the People's Republic of Bangladesh*, Bangladesh.

Parveen, S. & Faisal, M. I. (2002). Open Water Fisheries in Bangladesh: A critical Review. *Environmental Studies*, North South University, Dhaka, Bangladesh. 20.

Pingali, P. L. & Gerpacio, R. V. (1997). Living with reduced insecticide use for tropical rice in Asia. *Food policy, 22*, 107-118.

Pullin, R. S. V., Eknath, A. E., Gjedrem, T., Tayamen, M., Julie, M. & Tereso, A. (1991). The genetic improvement of farmed tilapias (GIFT) Project. *Naga, the ICLARM Quarterly, 14(2)*, 210-315.

Rahman, M. M. (2004). Uses of persistent organic pollutants (POPs) in Bangladesh. Paper presented at the Inception Workshop of the Project Bangladesh: Preparation of POPs National Implementation Plan under Stockholm Convention (POP NIP), Department of Environment, *held at Hotel Sonargaon*, Bangladesh.

Rahman, A. K. A. (2005). Freshwater Fishes of Bangladesh. Second edition, *Zoological Society of Bangladesh*, Dhaka, Bangladesh. 394.

Rohar, J. R. & Crumrine, P. W. (2005). Effects of an herbicide and an insecticide on pond community structure and processes. *Ecological Applications, 15(4)*, 1135-1147.

Saha, S. B., Bhagat, M. J. & Pathak, V. (1990). Ecological changes and its impact on fish yield of Kulia *beel* in Ganga Basin. *J. Inland Fish. Soc. India, 22(1-2)*, 7-11.

Sugunan, V. V. & Bhattacharjya, B. K. (2000). Ecology and fisheries of *beels* in Assam. Central Inland Capture Fisheries Research Institute. Bull. No. 104. *Barrackpore*, India. *65*.

Talwar, P. K. & Jhingran, A. G. (1991). *Inland Fishes of India and Adjacent Countries*. Oxford & IBH Publishing Co., Calcutta, *1158*.

Tiersch, T. R., Figiel, C. R., Wayman, W. R., Williamson, J. H., Carmivhael, G. J. & Gorman, O. T. (1998). Cryopreservation of sperm of the endangered razorback sucker. *Transactions of the American Fisheries Society*, *127*, 95-104.

Tsai, C. & Ali, L. (1987). The Changes in Fish Community and Major Carp Population in Beels in the Sylhet-Mymensingh Basin, Bangladesh. *Indian Journal of Fisheries*, *34(1)*, 78-88.

Weis, J. S., Smith G., Zhou T., Santiago-Bass, C. & Weis, P. (2001). Effects of contaminants on behavior: biochemical mechanisms and ecological consequences. *Bioscience*, *51*, 209-217.