CHAPTER – I

General Introduction

The mighty river Brahmaputra in north-east India with its large numbers of perennial tributaries, numerous hill streams and connected beels affords lucrative aspects of fishery of various freshwater Ichthyo-species. Very little information is available at present regarding the magnitude and behaviour of the fish population and fisheries of this river system (Kottelat, 1989). In Assam, where fish is one of the important dietary components of the population, the necessity for the proper development and judicious exploitation of the fishery resources of the state definitely need detailed investigation.

Assam, one of the largest of the eight states of the north-east of India nestles between the Eastern Himalayan foot-hills and the Patkai (Fig-3.B) range (24°0"N Latitude and 89°45'0"-96°0.0" E Longitude). It occupies a triangular area of roughly 79,000 Km² divisible into two main regions the Brahmaputra valley (56,339 Km² ) and Barak valley; 6962 Km² (Mahanta et al., 1998). The Brahmaputra valley is bisected by the river Brahmaputra and major tributaries (a total of 4500 km) criss-crossing the length and breadth of the state (Fig-3.C), the flood plain wetlands locally called ‘beels’ constitute the vast and various fisheries, where 1392 enlisted beels cover an area of 1 lakh hectares conspicuously occupy the landmass and contribute about 93% of the total fish prone water areas excluding rivers and tributaries and about 81% of the total lentic area (Day, 1878) in the state. The northeastern part of India is considered as one of the hot spots of freshwater fish biodiversity in the world (Kottelat and Whitten, 1996). All the
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northeastern states viz. Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura have a wide variety of ichthyspecies of fishes in terms of many rivers, streams, floodplain wetlands, lakes, ponds etc. The diversity is attributed to various factors viz. the geomorphology, consisting of the hills, plateaus and valleys, resulting in the occurrence of a variety of torrential hill streams, rivers, lakes and swamps, drainage pattern which include the Ganga-Brahmaputra, Koladyne and Chindwin-Irrawady systems, the distinct entity in the tectonic setting in the South-east Asia resulting by collision of Indian, Chinese and Burmese plates, and the formation of the mighty Himalayas and Indo-Burman range (Kottelat, 1989). The lucrative field for ichthyological studies that is being provided to this region has attracted many workers from earlier times till date. A survey on the ichthyofauna of this region has been carried out by many workers of the last century. De (1910) recorded 154 species of fishes from eastern Bengal and Assam. Subsequently different workers had undertaken number of studies and reported the presence of a diversified fish fauna in the region. A perusal of literature reveals that a great deal of scattered informations are available from their studies.


The North East region shares its fish fauna predominantly with that of the Indo-Gangetic fauna and to a small extent with the Burmese and South China fish fauna (Yadav and Chandra, 1994). Sen (1985) and Mahanta et al., (1998) recorded altogether 187 fish species from Assam and the neighbouring North Eastern states of India. Compilation of Yadav and Chandra (1994) listed a total of 129 species. Sinha (1994) in his comprehensive review gave a list of 230 fishes as available from North Eastern region. Recently, Nath and Dey (1989) recorded a total of 131 species from the drainages of Arunachal Pradesh. Sen (2000) has indicated that more number of species has been reported from North East India. The various reports show a wide variation in the total number of species reported. In the present communication 186 potential food, sports and aquarium fish species belonging to 27 families under 84 genera, have been presented along with state wise distribution, abundance along with potential fisheries. While the list of 267 fish species given by Sen (2000) includes all indigenous and exotic species found in North East India.

Assam, one of the significant components of the north-east states, comprises about 30% of the region’s land area covering twenty seven districts. Located at the gateway of the northeast India, Assam is a land of myths and mysteries. “The land of Red Rivers and Blue Hills”, as it is described, has a unique landscape with sprawling tea gardens and unending stretches of paddy fields interspersed with groves of coconut, areca nuts and banana trees. Assam can be divided into three distinct physical units: the Brahmaputra valley in the north, the Barak valley in the narrow protruding south, and the state’s hilly region separating the two valleys.
The mighty Brahmaputra, the seventh largest river system in the world and aptly termed a moving ocean, is not only the greatest drainage system of Assam but also covers directly or indirectly as tributaries all the adjoining northeastern states. The Brahmaputra runs through the state of Arunachal Pradesh, which has only recently been opened for tourism. This mighty river is one of the world's largest, on a scale with the Indus, Mississippi, and the Nile. It runs through dense forests and tribal settlements. The Brahmaputra (2900 km in total length) has its source at holy Mount Kailash Mansarover in Tibet, traverses the entire Tibetan plateau, and then makes its great bend into India, running a total length of 1625 km. in Tibet, cutting into the Himalaya the deepest gorge in the world, a canyon which has as yet eluded all attempts at exploration. It enters India near Tuting in Arunachal Pradesh, united with Dibang and Lohit near Sadiya, emerges on to the plain by taking the name Brahmaputra. Bisecting the Brahmaputra valley, the river flow for a distance of nearly 724 km. in Assam and 918 km. in India turning south and finally enters Bangladesh as river Padma running a total length of 354 km. In Bangladesh, the Brahmaputra splits into two branches: the much larger branch continues due south as the Jamuna (Jomuna) and flows into the Lower Ganges, or Padma (Pôdda), while the older branch curves southeast as the lower Brahmaputra (Bromhoputro) and flows into the Meghna. Both paths eventually reconverge near Chandpur, Bangladesh and flow out into the Bay of Bengal. Fed by the waters of the Ganges and the Brahmaputra, this river system forms the largest river delta in the world. It is navigable for most of its length. The lower reaches are sacred to Hindus. The river is prone to catastrophic flooding in spring when the Himalayan snows melt. It is one of the few rivers in the world that exhibit a tidal bore. Most Indian and Bangladeshi rivers bear the name of a female, but this one has a rare male name, as putra means "son" in Sanskrit. (Internet, Wikipodia).
The river Brahmaputra, along with 47 major tributaries covers a total length of c.4000km, catchments of c.580000 sq. km and an average annual water carriage of 510450 million cubic meter (Rao, 1979). The river is characterized by multiple flood cycles and pronounced seasonal variability in discharge. The river and its tributaries maintain unstable courses in the plains with constant movement of their channels. Heavy rains, topography and frequent earthquakes have made the rivers capricious and destructive. The adverse features have resulted in the formation of flood plains lakes, a vital resource in the Brahmaputra valley (Anon, 2000). Some of the important tributaries of Brahmaputra are- Gangadhar, Gadadhar, Saralbhanga, Champabati, Manas, Buki, Pagladia, Puthimari, Dhansiri, Jiabharali, Sobansiri and Burio. etc. in the north bank and Zingiram, Dudhnoi, Krishnai, Kulsi, Kalang, Dhansiri, Dikho and Disang. etc. on the south bank. The northern bank tributaries receive snowmelt water, which results in different temperature regimes, water velocity and consequent zonations (e.g. Loach or head, rapid clear and rapid turbid water zones). However, such distinct zonations could not be observed in the southern bank of Brahmaputra. Further, the northern tributaries are large with steep, shallow, braided channels carrying high silt discharge (average 6667 m$^3$ km$^{-2}$), whereas, those on the southern bank are deeper with meandering channels, low gradient and lesser silt load (66.7 to 95.7 m$^3$ km$^{-2}$) (Yadava and Chandra, 1994). In Assam total riverine length covers 4820 km, flood plain wetlands (beels) and swamps 1.12 lakh ha, ponds and tanks 0.23 lakh ha, and low lying paddy field etc. covers 33.45 lakh hectors.

Assam, thus, with its unique topography, diverse physiographic features and varied watershed pattern is a lucrative field for ichthyological studies. With snow fed Himalayan rivers and widespread wetlands, the state is enriched with fish species of both hill streams and plains. The climatic condition of the state falls under three categories, i.e. tropical, sub-tropical and temperature. Most of the rivers are flow through the plains where the current is slow expecting during
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monsoon season and the beds are sandy and muddy. In the hill streams, the water flows over rocks and boulder beds either through steep gradients in deep and narrow channels or through broad and shallow environments. In the rainy season, such streams take a torrential course while in dry months, many of them have a reduced flow or may even dry up. It is in this rigorous environment that the evolution of new forms with adaptive modifications takes place. Geological upheavals of the past have resulted in the mixing up of drainage and their fish fauna in the entire northeastern region. This admixture has rendered the Assam Himalayas very important from the faunistic point of view (Menon, 1974). The fauna of the region corresponds predominantly with that of Indo-Gangetic fauna and to a small extent Indo-Malayan fauna. Assam's rich fish biodiversity has attracted many workers to this region.

An account of the state's fish fauna was carried out by many authors at different times viz. De (1910), Chaudhury and Yadav (1986), Hora (1920, 1921b, 1941), Hora and Mukherjee (1953) etc. Shaw and Shebbeare (1937) accounted a compact collection of fishes from northern Bengal. It was revealed that they might have covered some parts of Assam, if not all, regarding their collecting localities. Further, records about the exploitation on the fish fauna of Assam can be obtained from the works of Menon. (1952), Sehgal (1959) etc. Motwani et al., (1962) had carried out an organized survey on the fish and fisheries of Brahmaputra river system. Sen (1985) had made a comprehensive survey on the fish fauna of Assam and neighboring north-east states. He recorded 187 species from the survey. Sinha (1994) has mentioned the occurrence of 185 species belonging to 98 genera under 34 families. Yadava and Chandra (1994) stated that 33 representatives of ichthyofauna are endemic to the region. Recently Goswami et al., (2007) has reported to record 288 species under 37 families and 10 orders from north-east India.
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Of the approximately 806 species inhabiting freshwater of India (Talwar and Jhingran, 1991), northeastern India is represented by 267 species (recorded and reported) belonging to 114 genera under 38 families and 10 orders (Sen 2000). Located between 21.57° to 29.3° north latitude and 84.46° to 97.3° east longitude covering elevation from c. 200 to 900 m. from the sea level, the N.E. region's fish fauna is approximately 33.13% with that of total Indian freshwater fishes. The region has 19,150 km of rivers, 23,972 ha. of reservoirs, 1,43,740 ha of lakes, 40,809 ha of ponds and 2,780 ha of rice-cum-fish culture area. The rich ichthyological diversity has made this hill dominated region of India as one of the hot spots for the freshwater fishes inviting global attraction.

Hilsa (*Tenualosa ilisha*) any of the members of the genus Hilsa of the family Clupeidae, order Clupeiformes. Locally known as *Ilish*, the fish has been designated as the national fish of Bangladesh. The body is strongly compressed and moderately deep with dorsal and ventral profile equally convex. The upper jaw has a distinct median notch. Regularly arranged medium-sized scales cover the metallic silver-coloured body. Body length may reach up to 60 cm, but commonly found specimens measure 35 to 40 cm. A large-sized Hilsa weighs about 2.5 kg. Females grow faster, and are usually larger than males. The Hilsa is known to be a fast swimmer, and attains maturity in one to two years (Talwar and Jhingran, 1991).

Hilsa has a wide range of distribution and occurs in marine, estuarine and riverine environments. The fish is found in the Persian Gulf, Red Sea, Arabian Sea, Bay of Bengal, Vietnam Sea and China Sea. The riverine habitat covers the Satil Arab, and the Tigris and Euphrates of Iran and Iraq, the Indus of Pakistan, the rivers of Eastern and Western India, the Irrawaddy of Myanmar, and the Padma, Jamuna, Meghna, Karnafully and other coastal rivers of Bangladesh. (Pillay and Rosa, 1963).
The fish is anadromous, with a life cycle that follows the general pattern of breeding upstream in fresh water and the larvae hatching from the free-floating eggs. The immature young stages grow in river channels and then descend to the sea for a period of feeding and growth before returning to the rivers as mature breeding adults to complete the cycle. The Hilsa is a highly fecund fish. A large-sized female may produce up to 2 million eggs De (1980). Although Hilsa spawn more or less throughout the year, they have a minor spawning season during February-March and a major season in September-October. Immature Hilsa fish (6-10 cm), known as Jatka, are extensively caught during their seaward migration in some of the major rivers of the country (Jones and Menon, 1951).

Hilsa is primarily a plankton feeder and its food includes blue-green algae, diatoms, desmids, copepods, cladocera, rotifers, etc. The feeding habit may vary according to the season and age of the fish (Hora, 1938 & 1940; Jones and Sujansingani, 1951).

The fish is exploited by intensive fishery for the mature migrating adults in the estuaries and river channels, and to a lesser extent by the capture of the Jatka in the river. Nearly 16.4% of the country's total fish production is contributed by this fishery. In terms of production and quantity exported, Hilsa has played a significant role in the economy of Bangladesh in recent years. An amount of Tk 1,34,79 million was earned by the fish and fisheries commodities in 1996-97, with Hilsa alone contributing about Tk 4,88 million. It is estimated that about 2 million fishermen and traders are engaged in Hilsa fishing in the country.

Scientific interest in the fish and its exploitation became evident in the late 1940s when attempts were made to define the major biological parameters of the species. Little attention, however, was paid to the fisheries. The shortage of information necessary for fisheries evaluation and management and lack of any
programme of fisheries investigation led to the establishment of the Hilsa Fisheries Investigation and Management Unit to provide necessary information for optimum utilization of this important national resource.

Until about 1972 the Hilsa fishery was restricted to the upstream rivers, mainly in the rivers Padma, Meghna, Karatoya, Rupsa, Shibsa and Payra. At present, the fishery has severely declined in the upstream areas and is mainly concentrated in the downstream rivers, estuaries, coastal areas and the sea. Since the construction of the Farakka Barrage in India to divert water from the Ganges, the fish are being caught in the coastal and estuarine waters before they can migrate upstream for spawning. Local fishermen catch migrating adults from May to October, and the juveniles from February to May. During the dry winter months from October to February, Hilsa are also caught by the coastal fishermen. The adult Hilsa are caught using fixed or drifting gillnets (*chandi jal*) and lesser quantities are caught in *ber jal* and lift nets (*Clap net*). In the river these fishing units usually consist of non-mechanized single or two-boat teams, whilst at sea the fishing is done with mechanized 10-13m boats or trawlers. A system of collector boats, wholesale markets and transporter-traders supplies the inland markets with this prized fish.

During 1980s Hilsa production was fairly stable. In recent years, however, the production has shown a downward trend, particularly in the inland fishery. In 1999 the production was significantly low and in 2000 the fishery continued to decline steeply.

Water resources development activities such as the Flood Control Drainage (FCD), and Flood Control Drainage and Irrigation (FCDI) projects have also adversely affected the aquatic ecosystem and Hilsa fishery. The Chandpur Irrigation and Flood Control Project and the Meghna-Dhanagoda Irrigation and Flood Control Project have also exerted similar negative effects on the Hilsa fishery through destruction of nursery grounds of the juvenile Hilsa. Jatka the
local name for the young or juvenile stage of Hilsa. Migrating adult females release eggs upstream in major rivers, including the Padma, Jamuna and Meghna. After hatching from free-floating eggs, the larvae remain in their nursery grounds for some time where they feed and grow. In about six to ten weeks they grow to about 12-20 cm and become known as jatka. At this stage they start descending to the sea for further growth and maturity.

The determination of the precise mathematical relationship between length and weight of fish can be formulated in an equation through which one measure can be converted into. The equation has biological significance because it represents isomeric growth i.e. the weight increase as the cube of the length. Empirical observations, however, strictly do not always conform to the cube law and equilibrium constant shows certain variability around 3. Since the weight of a fish is usually closely proportionate to the cube of its length. The weight of a fish is supposed to vary with the cube of its length. Hence, any derivation from the above relationship may be attributed to physiological changes in the fish.

In successful management of a particular fishery it is of utmost importance to determined how long its takes a fish to attain a certain length of weight. At what age the fish attain sexual maturity or breeding age along with the age that will give to a catchable size are also important issues to be considered. Age and growth are always regulated through various factors such as food, feeding habit, environmental factors and the physiological conditions, etc. A knowledge of age and growth of fish is ‘Sine qua non’ for the development and conservation of fishery. The commercial catches of adult Hilsa in the river systems of India are reported to be composed of age groups 1+ to 5+ years, the dominant age classes being the 2+ and 3+ year groups. The monsoon fisheries are contributed mainly by the larger sized fish, the small sized groups forming the fishery during the winter months. This general pattern has been found to hold good in the Hooghly, Padma, Ganga and Godavari where there are distinct monsoon and winter
fisheries for the species (Pillay and Rosa, 1963). Pillay (1957a) attributed the success of the fishery in 1954 and 1955 to the contributions made by the 3+ and 4+ year old classes, which he traced to successful spawning in the monsoon of 1950.

Fecundity is a valuable population parameter because it provides some insight into a population's reproductive potential. Fecundity is a measured on individual fish but it is typically expressed as a function of body length and data for the entire population plotted. The curve or equation that results can be used predict fecundities from lengths. Potential egg production of a fish population can be estimated from knowledge of fecundity, a population's age structure and sex ratio and population abundance. Spawning is generally highly synchronized with water temperature and photoperiod. Fecundity, According to Bagenal (1967), it is the number of eggs found in the female just prior to the spawning.

Ammonia is the chief nitrogenous excretory product of teleost and is released mainly from the gills. Under some circumstances, however significant amount of urea may be produced. Other nitrogenous substances such as amino acids, uric acid, and creatine may be excreted, but are almost always in extremely small quantities. A detailed analysis of Love (1980) shows that about 85% of species are carnivores, 6% herbivores, 4% omnivores, 3% detrivores and 2% scavengers and parasites. Herbivores are undoubtedly the most important species of food fish in the world for aquaculture, yet they have received far less attention in the physiological studies than the carnivores. Hickling (1940) reported that herbivores are characterized by generally low digestibility of their plant food (60-70%).

The importance of fish oil is associated with a series of physiological factors of human nutrition. After the discovery of the Polyunsaturated fatty acids containing omega-3 fatty acids from fish, a survey on the fatty acids profiles of fish has
become necessary in understanding the nutritional and biochemical status high food value. In the present experiments it has been discussed that Hilsa being as anadromous migratory species travels more than 500 km. on its way from the estuary of the Bay of Bengal to the Brahmaputra river system (total km. from estuary to Guwahati 670 km.). Further, it has been seen that the fish does not consume any food items and this time, which results in loss of weight (chapter-Nitrogen-N and Urea-N metabolism). The basic question related to the energy metabolism that the fish spends a high and significant amount lipids reserve or fatty acids. The fish require a high energy to swim such a great distance from the estuary. The energy is metabolized from the proteins and lipids, where breakdown of protein ultimately affects the amino acids. In lipids the different fatty acids will spend their content, thus participating the energy supply to the fish during migrations.

Several workers have studied the fatty acids profiles of both freshwater and marine fish. (Gopakumar, 1997; Nair and Mathew, 2000; Mukhopadyay and Ghosh, 2003; Ackman, 1967 & 1973; Reginal et al., 1995; Tocher and Sargent, 1984; Vazquez et al., 1994; Watanabe, 1982; Majumder et al., 2004; Majumder, and Basu, 2004; Juan et al., 1998 and El-Faer et al., 1992). Gopakumar (1957) and his collaborators have reviewed the fatty acids profile of several commercially important species. In the present studies an attempt has been made to study the fatty acids profiles of the fish, taking samples from Bay of Bengal, which is regarded as the base line. Further samples were collected from the Guwahati and their fatty acids profile was estimated.

Gopakumar (1957) reported the biochemical composition with reference to % of moisture, protein, fat and ash along with the amino acids and fatty acids profile. The protein content varies from 16-21%, while fat 10-12%. A thorough investigation on the energy metabolism with the protein and lipid turnover during
the migration is extremely essential which would provide the utilization and energy budget of the fish during migration.

In India, Hilsa distribution has been recorded from the Narmada and Tapti Rivers and from the Vembanad backwaters of western India. In the eastern region Hilsa is distributed in the Cauvery, Krishna, Godavari, Mahanadi, Hooghly, and Ganga Rivers (Chonder, 1999). In 1873, Day described two classes of Hilsa from the rivers, a) one-year-old Hilsa appearing not to breed and, b) those breeding at the start and during the monsoon. Jenkins (1938) raised the question whether two or more Hilsa races or varieties exist with different spawning grounds. Mojumdar (1939) recognized three ecotypes of Hilsa: from saline water of the sea, muddy freshwater and clear freshwater. Pillay et al., (1963) differentiated three stocks of Hilsa using biometrical studies. Based on morphological characteristics, Ghosh et al., (1968) and Quddus et al., (1984) differentiated Hilsa into slender and broad morphotypes. Pillay et al., (1963) concluded that the Hilsa populations of the Hooghly, Padma and Ganga show little or no movement between the rivers, with little intermingling of populations. Dahle et al., (1998) used random amplified polymorphic DNA (RAPD) and discriminated between three different populations of Hilsa. Similarly, Shifat et al., (2003) used RAPD to differentiate the Padma and Meghna River Hilsa populations into two genetically different stocks or races.

The natural habitat of Hilsa is located in the high seas and the high percentage of catch in the coastal waters in the post-monsoon period is due to the rich grazing ground of that area, Naidu (1939). Jones and Menon (1950) have remarked that this species ascends the estuaries for breeding during the monsoon, and has been observed as far as Delhi (Pillay 1955). Hilsa therefore has the capacity to withstand variable salinity conditions, especially low salinity. According to Mitra and Dersundaram (1954), Hilsa has a preference for low salinity. It is possible that the temperature tolerance and other factors connected with the spawning of
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Hilsa may be the pointer to thin congregation in inshore waters. Malhotra et al., (1970) report that, under laboratory conditions, the hatching of Hilsa varies between 5 to 8% where the surface temperature ranged between 26.5 C to 30 C with a pH value of 8.2 to 8.3. The secondary rise in the catch of this species corresponds to the spawning migration, which is coupled with the slow rise in temperature in the post-winter days.

AIMS AND OBJECTIVES

The present investigations aim to examine the following aspects regarding the Hilsa of the Brahmaputra river system. The aims and objectives are as :-

- to examine the taxonomic status, distribution, morphometrics and habitat of the Hilsa, *Tenualosa ilisha*.
- to examine the ecology and physico-chemical characteristics of the Brahmaputra river and its tributaries.
- to evaluate the food and feeding habits of the Hilsa.
- to examine the Length-Weight relationship of the Hilsa.
- to determine the age and growth of Hilsa.
- to examine the Random Amplification of Polymorphic DNA (RAPD) analysis of Hilsa to see the genetic trend of the species.
- to estimate the fecundity of Hilsa in Brahmaputra river system.
- to study on the migration and distribution of Hilsa.
- To examine the biochemical and physiological changes with reference to amino acids profile, ammonia excretion and fatty acid profile during migration.
- to observe the fisheries of Hilsa in Brahmaputra river system.