CHAPTER - XIII

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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 range (24°0' 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 the Barak valley (6962 Km²), Mahanta et al., 1998. The Brahmaputra valley is bisected by the river Brahmaputra and its major tributaries (a total of 4500 km) criss-crossing the length and breadth of the state, 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.

All the northeastern states have a wide variety of ichthyospecies inhabiting 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. 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 (2001) includes all indigenous and exotic species found in North East India. Many more species could be distributed in the drainage of the north east. Of the approximately 806 species inhabiting freshwater of India (Talwar and Jhingran, 1991), northeastern India is represented by 288 species (recorded and reported) under 37 families and 10 orders (Goswami et al., 2007).
The genus *Tenualosa* (Fowler, 1934) belongs to the family Clupeidae. Although various synonyms and other taxonomic status were given from the time of Day (1758) being as states as *Clupea ilisha*, the present findings as well as the review of various workers established that *Tenualosa ilisha* or *Clupea ilisha* are the same species found in the present investigation. Talwar and Jhingran (1992) reported that there are 6 species of *Tenualosa*, that are found outside the Indian region, but only 3 species are found in inland water of Indian sub-continent. Out of 3 species only *Tenualosa ilisha* is found in Brahmaputra river system. Dey (2002) has reported the presence of Hilsa from Brahmaputra and Barak river system.

Hilsa, is uniformly distributed world wide including N.E. India: Assam, Tripura. Rest of India: Ganga, Cauvery, Godavari, Krishna, Narmada, Pennar, Tapi, Yamuna river. Other parts: Bangladesh, Pakistan, Sri Lanka, Myanmar, Burma and the Arabian Gulf area. Hilsa is marine, eurohaline, anadromous, ascending rivers for breeding purposes. It breeds mainly in rivers, river beds and shallow water. The body of Hilsa is fusiform, deep and compressed, body depth 3.1 to 3.7 times in standard length, weakly developed lines on top of the head with a terminal mouth. Gillrakers are fine and numerous, about 100 to 250 on lower part of the first arch. Gill rakers on inner arches are straight, not curled. Scales of Hilsa are moderate, regularly arranged. Teeth are small or absent, branchistegal rays 5-10 and attain 58 cm total length and 2.49 kg for females and 43 cm and 2.68 kg for males (Talwar and Jhingrang, 1991).

From morphometric studies is reported that there are variations of the fin rays of anal, pectoral and caudal fins. Apart from that there is no such marked difference in other parameters of the body parts. Al-Abaychi in 1973, compared the Basrah population with that of Pakistan (Arabian Sea) and found that there is a significant difference between the two populations (Al-Hassan 1982).
The Brahmaputra river system has its origin in the Himalayas and like other snow fed rivers, this river system is also perennial. Heavy rains in the Himalayas and its foot hills during monsoon periods cause the water level to rise and flood the neighboring areas (Michael, 1975). The climatic conditions in the surrounding areas of Brahmaputra may be classified as – pre-monsoon, monsoon, post-monsoon and winter. The tributaries of the Brahmaputra river system in the higher gradient have 'V' shaped valley, clear water, rapid flow with rocky to gravelly bottom. The rivers carries a heavy amount of fine particles of sand while the water of the stream is derived from the fallen rain as well as melting snow. Admittedly, a direct relationship between the temperature of air and water, as a general norm, is discernible in the river system when water temperature follows air temperature fairly closely. The water temperature is highest in monsoon and lowest in winter. The ecological factor has a direct relation with the growth of planktons and dissolved oxygen.

A significantly difference of dissolved oxygen was found in the sample means of upper and lower reaches during the period of investigation. In tributaries also significant difference was found in the sample means of the north and south bank tributaries. For carbon-dioxide, no significant difference was observed in the sample means of upper and lower reaches in each of the three years of the investigation. In the tributaries also no significant difference was observed in the sample means of north and south bank tributaries in each of the three years of investigation. Regarding alkalinity no significant difference was observed between physico chemical parameters of upper and lower reaches in each of the three years of investigations. In case of tributaries, significant difference was found in the sample means of north and south bank tributaries. Significant difference in hardness was found in the sample means of upper and lower reaches. In case of pH and temperature significant difference was found in the sample means of upper and lower reaches and in tributaries, significant difference was found. Regarding velocity and depth, no significant difference was found in sample means of upper
and lower reaches during three years investigation. In case of tributaries significant
difference was found in the sample means of north and south bank tributaries.

Regarding the food and feeding habits of Hilsa, during the early and post-larval
stage, Hilsa are planktophagus and mainly subsist on crustaceans and algae. The
juveniles of Hilsa also prefer crustaceans besides consuming plant matter and
insects. During August the amount of preponderance were highest (80.92%) compared to the April (15.65%) which was recorded as the lowest amount of
preponderance. Zooplankton was the main food of the juvenile Hilsa (index of
preponderance) average of 53.29%. Copepods and rotifers were represented the
chief food materials in that size range of Hilsa. Phytoplankton specially Algae and
Diatoms were recognized the chief food item constituting 45.50% of the total food
materials in the adult mature Hilsa. Blue-green algae specially Spirogyra, Eudormia
and Pediatrum were encountered in the pre-spawning periods. Diatom encountered
predominant in the post-spawning months. Copepods specially Cyclops were the
chief food materials preferred by smaller sized ilisha. Rotifers specially Keratella
and Monostyla were encountered in the pre-spawning periods. Insects comprises of
protozoan larvae were encountered in the post-spawning periods. Sand granules are
found more or less in all seasons. In breeding seasons most of the stomach were
empty whereas in winter migration it also seen that a greater number of stomach
were found to be empty or very little food in their stomach. It is reported that the
fish do not consume food or little amount of food while in migration.

Hilsa is essentially a plankton feeder and does not show any selectivity in feeding
with its closely-set sieve-like gillrakers. Generally, the items which are
preponderant are crustaceans (particularly copepods), diatoms, green and blue
algae; organic detritus, mud and sand have also been recorded. Pillay and Rosa,
(1963), have further observed that the stomach of spawning Hilsa contains
considerable quantities of mud and sand, showing that they feed at the bottom and
that the intensity of feeding during the post-spawning period appears to be very
high. Pillay and Rosa, 1963) noted that both young and adult Hilsa feed at the bottom in the Godavari. Marked variations in the intensity of feeding were recorded by Halder (1968). He later observed that the fish feed at all depths and that in the juveniles up to 120 mm, crustaceans dominated, and in the size range 120-160 mm diatoms dominated, but the situation was the reverse in the 180-200 mm group (Halder, 1971). Quereshi (1968) was of the opinion that in Bangladesh waters, the fish appears to feed only in the sea and they stops feeding while ascending the rivers. Hynes (1950) has generalized that any of the more common methods of gut content analysis and has found that Hilsa to eats a large number of small organisms in addition to larger ones. In this condition the analysis of the diet in both volume and occurrence gives a better indication of the relative nutritive importance of the different organisms in the diet than either the occurrence or volume method. De (1986) has pointed out that the empty stomachs in fishes during winter, probably were traceable to irregular due to lowered metabolic rates. Labour (1921) has also indicated that the empty tracts in summer, probably reflected the low water level and low density of available food organisms. During the present investigation, the catfish were observed to have empty stomachs and stomachs with ¼ full to ½ full food in the summer and winter months respectively.

The relatively high rate of feeding intensity during the pre-monsoon months may be due to extra energy required for building up of the gonads. The second phase of intensive feeding occurs after the spawning season which is probably utilized for the recovery of fish from spawning and for building up winter reserves (Thakur, 1977).

The Hilsa shows an isometric pattern of growth in the Brahmaputra river system. The weight of the fish shows a proportionate increase to the cube of its length. The exponential value observed clearly indicate that the fish is neither heavier nor lighter than its length in its natural habitat of Assam. The exponent value of the present studies does not significantly differ from the value observed by Choudhury
et al., (1990). Under such an observation it can be concluded that the hydrobiological condition of the Brahmaputra river is more suitable for the growth of the Hilsa fishes. The values of ‘n’ based on regression between length-weight indicated from different stations of the Brahmaputra river system showed the occurrence of four distinct categories. During the course of the study, it has been seen that four distinct categories of Hilsa occur in the Brahmaputra river system, as also confirmed from the biometrical and morphometrical study. From the present length-weight relationship studies it is confirmed that the Hilsa population is heterogenous. Different categories of Hilsa are found in the water bodies from different fish collecting stations. There may be introduction of different stocks at different times. From the RAPD analysis it has been found that Hilsa collected from different stations showed polymorphism, this revealing that the Hilsa collected from the different stations differ significantly in their genetic strains.

The low value of ‘K_n’ in size range may be associated with the first spawning in the life of fish. Further, rise and fall in ‘K_n’ values is cyclic in nature which may be as a result in of repeated recovery and spawning during the life of fish. As evident from maturation studies Hilsa has spawning maxima (April-July) which falls at the end of every year of life.

The seasonal variations in the relative condition indicate an increase from March reaching the peak during June. This may be due to development of gonads. Spawning might have resulted in a fall in the relative condition of fish during July. High values during winter may be again due to development of gonads. In Brahmaputra, fish appeared to lose the condition factor suddenly after each peak and gradually recovered leading to another peak. Such cyclical nature of increase and decrease in relative condition appears to be depend on sexual maturity. Pantulu (1961) has opined that the number of peaks and through in the relative condition of M. gulio may be well an index of the number of spawning during the life cycle of a fish. This may be true for the Brahmaputra Hilsa also.
The length frequency distribution data were examined for the purpose of age and growth of hilsa. By fitting normal curves to the histograms a homologous groups have been identified in these histograms. The first group with the model point at 6.8 cm. represents the juveniles which are obviously the progeny of the fish that have spawned in the area during the two spawning seasons. There is a much less dominant group of immature fish with a model length at about 17.1 cm. The third group is quite predominant and has its modal point at 24.8 cm. The individuals of this group are all mature and, based on the study of gonadial development, it has been inferred that this is the approximate size at which they become mature for the first time, and a full spawning season intervenes between their hatching and attainment of maturity. These are then to be considered as fish that are about 1.5 year old. The third and fourth groups have their modes at 36.4 cm. and 44.6 cm. respectively. These represents the 2.5 year old and 3.5 year old fish respectively as fish older than about a year and a half ascend the river only once a year during the monsoon. Rounsefell and Everhart (1953) have pointed out that ordinarily the length-frequency method of growth determination fails to give reliable results beyond the first three or four years. This has also been found to be the case with the available data in the present investigation.

The age and growth of two types of Hilsa from the Rivers Padma and Meyhna were examined by means of otolith readings (Quddus et al., 1984b). They have found that the relationship between body length and otolith size is linear for both Types A and B, and significantly different between types.

Based on morphological characteristics, Ghosh et al., (1968) and Quddus et al., (1984) have differentiated Hilsa into slender and broad morphotypes. Pillay et al., (1963) has 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. Thus, to gain insight into the structure of Hilsa populations, the RAPD technique was used to delineate populations from their spawning habitats in Indian rivers. This technique is also used in the Brahmaputra water bodies to trace the genetic population of Hilsa i.e. whether Hilsa catch from different areas are from same genetic stock. The RAPD fragments observed in the 72 individuals showed polymorphism within and between the populations. The population specific bands could not be discerned from the fragment patterns generated. The cluster diagram delineated the four different populations into two major clusters, which could be due to different spawning grounds of Hilsa. The pixel intensity for each population also shows a polymorphic relationship among each other. The RAPD analyses revels that the Hilsa populations from different regions show polymorphism with each others.

The number of ova released at a single spawning increases with the size of the fish. This phenomenon has been demonstrated for many fishes. For the river Brahmaputra the Hilsa measuring 28 cm to 54 cm in total length the egg production per fish ranged between 390500 ± 132.32 and 1854300 ± 85.36 and 301g to 1900g in weight, the egg production per fish ranged between 378000 ± 120.36 and 1680400 ± 98.56. Heavier fish yield more nos. of ova. It was again observed that the more fish weight results more ovary weight and yield more nos. of mature ova implies the relation between fish length, ovary length and fecundity of Hilsa. It was seen that the increasing of fish length results more production of mature eggs, which is applicable for ovary length also.

Fecundity and fish length show a high degree of positive correlation (r = 0.91). When the fecundity data was plotted against total weight, a linear relationship was obtained between weight of the fish and fecundity. Egg production was somewhat more highly correlated (r = 0.87) with weight than with length. Fecundity and fish length show a high degree of positive correlation (r = 0.96). A linear relationship was obtained between weight of the ovary and fecundity. Egg production was
somewhat more highly correlated \((r = 0.91)\). Pillay (1958a) and Pillay and Rao (1963) found that the relationship between fecundity and body weight of Hilsa is linear, and that between fecundity and length, curvilinear. The estimates of fecundity in relation to fish size by different authors for different places. These indicate that the fecundity of Hilsa increases with increasing size of the fish; the estimates range from 0.1 to 2.0 million eggs for fish ranging in length from 25 to 55 cm. Generally, it is seen that for fish in the size range of 25 to 40 cm the fecundity estimate is about 0.25 to 0.40 million; for fish in the size range of 40 to 50 cm the estimate is 0.4 to 1.6 million and for fish above 50 cm, it is 1.3 to 2.0 million. All these findings suggest that the Hilsa is a highly fecund fish. As the fish doesn’t show parental care, the high fecundity enables it to compensate for any great loss of progeny which may occur due to predation and unfavorable hydreadological conditions.

Hilsa is an anadromous migratory fish. It migrates from the Bay of Bengal to the freshwater Brahmaputra for spawning. In summer Hilsa migrate about 540 Km. from Dhubri to Itakhuli (Dibrugarh) in the Brahmaputra river system and a total of 894 km. from Bay of Bengal. In winter Hilsa migrate about 400 Km. from Dhubri to Dihingmukh (Sibsagar) in Brahmaputra river system and a total of 754 km. right from Bay of Bengal. The main Hilsa fishing season which is during the monsoon, represents the period of a large-scale migration up the river. The catches during the period consist of mature fish that have come up for spawning. As the fish migrate through Brahmaputra river, it is seen that they migrate or enter through some major north and south tributaries which have the direct connection with the Brahmaputra river. It is seen that during summer the range of migration or distance travelled by Hilsa was comparatively greater than that of the winter months. The occurrence of Hilsa also showed a gradual decline from the summer to the winter run of the species. Hilsa occur in the river Brahmaputra throughout the year but with marked differences in abundance of occurrence. Two distinct migrations of Hilsa are seen, one in summer starting from the month of April to July and the other in winter, from September to December. It has been seen that during the summer months
specially during May and June, juvenile as well as spent fish are recorded. In tributaries it is seen that during the summer season the rate of migration is high compared to that of winter. In river Brahmaputra Hilsa migrate for spawning only during the monsoon and not in winter. The reason for this could be that because the river Brahmaputra dries up considerably in winter.

Nitrogen metabolism is considered as one of the sensitive physiological systems in responses to environmental variations. Accordingly, the nature of major nitrogen excretery products in animals has altered with the evolution of vertebrates from water to the land habitat (Cohen, 1976, Campbell, 1991). Ammonia is a common pollutant in inland waters, and its toxicity to fishes has been a subject of extensive laboratory studies and also reviews (Alabaster and Lloyd, 1980, Haywood, 1983, Randall and Wright, 1987, Wood, 1993, Saha and Ratha, 1998). Therefore, ammonia needs to be excreted out in a very diluted due to its high toxicity.

For Hilsa fish, the rate of ammonia excretion was highest by the fish captured in Dhubri (6.77 ± 2.37 mmol/ kg/ hr) with a gradual fall of the rate of excretion captured in Sunari (6.76 ± 1.25 mmol/ kg/ hr), Goalpara (6.74 ± 0.69 mmol/ kg/ hr), Jogighopa (5.84 ± 1.20 mmol/ kg/ hr), Amingaon (3.33 ± 0.38 mmol/ kg/ hr) & Tezpur (2.56 ± 0.69 mmol/ kg/ hr). The rate of urea excretion showed a slight fluctuation among the six different stations captured from Sunari, Goalpara, Jogighopa, Amingaon and Tezpur. Fish captured from lower reaches of the Brahmaputra comparatively have higher excretion rate than captured from upper reaches. The maximum level of ammonia was found in the liver, followed by the muscle, brain and heart. Likewise, the level of urea was found to be maximum in the liver, followed by the heart, brain and muscle. The level of both ammonia and urea showed a decreasing trend from the fish collected from lower reaches (Dhubri) to the higher reaches (Tezpur) of Brahmaputra river system. The tissue activity of CPS, OTC, ASS, ASL and ARG was recorded to be 2.77, 50.86, 60.03, 0.93 and 100.3 units/ g wet wt respectively, in the liver. Whereas in the muscle the tissue activity of CPS, OTC, ASS, ASL and ARG were recorded to be 0.42, 48.37, 60.04,
0.001 and 10.02 units/ g wet wt respectively. The specific activity of CPS, OTC, ASS, ASL and ARG were recorded to be 0.05, 0.82, 0.96, 0.01 and 1.26 units/ mg protein, respectively. In the muscle, the specific activity of all the five urea cycle were recorded to be 0.01, 0.75, 0.91, 0.05 and 0.12, respectively.

During migration of Hilsa, the fish travelled several hundred kilometers. There are evidences that Hilsa migrated upto Dibrugarh which is about 894 km. from the estuary. In the present studies the protein and fat parameters such as (i) protein and amino acids and (ii) lipids and fatty acids profile containing different categories of fatty acids reveal interesting infants. The fish burn about % of protein along with lowers both essential and non-essential amino acids. All the amino acids lose their concentration and are significantly different from their initial amount estimated from the examine samples. Lipids content of fish also decreases significantly. The overall total lipids decrease from their initial amount. That has been observed in Guwahati after traveling about 680 K.M. and the % of less is 82.2%.

Hilsa forms an important fishery in the lower stretch of the river Brahmaputra. The natural habitat of Hilsa fish 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 1955a). Hilsa therefore has the capacity to withstand variable salinity conditions, especially low salinity. According to Mitra and Devasundaram (1954), Hilsa has a preference for low salinity. For the Brahmaputra river system the Hilsa fishing occurs throughout the year with marked fluctuations in the summer and winter months. It is seen that from April to July is the best seasons for Hilsa fishery. Another peak season for Hilsa fishery is starts from October to December peak in October. In the lower reaches of the river Brahmaputra fishing is seen in all time around the year while in upper reaches it seen very rare on catch of Hilsa in winter season. In the Brahmaputra two types of
nets are used in both reaches of the river, viz. upper reaches and lower reaches. In lower reaches of the river a special net is used for catching fish. This net is called ‘Sanglo jal’ or clap net. In upper reaches gill net is used for catching the fish. It is seen that in entire Brahmaputra river Hilsa fishing is done. The major fish landing stations viz. Dhubri, Goalpara, Ujanbazar (Guwahati), Mongaldoi (Darang), Tezpur, Jorhat, Kamalabari and Itakhuli (Dibrugarh) shows fluctuation in landing of fish population depending upon the seasons. Starting from 2003 (111386 kg), 2004 (139841 kg), 2005 (106136 kg) and 2006 (85277 kg.), the four years of data shows a gradual declining in the total landing of population with a marked exception in the year 2004. The colour of the net, seasonal and annual rainfall influences the visibility and consequent response of the fish (Kunjipalu et al., 1985). Over fishing, establishment of diesel engine boat ghats in the of Hilsa breeding place, low quality nets are some of the major problems in Hilsa fishery of the Brahmaputra river system.

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