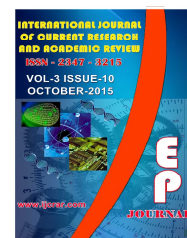




## International Journal of Current Research and Academic Review

ISSN: 2347-3215 Volume 3 Number 10 (October-2015) pp. 127-139

[www.ijcrar.com](http://www.ijcrar.com)



### Review of Global Studies on Food, Growth and Maturity Profile of Indian Shad (*Tenualosa ilisha*)

Utpal Bhaumik\*

Former Divisional Head, Riverie Ecology and Fisheries, Central Inland Fisheries Research Institute, Barrackpore, Kolkata, India

\*Corresponding author

#### KEYWORDS

Hilsa,  
Commercial  
fish,  
Food  
and  
feeding habit,  
Growth,  
Maturity

#### A B S T R A C T

The Indian shad (*Tenualosa ilisha*), is recognized as one of the most important commercial fishes of the Indo-Pacific region. The major portion of Hilsa (about 90%) is captured by Bangladesh, India and Myanmar. The most wide spread and well studied species *Tenualosa ilisha*, has been the subject to commendable research throughout the globe. Food and feeding habits of Hilsa in its various stages of life cycle have been studied by many scientists time to time in different water systems. Hilsa is mainly a plankton feeder. The age and growth of Hilsa varies with water bodies. It has been observed that Hilsa may attain first maturity at the end of first year or the beginning of the second year. The percentage occurrence of males and females in different stages of maturity in the water bodies reveals that spawning of Hilsa takes place in the month of August to November and January-March. In the paper attempt has been made to review global studies on food, growth and maturity profile of Hilsa.

### Introduction

The Indian shad also known as Hilsa shad (*Tenualosa ilisha*), belonging to the sub-family Alosinae of Family Clupeidae, is recognized as one of the most important commercial fishes of the Indo-Pacific region. It has a wide range of distribution and occurs in marine, estuarine and riverine environments. The fish is found in the rivers at the head of the Persian Gulf including the Dez, Bahmnshir, Jarrahi, Zohreh and Hilleh rivers in Iran. 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 namely the Ganga, Bhagirathi, Hooghly, Rupnarayan, Brahmaputra, Godavari, Narmada, Tapti and other coastal rivers, the Ayeyarwady of Myanmar, and the Padma, Jamuna, Meghna, Rupsa, Shibsha, Bishakhali, Feni, Muhuri, Karnafuly, Garai, Kumar, Madhumati, Arial Kha, Nabaganga, Dhaleswary, Kaliganga and Buriganga rivers of Bangladesh. At sea, it is found Persian Gulf, Red Sea, Arabian Sea, Bay of Bengal, Vietnam Sea and China Sea. The major portion of Hilsa (about 90%) is

captured by Bangladesh, India and Myanmar.

The most wide spread and well studied species *Tenualosa ilisha*, has been the subject to commendable research throughout the globe. The fish was first described by Russel (1803) and its first taxonomic status was described by Hamilton (1822). Huge number of literature on Hilsa is available throughout the world based on the investigations carried out by a large number of scientists. A critical analysis of available literature on Hilsa portrays huge information generated by different scientists across the world through their valuable studies time to time. In this paper attempt has been made to review those studies on food, growth and maturity profile of Hilsa.

### **Food and Feeding habits**

Food and feeding habits of Hilsa has been a century old topic of research interest to the fishery scientists of the Indo-Pacific region. Due to its migratory nature and occurrence in varied locations, it became an important subject to study various stages life history of Hilsa. The fish spends its various stages of life in different habitats; therefore, food and feeding habits may be flexible in different ecosystems.

Eventually food and feeding habits of Hilsa in its various stages of life cycle have been studied by a galaxy of scientists time to time in different water systems (Anon, 1957 to 2012). Hilsa is basically a plankton feeder. Hora (1938), Hora and Nair (1940) recorded that Hilsa fry (20–40 mm) mainly feed on diatoms, copepods, *Daphnia* and ostracods whereas; the younger Hilsa (up to 100 mm) feed on smaller crustaceans, insects and polyzoa. They also concluded from their studies that Hilsa feed at the bottom. Pillay (1958) reported that fry mainly subsists on

copepods, diatom and ostracods. Jones and Sujansingani (1951) confirmed that Hilsa are plankton feeder but they do not exhibit any selectivity towards feeding. Chacko and Ganapati (1949) and Malhotra *et al.* (1973) have confirmed the earlier findings which indicated that adult Hilsa is plankton feeder. Swarup (1959) studied the morphology, histology of the alimentary tract along with gut contents of juvenile and adult Hilsa obtained from the river Ganga near Allahabad. According to the investigator, the alimentary canal consists of buccal cavity, short pharynx, oesophagus, cardiac and pyloric stomach, duodenum, intestine and rectum.

Lakshminarayana (1965) studied the gut contents of *Tenualosa ilisha*, caught from the river Ganga at Varanasi, India which revealed the availability of blue green algae, *Merismopedia sp.*, various species of diatoms and occasional zooplankton. Pillay (1958) observed sizeable quantity of mud in the stomach of fish which indicates that they feed in the bottom and move along bottom zone of the river. He inferred that juveniles are voracious feeders and sexually matured Hilsa feeds during spawning migration. Halder (1968 and 1969) studied the food and feeding habits of young Hilsa in the Hooghly estuary and inferred that these were omnivorous. He further indicated that perhaps Hilsa stops feeding during its fluvial migration. Jafri (1988) is in agreement with this view as their observations on *Tenualosa ilisha* from the river Indus (Jamshoro, Pakistan), where gut contents were devoid of any food item, except some greenish-brown pulpy material which were unrecognizable. Bhaumik and Sharma (2012) during their investigation in the Hooghly estuary revealed similar observation. Jafri (1988) while studying the morphology of digestive tract of Hilsa indicated the feeding adaptation of the fish.

The absence of teeth in the mouth, presence of an efficient filtering mechanism in the form of fine, long gill rakers, the pharyngeal organ and the modification of stomach into gizzard, indicate that the mode of feeding is of strainer type. De (1986) and De and Dutta (1990a) studied the morphology, anatomy, histology of the alimentary canal of Hilsa in relevance to food and feeding habits, capturing it from freshwater zone of the Hooghly estuary. The study reveals that in young Hilsa (16–22 mm), the bulk of the stomach contents were found to be copepods. The histological studies of alimentary canal of Hilsa carried out by De (1986) and De and Dutta (1990b) indicate that taste buds are completely absent from buccal cavity, pharynx, pharyngeal pouch and oesophagus. Mucous cells are completely absent from cardiac and pyloric stomach but those are well compensated by the presence of a gastric gland. Bhaumik *et al.* (2013), while studying

food and feeding habits of the Hilsa of Vallabh Sagar Reservoir (Ukai) reported that in fry stage (up to 60 mm) the gut contents mainly comprised appendages of zooplankton and semi-digested diatoms, green algae and blue-green algae. As the fish grew in size the percentage of algal materials was more and the contents were mostly recorded in digested condition. In adult fishes the percentage of mud was quite high in particular during monsoon season.

In adult Hilsa, the gill rakers are numerous, plate like, fine processes and each raker is differentiated into four zones where the inner marginal layer possess conical papillae. All these distinct zones as well as papillae are not fully developed in the gill rakers of fishes below 50 mm in total length. Characteristics of gill rakers and relative length of guts in various size groups are shown in table 1 and table 2 (De, 1986; De, and Datta, 1990a).

**Table.1** Characteristics of gill rakers of *T. ilisha*

Fish size (mm)	No. of fish examined	Maximum length of gill raker (mm)	Width of gill rakers (mm) (flattened side)	Density (number) of gill rakers per mm	No. of gill 1 <sup>51</sup> branchial (left side only).
44-54	6	1.40-1.50	0.05-0.07	12.80-15.20	150-158
86-88	5	2.25-3.00	0.10-0.12	10.40-11.20	176-183
127	1	4.12	0.15	8.80	222
362-392	5	12.50-13.25	0.55-0.60	4.00-4.50	361-384
448-465	5	14.75-15.62	0.75	2.90-3.40	371-391

**Table.2** Relative Length of Gut (RLG) values of *Tenualosa ilisha*

Total length (mm)	No. of fish examined	Maximum/minimum value	Average
59-99	9	0.86-1.14	1.05
115-	2	1.08-1.17	1.13
230-285	10	1.26-1.55	1.37
309-392	21	1.35-1.70	1.47
401-475	12	1.43- I. 77	1.50
510-525	4	1.80-1.87	1.82

A gradual increase in RLG (Relative Length of Gut) value is also noticed among the fish of different length groups from fry (59 mm) to adult (525 mm) which varies from 0.86 to 1.87 (Table 2). The gill rakers of Hilsa are like the sieve; therefore they do not show selective preference for any food or food particles. The adult Hilsa has been found to feed on plankton and they are called 'planktivores'. Raja (1985) reviewed the food and feeding habits of Hilsa and found a general agreement on the food items of Hilsa among a large number of workers, who worked during late 30s to late 70s (Hora, 1938; Hora and Nair, 1940; Chacko and Ganapati, 1949; Pillay and Rao, 1962; Halder, 1968, 1969; Pillay, 1964; Qureshi, 1968a, Shafi *et al.*, 1977). According to them, the dominant food items of Hilsa were crustaceans (particularly copepods), diatoms, green and blue-green algae, organic detritus, mud and sands.

Mazid and Islam (1991) noted that relatively large but immature Hilsa preferred phytoplankton over zooplankton and *jatka* were voracious feeders. Rahman *et al.* (1992), identified 27 genera of phytoplankton and 12 genera of zooplankton in a post-*jatka* fish caught from the Meghna River. They further mentioned that Hilsa become gradually adapted to a feeding habit of mainly phytoplankton feeders as they grow. Rahman (1996) reported that the juveniles are plankton feeders, eating blue green and green algae, diatoms and desmids from their phytoplankters menu, and copepods, cladocerans and rotifers from their zooplankters menu. In a more recent document, the gut content analysis of adult Hilsa has shown that algae constituted 41–65% of the diet, sand particles 36.28%, diatom 15.36%, crustacean 1.89%, protozoa 1.22% and other miscellaneous items 0.41% (30). Coad (1997) expressed that food of juvenile of *Tenualosa ilisha* of Iranian

waters consists of phytoplankton and zooplankton, principally diatoms and copepods. Adults have empty stomachs on spawning run. Al-Hassan (1999) reported that Sbour (Hilsa) feeds mainly on diatoms, blue green algae and to a lesser extent on zooplankton.

### **Age and Growth**

It has been observed by the investigators that the age and growth of Hilsa varies with water bodies. The age and growth of Hilsa in different stages was studied by Pillay and Rao (1960), Jones and Menon (1951), Raj (1937) and Chacko and Dixitulu (1951). Chacko *et al.* (1948) and Kulkarni (1953) determined the age of the Hilsa by counting the radii on the scales. But scales used for this purpose could not be employed to interpret the age of the species. They interpreted direct correlation between the numbers of scale radii and fish length. Dewan and Raj (1950) opined that in Hilsa growth rings are many and ill defined for estimation of age whereas transverse radii in the anterior region of the scale are regular and well defined which could be found to provide evidence of age. Pillay (1940 and 1958) concluded that numbers of radii on the scales are not related to the age of Hilsa, so, it may not be useful in determining the age and growth of the species. Other workers namely Pillay and Rao (1952, 1960, 1962 and 1964), Rajyalakshmi (1972), De and Dutta (1990a,b), Gupta (1993) used length-frequency method to determine age, which was not found reliable as frequency distribution often overlapped due to protected spawning period and size selective sampling.

Ageing of Hilsa is a problem (Rahman, 2001). Chacko *et al.* (1948), Chacko and Kirshanamurti (1950), Raj (1937) and Chacko and Dixithulu (1951) proposed a

direct correlation between the number of scale radii and fish length. However, Pillay (1958) concluded that the number of radii on the scales is not related to the age of fish, so, it may not be useful in determining the age and growth of the species. Similar problems were found in European populations of shad (*Alosa* sp.) but careful examination of the scales makes ageing possible. Other workers (Pillay and Rao (1962), Ramakrishnaiah (1972), De and Datta (1990 a) used the length-frequency method to determine the age, which was not found reliable as the frequency distributions often overlapped due to protracted spawning periods and size selective sampling. Moreover, they did not use computer-based software such as ELEFAN or FiSAT to discriminate length modes, so, the analysis needs to be treated with caution.

Quddus (1982, 1984b) found otoliths are a good tool to study the age of the fish. Later Quddus *et al.* (1984a) discussed the age and growth of the two types of Hilsa (so called broader and slender type) from the Padma and Meghna rivers using otoliths. In the case of the broader type, hyaline zones appeared during June and July while in the slender type it was in January and February, i.e. during their respective spawning season. Consequently, it appears the stress of spawning may induce a growth mark.

It has been by the scientists that like other fishes, Hilsa grow faster in their early life stages up to about 600 mm (BOBP, 1987). Length-frequency of Hilsa in commercial catch in Bangladesh and Indian waters showed a general size range about 15-52 cm (Azad *et al.*, 1987; Bhaumik and Manna, 2010; Gupta, 1993). Hilsa have been classified into four size groups, small (less than 30 cm), medium (30–39 cm), large (40–49) cm and extra large (above 50 cm), but more than 90% of the catch falls within a range of 30–50 cm (Azad *et al.*, 1987).

Bhuiyan and Talbot (1968) reported total life span of Hilsa as at least 5 years whereas Pillay and Rao (1962) found Hilsa in Indian rivers live at least 6 years. Bhaumik *et al.* (2012) while recording largest Hilsa (*Tenualosa ilisha* - 614 mm in length and 4250 gm in weight) from the river Tapti estimated age of that fish at 7+ years. However, in Bangladesh waters length-frequency analysis using Bhattacharya's method indicated that there were four or five modal groups, at 22, 37, 41, 47, and 50 cm within the exploited size range (BOBP, 1987). Rahman (2001) separated six age groups found were 1+ to 6+ (Table 3). Sujansinghani (1957) reported the details of the results of a three-year study conducted on the growth of Hilsa in the Hooghly estuary. Growth increments were estimated to be 15–20 mm/month in the first 2–3 months after hatching, thereafter decreasing to approximately 10 mm/month.

The parameters 'a' and 'b' of the length-weight relationship,  $w = al^b$  (where,  $w$  = weight of fish;  $l$  = length of fish;  $a$  = constant; and  $b$  = exponent) were estimated by different workers in different water bodies. The values of the exponent (b) varies between 2.52 (Rahman, 1996) and 3.10 (Al-Baz and Grove, 1995) indicating a fairly symmetric growth rate of the fish (Bhaumik and Sharma, 2011). Daily growth ring on the otoliths of Hilsa have also been used for ageing in Bangladesh waters, as increments were found to be visible for the first few hundred days but the micro-structural pattern became unreadable thereafter (BFRI/RS, 1994; Mazid and Blaber, 1998.). This was because the increments were faint and very fine for extensive regions near the margin of the otoliths of the larger fish. Therefore, this method is suitable for small fish (smaller than 40 cm), but for large fish (larger than 40 cm) another method is required (Hossain, 1985; BFRI/RS, 1994; Mazid and Islam, 1991).



Rahman (2001) examined Hilsa otoliths and used to age Hilsa and validated length-based methods for ageing of the fish. Finally, Rahman and Cowx (2006) found lunar periodicity in the growth of Hilsa using otoliths. The linear relationships between the otolith-lengths and lengths of Hilsa were established for different environments and sexes (Rahman, 2001). The correlation coefficients of the relationships were highly significant ( $P < 0.01$ ) for all the equations, hence, the relationships are suitable for estimating the length of fish from its otolith-length or vice versa. The age groups found were 1+ to 6+ from otolith study as well as from length frequency study of Hilsa from Bangladesh waters. The separated length groups as predicted on the basis of biological information were validated by comparing with the annual growth obtained from otolith reading. The overall length range for a particular age group obtained from length frequency analysis, were compared with the minimum and maximum lengths obtained from the otolith reading. In the majority of the cases, the ranges of lengths obtained from length frequency analysis were within the minimum and

maximum lengths obtained for that age group from otolith reading. However, in some cases the maximum values from length frequency analysis were slightly higher than that obtained from otolith reading (Rahman, 2001).

The growth of juvenile Hilsa collected from the Hooghly estuary has been reported by Sujansingani (1957), De (1986 and 2001) and Bhaumik and Sharma (2012). The age and growth of the collected samples of adult Hilsa from Hooghly-Bhagirathi, Tapti and Vallabh Sagar Reservoir were observed to be dissimilar (Bhaumik *et al.*, 2012). They indicated that rate of growth of fish population may vary from one environment to other, or in the same environment from year to year due to changes in ecology including changes in food availability, density dependent growth factors etc. Southwell and Prashad (1918), Jones and Menon (1951) and Chacko and Ganapati (1949) have observed that the female fish attains larger size than the males. The largest Hilsa recorded so far in India, is also a female fish captured from the river Tapti (Bhaumik *et al.*, 2012).

**Table.3** Average size attained by Hilsa in the Hooghly estuary

Age (in month)	Length range (mm)	De, 1986	Sujansingani, 1957	Bhaumik and Sharma (2012)
		Average size (mm)	Average size (mm)	Average size (mm)
1	26-33	32.25	28.0	28.0
2	40-63	51.47	44.6	50.0
3	61-75	67.00	59.6	68.0
4	73-83	80.00	74.6	74.0
5	83-95	90.50	84.6	89.0
6	98-120	102.00	-	108.0

A fair degree of agreement was observed (Table 3) between lengths and ages of Hilsa by Pillay (1958), Jones and Sujansingani (1957), Pillay and Rao, (1960), De (1986), De and Datta, (1990a), Ramkrishnaiah (1972), Jhingran and Natarajan (1966), Reuben *et al.* (1972), Choudhury *et al.*

(1990), Bhaumik and Manna (2010) and Bhaumik and Sharma (2011 and 2012).

The table indicates that little faster rate of growth in juvenile Hilsa from the Hooghly estuary was observed during post barrage period (De, 1986; Karamchandani, 1961).

As regards the age and growth of adult Hilsa, a number of well documented accounts are available from Hooghly estuary and coastal waters of West Bengal, where age and growth studies have been made on length frequency data. Ageing of Hilsa estimated by several workers is presented in table 4. A fair degree of agreement was observed between lengths and ages obtained by Pillay (1958) and De and Dutta (1990a).

Panhwar *et al.* (2011), determined age class of *Tenualosa ilisha* of the river Sind, Pakistan based on interpretation of radii on scales. The age class comprised of 1 to 3 years. The individuals having an average number of radii 4–6 or less than 300 mm in

total length were assigned to age group 1<sup>+</sup>. Subsequently the individuals of length group 301–340 mm (7–9 radii) were assigned to 2<sup>+</sup> and 3<sup>+</sup> age groups respectively. Coad (1997) indicated that in the Bahmanshir river of Iran most *Tenualosa ilisha* are 4 to 5 years old. Narejo *et al.* (2005) while studying the age groups in *Tenualosa ilisha* of river Sind, Pakistan had reported that fishes of less than 250 mm belongs to age group 0<sup>+</sup> and fishes of size groups 251–300, 301–350, 351–400 and 401–450 mm belonged to age groups 1<sup>+</sup>, 2<sup>+</sup>, 3<sup>+</sup>, 4<sup>+</sup> and 5<sup>+</sup> respectively. Jafri *et al.* 1987 and 1988 had considered the specimens of *Tenualosa ilisha* of size range 151–200 mm in TL as belonging to age group 0<sup>+</sup>.

**Table.4** Ageing of Hilsa interpreted by several workers

Hooghly estuary (Pillay, 1958)		Hooghly estuary (De 1986; De and Datta 1990a)		Hooghly estuary (Bhaumik and Sharma, 2012)		North east of India of Hooghly estuary (Reuben <i>et al.</i> , 1992)		Brahmaputra river (Choudhury <i>et al.</i> , 1990)	
Age group (yr)	Length (cm)	Age group (yr)	Length (cm)	Age group (yr)	Length (cm)	Age group (yr)	Length (cm)	Age group (yr)	Length (cm)
1.5	24.7-26.5	1	18.9	1	21.5	1	23.8	1	23
2.5	34.5-39.1	2	27.7	3	41	2	37.2	2	33
3.5	39.3-43.6	3	35.1	3+	44.8	3	45.6	3	41
		4	41.3			4	50.8	4	47
		5	46.6			5	54.1		
		6	51.1			6	56.1		
Godavari estuary, (Pillay and Rao, 1960)		Chilika Lake (Jhingran and Natarajan, 1969)		Chilika Lake (Ramkrishnaiah, 1972)		Indus river, Pakistan (Panhwar <i>et al.</i> , 2011)			
Age group(yr)	Length (cm)	Age group (yr)	Length (cm)	Age group (yr)	Length (cm)	Age group (yr)	Length (cm)		
1	35.5	1	0–21.0	0	16.2	1+	30.0		
2	41.5	2	18.5–31.0	1	23.7	2+	30.5–34.0		
3	45.5	3	29.4–41.2	2	38.7	3+	34.1–38.0		
4	48.5	4	39.5–49.3						
5	50.5	5	48.8–56.0						
6	52.5	6	56.0–61.0						

Bhaumik and Sharma (2012) estimated age of Hilsa through study of otoliths. Thus, growth of the Hilsa of the Hooghly estuary has been recorded as 21.5 cm, 41 cm and 44.8 cm corresponding to the age of 1 year, 3 year and 3<sup>+</sup> year respectively.

### **Maturity**

It has been reported in all the studies that Hilsa is heterosexual, the females are distinguishable by the flat urinogenital opening and bulging abdomen whereas the males by a narrow genital opening and the prominence of a papillae. However, hermaphroditism has also been reported by Chacko and Ganapati (1949) and Swarup (1959). The species appears to be polygamous and fertilization is external (Pillay and Rosa, 1963). Pillay and Rao (1962) formulated useful guidelines to determine different maturity stages on the basis of both internal and external appearance of gonads of both male and female Hilsa and to assess the period of spawning and size at fish maturity.

Day (1878) observed that Hilsa may attain first maturity at the end of first year or the beginning of the second year. Jones and Menon (1951) have mentioned that their observations in the Hooghly, Chilika and Mahanadi corroborate this statement. It has been reported by Pillay (1958) that males of Hilsa in the river Hooghly matured when they were 16-17 cm and the females when 19-20 cm. Minimal size of fish at its first maturity has been studied by many investigators (Table 5) whereas stages of maturity of female gonads have been studied by limited number of workers in India namely Pillay (1958), Mathur (1964) and De (2001), Bhaumik (2012) and Bhaumik and Sharma (2011).

Perusal of the table 5, depicts that although females below 300 mm size groups are

rarely observed to be taking part in spawning activity but a female of 208 mm (weighing 105 gm) size with VII stage of maturity has been recorded recently from the river Hooghly (Bhaumik and Sharma, 2012). The small mature females observed in Hooghly estuary by De (2001 and 1990b) were around 341 mm (av. wt 550g). It was comparable to the sizes of Hilsa of the Ganga where the smallest mature female's collection at Allahabad, Varanasi (Mathur, 1964) and Godavari (Pillay and Rao, 1962) were 330, 310 and 370 mm respectively. In almost all cases the age resembles at 2+ or 3+ years of maturity. In the Hooghly higher values of Gonado-Somatic Index (GSI) of Hilsa were observed during September to March with a peak in October (15.8) whereas average Gonado Somatic Index was recorded as 10.2 (De, 2001, 1986).

In the Bahmanshir river of Iran, it has been reported that captured *Tenuaosa ilisha* belonged to 4–5 years old where maximum numbers were with a minimum total length, weight and age at maturity of 26.2 cm, 200 gm and 2 years for males and 32.2 cm, 450 gm and 3 years for females respectively (Coad, 1997). In Kuwait waters mature female Hilsa was observed at a length of 415 mm (Al-Baz and Grove, 1995). Al-Hassan, (1999) reported in the river Satt Al-Arab of Iraq, Sbour (Hilsa) passes through different stages of maturity. There appear to be two peaks in the gonado-somatic index namely March-May and July-August indicating that Sbour spawns more than once in a year. Hilsa become sexually mature after 1–2 years of life. The size at first maturity is around 22–25 cm for males and 28–30 cm for females (Pillay and Rosa, 1963; Azad *et al.*, 1987). In Bangladesh waters, the size at first maturity is reported as 26.5–30.5 cm for males and 30.0–35.0 cm for females (Dunn, 1982). In the River Godavari, the smallest mature male and female were 25 cm and 37



cm, respectively (Pillay and Rao, 1962). In the Hooghly estuary, however, the minimum size at maturity was 16–17 cm for males and 19–20 cm for females (Pillay, 1958). Pillay and Rao (1962) formulated a useful guide to determine the different maturity stages on the basis of both external and internal appearance of the gonads of both male and female Hilsa and assess the period of spawning and size at first maturity. Hilsa with mature gonads are available more or less round the year in

Bangladesh (Blaber and Mazid, 2001; Moula *et al.*, 1991). Samples with immature gonads are observed only in the month of December and January (Moula *et al.*, 1991; Pillay and Rao, 1962). The percentage occurrence of males and females in different stages of maturity (Table 3) revealed that spawning of Hilsa takes place in the month of August to November and subsidiary spawning in June-July and January-March (Jafri, 1987 and Moula *et al.*, 1991).

**Table.5** The size (mm) at maturity attained by Hilsa

Male	Female	Water system	Investigator(s)
170	208	Hooghly-Bhagirathi river	Bhaumik and Sharma (2012)
193	207	Ukai (Vallabh Sagar) reservoir	Bhaumik <i>et al.</i> (2012)
280	382	Godavari river	Chacko and Krishnamurthy (1950)
300	356	Godavari river	Chacko and Ganapati (1949)
216-254	267-305	Hooghly, Chilika and Mahanadi	Jones and Menon (1951)
160-170	190-200	Hooghly estuary	Pillay (1958)
----	266	Narmada river	Karamchandani (1961)
256	370	Godavari	Pillay and Rao (1962)
----	341	Hooghly estuary	De, (1980; 1986)
200	350	Ganga river	Mathur (1964)
----	330	Ganga at Allahabad	Mathur (1964)
----	310	Ganga at Varanasi	Mathur (1964)
175-300	200-300	Chilika lake	Jhingran and Natrajan (1966)
172	186	Chilika lake	Ramakrishnaiah (1972)
360	420-430	Godavari river	Rajyalakshmi (1973)
210	320	Meghna river	Shafi <i>et al.</i> (1978)
400	400	Bangladesh waters	Dunn (1982)
-	415	Kuwait waters	Al-Baz and Grove (1995)
250-420	300-600	Indus river, Pakistan	Bhuiyan and Talbot (1968)
250	330	Shatt Al-Arab, Iraq	Hussain <i>et al.</i> (1991)
262	322	Bahmanshir river, Iran	Coad (1997)

## Conclusion

It is evident from the studies that food and feeding habits, age and growth, maturity of Hilsa varied with the water bodies. But, by and large, the differences do not depict much significant impact on the Hilsa fishery. In view of its great importance in international arena, there is an imperative need of making further studies involving a collaborative mission by the scientists of each country having basic interest on the same.

## References

- Al-Baz, A.F., Grove, D.J. 1995. Population biology of Sbour, *Tenulosa ilisha* (Hamilton-Buchanan) in Kuwait. *Asian Fish. Sci.*, 8: 239–254.
- Al-Hassan, L.A.J. 1999. Shad of Shatt Al-Arab river in Iraq- a brief review of the biology of shad that spawn in the Satt Al-Arab river in southeastern Iraq. *Shad. J.*, 4(2): 1–4.
- Anon, 1957 to 2012, Annual Reports, *Central Inland Fisheries Research Institute*, Barrackpore.
- Azad, S.A., Hertel-Wullf, J., Hossain, M.M., Islam, M.S., Huq, C.M., Das, N.N. 1987. Some observations on Size groups in the fishery and migration of hilsa in Bangladesh waters during 1985-86. Bay of Bengal Programme, Colombo, Sri Lanka. BOBP/REP/36. Colombo, Sri Lanka: 46-63.
- BFRI/RS, 1994. Bangladesh Fisheries Research Institute, Riverine Station. Hilsa Fisheries Development and Management. *Annual Rep.BFRI/RS 94*: 21 pp.
- Bhaumik Utpal, Manna R.K. 2010, Present status of the fishery of Indian Shad, *Tenulosa ilisha*, in the Hooghly river system., In. Suresh, Manna, Bhaumik and Mitra eds. *Souvenir and Abstract, Seminar on Caring Wetlands and Riverine fisheries-its conservation*, Kolkata, October 2, 2010, 59–67 Pp.
- Bhaumik, Utpal, (2012). Status of Hilsa fishery in India, In. Hilsa: Status of fishery & potential for aquaculture, Eds; Wahab, Phillips & Rahaman, World Fish Centre, Bangladesh. Pp. 61–95
- Bhaumik, Utpal, Mukhopadhyay, M.K., Shrivastava, N.P., Sharma, A.P. 2012. The largest recorded Hilsa (*Tenulosa ilisha*) in India from Tapti estuary, Gujarat. *Fish. Chimes*, 31(12): 57–58.
- Bhaumik, Utpal, Sharma, A.P. 2011. The fishery of Indian Shad (*Tenulosa ilisha*) in the Bhagirathi-Hooghly river system, *Fish. Chimes*, 31(8): 21–27.
- Bhaumik, Utpal, Sharma, A.P., Mukhopadhyay, M.K., Shrivastava, N.P., Bose, Sritama, 2013. Adaptation of Hilsa (*Tenulosa ilisha*) in freshwater environment of Ukai (Vallabh Sagar) Reservoir, Gujarat, India. *Fish. Chimes.*, Annual issue, 33(1): 46–51.
- Bhaumik, Utpal, Sharma, A.P/ 2012, Present Status of hilsa in Hooghly-Bhagirathi river, CIFRI Bulletin 179: 42.
- Bhuiyan, N., Talbot, G.B. 1968. Fluvial migration, spawning, and fecundity of Indus river hilsa, *Hilsa ilisha*. *Transact. Am. Fish. Soc.*, 97(4): 350–355.
- Blaber, S.J.M., Mazid, M.A. 2001. Hilsa Fishery Research in Bangladesh. ACIAR Project 9430, Final Report, August 2001, 123–20 Pp.
- BOBP, 1987. Bay of Bengal Programme. Hilsa Investigations in Bangladesh. *FAO-UNDP Proj. Mar. Fish. Resour. Manage.* Bay of Bengal, Colombo, Sri Lanka. BOBP/Rep/36, 113 Pp.
- Chacko, P.I. 1952. A Survey of the dams and migratory fishes of Madras, *Contr. Freshwater. Fish. Biol. Stat.* Madras.
- Chacko, P.I. 1954. Past, present and future of the hilsa fisheries in Madras State. *J. Asiat. Soc.*, 20: 55–58.
- Chacko, P.I., Dixithulu, D.V.H. 1951. Further observation on the radii of scales of *Hilsa ilisha* (Ham.), Proc. 38th Indian Sci. Cong., Calcutta. 227 Pp.
- Chacko, P.I., Ganapati, S.V. 1949. On the bionomics of *Hilsa ilisha* (Hamilton) in

- the Godavari River. *Madras Univ. J.*, 18: 16–22.
- Chacko, P.I., Kirshanamurti, B. 1950. A biometrical study of *Hilsa ilisha* (Ham.) in the Godavari River. *J. Bombay Nat. Hist. Soc.*, 49: 315–316.
- Chacko, P.I., Zubairi, A.R.K., Krishnamurthy, B. 1948. The radii of scales of *Hilsa ilisha* (Ham.) as an index of growth and age. *Curr. Sci.*, 17: 158–159.
- Chandra, R. 1962. A preliminary account of the distribution and abundance of fish larvae in the Hooghly estuary. *Indian J. Fish.*, 9: 48–70.
- Choudhury, M., Chandra. R., Kolekar, V. 1990. Growth and production of Hilsa fisheries in the river Brahmaputra, *J. Inland Fish. Soc. India*, 22(1 and 2): 66–74.
- Coad, Brian, 1997. Shad in Iranian waters, *Shad. J.*, 2(4): 4–8.
- Day, F. 1873. Report on the freshwater fish and fisheries of India, and Burma, Calcutta. Pp. 22–36.
- Day, F. 1878. The Fishes of India, Vol. I & II (reprinted 1958). William Dawson & Sons. Ltd., London. Pp. 638–640.
- De, D.K. 1986. Studies on the food and feeding habit of Hilsa, *Hilsa ilisha* (Hamilton) of the Hooghly estuarine system and some aspects of its biology. Ph. D. Thesis, Calcutta University. 285 Pp.
- De, D.K. 2001. A overview of biology of hilsa, *Tenulosa ilisha* (Hamilton) and its fishery in the Ganga-Hooghly drainage system, Proceedings of the International Terubok (*Tenulosa* Sp.) Conference 11-12 Sept., Sarawak, Malaysia. Pp. 25–51.
- De, D.K., Datta, N.C. 1990a. Studies on certain aspects of morpho-histology of Indian shad, hilsa, *Tenulosa ilisha* (Hamilton) in relation to food and feeding habits. *Indian J. Fish.*, 37: 189–198.
- De, D.K., Datta, N.C. 1990b. Age, growth, length-weight relationship and relative condition in hilsa, *Tenulosa ilisha* (Hamilton) from the Hooghly estuarine system. *Indian J. Fish.*, 37: 199–209.
- Department of Fisheries (DoF), Government of Bangladesh. 2005-06. Annual Report. Md. Nazrul Islamv (Ed), DoF & MoFL. 111 Pp.
- Dewan Bhadur Dr., B. Sundara Raj, 1950. Are scales an index to the age and growth of Hilsa? *Proc. Nat. Inst. Sci. India*, Vol. XVII: 1–6.
- Dunn, I.C. 1982. The hilsa fishery of Bangladesh, 1982: An investigation of its present status with an evaluation of current data. FI:DP/8DG/81/034. Field Document 2. FAG, Rome, Italy. 71 Pp.
- Gupta, R.A. 1993. Abundance, recruitment and growth of the Indian shad, *Tenulosa ilisha* (Ham) and its present status in the Ganga river system. *J. Inland Fish. Soc.*, 25: 16–22.
- Halder, D.D. 1968. Observations on the food of young *Hilsa ilisha* (Ham) around Nabadwip in the Hooghly estuary. *J. Bombay Nat. Hist. Soc.*, 65(3): 796–798.
- Halder, D.D. 1970. Observations on the food of young *Hilsa ilisha* (Ham.) of the Hooghly estuarine system. *J. Bombay Natural Historical Soc.*, 67(3): 578–583.
- Hamilton, F. 1822. An account of the fishes found in the river Ganges and its branches. Archibald Constable and Company. Edinburgh. Pp. 243–246.
- Hora, S.L. 1938. A preliminary notes on the spawning grounds and bionomics of the so-called Indian shad, *Hilsa ilisha* (Ham.), in the river Ganges. *Rec. Indian Mus.*, 40: 147–158.
- Hora, S.L., Nair, K.K. 1940. Observations on the bionomics and fishery of the Indian shad. *Hilsa ilisha* (Ham.) in Bengal waters. *Records of the Indian Museum*, 42: 35–50.
- Hossain, M.M. 1985. Spawning times and early life history of *Hilsa ilisha* in Bangladesh. M.S. Thesis. University of British Columbia, Vancouver, B.C. Chanda. 90 Pp.
- Hussain, S.A., Al-Mukhtar, M.A., and Al-Daham, 1991. Preliminary investigation on fisheries and some biological aspects

- of Shour, *Hilsa ilisha*, from Satt Al-Arab river, Iraq. *Barsah J. Agricult. Sci.*, 4(1and2): 141–151.
- Islam, M.S., Huq, Q.M., Hossain, M.M., Azad. S.A., Das. N.N., 1987. Maturity and spawning of hilsa shad, *Hilsa ilisha*, of Bangladesh. Bay of Bengal Programme, Colombo, Sri Lanka. BOBP/REP/36: 82–95.
- Jafri, S.I.H. 1987. Morphology of the digestive tract of river shad, *Tenuulosa ilisha* (Clupeidae: Teleostei). *Sind Univ. Res. J.*, 19(1): 65–68.
- Jafri, S.I.H. 1988. Biology and fishery of river shad (Palla) - A review. *Pak. J. Agric. Res.*, 9(2): 252–263.
- Jhingran, V.G., Natarajan, A.V. 1966. Final Report on the fisheries of the Chilika Lake. *Bull. Cent. Inland Fish. Res. Inst. Barrackpore*. No. 8: 5 Pp.
- Jones, S., Menon, P.M.G. 1951. Observations on the life history of the Indian shad. *Hilsa ilisha* (Ham.). *Proc. Indian Acad. Sci.*, 31(3): 101–125.
- Jones, S., Sujansingani, K.H. 1951. *Hilsa fishery of Chilka lake*, *J. Bombay nat. Hist. Soc. Bombay* 50: 264–280p.
- Karamchandani, S. J. 1961. On the location of spawning grounds of Indian shad, *Hilsa ilisha* (Ham.), in freshwater regions of the Narbada River. *Curr. Sci.*, 30(10): 373–375.
- Kulkarni, C.V. 1953. *Hilsa ilisha* [Hamilton] on the West Coast of India, *J. Asiat. Soc. Sci.*, 20(1): 47–53.
- Lakshminarayana, M. 1965. Studies of the phytoplankton of the river Ganges, Varanasi, India. Pt. IV. Phytoplankton in relation to fish populations. *Hydrobiologia*, 25: 171–175.
- Malhotra, J.C., Mathur, P.K., Malhotra, S.N., Kamal, M.Y. 1973. Successful rearing of *Hilsa ilisha* (Ham.) in freshwater for years. *Proc. Nantl. Acad. Sci. India*, 43: 207–210.
- Mathur, P.K., Malhotra, J.C., Mehrotra, S.N., Shah, K.L. 1974. Experiments on the nursery rearing of spawn of *Hilsa ilisha* (Hamilton) in freshwater ponds. *J. Inland Fish. Soc. India*, 6: 205–210.
- Mathur, P.M. 1964. Studies on the maturity and fecundity of the hilsa, *Hilsa ilisha* (Ham.) in the upper stretches of the Ganga. *Indian J. Fish.*, 11: 423–448.
- Mazid, M.A., Blaber, S.J.M., 1998. *Hilsa fisheries research in Bangladesh*. Proc. BFRI/ACIAR/CSIRO workshop, 3–4 March, 1998, Dhaka, Bangladesh. 86 Pp.
- Mazid, M.A., Islam, S. 1991. *Hilsa Fishery Development and Management*. A report published by Fisheries Research Institute, Mymensingh, Bangladesh. 16 Pp.
- Moula G., Rahman, M.J., Mazid, M.A. 1991. Observations on the maturity and spawning of Indian shad, *Tenuulosa ilisha* (Hamilton) of the river Meghna, Bangladesh. *J. Zooogy*, 6: 109–117.
- Narejo, N.T., Laghari, S.M., Jafri, S.I.H., 2005. Food and feeding habit of Palla, *Tenuulosa ilisha* (Hamilton) from Ring dam (up-stream) river Indus. *Pak. J. Zool.*, 37(4): 265–267.
- Panhwar, S.K., Siddiqui, G., Ayub, Z. 2011. Reproductive pattern and some biological features of anadromous fish *Tenuulosa ilisha* (Family: Clupeidae) from Pakistan. *Indian J. Geo-Marine. Sci.*, 40(5): 687–696.
- Pillay, S.R. 1964. Maturation and spawning of the hilsa, *Hilsa ilisha* (Hamilton), of the Saurashtra coast, *Proc. Nat. Inst. Sci., India*, Sec B, 30(1): 8–14.
- Pillay, S.R., Rao, K.V. 1960. Observations on the biology and fishery of hilsa, *Hilsa ilisha* (Ham) on river Godavari, *Proc. Indo-Pacif. Fish.Counc.*, 10(2): 37–61.
- Pillay, S.R., Rosa, H. 1963. Synopsis of biological data on hilsa, *Hilsa ilisha* (Ham.) 1822. *FAO Fish. Synopsis*: 25: 61.
- Pillay, T.V.R. 1958. Biology of the hilsa, *Hilsa ilisha* (Ham.) of the river Hooghly. *Indian J. Fish.*, 5: 201–257.
- Pillay, T.V.R. 1964. Maturation and spawning of the hilsa, *Hilsa ilisha* (Ham.), of the Saurashtra coast. *Proc. Nat. Inst. Sci. India*, 30: 8–14.
- Pillay, T.V.R., Rao, K.V. 1962. Observation on the biology and fishery of *Hilsa ilisha*

- (Ham.) of river Godavary. *Proc. Indo. Pacif. Fish. Counc.*, 10: 37–61.
- Quddus, M.M.A. 1982. The types of *Hilsa ilisha* and their population biology from Bangladesh waters. Ph. D. Thesis, University of Tokyo, Tokyo, Japan. 180 Pp.
- Quddus, M.M.A., Makoto, S., Yukio, N. 1984b. Comparison of age and growth of 2 types of *Hilsa ilisha* in Bangladesh waters. *Bull. Japan. Soc. Sci. Fish.*, 50(1): 43–49.
- Quddus, M.M.A., Makoto, S., Yukio, N., 1984a. Spawning and fecundity of 2 types of *Hilsa ilisha* in Bangladesh waters. *Bull. Japan. Soc. Sci. Fish.*, 50(2): 177–181.
- Qureshi, M.R. 1968. Hilsa fishery in East Pakistan. *Pak. J. Sci. Ind. Res.*, 11(1): 95–103.
- Rahman M.J., Cowx, I.G. 2006. Lunar periodicity in growth increment formation in otoliths of hilsa shad (*Tenuulosa ilisha*, Clupeidae) in Bangladesh waters. *Fish. Res.*, 81: 342–344.
- Rahman, M. 1996. Studies on the effect of slating on the nutritive qualities of hilsa fish (*Hilsa ilisha*). M.S. Thesis submitted to the Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh.
- Rahman, M.A., Rahman, M.J., Moula, G., Mazid, M.A. 1992. Observation on the food habits of Indian shad, *Tenuulosa (Hilsa ilisha)* (Ham.) in the Gangetic river system of Bangladesh. *J. Zool.*, 7: 27–33.
- Rahman, M.J. 2001. Population biology and management of the hilsa shad (*Tenuulosa ilisha*) in Bangladesh. Ph.D. Thesis. The University of Hull, England. 253 Pp.
- Raj, B.S. 1937. Madras Fisheries Department Administrative Report for 1935-36 Madras, 37: 38 Pp.
- Raja, B.T.A. 1985. A review of the biology and fisheries of *Hilsa ilisha* in the upper Bay of Bengal. Proceedings of the Marine Fisheries Resource Management. Bay of Bengal, Colombo, Sri Lanka. FAO/UNDP BOBP/WP/37. 66 Pp.
- Rajyalakshmi, T. 1973. The population characteristics of the Godavari hilsa over the years 1963-1967. *Indian J. Fish.*, 20: 78–94.
- Ramakrishnaiah, M. 1972. Biology of *Hilsa ilisha* (Ham.) from Chilika lake with an account on its racial status. *Indian J. Fish.*, 19: 35–53.
- Reuben, S., Dann, S.S., Somaraju, M.V., Phillipose, V., Sathianandan, T.V. 1992. The resources of Hilsa Shad, *Hilsa ilisha* (Ham) along the Northeast coast of India, *Indian J. Fish.*, 39(3and4): 169–181.
- Russel, P. 1803. Description and figures of two hundred fishes collected at Vizagapatam on the coast of Coromandal. W. Bulmer and co., London. Pp. 77–78.
- Shafi, M., Quddus, M.M.A., Islam, N. 1977. Studies of gonad weight, sex-ratio and fecundity of *Hilsa ilisha* (Ham.-Buchanan) from the river Meghna. *J. Asiatic Soc. Sci. (Bangladesh)*, 2(2): 51–58.
- Southwell, T., Prashad, B. 1918. On Hilsa investigations in Bengal, Bihar and Orissa. *Bull. Dept. Fish. Bengal, Bihar, Orissa*, 11: 1–12.
- Sujansinghani, K.H. 1957. Growth of the Indian shad, *Hilsa ilisha* (Ham.) in the tidal stretches of the Hooghly. *Indian J. Fish.*, 4: 315–335.
- Swarup, K. 1959. The morphology and histology of the alimentary tract of *Hilsa ilisha* (Ham.). *Proceedings of the National Academy of Science, India* 29: 109–126.