Spawning frequency and sex reversal of *Tenualosa ilisha* (Clupeid): A review

BM Shahinur Rahman

**Abstract**

*Tenualosa ilisha* (Clupeidae) is the most important single species and national fish of Bangladesh. It accounts for more than half of the total marine catches and about 12-13% of total fish production and about 1.0 percent of GDP. Absence of small females and large males and transitional gonads of the histological data proved *Tenualosa toli* and *T. macrura* (Clupeidae) changes their sexes at the end of the first year and spawn as females in the second year. *T. toli* spawn in the middle reaches of estuaries and females deposit all their eggs at once while *T. macrura* spawn throughout the year in Sumatra but in Sarawak have a seasonal peak in the NE monsoon (December). The smaller sized *T. ilisha* are almost all males, a few small functionally female fish are present in Bangladesh water body. Male sex ratio of *T. ilisha* is less than female sex ratio (1:5.09).

**Keywords:** Sex change, spawning frequency, *Tenualosa ilisha*, clupeid

**Introduction**

The hilsa shad, (*Tenualosa ilisha*) is an important anadromous clupeid, migratory species in the Indo-Pak subcontinent, especially in Bangladesh, India and Myanmar [1]. It is the national fish of Bangladesh and the largest single species fishery contributing about 12-13% of total fish production of the country [2]. About 0.46 million peoples directly or indirectly are engaged in hilsa fishing and contributes 1.0% to the GDP [3]. During last decades Hilsa fishery has been suffered by a combination of factors viz. serious growth and recruitment over-fishing. It is important to know spawning frequency and sex reversal of *T. ilisha* species for the management and conservation of this important single stock.

**Taxonomy of Hilsa**

| Kingdom        | Animalia            |
|----------------|---------------------|
| Phylum         | Chordata            |
| Sub-phylum     | Vertibrata          |
| Class          | Actinopterygii      |
| Order          | Clupeiformes        |
| Family         | Clupeidae           |
| Genus          | *Tenualosa*         |
| Species        | *T. ilisha*         |

Corresponding Author:
BM Shahinur Rahman
Senior Scientific Officer
Bangladesh Fisheries Research Institute
Riverine Sub Station, Rangamati, Bangladesh

DOI: [https://doi.org/10.22271/fish.2020.v8.i6b.2371](https://doi.org/10.22271/fish.2020.v8.i6b.2371)
Literature Review and Discussion

Sex Change

Sex change is a process by which a person or animal changes sex, by which female sexual characteristics are substituted for male ones, or vice versa. Generally Fishes or other animals changes their sex by two ways: Protandry: Where an organism is born as a male and then changes sex to a female [4].

Ex: Tenualosa toli, Clownfishes (Amphiprion sp.) Protogyny: Where the organism is born as a female and then changes sex to a male [4]. Ex: Large groupers (Serranidae), parrotfishes (Scaridae).

Conducted a study in Sarawak Malaysia on Tenualosa toli (Clupeidae) and found absence of small females and large males, together with histological data showing transitional gonads, suggest that T. toli is a protandrous hermaphrodite [5].

Carried a study on Tenualosa macrura (Alosinae: Clupeidae): monthly from August 1996 until October 1998 throughout the estuaries and coastal waters of Sumatra and Borneo where it formed the basis of flourishing fisheries. They stated the evidence from sizes of sexes, sex ratios and histology is that T. macrura is a protandrous hermaphrodite. Most fish less than 200 mm SL were male, although a few females were between 135 and 200 mm. All fish over 210 mm SL were functional females [6].

Conducted a further study from January 1997 to December 2003 along the South China Sea coast of Sarawak and Sabah in Malaysia on Tenualosa macrura (Clupeidae) that indicate the sex ratio highly biased by length and most fish <20 cm were males whereas those >20 cm were females. Gonadosomatic index (GSI) and histological data of T. macrura indicate that Males mature at ≥10 cm and females at ≥20 cm. They found T. macrura is protandrous, but low numbers of small females suggest diandry [7].
Found 774 males and 3937 females from 4711 specimens of *Tenualosa ilisha* (Clupeidae) in Bangladesh, indicates the sex ratio of 1 male to 5.09 females [8].

[9] Found significant differences in sex ratio of Indian River Shad, *Gadusia chappa* (Clupeidae) from the expected value 1:1 (male: female = 1:0.86, $x^2 = 11.07$, p<0.001). Length-frequency distribution showed a size predominance of females over males, where mean female size consistently exceeded that of males throughout the year. Female size at first sexual maturity was estimated as 8.3 cm in standard length (SL). Monthly gonadosomatic index (GSI) was higher during March-September with a peak in April, indicating this was the main spawning season.

Observed some aspects of the reproductive biology of Hilsa Shad, *T. ilisha* from the Persian Gulf (PG) and rivers of Khuzestan Province of Iran. A total of 485 fish were sampled by gillnet from Arvand (AR) and Bahmanshir (BR). Reproductive characteristics of *T. ilisha* showed that females predominate than males (M: F=1:2). Monthly variations in gonado somatic index (GSI) of both sexes were quite apparent. In PG, maximum values were recorded in April for male and female [11].

Found sex ratio of *Hilsa ilisha* along the northeast coast of India 1:1.3. There was differential growth in sexes, the female having slightly faster growth. The ova diameter progression indicate single batch of ova only get segregated for spawning. They also indicate ovaries spent partially and fecundity ranged 467100 to 1369500 for 370-540 mm size fish [12]. Stated that the male *T. toli* that are smaller in size usually change their sex to female at the size of 27 cm and weight of 600 g. [13].

Found the fecundity of *Hilsa ilisha* (Hamilton, 1822) caught from the Padma river near Godagari, Rajshahi, Bangladesh vary from 5,58,700 to 18,67,000, mean 1239360.35 ± 405068.97 for the fishes with 350-557 mm in total length and mean 455.25± 59.94 mm and with 600 -1775 g in total body weight and mean 1181.85±356.12 g. They also identified Mean GSI of *H. ilisha* 10.14±3.45 [14].

Studied on fecundity of *H. ilisha* (Hamilton, 1822) from the Bay of Bengal. The fecundity (F) was found to range from 1030951 to 1940620 (mean 1377884±290145) in fishes between 39 and 51 cm total length (TL) with the mean of 44.08±3.84 cm. Standard length (SL), body weight (BW), gonad weight (GW), mean diameter of egg and gonad somatic index (GSI) were found to range from 34 to 46 cm (mean 39.45±3.67), from 800 to 1700g (mean 1155.50±260.76), from 71.15 to 217 g (mean 141.33±42.22), from 0.66 to 0.85 mm (mean 0.78±0.66) and from 7.5 to 15.85 (mean 12.15±2.19); respectively. The regression line for the TL, SL, BW and GW of the fishes were found to be linear when they were plotted against their fecundity on logarithmic scales. Highly significant (p<0.05) linear relationship for logarithmic scale was obtained for all the variables. Body weight was

---

**Fig 3:** Sex changes of *T. macrura* [6].

**Fig 4:** Size group with sex ratio of *Tenualosa ilisha* in Bangladesh [10].
found to be the best indicator of the fecundity of *H. ilisha* [15]. Reported the smaller sized hilsa were almost all males, a few small functionally female fish were present. No hilsa with transitional gonads were found among the >2000 fish examined histologically. Thus, the sex ratio bias appears to be related to differential survival of males and females. Almost all males live less than two years [16].

Conducted a study on reproductive pattern of anadromous fish *T. ilisha* based on the histological examination of male and female gonads. They found overall sex-ratio was close to 1:1 ratio. The five stages of oogenesis, nearly ripe, fully developed, running ripe, partially spent and spent and four distinct phases of ovarian atresia alpha, beta, gamma and delta were observed. Five stages of spermatogenesis developing, nearly ripe, ripe, partially spent and spent were identified. The male and female specimens in ripe and partially spent stages were considered to be in spawning condition [17].

Estimated fecundity and gonado somatic index (GSI) of gangetic whiting, *Sillaginopsis panijus* (Hamilton, 1822) from the Meghna river estuary, Bangladesh. They stated the fecundity ranged from 173745 to 374077 with a mean of 310605±12283384 having an average total length of 36.06±0.52cm, body weight of 300.36±24.41g and gonad weight of 28.65±2.98g. The right ovaries of the specimens were more fecund than the left ones. Gonadosomatic index was found higher (9.95±0.15%) in peak season, August [18].

Stated *Herklotsichthys punciatus* (Spotted Herring) has been found to attain sexual maturity at an average size of 125 mm total length in the Andaman waters. Observations on the seasonal progression of ova indicated the sharp biannual spawning habit of the fish. The percentage occurrence of mature fish, fluctuations of the relative ovary weight during different months and ovary diameter frequency indicated that spawning occurs first in May-June and again in October-November. Fecundity has been found to vary from 6,530 to 10,690 in specimens ranging 115-144 mm total length [19].

Conducted a large multi vessel survey to provide nearly synoptic sampling of Red Snapper *Lutjanus campechanus* throughout their reproductive season in the U.S. Gulf of Mexico. A total of 2,487 Red Snapper were caught with a female: male ratio that was approximately 1:1. The ovaries of 1,002 females were histologically examined. Females (n = 391) were found with spawning markers (postovulatory follicles and hydrated oocytes) throughout the study area, but primarily in outer shelf waters [20].

**Spawning Frequency**

Spawning frequency is the number of days between spawning [20].

Spawning frequency was determined based on histological observation and two methods were utilized i.e. (a) the percentage of female in the late developing ovarian class with 0-h to 24-h postovulatory follicle (POF) in the ovary and (b) the percentage of female in the late developing class undergoing final oocyte maturation (FOM) [21]. Furthermore [22] stated that spawning frequency was determined by dividing 100 (representing the total population of fish) by the percentage of fish with FOMs or POFs in the ovaries.

Described ageing based otoliths of *Tenuelosa toli* (Clupeidae) indicates that individuals may not live more than about two years. Male fish spawn towards the end of their first year, change sex (transitional gonads were recorded in fish from 14 to 31 cm SL) and spawn as females in their second year. Spawning takes place in the middle reaches of estuaries and females deposit all their eggs at once [5].

Carried a study on *Tenuelosa macrura* (Alosinae:Clupeidae): stated the evidence from sizes of sexes, most fish less than 200 mm SL were male, although a few females were between 135 and 200 mm. All fish over 210 mm SL were functional females. It changes from male to female mainly between 14 and 20 cm SL (standard length) (six months to one year in age), after the male has spawned. Almost all fish in their second year are females; the species does not appear to live beyond two years [6].

Carried a further study from January 1997 to December 2003 along the South China Sea coast of Sarawak and Sabah in Malaysia on *Tenuelosa macrura* (Clupeidae) that indicate the sex ratio highly biased by length and most fish <20 cm were males whereas those >20 cm were females. Gonadosomatic index (GSI) and histology data OF *T. macrura* indicate that Males mature at ≥10 cm and females at ≥20 cm. They found *T. macrura* is protandrous, but low numbers of small females suggest diandry. In Sumatra this species spawn throughout the year, but in Sarawak have a seasonal peak in the NE monsoon (December) [7].

**Fig 5: GSI of Tenuelosa ilisha** [10].

Found Length-frequency distribution of Indian River Shad, *Gudusia chapra* (Clupeidae) showed a size predominance of females over males, where mean female size consistently exceeded that of males throughout the year. Female size at first sexual maturity was estimated as 8.3 cm in standard length (SL). Monthly Gonadosomatic index (GSI) was higher during March-September with a peak in April, indicating this was the main spawning season [9].

Observed some aspects of the reproductive biology of Hilsa Shad, *T. ilisha* from the Persian Gulf (PG) and rivers of Khuzestan Province of Iran. A total of 485 fish were sampled by gillnet from Arvand (AR) and Bahmanshir (BR). Monthly variations in gonadosomatic index (GSI) of both sexes were quite apparent. In PG, maximum values were recorded in April for male and female. In AR and BR, maximum values were recorded in June and May for male and female, respectively. Changes in GSI indices are considered as a proof that maturation season in AR and BR is started.
from March and spawning is started from April to July in AR and BR is started from March to August. [13]

Found Hilsa ilisha spent partially and fecundity ranged 467100 to 1369500 for 370-540 mm size fish [12].

Reported on Status of hilsa (Tenualosa ilisha) management in the Bay of Bengal and stated in case of Bangladesh, Spawning fish had been found in the lower Meghna estuary and around AriichaGhat North of Dhaka, Bangladesh. The project showed that hilsa matured at one year of age. Fish spawned throughout the country year round in low or zero salinity waters. There were two periods of more intense spawning that coincided with the main monsoon (July-November) and the spring warming (February-May). Spawning occurred in coastal areas and in the northern Bay of Bengal during the monsoon season when river flow was greatest. Fish fecundity was high (800000-100000000 eggs) but declining in many areas. Other unique aspects of hilsa reproductive biology included the sex ratio. This was found to be biased towards females in larger and older fish. Almost all two and three year old fish were females and their fecundity was related to size. BOBLME (2010) reported from the ACIAR project that smaller sized hilsa were males, a few small functionally female fish were found. ACIAR project histologically examined 2000 nos of T. ilisha and No transitional gonads of were found and this project also stated that almost all males live less than two years [16].

Stated T. ilisha spawning males were encountered during the period from May to October with the highest in July (90%), August (100%) and October (92%). While spawning females were also observed during the period from May to October, with almost all females being in spawning condition. The GSI of males and females were found highest in the month of April (1.21) and October (10.2) while the lowest GSI of males and females were found in the month of June (0.23) and April (6.77); respectively [17].

Stated Herklotsichthys punciatus (Spotted Herring) has been found to attain sexual maturity at an average size of 125 mm total length in the Andaman waters. Observations on the seasonal progression of ova indicated the sharp biannual spawning habit of the fish. The percentage occurrence of mature fish, fluctuations of the relative ovary weight during different months and ova diameter frequency indicated that spawning occurs first in May-June and again in October-November. Fecundity has been found to vary from 6,530 to 10,690 in specimens ranging 115-144 mm total length [19].

Studied gonad condition of some freshwater fishes and found spawning frequency of carps in the four riverine forms, [6.77]; respectively [17].

Boards, Edward M. Animal behavior desk reference: a dictionary of animal behavior, ecology, and evolution 2nd ed.). Boca Raton, Fla: CRC Press, 2001, p. 317.

Blaber SJM, Milton DA, Pang J, Wong P, Ong B, Nyigo L, et al. The biology of the tropical shad Tenualosa toli from Sarawak: first evidence of protandry in the Clupeiformes? Environmental Biology of Fishes 1996;46:225-242.

Blaber SJM, Brewer DT, Milton DA, Merta GS, Efizon D, Fry G, et al. The life history of the protandrous tropical shad Tenuolosa macrura (Alosinae: Clupeidae): fishery implications. Estuarine Coastal and Shelf Science 1999;49:689-701.

Blaber SJM, Fry G, Milton DA, Van der Velde T. The life history of Tenualosa macrura in Sarawak, further notes on protandry in the genus and management strategies. Fisheries Management and Ecology 2005;12:201-210.

Amin SM, Arshad A, Haldar GC, Shohaimi S, Ara R. Estimation of Size Frequency Distribution, Sex Ratio and Length-Weight Relationship of Hilsa (Tenualosa ilisha) in the Bangladesh Water. Research Journal of Agricultural and Biological Sciences 2005;1(1): 61-66

Ahamed F, Ahmed FZ, Hossain YM, Ohtomi J. Population Biology of the Indian River Shad, Gadusia chapra (Clupeidae) in the Old Brahmaputra River, North-Eastern Bangladesh. Sains Malaysiana 2014;43(11):1645-1655.

Zaher M, Rahman MA, Alam MA, Ahmed T, Flura Hasan SJ, Rahman BMS, et al. Hilsa Fisheries research
11. Roomiani L, Sotudeh AM, HakimiMofrad R. Reproductive biology of Hilsa shad (*Tenualosa ilisha*) in coastal Waters of the Northwest of Persian Gulf. Iranian Journal of Fisheries Sciences 2014;13(1):201-215.
12. Reuben S, Dan SS, Somaraju MV, Philipose V, Sathianandan TV. The resources of hilsa shad, *Hilsa ilisha* (Hamilton), along the northeast coast of India. *Indian Journal of Fisheries* 1992;39(3-4):169-181.
13. Phillip WPH. Working Paper on The Efforts in Conservation & Management of Terubok (*Tenualosa toli*) Fishery in Sarawak, Malaysia. Seminar on Terubok Conservation 2006.
14. Akter AM, Hossain MD, Hossain MK, Afza R, Bhuyian AS. The fecundity of *Hilsa ilisha* from the river Padma near Godagari of Rajshahi district. *Univ. j. zool. Rajshahi Univ* 2007;26:41-44.
15. Saifullah ASM, Rahman MS, Khan YSA. Fecundity of *H. ilisha* (Hamilton, 1822) from the Bay of Bengal. *Pakistan Journal of Biological Sciences* 2004;7(8):1394-1398.
16. BOBLME. Status of hilsa (*Tenualosa ilisha*) management in the Bay of Bengal, BOBLME-2010-Ecology-01 2010.
17. Panhwar SK, Siddique G, Ayub Z. Reproductive pattern and some biological features of anadromous fish *Tenualosa ilisha* (Family: Clupeidae) from Pakistan. *Indian Journal of Geo Marine Sciences* 2011;40(5):687-696.
18. Islam MR, Sultana N, Hossain MB, Mondal S. Estimation of fecundity and Gonadosomatic Index (GSI) of gangetic whiting, *Sillaginopsis panijus* (Hamilton, 1822) from the Meghna river estuary, Bangladesh. *World Applied Sciences Journal* 2012;17(10):1253-1260.
19. Marichamy R. Maturity and spawning of the spotted herring *Herklotsichthys punctatus* (Ruppell) from the Andaman Sea. *Indian J. Fish* 1971;18(1-2):148-155.
20. Porch CE, Fitzhugh GR, Lang ET, Lyon HM, Linton BC. Estimating the Dependence of Spawning Frequency on Size and Age in Gulf of Mexico Red Snapper, Marine and Coastal Fisheries 2015;7(1): 233-245.
21. Brown-Peterson NJ, Warren JW. The reproductive biology of Spotted seatrout, *Cynoscion nebulosus* along the Mississippi Gulf Coast. *Gulf of Mexico Sciences* 2001;1:61-73.
22. Brown-Peterson NJ, Overstreet RM, Lotz JM, Franks JS, Burns KM. Reproductive biology of cobia, *Rachycentron canadum*, from coastal waters of southern United States. *Fisheries Bulletin* 2001;99:15-28.
23. QASIM SZ, Qayyum A. Spawning frequencies and breeding seasons of some freshwater fishes with special reference to those occurring in the plains of Northern India. *Indian Journal of Fisheries* 1961;8:24-43.