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

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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	:	Vertebrata
Class	:	Actinopterygii
Order	:	Clupeiformes
Family	:	Clupeidae
Genus	:	<i>Tenualosa</i>
Species	:	<i>T. ilisha</i>

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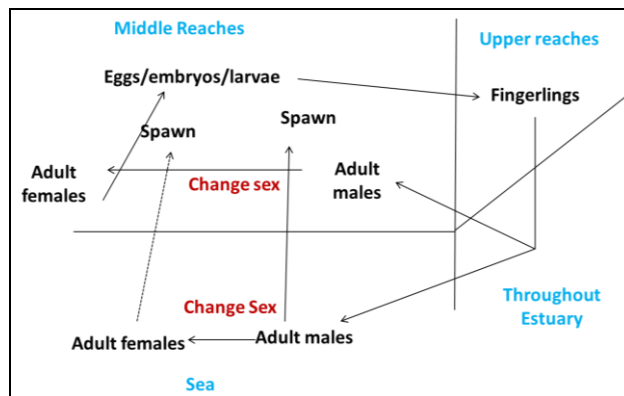


Fig 1: Life cycle of *T. toli* [5].

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: *Tenuulosa 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 *Tenuulosa 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 *Tenuulosa 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].

Carried a further study from January 1997 to December 2003 along the South China Sea coast of Sarawak and Sabah in Malaysia on *Tenuulosa 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].

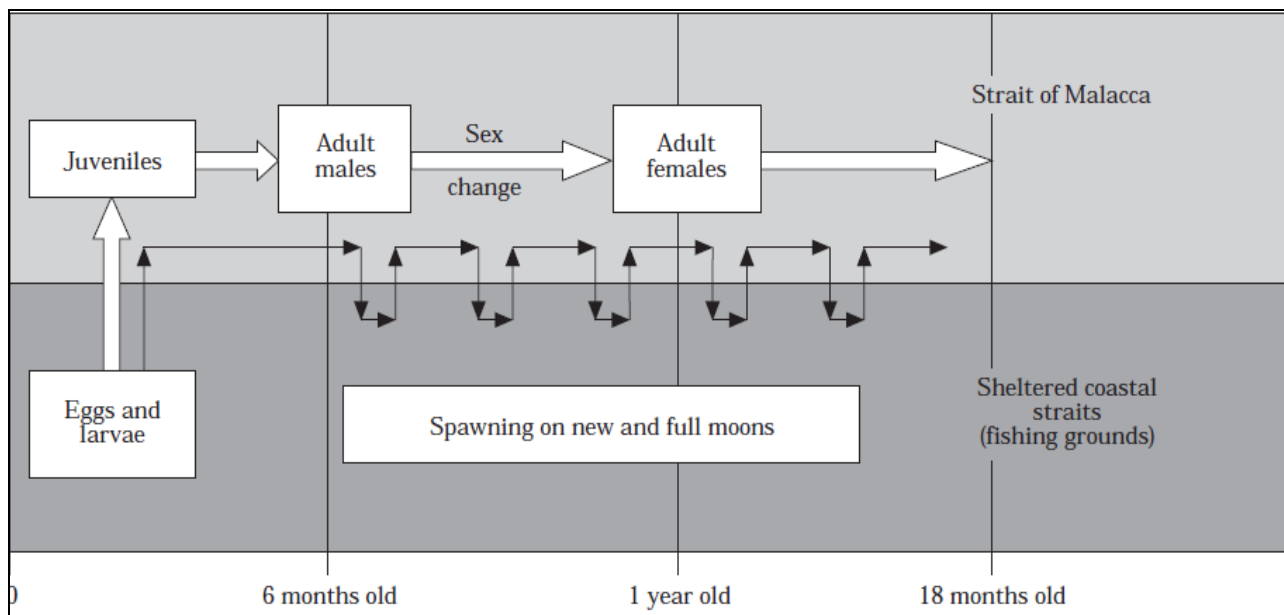


Fig 2: The life cycle of *T. macrura* [6].

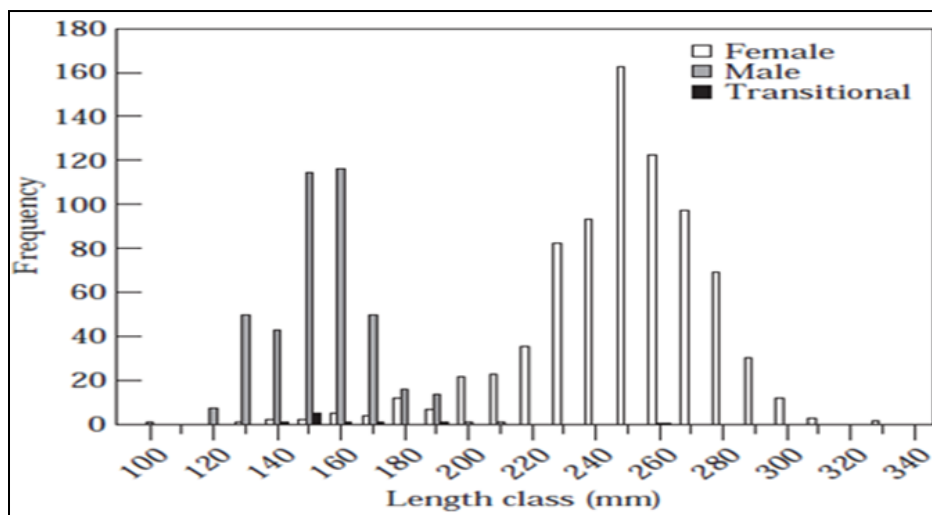


Fig 3: Sex changes of *T. macrura* [6].

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, *Gudusia chapra* (Clupeidae) from the expected value 1:1 (male: female = 1:0.86, $\chi^2 = 11.07$, $p < 0.001$). 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.

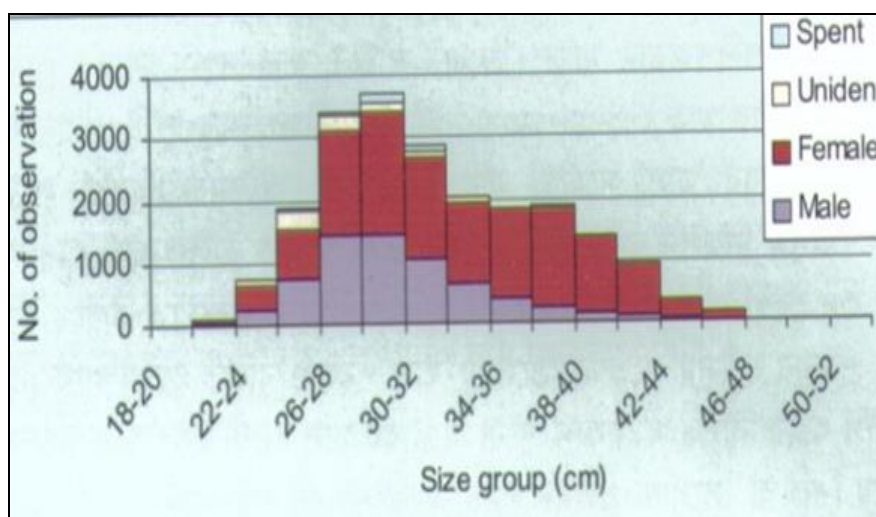


Fig 4: Size group with sex ratio of *Tenualosa ilisha* in Bangladesh [10].

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 350-557mm in total length and mean 455.25 ± 59.94 mm and with 600 -1775g 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

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 atresis 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 310605.1 ± 22833.84 having an average total length of 36.06 ± 0.52 cm, body weight of 300.36 ± 24.41 g and gonad weight of 28.65 ± 2.98 g. The right ovaries of the most specimens were more fecund than the left ones. Gonadosomatic index was found higher ($9.95 \pm 0.15\%$) in peak season, August [18].

Stated *Herklotsichthys punctiatus* (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].

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 *Tenuulosa 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 *Tenuulosa 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 *Tenuulosa 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].

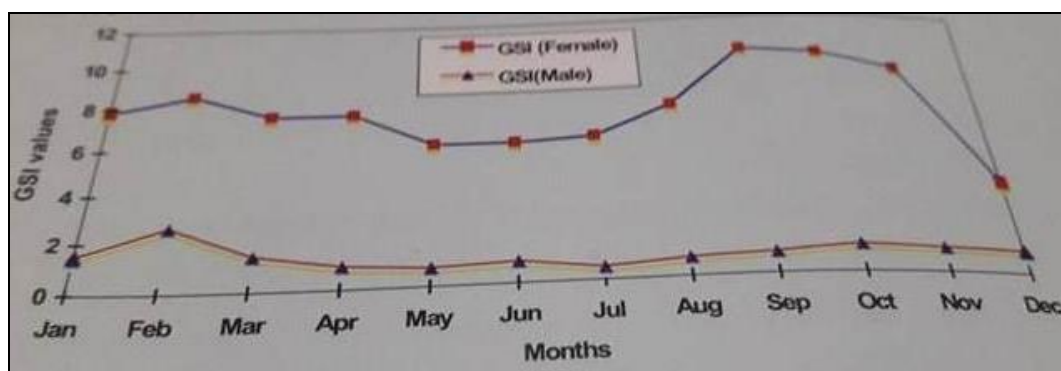


Fig 5: GSI of *Tenuulosa ilisha* [10].

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^[11].

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

Reported on Status of hilsa (*Tenulosa 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 ArichaGhat 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 (800000-1000000 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 almost all 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 punctatus* (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, namely, *Labeo rohita*, *Labeo calbasu*, *Cirrhina mrigala* and *Barbus sarana* single and their duration of spawning are practically the same, the breeding seasons last for about two months during the monsoons, July and August. *Barbus (Tor) puti tora* species spawn several times over a greater part of the year. Grey mullet, Spiney Eel and Catfishes play as a single spawning act whereas Murrels spawn long and last throughout the monsoon and post-monsoon months^[23].

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. 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. Statistical models were developed to quantify and test the dependence of the proportion of females bearing spawning markers (spawning fraction) on female length and age, time of year, depth, gear type (vertical line or longline), or region (east or west of the Mississippi River). Most of the variance in spawning fraction was explained by the time of year;

spawning fractions were generally low in spring, peaked in midsummer, and declined by fall^[20].

Conclusion

The hilsa fishery generates employment and income for millions of people in India, Bangladesh and Myanmar. No comprehensive study regarding spawning frequency and sex reversal of *T. ilisha* has yet published. Thus it is important to know spawning frequency and sex reversal of *T. ilisha* species for the management and conservation of this important single stock. After this study the size and age of *Tenulosa ilisha* during sex changing period will be known; the spawning frequency of *T. ilisha* before and after sex change age will be identified as well as probable factors that influence sex change will be found.

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