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Perspectives of reproductive biology and spawning behaviour of Indian Shad (*Tenualosa ilisha*) - A global review

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A B S T R A C T

The present study deal with the Indian shad [*Tenualosa ilisha*] commonly known as Hilsa. Also to review those studies on reproductive biology and spawning behaviour of Hilsa. The fish is found in the rivers at the head of the Persian Gulf including the Dez, Bahmshir, 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. Fecundity differs owing to various factors namely age, size, body and gonad weight and ecological conditions of the water body. A wide range of variation is observed time to time in the fecundity of Hilsa. Intensive fishing in all the water bodies is to be controlled without further lapse of time. In order to maintain sustainable yield and also increase production, regulation of selective fishing by adjusting mesh size of the gears and simultaneous control of juvenile destruction should be encouraged.

Introduction

The Indian shad (*Tenualosa ilisha*) commonly known as Hilsa, 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 recognized as one of the most important commercial 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, Bahmshir, 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.

Enormous literature is available across the globe based on the studies carried out Hilsa by the galaxy of scientists. A critical analysis of available literature on Hilsa portrays enormous information generated by different scientists of the world through their valuable studies time to time. The fish was first described by Russel (1803) and its first taxonomic status was described by Hamilton (1822). The paper has been dealt to review those studies on reproductive biology and spawning behaviour of Hilsa.

Reproductive biology of Hilsa

Fecundity is one of the important aspects of reproductive biology of fish species which provides information on the number of eggs in the ovary prior to the next spawning season. Fecundity differs owing to various factors namely age, size, body and gonad weight and ecological conditions of the water body. A wide range of variation is observed time to time in the fecundity of Hilsa.

Pillay (1958) recorded fecundity in the range of 2, 50,000 to 16,00,000 in fish measuring 253 to 481 mm in length from the Hooghly estuary. De (1986), computed the egg numbers ranging between 3, 73,120 and 14, 75,676 in fishes ranging between 334 mm and 522 mm in length. Swarup (1961) and Mathur (1964) while working on Hilsa

reproduction in the upper Ganga river system near Allahabad recorded fecundity values as 2,89,000 to 11,68,622 and 3,16,316 to 18,40,179 from the fishes of 315 to 506 mm and 310 to 436 mm size range respectively. Bhaumik and Sharma (2012) reported number of eggs in individual mature ovary of *Tenualosa ilisha* ranged from 44,002 numbers (length 274 mm / weight 234.5 g) to 15,54,894 numbers (length 403 mm / weight 855 g). It has been observed that number of ova increased with age of fish and egg diameter also increased with increasing fecundity. Bhaumik *et al.* (2012) indicated highest fecundity so far recorded in the globe as 29,49,750 from a gravid female weighing 4.250 kg obtained from the river Tapti.

Queshi (1968) while studying fecundity of *Tenualosa ilisha* from Indus river indicated number eggs to vary between 80,000 and 2,000,000 but size range was mentioned. Bhuiyan and Talbot (1968) while studying the reproduction of *Tenualosa ilisha* in detail revealed that fecundity of the species from the Indus river varies from 7,55,000 to 29,17,000. They also concluded that there is no close relationship between the fecundity and length or weight of Hilsa from the Indus. Panhwar *et al.*, 2011, reported fecundity of the *Tenualosa ilisha* collected from the river Indus with size range. The specimens belonging to the size classes 200-250 mm, 251-300 mm and 301-350 mm carried eggs with average number of 1, 13, 483, 3, 82, 105 and 5, 72, 709-6, 14, 482.

Coad (1997) indicated the fecundity of *Tenualosa ilisha* in Iranian waters may reach 1,616,560 eggs for fish 33.0-41.5 cm long. Al-Hassan, L.A.J. (1999) revealed that absolute fecundity of Sbour in the Satt Al-Arab river of Iraq ranges from 1, 00,000 to 20, 00,000 eggs per female.

Fecundity of the species from various water bodies estimated by different workers has been presented in table 1.

Spawning of Hilsa

Several workers have reported parameters responsible for the spawning activities, such as Job (1942) reported that the breeding period of Hilsa is slightly variable from place to place on account of different ecological conditions. It is well known that temperature plays a role in development of gonads as well as spawning. Nair (1958) reported that spermatogenesis and oogenesis processes of Hilsa are fully active when the temperature rose to 25⁰C, but a temperature of 30⁰C inhibits the effect on the gonadal activities.

While, De (1986), reported that a temperature between 24⁰C to 29⁰C has been found to be optimum for spawning. Through, several spawning grounds are reported in the major river systems, it is likely that these sites vary from year to year since there is no fixed spawning ground. Blaber *et al.* (2001, 2003) reported that Hilsa spawn in rivers, estuaries and on the coast of Bangladesh, although the proportion of fishes spawning on the coast is perhaps lower, but the pattern differs from year to year.

During the commencement of the South-West monsoon and consequent flooding of the rivers, Hilsa starts its spawning migration upstream. Investigations carried out by many workers on the reproductive biology of Hilsa indicated that the spawning of this species is seasonal. In almost all major river systems and lagoons *viz.*, Hooghly, Ganga, Chilika, Tapti, the spawning season of Hilsa has been noticed during the period between August and October.

Hilsa spawns in all freshwater reaches of the rivers (Hora, 1938, Malhotra *et al.*, 1973, Chandra, 1962) Rao and Pathak (1972) observed the peak spawning of Hilsa in the river Brahmaputra from May to July. Jones and Sujansinghani (1951) stated that the breeding season of Hilsa in the Chilika Lake is much shorter than in the Hooghly. Hora (1938, 1940) and Hora and Nair (1940) expressed that in the Hooghly Hilsa breeds throughout the year with a major peak in July-August and minor peak in May. Jones and Menon (1950, 1951) have stated that the breeding is restricted, if not stand still during the winter months of December and January.

Pillay (1958) has shown that these are two distinct spawning season in the river Hooghly, one starting in the monsoon season which extends up to November and the other during January-February. Sujansinghani (1957) inferred that the spawning of Hilsa cannot be demonstrated to cease by about January and expressed possibility of restricted spawning during January-February.

Chandra (1962) opined that there is no winter spawning for Hilsa and that the fish breeds during the monsoon months with one peak in August and other in October. Motwani *et al.* (1957) reported that the breeding of Hilsa in Ganga which appear to commence during September to December. Pillay and Rao (1962) observed that there is only one spawning season which lasts from July to November for the Godavari where no winter spawning was observed by them. Pillay (1964) expressed that the presence of maturing, mature and partially spent fish in the sea indicates that Hilsa probably breeds in the sea on the Saurashtra coast. The knowledge on early growth rate of the species in the Hooghly estuary as estimated by De (1986), De *et al.* (1994) and Bhaumik (2010a,b) and Bhaumik and Sharma, (2011)

indicated prolonged spawning season of the species i.e. during August - March with peak in October- November and February-March. Bhaumik (2012) reported availability of Hilsa seed along the entire stretch of the Hooghly round the year indicating the available sizes of the juveniles as 40 mm to 92 mm in December, 50 mm to 90 mm in January, 56 mm to 112 mm in February, 70 mm to 115 mm in March and 75 mm to 149 mm in April. It clearly indicates that major spawning takes place during September–November and minor spawning during June–July and February–March. Bhanot (1973) also reported collection of Hilsa juveniles in the Hooghly estuary round the year indicating the species breeds throughout the year with peak activity in February-March, July-August and October-November.

Al-Hassan, L.A.J., (1999) reported that in Iraqi waters resultant gonadal development indicates that Sbour spawns in the upper reaches Shatt Al-Arab river (probably in the marsh areas) during May-August and then migrate to the sea during September-November when they are landed in Kuwait.

Rahaman *et al.* (2012) reported in Bangladesh spawning of Hilsa occurs almost throughout the year from upstream to the coast at Chittagong and even in the sea off Cox's Bazar. Gonado-somatic Index (GSI) value showed that the peak spawning period is September and October with a minor peak in January-February. The frequency of spawning is still unknown. The spawning cycle of Hilsa is closely synchronized with lunar cycle and aggressive spawning is noticed during new moon and full moon. The perusal of the table 2 reveals spawning seasons in different water bodies across the world.

Hilsa spawns mostly in all fresh water rivers (Hora, 1938; Motwani *et al.* (1957); Chandra, 1962; Queshi, 1968; Mazid and Islam, 1991; Mazid, 1994, 1998). First positive evidence of location of spawning grounds was discovered by Hora (1940) when he identified the young of the species from the Pulta water works tanks, into which they would have gained access only in the form of eggs or early larvae. Pillay (1958) on the basis of ova studies inferred that the lower limits of the spawning grounds of Hilsa is Baghbazar area in Kolkata. Hora (1938) suggested that young immature specimens below one year stay in the river for much longer period and only spawn towards the end of their life or in the second year.

Karmachandani and Pisolkar (1976) identified the location of Hilsa spawning grounds in the Tapti river at a distance of 5-12 km upstream of Bodhan in the vicinity of Pipsra situated about 56 km far the Sea. Karmachandani (1961) reported the location of the freshwater spawning grounds of Hilsa in the Narmada River. Kulkarni (1950 and 1954) located Hilsa spawning grounds at the lower reaches of the Narmada River in the region of about 72 to 88 km from the river mouth. Pillay (1964), on the other hand, suggested that Hilsa on the Saurashtra coast may be marine spawners.

Mazid and Islam (1991) and BFRI/RS (1994) reported one spawning ground in Bangladesh waters in the Hatia-Sandip-Monpura area. There are two main nursery grounds in Bangladesh waters (Mazid and Islam 1991; BFRI/RS, 1994; Mazid, 1998; Rahman and Haldar, 1998). The largest riverine nursery ground is situated in the River Meghna, in and around Chandpur, from Mawa (Munshiganj) down to Hazimara.

The juveniles (2–12 cm) appear in this nursery ground in November and remain up to June, but peak period is approximately 15 February to 15 May. Another large nursery ground is situated in the coastal belt from Kuakata (Patuakhali) to Dubla Island (Khulna). Within this area comparatively large size (11 to 15 cm) Jatka are caught during December-January.

Bhaumik and Sharma (2012) reported that in the Hooghly-Bhagirathi system, stretch between Nishchintpur and Diamond Harbour at downstream, Hooghly Ghat and Kalna in freshwater tidal zone and Lalbagh to Farakka in Bhagirathi River, could be demarcated as potential breeding grounds for Hilsa.

Southwell and Prashad (1918) expressed that there are no fixed breeding grounds for the fish in the generally accepted sense of the term and that they probably breed during the rains when conditions such as weather, temperature and other undetermined factors are suitable. Hora (1938) inferred that the stretch of Hooghly River near Palta Waterworks forms one of the spawning grounds of the fish. This was confirmed by further observations made by Hora and Nair (1940 a) and Jones and Menon (1951). Pillay (1958) inferred that the lower limit of the spawning ground of Hilsa in the river Hooghly is Bagh Bazar in Calcutta. Chandra (1962) has also recorded the freshwater zone of the Hooghly River as the spawning grounds for Hilsa; this was later confirmed by Bhanot (1973). Both Chandra (1962) and Bhanot (1973) could not find any larvae in the tidal or gradient regions of the Hooghly. The Hilsa of Chilika Lake spawns in the lower regions of the Daya River (Jones and Sujansinghani, 1951).

Kowtal (1967 and 1976) observed from collection of eggs and larvae that the Daya

river mouth and the region close to it in the eastern shore of the northern sector are the breeding grounds of the fish. Motwani *et al.*, (1957) have described the spawning ground of Hilsa in the Ganga as the stretch of the river between Patna and Allahabad.

Ghosh and Nangpal (1970) have recorded the lower Ganga and Bagalpur areas to be the spawning grounds for the 'slender' variety of Hilsa in the winter period. The presence of larvae in the neighbourhood of Lalgola in the Padma indicates the probability of the fish spawning in that area also. In the Godavari, Pillay and Rao (1963) inferred that Hilsa breeds below the anicut at Dowlaiswaram to a distance of nearly 35 to 40 miles downstream in two of the three branches of the Godavari; these areas are about 20 to 25 miles from the Sea.

The authors observed that the fish may breed above the anicut also during years of very high floods when the fish are able to migrate above Dowlaiswaram, as evidenced by the presence of young fish in the upper stretches after the subsidence of flood. In the Brahmaputra, Rao and Pathak (1972) have recorded evidence of spawning through collection of larvae and post-larvae of 8-25 mm size.

Haldar (2002) reported that spawning grounds of Hilsa in Bangladesh waters were identified by the occurrence of ripe and oozing males and females and by catching Hilsa larvae/fry through experimental fishing. The lower stretches and estuarine part of the Meghna River was found as the major spawning ground of Hilsa in Bangladesh. Of this, (1) Kalichar Island (down to Sandwip), (2) Moulavirchar (south of Hatia), (3) surrounding of Monpura island (east of Bhola) and (4) Dhalchar island (Charfashion, Bhola) were observed to be as the most significant areas of Hilsa spawning.

Table.1 Fecundity of Hilsa (*Tenualosa ilisha*) from various water bodies

Water body	Fish size (mm)	Fecundity (nos.)	Author
Hooghly estuary	208 -475	44,002-15,54,894	Bhaumik and Sharma (2012)
Ukai (Vallabh Sagar) reservoir	207 – 420	30,097–92,070	Bhaumik <i>et al.</i> (2012)
Tapti	614	29,49,750	Bhaumik <i>et al.</i> (2012)
Hooghly estuary	253 -481	2,50,000-16,00,000	Pillay(1958)
Hooghly estuary	343 -522	3,73,120-14,75,676	De (1986)
Ganga and Yamuna (near Allahabad)	315 -506	2,89,000-11,68,622	Swarup(1961)
Ganga(near Allahabad and Varanasi)	310 -436	3,16,316-18,40,179	Mathur (1964)
Chilika lake	353 -515	3,90,379-11,20,304	Ramkrishnaiah (1972)
Godavari estuary	401 -548	4,00,000-13,00,000	Pillay and Rao (1962)
Narmada	452	18,64,000	Kulkarni (1950)
Padma and Meghna	275-483	90,000-20,00,000	Queshi (1968)
Padma	273-420	3,48,318-14,65,969	Doha and Hye (1971)
Meghna	380-520	3,80,000-18,20,000	Shafi <i>et.al.</i> , (1977)
Padma and Meghna	330-510 (Broad variety) 260-470 (Slender variety)	6,00,000-15,00,000 4,00,000-6,70,000	Quddus (1982)
Padma and Meghna	342-520 (Broad variety) 260-470 (Slender variety)	6,60,000-15,47,000 3,99,000-670,000	Quddus <i>et al.</i> , (1984)
Meghna	267-523	2,26,000-13,90,000	Moula <i>et al.</i> (1991)
Indus (Pakistan)	358-550	7,55,000-29,17,000	Bhuiyan and Talbot (1968)
Khuozestan river, Kuwait	380-500	37,482-19,54,144	Al-Baz and Grove (1995)
Meghna	287-523	2,26,000-19,31,000	Rahman, 1998
Ramgoti (Luxmipur)	355-470	1,35,600-17,03,200	Haldar, 2004
Chandpur/Ramgoti	240-480	1,12,554-9,50,625	BFRI, 2006-07
Iranian water	330-415	16,16,560	Coad (1947)
Indus (Pakistan)	200-250 251-300 301-350	1,13,483 3,82,105 5,72,709-6,14,482	Panhwar <i>et al.</i> , 2011
Satt Al-Arab (Iraq)	-	1,00,000-20,00,000	Laith A.j.Al-Hassan, 1999

Table.2 Spawning seasons of the Hilsa shad (*Tenulosa ilisha*) in different water bodies

Study area/water body	Peak Season(s)	Lean Season(s)	Reference
The Hooghly	May and July-August	All other months	Hora and Nair (1940) and Hora (1941)
The Hooghly	July-November	January-March	Pillay (1958)
The Ganga	September-December	July-August	Motwani <i>et al.</i> (1957)
The Ganga	March and August	January-February and June-July	Nair (1985)
The Ganga	September-November	--	Chandra <i>et al.</i> (1987)
The Narbada	August	June-July and September	Karamchandani (1961)
The Saurashtra coast	April-May	---	Pillay (1962)
The Godavari	August-November	---	Pillay and Rao (1962)
The Hooghly	August-March	All other months	De, 2001
The Hooghly	February-March, July-August and October-November	All other months	Bhanot (1973)
The Hooghly-Bhagirathi	September-November and February-March	June-July	Bhaumik (2012)
Bangladesh waters	October-November, July-August and February-March	All other months	Mazid (1994)
The Meghna	January-March and July-October	----	Shafi <i>et al.</i> (1978)
The Godavari	August-November	February-April	Pillay and Rao (1962)
The Meghna	October-November	All other months	Moula <i>et al.</i> (1991)
Bangladesh waters	Monsoon and winter	All other months	Raja (1985)
The Padma (type A)	July-October	All other months	Quddus <i>et al.</i> (1984)
The Padma (type B)	January-March	All other months	Quddus <i>et al.</i> (1984)
The Hooghly Estuary	August-October	All other months	Chandra (1962)
The Ganga	Post winter	All other months	Ghosh and Nangpal (1970)
Bangladesh waters	October-November	June-July and January-March	BOBP (1987)
Kuwaiti waters	June	May-July	Al-Baz and Grove (1995)
Shatt Al-Arab (Iraq)	May-August	----	Al-Hassan, L.A.J (1999)
Sind (Pakistan)	May to October	----	Panhwar <i>et al.</i> 2011
Shatt Al-Arab(Iraq)	March to September	----	Hussain <i>et al.</i> 1991, and 1994; Jabir, 1995

Queshi (1968) reported in the Indus River in Pakistan the spawning grounds have been restricted by the construction of the Gulam Mohamed Barrage, below which Hilsa spawns. Queshi (1968) indicated that *Tenulosa ilisha* spawns in fresh water stretches of rivers about 85 to 170 km away from the sea.

Van den Eaalart (1954) working in Iraq did not have any opportunity to determine accurately the spawning grounds of the species, but indicated that the main grounds are probably in the Euphrates, somewhere between Shinafia and Samawa and in the Tigris between Amara and Qalat Saleh.

Conclusion

There is an urgent need towards conservation of Hilsa in view of the present interest for sustaining its fishery in the world. Intensive fishing in all the water bodies is to be controlled without further lapse of time. In order to maintain sustainable yield and also increase production, regulation of selective fishing by adjusting mesh size of the gears and simultaneous control of juvenile destruction should be encouraged.

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