Iranian Journal of Fisheries Sciences 13(1)201-215 2014

Reproductive biology of Hilsa shad (*Tenualosa ilisha*) in coastal Waters of the Northwest of Persian Gulf

Roomiani, L.*[1], Sotudeh, A. M.[2] and Hakimi Mofrad, R[3].

Received: September 2012 Accepted: October 2013

Abstract

Some aspects of the reproductive biology of Hilsa Shad, *Tenualosa ilisha* from the Persian Gulf and rivers of Khouzestan Province of Iran were analyzed. A total of 485 fish were sampled by gillnet from landing center of Arvand (AR) and Bahmanshir (BR) rivers during period of April 2010 to September 2010. Reproductive characteristic of *T.ilisha* showed that sex ratio is M: F=1:2, in PG, AR and BR. This means that females predominate than males. 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. The Length - Weight relationship was measured for PG as $W= 1.459L^{2.687}$, AR and BR as $W=2.189L^{3.166}$ and $W=1.840L^{2.937}$, respectively.

Keywords: *Tenualosa ilisha*, Biological parameters, GSI, Sex ratio, Persian Gulf.

1- Department of Fisheries, Khouzestan Science and Research Branch, Islamic Azad University, Ahvaz, Iran

2- Department of Fisheries, Bandar Abbas Branch, Islamic Azad University, Bandar Abbas, Iran

3- Department of Fisheries, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran

*Corresponding author's email: L.roomiani@yahoo.com

Introduction

Five species of tropical shads (Clupeidae: *Tenualosa* spp.) live in the estuaries and coastal waters of tropical Asia. The most widespread and well studied species is *T.ilisha*. The Hilsa shad, belonging to the sub-family Alosinea of the family Clupeidae (Clupeiformes, Pisces), occurs in foreshore areas, estuaries, brackish- water lakes and freshwater rivers of the western division of the Indo-Pacific region. Its marine distribution extends from Iran and Iraq in the Persian Gulf to the west coast of India in the Arabian Sea and the Bay of Bengal (Ahmed et al., 2008). In Persian Gulf this fish migrates to Arvand river and Bahmanshir river for spawning.

Hilsa shad supports a commercial fishery and in the early 1970s composed more than 95 % of the total commercial catch in Bangladesh (Coad et al., 2003). The fishery provides livelihood to about 2.5 million people (about 2% of the total population) directly or indirectly (Mazid et al., 2007). The average annual landing of this species in 2006 was 4989.83 t and constituted about 15 % of Khouzestan Province total commercial fish landing. During 2008, 4645 t of *T.ilisha* were landed in the Khouzestan Province (Northwest of Persian Gulf). The reduction in the depth and discharge of rivers due to construction of dams has affected the spawning, feeding and migration of this fish (Roomiani and Jamili, 2011).

T.ilisha is a very important food fish in south- west of Iran. The Hilsa shad is an anadromous species, but two other ecotypes - a fluvial potamodromous type and a marine type - have been recognized. The potamodromous stocks appear to remain in the middle reaches of the rivers throughout the year and breed there in. The anadromous stocks, whose normal habitat is the lower region of the estuaries and the foreshore areas, ascend the rivers during the breeding season and return to the original habitat after spawning (Panhwar et al., 2011). The upstream migration during the main breeding season depends largely on the commencement of the Southwest monsoon and consequent flooding of the major rivers of Iran, Bangladesh, Burma and India. However, the exact spawning season for the species is still controversial, as spawning varies from a few months to all the year round. However, it is not known whether migratory populations mix during migration or whether they pass each other spatially and temporally (Coad et al., 2003).

Therefore, the exact stocks are still in dispute. As for other tropical fish, ageing of Hilsa is problematic, because of the absence of annual rings on scales (Rahman and Cowx, 2006). Most of studies on this species have been carried out in Bangladesh (Mazumder and Alam, 2009; Amin et al., 2009; Amin et al., 2008; Mazid et al., 2007; Rahman and Cowx, 2006; Haldar and Amin, 2005; Salini et al., 2004), in Pakistan conducted by Narejo et al., (2008), Hussain et al., (2010) and in India by Brahmane et al., (2006). In Iran, few studies have been done on the biological characteristics (Marammazi, 1995; Marammazi et al., 1998; Hashemi et al., 2010; Roomiani and Jamili, 2011).

The present study deals with the biological characteristic of *T. ilisha* in the Khuzestan Province of Iran.

Materials and methods

485 specimens of *T.ilisha* were collected from April 2010 to September 2010 during migration season from AR and BR and PG (Fig. 1). To avoid gillnet selectivity different landing centers were selected as different mesh of gillnet are used to catch the Hilsa fish on the availability of different size group of fishes. Total length and weight of specimens were measured in 'cm' and 'g' by board and digital scale, respectively.

Figure 1: The location of the study area

The length-weight relationship was calculated by the equation:

$$W = a L^b$$

where W is the total body weight (g), L is the total length (cm), (a) is a coefficient related to the body form and (b) is exponent indicating isometric growth when equal to 3 (Wootton, 1990). a and b parameters were estimated by linear regression on the transformed equation:

$$\text{Log10 (W)} = \log10\ a + \log10\ (L).$$

To determine sexual maturity, gonads from male and female were weighted and morphologically examined. In order to determine, Gonadosomatic Index (GSI) value for each month, were used according to the following formula:

$$GSI\ (\%) = \text{Gonad weight (g)} \times 100 / \text{Body weight (g)}.$$

The spawning seasons determined based on the monthly changes of GSI indices and proportions of each maturity stage (Zhang et al., 2009).

In the laboratory, gonads removed of excess of connective tissue, identified to gender and external macroscopic characteristics were recorded.

Sex ratio, which, the monthly proportion of male to the sum of male and female, was used to predict and estimate the spawning capability of fish.

A chi-square (X^2) test was used to detect differences in sex ratios of sampled fish. A chi-aquare test (X^2) was used according to the following formula:

$$X^2= (O-E)^2 / E$$

O: Observed of ratio and E: Expected (Predicted) of ratio (Sokal and Rohlf, 1995). The t-test was used in order to compare the difference between the sexes. All the statistical analysis was done by SPSS 14.0 software.

Results

-Length-frequency and Weight - frequency distribution of *T. ilisha*

A total of 485 *T.ilisha* were investigated. Amongest them, 165 were males, 320 females. The males were predominant in the smaller lengths and females in the larger lengths. Males were significantly smaller in length than the females ($p<.05$).

In PG, the mean length of male and female *T. ilisha* was 364.82 and 385.76 cm, AR and BR, 361.80, 380.12 and 381.00, 403.11 cm, respectively. In PG, the mean weight of male and female *T. ilisha* was 522.35 and 645.84 g and AR and BR, 587.66, 697.50 and 595.06, 722.83 g, respectively (Tables. 1, 2 and 3).

Table 1: Length and weight distribution of female and male of *T. ilisha* in PG

Month	N	Length (cm)		Weight (g)	
		Range	Average± SD	Range	Average± SD
			Female		
April	13	339-410	385.76±20.62	420.00-796.00	645.84±30.12
May	8	303-400	361.62±64.42	323.00-851.00	581.62±23.41
June	23	300-400	328.95±26.01	351.00-751.60	460.48±20.66
July	20	285-432	340.75-30.94	275.00-949.00	485.68±22.45
August	21	300-379	327.71-20.69	297.40-606.50	406.74±19.88
September	23	298-400	340.52±28.67	287.30-775.00	434.32±21.11
			Male		
April	17	331-388	364.82±16.21	402.00-643.00	522.35±22.00
May	7	286-405	344.14±47.06	258.00-733.00	493.85±24.00
June	8	297-367	324.87±27.46	342.00-599.30	435.76±19.78
July	9	315-390	339.22±22.11	335.00-660.00	438.34±21.66
August	8	295-360	325.25±21.85	290.95-532.70	397.78±17.77
September	7	279-370	322.42±34.61	230.90-605.00	389.65±16.34

Table 2: Length and weight distribution of female and male of *T. ilisha* in AR

Month	N	Length (cm)		Weight (g)	
		Range	Average± SD	Range	Average± SD
		Female			
April	6	323-401	357.00±31.52	354.0-684.0	486.00±17.99
May	8	335-410	366.50±26.16	434.0-946.0	627.87±26.66
June	16	315-406	380.12±26.01	379.0-882.0	697.50±30.00
July	19	299-432	367.80±28.09	331.5-981.0	631.78±28.99
August	22	280-320	296.50±10.57	260.0-380.0	321.84±15.76
September	20	285-359	323.88±10.57	250.0-420.0	320.57±14.00
		Male			
April	9	288-331	302.50±19.36	260.0-410.0	307.25±13.33
May	7	333-382	356.85±18.10	447.0-664.0	519.00±16.55
June	6	350-376	366.00±18.02	486.0-679.0	587.66±20.99
July	5	335-374	361.80±16.05	379.5-602.0	527.40±18.78
August	8	275-303	286.60±11.84	220.0-300.0	258.75±12.99
September	13	260-338	293.95±17.15	196.0-289.0	254.87±12.66

Table 3: Length and weight distribution of female and male of *T. ilisha* in BR

Month	N	Length (cm)		Weight (g)	
		Range	Average	Range	Average
		Female			
April	13	342-430	398.69±29.26	435.0-910.0	711.23±23.45
May	14	353-433	401.16±27.69	472.0-907.0	722.83±29.00
June	21	325-440	403.11±30.56	350.0-710.0	639.58±19.99
July	25	305-432	357.16±42.73	320.0-1000.0	580.32±12.22
August	26	302-445	355.66±51.40	325.0-1084.6	611.18±16.44
September	22	300-350	321.36±16.27	289.3-420.5	338.99±10.77
		Male			
April	17	354-401	379.23±15.48	449.0-752.0	595.06±16.66
May	18	338-361	380.00±20.37	432.0-533.0	453.65±12.99
June	9	332-418	381.00±27.75	420.0-545.0	535.23±15.34
July	5	347-382	346.50±13.46	453.0-629.0	515.24±14.32
August	4	375-340	346.00±18.92	439.0-610.3	480.21±13.22
September	8	265-300	286.60±13.27	196.3-289.0	297.35±10.00

In AR and BR, the bigger size of female and male *T. ilisha* was observed during the months April to June.

Length-weight regression was calculated separately for three study area. The logarithmic form of length-weight relationship of *T.ilisha* in PG was:

Log W= 2.687 Log L- 1.459

In AR and BR were:

Log W= 3.166 Log L- 2.189 and log W= 2.937 Log L- 1.840

The value of co-efficient of correlation (r) estimated for this species in PG, AR and BR was 82.95 and 93.00 ($p<.01$) respectively, which indicated that the relationship between length and weight of the fish was highly significant. It was observed that the weight bears a linear relationship after logarithmic transformation (Figs 2, 3 and 4).

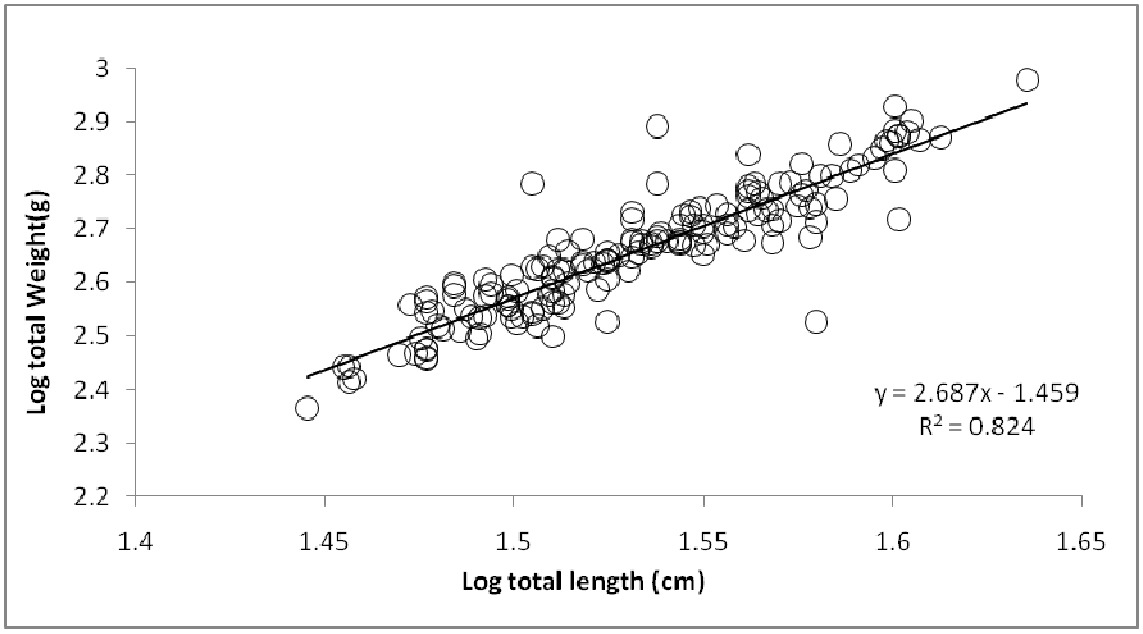

Figure 2: Relationship between log total length and log body weight of *T. ilisha* in PG

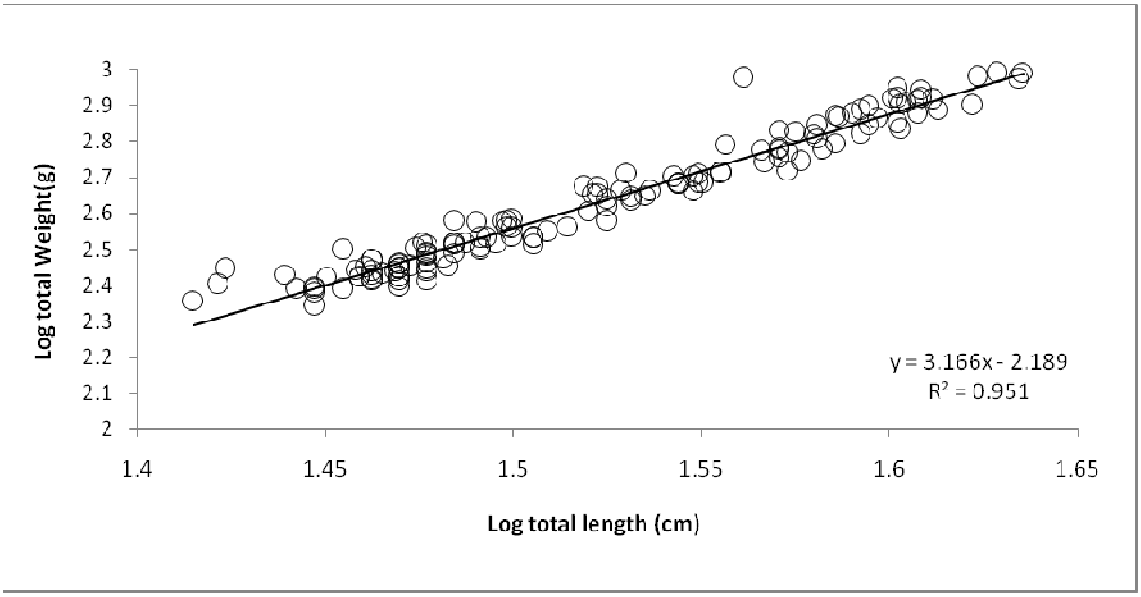

Figure 3: Relationship between log total length and log body weight of T. ilisha in AR

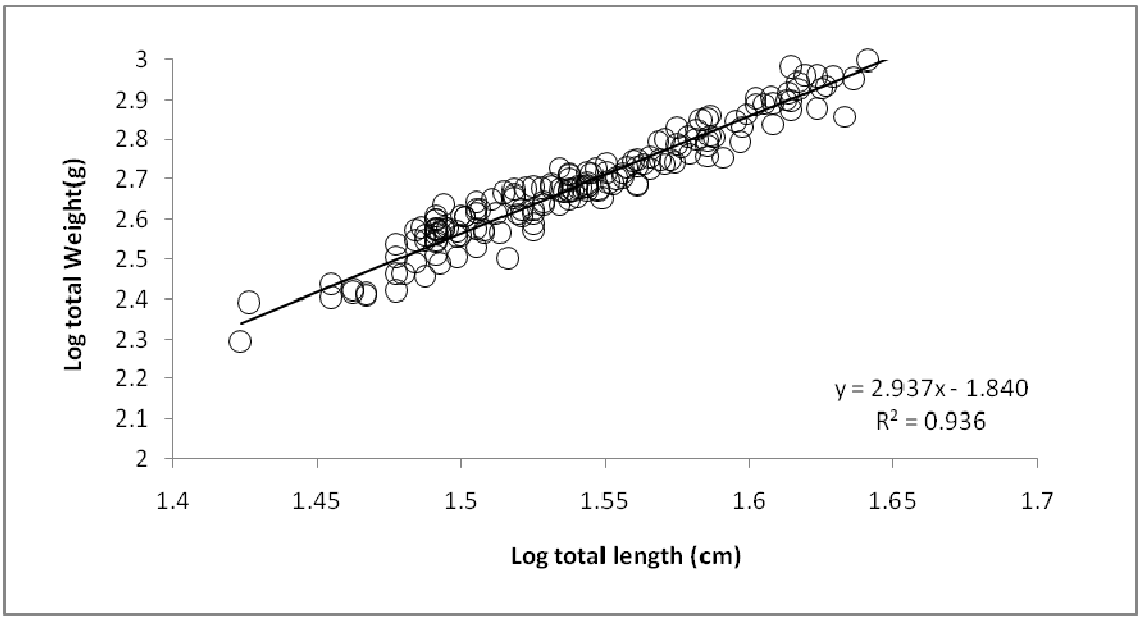

Figure 4: Relationship between log total length and log body weight of *T. ilisha* in BR

For *T. ilisha*, the sex ratio of the collected samples was M: F= 1:2 for whole study area. This means that females predominate of males. The sex ratio is not constant throughout the different months.

Chi-square analysis of the sex ratio by month showed significant difference from the theoretical 1:1 sex ratio ($p<.05$) ($p<.0001$, χ^2 = 44.28 in PG, AR: 47.91, BR: 64.69, df= 1) (Figs. 5, 6, 7)·

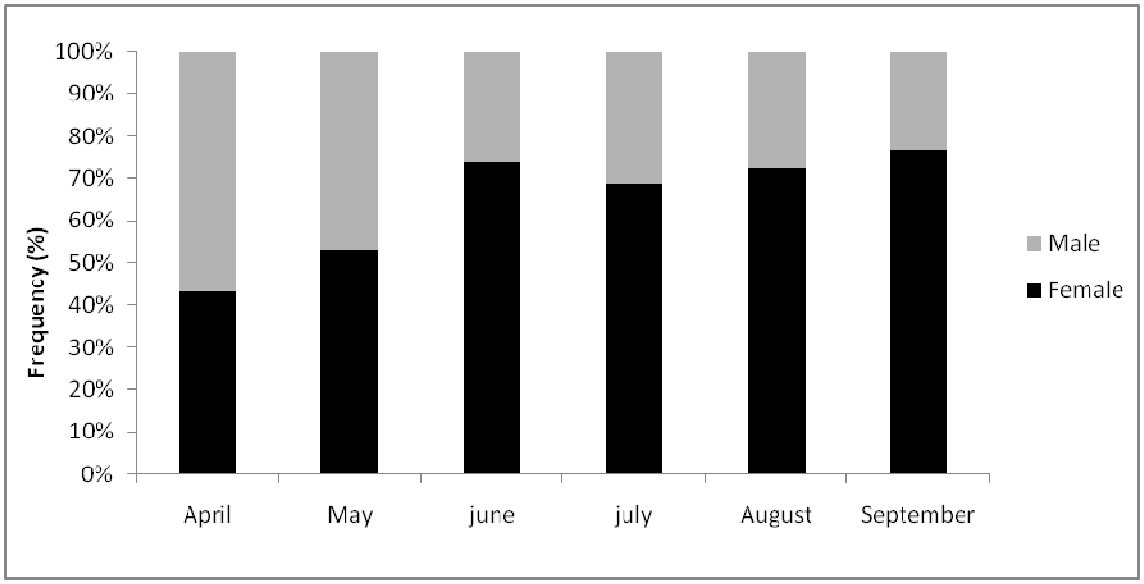

Figure 5: Percentage composition of male and female *T .ilisha* in different months of the year in Persian Gulf

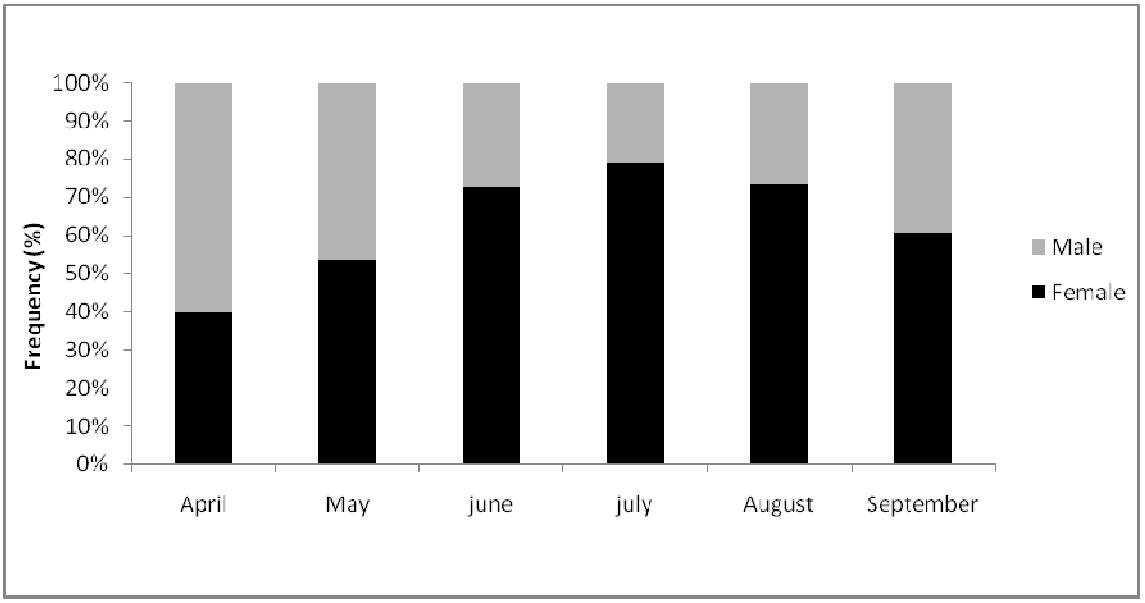

Figure 6: Percentage composition of male and female T .ilisha in different months of the year in Arvand River

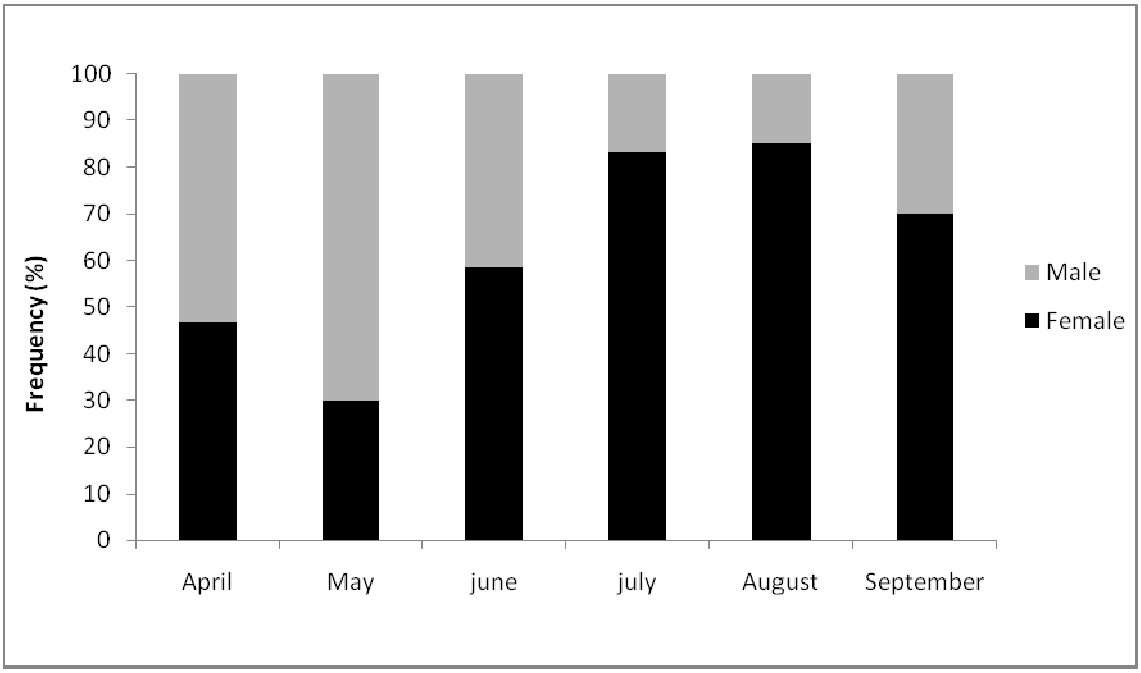

Figure 7: Percentage composition of male and female *T .ilisha* in different months of the year in Bahmanshir River

Reproductive seasonality was determined by monthly inspection of the development stages and by a GSI calculated monthly for each sex. Monthly variation in GSI of both sexes was quiet apparent. Maximum values were recorded in April in PG for male and female. In AR and BR maximum values were recorded in June and May for male and female, respectively (Figs. 8, 9, 10). In both sexes, in PG, the GSI increased significantly in May and reached a peak in April, and then dropped sharply in July. In AR and BR, the GSI increased in May and reached a peak in June and dropped in August. In BR, the GSI, increased significantly in May and reached a peak in June and dropped in September.

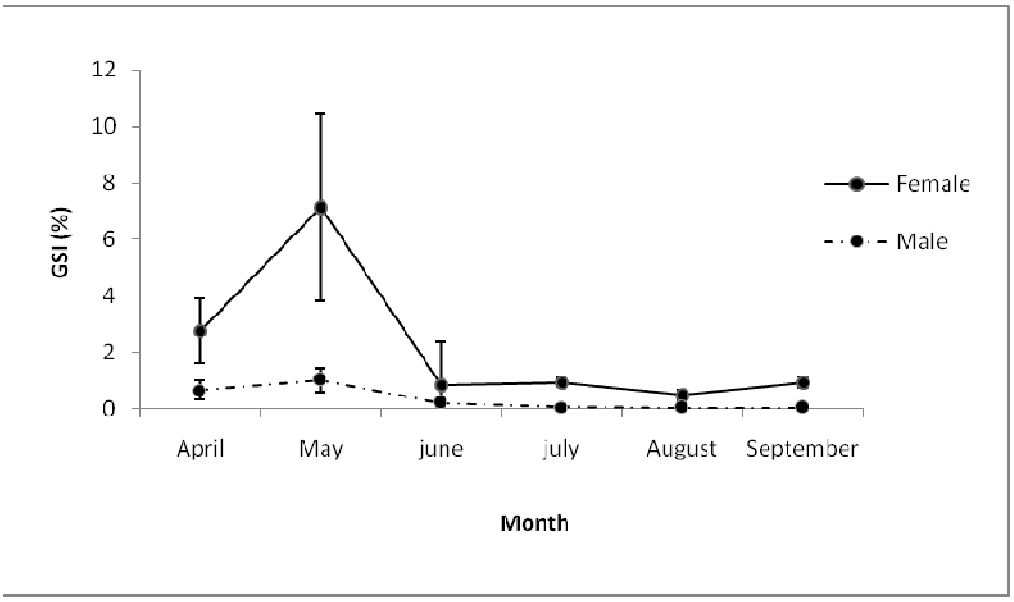

Figure 8: Monthly variation of the average GSI of female and male *T .ilisha* in Persian Gulf

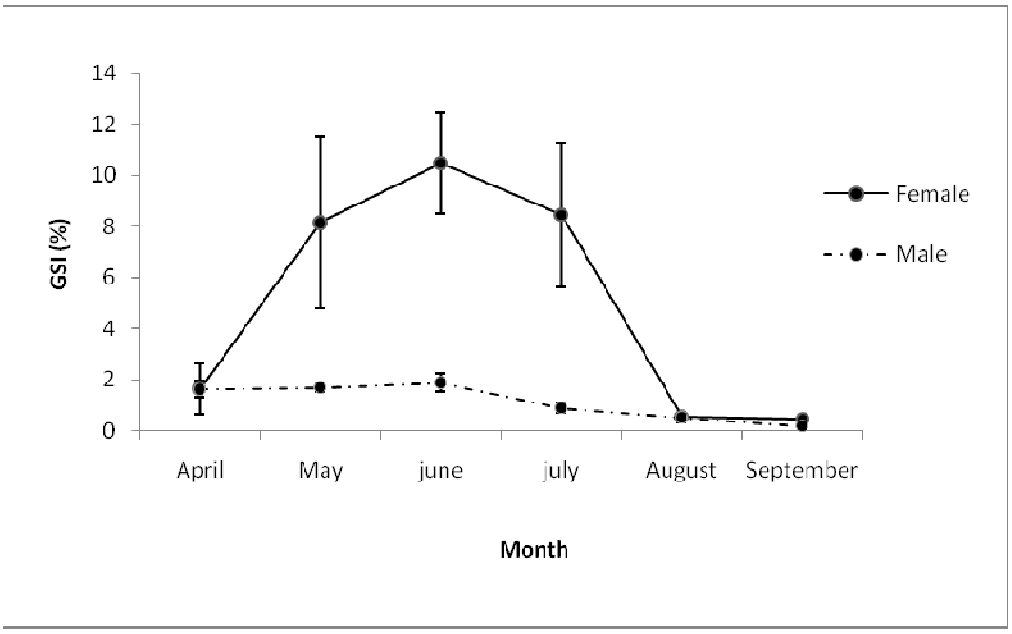

Figure 9: Monthly variation of the average GSI of female and male *T .ilisha* in Arvand River

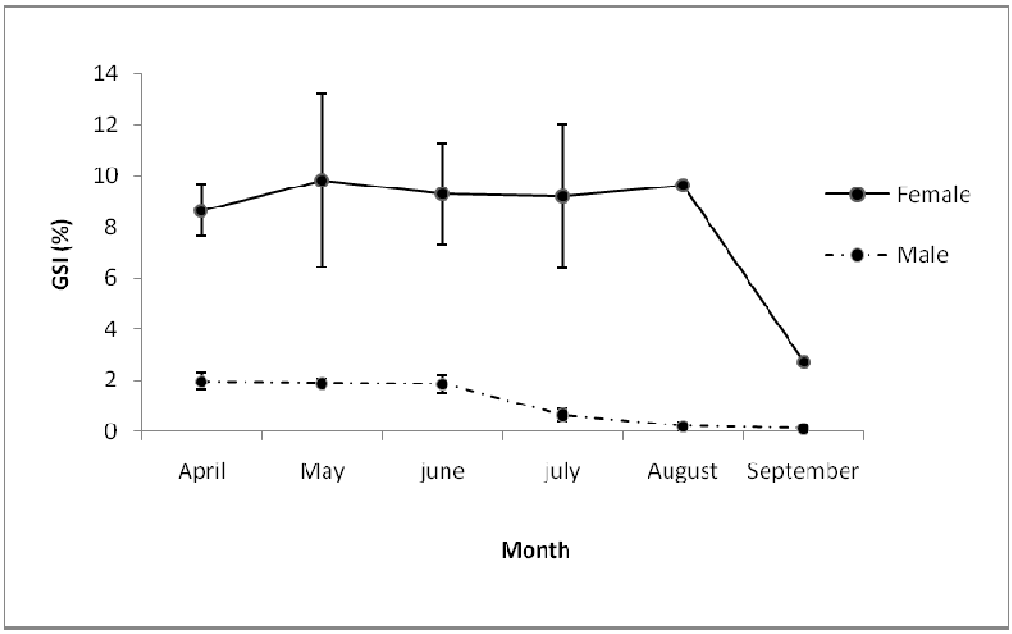

Figure 10: Monthly variation of the average GSI of female and male *T. ilisha* in Bahmanshir River

Discussion

Change of sex ratio corresponding to the body length is an important parameter which may be directly related with growth rate, natural and fishing mortalities (Guoping et al., 2008). In this study, the sex ratio of *T. ilisha* was M: F= 1:2. This sex ratio was changed between different months, but female predominate males. Dominance of females over the males complies with the results of Amin et al., (2005) (males to females 1:5.09). Contradictory views have been expressed by previous investigations on the sex ratio of *T. ilisha* populations (Quddus et al., 1984a; Ahmed and Saha, 1996). These variations may be caused by males and females often moving in separate shoals. Several reasons suggested for the unequal sex ratios (Zhang et al., 2009).

These include differences in mortality, growth and longevity, sex reversal, sex different in activity and migration in and out of the sampling area. However, these results were different from the sex ratios observed in the present study. This difference in seasonal trends between studies could be due to spatial effects caused by not partitioning the samples into the Persian Gulf, and the low sample size that would impede analysis of spatial differences. Nevertheless, it is evident that sex ratio at size varies temporally and spatially, as indicated by other studies (Arocha and Barrios, 2009).

Studies on sex ratio in *T.ilisha* have been made by Shafi et al., (1974 and 1978), Quddus et al. (1984a), Amin et al., (2005). These authors have reported dominance of either males or females in some months or seasons and showed the observed sex ratio was significantly different from the expected ratio of 1:1. In Kuwait coastal waters of PG, Al-Baz and Grove (1995) observed that females dominated throughout almost the entire year. Male to female ratio was 1:2.4. The present findings on sex ratio are generally consistent with those in Kuwait. It is very likely that this difference is caused by a differential rate of growth, hence the dominance of males in the smaller sizes and their absence in the larger sizes.

The length - weight relationship of male and female of *T.ilisha* showed that the growth is isometric. The correlation coefficient values were very close to 0.99, which indicates that the relationships between total length and weight of this species was highly significant ($p<.05$). This finding agrees with the results of Ahmed and Saha (1996). The results clearly indicated that the mean length of female was significantly higher than male *T.ilisha* ($p<.05$).

Amin et al., (2009) showed that the exponent 'b' usually lies between 2.5 and 4. The value of 'b' will be exactly '3' when the growth is isometric. The value of 'b' differs not only between species but sometimes also between the stock of the same species due to sex, maturity, seasons and even time of day because of changes in stomach fullness.

The regression coefficient (b) of the length-weight relationship of *T.ilisha* in the Khouzestan Province of Iran lies between 2.68 to 3.16 as Amin et al., (2005) suggested are reasonable values for this species. In Kuwait coastal waters of PG (b) value ranged from 2.98 to 3.1 (Al-Baz and Grove, 1995). Studies in Bangladesh and India (Ramakrishnaiah, 1972; Shafi and Quddus, 1974; 1978; Quddus et al., 1984b; Amin et al., 2002; 2004; 2005) found the (b) of *T.ilisha* to be in the range 2.76-3.38. These values are similar to those obtained for Iran fish. The small changes could be due to the different environmental conditions (Blaber et al., 2003). A marked decline was observed in mean length and weight of male and female during the months of August and September. This might be the cause of peak spawning period of *T.ilisha* in the months of June and July and subsequent recovery after this month.

The seasonal variation of GSI is consistent with the percentage composition of each maturity stage in gonads, suggesting that the spawning season of *T.ilisha* in Khouzestan Province (AR and BR) is from May to August. It was seen from sex distribution that the two sexes did not occur in the same proportion throughout the year. Different spawning periods have been observed for *T.ilisha*. This study found that *T.ilisha* spawns in May to August. In Kuwaiti coastal waters of PG showed that *T.ilisha* spawns in May to July with a peak in June. Unpublished data from Kuwaiti Institute for Scientific Research (KISR), regarding to a *T.ilisha* survey in the AR shows that this species spawns during May - August with a peak in May - June (AL-Baz and Grove, 1995). These differences in the spawning periods of populations in different

area may be due to genetics and environmental factors as mentioned before.

Reference

Ahmed, K. K. and Saha, S. B., 1996. Length-weight relationships of major carps in Kaptai Lake, Bangladesh. NAGA, 19(**2**), 22.

Ahmed, M. S., Sharif, A. S. M. and Latifa, G. A., 2008. Age, growth and mortality of Hilsa shad, *Tenualosa ilisha* in the River Meghna, Bangladesh. *Asian Journal* of *Bio Science*, 1, 69-76.

AL – Baz, A. F. and Grove, D. J., 1995. Population biology of Sobour, *Tenualosa ilisha* (Hamilton – Buchanan) in Kuwait. Asian Fisheries Society, 8 (**3-4**), 239 – 254.

Amin, S. M. N., Rahman, M. A., Haldar, G. C., Mazid, M. A. and Milton, D., 2002. Population dynamics and stock assessment of Hilsa Shad in Bangladesh. *Asian Fisheries Science*, 15, 123-128.

Amin, S. M. N., Rahman, M. A., Haldar, G. C., Mazid, M. A., Milton, D. A. and Blaber, S. J. M., 2004. Stock Assessment and Management of *Tenualosa ilisha* in Bangladesh. *Asian Fisheries Society,* 17, 50- 59.

Amin, S. M. N., Arshad, A., Haldar, G. C., Shohaimi, S. and Ara, R., 2005. Estimation of Size Frequency Distribution, Sex Ratio and Length-Weight Relationship of Hilsa (*Tenualosa ilisha*) in the Bangladesh Water. *Research Journal of Agriculture and Biological Sciences*, 1(**1**), 61-66.

Amin, S. M. N., Rahman, M. A., Mazid, M. A., Haldar, G. C. and Milton, D. A., 2008. Catch per unit effort, exploitation level and production of Hilsa Shad in Bangladesh waters. *Asian Fisheries Society*, 21, 175-187.

Amin, S. M. N., Arshad, A., Siraj, S. S. and Japar, S. B., 2009. Population structure, growth, mortality and yield per recruit of segestid shrimp, *Acetes japonicus* from the coastal waters of Malacca, Peninsular Malaysia. Indian Journal *of Marine Sciences***,** 38, 57-68**.**

Arocha, F. A. and Bárrios, A., 2009. Sex ratios, spawning seasonality, sexual maturity and fecundity of white marlin (*Tetrapturus albidus*) from the western central Atlantic. *Fisheries Research*, 95, 98-111.

Blaber, S. J. M., Milton, D. A., Chenery, S. R. and Fry, G., 2003. New insights into the life history of *Tenualosa ilisha* and fishery implications. American Fisheries *Society Symposium*, 35, 223–240.

Brahmane, M. P., Das, M. K., Sinha, M. R., Sugunan, V. V., Mukherjee, A., Singh, S. N., Prakash, S., Maurye, P. and Hajra, A., 2006. Use of RAPD fingerprinting for delineating populations of hilsa shad *Tenualosa ilisha* (Hamilton, 1822). *Genetics and molecular research,* 5, 643-652.

Coad, B. W., Hussaina, N. A., Ali, T. S. and Limburg, K. E., 2003. Biodiversity, Status and Conversation of the World Shads. American Fisheries Society, Bethesda, Maryland. 123P.

Guoping, Z., Liuxiong, X. U., Yingqi, Z. and Liming, S., 2008. Reproductive Biology of Yellowfin Tuna *T. albacares* in the West-Central Indian Ocean. *Oceanic and Coastal Sea Research.* ISSN 1672-5182, July 30, 7(**3**), 327-332.

Haldar, D. C. and Amin, S. M. N., 2005. Populations dynamics of male and female Hilsa,

Tenualosa ilisha of Bangladesh. *Pakistan Journal* of Biological Sciences, 8, 307-313.

Hashemi, S., Mohammadi, G. and Eskandary, G., 2010. Population Dynamics and Stock Assessment of Hilsa Shad, *(Tenualosa ilisha* Hamilton- Buchanan, 1822) in Coastal Waters of Iran (Northwest of Persian Gulf). *Australian Journal of Basic and Applied Sciences*, 4(**12**), 5780-5786.

Hussain, S. M., Papemo, R. and Khatoon, Z., 2010. Length- Weight relationship of fishes collected from the Korangi-Phitti Creek area (Indus Delta). *Journal of Applied Ichthyology*, 26, 477-480.

Marammazi, J., 1995. Survy biology *Tenualosa ilisha*, South of Iran Aquaculture Research Center, Ahwaz. Iran. 212P. (in Persian)

Marammazi, J., AL-Mukhtar, M. A. and Kiabi, B. H., 1998. Comarison of morphometric and meristic traits and length frequency in soboor (*Tenualosa ilisha*) of the migration pathways in Khouzestan Province. Pajouhesj-va-Sazandegi, 11, 113-121. (in Persian)

Mazid, M. A. M., Rahman, J. and Mustafa, M. G., 2007. Source and abundance of Jatka (juvenile hilsa, *Tenualosa ilisha*) in the Gajner *beel*, Sujanagar, Pabna. *Bangladesh Journal of Fisheries* (Special Issue) , 30, 37-51.

Mazumder, S. K. and Alam, M. D. S., 2009. High levels of genetic variability and differentiation in hilsa shad, *Tenualosa ilisha*, populations revealed by PCR-RELP analysis of the mitochondrial DNA D-loop region. *Genetics and Molecular Biology*, 32, 190-196.

Narejo, N. T., Lashari, P. K. L. and Jafri, S. I. H., 2008. Morphometric and Meristic Differences between Two Types of Palla, *Tenualosa ilisha* (Hamilton) from River Indus, *Pakistan. Pakistan Journal of Zoology*, 40(**1**), 31-35.

Quddus, M. M. A., Shimizu, M. and Nose,Y., 1984a. Meristic and morphometric differences between two types of *Hilsa ilisha* in Bangladesh waters. *Bulletin of the Japanese Society of Scientifc Fisheries*, 50(**1**), 43- 49.

Quddus, M. M. A., Shimizu, M. and Nose, Y., 1984 b. Comparison of age and growth of two types of *Hilsa ilisha* in Bangladesh waters. Bulletin of the Japanese Society of Scientific Fisheries, 50(**2**), 177-181.

Panhwar, S. k., Siddiqui, G. and Zarrien, A., 2011. Reproductive pattern and some biological features of anadromous fish *Tenualosa ilisha* from Pakistan. *Indian Journal of Geo- Marine Sciences*, 40(**5**), 687-696.

Rahman, M. J. and Cowx, I. G., 2006. Lunar periodicity in growth increment formation in otoliths of hilsa shad (*Tenualosa ilisha*, Clupeidae) in Bangladesh waters. *Journal of Fisheries Science*, 81, 342-344.

Ramakrishnaiah, M., 1972. Biology of *Hilsa ilisha* (Hamilton) from the Chilka Lake with an account on its racial status. *Indian Journal of Fisheries*, 19, 35-53.

Roomiani, L. and Jamili, S., 2011. Population Dynamics and Stock Assessment of Hilsa Shad, *Tenualosa ilisha* in Iran (Khuzestan Province). *Journal Fisheries and Aquatic Science*, ISSN: 1816-4927.

Salini, J. P., Milton, D. A., Rahman, M. J. and Hussain, M. G., 2004. Allozyme and morphological variation throughout the geographic range of the tropical shad, *Tenualosa ilisha. Fisheries Research*, 66, 53–69.

Shafi, M. and Quddus, M. A., 1974. The length-weight and length – girth relationship and condition in *Hilsa ilisha* Hamilton – Buchanan (Clupeidae). *Bangladesh Journal of Zoology,* 2(**2**), 150-343.

Shafi, M., Quddus, M. M. A. and Islam, N., 1978. Maturation and spawning of *Hilsa ilisha* (Ham.-Buchanan) of the River Meghna. Dacca University, B, 26**,** 63-71.

Sokal, R. R. and Rohlf, F. J., 1995. Biometry: the principles and practice of statistics in biological research.3rd edition.W.H. New York, 887P.

Wootton, R. J., 1990. Ecology of teleost fishes. Chapman and Hall. London, 404P.

Zhang, J., Takita, T. and Zhang, C., 2009. Reproductive biology of *Ilisha elongata* (Teleostei: Pristigasteridae) in Ariake Sound, Japan: Implications for estuarine fish conservation in Asia. Estuarine, *Coastal and Shelf Science*, 81, 105–113.