Journal of
Fisheries and Aquatic Science

ISSN 1816-4927

Academic
Journals Inc.

www.academicjournals.com

OPEN ACCESS Journal of Fisheries and Aquatic Science

ISSN 1816-4927
DOI: 10.3923/jfas.2017.82.89

Research Article
Some Reproductive Aspects of Freshwater Garfish, *Xenentodon cancila* (Hamilton, 1822) from North-East Bangladesh

[1,3]Sohel Mian, [1]Sumi Dash Papree, [2]Tanwi Dey, [1,4]Mohammad Amzad Hossain, [1]Mohammed Mahbub Iqbal, [3,6]Ambok Bolong Abol-Munafi and [5]M. Sadiqul Islam

[1]Department of Fisheries Biology and Genetics, Sylhet Agricultural University, Sylhet, Bangladesh
[2]Department of Aquaculture, Sylhet Agricultural University, Sylhet, Bangladesh
[3]School of Fisheries and Aquaculture Sciences, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Malaysia
[4]College of Science and Technology, Université de Bordeaux, Bordeaux, France
[5]Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh, Bangladesh
[6]Institute of Tropical Aquaculture, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia

Abstract

Background and Objective: Proper knowledge on reproductive biology is important for the successful management of fisheries, aquaculture and conservation of a target species in the wild. The present study was investigated to uncover the reproductive biological information including the spawning season of *Xenentodon cancila*. **Materials and Methods:** About 325 *Xenentodon cancila* samples were collected from the waters of North-East Bangladesh for a period of 1 year. Data on length, weight, sex ratio, condition factor, fecundity and Gonado Somatic Index (GSI) were recorded to uncover the breeding biology of this fish in wild condition. **Results:** The length ranged between 20.20-23.91 cm (Mean±SD = 20.57±2.59) and their weight ranged between 19.70-43.85 g (Mean±SD = 30.22±8.12). Females were dominant in larger length groups being most apparent during the resting phase of reproductive cycle and in the peak of the spawning period, occurring in the month of June. The sexual ratio of all specimens was m/f = 1:1.11. The mean batch fecundity was 1789.69±347.06 of matured oocytes per ovary. Gonado somatic index data showed continuously increasing trend during the months of January-April until it reaches to the peak in June and followed by gradually decreasing in the months of September-November. **Conclusion:** On the basis of the collected data, it can be concluded that spawning season for this fish in wild ranged from April-August while peak in June in weather condition of North-East Bangladesh.

Key words: Reproductive biology, freshwater garfish, sex ratio

Received: November 29, 2016 Accepted: January 18, 2017 Published: February 15, 2017

Citation: Sohel Mian, Sumi Dash Papree, Tanwi Dey, Mohammad Amzad Hossain, Mohammed Mahbub Iqbal, Ambok Bolong Abol-Munafi and M. Sadiqul Islam, 2017. Some reproductive aspects of freshwater garfish, *Xenentodon cancila* (Hamilton, 1822) from North-East Bangladesh. J. Fish. Aquat. Sci., 12: 82-89.

Corresponding Authors: Sohel Mian, School of Fisheries and Aquaculture Sciences, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia Ambok Bolong Abol-Munafi, Institute of Tropical Aquaculture, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The freshwater garfish, *Xenentodon cancila* (Hamilton, 1822) is a fish available in marine, freshwater and brackish-water but commonly known as 'Freshwater garfish while a Bengali vernacular name is *Kakila* or *Kaikka*. This fish is widely distributed across South and Southeast Asia from Bangladesh, India and Sri Lanka to the Malaysian Peninsula[1,2]. *Xenentodon cancila* primarily dominant in rivers especially in the Ganges-Brahmaputra system[1] but also found in ponds, canals, *beels* (large bowl shaped depressions) and inundated fields[3]. It is a solitary fish that swims in midwater, usually against the current and is capable of bursts of speed, especially when in pursuit of its prey. This species is oviparous and slight sexual dimorphism exists. Wild fish spawn between the months of May and September each year and captive reproduction is also possible though rarely achieved[4]. Warmer temperatures of 28-29°C alongside a number of cool water changes may help to stimulate spawning behaviour. Successful management of fisheries and mobilization of seed resources mainly depends on the proper knowledge on reproductive biology of any fish[5]. However, fishery biology information, which is essential for fishery management of this species, is still poorly known. The information of different aspects of biology i.e., Gonado Somatic Index (GSI), gonadal development, fecundity and condition factor of this species is of great importance in fishery research programme as it plays the vital role both in breeding and fisheries management. Reproductive aspect like sex ratio states the proportion of male to female fish in a population and indicates the dominance of sex of fish species in a given population. It also constitutes basic information necessary for the assessment of the potential of fish reproduction and stock size estimation in fish population[6]. This fish is considered to be a popular fish in different areas of Bangladesh for having its medicinal value. Now a days it has been a fish of high value in urban areas of Bangladesh[3]. Moreover, this fish is disappearing in the wild condition of Bangladesh and adjacent areas due to some man-made and natural catastrophes. Considering the above facts, the current study was conducted to figure out gonado somatic index, fecundity and condition factor of this species and to uncover the reproductive biological information including the spawning season of this fish.

MATERIALS AND METHODS

Sample collection: About 325 samples of *Xenentodon cancila* were collected from different landing centres or direct fishermen catch from Sylhet and Sunamgonj districts (North-East Bangladesh) for a period of 1 year. *Xenentodon cancila* samples were caught by the traditional fishing gears including cast nets, square lift nets and also some traps. Samples were immediately preserved with ice in the fish landing area and later on fixed with 5% formalin upon arrival in the laboratory of the Department of Fisheries Biology and Genetics, Sylhet Agricultural University.

Estimation of total length, body weight and gonad weight: The total length of each specimen was taken to the nearest 0.1 cm with the help of an absolute vernier calliper (Mitutoyo, Japan) and body weights were recorded to the nearest 0.1 g by using triple-beam digital weighing balance. Then the specimens were dissected to take out the gonads. Each lobe of ovaries was weighed nearest 0.01 g by a sensitive electric (model: GemPro 250 digital gems scale) balance.

Length-weight relationships: The length-weight relationship was calculated using the expression:

$$W = aL^b$$

where, W is the body weight (g) and L is the total length (cm). Parameters a and b were estimated by linear regression analysis based on natural logarithms:

$$\ln(W) = \ln(a)+b\ln(L)$$

Additionally, 95% confidence limits of b and the coefficient of determination r^2 were estimated. In order to confirm whether b values obtained in the linear regressions were significantly different from the isometric value (b = 3), a t-test was applied, expressed by the equation according to Sokal and Rohlf[7]:

$$t_s = \frac{b-3}{sb}$$

where, t_s is the t-test value, b is slope and s_b is standard error of the slope (b). The comparison between obtained values of t-test and the respective tabled critical values allowed for the determination of the b values statistically significant and their inclusion in the isometric range (b = 3) or allometric range (negative allometric; b<3 or positive allometric; b>3).

Condition factors: Fulton's condition factor (K_F)[8] was calculated using the equation:

$$K_F = 100\times(W/L^3)$$

where, W is the total body weight (BW, g) and L is the total length (TL, cm). The scaling factor of 100 was used to bring the K_F close to unit.

Gonad morphological observation: Preserved specimens were brought in to laboratory and dissected out to locate the position and appearance of gonads in coelom cavity. The gonads were taken out and put into physiological saline solution. The gonads were washed properly to remove the blood, adhering tissues and fats. Observations were made to record the colour, size, length and weight of the gonads carefully. The colour of the gonads was observed with the help of naked eye. The lobular size, volume and transparency of the gonads were observed profoundly.

Calculation of GSI: The Gonado Somatic Indices (GSI) is an indicator of the state of gonadal development. The ration of gonad weight to body weight, GSI was determined by using the following formula according to Brooks *et al.*[9]:

$$GSI = \frac{\text{Gonad weight}}{\text{Body weight}} \times 100$$

Determination of fecundity: The fecundity was calculated by following methodology described by Muchlisin *et al.*[10]. Only samples of adult females in late or final oocyte stage (diameter >1.9 mm)[11] maturation stage were used for fecundity analysis[12,13]. Minimum oocyte size counted for fecundity was greater than 0.5 mm as described by Liao and Chang [11]. About 50% of matured females at final oocyte maturation stages were randomly selected from monthly samples. Three sub-samples of ovaries weighing 0.1-0.2 g were obtained from the anterior, posterior and the middle of gonad and soaked in solution comprising of 60 mL ethanol, 30 mL formaldehyde and 10 mL glacial acetic acid. The solution was used to wash the mucus to prevent the eggs from adhering together, to ease observation. The eggs were placed into a dish and counted under stereo light microscope (Nikon, YS-100). The mean from the three sub-samples were used to calculate absolute and relative fecundity using gravimetric method[14].

Fecundity was calculated by the following formula:

$$F = \frac{n \times G}{g}$$

where, F is fecundity, n is the average number of eggs in sub-sample, G is weight of the gonads and g is the weight of the sub-sample.

Statistical analysis: Data were analysed using the SPSS (software version V20.0; Chicago, USA) with the level of significance at $p<0.05$. Correlations and regression between fecundity and other parameters such as total length, body weight, gonad weight and GSI were also determined. Data have been presented as Mean±SEM.

RESULTS

This study described the general ovarian morphology, gonado-somatic index, sex ratio, length-weight relationship, Fulton's condition factor and fecundity of *X. cancila* using a number of specimens with various body sizes from the natural water bodies of North East Bangladesh.

Sex ratio: From the 325 specimens of *X. cancila* collected, 48.3% were males and 51.7% were females (male:female = 1:1.11). The overall sex ratio did not differ statistically from the expected value of 1:1 (df = 1, $\chi^2 = 0.04$, $p<0.05$). Females were dominant in larger length groups being most apparent during the resting phase of sexual cycle and in the peak of the spawning period, occurring in May and June (Table 1).

Table 1: Number and sex ratio of *X. cancila* throughout the study period

		Male		Female		
Months	Sample size	No.	%	No.	%	Sex ratio (M:F)
January	26	12	46.15	14	53.85	1:1.16
February	30	18	60.00	12	40.00	1:0.67
March	28	11	39.30	17	60.70	1:1.54
April	24	10	41.67	14	58.33	1:1.40
May	32	17	53.12	15	46.88	1:0.88
June	28	13	46.43	15	53.57	1:1.15
July	25	10	40.00	15	60.00	1:1.50
August	26	15	57.69	11	42.31	1:0.73
September	24	10	41.67	14	58.33	1:1.40
October	30	17	56.67	13	43.33	1:0.76
November	28	13	46.43	15	53.57	1:1.15
December	24	11	45.83	13	54.17	1:1.18
Total	325	157	48.30	168	51.70	1:1.11

Length-weight relationship: The length and weight frequency distributions indicated that females were in the range of 18.5-23.91 cm with body weights of 19.8-55.6 g, while males were in 17.6-21.6 cm with body weights of 19.4-43.4 g. The length-weight relationships were estimated as: BW = -0.627TL+34.29 ($p<0.05$, n = 168) and TL = -0.274 BW+22.44 ($p<0.05$, n = 157).

Gonad morphology: The gonads of *X. cancila* were slight elongated paired structures which lie posteriorly in the body cavity ventral to the air bladder. Both halves of the gonads were in close contact with each other. The right half was always slightly larger in size. The gonads of *X. cancila* showed well marked changes in their morphological (shape, size and volume) features during different months of sampling. On the basis of these changes, the reproductive cycle was divided into spawning, post-spawning and pre-spawning periods. Since the fresh reproductive cycle begins at the end of the spawning period, it has been described first in the following account.

Spawning period (April-August): During this period, the ovaries were large in size, beaded in appearance and orange in colour. In June, the ovaries of few fishes had a little granular surface. In the month of July, the ovarian wall was thin and the ovigerous lamellae lost their identity. In the month of August the ovarian wall is thick, the ovigerous lamellae begin to reappear.

Post-spawning period (September-December): During these months, the ovaries were thin, small in size and smooth in appearance. They are yellowish in colour. The ovarian wall was thick and ovigerous lamellae were distinct.

Pre-spawning period (January-March): The ovaries in the pre-spawning period were small and cylindrical in shape. They were smooth in appearance and yellowish in colour. In the ovaries of sampled fishes during January-March, the ovarian wall was thick.

GSI: In the present study GSI of female *X. cancila* was recorded in every month of the study period (Fig. 1). During the spawning period (April-August), the average values for the ovarian volume and the GSI show a gradual increase till they attain the peak in the month of June (14.14) and then onwards these values gradually decrease. It indicates the high metabolic activity of the fish during this period and the maximum spawning of the fish takes place in June.

Fecundity: Fecundity of fishes is usually determined from the number of ova of the mature group in the ovary. The fecundity

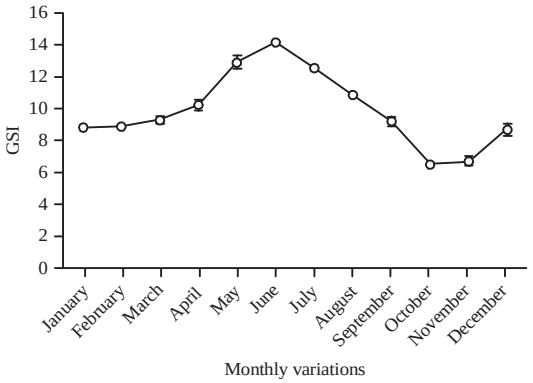

Fig. 1: Monthly variations of gonado-somatic-indices of *X. cancila* examined throughout the study period

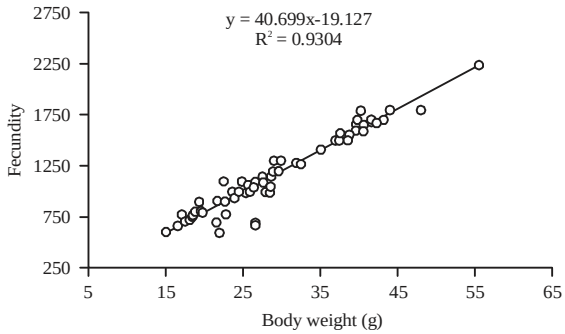

Fig. 2: Relationship between fecundity and body weight of the sampled fish

Table 2: Mean ovary weight, GSI and mean fecundity in different sampling months

Months	Mean ovary weight	GSI	Mean fecundity
January	3.90±0.01	8.8	413.65±34.45
February	4.10±0.05	8.9	517.89±40.75
March	5.60±0.10	9.3	556.41±12.97
April	11.46±0.40	10.2	1328.33±50.21
May	15.68±0.62	12.9	1951.67±30.87
June	18.99±0.48	14.1	2234.33±50.37
July	14.45±0.55	12.5	1875.79±33.04
August	12.45±0.66	10.8	1570.33±35.00
September	5.70±0.04	9.1	500.56±10.01
October	4.50±0.03	6.5	-
November	3.70±0.11	6.7	-
December	3.80±0.05	8.7	300.54±24.43

of *X. cancila* varied from 1328±140.20 to 2234.33±210.37 (Table 2). The fecundity was not calculated in the months of October and November as the ovaries found to be in resting stage.

Relationship between fecundity and total weight: The observed values of fecundity were plotted against the weight of fish in Fig. 2. The relationship between fecundity and

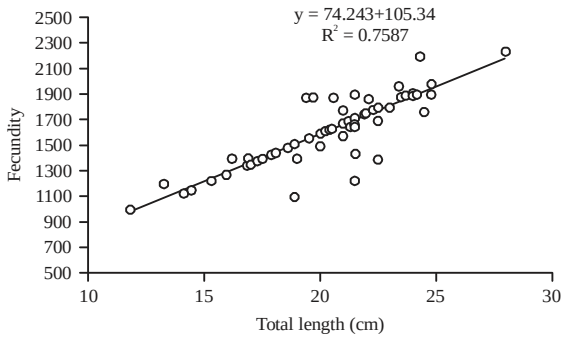

Fig. 3: Relationship between fecundity and total length of the sampled fish

weight of fish in female *X. cancila* was linear and it showed gradual increase of fecundity with increase in total weight. The regression equation of fecundity on total weight can be expressed as:

$$Y = 40.699X-19.127$$

where, Y is fecundity and X is total weight with r^2 value of 0.9304.

Relationship between fecundity and total length: The number of eggs produced by individuals of *X. cancila* was plotted against the length of fish (Fig. 3). In the present study, fecundity showed low correlation coefficient with the total length of the fish. The regression of fecundity and total length can be expressed as:

$$Y = 74.243TL+105.34$$

where, TL is total length and r^2 value was 0.7587.

Condition factor: The values of condition factor (K) found to vary between 0.24-0.70 for *X. cancila*.

DISCUSSION

North-East Bangladesh is very rich in biodiversity. But the situation is changing day by day due to some causes and fishes are the prime victims of it. Data on reproductive biology is important to protect a species in the wild condition by knowing its habitat and breeding characteristics. An initiative was taken to tabulate some aspects on reproductive biology of *X. cancila* i.e., sex ratio, gonadal morphology, gonado-somatic indices, fecundity, etc. Very few information are available on the reproductive biology of *X. cancila* except some life-history traits work done by Hossain *et al.*[2].

In this study, out of the 325 specimens of *X. cancila* sampled, the male-female sex ratio found to be 1:1.11. Hossain *et al.*[15] stated that a deviation from a 1:1 sex ratio is not expected for most aquatic species, despite the fact some finfish and prawn populations may show a strong bias in this ratio. However, our current investigation revealed there was no significant difference with the expected value of 1:1. Avsar[16] pointed out that in a typical population, female to male ratio will vary between 1:1 and 1:1.3.

Variations in the sex ratio may be influenced by a number of factors including differential mortality, the growth rate, longevity, sex reversal, seasons, fishing grounds and fishing methods[17,18]. In addition, differences in growth among sexes, sexual dimorphism and migration may also be influencing factors[19]. Therefore, the increase in the sex ratio with an increase in size might be related to differential growth, mortality and longevity between sexes.

First study reported on length frequency distribution of this fish was by Hossain *et al.*[2]. The smallest size fish found during this study was 17.6 cm. On the other hand, Hossain *et al.*[2] recorded a catch of minimum 10.50 cm TL which was attributed to either the absence of small sized fish (<10.50 cm TL) in the populations or selectivity of the fishing gears. The maximum size of *X. cancila* witnessed in this study within the North East Bangladesh was 23.90 cm TL which is almost similar with the findings of Satrawaha and Pilasamorn[20] though far less than the maximum reported value of 40 cm TL[1]. Nonetheless, Shrestha[21] reported the maximum TL of *X. cancila* as 20 cm TL in Nepal which is lower than that recorded in the present study.

Under present investigations, spawning period was estimated on the basis of monthly changes in the gonad weight i.e., rise and fall in the GSI of *X. cancila*. However, the spawning period is found to be extending from April-August. In this study, the reproductive cycle has been assessed on the basis of morphological changes taken place in the gonads so as to correlate it with the seasonal changes in the reproductive system of the fish.

During the spawning period (April-August), the average values for the ovarian weight and the GSI show a gradual increase till they attain the peak in the month of June and then onwards these values gradually decreases during the months of post spawning season. It indicates the high metabolic activity of the fish during this period and the maximum spawning of the fish takes place in June and July.

During the post-spawning period (September-December), the average weight of the ovaries and the average GSI of the female fish decreases gradually which justifies the gradual

shrinkage in the ovaries during this period. It indicates that during this period, the metabolic activity of the fish becomes low after spawning.

During the pre-spawning period (January-March), the average values for the ovarian volume and the GSI are observed in an increasing order. It indicates that the ovaries are in active state during this period and the process of oogenesis has been accelerated. The state of maturity of a fish may be determined by the size of ovaries. The GSI indicates the stage and readiness of the ovary for maturation and spawning.

The GSI is the ratio of gonad weight to body weight used to estimate reproductive condition. According to Ahirrao[22] it is the method of studying the spawning season to follow the seasonal changes in gonadal weight in relation to body weight. Gonads undergo regular seasonal cyclic changes in weight; particularly in females indicate the spawning season[23]. The GSI values of the current study indicate that April-August is the breeding period of this fish in the weather condition of North-East Bangladesh. However, other researchers argued that GSI cannot correctly indicate the breeding period of a species particularly in the later stages of gonad development[11,24]. On the other hand, GSI is one of the important parameter of the fish biology, which gives the detail idea regarding the fish reproduction and reproductive status of the species and help in ascertaining breeding period of fish[25-27].

This happened because the water temperature started to rise in Bangladesh during those months. Findings of Liu *et al.*[28] supports the current statement and they suggested that the development of ovaries and the process of oocyte development may be stimulated by a change in the water temperature. The spawning season of fresh water garfish began in April in lower lake, Taiwan[11] which coincides with the time when water temperatures begin to rise in the waters around Taiwan. A similar finding was mentioned by Liu *et al.*[28] for *Priacanthus macracanthus*.

Fecundity is an important indicator for fish reproduction and population dynamics[11]. The knowledge of fish fecundity has much relevance in fish population studies and in successful management and exploitation of the fishery[29]. Large variations in batch fecundity in teleosts were documented by many researchers. The egg production varies not only among different species but also within the same species depending upon the length and weight of gonad, influenced by the environment[30]. Even the geographical distribution is known to influence the fecundity[31].

In the present study fecundity of *X. cancila* varied from 1328±50 to 2234±50 during the spawning period. This finding was similar to that of an earlier work done by Bhuiyan and Islam[32]. On the other hand, the fecundity of needlefish, *Tylosurus acus melanotus* was estimated to 14.836-41.117 eggs[11].

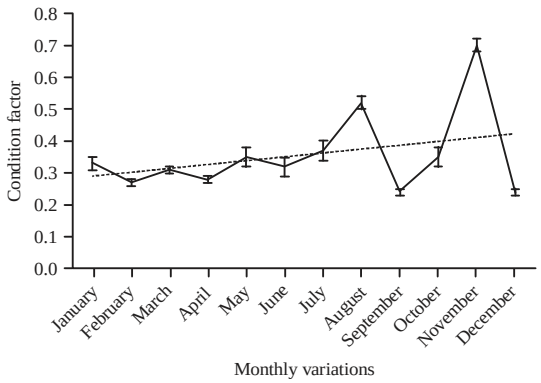

Fig. 4: Monthly variations of the condition factors throughout the study period

Fulton[8] condition factor was determined for this study and found that it is an indicator of the changes in food reserves and the general fish condition related to the fish reproduction (Fig. 4). In general, the seasonal cycle in the condition of the fishes suggested a relationship with gonadal development.

CONCLUSION AND RECOMMENDATIONS

This study suggested that *X. cancila* is a fish where the breeding activity initiates after February and breeding occurs between late April and early July in Bangladesh. *Xenentodon cancila* is one of the target species to conserve in the wild where it is indigenous like Bangladesh and adjacent countries. The major problem with its conservation is the availability of seed under hatchery conditions for which basic studies on reproductive biology are required. No specific study is available on this aspect of the species especially with regard to Bangladesh and only a few studies or indirect references are available from other part of the globe. The present study examined of growth and reproductive biology of the fish as exhibited under the conditions of the North-East Bangladesh. The study thus provides fundamental information on the reproductive pattern of *X. cancila* to assist in understanding useful biological processes that may be responsible for maintaining the underlying stock structure for proper conservation and management in its natural habitat.

ACKNOWLEDGMENTS

The authors would like to thank Dr. Helena Khatoon for her valuable suggestions on this manuscript. Thanks are also

due to my friends for their assistance. Thanks to the staffs of the Department of Fisheries Biology and Genetics, Sylhet Agricultural University for technical supports.

REFERENCES

1. Talwar, P.K. and A.G. Jhingran, 1991. Inland Fishes of India and Adjacent Countries. 1st Edn., Oxford and IBH Publishing Co. Pvt. Ltd., Calcutta, pp: 152-541.
2. Hossain, M.Y., M.A.S. Jewel, M.M. Rahman, A.B.M.M. Haque, H.A.M. Elbaghdady and J. Ohtomi, 2013. Life-history traits of the freshwater garfish *Xenentodon cancila* (Hamilton 1822) (Belonidae) in the Ganges River, Northwestern Bangladesh. Sains Malaysiana, 42: 1207-1218.
3. Rahman, A.K.A., 2005. Freshwater Fishes of Bangladesh. 2nd Edn., Zoological Society of Bangladesh, Dhaka, Bangladesh, Pages: 263.
4. Bano, Z., S. Manohar, R. Chauhan, N.A. Bhat and T.A. Qureshi, 2012. Annual changes in the ovary of *Xenentodon cancila* (Ham.). Int. J. Environ. Sci., 2: 1239-1245.
5. Chakrabarti, P. and A.S. Banerjee, 2015. Histological findings and seasonal distribution of different germ cells in the testicles of freshwater needle fish, *Xenentodon cancila* (Hamilton). Int. J. Fish. Aquat. Stud., 2: 74-80.
6. Vicentini, R.N. and F.G. Araujo, 2003. Sex ratio and size structure of *Micropogonias furnieri* (Desmarest, 1823) (Perciformes, Sciaenidae) in Sepetiba Bay, Rio de Janeiro, Brazil. Braz. J. Biol., 63: 559-566.
7. Sokal, R.R. and F.J. Rohlf, 1987. Introduction to Biostatistics. 2nd Edn., Freeman Publication, New York, ISBN: 9780716718055, Pages: 363.
8. Fulton, T.W., 1904. The rate of growth of fishes. Twenty-second Annual Report, Part III, Fisheries Board of Scotland, Edinburgh.
9. Brooks, S., C.R. Tyler and J.P. Sumpter, 1997. Egg quality in fish: What makes a good egg? Rev. Fish Biol. Fish., 7: 387-416.
10. Muchlisin, Z.A., M. Musman, N. Fadli and M.N. Siti-Azizah, 2011. Fecundity and spawning frequency of *Rasbora tawarensis* (Pisces: Cyprinidae) an endemic species from Lake Laut Tawar, Aceh, Indonesia. AACL Bioflux, 4: 273-279.
11. Liao, Y.Y. and Y.H. Chang, 2011. Reproductive biology of the needlefish *Tylosurus acus melanotus* in waters around Hsiao-Liu-Chiu Island, Southwestern Taiwan. Zool. Stud., 50: 296-308.
12. Yoneda, M., K. Futagawa, M. Tokimura, H. Horikawa, S. Matsuura and M. Matsuyama, 2002. Reproductive cycle, spawning frequency and batch fecundity of the female whitefin jack *Kaiwarinus equula* in the East China Sea. Fisher. Res., 57: 297-309.
13. Murua, H. and F. Saborido-Rey, 2003. Female reproductive strategies of marine fish species of the North Atlantic. J. Northwest Atlantic Fish. Sci., 33: 23-31.
14. Biswas, S.P., 1993. Manual of Methods in Fish Biology. 1st Edn., South Asian Publishers Pvt. Ltd., New Delhi, India, ISBN-13: 9788170031581, Pages: 157.
15. Hossain, M.Y., J. Ohtomi, A. Jaman, S. Jasmine and R.L. Vadas Jr., 2012. Life history traits of the Monsoon River prawn *Macrobrachium malcolmsonii* (Milne-Edwards, 1844) (Palaemonidae) in the Ganges (Padma) River, Northwestern Bangladesh. J. Freshwater Ecol., 27: 131-142.
16. Avsar, D., 1998. Fisheries Biology and Population Dynamics. 2nd Edn., Baki Publication, Adana, Turkey, pp: 303.
17. Wu, C.C., W.C. Su and T. Kawasaki, 2001. Reproductive biology of the dolphin fish *Corphaena hippurus* on the east coast of Taiwan. Fish. Sci., 67: 784-793.
18. Koutrakis, E.T., N.I. Kamidis and I.D. Leonardos, 2004. Age, growth and mortality of a semi-isolated lagoon population of sand smelt, *Atherina boyeri* (Risso, 1810) (Pisces: Atherinidae) in an estuarine system of Northern Greece. J. Applied Ichthyol., 20: 382-388.
19. Wu, C.C., J.S. Weng, K.M. Liu and W.C. Su, 2008. Reproductive biology of the notchedfin threadfin bream, *Nemipterus peronii* (Nemipteridae), in waters of Southwestern Taiwan. Zool. Stud., 47: 103-113.
20. Satrawaha, R. and C. Pilasamorn, 2009. Length-weight and length-length relationships of fish species from the Chi River, Northeastern Thailand. J. Applied Ichthyol., 25: 787-788.
21. Shrestha, J., 1994. Fishes, Fishing Implements and Methods of Nepal. Smt. M.D. Gupta, Lashkar, India, pp: 150.
22. Ahirrao, S.D., 2002. Status of gonads in relation to Total Length (TL) and Gonadosomatic Index (GSI) in freshwater spinyeel (pisces) *Mastacembelus armatus* (Lacepede) from Marathwada region Maharashtra. J. Aquat. Biol., 17: 55-57.
23. Dadzie, S., F. Abou-Seedo and T. Al-Shallal, 2000. Reproductive biology of the silver pomfret, *Pampus argenteus* (Euphrasen), in Kuwait waters. J. Applied Ichthyol., 16: 247-253.
24. West, G., 1990. Methods of assessing ovarian development in fishes: A review. Aust. J. Mar. Freshwater Res., 41: 199-222.
25. Mohan, D. and A. Jhajhria, 2001. Comparitive growth and production studies of carps in Skekhawat pond Jodhpur. J. Nat., 13: 123-130.
26. Gupta, J.P. and S.P. Srivastava, 2001. Maturity determination by gonadosomatic index during annual reproductive cycle in *Passer domesticus*. Environ. Ecol., 191: 216-218.
27. Shankar, D.S. and R.S. Kulkarni, 2005. Somatic condition of the fish, *Notopterus notopterus* (Pallas) during different phases of the reproductive cycle. J. Environ. Biol., 26: 49-53.
28. Liu, K.M., K.Y. Hung and C.T. Chen, 2001. Reproductive biology of the big eye *Priacanthus macracanthus* in the North-Eastern waters off Taiwan. Fisher. Sci., 67: 1008-1014.
29. Alam, M.D. and N.G. Das, 1996. Fecundity and condition index of *Crassostrea madrasensis* (Cupped oyster) in the intertidal water of the Moheshkhali Channel of the Bay of Bengal. J. Inland Fish Soc. India, 28: 105-109.

30. Barmanh, R. and S.J. Saikia, 1995. Length-weight relationship and some ecological observations of *Cirrhina reba* (Ham.) from the wetlands of Assam, India. Environ. Ecol., 13: 721-724.
31. Shinde, V.R., M. Rafiq, S.V. Sathish and R.S. Kulkarni, 2002. Fecundity of the freshwater fish *Channa punctatus* (Bloch) from three aquatic bodies. J. Environ. Biol., 23: 429-432.
32. Bhuiyan, A.S. and M.N. Islam, 1990. Fecundity of *Xenentodon cancila* (Hamilton) (Belonidae: Beloniformes). Environ. Ecol., 8: 1004-1007.