J. Asiat. Soc. Bangladesh, Sci. 44(1): 91-99, June 2018

SOME ASPECTS OF REPRODUCTIVE BIOLOGY OF THE MUDSKIPPER *APOCRYPTES BATO* FROM THE COAST OF CHITAGONG

MOHAMMED SADEQUER RAHMAN[1], MD. SOHEL PARVEZ[2*], MOHAMMAD MIZANUR RAHMAN[1], MD. RASHED-UN-NABI[1] AND MD. WAHIDUL ALAM[3]

[1]Institute of Marine Sciences and Fisheries, University of Chittagong, Chittagong-4331, Bangladesh
[2]Department of Oceanography, Noakhali Science and Technology University, Noakhali-3814, Bangladesh
[3]Environmental and Resource Protection Law, School of Law and Political Science, Ocean University of China, Qingdao, China

Abstract

Some aspects of reproductive biology of the mudskipper *Apocryptes bato* (Hamilton 1822) from the coastal waters of Chittagong, Bangladesh was conducted. Disproportionate occurrence of male and female *(*1.20 : 1) was observed in the number of two sexes. A prolonged spawning season was found from June to early October with a single peak. The aspects in the ovary indicate one complete spawning of females in a single spawning season. The fecundity was found to vary from 7453 - 31195 with an average of 17590 ± 6867. Significant coefficient of correlation between the diameters of the eggs of corresponding anterior, middle and posterior regions of the right and left ovaries indicated the simultaneous release of eggs from both the ovaries. A much closer relationship of fecundity and the significant 't' values indicated fecundity increases with the increase of total length, standard length, body weight and gonad weight.

Key words: Sex ratio, Maturation, Spawning, Fecundity

Introduction

Apocryptes bato (Hamilton 1822) is a member of amphibious gobies of the family Gobiidae locally called 'Chiring' or 'Dali Chewa' in Bangladesh (Rahman *et al.* 2016). The species is widely distributed from the eastern coast of India to south-east Asia and Australia. It is found in shallow and exposed inter tidal mudflats of estuaries and mangrove swamps with other sympatric species is amphibious in nature (Daniel 2002, Shukla *et al.* 2014). Reproduction in most mudskippers follows a nuptial parade and elaborate courtship routine where the male leads the female to his burrow for mating after which eggs are deposited on the wall of the burrow (Chukwu *et al.* 2010, Brillet 1970). Studies of the reproductive biology are a prerequisite for sustainable management of a fisheries (Parvez and Nabi 2015). Hence the present study is designed to reveal the aspects of reproductive biology like sex ratio, maturity, spawning and fecundity of *A. bato* from the coast of Chittagong, Bangladesh.

[*] Author for correspondence: Email: sohel@nstu.edu.bd

Materials and Methods

A total of 132 specimens were collected from *Fisheries Ghat* landing center and three local markets of Chittagong, Bangladesh during June, 2009 to February, 2010. Gravid individuals were sorted out for fecundity. The body length-weight and the gonad and liver weight were recorded. The eggs were taken at random from the anterior, middle and posterior region of both lobes of the ovaries. All the ovaries were preserved in 5% formalin and then the diameter of eggs were measured by ocular micrometer.

Sex ratio, period of maturity and spawning were determined from the Gonadosomatic Index (GSI), Hepatosomatic Index (HSI) and Condition factor (K) of both sexes. Fecundity was studied to assess the productive potential of the fish stock and relationship established with the body length, body weight and gonad weight of the fish. The ratio of sexes were tested by "F" test to distinguish the difference, if any, from the hypothetical ratio 1 : 1. The value of "F" was calculated by the formula:

$F = \frac{Sx^2 . \delta x^2}{Sy^2 . \delta y^2}$ where, $Sx^2 = \frac{Nx}{Nx-1} . Sx^2$ and

$Sy^2 = \frac{Ny}{Ny-1} . Sy^2$.

Here, Sx^2 = Sample variance, δx^2 = Population variance,
Nx = Sample size for male and Sy^2 = Sample variance,
δy^2 = Population variance, Ny = Sample size for female.
The GSI of the gonads of each fish were calculated using the formula,
$GSI = \frac{\text{Gonadal weight}}{\text{Total weight}} \times 100$, (King 1995). HSI was calculated by the formula, $HSI = \frac{\text{Weight of liver}}{\text{Gutted weight of body}} \times 100$, (El-Boray 2004) and K was calculated by the formula, $K = \frac{\text{Body weight - Gonad weight}}{(\text{Length})^3} \times 100$ (Nabi 1994).

The pre-spawning, spawning and post spawning periods were determined critically after assessing the month-wise values GSI, HSI and K. Stages of maturity were determined from the weight, colour, shape, and transparency of the gonad, GSI, ova diameter and consistency of the ovary. For estimation of fecundity the gravimetric method was followed after McGregor (1922) and value of fecundities presented as the total number of eggs in both the ovaries followed by Healy and Nicol (1975). Total number of eggs for fish was calculated from the sample mean and the total weight of the ovary. Arithmetic relationships were, fecundity (F) – total length (TL) : F = a + b TL, fecundity (F) – standard length (SL) : F = a + b SL, fecundity (F) – body weight (BW) : F = a + b BW, fecundity (F) – gonad weight (GW) : F = a + b GW, the coefficient of correlations (r) were calculated and the regression lines were derived following the method of least square (LeCren 1951, Hartman and Conkle 1960). The significance of r was tested at 5% level of significance. Value of 't' was calculated with (n – 2) degrees of freedom from the formula: $t = \frac{r\sqrt{n-2}}{\sqrt{(1-r^2)}}$.

Results and Discussion

The sex ratio of male to female was found as 1.20: 1, showing dominance of male over female. The monthly occurrence and different standard length group wise distribution of male and female is represented in Fig. 1. The monthly distribution and different standard length group wise distribution of male and female *A. bato* were tested by 'F' test and the calculated value of 'F' was found 16.50 and 6.66, respectively for both distributions which were highly significant at 5% level of significance.

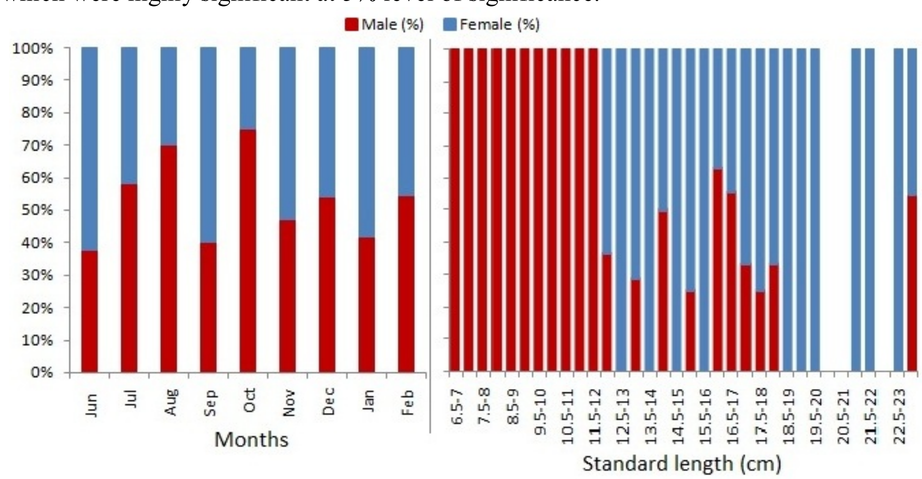

Fig. 1. Monthly and standard length group wise distribution of male and female *A. bato*.

Difference in the number of males and females of *A. bato* disagrees with the universal hypothesis that the number of individual of two sexes of a species in an ecosystem should be 1.0 : 1.0. This hypothesis is not found for all organisms as the dominance in number of male over female or *vice versa* of a population depends on the surrounding ecological environment (Parvez and Nabi 2015). Disproportionate occurrence in the number of two sexes of *A. bato* agrees with Chukwu *et al.* (2010) for *Preophthalmus barbarus* and Hoda and Akhtar (1982) in the case of *Boleophthalmus dentatus* but disagrees slightly with the report of Murdy (1989) on the same species and on the *P. papilio* where females were found significantly more than the males with a ratio of 1 male to 1.42 females in Lagos lagoon, Nigeria (Lawson 2010). Dominance of the males over the females during the spawning period (except the months August and September) may be due to the requirement of higher number of males for successful mating.

Monthly changes were found to occur in the GSI, HSI and K both for male and female (Fig. 2, Table -1). The gradual changes in the weight of the testes and ovary were uniform and more or less parallel.

Table 1. Average value of GSI, HSI and K (percentages with mean and standard error of mean are given) of male and female *A. bato*.

	Male			Female		
	GSI ± S.E.	HSI ± S.E.	K ± S.E.	GSI ± S.E.	HSI ± S.E.	K ± S.E.
Jun.	0.94 ± 0.49	0.30 ± 0.06	0.41 ± 0.24	11.55 ± 0.98	1.55 ± 0.13	0.47 ± 0.05
Jul.	0.60 ± 0.27	0.39 ± 0.07	0.41 ± 0.17	4.48 ± 0.76	0.62 ± 0.19	0.45 ± 0.07
Aug.	0.79 ± 0.28	0.24 ± 0.13	0.54 ± 0.17	3.25 ± 0.26	0.36 ± 0.27	0.30 ± 0.07
Sep.	1.21 ± 0.60	0.13 ± 0.05	1.07 ± 0.22	3.55 ± 0.97	0.46 ± 0.19	0.53 ± 0.11
Oct.	1.62 ± 0.41	0.58 ± 0.24	1.00 ± 0.09	7.89 ± 0.96	1.12 ± 0.15	0.45 ± 0.17
Nov.	1.24 ± 0.50	0.24 ± 0.04	0.78 ± 0.17	7.15 ± 0.89	0.91 ± 0.19	0.37 ± 0.06
Dec.	0.17 ± 0.06	0.23 ± 0.03	0.89 ± 0.07	3.05 ± 0.61	0.67 ± 0.21	0.49 ± 0.08
Jan.	0.08 ± 0.02	0.40 ± 0.06	0.84 ± 0.10	4.63 ± 0.82	0.61 ± 0.23	0.38 ± 0.08
Feb.	0.12 ± 0.04	0.60 ± 0.21	0.86 ± 0.21	3.40 ± 0.38	0.40 ± 0.14	0.42 ± 0.06

The mean GSI value of male increases gradually from July and reached peak in October and then it decreased. In the case of female it fluctuated with two peaks in June and October-November. The mean HSI value of male has two peaks in October and February (Fig. 2). There were also two peaks in female during June and October after that it decreased up to February. The mean value of K for male was comparatively low from June to August and high from September to February with little fluctuation (Fig. 2). In female, it was found almost similar with fluctuating in a zig zag manner.

From the morphological study two stages of the testis was ascertained as, Stage-I (Immature): The testis of this stage was thread like in structure, whitish in color and GSI ranged from 0.02 (February) to 0.06 (End of February). Stage-IV **(**Ripe): The testes of this stage were milky white and if stripped by fingered creamy milt comes out of them. GSI ranged from 0.06 (June) to 0.16 (July).

The five maturity stages of the gonads of the female *A. bato* were observed in different spawning periods which were determined from the morphological study of ovaries, from GSI values and from ova diameters. The stages were, Stage-I (Immature): The tiny transparent immature ova vary from 0.29 mm to 0.93 mm in diameter and their GSI ranged from 0.13 to 0.87. Stage-II (Maturing or rebuilding): Ovaries are whitish to yellowish in colour and somewhat longer than the immature ovaries. The diameter of maturing ova varies generally from 0.33 mm to 0.84 mm and their GSI ranged from 0.13 to 2.99. Stage-III (Mature): Ovaries are yellowish to yellow white in color and large in shape. Ova are firmly attached to the ovarian tissue and themselves. Ova diameter ranged from 0.84 mm to 0.98 mm and their GSI vary from 1.23 to 4.84. Stage-IV (Ripe):

Ovaries are yellowish to dark yellowish and ova are not firmly attached with ovarian tissue. Ova diameter ranged from 0.73 mm to 0.95 mm and their GSI vary from 4.84 to 7.70. Stage-V (Spent): Empty ovarian bags with very small white eggs (Granule like) present. Ova diameter varies from 0.64 mm to 0.87 mm and their GSI vary from 0.17 to 2.25.

The HSI value remained relatively high and nearly constant for both male and female throughout the maturation period until the beginning of the spawning indicating the reserves in the liver are not seriously depleted during the process of yolk formation. It is probably because of *A. bato* is a carnivorous fish (Rahman *et al.* 2016) and it was found to continue feeding during the period of maturation. The condition factor remained relatively high and nearly constant for both male and female during the pre-spawning period agrees with the report of Day (1871) for *A. cantories*.

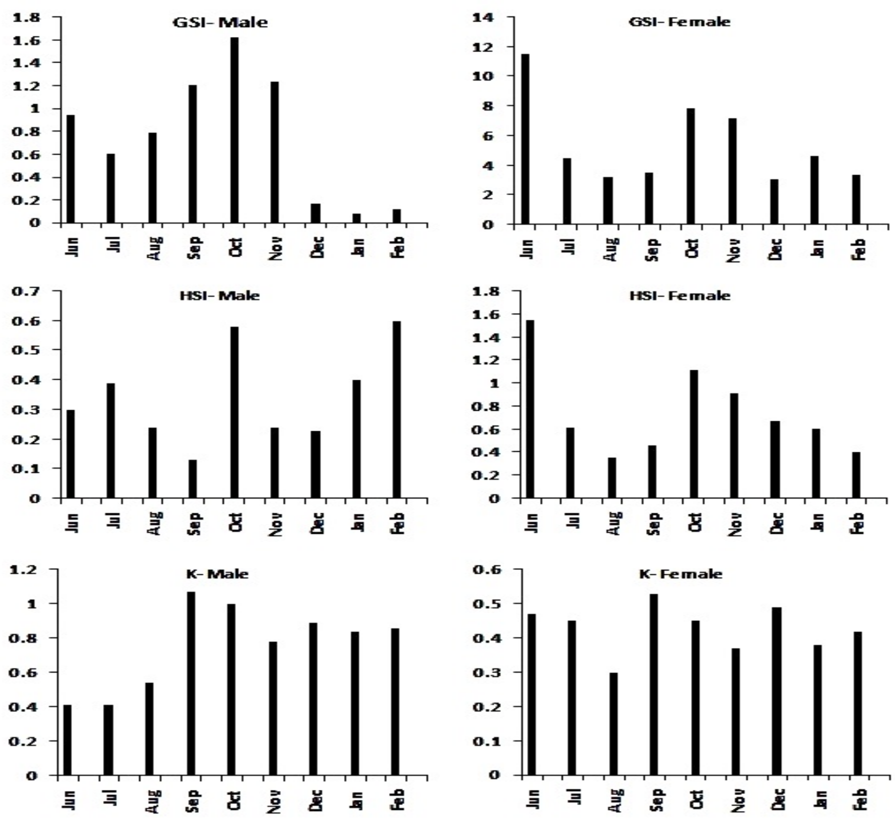

Fig. 2. Monthly variation in GSI, HSI and K of male and female *A bato*.

Spawning: A prolonged spawning period (June to early October) with a peak in June to July was found for *A. bato* in the present study. Rahman (1989) observed one major spawning period from December to February for *A. bato* and *A. cuvieri*. *Boleophthalmus pectinirostris* was found to spawn from May to July with intensive spawning in June (Prefecture *et al.* 1993). Late January to early February are the pre-spawning months of the male *A. bato* while late January to late February are the pre-spawning months of female. In the present investigation mature and immature ova were not found simultaneously with residual ripe ova and post-ovulatory follicles in the spent ovarian bags. These aspects in the ovary indicate that the females spawn ripe ova completely once in a single spawning season.

Fecundity: The fecundity of *A. bato* varied from 7453 to 31195 (Table 2). The average number of eggs was 17590 ± 6867 indicate the high fecundity for its size. High fecundity of *A. bato* for its size agrees with the result of Murdy (1989) in the same species from the Hooghly estuary. But Chukwu *et al.* (2010) reported low fecundity for *P. barbarous* with a mean of 4400 ± 545. The difference in fecundity follows a pattern to be expected from a series of intergrading population (Nagasaki 1958).

Table 2. Characteristics of fish having the maximum and minimum fecundity value.

Fecundity	TL (cm)	BW (g)	GW (g)
31,195	20.60	34.40	4.46
7,453	19.20	26.9	1.3

The weight of the ovaries varied from 0.16 g to 0.97 g and the mean weight was calculated to be 2.38 ± 1.14. The eggs were spherical in shape. The diameter of eggs varied from 0.16 mm to 1.01 mm and the mean diameter was found to be 0.52 ± 0.25 mm. Coefficient of correlation between the diameters of the eggs of the corresponding anterior (r_a = 0.96, t = 13.73, middle (r_m = 0.95, t = 13.33) and posterior (r_p = 0.98, t = 13.57) regions of the right and left ovaries at 5% level of significance indicates simultaneous release of eggs from both the ovaries.

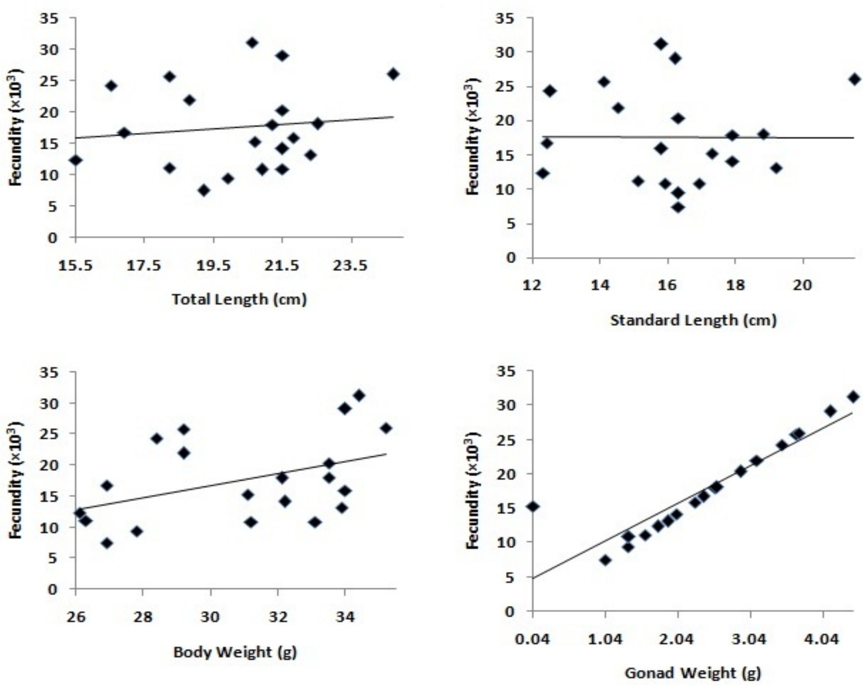

Fig. 3. Relationship of fecundity with total length, standard length, body weight and gonad weight.

The relationships of fecundity with total length were found, F = –24132 + 623 TL (r = 0.98, t = 5.20); for standard length, F = –17523 + 864 SL (r = 0.98, t = 5.45); for body weight, F = –12579.25 + 974.78 BW (r = 0.99, t = 9.38) and F = 4556 + 5462 GW (r = 0.82, t = 5.46) for gonad weight. The regression lines were linear and positive (Fig. 3) and the resulting correlations were found to be highly significant ($t_{0.05}$ = 2.09) at 5% level of significance. Linear and positive relationship between the fecundity and other factors agrees with the result of Murdy (1989) for the same species from the Hooghly estuary.

Significant correlations between the diameters of the eggs of corresponding anterior, middle and posterior regions of the right and left ovaries indicates the simultaneous release of eggs from both the ovaries and same rates of maturation. This agrees with the report of Murdy (1989) on the same species from Hooghly estuary. The aspects in the ovary indicate that the females do not spawn several times in a single spawning season. The *Apocryptes bato* has high fecundity and fecundity increases with the increase of length, body weight and gonad weight of the fish.

A disproportionate occurrence in the number of two sexes and dominance of male over female was found in the fishery of *A. bato* in the coast of Chittagong. A long spawning season with a peak in June to July was found in the present study. The fish has a comparatively high fecundity for its body size. The findings of aspects of reproductive biology obtained in the present study could be used in taking appropriate measures for the sustainable management of the *Apocryptes bato* fishery. The information will increase the life history database of the fish and will provide a baseline data for further studies of the species.

References

Brillet, C. 1970. Relations entire territoiret compartment afresivite chez les Periophthalmes. *C.R. Aead. Sci. Poris Serv. D.* **270**: 1507-1510.

Chukwu, K.O., S.N. Deekae. and U.U. Gabriel. 2010. Reproductive biology of *Periopthalmus barbarus* (Linneaus 1766) in new Calabar River, Nigeria. *Agric. Biol. N. Am.* **1**(6): 1158-1161. doi:10.5251/abjna.2010.1.6.1158.1161.

Daniel, R.J.R. 2002. *Freshwater Fishes of Peninsular India*. University press. 288 pp.

Day, F. 1871. On the fishes of the Andaman Islands. Proceedings of the General Meetings for Scientific Business of the Zoological Society of London 1870 (pt 3): 677 - 705.

El-Boray, K.F. 2004. Reproductive biology and histological characters of male rhabdosargus haffara (teleostei; sparidae) from Suez bay, Red sea. *Egyptian Journal of Aquatic Research* **30**(B): 226-233.

Hartman, W.L. and C.Y. Conkle. 1960. Fecundity of red salmon at Brooks and Karkuk lakes, Alaska. Fishery. *Bull. Fish Wilds. Serv. U.S.* **180**: 53-60.

Healy, M.C. and C.W. Nicol. 1975. Fecundity comparisons for varius stocks of lake white fish, *Coregonus chupeaformes. J. Fish. Res. Board, Can.* **32**(3): 404-407.

Hoda, S.M.S. and Y. Akhtar. 1982. Maturation and Fecundity of Mudskipper *Boleophthalmus Dentatus* in the Northern Arabian Sea. *Centre of Excellence in Marine Biology, University of Karachi, Karachi* 32, *Pakistan* 64-73 pp.

King, M. 1995. Fisheries biology, assessment and management,1st ed. Fishing News Books, London. 341 pp.

Lawson, E.O. 2010. Aspects of Reproductive Biology in Mudskipper, *Periophthalmus apilio* from Mangrove Swamps of Lagos Lagoon, Lagos, Nigeria. *Journal of Fisheries International* **5**(2): 36-43. DOI: 10.3923/jfish.2010.36.43

LeCren, E.D. 1951. The length-weight relationship and seasonal cycle in gonadal weight and condition in the perch (*Perca fluviatilis*). *J. Anim. Ecol.* **20**: 271-279.

McGregor, E.A. 1922. Observations on the egg yield of Klamath River King Salmon, Calif. *Fish Game* **8**: 160-164.

Murdy, E.O. 1989. A Taxonomic Revision and Cladistic Analysis of the Oxudercine Gobies (Gobiidae: Oxudercinae) Records of the Australian Museum Supplement **11**: 1-93.

Nabi, M.R.U. 1994. On the study of the thread fin *Polinemous paradiscus* from the landing centers and local market of Chittagong, M. Sc. Thesis, Institute of Marine Sciences, University of Chittagong.

Nagasaki, F., 1958. The fecundity of Pacific herring *(Clupea pallasi*) in British Columbia coastal waters. *J. Fish. Res. Bd. Can.* **15**: 313-330.

Parvez, M.S. and M.R.U. Nabi. 2015. Reproductive Biology of Tapper Tail Anchovy *Coilia ramcarati* along the Coast of Chittagong. *Suranaree Journal of Science and Technology* **22**(4): 397-408.

Prefecture, K., M. Washio, S. Komiya. and T. Takita. 1993. Maturation of the Mudskipper *Boleophthalmus pectinirostris* distributed in the mud flats of the Midori river. *Nippon Suisan Gakkaishi* **59**(4): 575-580.

Rahman, A. 1989. Freshwater Fishes of Bangladesh, *In:* Kabir, S.M.H. (Ed.). Zoological Society of Bangladesh, Department of Zoology, University of Dhaka. Bangladesh.

Rahman, M.S., M.M. Rahman, M.S. Parvez. and M.R.U. Nabi. 2016. Feeding habit and Length-Weight Relationship of a Mudskipper *Apocryptes bato* from the coast of Chittagong. *Journal of Bangladesh Academy of Sciences* **40**(1): 57-64.

Shukla, M.L., J.N. Trivedi, G.M. Soni, B.K. Patel, and K.D. Vachhrajani. 2014. Mudskipper (Gobiidae: Oxudercinae) fauna of Northern Gulf of Khambhat with two new record of the species from Gujarat, India. *European Journal of Zoological Research* **3**(3): 67-74.

(Revised copy received on 22.5.2018)