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REPRODUCTIVE BIOLOGY AND ITS PERIODIC VARIATION OF ENDANGERED MUD EEL *Monopterus cuchia* (Hamilton) FROM MEGHALAYA, INDIA

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Abstract: **Reproductive biology of an endangered freshwater, air breathing mud eel, *Monopterus cuchia* (Hamilton) was analyzed to identify its peak breeding season. The samples were collected from January 2016-February 2018. In males, highest GSI value of 3.4±0.8 was observed during the month of May and lowest value of 0.02±0.1 was observed during the month of September. Similarly in case of females, highest GSI value of 7.33±0.081 was observed during the month of May and the lowest GSI value of 0.27±0.089 was observed during the month of September. Thus this indicates the maturity of the species which corresponding to the breeding period. Monthly variation in the fecundity of female *M. cuchia* was also calculated and found out that the fecundity of female *M. cuchia* was highest during the month of May with a peak value of 924 eggs (length= 78cm, weight= 344 gms) and lowest during the month of September with a value of 150 eggs (length= 70cm, weight= 365 gms). Ova diameter was analyzed during breeding season and observed to vary from 0.0 to 4.0 mm during September to May. However, this analysis implies that highest GSI value in May is indicative of the fact that *M. cuchia* may have peak breeding season in May.**

Keywords: **Fecundity, Gonado-somatic Index, *M. cuchia*, Ova diameter, Reproductive biology.**

I. INTRODUCTION

Mud Eel, *Monopterus cuchia*) is a fresh water fish belonging to Synbranchidae family of the order Synbranchiformes. It is a highly nutritious food fish with therapeutic value and it also has a high market demand in the North-Eastern states of India including Meghalaya. *M. cuchia* is locally known as *Khabseiñ* in Khasi language (Meghalaya) and considered as highly palatable and nutritious fish as well as a valued remedy in oriental medicine. The fish can be cultured in backyard tank but non- availability of seed is a hindrance in culture. Hence, artificial propagation is important for smooth supply of seed to the fishers. Nevertheless it is important to know the duration of reproductive season and its peak breeding period. Analysis of reproductive biology in fishes is an important parameter in fish biology since it has its practical importance in solving fishery management questions such as the determination of spawning stock. The availability data based on reproductive parameters and environmental variation lead to a better understanding of observed fluctuation in reproductive output and enhances our ability to estimate recruitment (Kraus *et al*., 2002). Studies on the reproductive biology of any fish is essential for evaluating the commercial potentialities of its stock, life history, cultural practice and actual management of indigenous fishes (Lagler, 1956) (Doha and Hye, 1970). Reproductive strategies depend on the abiotic environment, food availability, pressure of predators and the habitat of parental fish (Wootton, 1990). The study of fecundity is useful in the estimation of population and productivity (Agbugui, 2013.

Reproductive potential of a population is one of the basic exigencies to designate the individuals of that population in respect to their gonadal conditions (Jhingran and Verma, 1972). Knowledge of gonad development and the spawning season of a species allow subsequent studies on spawning frequency of its population, which is very important for its management (Chakraborty, 2018).

Several workers have reported on the studies of biology, breeding behavior and biochemical composition of various fish species at different levels. However, no comprehensive report is available on reproductive biology of *Monopterus cuchia* in Meghalaya. Therefore, overall study of reproductive physiology will help in achieving basic information on breeding season, breeding potential, gonadal maturity and reproductive performance of the fish. Since this species has high economic and medicinal value, the study on reproductive biology and breeding behavior of fish will help in induced propagation of seed of the fish and development of large scale as well as backyard culture of the species.

The present study describes the Gonado-Somatic Index (GSI), ova diameter and fecundity study of *Monopterus cuchia* with the objectives to determine monthly variation in development of reproductive organs of both male and female to determine the peak reproductive season which eventually help in development of protocol for artificial breeding of the fish.

II. MATERIALS AND METHODS

Monopterus cuchia were brought from different areas of Meghalaya and the studies were conducted for a period of January 2016-February 2018 and collected specimens were stocked and reared in the hatchery complex of the Department of Fishery Science, St. Anthony's College Shillong. For analyzing the development of gonads, random sampling of one hundred fishes i.e. fifty (50) males and fifty (50) females were selected and sampled every month during this study. Seasonal variation in the condition of gonads is important biological parameters in analyzing the reproductive biology as well as establishing the stages of maturity of the species under study. Fish body weight and gonads weight give the overall Gonado-Somatic Index (GSI). In general, Gonado-Somatic Index is helpful in identifying days and seasons of spawning, as the ovaries of gravid females increase swiftly in size just prior to spawning. The length of the samples collected was done using measuring tape and a ruler and the weight of the fish was determined by using an electronic balance. The samples were weighed and the abdominal region was dissected out to determine the sex of the fish. Sex of fish was done by visual examination of the gonads. After the samples have been dissected, gonads were taken out and placed in a petridish and weighed. The proportion of the two sexes relative to one another was used to calculate the sex ratio. These parameters were recorded on a data collected sheet. The Gonado-Somatic Index (GSI) was calculated as per Nikolsky (1963) method using the formula:

GSI=Weight of the Gonad (g)/ Weight of the fish (g) X 100

The ovary was carefully removed and the moisture was blotted using a blotting paper. Fecundity was determined based on the method proposed by Bagenal (1978). Moreover, eggs were counted by spreading on the tray for confirmation of results. The weight of the extracted ovary was recorded in grams, ova diameter was measured by using slide-calipers, age at first maturity was adopted by Biswas (1993) and the collected data were statistically analyzed using MS Excel.

III. RESULTS

During this period of analysis, it was found out that the mean Gonado-Somatic Index (GSI) values for males ranged from 0.02±0.1 to 3.4±0.8 whereas in case of females the mean GSI values ranged from 0.27±0.089 to 7.33±0.081. In case of males, highest GSI value of 3.4±0.8 was observed during the month of May and lowest value of 0.02±0.1 was observed during the month of September. Similarly in case of females, highest GSI value of 7.33±0.081 was observed during the month of May and the lowest GSI value of 0.27±0.089 was observed during the month of September. Thus this indicates the maturity of the species which corresponding to the breeding period.

The results obtained for the monthly variation in mean GSI values of both male and female *M. cuchia* were presented in TABLE-1, TABLE-2 and Fig-1 respectively.

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TABLE-1: Monthly variation of male body weight, gonad weight and GSI of *M. cuchia*.

Sl. No	Months	Fish examined	Mean Body Weight (gm) ± SD	Mean Testis Weight (gm) ± SD	GSI (%) ± SD
1	January	4	411±8.60	0.187±0.01	0.0454±0.5
2	February	4	658±6.16	0.510±0.03	0.077±0.4
3	March	4	430±2.16	7.03±0.02	1.634±0.2
4	April	4	204±2.16	6.098±0.08	2.989±0.2
5	May	4	204±2.16	7.00±0.40	3.4±0.8
6	June	4	400±3.74	0.379±0.08	0.947±0.66
7	July	4	215±4.08	0.207±0.01	0.096±0.14
8	August	4	236±4.54	0.207±0.04	0.0877±0.6
9	September	6	400±2.09	0.111±0.01	0.02±0.1
10	October	4	215±4.08	0.207±0.01	0.096±0.14
11	November	4	179±0.81	0.20±0.01	0.111±0.8
12	December	4	351±1.41	0.214±0.05	0.060±0.14

TABLE-2: Monthly variation of female body weight, gonad weight and GSI of *M. cuchia*.

Sl. No	Months	Fish Examined	Mean Body Weight (gm) ± SD	Mean Ovary Weight (gm) ± SD	GSI (%) ± SD
1	January	4	260±1.60	0.838±0.02	0.322±0.02
2	February	4	215±3.36	0.972±0.08	0.452±0.05
3	March	4	363±0.80	3.075±0.01	0.847±0.01
4	April	4	344±0.50	23.0±0.05	6.686±0.05
5	May	4	450±1.15	33.0±0.81	7.33±0.081
6	June	4	482±0.8	3.74±0.04	0.775±0.08
7	July	4	299±8.04	1.710±0.03	0.571±0.08
8	August	4	210±8.16	0.953±0.02	0.453±0.01
9	September	6	127±6.26	0.343±0.06	0.27±0.089
10	October	4	299±8.04	1.710±0.03	0.571±0.08
11	November	4	271±2.16	1.875±0.02	0.691±0.08
12	December	4	253±3.55	0.916±0.01	0.362±0.02

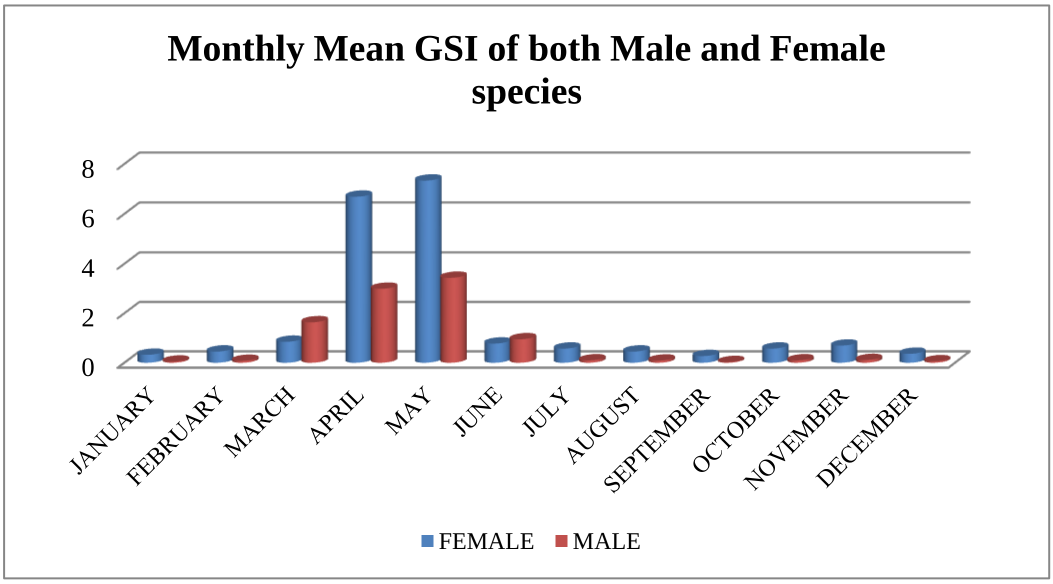

Fig-1: Cylinder chart showing monthly variation of Gonado-Somatic Index (GSI) of both male and female species.

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Knowledge of fecundity is an important factor in fisheries stock management and it is also used to describe fishes which are spawning for their first time. Moreover, fecundity is necessary to evaluate the reproductive potential of individual fish species and the monthly variation in the fecundity of this species was ranged from 150-924 eggs. During this course of study, it was found out that the fecundity of female *M. cuchia* was highest during the month of May with a peak value of 924 eggs (length= 78cm, weight= 344 gms) and lowest during the month of September with a value of 150 eggs (length= 70cm, weight= 365 gms) and the ova diameter was also calculated and this is as shown in TABLE-3, Fig-2 and Fig-3 respectively.

TABLE-3: Monthly fluctuations in the fecundity and ova diameter of female *M. cuchia*.

Sl. No	Months	Fecundity (Eggs)	Ova Diameter (in mm)
1	January	200	0.29
2	February	398	1.22
3	March	668	3.00
4	April	752	3.50
5	May	924	4.00
6	June	505	2.50
7	July	455	0.00
8	August	401	0.00
9	September	150	0.00
10	October	455	0.00
11	November	530	1.70
12	December	351	0.85

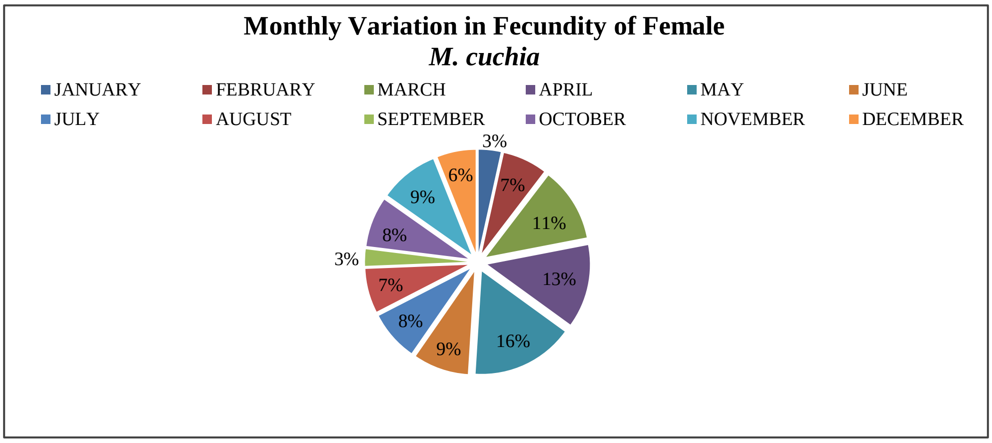

Fig-2: Pie-chart showing month-wise changes in the fecundity of *M. cuchia*

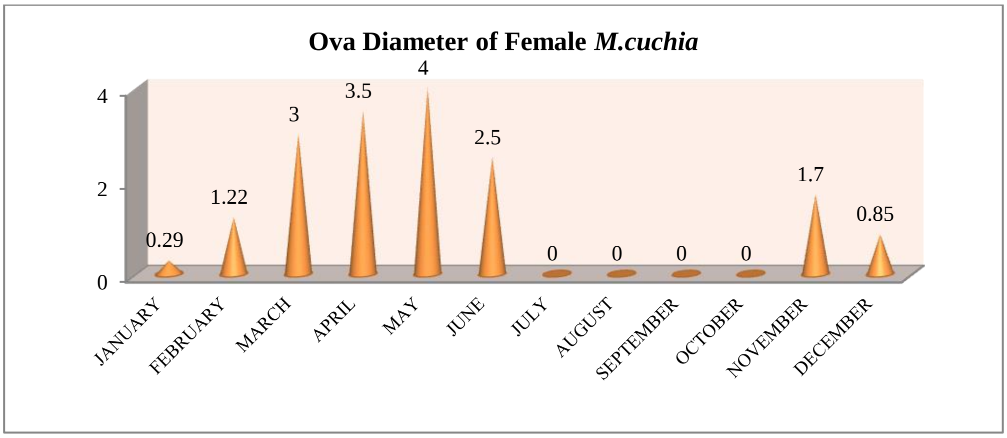

Fig-3: Cone-chart showing monthly fluctuations in the ova diameter of female *M.cuchia*

In order to gain a successful fish culture, it is necessary to analyzed and assessed the monthly variation of breeding cycle of the target species. During this period of analysis, the Gonado-Somatic Index, Fecundity and egg diameter was calculated and this is as shown in Fig-4 respectively.

Fig-4 (a): Ovary of Female *M. cuchia*

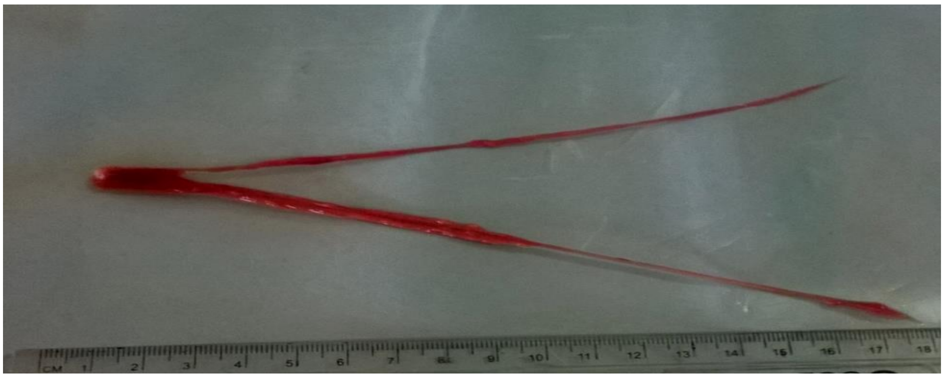

Fig-4(b): Testis of Male *M. cuchia*

Fig-4(c): Measurement of Ova diameter using Slide Callipers

IV. DISCUSSION

The Gonado-Somatic Index (GSI) is the calculation of the gonad mass as a proportion of the total body mass (Anderson and Gutreuter, 1983). According to (Dadzie and Wangila, 1980), Gonado-Somatic Index (GSI) which is an index of gonad size relative to fish size is a good indicator of gonadal development in fish. Moreover, the Gonado-Somatic Index increases with the maturation of fish, being highest during the period of peak maturity and declining abruptly thereafter, when the fish become spent (Le Cren, 1951). According to (King, 1996), Gonado-Somatic Index (GSI) is the measure of the relative weight of the gonad with respect to total or somatic weight. Gonadosomatic index (GSI) is also defined as the relative portion of which the ovaries constitute of the total weight (Gundersen *et al*., 1998).

It is important of know the reproductive physiological factors of a fish such as fecundity, gonado-somatic index (GSI), gonad developmental stages etc. to develop artificial breeding technique (Mithu *et al*., 2013). In general, Gonado-Somatic Index is usually important for both male and female and in addition to this; (De Vlaming *et al*., 1982) had also discussed the utility of GSI as indicator of the reproductive activity of a stock. According to (Mithu *et al*., 2013), Gonado-Somatic Index is the indicator of the state of maturity, gonadal development and onset of spawning season and at the same time it helps to know the breeding biology and breeding season of a species. To determine the breeding season, it is necessary to know the condition of the female, its ovaries and eggs size (Islam and Das, 2006).

Gonado-Somatic Index also determined the percentage of fish body weight that is used for egg production. GSI is also applied frequently since it determines the spawning frequency of many fishes. Monthly variation in the mean GSI values of both male and female species of *M. cuchia* were presented in TABLE-1 and TABLE-2 respectively. Mean Gonado-Somatic Index of *M. cuchia* was found to increase as the fish reaches the maturity stage and decreases gradually after the spawning stage. In case of male, the weight of the testes gradually increases from December with a peak value during the month of May. Highest GSI value (3.4±0.8) was recorded during the month of May and the GSI values began to fall gently from June (0.947±0.66) to November (0.111±0.8). In case of female, the weight of the ovary gradually increased from December with a peak value during the month of May. Highest GSI value (7.33±0.081) was recorded in the month of May and the GSI values began to fall gently from June (0.775±0.08) to November (0.691±0.08). Similar finding was also reported by (Chakraborty, 2018). Therefore the overall GSI value ranged from 0.02±0.1 to 3.4±0.8 for males and from 0.27±0.089 to 7.33±0.081 for female was presented in the Fig-1.

Monthly variation of Gonado-Somatic Index reflects the ovarian activity of the species. Moreover, the results of the present investigation indicated that the Gonado-Somatic Index of *Monopterus cuchia* was high during the month of May when the fish reached the maturing stage. The increasing GSI of *M. cuchia* suggests that the ovary harbours percentage of yolk laden ripe eggs in May which is more or less similar to (Dewan, 1973), (Chakraborty, 2010), (Chakraborty *et al*., 2007) and (Chakraborty, 2018).

During this period of analysis, highest GSI value in the month of May indicates the fact that *M. cuchia* may have a peak breeding season during the month of May. This result is very similar to those obtained by (Rahman, 2007). On the other hand, (Alam, 2012) also reported that the peak breeding season *M. cuchia* is from late April to mid-May. Moreover from this study it implies that the variation in GSI of *Monopterus cuchia* only occurred in mature fishes, which would be indicative of the peak period of spawning which is very similar as reported by (Narejo *et al*., 2003). From this analysis it implies that Gonado-Somatic Index of the fish is an important parameter to verify the breeding season of the species.

It is evident from the present study that Gonado Somatic Index (GSI) and fecundity is helpful to identify accurate spawning cycle of *M. cuchia* (Chakraborty *et al*., 2013). Similar findings were also reported by (Al-Ogaily and Hussain, 1990) for high values of GSI in case of trout sweet lip grunt *Plectorhynchus pictus*. From the experiment conducted it was found out that prior to spawning, *Monopterus cuchia* undergoes an increase in gonad weight. Similar findings as reported by (Fedorov, 1968) on Greenland halibut.

An important aspect of reproductive biology in fish is the fecundity, which gives information on the number of eggs in the ovary before the next spawning season (Bagenal, 1978). Studies on fecundity of fish species are pertinent and useful for systematic in racial studies related to total population estimation and productivity (Adebiyi, 2013). Fish fecundity is described as seasonal spawning potential and alternatively is defined as the number of eggs ripening between current and next spawning period in a female (Bagenal and Tesch, 1978). Moreover, fecundity is the number of ova that are likely to be laid by a fish during spawning season. Number of eggs produced by a fish differs in different species and it also depends on the size and age of the species (Lucy Towers, 2014). In general, fecundity which is defined as the number of vitellogenetic oocytes developing in each female prior to the spawning season is important for understanding spawning-stock recruitment relationships (Gundersen *et al*., 1998).

The study of fecundity is useful in the estimation of population and productivity (Agbugui, 2013). (Lagler *et al*., 1967) reported that the number of eggs produced by an individual female was dependent on various factor like size, age and condition of the species. It was also observed in some cases that the fecundity of some larger fishes was much less than that of some smaller fish. This type of variation was also reported by (Ahmed *et al.*, 1979). Fecundity is an important parameter to assess the reproductive potential of the species as reported by (Bora and Borah, 2008).

(Kiran and Puttaiah, 2003) indicated that ovary weight is a better index of fecundity than the total length and total weight for *Chela untrahi*. Moreover, gonadal development and fecundity also depends on food quality and quantity (Bielsa *et al*., 2003). In the natural environment, food conditions are subjected to seasonal variations. Fish adaptation capacity to environmental fluctuations will be determining for both survival and reproductive success (Adams, 1998).

Fecundity is one of the most important aspects of fish biology that explains variations in the level of production, success of induced breeding etc., it also help to explain the breeding cycle (Hunter *et al*., 1992). Generally, fecundity of the fish is found to vary from species to species, depending on age, length, weight and environmental condition (Biswas, 1982). High fecundity is often correlated with small egg size (Rath, 2000) and vice versa. Increase in fecundity with the increase in body weight was also reported in various fishes notably, *Mastacembelus pancalus* by (Karim and Hossain, 1972), *Puntius sarana* (Mustafa *et al*., 1983) and *Sarotheradon nilotica* (Mian and Dewan, 1984).

In this case, fecundity was determined based on the method proposed by (Bagenal, 1978). From the experiment conducted, it was found out that fecundity increased with the increase in total length of the species. Similar results were obtained in *Heteropneustes fossilis* (Azadi and Siddique, 1986) and (Das *et al*., 1989). In the present case, it was observed that the egg diameter of *M. cuchia* is much larger which may be a reason for less number of eggs, accommodating to the snake like slender body cavity of the fish. This result is very similar to those obtained by (Bora and Borah, 2008). Moreover, (Nasar, 1989) also calculated the fecundity of *M. cuchia* and revealed that fecundity of this species ranged from 118- 687 eggs. As shown in TABLE-3 and Fig-2, the fecundity in the present study is much higher than the estimated fecundity given by (Nasar, 1989). The fecundity also varied with the seasons, climatic conditions and environmental habitat, nutritional status and genetic potential (Bromage *et al*., 1992). It was observed during this present investigation that the fecundity increases with the increase in body weight and gonad weight of the species.

Monthly variation in the fecundity of *M. cuchia* ranged from 150-924 eggs. Highest fecundity with a peak value of 924 eggs (length= 78cm, weight= 344 gms) was recorded during the month of May and the lowest fecundity value of 150 eggs (length= 70cm, weight= 365 gms) was recorded during the month of September. During this period of analysis, fecundity was found to increase with the increase of gonad weight of *M. cuchia*; similar relationship was also reported in *Puntius stigma* (Shafi and Quddus, 1974).

For analysis of reproductive biology in any fish species, it is necessary to have a clear concept on the spawning season of the species of interest. Moreover, spawning season can be predicted by analyzing the period of maturation as well as by measuring the ova diameter. During this course of study, it was found out that the fecundity of the fish was inversely proportional to the ova diameter i.e. the fecundity increases with the decrease in ova diameter. (Pathak and Jhingran, 1977), (Nabi and Hossain, 1996), (Narejo *et al*., 1998) and (Afroz *et al*., 1990) have reported higher fecundity with small ova diameter. Similarly fecundity decreases with the increase in ova diameter and this was reported by (Das *et al*., 1989), (Faruq *et al*., 1998), (Shaima *et al*., 1992) and (Faruq *et al*., 1996).

Month-wise changes in the ova diameter of Mud Eel ranged from 0.0 to 4.0mm. The highest ova diameter of 4.0 mm was found in month of May and lowest ova diameter of 0.0 mm was observed during the months of July, August, September and October. All the ova of an individual were found to have same diameter. In case of *Monopterus albus*, ova diameter was found out to be 3 to 4 mm and eggs were not uniform (Khanh and Ngan, 2010). The ova diameter in *Monopterus albus* is close to *Monopterus cuchia* but they differ in uniformity of egg size. The above findings are similar as obtained in the present study. Therefore, from the above findings it was assumed that the fish spawned once a year with one spawning peak in the month of May as indicated by the values of both ova diameter (4.0 mm in May) and Gonado-Somatic Index (GSI of males= 3.4±0.8 and GSI of females= 7.33±0.081) respectively. (Singh *et al*., 1989) described the spawning season of *M. cuchia* in summer i.e. from May to June and the above findings are similar as obtained in the present study. Monthly fluctuations in the ova diameter of female *M. cuchia* were shown in TABLE-3 and Fig-3 respectively. During this period of analysis, it was found out that the ova diameter ranged from 0.0 mm to 4.0 mm during September to May. (Singh *et al*., 1989) reported that the ova diameter in *M. cuchia* ranging from 3–4.0 mm, which is nearer to the present results. All the ova were found to be spherical and having a uniform diameter, which indicates that the eggs were shed in a single batch during the period of spawning. Moreover, no ova were observed during the month of

July to October. (Nabi and Hossain, 1996) have published similar observations in the spiny eel, *Macrognathus aculeatus*. Relationships between ovary weight and mean ova diameter indicated that ova diameter increased with the increase in gonad weight. Similar findings were also reported by (Mithu *et al*., 2013).First maturity of this species was found to attain at 25.2 cm in total length and both the stages of maturity and cycle of maturation of ovaries indicated that this species spawn only once a year.

V. CONCLUSION

Gonado-Somatic Index is an important parameter to determine the maturity stages in fishes. Mean Gonado-Somatic Index of *Monopterus cuchia* was found to increase as the fish reaches the maturity stage and decreases gradually after the spawning stage. The fecundity of *M. cuchia* is very low in comparison to other cultivable fish species and this may be the main reason for declining trend in natural population of the species. In the present analysis, high values of GSI and ova diameter denoted the attainment of peak maturity of the gonads. The breeding season for the species is from April to June with peak in the month of May. The species was found to breed only once a year.

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REFERENCES

[1] Kraus, G., Tomkiewicz, J., and Koster, F.W. 2002. Egg production of Baltic cod in relation to variable sex ratio, maturity and fecundity. *Canadian Journal of Fisheries and Aquatic Science*. 59: 1908-1920.

[2] Lagler, K. F. 1956. Fresh Water Fishery Biology. 2nd Edition, WM Brown Company, Bubuque, Lowa; p. 541.

[3] Doha, S., and Hye, M.A. 1970. Fecundity of Padma River hilsa, Hilsa ilisha (Hamilton). *Pakistan Journal of Science*. 22(3-4): 176-178.

[4] Wooton, R. J. 1990. Ecology of Teleost Fishes. First Edition Chapman and Hall, London; p. 344.

[5] Agbugui, M.O. 2013. The Sex Ratio, Gonadosomatic index, Stages of Gonadal Development and Fecundity of the Grunt, *Pomadasys jubelini* (Cuvier, 1830) in the New Calabar-Bonny River. 5 (11). http://www.sciencepub.net/report.

[6] Jhingran, A.G., and Verma, D.N. 1972. Sexual maturity and spawning of Gadusia chapra (Hamilton) in Ganga river system. Proceedings of the National Science Academy, India. 42 (2): 207-224.

[7] Chakraborty, B.K. 2018. Reproductive cycle of the Mud eel, *Monopterus cuchia* (Hamilton-Buchanan, 1822) in Bangladesh. *International Journal of Oceanography and Aquaculture*. 2 (2): 000132.

[8] Nikolsky, G.V. 1963. The Ecology of fishes. Academy Press, London and New York.

[9] Bagenal, T. B. 1978. Methods of assessment of fish production in freshwater. Blackwell Scientific Publication, Oxford.

[10] Biswas, S. P. 1993. Manual of Methods in Fish Biology. South Asian Publishers Private Limited, New Delhi; p.157.

[11] Anderson, R. O., and Gutreuter, S. J. 1983. Length, Weight and Associated Structural Indices. In: Fisheries Techniques. Nielsen, L. A. and D. L. Johnson (editions). *American Fisheries Society, Bethesda, MD*; p. 283–300.

[12] Dadzie, S., and Wangila, B.C.C. 1980. Reproductive biology, length-weight relationship and relative condition of pond raised *Tilapia zilli* (Gervais). *Journal of Fish Biology*. 17: 243-253.

[13] Le Cren, E.D. 1951. The Length-Weight Relationship and Seasonal Cycle in gonad weight and condition in Perch. *Journal of Animal Ecology*. 20: 201-219.

[14] King, R. P. 1996. Length – Fecundity relationship of Nigeria fish population. *Naga ICLARMQ* 20 (1): 29- 33.

[15] Gundersen, A.C., Kjesbu, O.S., Stene, A., and Nedreaas, K.H. 1998. Fecundity of Greenland halibut *(Reinhardtius hippoglossoides)* in the North East Arctic. *International Council for the Exploration of the Sea*. ICES CM 1998/0:29. Theme Session Deepwater Fish and Fisheries.

[16] Mithu, M.M., Alam, M.J., Siddique, M.A.T., Sukhan, Z.P., Kabir, M.S., Hossain, M., and Rashid, H. 2013. An Investigation of the Reproductive Physiology of Endangered Mud Eel *Monopterus cuchia*. Conference: 4th the International Conference on Environmental Aspects of Bangladesh, At Fukuoka, Japan. 128-131.

[17] De Vlaming, V., Grossman, G., and Chapman, F. 1982. On the use of the Gonado-Somatic Index, Comparative Biochemistry and Physiology Part A. 73; p. 31-39.

[18] Islam, M. K., and Das, M. 2006. Fecundity of gulsa *Mystus cavasius* from the Brahmaputra and Kongsa rivers. *Journal of Bangladesh Agricultural University*. 4 (2): 347-355.

[19] Dewan, S. 1973. Investigation into the ecology of fishes of Mymensingh Lake. PhD dissertation, Bangladesh Agricultural University Mymensingh, Bangladesh, pp. 235.

[20] Chakraborty, B.K. 2010. Fecundity and Induction of spawning in spiny Guchi, Macrognathus pancalus (Bloch &Schneider, 1822) in Bangladesh. *Bangladesh Journal of Zoology*. 38(1): 77-91.

[21] Chakraborty, B.K., Mirza, Z.A., Miah, M.I., Habib, M.A.B., and Chakraborty, A. 2007. Reproductive cycle of the Endangered Sarpunti, *Puntius sarana* (Hamilton, 1822) in Bangladesh. *Journal of Asian Fisheries Science*. 20 (2): 145-164.

[22] Rahman, M.M. 2007. Reproductive Biology and fry rearing of freshwater eels *Monopterus cuchia* (Hamilton) and *Mastacembelus armatus* (Lacep.) of Mymensingh, Bangladesh. PhD Dissertation, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, pp. 173.

[23] Alam, M.J. 2012. Histological study of gametogenesis in endangered Mud Eel *Monopterus cuchia*. MS Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh, pp. 33-36.

[24] Narejo, N.T., Rahmatullah, S.M., and Mamnur Rashid, M. 2003. Reproductive biology of air-breathing freshwater Mud Eel, *Monopterus cuchia* (Hamilton) from Bangladesh. *Indian Journal of Fisheries*. 50 (3): 395-399.

[25] Chakraborty, B.K., Azad, S.A., Barmon, B., and Faruque, A.M.O. 2013. Fecundity and Gonado Somatic Index of Gangetic Mud Eel, *Monopterus cuchia* (Hamilton, 1922). *Bangladesh Journal of Zoology*. 41(2): 165-172.

[26] Al-Ogaily, S. M., and Hussain, A. 1990. Biology of grunt *Plectorhynchus pictus* (Thunberg, 1972 (Haemuliudae, Teleostei, Percoidei) from the red sea (Jizan area). *Fisheries Research. 9*: 119-130.

[27] Fedorov, K.Y. 1968. Oogenesis and sexual maturity cycle of Greenland halibut. Trudy PINRO: 425-451.

[28] Adebiyi, F.A. 2013. The Sex Ratio, Gonadosomatic Index, Stages of Gonadal Development and Fecundity of Sompat Grunt, *Pomadasys jubelini* (Cuvier, 1830). *Pakistan Journal of Zoology*. 45 (1): 41-46.

[29] Bagenal, T., and Tesch, F.W. 1978. Age and growth. In Bagenal T. (ed.) Methods for assessment of fish production in fresh water, 3rd Edn. IBP Handbook Blackwell Sci. Pub. Oxford; 3, pp. 101-136.

[30] Towers, L. 2014. Maturation and Spawning in fish. The Fish Site.

[31] Lagler, K.F., Bardach, J.E., and Miller, A.R. 1967. Ichthyology. John Wiley & Sons. Newyork: USA; p. 545

[32] Ahmed, A.T.A., Mustafa, G., and Hai, A. 1979. Fecundity of Cat Fish, *Clarias batrachus* (L.). *Journal of the Asiatic Society of Bangladesh Science*. 5 (2): 7-12.

[33] Bora, I.B., and Borah, B.C. 2008. Gonadal development and fecundity of Gangetic Mud eel *Monopterus cuchia* (Hamilton-Buchanan) in Assam. *Journal of Inland Fisheries Society of India.* 40 (1): 69-74.

[34] Kiran, B.R., and Puttaiah, E.T. 2003. Fecundity studies on *Chela untrahi* (Day) from Bahdra reservoir, Karnataka, India. *Journal of Inland Fisheries Society of India.* 35: 41-44.

[35] Bielsa, S., Francisco, P., Mastrorillo, S., and Parent, J.P. 2003. Seasonal changes of periphytic nutritive quality for *Sicyopterus lagocephalus* (Pallas, 1770) (gobiidae) in three streams of Reunion Island. *Annales de limnologie-International Journal of Limnology*. 39 (2): 115-127.

[36] Adams, S.M. 1998. Ecological role of lipids in the health and success of fish populations. In Arts M.T. & Wainman B.C. (Editions). *Lipids in freshwater ecosystems*. Springer-Verlag New York; p. 132-160.

[37] Hunter, J.R., Macewicz, B.J., Lo, N.C.H., and Kimbrell, C.M. 1992. Fecundity, spawning and maturity of female Dover Sole, *Microstomus pacificus*, with an evaluation of assumptions and precition. Fish. Bull., U.S. 92; p.101-108.

[38] Biswas, S. P. 1982. Studies on certain aspects of the Biology of *Labeo pangusia* and *Labeo dero* in North-East India. Ph.D. Thesis, North Eastern Hill University, Shillong. 157 pp.

[39] Rath, R. K. 2000. Freshwater Aquaculture -2nd Edition. Scientific Publication (India), Jodhpur; p. 445.

[40] Karim, M.A., and Hossain, A. 1972. Studies on the biology of *Mastacembelus pancalus (*Spiny eel) in Artificial Ponds. Part 11. Sexual Maturity and Fecundity. *Bangladesh J. Biol. and Agriculture Sci*ence, 1: 15-18.

[41] Mustafa, G., Islam, K.R., Ali, S., and Ashraftil-Alain, A.K.M. 1983. Some aspects of the biology of *Puntius sarana* (Hamilton): 1. Food and feeding habits in relation to fish size and fecundity. *Bangladesh Journal of Zoology*. 10: 92-100.

[42] Mian, A.M., and Dewan, S. 1984. Studies on the Fecundity of *Sarotherodon nilotica* (Linnaeus) in a fish pond. *Bangladesh Journal of Zoology*. 12 (2):99-103.

[43] Azadi, M.A., and Siddique, M.S. 1986. Fecundity of catfish (in Bangladesh), *Heteropneustes fossilis* (Bloch). *Bangladesh Journal of Zoology*. 14: 33-39.

[44] Das, M.S., Dewan, S., and Debnath, S.C. 1989. Studies on the fecundity of *Heteropneustes fossilis* (Bloch) in a mini-pond of Bangladesh Agricultural University, Mymensingh. *Bangladesh Journal of Agricultural Science*. 16:1-6.

[45] Nasar, S. S. T. 1989. Parental care and fecundity in *Monopterus* (*Amphipnous*) *cuchia* (Hamilton). *Journal of Freshwater Biology*. 1 (1): 67-70.

[46] Bromage, N., Jones, J., Randall, C., Thrush, M., Davies, B., Springate, J., Duston, J., and Baker, G. 1992. Brood stock management, fecundity, egg quality and the timing of egg production in the rainbow trout (*Oneorhynchus mykiss*). *Aquaculture*. 100: 141-166.

[47] Shafi, M., and Quddus, M.M.A. 1974. Fecundity of the common Punti *(Puntius stigma). Bangladesh Journal of Zoology*. 2: 133-145.

[48] Pathak, S.C., and Jhingran, A.G. 1977. Maturity and Fecundity of *Labeo calbasu* (Hamilton) of Loni reservoir, Madhya Pradesh. *Journal of Inland Fisheries Society of* India. 9**:** 72-83.

[49] Nabi, M.R., and Hossain, M.A. 1996. Reproductive Biology of the freshwater Spiny Eel, *Macrognathus aculeatus* (Bloch). *Bangladesh Journal of Zoology*. 24 (2): 115-120.

[50] Narejo, N.T., Ali, S.S., Jafri, S.I.H., and Hussain, S.M. 1998. Studies on the Reproductive Biology of Palla, *Tenualosa ilisha* from the river Indus. *Pakistan Journal of Zoology*. 30 (3): 223-227.

[51] Afroz, T., Nabi, M.R., and Mustafa, G. 1990. Fecundity of Chapila, *Gudusia chapra* (Hamilton) from Jahangirnagar University ponds. *Bangladesh Journal of Life Science*. 11(1-2): 45-51.

[52] Faruq, M.A., Saha, J.K., Mian, M.I., and Rahmatullah, S.M. 1998. Fecundity, length and weight relationship and condition factor in *Heteropneustes fossilis* (Bloch). *Bangladesh Journal of Fisheries*. 21(1): 77-81.

[53] Shaima, K., Nashida, B., and Isabella, B. 1992. Studies on some aspects of the Biology and Fecundity of *Mystus tengara* (Hamilton-Buchanan, 1822). *Bangladesh Journal of Zoology*. 20 (2): 333-340.

[54] Faruq, M.A., Saha, J.K., Mian, M.I., and Rahmatullah, S.M. 1996. The Fecundity of *Clarias batrachus* (Linnaeus) and the relationship of fecundity with length and weight. *Bangladesh Journal of Fisheries*. 19(1-2): 67-70.

[55] Khanh, N.H., and Ngan, H.T.B. 2010. Current practices of rice field eel *Monopterus albus* (Zuiew, 1973) culture in Vietnam; p. 48-51.

[56] Singh, B. N., Towheed, M.A., and Munshi, J.S.D. 1989. Respiratory adaptations in the larvae of *Monopterus cuchia* (Hamilton). *Journal of Fish Biology*. 34: 637- 638.