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RESEARCH ARTICLE

THE QUANTITATIVE ESTIMATION OF REPRODUCTIVE CYCLE OF A FEMALE CATFISH, *Mystus cavasius* IN RELATION TO SEASONAL VARIATION IN PHOTOPERIOD AND WATER TEMPERATURE OF CHAMBAL RIVER

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ABSTRACT

The quantitative study of reproductive cycle of *Mystus cavasius* has been done in respect of gonadosomatic index and fecundity of fish. The gonadosomatic index of *Mystus cavasius* from Chambal River was observed from September, 2011 to August 2012 and fecundity was studied from May to August, 2012. The gonadosomatic index increased with the progressively development of gonad of the fish. The gonadosomatic index of this fish was increased significantly in May (6.06 ±0.09) and it reached its peak point in month of June (7.97±0.14) and lowest value of the gonadosomatic index of this fish was observed in the month of January (3.04±0.08). Therefore, the gonadosomatic index is in perfect positive correlation with the gonad weight. The correlation coefficient between gonadosomatic index and gonad weight were $r = 0.9936$. The fecundity of female species was varied from 6442.68±1293.38 to 18,707.95±1355.59 depending on gonad weight, body weight and age of fish. The maximum fecundity was observed in month of July and lowest was observed in the month of August. It has also shown a strong correlation with the gonad weight. The coefficient of correlation between fecundity and body weight was $r = 0.888$, fecundity and gonad weight was $r = 0.993$ and fecundity and body length was $r = 0.496$. The water temperature and photoperiod has also shown a close correlation with the gonadosomatic index and fecundity of the fish. The correlation coefficient between gonadosomatic index and water temperature and photoperiod were $r = r = 0.654$ and $r = 0.872$ respectively and regression equation between gonadosomatic index and water temperature and photoperiod were $Y=0.1822x-0.2174$ and $Y= 1.0194x+7.451$ respectively. The correlation coefficient between fecundity and water temperature and photoperiod were $r = 0.1311$ and $r = 0.9399$ respectively and regression equation between fecundity and water temperature and photoperiod were $Y= -1733.8X+72494$ and $Y= 18338X – 236447$ respectively.

INTRODUCTION

The quantitative study of reproductive cycle of *Mystus cavasius* has been done in respect of gonadosomatic index and fecundity of fish. The gonadosomatic index is reliable indicatior of gonadal state of fish. The gonadosomatic index is particularly helpful in identifying the time and season of spawning as the ovaries of gravid females swiftly increases in size just prior to the spawning. The utility of gonadosomatic index as the indicator of the reproductive activity of the stock has also been discussed. Saksena (1987) has shown that gonadosomatic index in *Glossogobius giuris* is closely connected with its gonadal activity. The fecundity of fish may be defined as the capacity of fish in terms of egg production, the total number of eggs produced by a female during the average life span or the number of ripe eggs in the ovaries of a female before spawning and the number of eggs per unit of length or weight of fish. Fecundity of any animal is an adaptation which ensures the survival of species under the condition in which it has been evolved, originated and lived. It also appears to bear some broad relationship to the care accorded to the eggs. Knowledge about fecundity of a fish has been an essential feature for evaluating the commercial potentialities of its stock, egg production, life history, culture and actual management of the fishery. The measure of fecundity in fishes is a basic determinant of productivity and contributes to the development of pisciculture. Royce (1972) stated that fecundity, among egg laying animals, is the number of eggs being studied for next spawning by a female. Fecundity of fish is variously related to the egg sizes, gonad size, length, weight of female fish and the age. It is assumed that large sized fish would be more fecund than the small sized fish. Recent work on gonadosomatic index and fecundity was done by several workers on different species viz., (Abedi *et al.*, 2011, Hossain *et al.*, 2012, Isa *et al.*, 2012, Mishra and Saksena, 2012, Kashief-El *et al.*, 2013, Nandikeshwari and Anandan, 2013 and Gupta and Banerjee, 2013). The main aim of this communication is to collect information about the reproductive potentiality of a freshwater catfish, *Mystus*

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cavasius (Ham.) which may be helpful in understanding the importance of gonadosomatic index and fecundity in reproduction of this fish which is mainly consumed by the common people in the area.

MATERIALS AND METHODS

To determine the gonadosomatic index sexually mature females of catfish, *Mystus cavasius* were collected from Chambal River, Morena, Madhya Pradesh during a period from September, 2011 to August, 2012 while for the determination of fecundity the collection was made during May to August, 2012. The female specimens of 14.71 ± 0.21 cm in total length and 56.31 ± 0.92 gm in total weight were used for the study. They were caught with the help of local fisherman using cast net. The fishes were sacrificed to remove ovaries and the weight of the ovaries were recorded by using spatula balance in gm. To estimate the fecundity, of fish species the ovaries were kept in Gilson's fluid in separate vials. This fluid not only preserved the ovaries but also separated the eggs from each other for their counting. The gonadosomatic index and fecundity of fish were calculated by using following formula:

$$\text{Gonadosomatic index} = \frac{\text{Weight of ovary}}{\text{Weight of the fish}} \times 100$$

$$\text{Fecundity} = \frac{\text{Number of ova in the subsamples of ovary}}{\text{Weight of the subsample of ovary}} \times \text{Weight of ovary in gm.}$$

Fecundity per cm = Fecundity / Total length of fish in cm

Fecundity per gm = Fecundity / Total weight of fish in gm

The water temperature and photoperiod was recorded on the monthly basis for a period of September, 2011 to August, 2012.

RESULTS

Gonadal development of *M. cavasius* has been studied by using the gonadosomatic index during the reproductive cycle. During post spawning phase (October-November), there was a gradual increase in the gonadosomatic index after spawning, the weight of the ovary increased gradually. After the post-spawning phase, the reproductive cycle undergoes a preparatory phase (December – February), the gonadosomatic index was found to be minimum during January (3.04±0.08). The preparatory phase follows the maturing phase of the reproductive cycle, which occurs from March to April, when the gonadosomatic index of the fish was increasing from the previous months. During the pre-spawning phase (May-June), the gonadosomatic index, there was significant increase in the weight of the gonad and which consequently, results the increase in the gonadosomatic index of the fish. The highest gonadosomatic index was noticed in the month of June (7.97±0.14) and lowest value (3.04±0.08) in the month of January (Table 1). The gonadosomatic index has shown a positive correlation with the gonad weight. The correlation coefficient and regression equation between gonadosomatic index and gonad weight is r = 0.9936 and Y = 0.6725X – 0.4943 respectively (Table 2 and Fig. 3). The gonadosomatic index shown seasonal variation which exhibited correlation with the water temperature and photoperiod of the river (Fig.1 and 2).

Table 1. The seasonal variation in the gonadosomatic index of *M. cavasius* along with the change in the photoperiod and water temperature of the Chambal River

Months	Gonadosomatic index Mean±S.E	Photoperiod Hours: Minutes	Water temperature ^{0}C	Phases of the reproductive cycle
September	4.70±0.17	12:17	34.4	Spawning
October	4.25±0.08	11:34	28.7	
November	4.26±0.07	10:82	24.5	Post-spawning
December	3.12±0.07	10:20	22.5	
January	3.04±0.08	10:29	15.2	Preparatory
February	3.63±0.15	11:20	18.6	
March	4.51±0.09	11:98	26.4	
April	4.72±0.05	12:73	32.6	Maturing
May	6.06±0.09	13:59	34.2	
June	7.97±0.14	13:93	34.8	Pre-spawning
July	6.63±0.25	13:82	32.1	
August	5.90±0.31	13:26	34.6	Spawning

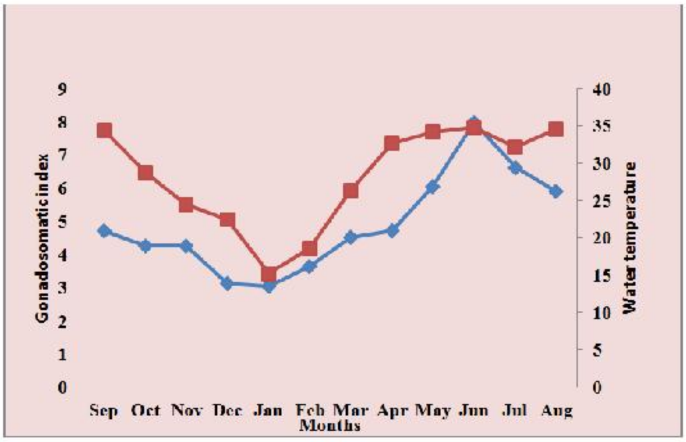

Fig.1. The seasonal variation in gonadosomatic index of *M. cavasius* along with the water temperature

Fig.2. The seasonal variation in gonadosomatic index of *M. cavasius* along with the water temperature

The water temperature of Chambal River was decreasing from October to December, while its minimum value was recorded as 15.2^{0}C in the month of January. The water temperature increased gradually from March to May and the highest temperature is recorded as 34.8^{0}C in June. Photoperiod of Chambal River was fluctuated between 10:20 hours-minutes to

13:93 hours-minutes. The maximum photoperiod (13:93 hours-minutes) in the month of June and minimum light (10:20 hours-minutes) during December (Table 1). Thus, the gonadosomatic index has been found to be positively correlated with the water temperature and photoperiod in different months. The correlation coefficient between gonadosomatic index and water temperature and photoperiod were r = 0.654 and r = 0.872 respectively and regression equation between gonadosomatic index and water temperature and photoperiod were Y=0.1822x-0.2174 and Y= 1.0194x+7.451 respectively (Table 2 and Fig. 4 and 5).

Table 2. The correlation coefficient and regression equation between gonadosomatic index and ovary weight of *M. cavasius*

Relationship	Correlation (r)	Regression equation
Gonadosomatic index and gonad weight	0.9936	Y = 0.6725X – 0.4943
Gonadosomatic index and water temperature	0.6542	Y=0.1822x-0.2174
Gonadosomatic index and photoperiod	0.872	Y= 1.0194x+7.451

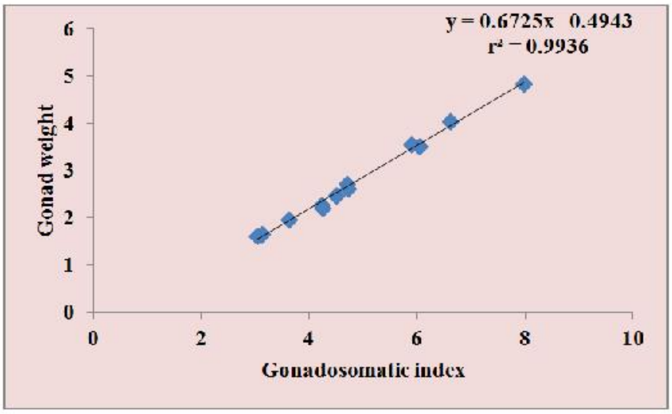

Fig. 3. The regression equation and correlation coefficient between gonadosomatic index and ovary weight

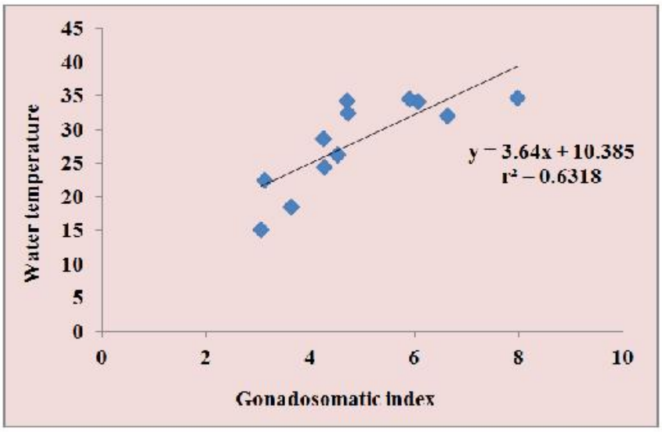

Fig. 4. The regression equation and correlation coefficient between gonadosomatic index and water temperature

The fecundity of female species was varying from 6442.68±1293.38 to 18707.95±1355.59 ova/ fish depending on the weight of gonad and maturity stages. The highest fecundity of *M. cavasius* was observed in the month of July (18707.95±1355.59 ova/ fish) and lowest in the month of August (6442.68±1293.38 ova/ fish) (Table 3 and Fig. 8).

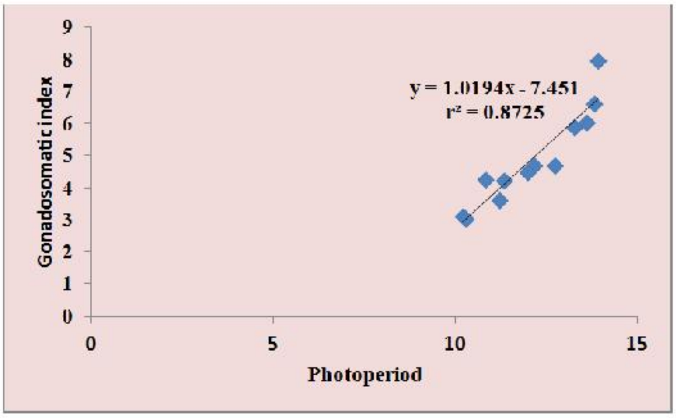

Fig. 5. The regression equation and correlation coefficient between gonadosomatic index and photoperiod

Table 3. The mean contribution of fecundity, fecundity/ cm of body length and fecundity/ gm of body weight of *M. cavasius* from May 2012- August 2012

Months	Fecundity	Fecundity/ cm of bodylength	Fecundity/ gm of bodyweight
May	13132.55±1388.06	811.28±78.34	217.17±22.20
June	17462.56±1136.55	1097.32±59.27	287.75±18.10
July	18707.95±1355.59	1162.80±83.20	307.581±19.73
August	6442.68±1293.38	413.28±84.30	112.63±23.79

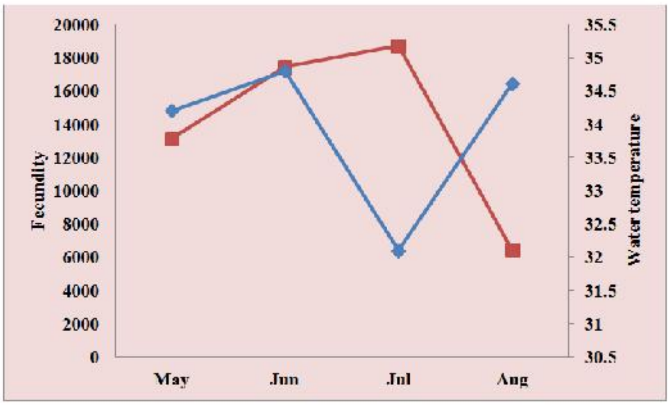

Fig. 6. The seasonal variation in the fecundity of *M. cavasius* along with the water temperature

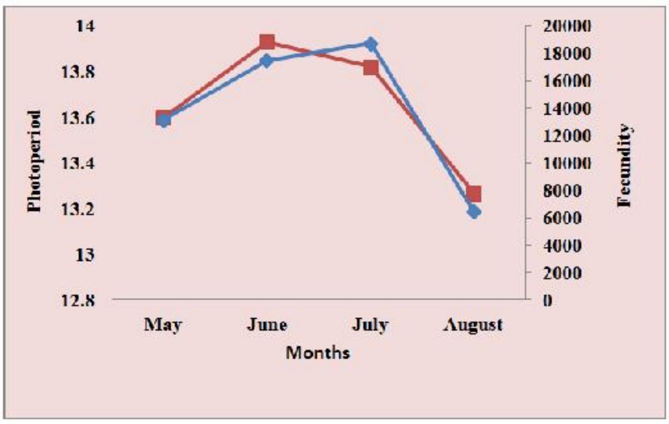

Fig. 7. The seasonal variation in the fecundity of *M. cavasius* along with the photoperiod

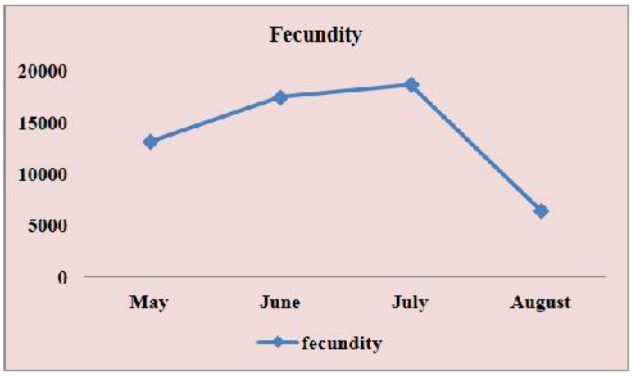

Fig. 8. The seasonal variations in the fecundity of *M. cavasius*

The average fecundity per cm of body length was 871.17± 170.64 ova/ cm and average fecundity per gm of body weight was 231.28 ± 44.05 ova/gm (Table 3). The fecundity increases with the increasing in the gonad weight. It is highly positively correlated with the gonad weight. The correlation coefficient and regression equation between fecundity and body weight was r = 0.8882 and Y= 0.0002X + 56.387, fecundity and gonad weight was r = 0.993 and Y = 0.0001X + 2.6812 and fecundity and body length was r = 0.4969 and Y= 16892X + 15.511 respectively (Table 5 and Fig. 9, 10 and 11).

Table 4. The mean contribution and S.E. of fecundity, fecundity/cm of body length and fecundity/ gm of body weight of *M.cavasius*

S.No	Fecundity parameters	Mean ± S.E
1.	Fecundity	13936.44±2768.927
2.	Fecundity / cm body length	871.17± 170.64
3.	Fecundity/ gm body weight	231.28 ± 44.05

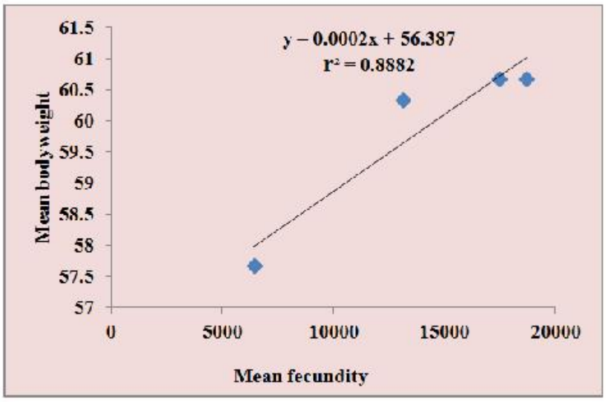

Fig.9. The regression equation and correlation coefficient between fecundity and body weight

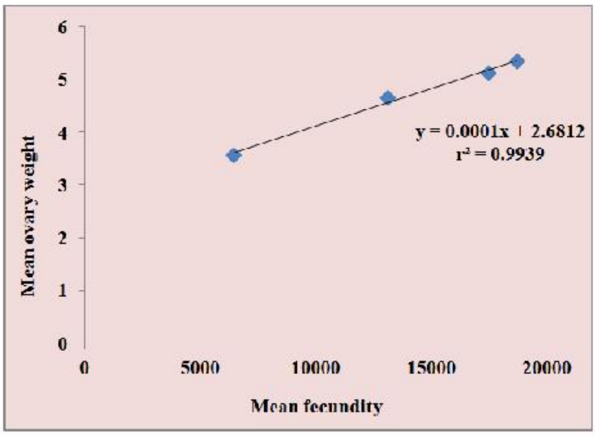

Fig. 10. The regression equation and correlation coefficient between fecundity and ovarian weight

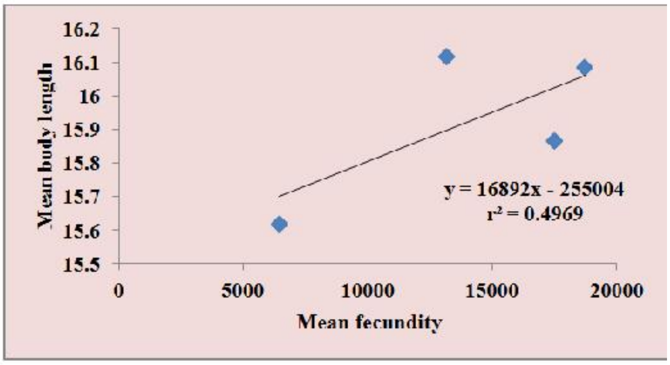

Fig. 11. The regression equation and correlation coefficient between fecundity and body length

The fecundity of this fish showed a alteration with the seasonal variations in water temperature and photoperiod of Chambal river (Fig. 6 and 7). The fecundity also showed a correlation with the water temperature and photoperiod of Chambal River (Table 5). The correlation coefficient between fecundity and water temperature and photoperiod were r = 0.1311 and r = 0.9399 respectively and regression equation between fecundity and water temperature and photoperiod were Y= -1733.8X+72494 and Y= 18338X – 236447 respectively (Table 5 and Fig. 12 and 13).

Table 5. The correlation coefficient and regression equation of fecundity with ovary weight, total body weight and body length of *M. cavasius*

Relationship	Correlation (r)	Regression equation
Fecundity (Y) and body weight (X)	0.8882	Y= 0.0002X + 56.387
Fecundity (Y) and ovary weight (X)	0.9939	Y = 0.0001X + 2.6812
Fecundity (Y) and body length (X)	0.4969	Y= 16892X + 15.511
Fecundity (Y) and water temperature (X)	0.1311	Y= -1733.8X+72494
Fecundity (Y) and photoperiod (X)	0.9399	Y= 18338X – 236447

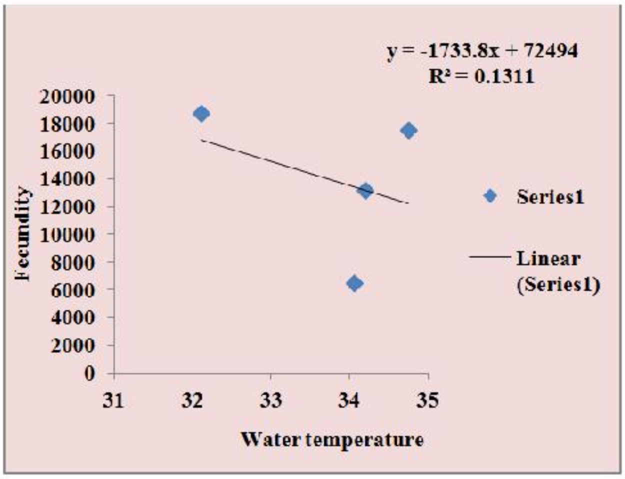

Fig. 12. The regression equation and correlation coefficient between fecundity and water temperature

DISCUSSION

M. cavasius has shown variation in different months of the study. During post spawning phase (October-November), there was a gradual decrease in the gonadosomatic index value as after spawning, the weight of the ovary increases gradually. After the post spawning phase the reproductive cycle

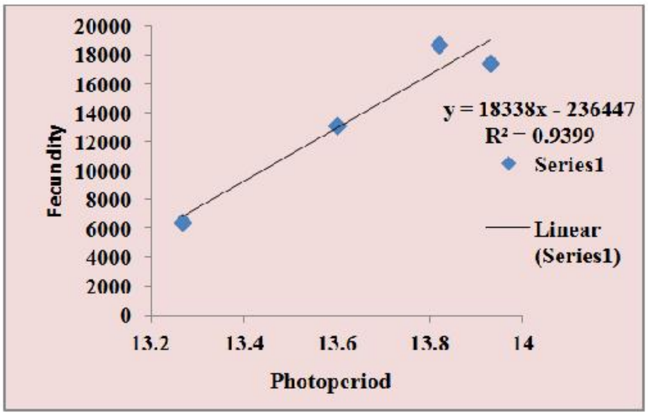

Fig. 13. The regression equation and correlation coefficient between photoperiod and fecundity

undergoes preparatory phase (December – February), the gonadosomatic index was found minimum during January (3.04±0.08). The preparatory phase has undergone for a maturing phase, which is from March to April, when the gonadosomatic index of the fish was increased over the previous months. During the prespawning phase (May-June), in gonadosomatic index, there has been significant increase in the weight of the gonad which results in an increase in the gonadosomatic index of the fish. The highest value of gonadosomatic index was noticed in the month of June (7.97±0.14). During spawning period (July-September), the gonadosomatic index of fish was high but lesser than the months of prespawning period. A correlation coefficient between the gonadosomatic index and weight of ovary (r = 0.9936) has also been made and a perfect positive correlation exists between them. The gonadosomatic index was increased with the increase in gonad weight and gonadal maturity. It has been suggested that the gonadosomatic index indicates the female reproductive maturity of fish (Lowe-McConnell, 1982). This has been confirmed in several studies including that of Rao and Krishnan (2009), Ghanbahadur and Ghanbahadur (2012) and Mishra and Saksena (2012) who have recorded increased gonadosomatic index with that of maturation stages of the fish and reached its maximum at the peak of maturity and declines with the beginning of the spawning period of the fish Nandikeshwari and Anandan (2013). Gupta and Banerjee (2013) have found that the gonadosomatic index of *Amblypharyngodon mola* also was highest during June and lowest during January.

The fecundity of a fish has shown a positive relationship with the weight of ovary and body weight. The maximum number of eggs was observed in the month of July when the ovary reaches its peak maturity stage. The prediction is that spawning takes place in the month of July and highest spawning is in the month of August, when average number of matured ova was observed minimum. The average fecundity estimated was 13936.44±2768.927 ova/fish and the mean fecundity per cm of body length has been 871.17± 170.64 ova/cm and mean fecundity per gm of body weight has been 231.28 ± 44.05 ova/gm. It exhibited a strong correlation with the gonad weight. The correlation coefficient and regression equation between fecundity and body weight was r = 0.888 and Y=3592X-200984, fecundity and gonad weight is r = 0.993 and Y = 0.0001X + 2.6812 and fecundity and body length is r = 0.496 and Y = 16892X + 15.511. According to Khan *et al.* (2002), a linear relationship existed between fecundity and total length, body weight and ovarian weight in *Plotosus canius*. The fecundity of *Hilsha ilisha* from Bay of Bengal is significantly correlated with the body length; body weight and gonad weight (Saifullah *et al.,* 2004). The fecundity of *Epinephelus diacanthus* showed that the gonad weight and the total fecundity had a significant linear relationship (Rao and Krishnan, 2009). In *Garra rufa*, Abedi *et al.* (2011) have observed a significant relationship between fecundity and fish size and also between absolute fecundity and gonad weight. Mishra and Saksena (2012) have reported that the fecundity of *Labeo calbasu* was increasing with the increase in the fish length, fish weight and gonad weight. The fecundity was more significantly correlated with the body weight and provides useful information to conserve the threatened species, *Puntius ticto* in the Ganges River and nearby areas of Bangladesh (Hossain *et al.* (2012). Teleost fish, *Notopterus chitala* has shown a positive linear relationship between fecundity and body weight (Kohinoor *et al.,* 2012). The similar observations were also made by Roy and Hossain (2006) on the fecundity of this fish and found that the mean fecundity was 12432.38 ± 3401.92. In our study the mean fecundity was 13936.44±2768.927 ova/fish of this species which shows similarity with the mean fecundity (12432.38 ova/fish) obtained by Roy and Hossain (2006) on the same fish species.

Various environmental factors affect the development and maturity of the gonads. Temperature is one of the most important factors which directly effect the maturation of the gonads of the fish. It was stated that the temperature and photoperiod controls the functional maturity in some species of the fish while in other species as it controlled the spawning. The temperature effects positively the reproductive cycle of the fish has been shown by Shimizu (2003), Hilder and Pankhurst (2003) and Pankhurst and King (2010). Our findings have shown that the water temperature started decreasing from October to February, it again increasing from March to May, and reaching to the maximum during June and minimum during January. These variations in temperature follow the trends of the gonadosomatic index which was maximum during June and minimum during January. Similar findings were obtained by Huber and Bengtson (1999) in *Menidia beryllina*. The latter phases of gonadal development in *Fundulus heteroclitus* were accelerated by warm temperature regardless of the photoperiod (Shimizu, 2003). The photoperiod considered as another most important parameter which showing an influence on the reproductive cycle of the fish. Maturation in *Menidia beryllina* takes place when fish is exposed to high temperature and photoperiod (Huber and Bengtson, 1999). Maitra *et al.* (2006) reported that the long photoperiod exposure brings precocious development of an ovary of *Catla catla*. *Channa punctatus* showed gonadal maturity when exposed to long photoperiod regime while low photoperiod inhibited the gonadal maturity of this fish (Renuka and Joshi, 2012). Long photoperiod stimulates the maturity of gonads in fish as predicted by many authors. This finding is also in the favour of above studies shown by several authors. The greater photoperiod was noticed in the month of May, June and July which was the peak maturity period of the gonads and gonadosomatic index and fecundity of this fish species is also obtained higher during this period.

Conclusion

The present study on quantitative estimation of reproductive cycle of *M. cavasius* has revealed that the gonadosomatic index of this fish has a gradual increase in the values from October-April and it has significantly increased in the May and reaches its peak point in the month of June while it again declines from July onwards. The gonadosomatic index of the fish also shows a positively correlation with the gonad weight and maturity of the fish. The gonadosomatic index showed a positive correlation with water temperature and photoperiod. As regard to the fecundity of the fish which was maximum during July while minimum in August. The fecundity of the fish has shown a strong correlation with the gonad weight, fish weight and photoperiod. It may be concluded that the gonadosomatic index and fecundity provide useful information about the reproductive potential of individual fish.

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