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Maturity and breeding of *Labeo gonius* (Ham.) from Brahmaputra

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Abstract: The average sex ratio of *L. gonius* from the river Brahmaputra was found to be 1: 1.14. The male attained maturity at 172 mm, while the female at 186 mm total body length. The spawning season of the fish commenced in late July and continued up to August. The ovary contained a single batch of ova and spawned only once during the year. Rise in water temperature and heavy showers and other physico-chemical factors appeared to stimulate the spawning of this species. The gonadosomatic index was found to reach its peak value in male and female during June and July, respectively. The fecundity in *L. gonius* ranged from 18,697 to 2,03,233, with an average of 99,098. The fecundity followed the cube law with respect to fish length. Fecundity seemed more related to weight than the length of the fish. The observations on various aspects of breeding biology of *L. gonius* from the river Brahmaputra were generally comparable with the findings on several other species of Indian carps.

Key words: *Labeo gonius*; maturity; breeding; Brahmaputra.

1. Introduction

The study of maturity and breeding of a fish is important as it provides information on the size and age at first maturity, synchronization of maturity in the two sexes, breeding behaviour, breeding season, frequency of breeding, fecundity and its relation with size and age. The information on breeding biology is important for fishery regulations, exploitation and conservation measures. The sustenance of population depends on the availability of adequate breeding population in an environment, and its capacity to produce in sufficient number. Fish are known to exhibit extreme variations in their breeding biology. Species-wise information on the subject is, therefore, warranted.

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Numerous workers in India and abroad have contributed to the study of above aspect of fishery biology (Hickling and Rutenberg, 1936; Hickling, 1940; Allen. 1951; Simpson,1951; Alikunhi, 1956; Bagenal, 1957, 1963, 1971, 1973, 1978; Qasim and Qayyum, 1962,1963; Hardisty, 1964; Qayyum and Qasim, 1964; Bhatnagar, 1972; Parameswaran et a!., 1970, 1972, 1974; Saxena, 1972; Varghese, 1973; Rao, 1974; Sobbana and Nair, 1974, Murty, 1975; Siddiqui *et al.*, 1976,1977; Raina, 1977; Joshi and Khanna, 1980; Pathani, 1981, Nautiyal, 1985; Somvanshi, 1985; Dobriyal, 1988; Jessop, 1993; Kurup, 1994; Gaur and Pathani, 1996; Kalita and Rath, 2000; Alam and Pathak, 2010; Kingdom and Allison, 2011; Zin *et al.,* 2011; Mekkawy and Hassan, 2011; Mishra and Saksena, 2012; Islam *et al.,* 2012; Ratnakala *et al.*, 2013; Shafi *et al.*, 2013; Monika, *et al.*,2013 and Paul, *et al.*, 2014; . However, information on fishes from North-eastern region of India remained fragmentary. Sen (1982) estimated the fecundity of four species of *Garra* from Meghalaya. Das (1989) determined the fecundity of *Tor tor* and *T. putitora* from the river Jia Bharali, Assam. Other works on breeding biology of fishes from North-east are those of Parameswaran *et al.* (1970), Rao and Pathak (1972), Kaur (1981), Rao and Mahanta (1981), Biswas (1982), and Das (1990).

L. gonius (Ham.) is one of the important medium size freshwater carps of India. Several workers have studied the reproductive biology of this fish in the past (Mookerjee and Ganguly, 1949; Ray *et al.*, 1969; Chondar, 1970; Paramesawaran *et al.*, 1974; Siddiqui *et al.*, 1976; Unnithan, 1978) but no work seems to have been made on this fish from the river Brahmaputra

In the present study, efforts have been made to examine the condition of the gonad and reproduction, sex ratio, spawning season, gonadosomatic index, ova diameter, size frequency distribution of ova in different months, fecundity and its relationship with other body measurements in *L. gonius* from the river Brahmaputra.

2. Materials and Methods

During the present study monthly samples were collected from Uzan Bazar fish landing centre. A total of 500 fish specimens of different size-groups, ranging from 100 to 496 mm in total length, were examined over a period of two years, from October, 2000 to September, 2002.

Maturity

After recording the necessary morphometric details, each specimen was dissected; the gonad was carefully removed, weighed and examined to determine the stage of maturity following the scheme proposed by Qayyum and Qasim (1964b).

Sex ratio

The sex ratio was determined with reference to size and month. Size at first maturity was taken as the size at which 50% of the population matured.

Gonadosomatic index (GSI)

The gonads were weighed to the nearest 0.1g, and fixed in 10% formalin for further studies. GSI, which expressed the weight of the gonad as a percentage of total body weight, was calculated using the following formula:

GSI Weight of gonad (g) / Total body weight (g) x 100

Ova diameter

For the study of size frequency distribution of ova in different months, random samples of over 100 ova were taken from each ovary. Individual ova diameter was measured with the help of an ocular micrometer following the method described by Clark (1925, 1934), and Jhingran *et al*. (1969).

Fecundity

Fully mature fish, collected just before spawning, was considered for fecundity studies. From these fish the ovaries were taken out, soaked on to a blotting paper, and their weight taken on a sensitive chemical balance. For determining the fecundity, three sub-samples of 100 mg each were randomly taken from anterior, middle and posterior regions of the ovary of each specimen. Before counting, the eggs were treated with Glison's solution. The number of eggs in each sample was counted under a binocular microscope and their total number estimated in each ovary using the following formula:

$$F = S \times OW$$

Where,

F = fecundity

S = average no. of eggs obtained from 3 different sub-samples of 100 mg each

OW = weight of the ovary (g)

Apart from absolute fecundity, relative fecundity was also calculated according to the following formula (Hardisty, 1964):

Relative fecundity = Total number of eggs in the ovary/Body weight (g)

The relationship between fecundity and total body length, fecundity and body weight, fecundity and weight of the ovary were examined and transformed into logarithmic form $\log Y = \log a + b \log X$

3. Results

Sex ratio

Sex ratio of *L. gonius* in different months of the year ranged from 1:0.80 to 1:1.64. The average ratio of male to female over the period of study was found to be 1:1.14. From September to February, the males dominated the population with a ratio of 1:0.88. During the breeding season, from May to August, the females dominated significantly over the males. The male: female ratio during this period was 1:1.53 (Table1). There was no significant deviation in observed sex ratio from expected 1:1. Variation in sex ratio was also evident in different size-

groups of *L. gonius*. The ratio of male to female was significantly higher (1:0.74) in fish of lower size-group (150 to 250 mm, total length). In higher size-group (250 to 450 mm, total length), the pattern was found to be opposite, with females dominating over the males. The sex ratio in this size-group remained as 1: 3.38 (Table 2).

Table 1. Sex ratio of *L. gonius* in different months

Month	No. of males	No. of females	Per cent males	Per cent females	Sex ratio
Oct.	23	20	53.48	46.51	1:0.86
Nov.	22	21	51.16	48.83	1:0.95
Dec.	30	28	51.72	48.27	1:0.93
Jan.	23	19	54.76	45.23	1:0.82
Feb.	27	25	51.92	48.07	1:0.92
Mar.	14	17	45.16	54.83	1:1.21
Apr.	15	22	40.54	59.45	1:1.46
May.	11	16	40.74	34.04	1:1.45
Jun.	15	23	39.47	60.52	1:1.53
Jul.	17	28	37.77	62.22	1:1.64
Aug.	17	26	38.63	59.09	1:1.52
Sep.	21	17	55.26	44.73	1:0.80
Average			**47.28**	**52.71**	**1:1.14**

Values are mean of 24 month data

Table 2. Sex ratio in different size-group of *L. gonius*

Length group (mm)	Male	Female	Male-Female
150-250	130	97	1:0.74
250-450	34	115	1:3.38

Stages of maturity

The ovaries of *L. gonius* were arbitrarily classified into the following five stages of maturity on the basis of macroscopic and microscopic observations:

1. **Immature:** Characterized by very small, transparent sexual organ, close to vertebral column; eggs visible to naked eye, colourless to grey; ova diameter ranged from 0.032 to 0.240, with an average of 0.129 mm.
2. **Maturing virgin and recovering spent:** Sexual organ translucent, grey to red, with a length half or more than half of the body cavity; eggs small with nucleus visible with a magnifying glass; ova diameter ranged from 0.129 to 0.481 mm, with an average of 0.31 mm.
3. **Maturing gonad**: Opaque, reddish with blood capillaries, extending over half of the body cavity; eggs appearing as whitish granule, visible to naked eye, formation of yolk granule and nucleus visible slightly; ova diameter ranged from 0.481 to 1.07 mm, with an average of 0.77 mm.
4. **Mature and ripe:** Sexual organ occupying the entire body cavity (Plate, 1a-b); eggs opaque, round and distinct, nucleus not visible. In males, milt oozing out with a slight pressure. Ova diameter ranged from 1.07-1.391 mm, with an average of 1.23 mm.
5. **Spent:** Ovaries flaccid, with few mature eggs; majority of ova were small, transparent, invisible to naked eye. No opaque eggs left in the ovary; ova diameter ranged from 0.07-0.26 mm, with an average of 0.165 mm. Testes becoming distinct and lobular with the advancement in maturity (Plate, 1c-d).

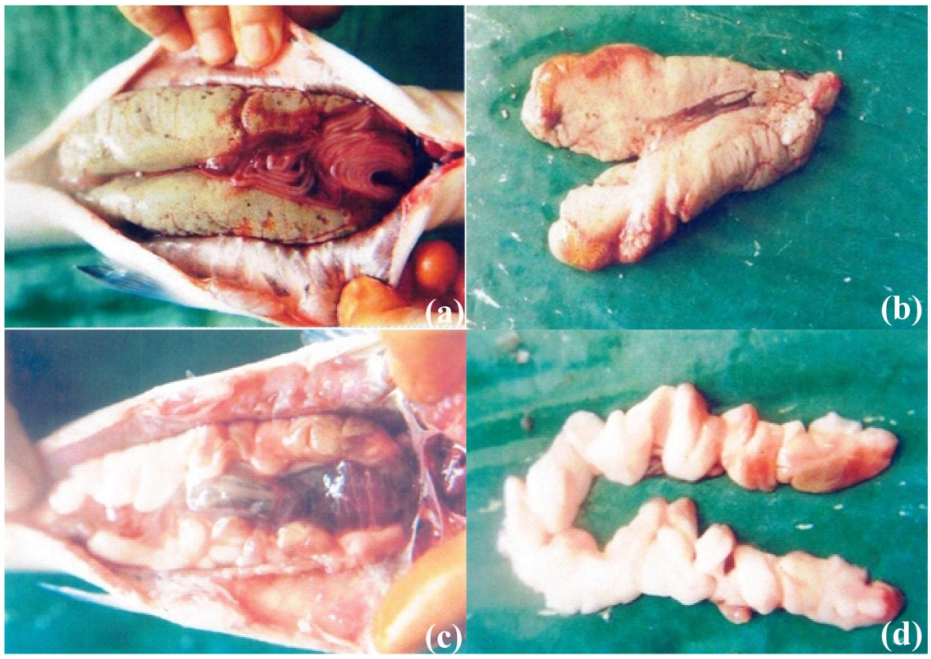

Plate 1(a-d): (a) Mature ovary (stage IV); (b) Fully mature ovary; (c) Mature testis (stage IV) and (d) Fully mature testis of *L. gonius*

Size at first maturity

Male fish were found to mature earlier and at smaller size than the female. The smallest mature male encountered during the study measured 172 mm in total length and 52 g in weight, while the smallest mature female measured 186 mm in total length and 67 g in weight. It was observed that 50% of male fish matured at the total length of 190 mm whereas 50% of females matured at 200 mm. 100% maturity in male fish were found at the total length of 230 mm. In female, 100% maturity was seen at the total length of 270 mm. At the body weight of 70-90 g, 50% male population attained maturity. At 170-180 g body weight, half the female populations were found mature. 100% maturity in male and female fish occurred between of 130-160 g and 280-300 g body weight, respectively (Fig., 1).

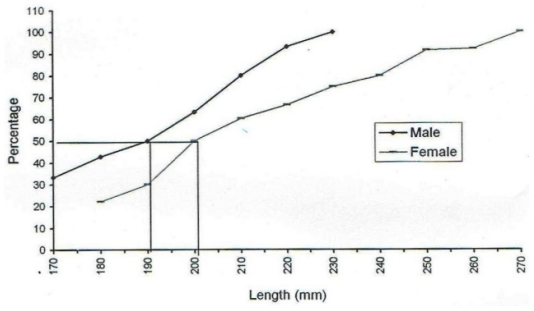

Fig. 1. Per cent frequency distribution in mature male and female *L. gonius* in relation to total length

Spawning season

The percentage of fish of different maturity stages observed over a year gives sufficient idea about its breeding season. In *L. gonius,* immature fish were encountered throughout the year. Individuals with maturing gonad appeared for the first time during March and became predominant in April. Fully mature gravid fish appeared in May and their percentage increased from June to July.

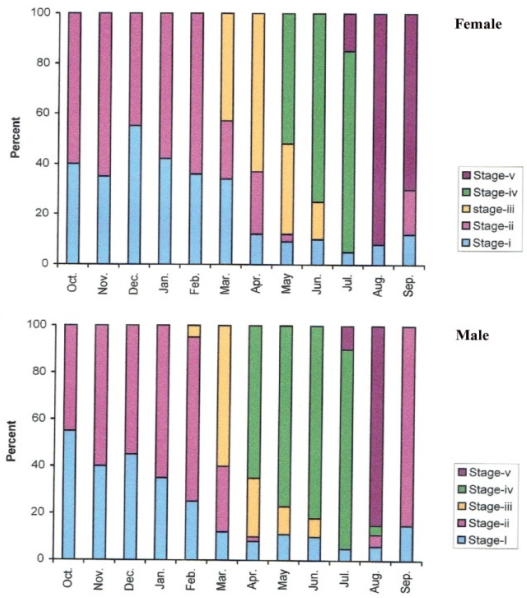

Fig. 2. Percentage of maturity in *L. gonius* in different months

In late July, a few spent fish appeared. The maximum percentage of spent fish and absence of ripe fish were noticed during August, confirming that spawning season of *L. gonius* in the North-east remains restricted to late July and August (Fig., 2).

Spawning periodicity and spawning behavior

The ova diameter frequencies of *L. gonius* (Fig., 3) showed presence of single batch of eggs, suggesting that the fish spawn only once during the short spawning season. Immature eggs below 0.16 mm diameter were present in all the ovaries. During March when maximum (40%) fish were in maturing stage, eggs formed a mode at 0.65 mm. The mode shifted to 0.75 during April. In May and June, fish were in fully ripe condition, forming modes at 0.88 mm and 1.10 mm, respectively. In July, the mode occurred at 1.20 mm. The biggest ova size recorded was 1.35 mm. During August, examination of spent ovaries revealed the presence of only immature eggs, averaging 0.25 mm in diameter, thereby indicating towards complete shedding of ova. Thus it can be concluded that the individual fish as well as its population as a whole spawn for a very short period from late July to August.

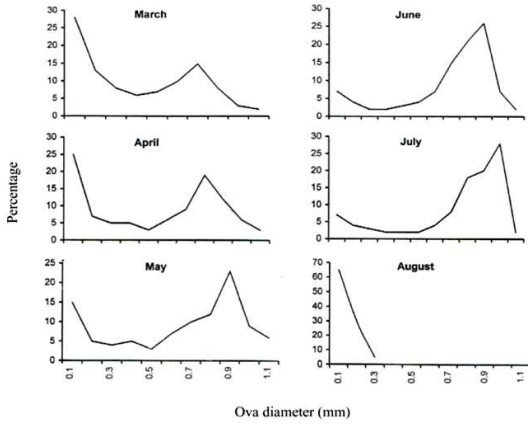

Fig. 3. Per cent progression in ova diameter in different months

Gonadosomatic index (GSI)

Monthly variation in GSI showed almost similar trend of changes in both the sexes. The GSI registered the maximum value in June in male and in July in female (Fig., 4a). The seasonal changes in GSI of male fish were not as distinct as in female. The minimum (0.44) GSI in male was registered during September. A gradual increase in GSI was observed from November onwards which reached its peak (9.71) in June.

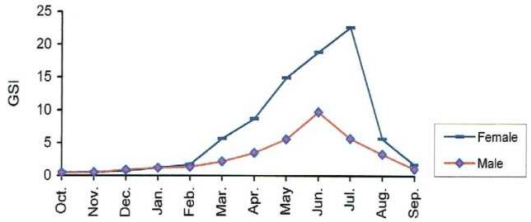

Fig. 4a. Monthly variation of GSI in *L. gonius*

In female, the GSI remained low (0.47 to 0.71) from November to December. A rapid increase in its value was observed from February onwards. In August, the GSI declined sharply, indicating towards shedding of gonadal product. The appearance of a few spent fish during late July followed by a drastic fall of GSI in August, indicate that *L. gonius* spawn from late July to August. GSI in both the sexes were found to increase with the increase in water temperature (Fig., 4b).

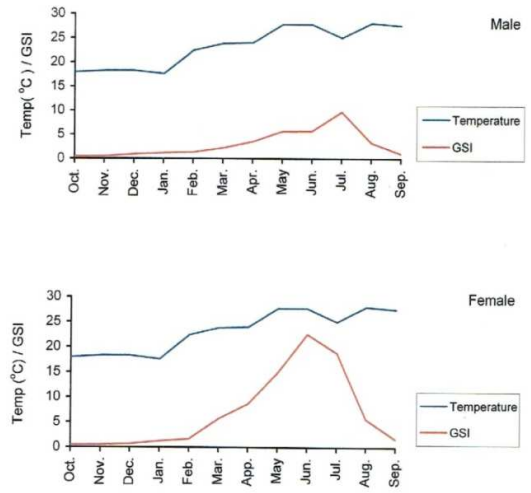

Fig. 4b. Monthly variation in temperature and GSI in *L. gonius*

Fecundity

Fecundity was studied in 80 specimens, measuring 220-496 mm in total length, with ovarian weight ranging from 12.72 to 245 g. The fecundity was found to range from 18,697 to 2,03,233 with an average of 99,098. The relative fecundity was found to range from 127.8 to 215/g. with an average of 198/g body weight. The number of ova per mm body length and per gram ovary weight was 271 and 1,302, respectively.

Relationship between weight of the ovary and total body length

The relationship between ovarian weight and total body length (TL) has been found to be

linear and expressed by the equation Log OW - 16.677 + 3.590 log TL. The weight of the ovary was found to increase sharply with increase in total body length (Fig., 5a). The coefficient of correlation for the relationship was positive and highly significant (r = 0.961).

Relationship between fecundity and total body length

The relationship between fecundity and total body length (TL) has been expressed by the equation Log F = -5.131 + 2.848 log TL. The exponential value was found close to 3, indicating that the fecundity of *L. gonius* is related to the cube of the total length. The relationship was linear and positively correlated with fecundity (Fig., 5b). The coefficient of correlation for the relationship was significant (r = 0 .878).

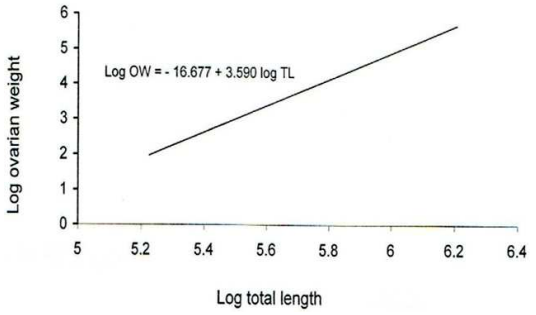

Fig. 5a. Relationship between weight of the ovary and total body length in *L. gonius*

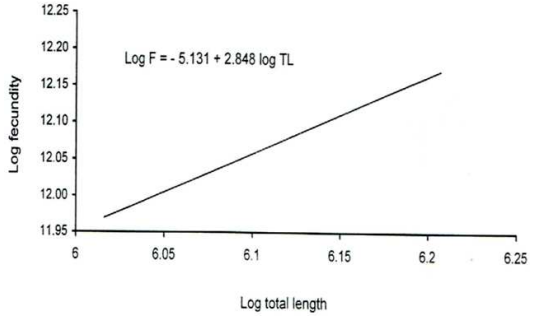

Fig. 5b. Relationship between fecundity and total body length (mm) in *L. gonius*

Relationship between fecundity and body weight

The relationship between fecundity and the body weight (BW) was expressed by the equation Log F= -5.785 + 0.917 log BW. The relationship was found to be linear (Fig., 5c). The coefficient of correlation was positive and highly significant (r = 0.968).

Relationship between fecundity and weight of the ovary

The relationship between fecundity and ovarian weight has been expressed by the equation Log F = -8.249 + 0.720 log OW. The relationship was linear (Fig., 5d). The coefficient of correlation for the above relationship was highly positive and significant (r=0.957). The minimum (18,697) number of eggs were obtained at the ovarian weight of 12.72 g and the maximum (2,03,233) at 245 g.

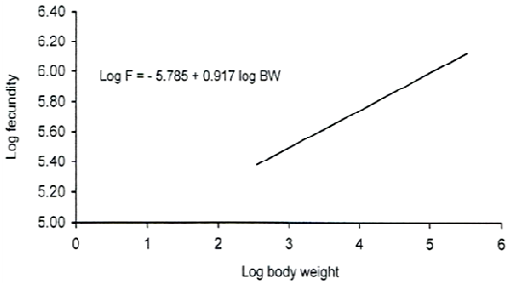

Fig. 5c. Relationship between fecundity and total body weight (g) in *L. gonius*

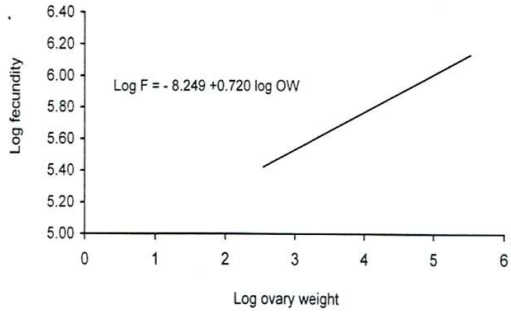

Fig. 5d. Relationship between fecundity and weight (g) of the ovary in *L. gonius*

Relationship between fecundity and length of the ovary

The relationship between fecundity and length of the ovary (OL) has been expressed by the equation Log F = -6.663 + 1.777 log OL. The relationship was linear (Fig., 5e). The coefficient of correlation was positive and significant (r =0.736).

4. Discussion

Observations on maturation of gonad, size frequency distribution of ova and gonadosomatic index indicate that *L. gonius* from the river Brahmaputra breeds only once during the spawning season in a synchronized manner. The breeding season of the fish appeared to be short, lasting for two months from July to August. All the ova are shed in a single spawning act. The phenomenon is generally reported in species

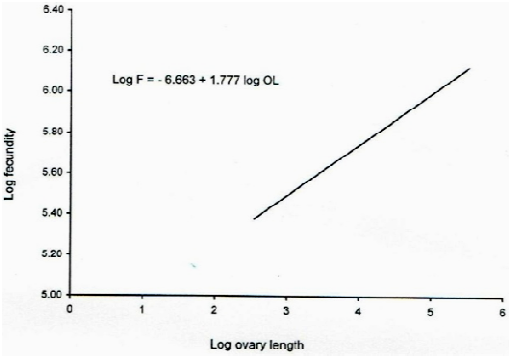

Fig. 5e. Relationship between fecundity and length (mm) of the ovary in *L. gonius*

having unimodal distribution of mature ova, distinct from immature ones (Prabhu, 1956; Qasim and Qayyum, 1962). Early spawning of carps in Assam during April and May has been reported by Parameswaran *et al*. (1970) but during the present study spawning in *L. gonius* was found to commence from July and continue up to August. Siddiqui *et al*. (1976) reported spawning in the same species from July to August in the river Kali. Similar trends were observed in other cyprinids from other parts of India (Khan, 1924; Ahmad, 1936; Alikunhi, 1956; Qasim and Qayyum, 1962; Chakrabarty and Singh, 1963; Natarajan and Jhingran, 1963; Karamchandani *et al*., 1967; and Chondar, 1970).

GSI in *L. gonius* was observed to vary with season. A gradual and distinct development of gonad was seen to begin from March, reaching its peak during June in male and during July in female. Thereafter, the GSI declined abruptly. Seasonal changes in GSI were more distinct in female than in male fish.

Physico-chemical factors such as light, temperature, Ph, rainfall, sudden increase in water level, increased dissolved oxygen are considered important for natural spawning of the Indian carps, including *L. gonius.* Long photoperiod and increased temperature during June and July appeared to stimulate spawning in *L. gonius.* In the river Brahmaputra , water temperature during the above period ranged from 4.5-28.3°C. Slightly alkaline pH (6.9-7.2) and total alkalinity (39.9-60.5 mg/l) were also noticed in the river water during June-July. Dissolved oxygen which was found to fluctuate between 4.0-4.6 mg/I could also be one of the stimulating factors for the spawning of the carps. Low pH and low alkalinity, coupled with abrupt rise in water temperature, were reported to be favourable for the spawning of *P. sarana* (Chaudhuri, 1962). The maturation, breeding season and duration of spawning in fishes have a direct relationship with the monsoon cycle (Qasim and Qayyum, 1962). Heavy monsoon showers occur in Assam during July, which continue up to August.

Spawning in *L. gonius* was found to coincide with the period. Onset of monsoon is generally earlier in Chittagong (Bangladesh) hence the Indian major carps are reported to breed early, from April onwards, in this region (Hora, 1945; Ahmad, 1948). It may be pointed out that during July and August river water become highly turbid and the water current also increases due to heavy rain, and these could also be important in stimulating *L. gonius* to spawn. Numerous floodplain wetlands connected with the Brahmaputra river usually get inundated during rainy season and these provide a suitable spawning ground for this fish. Interestingly, the fish were found to select a suitable place in these sites for spawning.

The overall sex ratio of 1:1.14 in the population indicated a slight domination of female over male in *L. gonius*. There was no significant departure from 1:1 ratio, excepting in breeding months. Siddiqui *et al*. (1976) reported slightly higher sex ratio (1:1.86) in *L. gonius* from the river Kali. Sex ratio of 1:1 has also been recorded in other carps, namely, *Cirrhinus mrigal, Catla catla and L. rohita* (Chakrabarty and Singh, 1963; Natarajan and Jhingran, 1963; Khan, 1972). In smaller size-group, males were dominant, probably due to their higher growth rate in juvenile stage. Smaller fish, being active, were more vulnerable to catch. Sex ratio favoured females significantly in larger size-groups. This may be attributed to their sluggishness and selectivity of gears to catch them. The dominance of male over female in smaller size-group and that of female in lager size-group were evident in other fish species as well (Mc.Fadden and Cooper, 1962; Bailey, 1963; Bhatnagar, 1972; Vinci and Sugunan, 1981). Differences in sex ratio at different sizes were also reported by Nikolsky (1963).

Male fish matured at a smaller length (172 mm) than the female (186 mm) in *L. gonius.* Maturity at smaller length in male (142 mm) and female (188 mm) was observed by Parameswaran *et al.* (1974) in *L. gonius* from the tanks of Sibsagar. Unnithan (1978) also

reported similar findings for this fish. Mature male fish were also encountered earlier than the female and continued to be present till August. Occurrence of mature male fish for a longer period presumably ensured maximum fertilization. Similar fact has been reported in several other fish species (Qasim and Qayyum, 1962; Parameswaran *et al.*, 1974).

In fully mature *L. gonius,* ova diameter was seen to range from 1.07 to 1.35 mm. The average diameter of mature ova was almost similar in fish of different size-groups. Similar findings were made on L. rohita (Khan, 1972) and *L. gonius* (Siddiqui *et.al.*, 1976).

In the present investigation absolute fecundity or the total number of ripe eggs produced during a single breeding season by the fish was found to range from 18,697 to 2,03,233 in *L. gonius* of 220 to 496 mm total length. For the same species, Parameswaran *et al.* (1974) observed absolute fecundity in the range of 9,892 to 2,99,999 from the tanks of Assam. Joshi and Khaima (1980) reported that absolute fecundity of this species ranges from 47,168 to 3,80,714 in fish from Nanaksagar Reservoir. Chondar (1970) observed absolute fecundity value ranging from 2,73,955 to 5,39,168 in fish from Keetham lake, Agra.

The relative fecundity was found to range from 126 to 215 ova/g body weight in *L. gonius* from the river Brahmaputra. However, relatively higher values, 254.75 and 271 ova/g body weight were reported for this species by Parameswaran *et al.* (1974) and Joshi and Khanna (1980), respectively. Various other investigators also calculated the relative fecundity in other fish species from different water bodies. The relative fecundity of 256 ova/g body weight was observed in *L. rohita* (Varghese, 1973) and 252 ova/g body weight in *L. calbasu* (Pathak and Jhingran, 1977). In *Cyprinus carpio communis,* relative fecundity was observed to be 1559 ova/g body weight (Parameswaran *et al.*, 1972). Babu and Nair (1985) reported the value of 999 ova/g body weight for *Amblypharyngodon chakaiensis*.

The above observations support the finding of Nikolsky (1963) that fecundity in a fish species may vary from population to population. Although fecundity is a phylogenic character, it is found influenced greatly by various environmental factors like food supply, rainfall, salinity, etc., which a fish may encounter during its life. Variations in fecundity with time and space have also been reported by other workers (Pankhurst, 1988; Bell *et al.*, 1992).

A linear relationship was noted between fecundity and TL in *L. gonius* from the river Brahmaputra. A high degree of correlation was found between fecundity and total length of this species, with exponential value being nearer to 3, indicating that fecundity in *L. gonius* follows the cube law. The observed linear relationship between fecundity and total length find corollary in the work of several other workers on Indian fishes (Sarojini, 1951; and Pillay, 1954). Similarly, a cube relationship between fecundity and fish length was noted by other workers as well (Simpson, 1951; Bagenal, 1978; and Biswas 1982). In contrast, a non-linear relationship was reported for *L. gonius* by Parameswaran *et al.* (1974) and Siddiqui *el al.* (1976).

In the present study, fecundity was, however, found to be more related to the weight than the length of the fish. The straight-line relationship between fecundity and fish weight has been reported in various fish species, including *L. gonius* by Bagenal (1957), Parameswaran *et al.* (1974), Varghese (1973), Qayyurn and Qasim (1964c), Raina (1977), Agarwal (1996), Dobriyal (1988), and Jessop (1993).

A linear relationship during the present study between ovarian weight and fecundity indicates that fecundity increases in proportion to the weight of the ovary. Similar linear relationship was reported by Parameswaran *et al.* (1974) and Siddiqui *et al.* (1976) in *L. gonius.* Parameswaran *et al.* (1972) in *Cyprinus carpio*, Somvanshi (1985) in *Garra mullya*, and Das (1990) in *G. Iissorkynchus* and *Acrossocheilus hexagonolepis*. On the contrary, a non-linear relationship between ovarian weight and fecundity has also been observed in some fish species (Bagenal, 1957; Gaur and Pathani, 1996).

Conclusion

The average sex ratio of *L. gonius* from the river Brahmaputra was found to be 1: 1.14. The male attained maturity at 172 mm whiles the female at 186 mm total body length. The spawning season of the fish commenced in late July and continued up to August. The ovary contained a single batch of ova and spawned only once

during the year. Rise in water temperature and heavy showers and other physico-chemical factors appeared to stimulate the spawning of this species. The gonadosomatic index was found to reach its peak value in male and female during June and July, respectively. The fecundity in *L. gonius* ranged from 18,697 to 2,03,233, with an average of 99,098. The fecundity followed the cube law with respect to fish length. Fecundity seemed more related to weight than the length of the fish. The observations on various aspects of breeding biology of *L. gonius* us from the river Brahmaputra were generally comparable with the findings on several other species of Indian carps.

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