

Reproductive Biology of Gangetic Leaf Fish *Nandus nandus* (Hamilton 1822) at Borsola Beel, Jorhat, Assam

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ABSTRACT

The present study has been carried out from the Borsola a floodplain wetlands of Jorhat district, Assam from January, 2017 to June, 2019. The Gangetic leaf fish, *Nandus nandus* (family: Nandidae) is an important edible species found in the slow moving and stagnant water bodies of Brahmaputra basin. Out of 187 fish specimens examined, 91 were males and 96 females. Usually the females are larger in size and have shorter dorsal and anal fin, whereas the males are brighter in colour. The sex ratio (M:F) ranged from 1:0.7 to 1:1.33 and overall sex ratio was 1:1.05. The gonado-somatic ratio or index (GSR or GSI) value for male was ranged 0.53±0.13 (December) to 2.97±1.19 (July) and for female from 0.75±0.38 (December) to 16.37±4.48 (July). The GSR increases gradually from February to August and being peak in July for both males and females, but abruptly declines in October onwards and again found to be increased in February. The maximum GSR value for both the males (2.81±1.39) and females (15.53±3.57) was observed in ripe (gravid) stage whereas the minimum (0.38±0.26) for males and females (0.42±0.22) was recorded in spent individuals. The average ova diameter was ranged from 0.52±0.02 mm (January) to 0.68±0.04 mm (July). The lowest (0.5 mm) ova diameter was observed in immature stage and that of highest (0.71 mm) was in ripe stage. The size of the ova was gradually increase from January onwards and being peak in July. The overall absolute fecundity was found to be highly fluctuating and varies between 4428.4 and 38332.3 while, the relative fecundity was ranged from 130.98 to 1081.61. The maximum absolute fecundity (25212.89±5536.47) was found in the length group of 12.6-15.5 cm while the minimum (7521.90±823.44) in the length group of 6.5-9.5 cm. In case of relative fecundity, it varied from 544.23 (±420.56) to 649.30 (±491.26) in the size group of 6.5-9.5 and 9.6-12.5 cm respectively. It reveals that species has high and moderate fecund and observed spawning period from April onwards upto August and spawned once in a year with peak being in June/July.

Keywords: Assam, Fecundity, GSR, *Nandus nandus*, Ova diameter

INTRODUCTION

Reproductive biology of fish is essential for evaluating the commercial potentialities of its stock, life history, culture practice and management of its fishery (Schaefer 1998). In order to achieve success in fish culture, it is important to assess the yearly breeding cycle of culturable fishes. The Gangetic leaf fish (family: Nandidae) is a common fish throughout South-East Asia, in the area between Pakistan (Indus Valley), India, Nepal, Bangladesh, Myanmar and Thailand (Talwar and Jhingran 1991). It is found in brackish water, drains, paddy field, wetlands, Muddy streams, river and marshes areas (Talwar and Jhingran 1991, Hossain et al. 1992). Body is deep

laterally compressed, nearly straight belly and arched back. Head is large, compressed and snout is pointed. Body colour is blackish to greenish brown. Fins greenish to yellowish, some narrow dark bands radiate from eye. Dorsal spines strong and soft portion of the dorsal fin is rounded. Anal spines moderately strong, second spine largest, caudal fin slightly rounded, pectoral spine weak, scales ctenoid, lateral line interrupted (Rahman 2005, Talwar and Jhingran 2001).

Only a few studies have been carried out in the Indian sub-continent region. Parameswaran et al. (1971) reported on the biology and life history of *Nandus nandus* in general while Goswami and Dasgupta (2004) reported it from West Bengal. Paul et al. (2009) studied on the life history of *N. nandus*

in captivity condition. Ray (2013) studied on the some taxonomic and biological features of *N. nandus* from Tripura. Hossain et al. (2017) studied on growth, maturity and mortality of *N. nandus* from the Ganga River at northwestern Bangladesh.

In Assam, it is vernacularly known as *Gedgedi* or *Gadgadi*. This is a very hardy fish, predatory nature and is of considerable fisheries interest. It is a high priced fish in spite of its spinous fins and ugly black bands and blotches all over the body (Talwar and Jhingran 2001). They are commercially caught for the aquarium trade and body colour is varies from one habitat to another habitat of different geographical area. The fish is an important edible species found in the slow moving and stagnant water bodies (ponds, lakes, ditches, and flooded fields) of Brahmaputra basin. According to IUCN (2021), the fish species is included under the 'Least Concerned' (LC) category. So far, there is no comprehensive work on the reproductive biology of *N. nandus* from of north-eastern region of India as a whole. Therefore, the present investigation has been undertaken to obtain the information on certain aspects of reproductive biology of *N. nandus* from Upper Assam, India.

MATERIALS AND METHODS

A total of 187 specimens of *Nandus nandus* were collected from the Borsola beel (N 26° 50' 22.3" and E 94° 13' 12") at Jorhat district, Assam during

January, 2017 to June 2019. Borsola *beel* (wetland) is open type and one of the largest floodplain lakes in upper Assam (Fig.1). The Borsala *beel* is directly linked with River Brahmaputra through a connecting channel. The area of Borsala *beel* is 90 ha, respectively and depth was recorded between 8.0 and 15 m. The sampling was done on monthly basis using cast net and other local made gears. Collected fish species were immediately preserved in 5% formalin for further investigation. Each fish specimen was measured for total length (cm) and weighed (g). After dissection of the each specimen, take weight of each gonad.

Sexual dimorphism and Sex ratio: Sexual dimorphism of fish species was studied by visual inspection and later confirmed by the description of Talwar and Jhingran (1991) and Darshan et al. (2018). The sex ratio was expressed as the proportion of males to the total number of the fish sampled. Sex ratio of the fish was studied using Chi-square test (X^2), following the equation of Fisher (1970), assuming that the ratio of male to female in the population to be 1:1.

Gonadosomatic ratio or index (GSR or GSI): The gonadosomatic ratio or index has been used for estimating the development of gonad and spawning season of a species (Abujam and Biswas 2020). For estimation of GSR, the ratios were calculated month-wise and sex-wise as suggested by Nikolsky (1963),



Figure 1. Overview of Borsola beel (wetland)

Hopkins (1979) and Biswas (1993):

GSR = (Weight of the gonad/Total body weight) x 100

Fecundity: Ovaries from mature specimens (includes just before breeding) were used for fecundity studies. First, the ovaries were removed from the preserved gravid females of the species of known length and weight. Sub sample by weight method has been employed and fecundity has been calculated from the counts of mature ova in triplicate random sub samples of the ovary of known weight after drying off the excess moisture with the help of a blotting paper. The absolute fecundity was calculated as suggested by Grimes and Huntsmen (1980).

Absolute fecundity (AF) = NG/ g

Where, F = fecundity; N = No. of eggs in the sub sample; G = Weight of the ovaries; g = Weight of the sub-sample.

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

Relative Fecundity (RF) = Absolute fecundity/
Body weight

Maturity stage or gonadal cycle: Routine assessment of maturity stages is normally done by assessing individuals to stages by characters which can be differentiated with the naked eye. Periodical, microscopically examinations of gonads were done as per methods of Crossland (1977).

Ova diameter: For measurement of the diameter of ova, formalin preserved materials were taken from anterior, middle and posterior part of individual ovary and among individuals of the paired ovary. Consequently, random sub-samples were taken and monthly determined the ova diameter progression through visual and microscopically examination as described by Biswas (1993).

RESULTS AND DISCUSSION

Sexual dimorphism and Sex ratio (male: female): Out of 187 fish specimens examined, 91 were males

and 96 females. Sexual dimorphism of *Nandus nandus* is somewhat difficult to identify the sexes externally during young but, the sexes can be distinguished externally during the breeding season, by the difference in the general coloration and body size (Fig. 2). Generally, the females are larger in size and have shorter dorsal and anal fin, whereas the males are brighter in colour. Internally, the sexes of the fishes can be easily distinguished by dissection and examination of gonads. The present study reveals that the sex ratio (M:F) ranged from 1:0.7 to 1:1.33 (Table 1). The overall sex ratio of the examined fish was recorded 1:1.05. The monthly sex ratio and chi-square test showed that there was no significant deviation from the usual 1:1 ratio. The overall M:F ratio indicated a more or less uniform distribution of males and females. Generally, sex ratios of fishes have been considered vital in fisheries and sex ratio is generally close to 1:1 (Swarup et al. 1972). Similar observation was also reported by Cek et al. (2001) in *Puntius conchoniis*, Sarma (2008) in *Puntius gelius* and Muchlisin et al. (2010) in *Rasbora tawarensis* where females slightly dominated over their male counterpart except fewer months. However, predominance of males in different freshwater fish species was reported by Fagade et al. (1984), Abujam and Biswas (2011, 2020) and Dakua and Abujam (2021).

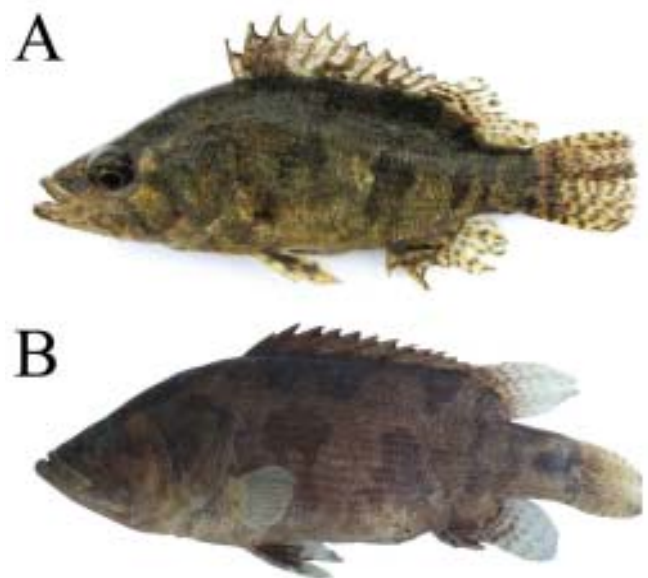


Figure 2. *Nandus nandus*: (A) Mature male and (B) Mature female

Table 1. Monthly variation on sex ratio of *N. nandus*

Month	Males	Females	Total Sex no.	Sex ratio	Chi square
January	9	8	17	1:0.89	0.06
February	10	7	17	1:0.7	0.53
March	9	7	16	1:0.78	0.25
April	8	8	16	1:1	0.00
May	8	8	16	1:1	0.00
June	7	8	15	1:1.14	0.07
July	6	8	14	1:1.33	0.29
August	7	8	15	1:1.14	0.07
September	7	8	15	1:1.14	0.07
October	6	9	15	1:1.5	0.6
November	7	9	16	1:1.29	0.25
December	7	8	15	1:1.14	0.07
Overall	91	96	187	1:1.05	0.13

Gonadosomatic ratio or index (GSR or GSI):

Monthly variation in GSR value of males and females was given in Table 2. GSR value for males was ranged from 0.53 ± 0.13 (December) to 2.97 ± 1.19 (July) and for females from 0.75 ± 0.38 (December) to 16.37 ± 4.48 (July). The GSR increases gradually from February to August and being peak in July for both males and females, but abruptly declines in October onwards and again found to be increased in February. The GSR value for both sexes increases with the maturation of fish from March and gradually declining September onwards. The maximum GSR

Table 2. Monthly variation in GSR of *N. Nandus*

Months	Male GSR	Female GSR
January	0.70 ± 0.17	1.03 ± 0.70
February	0.74 ± 0.20	5.78 ± 2.70
March	1.3 ± 0.65	9.84 ± 1.61
April	1.43 ± 0.41	9.96 ± 4.9
May	1.92 ± 0.72	10.28 ± 2.50
June	2.82 ± 1.35	12.15 ± 3.26
July	2.97 ± 1.19	16.37 ± 4.48
August	1.03 ± 0.14	9.33 ± 3.20
September	1.29 ± 0.17	5.87 ± 1.42
October	0.63 ± 0.21	1.78 ± 0.49
November	0.60 ± 0.22	0.84 ± 0.04
December	0.53 ± 0.13	0.75 ± 0.38

value for both the males (2.81 ± 1.39) and females (15.53 ± 3.57) was observed in ripe (gravid) stage whereas the minimum (0.38 ± 0.26) for males and female (0.42 ± 0.22) was recorded in spent individuals (Table 3).

Table 3. Gonado Somatic Ratio (GSR) at different maturity stages for *N. nandus*

Maturity stages	Males	Females
Immature (Stage-I)	0.71 ± 0.35	0.98 ± 0.47
Maturing (stage-II)	1.08 ± 0.40	6.73 ± 2.49
Mature (stage-III)	1.70 ± 0.88	9.56 ± 3.42
Ripe (stage-IV)	2.81 ± 1.39	15.53 ± 3.57
Spent (stage-V)	0.38 ± 0.26	0.42 ± 0.22

The GSR is an indicator of the seasonal development of the gonads. The higher GSR for both sexes of *N. nandus* was observed in pre-monsoon and monsoon season (peak in June/July) and subsequently decreased from September onwards and became very low in winter season. The peak season was coinciding with the peak breeding and indicating commencement of active breeding from April to July. This indicates that the spawning is over by August for the species. The highest GSR for both sexes were recorded in ripe stage whereas the lowest in spent stage. The higher values of GSR in ripe stage and thereafter sudden fall of the values in spent stage indicated spawning was over. The GSR values decreased in spent stage and higher GSR obtained in ripe stage of the species were also observed by Komolafe and Arawomo (2007), Saikia (2011), Abujam and Biswas (2011, 2020) and Dakua and Abujam (2021). In spent stages, there were fewer or no eggs in the ovary after spawning.

Maturity stages: Five stages of maturity in *N. nandus* have been identified based on the morphology and gonad occupied in the body cavity (Fig. 3). The physical characteristics for both ovary and testis of this species at various stages of development were recorded. Therefore, the morphological description of the gonads has been described under one classification system. The gonads in immature stage (Stage I) is highly undeveloped and whitish in colour and occupied only 1/4th of the cavity. They are and hardly visible with naked eyes. In the maturing (Stage

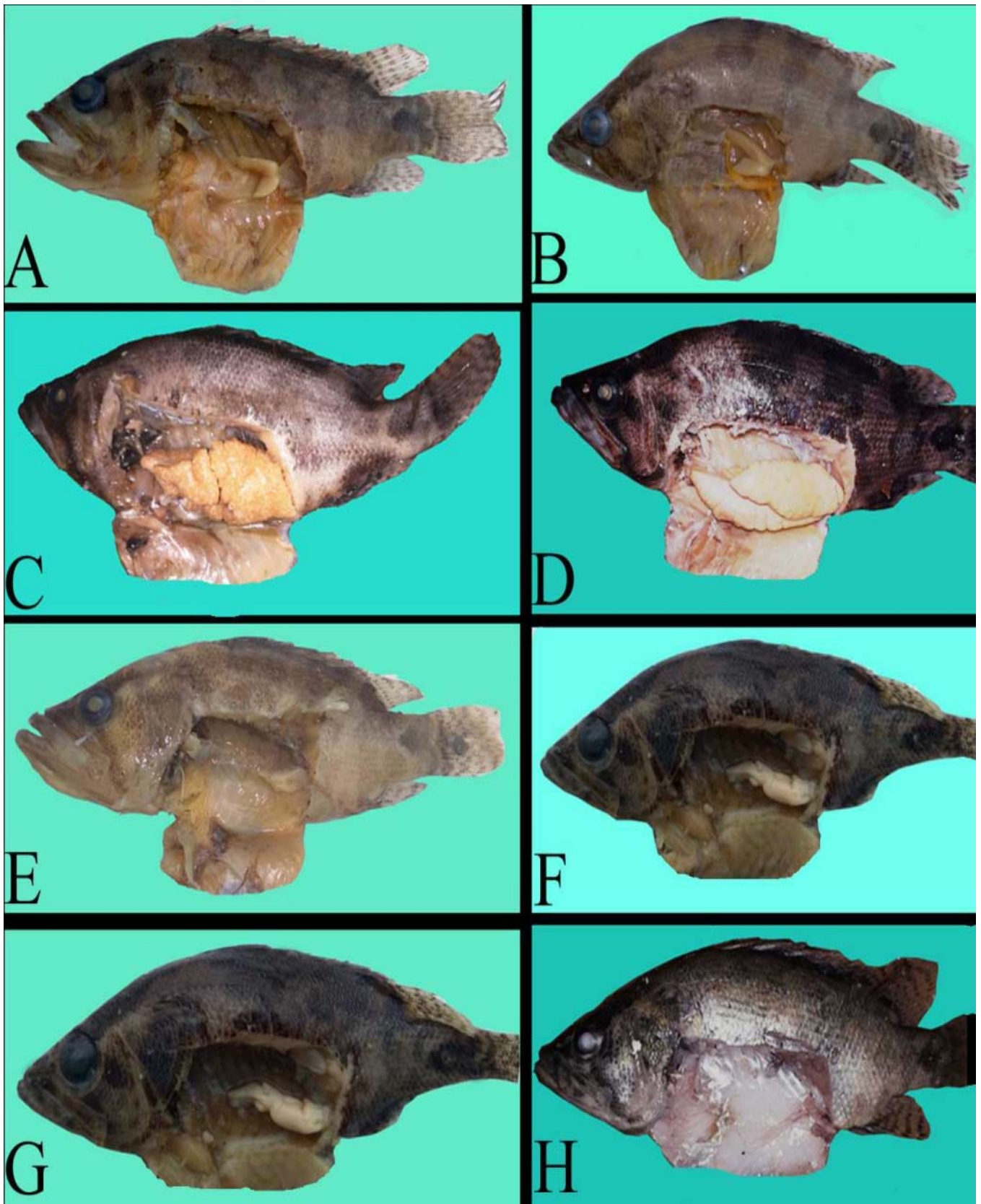


Figure 3. Various developmental stages of male and female of *Nandus nandus*: A- female immature (stage I); B- female maturing (stage II); C- female mature(stage III); D-female ripe (stage IV); E- male immature (stage I); F- male maturing (stage II); G-male maturing (stage III); H- male spent (stage V).

II) and mature stages (Stage III) gonads occupy about half of the body cavity and 3/4th of the body cavity respectively. In stage II, testes uniformly ribbon-like while, ovaries distinctly visible opaque and orange eggs. In stage III, mature testes large & highly convoluted while, most eggs are opaque, rounded & orange in colour. As the maturity progressed, the gonads became thicker, changed to orange/reddish colour due to development of blood vessels. At ripe stage (Stage IV), gonads occupied almost the entire abdominal cavity. Testes creamy, soft milk and freely or extrude sperm when compressed slightly while, ovaries large and eggs are extruded from the body under slight pressure. However, gonads were found highly shrunked at spent stage (Stage V). Qasim (1973) viewed that in tropical and subtropical forms, the classification of gonads should be limited to about 5 maturity stages and in continuous spawners, it may be reduced from 5 to 3. Many authors described five maturity stages in different fishes, they are Nautiyal and Lal (1985) in *T. putitora*; Abujam and Biswas (2011, 2020) in *Macrornathus pancalus* and *M. aral*; Dakua and Abujam (2021) in *Parluciosoma daniconius*. Morphologically, the immature testes did not differ much from the immature ovaries either in shape or size (Abujam and Biswas 2011, 2020). The testes, however, do not occupy the body cavity as much as the ovaries in most of the fish species.

Ova diameter and its morphology: The overall, the ova diameter of *N. nandus* was ranged from 0.5 to 0.71 mm (Table 4). The mean ova diameter was ranged from 0.52±0.02 mm (January) to 0.68±0.04 mm (July). The size of the ova was gradually increase from January onwards and being peak in July. The ovary was yellowish colour, cylindrical shaped, almost equal size, double lobes lying in the body cavity and occasionally one lobe was larger than the other. In relation to the different maturity stage, the lowest (0.5 mm) ova diameter was observed in immature stage and that of highest (0.71 mm) was in ripe stage (Table 5).

In the present investigation, the ova diameter of *N. nandus* progressively increased from January onwards upto July and maximum size of intra-ovarian egg was observed in April-August when the peak breeding of the fishes took place. The occurrence of mature and ripe ova was decreased

Table 4. Monthly variation in ova diameter of *N. nandus*

Months	Range (mm)	Mean±SD
January	0.5-0.55	0.52±0.02
February	0.51-0.62	0.53±0.04
March	0.52-0.62	0.59±0.03
April	0.57-0.71	0.61±0.07
May	0.59-0.71	0.62±0.08
June	0.62-0.71	0.67±0.04
July	0.62-0.71	0.68±0.04
August	0.55-0.71	0.62±0.06
September	0.5-0.62	0.55±0.05
October	Spent	Spent
November	Spent	Spent
December	Spent	Spent

Table 5. Ova diameter (mm) at different maturity stages of *N. nandus*

Maturity stages	Ova diameter	Mean±SD
Immature (stage-I)	0.5-0.55	0.51±0.02
Maturing (stage-II)	0.55-0.62	0.55±0.03
Mature (stage-III)	0.55-0.71	0.64±0.04
Ripe (stage-V)	0.62-0.71	0.69±0.03

from September onwards and indicating that the spawning was over. It reveals that the species breeds/spawns between April and August. This is further supported by occurrence of spent females and males during October to mid January. Thus, it may be concluded that the spawning was over by July/August. Thereafter, the development of gonads began to rise from January/February onwards. This also indicated that the species has probably a relatively prolonged spawning period. Further, it also reveals that *N. Nandus* spawns once in a year with single spawning peak. Similar observation was also reported by Hossain et al. (1991) and Paul et al. (2009) where breeding period of this fish from April to August/September. However, the present observation was contradict with the findings of Parameswaran et al. (1971) where its breeding season extends from late March to the middle of July.

Fecundity: A total 96 females were used for monthly

Table 6. Monthly mean variation of fecundity in *N. nandus*

Months	Total length (cm)	Body weight (g)	Ovary weight (g)	Fecundity	
				Absolute	Relative
January	12.35±1.75	33.81±11.45	0.44±0.15	4428.4±684.5	130.98±65.81
February	10.95±1.76	24.24±7.17	1.32±0.59	5769.8±832.7	237.99±78.991
March	12.65±0.72	40.68±7.86	3.94±0.75	12046.2±1245.4	296.12±93.76
April	11.57±1.71	31.20±13.49	3.12±2.22	24875.8±2044.8	797.27±216.15
May	11.96±2.07	35.95±19.70	3.89±2.62	27177.9±2218.6	920.76±357.32
June	12.02±1.71	34.92±13.77	4.01±1.86	37228.7±5153.7	1066.11±407.3
July	12.28±1.12	35.44±9.77	5.46±0.98	38332.3±7524.2	1081.61±357.32
August	13.07±0.26	41.95±5.93	3.81±1.07	22989.2±1381.9	548.01±180.80
September	11.21±1.95	27.82±12.17	1.57±1.0	6018.4±865.4	216.32±61.73
October	12.71±1.16	39.88±13.09	0.27±0.13	Spent	—
November	11.6±1.51	26.6±0.79	0.20±0.05	Spent	—
December	13.23±1.54	38.10±17.34	0.31±0.11	Spent	—

fecundity estimation (Table 6) and their mean total length ranged from 10.95 (± 1.76) to 13.23 (± 1.54) cm and mean body weight from 24.24 (± 7.17) to 41.95 (± 5.93) g. The average absolute fecundity ranged from 4428.4 (± 684.5) to 38332.3 (± 7524.2) while, the relative fecundity ranged from 130.98 (± 65.81) to 1081.61 (± 357.32) in the ovary weights of 0.44 (± 0.15) and 5.46 (± 0.98) g, respectively. The highest fecundity was observed in July and lowest in January. The highest fecundity was recorded in 12.28 (± 1.12) cm and 12.28 (± 1.12) g, respectively. The lowest fecundity was recorded in 12.35 (± 1.75) cm and 33.81 (± 11.45) g, respectively. In relation to the different length groups, the maximum absolute fecundity (25212.89±5536.47) was recorded in the length group of 12.6-15.5 cm while the minimum (7521.90±823.44) in the length group of 6.5-9.5 cm (Table 7). In case of relative fecundity, it varied from 544.23 (± 420.56) to 649.30 (± 491.26) in the size

group of 6.5-9.5 and 9.6-12.5 cm, respectively.

Estimation of fecundity of fish is an indicator of reproductive potential of the species. A thorough knowledge of the fecundity of a fish is essential for evaluating the commercial potentialities of its stock, breeding programme, life history, practical culture and actual management of the fishery (Pankhurst 1998, Hyndes et al. 1992). In relation to the length groups, the average fecundity of present study was similar with results of Parameswaran et al. (1971) where the fecundity of *N. nandus* (75 to 138 mm) ranged from 1,573 to 23,546. The minimum and maximum of fecundity of *N. nandus* were observed during winter and monsoon, respectively. In the present study, the maximum fecundity was found in higher length groups and the minimum in shorter length group. The variation in the number of fecund in the present study may be due to environmental factors in a different geographical location. Similar observations were made by Sarkar et al. (2002), Abujam and Biswas (2011, 2020) and Dakua and Abujam (2021) in different fish species. Fecundity of fish is found to vary from species to species, depending on age, length, weight and environmental condition (Nasar and Biswas 1982, Abujam and Biswas 2011, 2020). Furthermore, it may be concluded that fecundity increased with increase in fish weight and have a moderate fecund in the studied specimens.

Table 7. Fecundity at different length groups for *N. nandus*

Length groups (cm)	Fecundity	
	Absolute	Relative
6.5-9.5	7521.90±823.44	544.23±420.56
9.6-12.5	19913.27±2451.55	649.30±491.26
12.6-15.5	25212.89±5536.47	586.77±386.73

Authors' contributions: Saikia designed and collected the data. Abujam analyzed the data and prepared the manuscript. Biswas revised the manuscript.

Conflict of interest: The author(s) declare no competing interests.

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