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Biometric features and reproductive biology of the dwarf chameleon fish *Badis blosyrus* from Brahmaputra river system of Assam, North-east India

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Abstract

The present study was carried out to understand the biometric features and reproductive traits of indigenous dwarf chameleon fish *Badis blosyrus* (Kullander and Britz, 2002). This species, a potential candidate for ornamental fish trade, holds significant conservation and commercial value but remains relatively understudied. Altogether seventy-five wild fish specimens were collected from the Brahmaputra River and its associated streams and wetlands of Assam during October 2021 to March, 2022. Morphometric and meristic characteristics were recorded. Important parameters estimated for reproductive biology includes sex ratio, gonad weight, gonadosomatic index (GSI), absolute and relative fecundity as well as egg diameter. Sexual dimorphism is well noticeable by their colour pattern, with adult males displaying bright colour and larger in size than the females. Gonadosomatic index (GSI) values ranged from 1.26 to 11.42 in male and 1.48 to 13.57 in females. The absolute fecundity varied from 892 to 940 eggs per fish while the relative fecundity ranged from 142 to 150 eggs per g of body weight. The fish due to its attractive and unique colour pattern have high demand in ornamental fish market. In view of limited knowledge on *B. blosyrus*, the present study aimed to generate baseline data which will be useful for conservation biology, designing breeding protocols and formulating sustainable management strategies.



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The information on fish biology particularly biometric parameter and reproductive biology are of utmost importance for species identification, conservation and aquaculture production. The biometric characteristics including morphometric measurement and meristic counts remain the simplest and direct method for fish stock and species identification (Turan *et al.*, 2004). Variability and differences in species provides information regarding its phylogeny, evolution, population structure and stock characterisation (Umaru *et al.*, 2015; Xiao *et al.*, 2022). Studies on reproductive biology, such as sex ratio, gonadosomatic index, maturation stages and fecundity are required for understanding the biological processes and better management of fisheries and aquaculture systems (De Carvalho *et al.*, 2009). The

reproductive characteristics play significant roles in determining minimum catch sizes and to evaluate the commercial potentials of the fish species for the particular region (Amin *et al.*, 2016; Carvalho *et al.*, 2021). Increase in fish reproductive biology studies is the result of efforts to understand biological processes and conservation of aquatic ecosystems (Lowerre-Barbieri, 2009; Jakobsen *et al.*, 2016). Chameleon fish of the genus *Badis* of the family Badidae, has currently 28 valid species widely distributed in Asian countries, with maximum number of species from India and Myanmar. *Badis* male and female can be easily distinguished during breeding season by its colouration and body shape. Female *Badis* are pale in colour with a swollen belly, whereas males are more colourful than female and aggressive

in nature. *Badis* species are generally cave spawners where mature male fish stays in the cave and ripe female initiates the spawning in the cave. The breeding season of *Badis* fish extends from late July to December (Dutta *et al.*, 2020).

The dwarf chameleon fish *Badis blosyrus* (Kullander and Britz, 2002), a small freshwater fish under *B. assamensis* species group, inhabits in small streams, hill streams and wetlands throughout the Brahmaputra River mainly in Western Assam of North-east India (Ruber *et al.*, 2004; Khyntiam and Sen, 2011). The fish is commonly known as dwarf chameleon fish and locally known as 'Dum bhecheli'. The fish has two rows of irregular blackish blotches together with noticeable dark blotches on opercle post-dorsally. Fish are orange-reddish in colour with sporadic bluish-black spots on their lateral sides and their hyaline fins have orange-reddish colour in anal, dorsal and caudal fin origins. There are two large black blotches, one at the centre of the caudal peduncle and the other at the first few rays of the dorsal fin (Kullander and Britz, 2002). The fish due to its attractive and unique colouration have high demand in ornamental fish market, costing around ₹25-40 per fish in the retail market. Although the fish is listed as Least Concern (LR-Lc) as per IUCN category, due to its increasing demand in ornamental trade it is rapidly declining due to over exploitation, habitat degradation and other climatic factors (such as changes in temperature, rainfall pattern) which may profoundly affect growth, gonadal maturation and spawning in fish (Sarkar *et al.*, 2019; Sarkar and Das, 2021; Barbarossa *et al.*, 2021; Huang *et al.*, 2021). Although the fish has high commercial significance and conservation importance, no systematic study has been carried out so far on its biology, feeding and reproductive biology. Therefore, the present study was undertaken to understand the biology and characterise the biometric features and reproductive biology from the Brahmaputra basin for sustainable management of wild genetic resources.

A total of 75 fish specimens were collected from wetlands and streams of Guwahati, Kamrup (M), Assam during October 2021 to March, 2022 for the study. Fish were collected on monthly basis for six months. The fishes were taken to Guwahati Regional Centre of ICAR-Central Inland Fisheries Research Institute, (ICAR-CIFRI) wet laboratory in live condition and maintained in indoor aquaria for further studies. Twenty eight fish specimens were taken for morphometric and meristic counts. Morphometric measurements were done with a digital caliper to the nearest 0.1 mm. Body proportions were expressed in percentage in relation to standard length. The mean values, range and standard deviation (SD) were also included. Counts and measurements were done according to Jayaram (1999) and Kullander and Britz (2002). Sex ratio was calculated as the monthly percentage of male to female (M: F). Chi-Square test was used to find significant difference of sex ratio from 1:1 at significance level of 0.05. Gonadal maturation stages were determined based on the measure of Nikolsky (1963) as follows:

Stage I (Immature): Ovaries are thin, elongated, cylindrical, pale in colour, transparent and irregular in shape, occupying a small part (1/3rd) of the body cavity whereas testes are smaller, slender translucent and vas deferens not prominent.

Stage II (Maturing): Ovary became slightly swollen and increases in length and weight with small opaque whitish eggs, occupying about half of the body cavity. Testis elongated and distended, white creamy in colour and opaque.

Stage III (Mature): Ovaries yellow-reddish in colour, lobulated occupied almost entire body cavity. Ova are opaque and clearly visible to naked eye. Testes extensive, thicker in size with the blood capillaries conspicuous and reduced in length. The testes occupied less than half of the body cavity.

Stage IV (Ripe): Ovaries light yellow in colour with partial red blood capillary, occupying entire body cavity. Ripe eggs were visible over the ovarian wall and some were present in oviduct. Ripe eggs ooze out with a gentle press in the abdomen. Testes weighted highest, turgid and milky in colour and occupied about half of the body cavity. Milt oozes out on slight pressure on abdomen and vas deferens vestigial.

Gonado-somatic index (GSI) was estimated by the formula given by Brooks *et al.* (1997) as follows:

$$GSI = 100 \times G/W$$

where, (G) is the weight of gonad and (W) is the total body weight.

Fecundity estimation was made from the ripe ovaries during the developmental stages by gravimetric method. Ovaries (0.1 g) was taken separately from anterior, middle and posterior portion of each lobe. Each sub-sample was taken in a petri-dish with drop of distilled water and the eggs were counted under binocular microscope (10X). Ova diameters were recorded and measured to the nearest 0.001 mm. The absolute and relative fecundity were determined according to Bagenal (1978) and Ekanem (2000):

Absolute Fecundity = No. of eggs in sub sample $\times$ Gonad weight/Weight of sub sample

Relative fecundity = Absolute fecundity/Total weight of fish

The relationships between fecundity, body weight and body length were described with power curves and were calculated using the following equations:

$$F = aL^b, F = aW^b \text{ (Bagenal, 1978)}$$

where F is absolute fecundity, L is the total fish length (cm), W is total fish weight (g), a is constant and b is the exponent.

The details of the biometric parameters of *B. blosyrus* are listed in Table 1 showing the morphometric traits and the meristic counts. The total length and the body weight of *B. blosyrus* ranged from 2.1-8.5 cm and 1.25-7 g respectively. The meristic count of the fish ranged from 16-17 for dorsal fin spine count, 8-11 for dorsal fin soft rays, 6-7 for pectoral fin rays, 8-10 anal fin rays, caudal fin rays 12-14 and 24-26 scales in lateral line. Live fish appears orange-reddish in colour with irregular scattered bluish-black blotches on the lateral side with orange-reddish colour at the origin of dorsal, anal and caudal fins. There are two large black blotches, one at the centre of the caudal peduncle and one at the first few rays of the dorsal fin. Similar observations were also made by Kullander and Britz (2002), while defining the fish. *B. blosyrus* belongs to *B. assamensis* group therefore it has a similarity with *B. assamensis* in appearance but there are major dissimilarities in morphometric characteristics and meristic counts. The fish is distinguished from its congeners in having less number of lateral line scales than *B. assamensis* (27-28 vs 29-32) and *B. badis* (25-29) (Khyntiam and Sen, 2011; Ramliana *et al.*, 2021). *B. blosyrus* has longer jaw (upper jaw 12-13.6% SL; lower jaw 16.3-18.5% SL) reaching below the centre of the eye margin, as compared to *B. assamensis*, the

Table 1. Biometric characteristics of *B. blosyrus* collected from Brahmaputra River, Assam, during October 2021 to March 2022

Morphometric traits	Minimum	Maximum	Average	Meristic characteristics (No.)	Range
Weight (g)	1.25	9.0	4.15	Dorsal fin spine count	16-17
Total length (cm)	2.1	8.5	6.34	Dorsal fin soft ray count	8-11
Standard length (cm)	3.1	7.0	5.02	Pectoral fin ray count	6-7
Head length (cm)	0.8	1.2	1.075	Anal fin ray count	8-10
Body depth (cm)	1.1	1.3	1.2	Caudal fin ray count	12-14
Eye diameter (cm)	0.21	0.28	0.23	Scales in lateral line	27-28
Snout length (cm)	0.2	0.25	0.22	Circum-peduncular scales	20
Dorsal fin length (cm)	2.0	2.2	2.1		

mouth opening of which reaches just to the anterior margin of the eye (Kullander and Britz, 2002). It differs from *B. singenensis* from Brahmaputra basin by the absence of a black blotch at the base behind the fifth soft anal fin ray (Geetakumari and Kadu, 2011). It differs from other closely related species from the Brahmaputra basin (*B. dibruensis* and *B. pancharatnaensis*) by the presence of a blotch on opercle (Geetakumari and Vishwanath, 2010; Basumatary *et al.*, 2016).

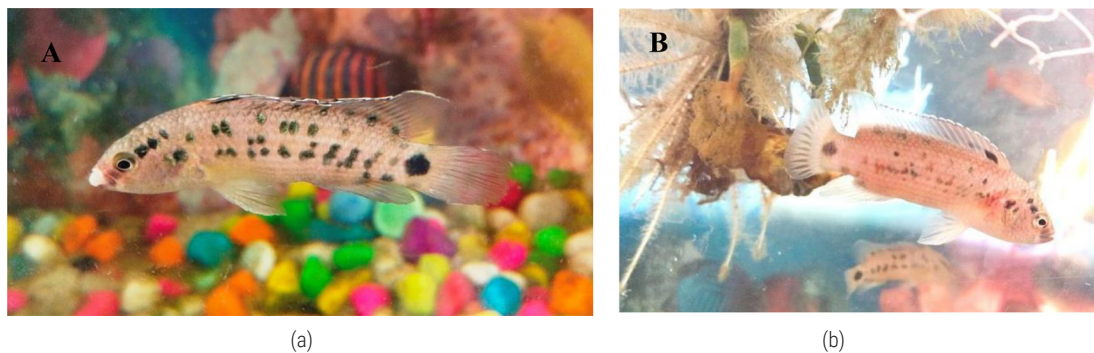
The males are bigger in size than females, are brighter, have longer body profile and extended dorsal and anal fins while the females have duller pattern with shorter and rounded body profile (Fig. 1). During breeding season, males are aggressive towards other males and display intensification of their body colour. It has been observed that the male remains in caves/hideouts most of the time and shows paring behaviour during breeding season. Mature females have enlarged abdomen with swollen belly. In gravid females and males, eggs and milt oozes out with a light press in the abdominal region. Similar phenomena were observed in *B. badis*, where males were larger than females, growing to a maximum length of 5.2 cm and adult males display bright colours during breeding season (Dutta *et al.*, 2020). Mahapatra *et al.* (2016) also observed similar sexual dimorphism of *B. badis* from North-eastern hilly regions mainly

from Assam and Meghalaya, where males are more colourful than females (without red or blue colour on their flanks) attaining first maturity at 5+ months and female at 6+ months of age.

Out of the 75 specimens of *B. blosyrus*, 27 were males representing 34.84% of total with an average length of 5.15 ± 0.42 cm, while females were 48 numbers with an average length of 4.40 ± 0.31 cm, representing 65.16% of the total (Table 2). Females were predominant over males in practically every month. The highest percentage (71.43%) of female fish was observed in January and the lowest (60%) in March and October. For male, the highest percentage (40%) was found in March and October and lowest (28.57%) in the month of January (Fig. 2). The sex ratio of the fish ranged from 1: 1.5 to 1: 2.5 with an overall sex ratio of 1:1.77 (M: F) with no significant differences (Table 2). This result agreed well with Amin *et al.* (2016), who observed red mullet female dominant over male fish with an overall sex ratio of 1.0:1.75 (M: F). Carvalho *et al.* (2021) also studied sex ratio in seven fish species, where females are predominant for all species, except for *Plagioscion squamosissimus*. However, Aung and Sein (2019) observed that in *Channa punctata*, males dominant over females with sex ratio of 1: 0.76 and Tessema *et al.* (2020) observed *Cyprinus carpio* male (56.5%) dominant over female (43.5%) in Hayq Lake. Mishra *et al.* (2013)

Table 2. Percentage of male and female and sex ratio (male: female) of *B. blosyrus* at different months

Month	Male	Percentage (%)	Female	Percentage (%)	Chi-square	Sex ratio
October	6	40	9	60	0.6	1:1.50
November	4	36.37	7	63.63	0.818	1:1.75
December	3	33.33	6	66.67	0.333	1:2
January	2	28.57	5	71.43	1.285	1:2.5
February	4	30.76	9	69.24	1.923	1:2.25
March	8	40	12	60	0.8	1:1.50
Total	27		48		5.759	1:1.77

Fig. 1. Male (a) and female (b) of *B. blosyrus*

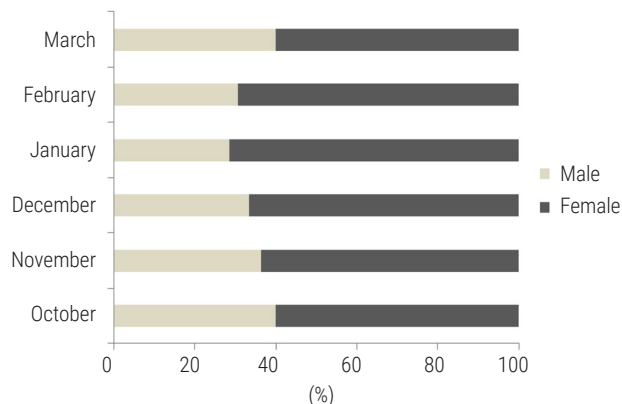


Fig. 2. Monthly variation (%) of sex ratio between male and female *B. blosyrus*

studied biological parameters in *Ompok bimaculatus* where sex ratio of the fish ranged from 1:1.03 to 1:1.3 and males are found larger in size (14.026.6 cm) than females (11.229.0 cm). Kumar et al. (2014) observed female of freshwater mullet, *Rhinomugil corsula* predominated throughout the year with average sex ratio (M:F) of 1:1.32.

The GSI for the *B. blosyrus* females ranged from 1.01% (minimum) during November month with gonad weight of 0.0127 g to 17.89% (maximum) during March month with gonad weight of 0.617 g. The mean GSI value for females ranged from 1.48±0.091% to 13.57±1.09% (Table 3). The GSI value of female was low during October to December indicating post-spawning period and gradually increased during January to March indicating onset of spawning season. The breeding season of *B. blosyrus* of the fish is long starting from late February to August. In male, similar trend was observed with a mean GSI ranging from 1.26 ± 0.120 to 11.42 ± 0.894, highest during March (13.21%) and lowest during November (0.94%) (Table 4). Similar trend was found by Aung and Sein (2019) in *Channa punctata*, where higher GSI was obtained from April to August with onset of spawning from April. Dutta et al. (2020) observed that GSI of gravid females of *B. badis* ranged from 0.037 to 0.15 with an average of 0.077. Highest GSI value was

found in the month of July and August in *O. bimaculatus* which gradually started increasing from January to August (Mishra et al., 2013). Similarly, GSI values in *Cirrhinus mrigala* ranged from 0.23 to 7.93 in male and 0.83 to 16.9 in female with maximum value in July (Das et al., 2016). Himalayan endangered *Tor putitora* also showed increased GSI values from late June to early July and maximum in August (Joshi et al., 2018).

The absolute fecundity varied from 892 to 940 eggs per fish while the relative fecundity ranged from 142 to 150 eggs per gram of body weight. The ovary of the fish is yellowish in colour with prominent blood capillaries (Fig. 3). The ova diameter ranges from 69.44 to 701.9 µm. The relation between absolute fecundity with body weight (BW) and total length (TL) was linear. There was significant relation in absolute fecundity with BW and TL ($p < 0.05$). Absolute fecundity increases with increase in total length and body weight of the fish. With respect to correlation coefficient, the relation between absolute fecundity and fish total length and body weight revealed a strong relationship ($r = 0.925$, $R^2 = 0.5135$) and ($r = 0.751$, $R^2 = 0.5135$) respectively (Fig. 4 and 5). Dutta et al. (2020) observed pre-spawning absolute fecundity of *B. badis* to be 305.3 as mean and the range was 372-502. Similarly, Mahapatra (2016) recorded average fecundity of *B. badis* from North-eastern hill region as 307.50. Tessema et al. (2020), also observed linear relation between absolute fecundity, total weight, total length and gonad weight of Common carp. Similarly, Amin et al. (2016) observed strong relationship between absolute fecundity and fish length of striped red mullet *M. surmuletus*. A significant positive correlation and linear relationship was observed between fecundity, total length, body weight and gonad weight in *C. mrigala* and *Puntius sophore* (Das et al., 2016; Kant et al., 2016).

The study is the first research effort to describe and document systematic information about the sex ratio, GSI, fecundity and gonadal maturation of an understudied fish from Assam, India. The fish due to its attractive and unique colour pattern have high demand in ornamental fish market. The study of sex determination and sex ratio provides information about the population and its dominance of sex in wild population. The knowledge of GSI and fecundity will provide information on breeding season; spawning periodicity and natural recruitments. The information generated forms baseline

Table 3. Pattern of GSI of *B. blosyrus* female

Month	Total length (cm) (Mean±SE)	Body weight (g) (Mean±SE)	GSI (Mean±SE)
October	3.25±0.306	1.73±0.170	1.57±0.205
November	2.69±0.172	1.49±0.072	1.48±0.091
December	3.53 ±0.125	1.70±0.104	1.81±0.155
January	4.48 ±0.26	2.276±0.186	4.45±0.134
February	5.7±0.461	3.37±0.549	6.31±0.626
March	6.8±0.553	4.18±0.586	13.57±1.09

Table 4. Pattern of GSI of *B. blosyrus* male

Month	Total length (cm) (Mean±SE)	Body weight (g) (Mean±SE)	GSI (Mean±SE)
October	5.38±0.488	3.25 ± 0.316	1.53 ± 0.114
November	1.9±0.353	2.22 ± 0.192	1.26 ± 0.120
December	4.2±0.173	2.46 ± 0.387	1.59 ± 0.155
January	4.95±0.35	3.285 ± 0.165	3.36 ± 0.028
February	7.7±0.636	4.4 ± 0.578	8.59 ± 0.984
March	6.8±0.537	4.58 ± 0.430	11.42 ± 0.894

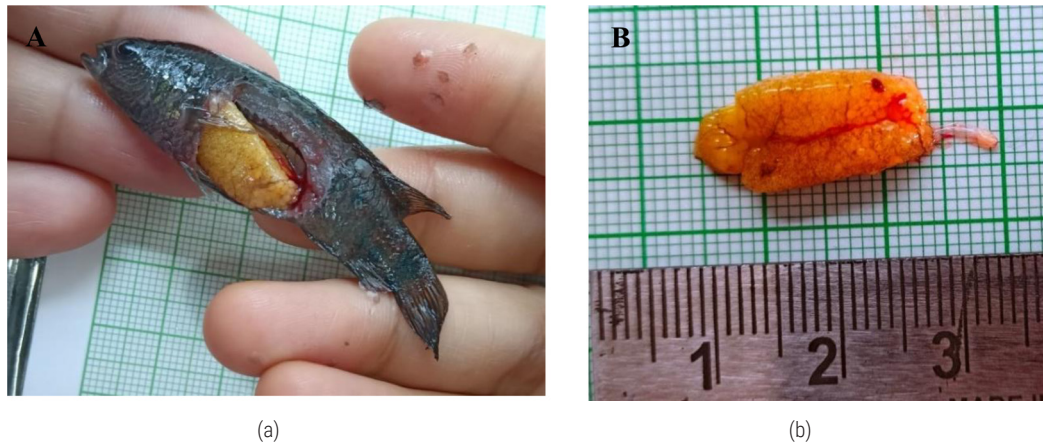


Fig. 3. (a) *B. blosyrus* gravid fish with ovaries, (b) Ripe ovary

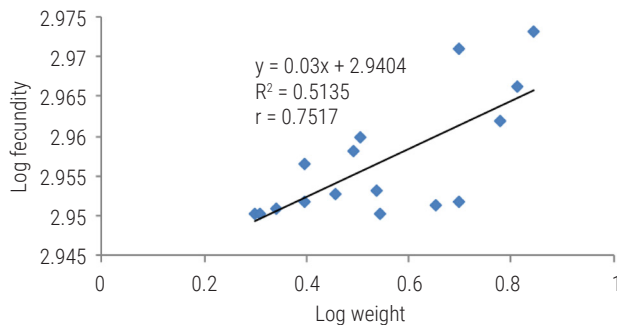


Fig. 4. Relationship between body weight and fecundity of female *B. blosyrus*

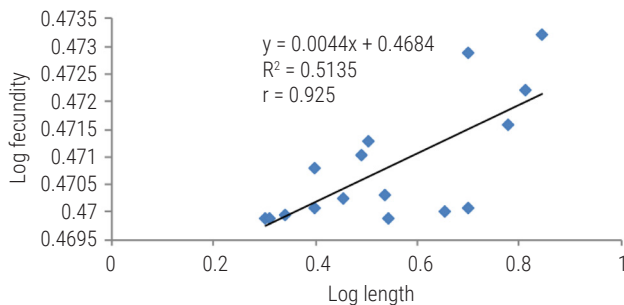


Fig. 5. Relationship between total length and fecundity of female *B. blosyrus*

for further research and understanding the conservation biology in the changing environment. The study recommends more studies at spatio-temporal scale to unravel the population dynamics, spawning habitat, natural recruitments, larval characteristics as well as survival and revisiting the conservation status of the species.

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