

RESULTS

4.1. General biology

4.1.1. Morphological studies

In Laboratory, about 20 morphometric and 8 meristic characters of each fish sample were made in the present study. The length of studied fish is ranges between 16.5-59.3 mm the weight ranges between 0.05-2.52 g. The standard length is about 79.59% and head length is about 24.41% of total length. The eye diameter is about 33.33% of head length of the fish. The head length and head depth ratio is about 4:3 and the standard length and body depth ratio is about 5.5:2. The Mean value for Total length (TL) = 35.73 mm, Standard Length (SL) = 26.26 mm, Head length (HL) = 6.73 mm, Body Depth (BD) = 7.93 mm, Eye Diameter (ED) = 3.06 mm and Snout Length (SnL) = 3.53 mm. **Table 1** given below gives information about Maximum (Max) limit, Minimum (Min) limit and their range differences.

Body slightly compressed and moderately elongated. In maximum cases, alternate belts are of black and green colour, but in case of aged fishes especially from dirty water, the bands are black and dirty red. Fins are yellowish-green, bluish or dark blue. Possess a prominent dark blotch postero-dorsally on opercle and two rows of irregular blackish blotches alongside (**Fig. 8**).



Fig. 8 Fresh specimen of dwarf chameleon fish, *B. badis*
(See colour photo in Plate 7)

Table 1. Different morphological measurements of the *B. badis*

CHARACTERS	MAX (mm)	MIN (mm)	AVG (mm)
TL	49	20	35.73333
SL	39	4	26.26667
BD	14	5	7.933333
HL	12	4	6.733333
HD	9	5	6.727273
TVL	4	3	3.727273
CPL	5	3	3.8
CFL	10	4	7.333333
DFL	26	1	15.06667
AFL	12	1	7.6
PCL	9	5	6.866667
PVL	9	6	7.4
PPCL	17	9	11
POPCL	22	17	19
PDL	17	10	12.06667
PODL	43	30	35.25
PPVL	17	10	12.33333
POPVL	22	17	19.75
ED	4	2	3.066667
SNL	4	3	3.533333

4.1.2. Meristic studies

Variations in the meristic characters of *Badisbadis* are given in **Table 2**. This table gives information regarding the range and mode of Dorsal Spines and soft rays (D), Anal spines and Soft Rays (A), Pelvic Fin (V), Pectoral Fin (P), Caudal Fin (C). Based on the present study, we can get the fin formula of this fish D. XV-XVI, 8-10; P.12; A. 6-8; V. 6-7; C. 12-13.

Table 2. Comparison of meristic data between present and previous study

Characters	Bhuiyan, 1964	Rahman, 1989	Talwar and Jhingran, 1991	Shafi and Quddus, 2001	Mahapatra, 2016	Present Study
Dorsal Fin Ray	XVI-XVIII, 7-10	XIII, 12	XVI-XVIII, 7-10	VI-XVII, 7-10	XV-XVII, 8-10	XV-XVI, 8-10
Anal Fin Ray	III/6-8	III/7-8	III/6-8	III/6-8	6-8	6-8
Pelvic Fin Ray	-	-	I/5	-	6-7	6-7
Pectoral Fin Ray	12	15	12	12	12	12
Caudal Fin Ray	16	-	-	16	12	12-13
Lateral Line Scale	-	-	-	-	26-31	26-32
Transverse Scale	-	-	-	-	8-10	7-10
Caudal Peduncle scale	-	-	-	-	-	3-5

4.1.3. Length-weight relationship

On the basis of different size length 4 groups are observed for length-weight relationship. 83 specimens were in the size length group 'a' 16-22.50 mm and the weight ranges between 0.05-0.26 g; 130 specimens were in the size group 'b' 23-26.50 mm and

weight ranges between 0.15-0.35 g; 124 specimens were in the size group 'c' 27-29.50 mm and weight ranges between 0.22-0.39 g and 127 specimens were in the size group 'd' 30-59.50 mm and weight ranges between 0.26-2.52 g.

The length and weight data of *B. badis* was converted into logarithm form to estimate the length weight relationship. The details descriptive statistics of the length and weight of the fish are represented in **Table 3**. The relationship between length and weight was presented in the form of scatter diagram which revealed that the relationship is linear [**Fig. 9 and 10 (a-d)**]. Calculation of coefficient of correlation (r) along with coefficient of determination (r^2) and the regression equation of different length-weight relationships are presented in the **Table 4**. From the closeness of the scatter diagram and from the parabolic nature of the plot, it is clear that there is a good relationship between every variables of the fish and also the suitability of fitting the exponential formula, $W=aL^b$ to the data. In every cases the correlation coefficient (r) are showing a high degree of correlation between the two parameters. In combined fishes the 'b' value is more than '3' indicates the positive allometric growth. Both the size group of 16-22.50 mm and 23-26.50 mm are showing positive allometric growth where as both the size group of 27-29.50 mm and 30-59.50 mm indicates negative allometric growth.

The condition factor of the fish is 1.61 which indicates the well physiological condition like good growth, good L-W relationship of the fish.

Table 3. Descriptive statistics of LWR of *B. badis*

	N	Range	Min	Max	Mean		Std. Deviation	Variance
					Stat.	Std. Error		
TL	464	42.80	16.50	59.30	27.79	0.300	6.480	42.002
WT	464	2.47	0.05	2.52	0.35	0.013	0.300	0.090
Valid N	464							

Table 4. Relationship between total length and weight of *B. badis*

L-W Relationship	Equation	Regression statistics	
		R	R ²
Combined	Log W= -5.043+3.133L	0.978	0.957
L-W for the size group of 16-22.50 mm	Log W= -5.957+3.814L	0.899	0.806
L-W for the size group of 23-26.50 mm	Log W= -5.131+3.204L	0.855	0.720
L-W for the size group of 27-29.50 mm	Log W= -4.489+2.754L	0.514	0.233
L-W for the size group of 30-59.50 mm	Log W= -4.291+2.645L	0.946	0.893

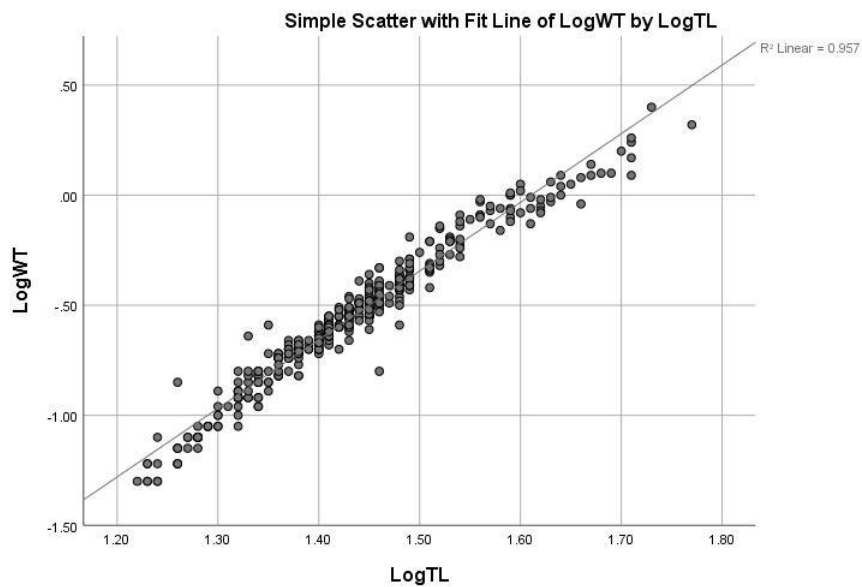


Fig. 9 Length-weight relationship of combined fish of *B. badis*

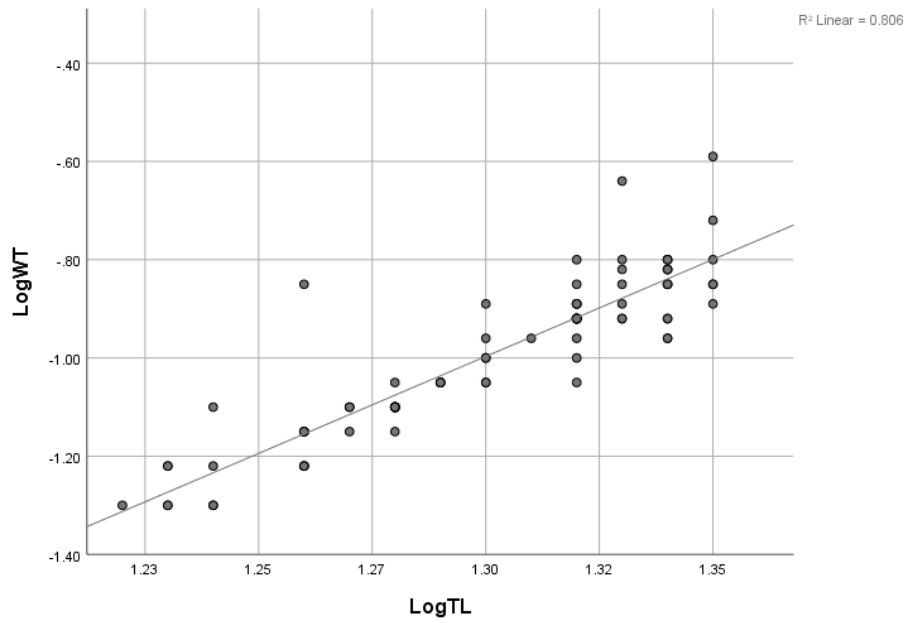


Fig. 10.a Length-weight relationship of *B. badis* for the size group of 16-22.50 mm

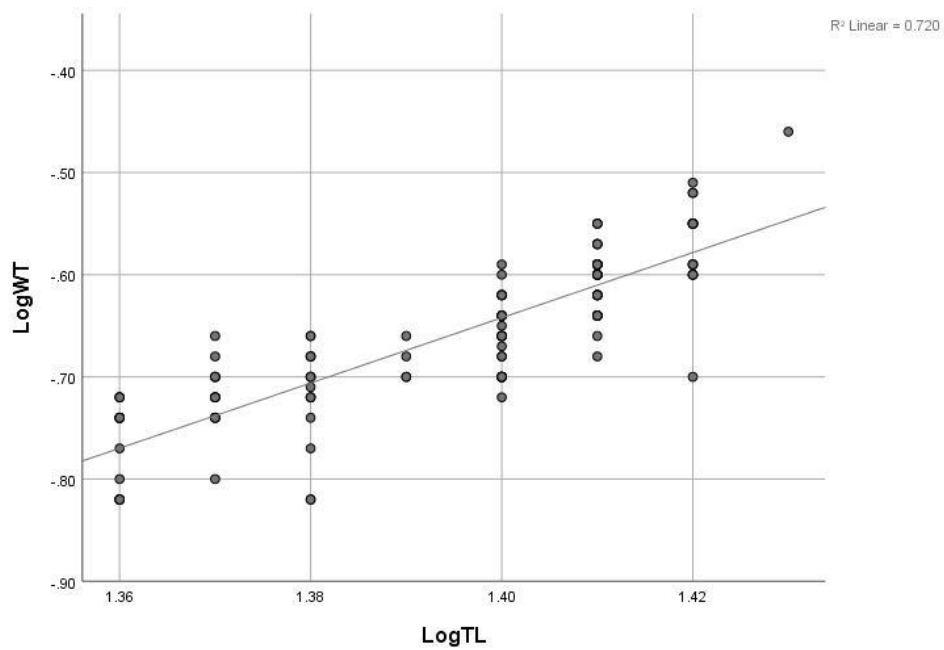


Fig 10.b Length-weight relationship of *B. badis* for the size group of 23-26.50 mm

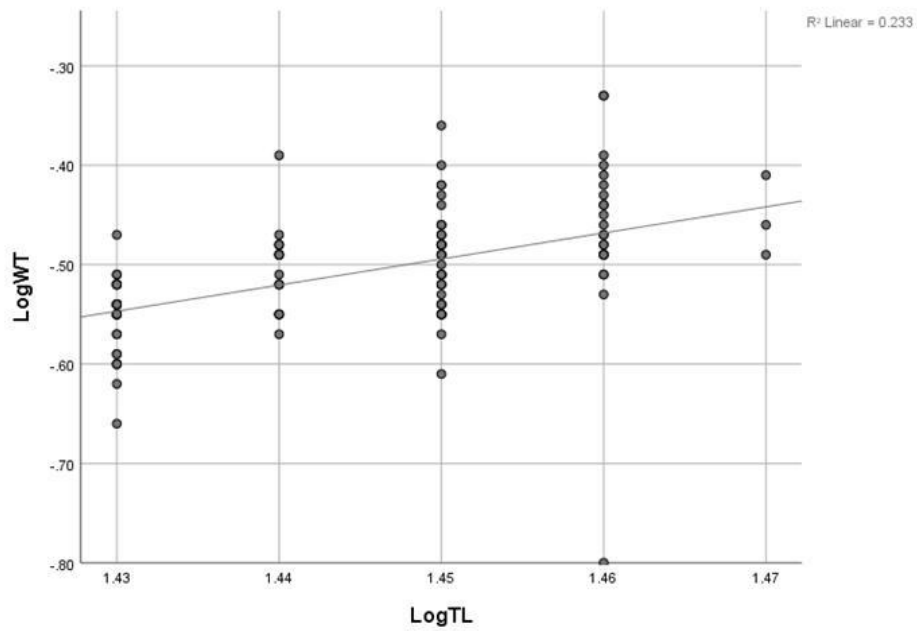


Fig 10.c Length-weight relationship of *B. badis* for the size group of 27-29.50 mm

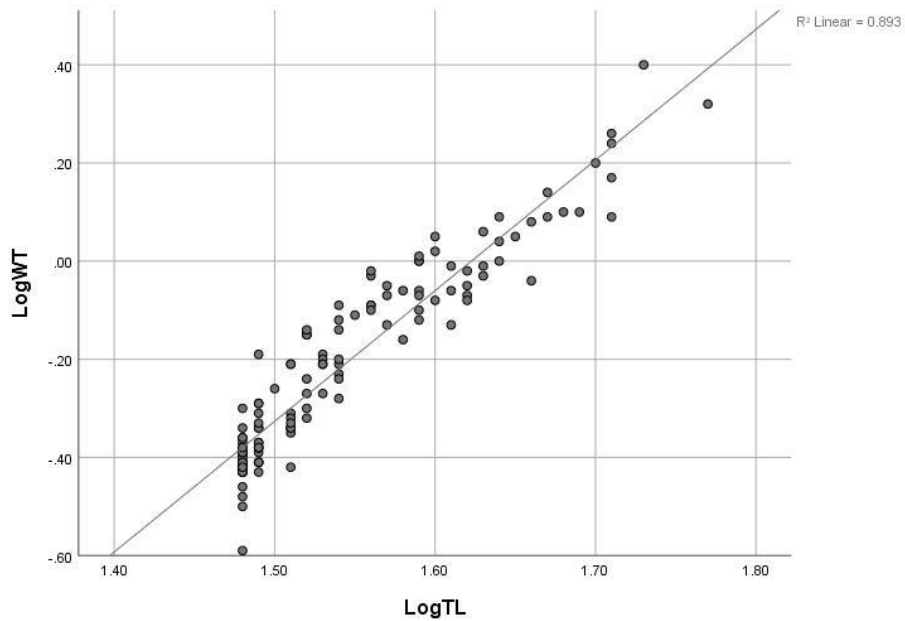


Fig 10.d Length-weight relationship of *B. badis* for the size group of 30-59.50 mm

4.2. Feeding biology

Fish that eat essential nutrients do not suffer from ill health occasionally and grow very fast. Well-fed fish also maintain an attractive colour, looking quite beautiful in the process. The dwarf chameleon fish is micro predators feeding on small aquatic crustaceans, worms, insect larvae and other zooplankton feeds on phytoplankton, zooplankton and insects; however, having a preference. The mouth of the fish is terminal. In the aquarium they often refuse dried foods, and should instead be offered small live or frozen fare such as glassworm, Artemia, Daphnia etc (**Fig. 11**). While they tend to be shy, under low light, they feed well and may have issues with obesity if a lot of food is provided to them.

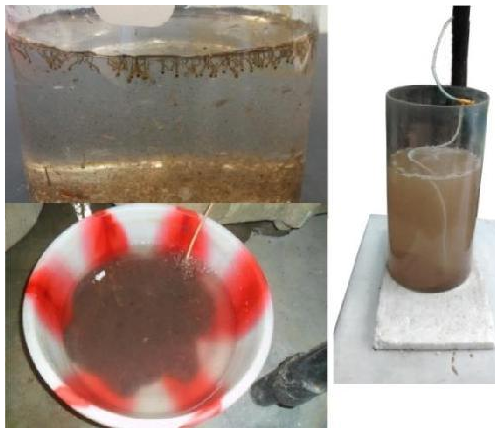


Fig. 11 Live fish feed

4.2.1. Relative gut length

The Relative Gut Length of *B. badis* species was recorded in different length groups (**Table 5**). The mean RLG was found to be highest (0.80 ± 0.02) in the length

group of 22-27mm and lowest (0.52 ± 0.03) in the length group of 12-17 mm. The alimentary canal is short in length and the range of RLG varies from 0.46 mm to 0.84 mm, which implies that the fish is carnivorous in nature.

Table 5. Relative length of gut in different length groups

Length Group (mm)	Combined Sex (RLG)
12-17	0.52 ± 0.03
17-22	0.70 ± 0.06
22-27	0.80 ± 0.02

4.2.2 Gastro-somatic index –

Gastro-somatic index (GaSI) of *B. badis* was found out for 12 months from July, 2017 to June 2018. The average gastro-somatic index of *B. badis* species was found to be 4.76 ± 1.27 . The range of GaSI varies from 2.74mm to 7.14mm. The variations of GaSI in combined sexes have been summarized in **Table 6**.

Table 6. Variation of Gastro-somatic index in combined sex

GaSI	Combined Sex
Mean	4.76 ± 1.27
Range	2.74-7.14

4.2.3. Gut content analysis

The important groups of phytoplankton during the study period in their diet include diatoms and desmids like *Asterionella*, *Closterium*, *Cosmarium*, *Cryptomonas*,

Eaustrum, *Fragilaria*, *Navicula*, *Oscillatoria*, *Pleurotaenium* and *Spirogyra*. Occasionally, zooplankton like *Acroperum*, *Alona*, *Chydorus* and *Cyclops*, Nematodes were also encountered. Nematodes and worms also formed a part of their diet. 90 % of which was constituted by Phytoplankton and the rest was zooplankton (**Fig. 12**). Myxophyceans has been observed with an average of 81.52% according to the percentage of occurrence method. Myxophyceans has been found as the most abundant group and has been observed on regular basis in the gut contents throughout the study period. *Navicula*, *Fragillaria* have been observed as the dominant genus among them (**Fig. 13**). The major zooplankton genus was represented by *Chydorus*. *Cyclops*, *Alona* and *Acroperum* were the genus which was frequently observed in the gut of *B. badis* (**Fig. 14**). Nematodes and worms also formed a part of their diet.

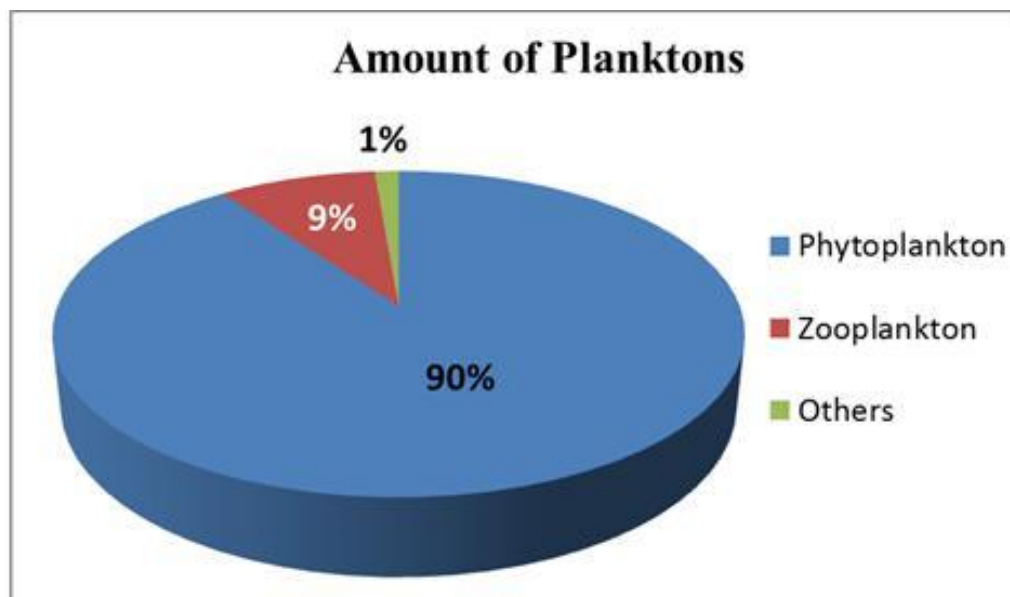


Fig. 12 Percentage composition of gut content
(See colour photo in Plate 8)

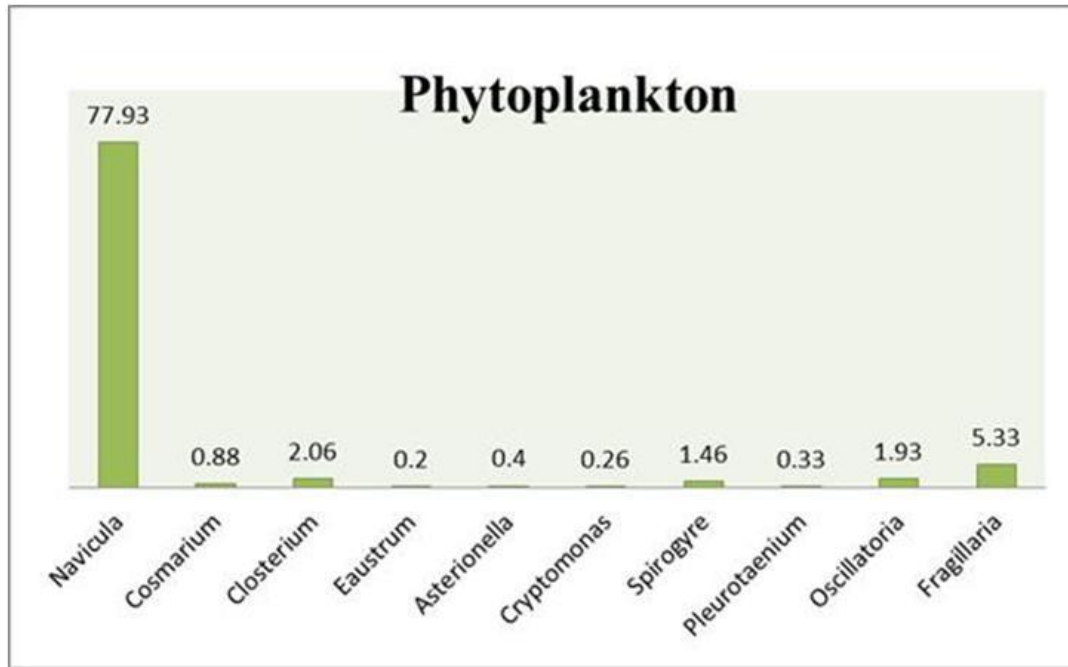


Fig. 13 Percentage composition of phytoplankton in the gut of *Badis badis*
(See colour photo in Plate 8)

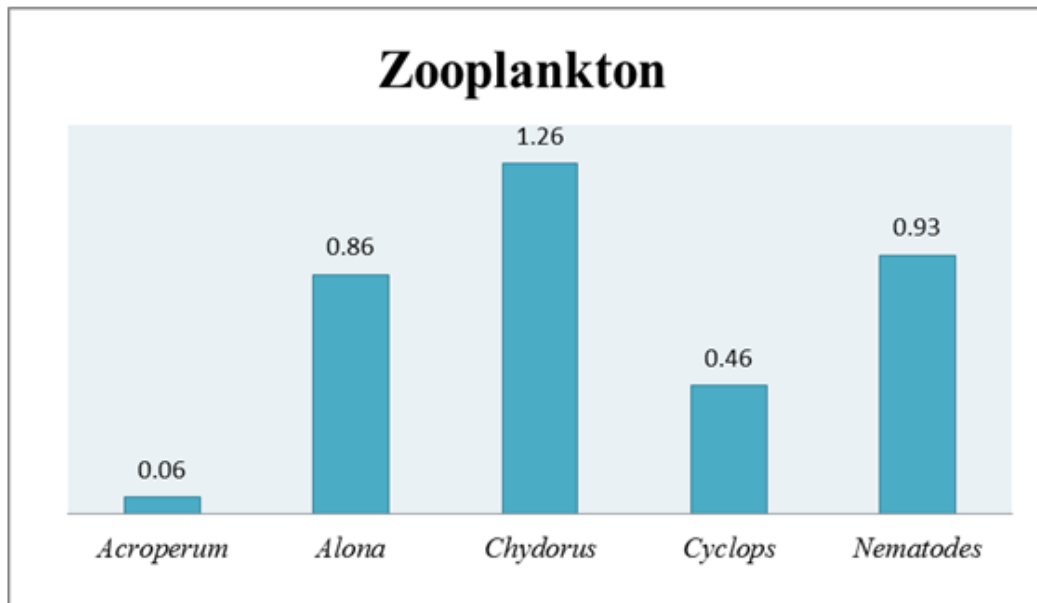


Fig. 14 Percentage composition of zooplankton in the gut of *Badis badis*
(See colour photo in Plate 8)

4.3. Reproductive biology

4.3.1. Sexual dimorphism

Sexual dimorphism is observed between both the sexes of blue perch, *Badis badis*. The male blue perch is more colourful and attractive than the female blue perch (which are without the red or blue colour on their flanks). The colours become more vibrant during the breeding season. The detail comparison between the two sexes is given below.

During breeding season, a matured male can be identified by seeing the blue patch of colour at the ventral region between the opercula and the pectoral fin. During breeding season the female can be identified by the enlarged fat abdomen swollen belly. Males are larger than females growing to a maximum length of 5.2 cm and females are smaller in size. Males possess a straight looking body compare to females (shorter and rounder looking body). Adult males display bright colour with 5 pairs (10 nos.) of black stripes visible on the body and females are less colourful (**Fig. 15**). Mature males develop extended dorsal and caudal fins. No such characters are found in females. Mature males display blue pigmentation in the fins. Sexually motivated males are black associated with extreme aggressiveness.

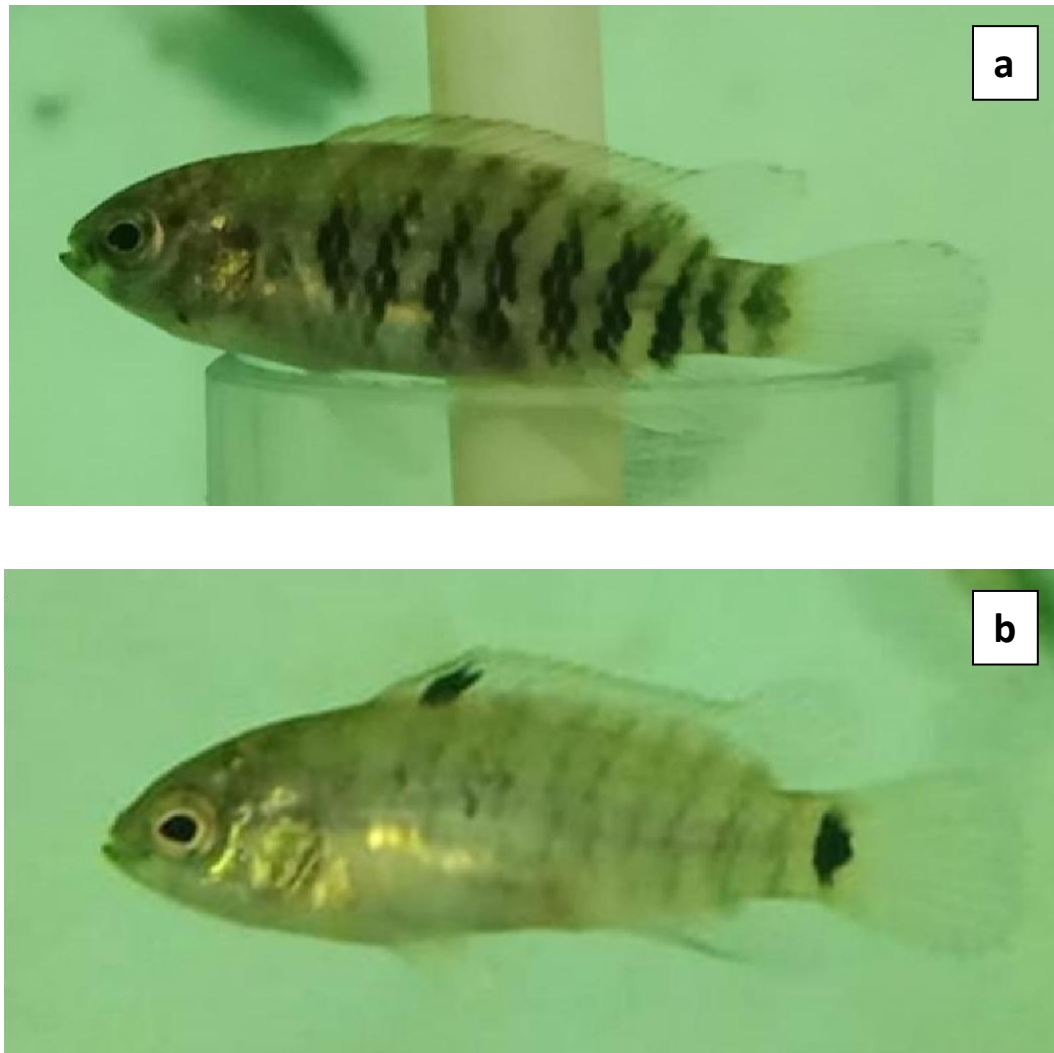


Fig. 15 Adult *Badis badis* (a) Male; (b) Female
(See colour photo in Plate 9)

4.3.2. Gonadosomatic index (GSI)

Gonadosomatic index (GSI) of blue perch, *Badis badis* was found out for 12 months from July 2018 to June 2019. The gonad of the fish is small in length and slight yellowish in colour (**Fig. 16**). 50% of all female specimen attaining a length of 75-85 mm and weight of 6.50-7.75g was matured. The breeding season of the fish extend from

late July to December. The Gonado-Somatic Index (G.S.I.) for the gravid females ranged from 0.037 to 0.15 with an average of 0.077.



Fig. 16 Matured gonad
(See colour photo in Plate 9)

4.3.3. Fecundity

Pre-spawning absolute fecundity of blue perch, *Badis badis* was found out to 305.3 as mean and the range was 372 – 502. The minimum number of ova produced was 116 in a female having a length of 27 mm and weight of 0.28 g. A maximum of 518 numbers of ova was produced by a female having a length of 29 mm and weight of 0.47 g.

4.3.4 Breeding behaviour

In breeding condition rival males will become increasingly combative and begin to display courtship behaviour towards females. During this process males display changes in colour pattern, with the body darkening to almost black and the blue fins intensifying in colour. In early stages of spawning male closely swims with female. The male drag females into the cave.

4.3.5 Captive breeding, seed production and rearing

The parent fish is conditioned prior to breeding by providing them with a high protein diet of live foods and daily water changes in the breeding tank with offer them the highest water quality possible. The male display a more intense colouration to display to the female and they will pair off. *B. badis* are cave-spawners that form temporary pair bonds. For this breeding tank is set using river sand and gravel for the substrate and provided couple of upturned plant pots and broken earthen pot as spawning sites. The water maintained soft and slightly acidic, the temperature set at 24 °C. A single pair or a group of adults can be used for breeding set up but for multiple males several number of cave have to provide for each pair. To ensure a higher rate of success 2-3 females to each male.

During spawning male drag females into the cave. A receptive female will enter and spawning takes place with 30-100 eggs. During this time female deposit eggs and male fertilize the egg by swimming over them. After spawning takes place remove the female from the breeding tank as the male may turn aggressive towards the female. The male shows parental care towards the eggs and fry, and defending the territory and fanning with the fins. The eggs hatched after 2-3 days but the fry do not become free swimming until they are 6-8 days old, and not leave the vicinity of the cave for another week or so after that. From this point the adults (parent male included) may begin to regard them as food and are best transferred to a separate aquarium. The young fish are quite sedentary for the first few days. Microworm is an ideal initial food, but once they

are visibly swimming in the water column *Artemia nauplii* is used to the diet thrice daily. The growth rate quite quick and once the larvae reach a size of 0.75 - 1 inch (2 - 2.5 cm) they moved into a larger aquarium for rearing.

Water quality parameters: Water quality parameters for rearing and spawning at ICAR-CIFE, Kolkata were analyzed throughout the year. There was no significant difference observed in all the parameters analysed for 12 months, except the temperature which remained within a range of 20 – 28 °C, having seasonal fluctuations. Hardness was in the range of 224.00 - 231.50 ppm, Total alkalinity 185.25 ppm and pH in the range 7.13 -7.25. Dissolved oxygen range was in range of 5.13 - 5.38 ppm. The monthly details of the water quality parameters are given below in the **Table 7**.

Table 7. Water quality parameters for Water quality parameters for rearing and spawning at ICAR-CIFE, Kolkata

MONTH	Temperature (°C)	pH	Dissolved O ₂ (ppm)	Hardness (ppm)	Total Alkalinity (ppm)
JULY	24.27 ±0.17	7.26±0.29	5.22±0.05	225.00±1.63	178.00±0.82
AUGUST	24.29±0.14	7.14±0.25	5.26±0.06	224.00±2.16	179.25±1.26
SEPTEMBER	24.77±0.10	7.13±0.25	5.27±0.05	223.00±0.82	185.26±1.49
OCTOBER	27.64±0.14	7.25±0.28	5.13±0.07	226.00±1.43	182.50±1.81
NOVEMBER	27.50±0.08	7.23±0.25	5.15±0.09	225.25±1.36	178.50±0.58
DECEMBER	26.05±0.37	7.25±0.29	5.28±0.05	226.75±0.96	178.75±0.50
JANUARY	20.58±0.17	7.13±0.21	5.38±0.06	224.50±1.00	186.75±1.50
FEBRUARY	24.58±0.08	7.17±0.25	5.32±0.00	227.75±0.50	183.60±1.92

MARCH	25.63±0.09	7.25±0.29	5.24±0.05	233.50±0.58	178.49±0.48
APRIL	26.60±0.26	7.13±0.25	5.23±0.05	228.50±0.58	177.75±3.40
MAY	27.18±0.33	7.25±0.29	5.28±0.05	229.00±0.82	184.75±1.89
JUNE	23.08±0.48	7.13±0.35	5.35±0.06	227.25±0.50	186.75±0.86
RANGE	20.58 - 27.50	7.13 - 7.25	5.13 - 5.38	224.00 - 233.50	177.75 - 186.75