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Bionomics of gangetic leaf fish, *Nandus nandus* (Hamilton, 1822), an important food fish of Assam

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Abstract
Nandus nandus (Ham) is a carnivorous fish. The fish is highly predatory and feeds primarily on finfish, shellfish and aquatic insects. The victual spectra trend of the gut contents of the fish has been studied through the four pronounced seasons of the year as ascertained by the index of preponderance. The relative length of gut reveals distinctly carnivorous behaviour. In males at maximum size range of 110 – 115 mm mean RLG is 1.03 whereas in females at size range of 110 – 115 mm, the RLG is only 0.903 indicating that females of the test species are more carnivorous than the males. The hepatosomatic index of the species depicts the feeding intensity of the test species. Lineament of feeding shows that the fish is a column feeder but is well competent to feed both at the surface as well as bottom level when food is supplied in the aquaria. The gill raker configuration reveal carnivorous pattern both in structure and number. The gill rakers are short and pointed backward.

Keywords: Food, relative gut length, hepatosomatic index, feeding habits, *Nandus nandus* (Ham)

Introduction
The growth process is specific for each species of fish, as for any other organism. Growth is a specific adoptive property, ensured by the unity of the species and its environment. The food spectra of an individual species changes along as the animal grows as well at different seasons and locality. Nature offers a great variety of foods to fishes including nutrients in solution and hosts of different plants and animals. Little is known of the direct uptake of soluble nutrients by fishes. Fishes has adapted to a wide variety of foods such as feeding on planktons, plants, animals including larval form, blood of other fishes in parasitic fishes. Food and feeding habit of fishes are significant biological factors for choosing a group of fish for culture in ponds (Dewan and Saha, (1979) [5]. Food and feeding habit of different fishes have been made by many researchers like Moffet and Hunt (1943) [14], Khan (1947) [12], Karim and Hossain (1972) [11], Doha (1974), Dewan and Saha (1979) [5], Bhuiyan and Islam (1990) [2], Reddy and Rao (1993) [18], Akpan and Isangedhi,(2005) [1], Khabade (2015) [10], Tamlurkar (2018) [22], Naganyal and Saxena (2019) [15]. It was indeed Dey and Sarmah (2003) [6], who made empirical studies on the nutrition of some native ornamental fish species of N.E. India hitherto remain unattended. The freshwater leaf fish *Nandus nandus* (Hamilton, 1822), commonly known as mottled nandus is an important food as well as ornamental fish of North eastern India. In North eastern India the fish is found in all the states except in Sikkim and Mizoram. It lives in lentic water bodies and migrates to lotic water systems during the monsoon season. The fish is carnivorous. Despite having a good market values the fish in not cultured in commercial level in this region. The present paper deals with the food propensity enumeration of this species which would help in their successful culture in confined water.

Materials and Methods
The study was conducted from March 2014 to February 2015.Fish species were collected from Haribhanga Beel of Nowgaon district of Assam.
For victual spectra study, an average of c 50 fishes per season was collected and preserved in 8-10% formaldehyde. A total of 200 fishes were analysed during the period of study. The gut content of *Nandas nandus* (Ham) was analyzed after Hynes (1950) [7], and Lagler (1952) [13]. The entire digestive tube was cut open lengthwise and the contents were emptied into petri-dishes for analysis and the different food items were separated. The large food items were isolated and identified and the smaller food constituents were identified with the aid of

microscope. All the food items were ascertained upto the genus or the family level, depending upon the completeness of the organism and the extent of digestion. If digestion has progressed to an advanced state making identification difficult, it was treated as digested. The food items are identified according to authoritative sources. The number of empty and non-empty guts was also observed.

The relative length of the gut (RLG) exhibits the precise relation between the gut dimensions to the actual body length. The RLG is analysed after Jacobshagen (1913) [9] using the formula, $RLG = \frac{GL}{TL}$, where GL – gut length and TL – total length of the fish in cm.

The hepato-somatic index (HSI), which is an estimation of the feeding intensity of the fish, was calculated by the formula, $HSI = \frac{w \times 100}{W}$, where w and W are the weight of the gut content and the fish respectively.

In order to give a summary picture of the frequency of occurrence in conjugation with the bulk of the various food items consumed, an index taking two variable factors into consideration seems desirable. Such an index is given by Natarajan and Jhingran (1961) [6] designated as the index of preponderance (PI) which is deduced by, $PI = \frac{v_i o_i \times 100}{\sum v_i o_i}$, where '$v_i$' *and* '$o_i$' are the volume and occurrence indices of food items as indicated by their percentage. The index of preponderance (PI) of different food items has been recorded in 30 specimens ranging from 12.5-14.2 cm in Total Length (TL).

The gills of the test species are dissected out and studied under the microscope to find out the gill raker condition and correlated with food habit after Nikolsky (1963) [17].

Results and discussion:

Victual spectra: On an average of c 50 fishes per season is analysed for victual spectra out of which the gut of an average of c 16.5 (33%) were found empty and c 33.75 (67.5%) possessed filled stomach. On the basis of PI, the food of the fish may be summarized as follows in different seasons

Pre-monsoon: (March – May) Undigested animal muscles (93.33) > Debris (20) > Shell fish (13.38) > Fin fish (10) >Aquatic insects (3.33), Fig 1

Digested animal muscles (93.33% by volume) are represented by half digested animal tissues. Debris (20% by volume) are represented by mud (95%) and stones (5%) Shell fish (13.33 by volume) are represented by shrimps 30%, appendages 40%, pleopods 7%, Uropod and telson 10%, shell 12%. Fin fish (10% by volume) of which *Puntius sp* 30%, *Chanda sp* 20%, *Colisa sp* 20%, *A. mola* 10%, half digested fish 10%.Vertebra and scales 10%. Insect parts 3.33%.

Monsoon (June – August): Digested muscle fibres 52.38% > Fin fish 38.10 > Shell fish 38.10% > Debris 4.76%. Fig 1

Digested animal muscles 52.38% represented by bolus of digested animal tissues. Fin fish (38.10%) is represented by *Puntius spp* 75% > *A. mola* 25%. Shell fish (38.10%) is represented by Prawn 75% > antennae 12.5% and carapace 12.5%.

Post – monsoon (Sept. – Nov.): Muscle fibres 83.33% > Fin fish 22.22%, Shell fish 13.89% > Debris 27.78% > Aquatic plant parts 8.33% > Fluid 2.78%. Fig 1

Fin fish (22.22%) represented by *A. mola* 50% > *Puntius spp* 25% > *Colisa* 12.5% > Opercular bone, spines, vertebral column 12.5%. Shell fish (13.89%) represented by Shrimp 40% > appendage 20% > Chelate legs 20% > Pleopod 20%. Debris (27.78%).- Mud 60% > sand 40%.

Winter (Dec. – Feb.): Muscle fibres 88.24% > Shell fish 26.47%, Fin fish 8.82% > Fluid 8.82% > Debris 5.88% > Aquatic insect 2.94. Fig1

Muscle fibres 88.24%. Shell fish (26.47%) represented by Shrimp 88.89%, appendages 22.22%. Fin fish (8.82%) of which Puntius 33.33%, Opercular bone and scales 66.33%. Debris (5.88%) is represented by Mud 50%, sand 50%. Aquatic insect 2.94%.

Lineament of Feeding

As column feeder the fish move to the column and stay for sometime → intake of food → return to the bottom or retraces back among aquatic plants → moves to the surface level → intake of food → returns to the column level -_swimming back to the bottom level → intake of food → returns to the column level.

Relative length of gut: The relative length of gut (RLG) of the *Nandus nandus* (Ham) have been studied separately for male and female and is purported below in Table 1

Table 1: RLG in different size range of male and female *Nandus nandus* (Ham)

S. No	Size Range (TL mm) Male	RLG (cm)	Size Range (TL mm) Female	RLG(cm)
1.	0 – 80	0.880	0-90	0.761
2.	80 – 85	0.900	90-95	0.866
3.	85 – 90	0.907	95-100	0.817
4.	90 – 95	0.925	100-105	0.926
5.	95 – 100	0.890	105-110	0.912
6.	100-105	0.933	110-115	0.902
7.	105-110	1.045	115-120	0.902
8.	110-115	1.030	120-125	0.927

Comparative analysis between male and female of *Nandus nandus* (Ham) reveals that the females have shorter alimentary canal than the males.

Hepato- somatic index: The HSI of *Nandus nandus* (Ham) is studied separately for both male and female and recorded below in a tabular form in Table 2 and 3 respectively.

Table 2: Male

S. No	TL (mm)	HSI	HSI RANGE	HSI MEAN
1.	74	1.053	0.060 – 4.100	2.081
2.	77	0.345		
3.	80	0.151		
4.	81	0.303		
5.	82	0.439		
6.	91	0.285		
7.	92	0.879		
8.	95	0.209		
9.	101	2.778		
10.	103	0.770		
11.	105	0.060		
12.	112	0.882		
13.	118	4.100		

Table 3: Female

S. No	TL (mm)	HSI	HSI RANGE	HSI MEAN
1.	0 – 80	2.819	0.436 – 2.819	1.628
2.	80 – 90	1.090		
3.	90 – 100	0.956		
4.	100 – 110	0.644		
5.	110 – 120	1.084		
6.	120 – 130	1.374		
7.	130 –140	0.436		
8.	140 – 150	0.829		
9.	150 – 160	0.192		

Index of pre-ponderance (PI) in *Nandus nandus* (Ham)

The PI does not differ significantly between male and female in the present species, which is why, an overall trend of PI in *N. nandus* has been depicted in Table 4.

Table 4: Index of preponderance in *Nandus nandus*

Food Items	Occurrence Oi (%)	Volume V*i* (%)	Oi V*i*	PI
Fin Fish	10.0	33.93	339.30	7.05
Shell Fish	13.33	8.93	119.04	2.47
Aquatic insect parts	3.33	3.57	11.89	0.25
Undigested animal muscle	93.33	44.64	4166.25	86.53
Debris	20.0	8.92	178.60	3.71

Gill raker exposition

The anterior portion of the ventro-lateral wall of the pharyngeal cavity is perforated by five pairs of gill slit like opening separated by four pairs of gills. Each gill has a long lower limb and a shorter upper limb. The four gill arch separates the five gill slits in either side. Each gill arch is provided with two rows of teeth like gill rakers on the inner concave border projecting internally into the pharyngeal cavity, and two rows of comb like filament or gill lamellae on outer convex border.

The gill raker protects the delicate gill lamellae from injury apart from its principle role in feeding. They serve to prevent the food particles from escaping out through the respiratory current of water. The rakers form a very effective sieve like apparatus across the gill slits for filtering the water in order to retain the food items in the bucco-pharynx.

Gill raker is modified in relation of food and feeding habit. The gill rakers of *Nandus nandus* (Ham*)* are short, straight and pointed. The gill rakers are longer in the central part of both the limb. The gill raker configuration is purported in Table 5

Table 5: Gill raker configuration of Nandus nandus (Ham)

Particulars	*Nandus nandus*
Size range of fish	10.1 – 15.4 cm
No. of gill raker/gill arch	20
Size of gill raker	0.1 – 0.2 cm
Length of gill lamellae	0.4 – 0.5 cm
Length of gill arch	2.8 – 4.0 cm.

Based on the recorded variation in the type of food consumed *Nandus nandus* (Ham) may reasonably be classified as euryphagic feeder. Euryphagism (Nikolsky, 1963) [17] has evolved as an adaptation to unstable supply of food. The present study portrays that the basic food of *Nandus nandus* (Ham) is fin fish and shell fish showing variation in their percentage of consumption during the different seasons. Besides this, the findings also reveal that the secondary food of the test species comprises of earthworm, tadpole, aquatic insects and mosquito larva. Semi digested muscle fibre is found to occur in maximum percentage throughout the year whereas aquatic plants are incidental food. The overall victual spectra are almost similar in both male and female of the species. The gut content during the pre-monsoon, monsoon and post monsoon season of the species reveal that the percentage of occurrence of fin fish and shell fish vary depending upon the presence of the young ones. Therefore, the supply of food thus changes through the year and the seasonal rhythm of feeding is connected with the trend to a significant extent. Normally, *Nandus nandus* (Ham) is a column feeder but it is well competent to feed both at surface as well as bottom level when food is supplied in the aquaria.

The relative gut length (RLG) is closely related to the food habit (Das, 1958) [3]. The length of the gut varies not only with the food habit but also in relation to size and age of the species (Sinha and Moitra, 1975 a,b and Sinha, 1972) [19-21]. Low and high RLG indices purport for the carnivores and herbivores respectively with an intermediate value prevailing for the omnivores. This is for the obvious fact that long intestine of the herbivores helps in the digestion and absorption of the vegetable matters than the carnivores whose diet is easily assimilated consisting of animal matter.

The present findings reveal specific changes in RLG of the species for every 5.0 mm increment in body length from sub – adult to adult. In males at maximum size range of 110 – 115 mm mean RLG is 1.03 whereas in females at size range of 110-115 mm, the RLG is only 0.903 indicating that females of the test species are more carnivorous than the males.

The hepato somatic index (HSI), considered as an exponent of feeding intensity shows direct relationship with size range in the test species. HSI changes in relation to food supply and seasonal rhythm in food consumption through adaptive change in the abiotic condition (Nikolsky, 1963) [17] appear plausible based on the present findings. However, in breeding season, the HSI in the female shows more or less decreasing trend than the overall HSI. The low feeding during breeding season in the females may be attributed to the development of gonads during spawning season, which occupy the major space of the abdominal cavity (Jhingran, 1991) [8]. Thus it can be inferred that the intensity of feeding shows a downward trend in the approach of the maturation phase and ingestion only improve when the spawning period is over.

The structure of the gill raker is closely related to the feeding behaviour of the fish. The number and structure of the gill rakers can vary considerably, from a few small hard tubercles in predatory fishes to a complex network of numerous raker in

planktophagic fishes. The gill raker configuration of the test species under investigation, basically reveal carnivorous pattern both in structure and number. The gill rakers are short and pointed backward.

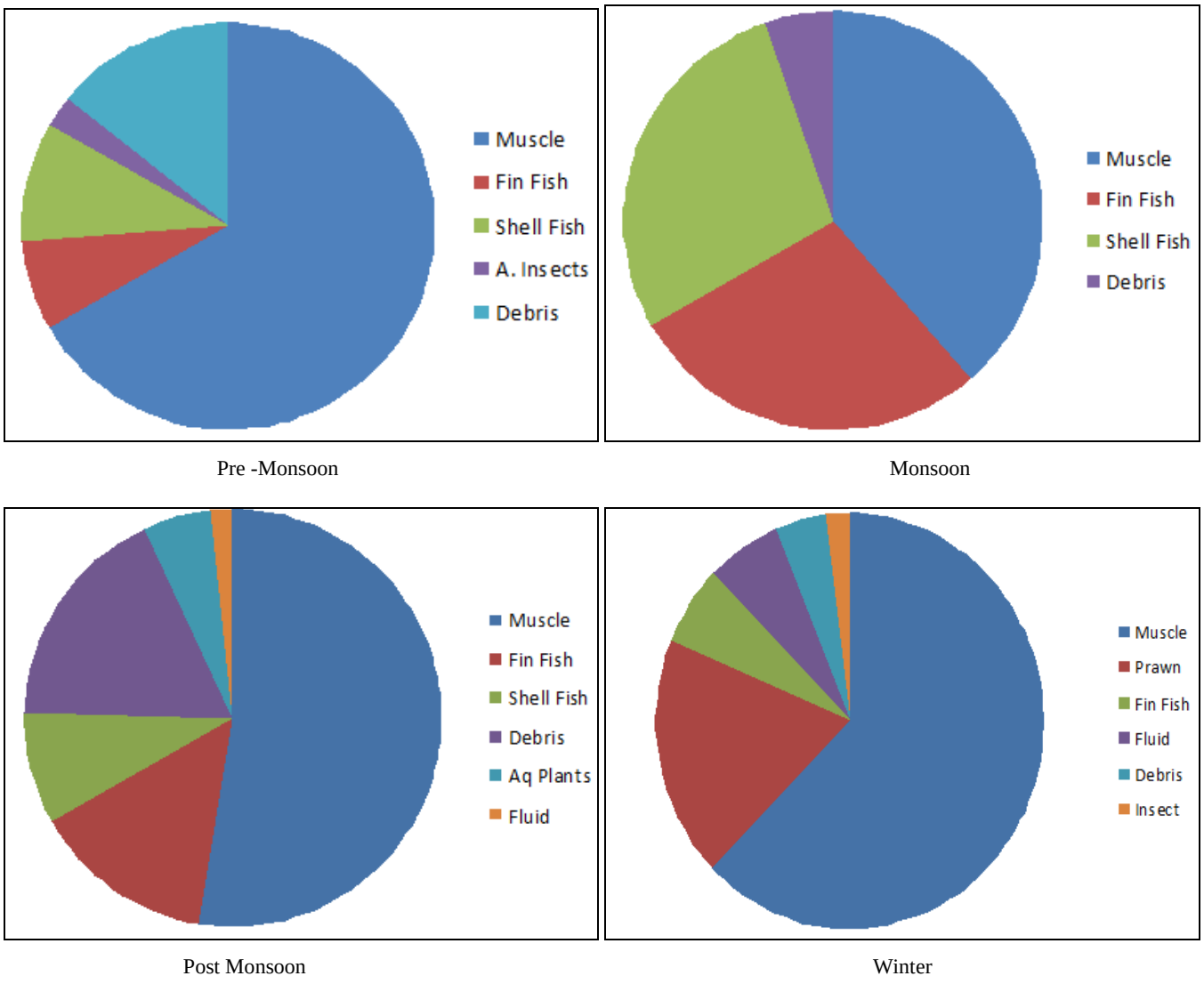

Fig 1: Victual Spectra of *Nandus nandus* through four seasons Pre Monsoon, Monsoon, Post Monsoon and Winter

Conclusion

The depiction of the food spectra of the test species will be a great help for fisherman community to take up the culture of the fish. This will help in the generating income sources for the local fisherman community.

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