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Food and Feeding Habits of *Aborichthys kempi* (Chaudhuri, 1913) from Arunachal Pradesh, India

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ABSTRACT

The feeding habits of *Aborichthys kempi* was carried out from the different streams of Papumpare district, Arunachal Pradesh during April, 2016 to March, 2017. A total of 72 fish samples were examined and total body weight ranged from 0.69 to 4.47g and body length ranged from 40.18 to 149.40mm. The mouth is small, inferior with thick, fleshy and papillae lips and upper lip is continuous but lower lip is interrupted in the middle and not fringed. The alimentary canal starts from a short oesophagus followed by a prominent stomach and a relatively shorter uncoiled intestine. The number of gill rakers ranged from 10 to 12 and they are short and widely spaced. Highest Relative length of the gut (RLG) (0.68±0.05) was recorded in 0-50 mm and lowest (0.47±0.07) in 100 mm-above. It reveals that the fish falls in the category of carni-omnivorous fishes. Highest Gastro Somatic Index (GaSI) (3.42±1.73) was recorded in February and lowest (2.52 ±1.17) in August. Fullness of gut reveals that the overall feeding intensity of highest percentage of full gut was recorded as 15.28%; ¾ full gut as 25.0%; ½ full gut as 33.33%; ¼ full gut as 26.39%. It depicts the good feeding activity was observed in the seasons. The feeding index was also observed as highest (66.67) in February and that of lowest (52.08) in June. Percentage of occurrence method shows that insect larvae and insect parts were found as the most abundant group with an average 25.23% and followed semi-digested parts (24.71%); debris (23.85%); phytoplankton (17.20%); unidentified species (5.61%) and zooplankton (2.97%) of the total food content. The volumetric method revealed that insect larva and insect parts occupied the highest average percentage with 40.58% followed by unidentified species (0.54%), debris (10.33%), phytoplankton (20.96%) and semi-digested parts (27.3%). Indices of preponderance revealed the most preferred food items as insect larvae and insect parts which constitute 44.33% followed by semi-digested (29.21%), phytoplankton (15.62%), debris (10.67%), unidentified species (0.14%) and zooplankton (0.03%).

Key Words: Relative Length of the Gut; Fullness of Gut; GastroSomatic Index; Gut Content Analysis; Index of Pre-ponderance

INTRODUCTION

Aborichthys Kempi Chaudhuri 1913 (family Nemacheilidae) is a small freshwater ornamental species widely distributed in the state Arunachal Pradesh, India. It is locally known as “reibo” or “reibi” in the state. It is mostly bottom dweller and adapted to both fast and slow flowing streams, where it clings to small pebbles, rocks, gravel and boulders. It has been identified as a potential indigenous ornamental fish due to its unique characters as well as beautiful banding patterns and coloration.

Studies on the food and feeding habits indicate the species niche in the ecosystem, their food preferences and food spectrum overlaps (Padmakumar *et al*. 2009). Accurate report of diets and feeding habits also give the basis for understanding the trophic interactions in aquatic food webs (Zanden and Rasmunssen 2000). Without knowledge of the food requirements, feeding behaviour pattern, and predator-prey relationships, it is not possible to rear or culture any fish species in artificial environmental conditions. For successful fish farming a thorough knowledge about the food and

feeding habit is necessary (Bhuiyan et al. 2006 Begum et al. 2008). Therefore, investigation of food and feeding habits is an important part and also a crucial step towards successful cultivation of any fish species. So far, there is no scientific literature on the feeding habits of *Aborichthys kempi* in the north-eastern region of India. Hence, the present study has been taken up to investigate on the food and feeding habits of this species from different streams of Papumpare district, Arunachal Pradesh, India. Further, such studies could provide important information for successful rearing and rational management of this species.

MATERIALS AND METHODS

The samples of *Aborichthys kempi* (Figure 1) were collected on the monthly basis from the different streams of Papumpare district, Arunachal Pradesh during April, 2016 to March, 2017. A total of 72 fish samples were collected for the study and the total body weight ranged from 0.69 to 4.47 g and total length ranged from 40.18 to 149.40 mm. The sampling was done by the traditional fishing method called '*sibok patnam*' or '*hibok patnam*' in Adi and Galo tribe of Arunachal Pradesh. In this method, the direction of stream is diverted into a small channel by blocking with mud, woods, plants, debris and pebbles and boulders, so that the water from the stream is bailed out leaving the original passage arid and the fishes are caught easily by hand. Most of the fishes collected by this method include small size, bottom dwelling fish species which cannot be caught by net. The identification of the fishes and description was done with the help of standard keys of Nelson (2006). Freshly collected fish samples were brought to laboratory and the guts were removed from the specimen after measuring and weighing each specimen to the nearest mm and gram respectively and preserved in 5% formalin for subsequent analysis. The preserved guts were later cleaned off the attached fat and the length and weight were recorded. Morphological structure of mouth parts, Relative length of gut (RLG), Gastro-somatic index (GaSI), Gut fullness (Feeding Intensity) and Gut content analysis have been done in order to study the food items and feeding habit.

Figure 1. *Aborichthys kempi* (Chaudhuri, 1913)

Morphological structure of mouth parts, gill rakers and alimentary canal were observed visually and by physical examination. Photographs were taken of the mouth parts and gill rakers. After proper dissection, the alimentary canal was traced, cleaned and photographed.

Relative Length of Gut (RLG)

The RLG have been calculated in response to different size groups (length interval of 5 cm) to know any change of RLG value. It has been estimated following the formula of Al-Hussainy (1949).

$$RLG = \frac{\text{Total Length of Gut (cm)}}{\text{Total Body Length (cm)}}$$

Gastro Somatic Index (GaSI)

It was measured using the following formula of Desai (1970).

$$GaSI = \frac{\text{Total Weight of Gut (g)}}{\text{Total Body Weight (g)}} \times 100$$

Fullness of gut (Feeding Intensity)

The feeding intensity was based on the state of fullness of gut and the amount of food content in it. Based on this, the collected fish samples were categorized as follows: empty (when the gut is empty i.e. no food); poor intensity (when gut is filled with ¼ part of its capacity); medium intensity (when gut is filled with ½ part); good intensity (when gut is filled with ¾ part); high intensity (when gut is filled with more than ¾ part). The degree of stomach fullness has been assessed according to the subjective scale described by Lebedev (1946) as full, ¾

full, ½ full, ¼ full, and empty. Stomachs were classified as heavily fed (full and ¾ full), moderately fed (½ full and ¼ full) and poorly fed (empty) following the method used by Raje (2006). The data were used to calculate the monthly Feeding Index and Fullness Index to determine the percentage of feeding intensity. The Feeding Index and Fullness Index were measured using the following equation:

$$\text{Feeding Index} = \frac{P}{X \times N} \times 100$$

where, P= Total points allotted; X= point allotted to a full gut; N= Number of guts observed

$$\text{Fullness Index} = \frac{\text{Number of guts with same degree of fullness}}{\text{Total number of gut examined}} \times 100$$

Gut Content Analysis

Gut content analysis was done for examining seasonal variation in diet components. The volumetric and occurrence methods were used for gut content analysis.

a) *Occurrence method*: In this method, the number of guts containing a particular item of food was expressed as a percentage of the total number of gut examined (Hynes 1950).

b) *Volumetric method*: The content of each sample was taken as a unit and various items are expressed as % volume by eye inspection (Pillay 1952). The content of each gut was vigorously shaken with distilled water and then a drop of the content was examined under microscope. The area occupied by each food item was estimated arbitrarily.

Index of Preponderance

For evaluating the importance of all food items, the 'index of preponderance' method was employed (Natarajan and Jhingran 1961).

$$Ii = \frac{Vi\ Oi \times 100}{\Sigma Vi\ Oi}$$

Where, Ii = Index of preponderance; Vi = Volume of the particular food item; Oi = Occurrence of the particular food item

RESULTS AND DISCUSSION

Structure of Mouth Parts:

The mouth of *Aborichthys kempi* is small and inferior with thick, fleshy and papillae lips (Figure 2). Upper lip is continuous but lower lip is interrupted in the middle. The lips are not fringed. There are three pairs of barbels, two pairs of maxillary and one pair roastral barbel. The two pairs of barbels are present at the dorsal and the other pair at the ventral part of mouth. The ventrally placed mouth and the development of fleshy sensory lips naturally help the bottom feeding habit of the fish. The location of mouth and the structure of mouth parts vary with the nature of feeding habit in fishes.

Structure of Alimentary Canal:

The alimentary canal starts from a short oesophagus followed by a prominent stomach and a relatively shorter intestine with respect to body length. Intestine is rather uncoiled and close to the surface wall of the stomach (Figure 3). The short length of alimentary canal and the presence of prominent stomach support the character of carnivorous feeding habit.

Structure of Gill Rakers:

The number of gill rakers ranges from 10 to 12 (Figure 4.). The widely spaced and short gill rakers of this species suggest a secondary modification for retention of insect, insect larvae and worm, whereas particles of inorganic matter, such as sand, are rejected. The structure and spacing of gill rakers in fish determines the size of food particles trapped, and correlates with feeding behaviour.

Relative Length of the Gut (RLG)

The RLG ranged from 0.30 to 0.75 with a mean of 0.56±0.09. Mean RLG was highest (0.68±0.05) in the length group of 0-50 mm and the lowest (0.47±0.07) in the length group of more than 100 mm (Table 1). The result shows a significant difference in RLG values along with the different size groups of the species. This shows that the RLG value decreases with the increasing length of the fish indicating the change of feeding habit from omni–carnivorous diet in the early stage to a highly carnivorous in the adult stage. Das and Moitra (1963) reported that the RLG value is generally low in carni-

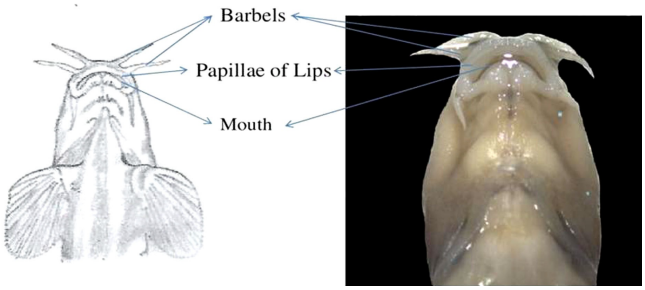

Figure 2. Structure of mouth parts.

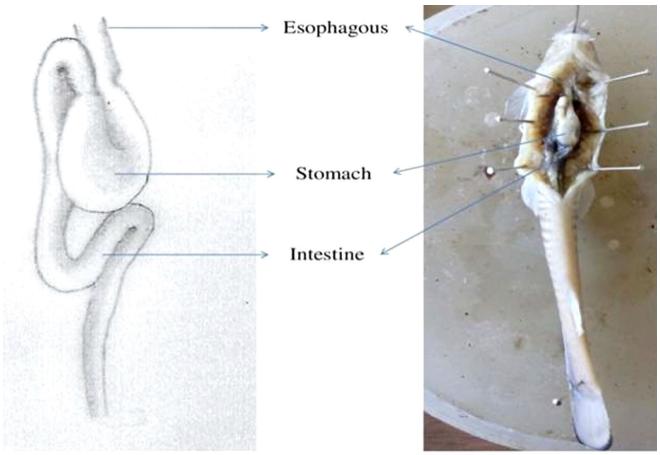

Figure 3. Structure of Alimentary canal.

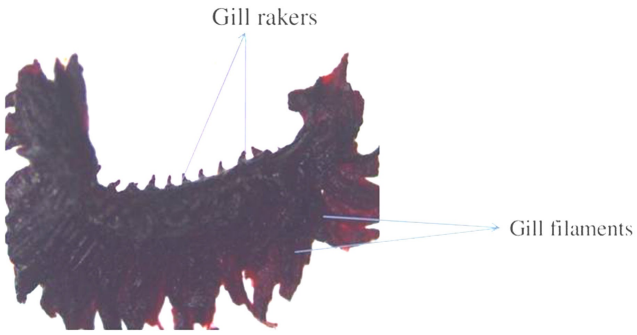

Figure 4. Structure of Gill rakers

vorous fish, higher in omnivorous fish and highest in herbivorous fish. Abujam et al. (2013, 2014) and Dakua (2018) found that the food and feeding habits changes as they grow into adult of freshwater spiny eels and *Esomus danrica* Hamilton 1822.

Table 1. RLG value in various length groups of *A. kempi*

Size group (mm)	RLG value
0-50	0.68 ±0.05
51-100	0.56 ±0.08
101 & above	0.47 ±0.07

Table 2. Monthly average value of Gastrosomatic Index (GaSI)

Month	GaSI
April	2.86 ±1.42
May	2.64 ±1.04
June	2.57 ±0.68
July	2.78 ±1.41
August	2.52 ±1.17
September	2.81 ±1.19
October	3.13 ±1.04
November	3.24 ±1.58
December	3.37 ±1.30
January	3.16 ±1.08
February	3.42 ±1.73
March	3.12 ±1.70

Gastro Somatic Index (GaSI)

The Gastrosomatic index (GaSI) value was highest (3.42±1.73) in February and lowest (2.52 ±1.17) in August (Table 2). GaSI was relatively high from October to March with the peak being in February and indicating active feeding periods. From April onwards the GaSI value declined steadily. The GaSI of fish is generally used as a reflexion of the intensity of feeding (De Silva and Wijeyaratne 1977).

Gut Fullness (Feeding Intensity)

Fishes with highest percentage of full gut was recorded in February and April (25.0% each) and overall feeding intensity with 15.28%; fishes with highest percentage of ¾ full gut observed in December and January (33.33% each) and overall with 25.0%; the highest percentage of ½ full gut observed in May, July, August, November and February (41.67% each) and overall with 33.33% (Table 3). Good feeding activity was observed all through the

seasons. No single fish species with empty gut was found during the study period suggesting that feeding has never been discontinued even during the breeding season. The result is in line with the findings of Abujam et al. (2013, 2014) and Dakua (2018) on the fullness of gut in freshwater spiny eels and *Esomus danrica* Hamilton 1822.

Table 3. Monthly variation of feeding intensities (%) (fullness of gut)

Month	Full gut	¾ Full gut	½ Full gut	¼ Full gut	Empty gut
April	25.0	25.00	16.67	33.33	-
May	8.33	25.00	41.67	25.00	-
June	8.33	25.0	25.00	41.67	-
July	8.33	25.00	41.67	25.00	-
August	16.67	16.67	41.67	25.00	-
September	16.67	25.00	33.33	25.00	-
October	16.67	33.32	33.33	16.67	-
November	16.67	16.67	41.67	25.0	-
December	8.33	33.33	25.00	33.33	-
January	16.67	33.33	33.33	16.67	-
February	25.0	25.00	41.67	8.33	-
March	16.67	25.00	25.00	33.33	-
Overall	15.28	25.00	33.33	26.39	-

Table 4. Monthly average Feeding Index of *A. Kempi*

Month	Feeding Index
April	60.41
May	56.25
June	52.08
July	54.60
August	56.25
September	58.80
October	62.50
November	56.25
December	60.90
January	63.0
February	66.67
March	66.66

The feeding index was also observed as highest (66.67) in February and that of lowest (52.08) in June (Table 4). The increasing trend of feeding index was observed from December onwards upto March while, it declined from April onwards upto September. The maximum feeding index were recorded from December to April which implies the basic food items were highest during these months, while during monsoon (May to July) the feeding index was low which shows the amount of basic food items were less encountered.

Gut Content Analysis

The food types which were observed during the gut content analysis of *A. kempi* have been broadly grouped into six categories namely: zooplankton, phytoplankton, insect larvae and insect parts, semi-digested parts, debris and unidentified species. The results of monthly analysis of gut content following percentage of occurrence method and volumetric method are given in Table 5 and Table 6. Insect larvae and insect parts were found to be the most abundant group and were observed regularly in the gut contents throughout the study period with an average 25.23% according to the percentage of occurrence method (Table 5). The highest average percentage of Insect larva and insect parts was observed during post-monsoon with maximum percentage recorded in December (29.41% of the total food content). The lowest average percentage was observed during monsoon with lowest percentage in June (20.83% of the total food content). Insect larvae belonging to orders Diptera, Trichoptera, Coleoptera, Plecoptera, Anisoptera and Ephemeroptera were observed during the analysis of gut content. The Chironomus (order Diptera) was the dominant genus among the insect larvae. The overall average percentage of occurrence food was that of semi-digested parts (24.71% of the total food content) followed by debris (23.85%); phytoplankton (17.20%) and unidentified species (5.61%). The lowest average percentage of occurrence food was that of the zooplankton with 2.97% of the total food content.

The percentage of occurrence of zooplankton was highest (13.04%) in January and lowest (4.76%) in July (Table 5). The zooplankton were absent in the months of April, May, August, September, October, November, December and March. The percentage of occurrence of phytoplankton was highest (22.73%) in April and lowest (11.77%) in December. The highest percentage of occurrence of insect larvae & insect parts, semi-digested parts and debris (29.41%) were recorded in December (29.41% each) and lowest (20.83% each) in June. The highest percentage of occurrence of unidentified species were recorded highest (12.50%) in June and lowest (4.35%) in January. The unidentified species were not found during November and December.

The results of the volumetric method revealed that insect larva and insect parts occupied the highest average

Table 5. Monthly variation in composition of different food items following percentage of occurrence method

Month	Zooplankton	Phytoplankton	Insect larvae & insect parts	Semi-digested parts	Debris	Unidentified species
April	-	22.73	22.73	22.73	22.73	9.09
May	-	19.05	23.81	23.81	23.81	9.52
June	8.33	16.67	20.83	20.83	20.83	12.50
July	4.76	19.05	23.81	23.81	23.81	4.76
August	-	15.78	26.32	26.32	26.32	5.26
September	-	12.50	31.25	25.00	25.00	6.25
October	-	15.78	26.32	26.32	26.32	5.26
November	-	20.00	25.00	25.00	25.00	-
December	-	11.77	29.41	29.41	29.41	-
January	13.04	17.39	21.74	21.74	21.74	4.35
February	9.52	19.05	23.81	23.81	19.05	4.76
March	-	16.67	27.78	27.78	22.22	5.55
Total Average	2.97	17.20	25.23	24.71	23.85	5.61

Table 6. Monthly variation in composition of different food items following percentage of volumetric method

Month	Zooplankton	Phytoplankton	Insect larvae & insect parts	Semi-digested parts	Debris	Unidentified species
April	-	31.90	46.91	13.01	7.46	0.41
May	-	13.89	40.95	28.80	15.86	0.50
June	0.41	40.26	28.89	22.94	6.33	1.16
July	0.18	28.92	42.04	17.30	11.20	0.37
August,	-	17.60	52.73	18.11	11.06	0.49
September	-	17.32	58.58	7.70	15.82	0.59
October	-	21.31	42.02	23.99	12.30	0.36
November	0.26	19.01	28.92	35.75	16.06	-
December	-	6.63	44.20	42.34	6.83	-
January	1.34	13.97	41.52	34.58	7.57	1.00
February	0.37	17.69	31.21	44.08	5.83	0.32
March	-	22.99	29.04	39.01	7.67	1.29
Total Average	0.20	20.96	40.58	27.30	10.33	0.54

percentage with 40.58% (Table 6) and followed by unidentified species (0.54%), debris (10.33%), phytoplankton (20.96%) and semi-digested parts (27.3%). The highest percentage of insect larvae & insect parts was observed in September (58.58%) and lowest in June (28.89%). The lowest percentage of volume was occupied by zooplankton (0.20%).

Index of Preponderance (IP)

Indices of preponderance revealed the most preferred food items of *A. kempi* as insect larvae (Table 7) and insect parts which constitute 44.33% followed by semi-digested parts of insects (29.21%), Phytoplankton (15.62%), debris (10.67%), unidentified species (0.14%) and zooplankton (0.03%).

The gut content analysis has represented insect larvae and insect parts as the most dominant food group and this result is also supported by the index of preponderance value (44.33%). The dominant insect larvae have identified from order Diptera, Trichoptera and Ephemeroptera. Among them, Diptera was the dominant group. The Chironomus larva (Diptera) was observed predominantly in the gut of this fish species.

Table 7. Index of Preponderance (IP) of food items in the gut content of *A. kempi*

Food items	Index of Occurrence (Oi)	Index of Volume (Vi)	Oi Vi	IP	Grade
Zooplankton	3.01	0.21	0.63	0.03	VI
Phytoplankton	17.20	20.96	360.51	15.62	III
Insect larvae &Insect parts	25.23	40.58	1023.83	44.33	I
Semi-digested parts	24.71	27.30	674.58	29.21	II
Debris	23.85	10.33	246.37	10.67	IV
Unidentified species	5.99	0.54	3.23	0.14	V

Semi-digested food materials have been observed to occupy the gut content as second dominant group after insect larva and parts with index of preponderance value of 29.21%. The phytoplankton occupied the third place with index of preponderance value of 15.62%. Chlorophyceae and Bacillariophyceae have been observed as dominant ingredients of phytoplankton group. Debris also occupied considerable amount of gut content with index of preponderance value of 10.67%. Unidentified species and Zooplankton were observed with index of preponderance value of 0.14% and 0.03% respectively. Thus the index of preponderance values represented omni-carnivorous type of feeding habits of *A. kempi*. This is also supported by high percentage of insect diets in food composition and low RLG value in adult of *A. kempi.* On the other hand, due to the limited literature sources it might also be possible that phyto-fragments entered the gut of this species while engulfing large insect lavae as suggested by Ganguly (2016).

CONCLUSION

From the above investigation, short alimentary canal with distinct stomach and structure of gill rakers suggested the feeding characters of carnivorous or omnivorous fishes. The present study revealed that the structure of alimentary canal, gill rakers and food preferences of *A. kempi* is related to carnivore species. Further, mean RLG value was found to be maximum in the lower length group and minimum in the higher length group. RLG value falls on the scale of carnivorous nature of feeding habit. Gastro-somatic Index (GaSI) was highest during post monsson and winter seasons and lowest during monsoon (breeding phase). It was also revealed from GaSI analysis that the basic food items were highest in the gut during winter. The result of monthly variation shows that the feeding index was correlated with GaSI values. The results shows insect diets as the dominant food items which indicates the highly carnivorous nature of feeding. But the presence of phytoplankton all through the year indicates the omni-carnivorous feeding habits of this fish species. At the same time the presence of sufficient number of phyto-fragments in their diet suggests the nature of feeding as omnivorous. There are also variations in the percentage composition of different items of food in the gut in different months. Index of Preponderance of various food compositions in the gut of *A. kempi* indicated that insect larvae and parts were the most dominant food item in the gut, followed by semi-digested insect materials, phytoplankton, debris, unidentified species and zoo-plankton. The gut content analysis revealed that no distinct variation in food intake of the species at different life stages was observed. Therefore, it is concluded that *A. kempi* is an omnivore and the feeding habit is highly carnivorous in nature. There is slightly a variation in food and feeding habits from month to month.

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Author contributions: First author (OE) collected all the data as part of her PhD program. Second Author (SA) compiled the data and drafted the manuscript, and DND revised the manuscript.

Conflict of interest: We declare that there is no conflict of interest at all.

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