J. Exp. Zool. India Vol. 15, No. 2, pp. 395-402, 2012 *ISSN 0972-0030*

FOOD AND FEEDING HABITS OF THREATENED *NOTOPTERUS NOTOPTERUS* IN GOMTI RIVER, LUCKNOW (INDIA)

S. M. Srivastava, S. P. Singh* and A. K. Pandey

National Bureau of Fish Genetic Resources, Canal Ring Road, Lucknow - 226 002, India
* Department of Zoology, Government Post-Graduate College, Satna - 485 001, India
e mail : srivastava.sm@rediffmail.com

(Accepted 7 May 2012)

ABSTRACT : Food of the threatened *Notoperus notopterus* in Gomti river, Lucknow consisted mainly of shrimps, teleosts, insects and their larvae followed by items of lesser importance like plant matter, organic detritus and fish scales and diatoms, the percent composition of which varied during pre-monsoon, monsoon and post-monsoon period. An unusual feature observed was the occurrence of pebbles in stomach of 70% fish examined. When fluctuation in feeding activity of all the age groups viewed together, December recorded the maximum feeding while lower temperature of January appears to retard the rate of digestion, thereby declining appetite of the fish ultimately reducing food intake. The moderate temperature of February-April improves feeding, onset of breeding season (May-July) reduced it while the spent fishes resorted to vigorous feeding in the subsequent months which was reflected in constantly increasing gastrosomatic index value.

Key words : Food, feeding, gastro-somatic index, index of preponderance, threatened, *Notoperus notopterus*, river Gomti.

INTRODUCTION

Study of food and feeding habits of fish is of considerable importance in fishery biology as it facilitates understanding of the causative aspects of biology of the fish such as growth, geographical distribution and migration. Certain fisheries can even be forecasted by the appearance of particular food organism which forms the principal food of that species in the environment (Balan, 1984). Food and feeding habits of fishes, particularly from riverine ecosystem, deserve considerable importance in India (Fortunotova, 1961; Das and Moitra, 1963; Lagler *et al*, 1977; Jhingran, 1991; Khanna, 2006). Nikolskii (1963) realized the importance of food study and remarked that deterioration in food resources might lead to reduced food consumption resulting in deceleration of growth rate, emaciation, delayed sexual maturity, changes in food spectrum and reduction in fish stock and an increase in the range of morphological variability of the species.

Fishes are also known to change the food habits as they grow, accompanied by correlative changes in the digestive system (Al-Hussaini, 1946; Islam, 1951; Kapoor, 1953; Das and Moitra, 1956; Agarwal and Mahajan, 1966; Lagler *et al*, 1977). For example, in most fishes the alimentary canal, after hatching or birth, is but a simple tube. However, after the absorption of yolk, when external feeding starts, the tube rapidly metamorphoses and within a few weeks the larvae develop the alimentary canal which they retain throughout their life. The fish larvae are in general planktophagous but, after a few weeks, they switch over to the feeding habits of the adult fish. Another remarkable feature regarding feeding is of its seasonal variations in selection of food and intensity of feeding. The former is linked with the availability of the food in the biotope. Due to this, different dietary patterns of the same fish from various habitats have been reported in the scientific literature. For instance, Amanov (1972) reported different types of feeding of the Turkestan gudgeon from four different water bodies of the Surknandarya basin. Similarly, diverse opinions have been expressed on the feeding variation of *Puntius sarana* from different Indian waters (Das and Moitra, 1955; Chitray, 1965; Sinha, 1972). Contrary to above, some fishes, inhabiting different geographical locations, subsist more or less on identical food (Sarojini, 1954; Rangaswami, 1973). An attempt has been made to study the food and feeding habits in relation with seasonal food preferences, intensity of feeding and fluctuation in diet of the threatened bronze featherback, *Notopterus notopterus* of Gomti river, Lucknow for rational management and sustainable fishery.

MATERIALS AND METHODS

There is great variation in the methods of analysis of food contents of fishes. Generally, the food items have been examined on two counts qualitative and quantitative. The qualitative analysis encompasses merely the listing of the organisms in the gut contents but fails to provide any idea of relative importance of the items of diet or their seasonal fluctuations. On the other hand, quantitative

analysis gives considerable information on the above subjects. It is divisible into three types - numerical (occurrence, dominance and number method), gravimetric and volumetric (eye-estimation, points volumetric, displacement method). In several studies various combinations of the two or more methods have been employed. A few investigators have prepared indices of food preponderance by taking into consideration the composite effect of more than one method in order to neutralize the shortcomings of the either (Hynes, 1950; Pillay, 1952, Izuka *et al,* 1954; Natarajan and Jhingran, 1961; Ricker, 1968).

In the present study, *Notopterus notopterus* (Pallas) were procured weekly from Daliganj and Khadra stations (Lucknow) of river Gomti depending on their availability during January 2009-December 2010). 250 fishes ranging from 166 to 330 mm (TL) were examined in the laboratory for stomach analysis. For racial studies, samples of *N. notopterus* from the river Gomti at Lucknow were collected. Efforts were made to collect the samples from both the sites through different seasons (winter, summer and monsoon) as to allow any variations in the characters which might occur.

The preserved fish specimens, brought to the laboratory, were used for food preference studies. At the time of analysis, the whole alimentary canal was carefully removed by dissecting the fish and its length recorded. The stomach was removed from fishes and preserved in 5% formaldehyde. Prior to preservation of the stomachs, their weights were recorded. At the time of food analysis, the stomachs were cut open and their contents were emptied in a petridish. The percentage volume of major gut items was estimated by using the point method of Pillay (1952) whereas contents of each stomach samples were as unity and the items were expressed as percentage volume by visual inspection. The percentage occurrence of food item was analyzed by the method of Hynes (1950). To estimate the dominant food items, results of the percentage occurrence and point method were combined to yield the index of preponderance (I_i) proposed by Natrajan and Jhingran (1961): $I_i = V_iO_i / (\acute{O}V_iO_i) \times 100$, where V_i = volume of the particular food items, O_i = occurrence of the particular food items, I_i = relative abundance of food items (mean %).

Feeding activity was expressed as feeding index ascertained in the percentage of fullness of stomach. Feeding Index = P x 100/ X x N, where P = total point of the gut that were examined, N= number of guts examined, X= total points allotted to the full gut. The food items collected from full guts of live fishes were used for counting food components. The gastrosomatic index (GSI) was determined as the ratio of the gut weight to the body weight.

GSI = GW x 100/ BW

where GW= gut weight in gm, BW= body weight in gm

Seasonal sampling were carried out and samples were collected accordingly during pre-monsoon (February-May), monsoon (June-September) and post-monsoon (October-January) for measuring GSI of fish. The above index has been widely used in the past by several workers to demonstrate and compare the interspecific and intraspecific feeding intensities on account of the seasonal fluctuations in food of the water body (Jhingran, 1961; Bhatnagar and Karamchandani, 1970).

RESULTS AND DISCUSSION

The alimentary canal of *N. notopterus* is short, muscular, bag - shaped and somewhat less coiled. As shown in Fig. 1-3, the preferred diets were crustaceans, insects, molluscs, minnows and fishes. Although there were some differences in the diet composition of *N. notopterus* among length groups studied, some level of variations between different populations of the different food items were also observed. The presence of detritus and molluscan remains in the gut also indicated a possible benthic feeding activity of *N. notopterus*. Mud and sand particles were encountered sporadically in the gut contents. Overall, the diet preferences of *N. notopterus* from different population were similar to those of air-breathing fishes.

Alimentary canal of *N. notopterus* is a short tube occupying 60% of the total length of the fish as in *Setipinna phasa, Clarias batrachus* and *Mystus aor.* Oesophagus is a short muscular tube, the posterior of which leads into a sac-like muscular stomach. Cardiac and pyloric ends of the stomach are narrow while the middle part is very wide, meant for storage and digestion of the food. Stomach is capable of distension to a fairly large extent for lodging big prey. Just behind the pylorus stomach, two finger-like pyloric caecae are present which have been reported by Rahimullah (1935, 1945), Khanna (1961) and Das and Nath (1965). From the pylorus comes out the intestine which has a wider anterior portion than the rest of it. The last portion of the intestine is designated as rectum and not externally demarcated as in most of the other fishes except *Silonia silondia* where it is well marked (Khanna, 1961). The rectum bears well-developed finger-like process named rectal caecum which is usually lacking in other teleosts.

Stomach, oesophagus and rectal caecum of *Notopterus notopterus* are characterized by the presence

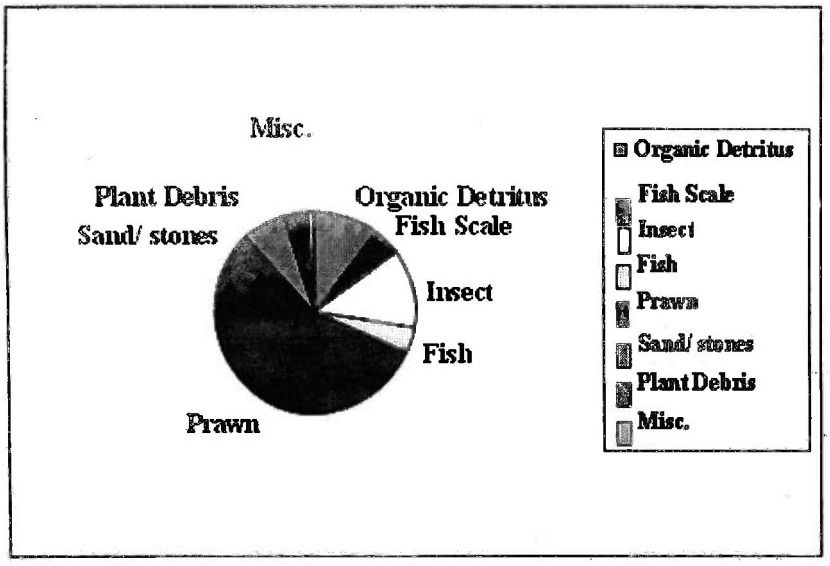

Fig. 1: Pre-monsoon variation of food spectrum of *N. notopterus*.

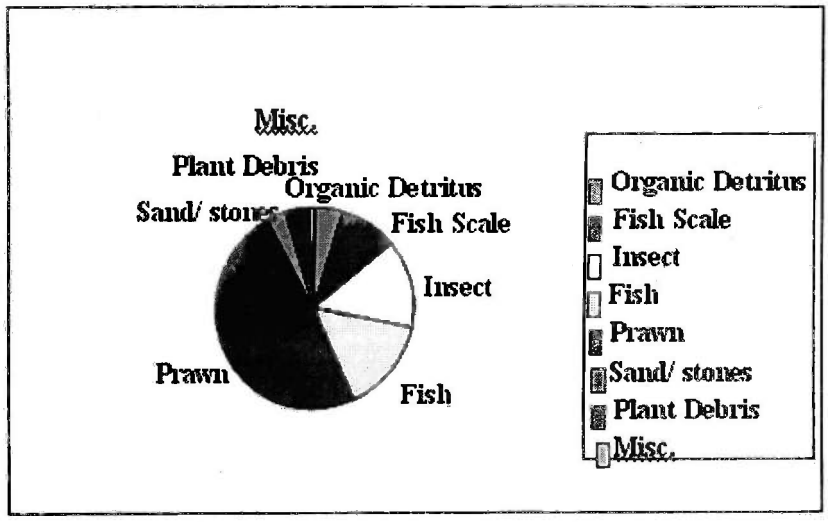

Fig. 2: Variation of food spectrum of *N. notopterus* during monsoon.

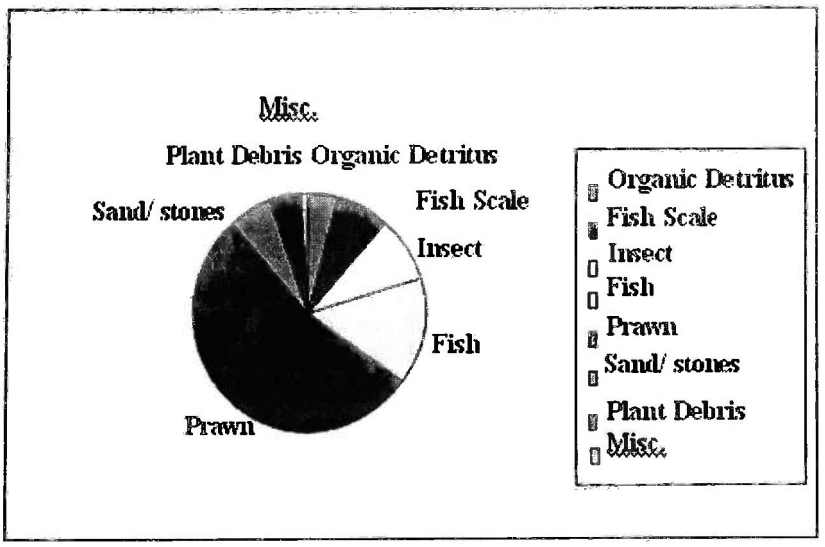

Fig. 3: Post-monsoon variation in food spectrum of *N. notopterus*.

of longitudinal fold internally, similar to those in other carnivorous fishes. However, inside the pyloric caeca and intestine, the folds are arranged transversally. Liver is a bilobed gland as found in *Puntius sarana* and *Silonia silondia* but it is not further subdivided as in *Mystus aor*. The right lobe of the liver is larger than the left one. Gall bladder is somewhat elliptical and gives off a short bile duct which opens into the intestine a little farther than pylorus. Spleen lies beneath the stomach. Pancreas is a diffused structure dispersed in the adipose tissues of the pyloric caeca similar to the other fishes.

Composition of Gut Contents

Food of the threatened *Notoperus notopterus* in river Gomti, Lucknow (India) consisted mainly of shrimps, teleosts, insects and their larvae followed by items of lesser importance like plant matter, organic detritus and fish scales and diatoms, the percent composition of which varied during pre-monsoon, monsoon and post-monsoon period. An unusual feature observed was the occurrence of pebbles in stomach of 70% fish examined. When fluctuation in feeding activity of all the age groups is viewed together, December recorded the maximum feeding while lower temperature of January retarded the rate of digestion, thereby declining the appetite of the fish and ultimately reducing the food intake. The moderate temperature of February-April improves the feeding, the onset of breeding season (May-July) reduced it while the spent fishes resorted to vigorous feeding in the subsequent months which is reflected in constantly increasing gastrosomatic index value. The percentage of various food elements was determined by volumetric as well as by frequency of occurrence methods. The index preponderance (I_1), derived statistically by grading the values obtained by the above mentioned methods is summarized in Table 1 and depicted in Fig. 1-3.

Prawns

Prawns were represented by

Macrobrachium spp. which constituted the main food items of the featherback. A definite cyclic trend in the fluctuation of this food element was observed. For example, prawns were abundantly encountered (by volume) in monsoon months (64.99%) being maximum in September (89.66%) followed by October (85.00%). They were less abundant in summer months attaining a maximum (56.25%) in April, followed by June (47.18%). More or less similar trend was observed by using frequency of occurrence method to the data. The I_i value of this food item was estimated at 41.67 for the above mentioned seasons. Surprisingly, prawns were completely absent from the fish diet in winter months. This food was observed 35.5% of the total stomachs examined. Smaller maxima were noticed in April and June when the average percentage were 56.25 and 47.15 by bulk, the average I_i being 68.96 and 63.10, respectively. The maximum number of prawns encountered in a single fish (340 mm TL) stomach was 3, and the length of the largest prawn recorded was 45 mm. The berried prawns were observed in summer and monsoon months indicating the extremities of the breeding period of prawns. Generally, prawns were recorded in undamaged condition from the stomach of fish suggesting devouring of this item without being subjected to mastication.

Fishes

Of the freshwater teleosts, a number of carp-minnows and weed fishes *viz. Puntius* spp., *Amblypharyngodon mola, Esomus danrica, Ambassis* spp. and *Glossogobius giuris* were observed in the stomach of *N. notopterus*. The presence of whole and semi-digested fishes inside stomach indicated direct swallowing of prey as in the case of prawns. The largest minnow (*P. sophore*), measuring 60 mm TL, was observed lying folded inside the stomach of *N. notopterus* measuring 330 mm in TL. This food items occupied second place in order of abundance among stomach inclusions. On an average, it formed 26.95% by volume and 12.88% by occurrence, the I_i being 23.65. The maximum abundance was recorded in winter, perhaps due to non-availability of the most preferred food item (prawns) to the fish in these months which amounted to 56.13% and 23.74% by bulk and occurrence, respectively, the I_i being 60.95. A declining trend in the intake of this food item was observed in monsoon when it constituted 9.73% by volume and 7.71 % by occurrence, the I_i value was 3.5. This food item was completely missing from the diet in September. In summer, the value of this food item ranged from 3.88-23.33%, being minimum in March and maximum in May. The I_i recorded for the above period ranged from 1.00-13.38. The maximal intake for this food stuff for a single month was observed in November (72.50%) and minimal in October (0.69%). On an average, this component of food occurred in 30.83% of the total number of specimens examined throughout the period of study.

Insects

In order to know the relative importance of aquatic insects and their larvae in the diet of *N. notopterus*, the analysis of the above two items was conducted separately. Most of the insects found in the stomachs were badly mutilated and could be identified through their exoskeleton and appendages only. This rendered them beyond the scope of identification to generic level. However, a few Coleoptera, represented by *Dytiscus* spp. and *Gyrinus* spp., found in good condition, could be identified. This group occurred regularly in stomach except in monsoon. The maximum abundance was observed in summer

Table 1: Index of preponderance of food items of *N. notopterus* in Gomti.

Food Items	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct.	Nov.	Dec.
I_i	I_i	I_i	I_i	I_i	I_i	I_i	I_i	I_i	I_i	I_i	I_i	
Fish	63.52	28.09	1.00	10.21	13.38	6.68	5.79	11.78	—	0.12	84.88	74.18
Prawn	—	—	1.70	68.96	39.17	63.10	73.63	50.70	92.66	86.01	—	—
Insect	15.83	48.06	80.58	10.20	17.36	16.37	1.93	—	—	1.65	11.18	8.29
Plant Debris	4.96	10.19	4.28	1.91	9.53	0.37	17.84	15.35	3.04	10.83	—	4.68
Sand / stone	9.01	10.19	8.16	10.21	18.95	11.84	0.81	22.17	1.72	1.20	3.94	8.87
Organic Detritus	6.68	3.47	4.28	0.77	1.38	—	—	—	2.58	—	—	3.98
Misc.	—	—	—	0.54	0.22	1.64	—	—	—	0.19	—	—
Total	100	100	100	100	100	100	100	100	100	100	100	100

months being on an average 18.17% by volume and 17.71% by occurrence, the I_i being 18.49. Among summer months, the ingestion of this food item was maximum in March followed by June, May and April in order of abundance. While in winter, it occurred regularly but constituted a lower percentage, ranging form 5.00% in January to 30.00% in February by volume and 5.88-18.80% by occurrence. The I_i ranged form 1.36 to 32.72 for the same period. On an average, insects constituted 11.27% by volume and 9.98% by occurrence, their I being 10.27.

Insect larvae

This group consisted mainly of Coleoptera and Diptera represented by *Cybister* spp. and *Tendipes* spp., respectively. The largest larva recorded was 30 mm in length and as many as 3 larvae were recorded form a fish stomach at a time. These larvae occurred in various percentage throughout the year except August and September. The maximal value was obtained in March when they amounted to 37.00 and the minimum in April (3.12%). Not much variation in average percentage of this food item was found in summer and winter when it occurred 11.55% by volume in the former and 13.62% in the latter months. However, in monsoon months, contribution of this group was comparatively lower being on an average 9.73% by bulk and 3.75% by volume. The I_i values calculated for winter, summer and monsoon months were found to be 15.84, 13.62 and 4.02, respectively. The insect larvae occurred in 33.34% stomachs out of the total fishes examined indicating the importance of this items as food for *Notopterus notopterus*.

Plant matter

This group comprised unidentified plant matter and occurred regularly in the stomach of the fishes though, comparatively in smaller quantities (average: 6.5% by bulk and 16.7% by occurrence), next to the insects and their larvae. This food constituent was observed more abundant in monsoon months being 9.4% by volume and 25.57% by occurrence. In summer and winter months, percentage of this food item was reduced to about half of that recorded for monsoon months.

Decayed organic matter

Small quantities of this item were regularly encountered in the stomach inclusions of the featherback, except in November, July and August when complete omission of this item from fish stomach was observed. The maximum abundance of this food items by volume was observed in October (17.07%) followed by December (5.45%). In other months, it varied by bulk on an average, from 2.92% in winter to 2.22% in summer. The I_i values were computed for the above period as 2.01, 2.22 and 10.82, respectively. Plant matter occurred in 40.83% of the stomach examined. A definite seasonal fluctuation was observed in the intake of this food item being maximum in monsoon.

Pebbles

As a matter of fact, this should not be included among food items as these are not subjected to the digestive process and are, therefore, of no caloric value to the fish. These might have been picked up from the bottom by the fish while actively feeding on other food items. These were found regularly in all the seasons but their highest concentration was observed in summer (10.46%) followed by monsoon (6.26%) and winter (5.23%). Pebbles were encountered in 70% of the fishes examined.

Miscellaneous food items

In this group, food items like scales of fishes and diatoms, which were occasionally picked up while feeding on other organisms on the bottom, are included. The fish scales occurred only in summer months being maximum in June (7.02%) and minimum in May (0.60%) by volume. Among diatoms, only *Melosira* spp. was encountered in negligible quantity (1.07%) in October. Judging by their occasional appearance, these items come under the category of accidental food.

Pooled monthly gastro-somatic index (GSI)

However, the other winter months (November, January and February) were characterized by low feeding intensities, particularly January when the GSI slumped to lowest value of 0.74. The average for the winter seasons was computed to be 1.138. The initiation of summer months accelerated the pace of the feeding activity as evident by higher GSI (1.29) in March, though highest value was attained in April (1.50). After attaining the peak, a fall was observed in subsequent months of May and June. The latter recorded the lowest value of the summer seasons (0.76) which was slightly higher than the lowest recorded values of winter. On an average, the GSI for summer season was recorded to be 1.236 which is again slightly higher than that of the winter season. The highest value of GSI of threatened *N. notopterus* was recorded for age-group I followed by age groups III and IV. The age groups II and V recorded comparatively lower values of GSI being 1.01 for the former and 0.95 for the latter. This indicates that immature group (156-215 mm) has the highest feeding intensity as compared to other age groups.

Mookherjee and Majumdar (1946), while generalizing the food of adult *N. notopterus* from West Bengal, stated

that adult fish subsists on fish, insect larvae, shrimps, worms, algae and vegetable debris. Describing the food and feeding habits of this species form Tamil Nadu, Menon *et al* (1959) stated that in the adolescent and adult stages, it is primarily a carnivore, feeding on small fishes (*Puntius* spp., *Esomus danrica;* 31.00%) followed by crustaceans. The fish is exclusively planktophagous till it attains about 30 mm in length, thereafter, it gradually switches over to a predominantly shrimp and insect diet (Parameswaran and Sinha, 1966). David *et al* (1969) reported that adult fish (230-354 mm) in Tungabhadra reservoir (Karnataka) fed on plant tissues (5%), prawns (5.5%), insects (43%), fish and fish remains (14.5%) and digested organic matter (14.5%). In the present study when feeding habits of all size groups are considered together, a more or less similar trend is discernible. However, in Loni reservoir the adults of *N. notopterus* (252-297 mm) mainly consumed a carnivorous diet comprising teleosts (40.5%), insects (51.00%), plankton (3.5%) and sand particles (2.6%), plant matter (2.00%) and molluscan shells (0.40%) (Sinha, 1972).

The data on feeding, when split into various age groups, revealed a diet succession with advancing age and length of the species resulting in segregation of two broad groups. The first group, consisting of fishes in age groups III-IV and ranges in total length from 156-314 mm. This group mainly subsists on prawn (53.60%) as primary food followed by insects and their larvae (20.8%), plant matter (6.13%) and fish remains (4.66%) as their secondary, tertiary and occasional food. This is supported by the findings of Parameswaran and Sinha (1966) who after conducting feeding experiments in aquaria, reported preference of the species (247-314 mm) for shrimp diet followed by insects. While the older fishes (age group VI and VII) ranging 315-345 mm in total length preferred minnows (55.80%) over prawns (19.50%) followed by insects and their larvae (10.20%).

Present study clearly indicates a succession in diet related to the age of *N. notopterus*. The older fishes feed on bigger food items like minnows whereas the adolescents feed on prawns and insects (smaller food items) and the fry subsist exclusively on plankters suggesting that fry are mainly surface feeders whereas the adolescents and adults explore all the strata of the water for obtaining their choicest food. This ability of exploring the various strata of water and change in composition of food with age of the fish is a significant adaptation towards increasing the range of food supply by allowing the species as a whole to widen their food spectrum. Jhingran (1973) observed a positive variation in the food components in *Setipinna phasa* with increase in size while Saigal (1964) found different feeding behaviour of fry, juviniles and adults of *Mystus aor.* Patnaik (1971), Prasadam (1971) and Domanevskiy and Stepkina (1972) also recorded similar shift in the food items of *Gerres setifer, Etroplus suratensis* and *Dentax macrophthalmus,* respectively.

The present study revealed that adult *N. notopterus* is a carnivorous consuming 83% food of animal origin. This is further supported by anatomical structures of the organs associated with the digestive system. Thus, the obliquely placed and slightly upturned mouth, prominent lower jaw, a deep cleft reaching the outer rim of the orbit, presence of teeth on vomer, palatine and pterygoid, widely set gill rackers, muscular sac-like and well-developed stomach followed by a short intestine (less than 60% of the TL) are the prominent characters met in carnivorous fishes (Al- Hussaini, 1949; Das and Moitra, 1956).

A definite seasonal rhythm in the intake of various food items is observed in *N. notopterus* like that in *Siluris glanis* (Fortunatova, 1955, 1961) and some other fishes (Kanwal and Pathani, 2012). Nikolskii (1963) stated that the phenomenon of euriphagism is evolved in fishes to counteract the influence of unstable environment and ensuring a continuous supply of food organisms. The present study suggests such is the case in *N. notopterus*. The preponderance of the prawn in the stomach of *N. notopterus* during monsoon and summer months may be ascribed to the fact that their breeding season falls between April and October and as such they come out from their hiding places during these periods. Moreover, they become sluggish during the breeding season, especially the berried females, falling easy prey. This is corroborated by the presence of relatively more number of female prawns in the stomach contents of *N. notopterus*. However, the fast nocturnal movements probably enable the prawns to avoid their predators in winter. This may explain the absence of prawns in the stomach inclusions of *N. notopterus* in winter months. To compensate for this, fish resorts to feeding on minnows during this period which become abundant in Gomti river at both the sites since new recruits of minnows are added to the population by this time. Certain trends in regard to the feeding intensities among various age groups are discernable in the present study. The zero and first age groups experienced subdued feeding in winter and monsoon and active feeding in summer whereas age groups third and fourth resorted to subdued feeding only during monsoon and active feeding during summer and winter.

Most probably, these differences in the feeding intensity have physiological bearing *e.g.* the continuous feeding in the groups is due to their immature condition.

Similar trends have been observed in other fishes too (Nikolskii 1963; Lagler *et al*, 1977). The declined feeding of larger size group in monsoon may probably be caused by attainment of maturity and as soon as the breeding season is over, the fishes once again resort to active feeding. It is on record that many fishes reduce their food intake on the approach of breeding season. Bhimachar and George (1952) stated that progressive maturation of gonads reduced the feeding activity in fishes. Karekar and Bal (1960) also observed the coincidence of peak breeding with low feeding phase in *Polynemous indicus*. Jhingran (1961) observed that feeding intensity in *S. phasa* declined during peak breeding season. According to Natarajan and Jhingaran (1963), low level of feeding coincided with the maturation of *Catla catla*. Desai (1970) found the same holding good for *Tor tor* from river Narmada (Madhya Pradesh).

Furthermore, it is probable that the low temperature of January adversely affects the feeding of the younger age groups while the older groups remain unaffected possibly due to accumulation of fat in their tissues which neutralizes the affect of low temperature. When fluctuation in feeding activity of all the age groups is viewed together, it is revealed that December recorded the maximum feeding while the lower temperature of January retarded the rate of digestion, thereby, declining the appetite of the fish and ultimately reducing the food intake. The moderate temperature of February to April improves the feeding while the onset of breeding season (May-July) reduced it. Spent fishes resorted to vigorous feeding in the subsequent months which is reflected in constantly increasing values of gastrosomatic index.

ACKNOWLEDGEMENTS

We are grateful to the Director, NBFGR (ICAR), Lucknow and the Principal, Government Post-Graduate (Autonomous) College, Satna (Madhya Pradesh) for providing facilities to carry out the present investigation.

REFERENCES

Agarwal V P and Mahajan C L (1966) Studies on the physiology of digestion in *Sisor rabdophorus* Hamilton. *Jap. J. Ichthyol.* **14**, 121-131.

Al-Hussaini A H (1946) The anatomy and histology of the alimentary tract of the bottom feeder, *Mulloiders auriflamma* (Forsic). *J. Morph.* **78**, 151-154.

Al-Hussaini A H (1949) Functional morphology of the alimentary tract of some fish in relation. *J. Morph.* **80**, 251-286.

Amanov A A (1972) Morphology and mode of the life of the Turkestan eudgeon, *Gobio gobio lepidolaesus* (Kessler) *J. Ichthyol.* **12**, 601-607.

Balan V (1984) The Indian oil sardine fishery: a review. *Mar. Fish. Inf. Serv. (CMFRI)* **60**, 1-10 (Nov. - Dec).

Bhatnagar G K and Karamchandani S J (1970) Food and feeding habits of *Labeo fimbriatus* (Bloch) in river Narbada near Hoshangabad (M.P.). *J. Inland Fish. Soc. India* **2**, 30-50.

Bhimachar B S and George P C (1952) Observations on the food and feeding of the Indian mackerel, *Rostrelliger kanagurta* (Cuvier). *Proc. Indian Acad. Sci.* **36B**, 105-118.

Chitray B B (1965) The anatomy and histology of the alimentary canal of *Puntius sarana* (Ham.) with a note of feeding habits. *Ichthylogica* **4**, 53-62.

Das S M and Moitra S K (1955) Studies on the food of some common fishes of Uttar Pradesh, India. 1. The surface feeders, mid-feeders and bottom-feeders. *Proc. Nat. Acad. Sci. India* **25B**, 1-6.

Das S M and Moitra S K (1956) Studies on the food of some common fishes of Uttar Pradesh, India. Part II. *Proc. Nat. Acad. Sci. India* **26B**, 213-223.

Das S M and Moitra S K (1963) Studies on the food and feeding habits of some freshwater fishes of India. 4. A review on the food and feeding habits with general conclusion. *Ichthyologica* **2**, 107-115.

Das S M and Nath S (1965) The comparative anatomy of the alimentary tract and its modification in relation to the food and feeding habits in some fishes of Jammu Province (India). *Ichthyologica* **1**, 63-78.

David A, Ray P, Govind B V, Rajgopal K V and Banerjee R K (1969) *Limnology and Fisheries of the Tungabhadra Reservoir*. Bull. Cent. Inland Fish. Res. Inst., Barrackpore. **13**, 188 p.

Desai V R (1970) Studies on the fishery and biology of *Tor tor* (Hamilton) from river Narbada. I. Food and feeding habits. *J. Inland Fish. Soc. India* **2**, 101-111.

Domanevskiy L N and Stepkina M V (1971) Features of the biology of *Dentax macrophthalmus* (Bloch) in the Eastern Atlantic. *J. Ichthyol.* **11**, 346-353.

Fortunatova K R (1955) Methods of studying the feeding of predatory fishes. *Tr. Sov. Ikhtiol. Kom. Acad. Nauk* SSR **6**, 62-84.

Fortunatova K R (1961) Availability of sticklebacks as food for the predaceous fishes of the Volga Delta. *Fish. Res. Bd. Can. Bull.* No. **331**, 16 p.

Hynes H B N (1950) The food of fresh water sticklebacks, *Gasterosteus aculeatus, Pygosteus pungitius* with a review of methods used in studies of the food of fishes. *J. Anim. Ecol.* **19**, 36-58.

Islam A-U (1951) The comparative histology of the alimentary canal of certain freshwater teleost fishes. *Proc. Indian Acad. Sci* **30**, 297-321.

Iizuka A, Kurohagi, T, Ikuta K and Imai S (1954) Composition of the food of Alaska pollack (*Theragrachal congramma)* in Hokkaido, with special reference to its local differences. *Bull. Hokkaido. Res. Lab.* **2**, 7-20.

Jhingran A G (1961) Studies on the maturity and fecundity of the Gangetic anchovy, *Setipinna phasa* (Ham.). *Indian J. Fish.* **8**, 291-310.

Jhingran A G (1973) Diet succession in relation to advancing length of *Setipinna phasa* (Hamilton) from the Ganga river system. J. *Inland Fish. Soc. India* **5**, 55-70.

Jhingran, V G (1991) *Fish and Fisheries of India*. Hindustan Pub. Co., New Delhi.

Kanwal B P S and Pathani S S (2012) Food and feeding habits of a hill-

stream fish, *Garra lamta* (Hamilton-Buchanan) in some tributaries of Suyal river, Kumaun Himalaya, Uttarakhand. *Int. J. Food Nutr. Sci.* **1**, 16-22.

Kapoor B G (1953) The anatomy and histology of the alimentary tract in relation to feeding habits of a silurid fish, *Wallago attu* (Bloch & Schinder). *J. Zool. Soc. India* **5**, 195-210.

Karekar P S and Bal D V (1960) A study on the maturity and spawning of *Polydactylus indicus* (Shaw). *Indian J. Fish.* 7, 147-64.

Khanna S S (1961) The alimentary canal in some teleost fishes. *J. Zool. Soc. India* **13**, 206-219.

Khanna S S (2006) *An Introduction to Fishes.* 5th edn. Silverline Publications, Faridabad.

Lagler K F, Bardach J E, Miller R R and Passino D R M (1977) *Ichthyology: The Study of Fishes.* John Wiley & Sons, New York, London & Sydney.

Menon M D, Sreenivasan R and Krishnamurthi B (1959) *Report to the Indian Council of Agricultural Research on the Madras Rural Piscicultural Scheme Worked from 1st July, 1942 to 31 March, 1952.* Govt. Press, Madras: 171 p.

Mookherjee H K and Majumdar S R (1946) On the life - history of *Labeo calbasu* Ham.) *Jour. Dept. Sci. Calcutta. Univ.* **2**, 1-22.

Natarajan A V and Jhingran A G (1961) Index of preponderance- a method of grading the food elements in the stomach analysis of fishes. *Indian J. Fish.* **8**, 54-59.

Natarajan A V and Jhingran A G (1963) On the biology of *Catla catla* (Ham.) from the river Jamuna. *Proc. Nat. Acad. Sci. India* **29B**, 326-355.

Nikolskii G V (1963) *The Ecology of Fishes.* Academic Press, London & New York: 350 p.

Pathak S C (1975) Length-weight relationship, condition factor and food study of *Labeo calbasu* (Ham.) from Loni reservoir (M.P.). *J. Inland Fish. Soc. India* **7**, 58-64.

Parameswaran S and Sinha M (1966) Observations on the biology of the featherback, *Notopterus notopterus* (Pallas). *Indian J. Fish.* **13**, 232-250.

Patnaik S (1971) Observations on the fishery and biology of Chilka Jagili, *Gerres setifer* (Hamilton). *J. Inland Fish. Soc. India* **3**, 25-43.

Pillay T V R (1952) A critique of the methods of the study of food of fishes. *J. Zool. Soc. India* **4**, 185-200.

Prasadam R D (1971) Observations on the biology of the pearlspot, *Etroplus suratensis* (Bloch) from the Pulicat Lake, Madras. *J. Inland Fish. Soc. India* **3**, 72-78.

Rahimullah M (1935) On the pyloric caecae of the family Notopteridae, *Proc. Indian Sci. Congr.* p. 25.

Rahimullah M (1945) A comparative study on biology, histology and probable function of the pyloric caeca in Indian fishes together with a discussion on their homology. *Proc. Indian Acad. Sci.* **21B**, 1-37.

Rangaswamy C P (1973) Studies on the growth and food habits of grey mullet, *Mugil cephalus* Linn. of the Lake Pulicat. *J. Inland Fish. Soc. India* **4**, 9-22.

Ricker W E (1968) *Methods for Assessment of Fish Production in Freshwaters.* IBP Handbook

Saigal B N (1964) Studies on the fishery and biology of the commercial catfishes of the Ganga river system. II. Maturity, spawning and food of *Mystus (Osteobagrus) aor* (Ham.). *Indian J. Fish.* **2**, 1-44.

Sarojini K K (1954) The food and feeding habits of the grey mullets, *Mugil parsia* and *M. speigleri* Bleek. *Indian J. Fish.* **1**, 67-93.

Sinha M (1972) Observations on the biology of *Puntius sarana* (Hamilton) of Loni reservoir (M.P): length-weight relationship, food and condition factor. *J. Inland. Fish. Soc. India* **4**, 122-131.