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Food and Feeding Habits and Physiology of Digestion in Certain Riverine Teleosts

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Two important food fishes, *Rhinomugil corsula* and *Silonia silondia*, were collected from Chambal river (Rampura) to study their food and feeding habits and *p*H and digestive enzymes in the different parts of their gastrointestinal tract. The different food constituents which were present in the gut are analysed and discussed. The variations in *p*H and digestive enzymes in the different parts of the gastrointestinal tract of the two fishes, have been mentioned.

Key Words: **Food and feeding habits, Teleosts,** ***Rhinomugil corsula,*** ***Silonia silondia***

Introduction

The knowledge of food of fishes, their feeding behaviour and physiology of digestion is of great importance for the fishery biological investigations. The studies are receiving considerable attention with a view to produce huge crop of healthy fishes. Two important food fishes *Rhinomugil corsula* and *Silonia silondia* have been selected for investigation. The fish *R. corsula* belongs to family Mugilidae and generally called mullet. Several reports on the food of mullets are available in the literature showing varied opinion of workers, such as Gunther (1880), Hornell (1911), Jacot (1920), Kyle (1926), Orton (1926), Hora (1938), Mookerjee et al. (1946), Sarojini (1951), Pillay (1948, 1953), and Agrawal and Bala (1967).

The fish, *S. silondia* belongs to family schilbeidae and is called as catfish. The references on the food of the fishes belonging to schilbeidae are lacking in the literature. However, Bhimachar (1935), Mookerjee and Das (1945), Kapoor (1953), Khanna (1964), Khanna and Pant (1964), and Agrawal and Sharma (1966) have made a passing remark on the food of catfishes, investigated by them. The literature on the *p*H, and digestive enzymes in Indian teleosts is very limited. The work of Rahimullah (1945), Al-Hussaini (1949), Sarbhai (1951), and Agrawal and Tyagi (1963) are noteworthy. In the present study an effort has been made to correlate the nature of the food and digestive enzymes in the gastrointestinal tract of the two food fishes.

Material and Methods

Three hundred specimens each of *R. corsula* ranging from 290–435 mm and *S. silondia*

ranging from 375–510 mm in length were used in the present study. The fishes were collected from Chambal river (Rampura). The collections were made weekly throughout the year from the same locality. Five specimens of both species were examined weekly for the study of their gut contents. Filtration method (Whipple 1927) was followed to separate the different food components and the occurrence method (Hynes 1950) was followed for the quantitative assessment of each component. To calculate the percentage of organic and inorganic constituents of diet of *R. corsula*, the oxidising method was followed. In oxidising method, a known quantity of gut contents was oxidised with hydrogen per oxide by gently heating on spirit lamp up to dryness. Fifty living specimens of both species were sacrificed to record the *p*H in the different parts of their gastrointestinal tract. The *p*H was measured with the help of electrodes (*p*H meter), after separating and cleaning each part.

Experiments for biochemical analysis of digestive enzymes were done in the month of December at room temperature 18.5±2.5 °C. In these experiments, 10 freshly collected fishes of both species were dissected alive and different parts of their gastrointestinal tract were carefully separated and cleared off all food contents. The tissue extract of each part was prepared by grinding the mucosal layer with a little thymol and a few drops of glycerine to form thick uniform emulsion. The solution was diluted to about 10% strength with 50% glycerine. The mixture after being centrifuged at 3000 rpm for 35–45 min was kept over toluene which acted as an antiseptic. A few drops of tissue extract of each part of digestive tract of each fish was incubated with suitable substrate at room temperature and were tested after 24 hr for any digestion of substrate. Control test was performed in each case with boiled and cooled extract. The presence of carbohydrates, viz., amylase, glycogenase, invertase, raffinase, inulinase and salicinase was tested by Fehling's and Benedict's solutions, maltase and lactase were tested by Barfoed's test. Presence of lipase, protease, and trypsin was tested by condensed milk, albumen and blood fibrin experiments, respectively (Agrawal 1964). During the performance of biochemical activities of digestive enzymes, *p*H of incubated extracts was adjusted with sodium carbonate buffer to maintain the medium in which the enzymes actually react in natural condition.

Observations

Food and feeding

The data of qualitative and quantitative analysis of the gut contents of *R. corsula* in different months (table 1) indicate that mud, decayed vegetation, algae, diatoms and crustaceans constitute its food. The average percentage of these components, in a year was calculated as 34, 5, 32, 10 and 19 respectively. *Merismopedia* and *Oscillatoria*, among algae and mud, and several types of diatoms, viz., *Cymbella Navicula* and *Netrium* were found to be present regularly in the gut contents of all the fishes throughout the year while the occurrence of crustaceans and decayed vegetation was less frequent. *Daphnia* and *Cyclops* are identified among crustaceans, mostly from the contents of oesophagus and cardiac stomach in varying percentage. Regular presence of mud together with decayed vegetation, algae, diatoms, and crustaceans in the diet of the fish shows its omnivorous and bottom-feeding habit. The absence of crustaceans and decayed vegetation from the gut contents in September and May is due to non-availability of these constituents in the habitat (ecological investigation). It is also observed that the fish used to dip at right angle to procure the food from the bottom of the aquarium. Further the osteo-morphology of the mouth

Table 1. *Average percentage of various gut contents of* Rhinomugil corsula *(Qualitative and quantitative)*

Months	Number of Specimens examined	gut contents				
		Mud	Decayed vegetation	Algae	Diatoms	Crustacean
July	20	53.25	7.5	17.6	19.75	2
Aug.	20	50.12	3.5	32.78	11.8	1.8
Sept.	20	38.4	nil	50.02	6.58	nil
Oct.	20	26.74	9.84	49.8	5.42	8.2
Nov.	20	6.7	10.2	51.66	3.2	28.24
Dec.	20	6.95	10.0	40.25	2.5	40.75
Jan.	20	5.69	8.02	15.75	1.8	68.4
Feb.	20	18.2	6.68	26.25	1.0	48.87
Mar.	20	38.75	3.96	27.23	9.5	20.58
Apr.	20	45.0	2.25	23.8	18.95	10.0
May	20	58.62	nil	18.58	22.9	nil
June	20	60.7	6.0	21.27	10.53	1.5
Average percentage		34.09 (34%)	5.57 (5%)	31.65 (32%)	9.44 (10%)	19.22 (19%)

shows that it is protractile. By pulling down the lower jaw the premaxillaries hang downwards, maxillaries get twisted and the mouth opening is widened in the form of an inferior oval disc. It shows that the premaxillaries, dentaries and maxillaries are involved in the protractile mechanism. However, the maxillaries are completely excluded from the gap of the mouth. The premaxillaries of either side are fused in the centre, where a deep notch is present for the articulation of knob found at the mandibular symphysis, (figure 1). The premaxillaries bear a flattened dorsal process while the maxillaries are slightly curved and hook-like. A small gap exists between the dorsal process of premaxillaries where lies a boat-shaped unpaired piece of cartilage. The dorsal process of premaxillaries with the unpaired piece of cartilage work against the hook-like process of maxillaries in the form of a sliding stalk and provide the protractile mechanism to the mouth. The protractile mouth, which forms an inferior opening, also supports the bottom-feeding habit of the fish.

Qualitative and quantitative analysis of the gut contents of *S. silondia* in different months (table 2) indicate that fish, fry and fingerlings and macrocrustaceans constitute its main food. These components are observed in the contents of the oesophagus and stomach. In addition to these components, fish scales and bones, and unidentifiable pulpy mass are also observed in the intestinal contents of samples examined. The average percentage of these components is calculated to be as 38% fish fry and fingerlings, 12% macrocrustaceans, 15% fish scales and bones, and 35% unidentifiable puply mass. Fish fry and fingerlings

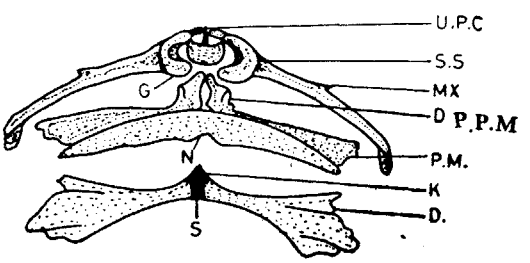

Figure 1 Upper and lower jaw bones of *Rhinomugil corsula* showing the protractile mechanism of the mouth **G**, groove; **N**, notch; **S**, symphysis **U.P.C.**, Unpaired Piece of Cartilage; **S.S.**, Sliding Stalk; **Mx.**, Maxilla; **D.P.P.M.** Dorsal Process of Premaxilla; **P.M.** Premaxilla; **K.** Knob; **D.** Dentary

Table 2. *Average percentage of various gut contents of* Silonia silondia *(Qualitative and quantitative)*

Months	Number of specimens examined	gut contents: Fish, fry, and fingerlings	Macrocrustaceans	Fish scales & bones	Unidentifiable pulpy mass
July	20	10.5	29.3	18.2	42.0
August	20	26.8	35.1	12.5	25.6
Sept.	20	30.0	30.0	5.8	44.2
October	20	30.0	18.2	9.0	42.2
Nov.	20	35.5	10.0	20.0	34.5
Dec.	20	40.0	nil	20.0	40.0
January	20	43.8	15.2	10.0	31.0
February	20	50.0	nil	30.0	20.0
March	20	60.0	nil	10.0	30.0
April	20	62.8	nil	8.3	28.9
May	20	53.0	7.0	10.0	30.0
June	20	29.0	1.0	20.0	50.0
Average percentage		38.45 (38%)	12.15 (12%)	14.48 (15%)	34.91 (35%)

are found to be present in the gut contents throughout the year. On the contrary, macrocrustaceans could not be observed regularly. The maximum percentage of macrocrustaceans in the diet of the fish is observed in August when the quantity of fry consumption is less. The maximum consumption of fish fry and fingerlings is recorded in April, when the macrocrustacean's consumption was nil. Similarly, whenever the macrocrustaceans were absent from the diet, the consumption of fish, fry, and fingerlings was higher. It was also observed in the aquarium that the fish preys upon fiingerlings. Present observations indicate its predatory and carnivorous habits. The terminal crescentic mouth with canniform teeth in both jaws also confirm predatory and carnivorous feeding habit of the species (figure 2).

Digestive Physiology

Study on *p*H is an important aspect to understand the digestive physiology, as the different enzymes act optimally under different hydrogen-ion-concentrations. The *p*H values of different parts of the gastrointestinal tract of *R. corsula* and *S. silondia* are given in tables 3 and 4 respectively. Data in table 3 indicate that the buccopharynx, oesophagus and intestine of *R. corsula* have nearly neutral medium while the medium is weakly acidic in the stomach and in the intestinal caeca of the fish. Similarly the data in table 4 indicate that the medium in the buccopharynx and in the rectum of *S. silondia* was neutral. It is weakly acidic in the oesophagus and in the intestine while in the stomach, it is distinctly acidic.

The digestive enzymes which could be suspected in accordance with the food habits of the fishes, were studied in the extract of the different parts of the gastrointestinal tract. The results of the experiments are recorded in table 5. The data show that carbohydrates are digested in all the parts of the gastrointestinal tract of *R. corsula*, while the protein is digested in the cardiac stomach. The fat is digested in oesophagus, in cardiac stomach, in intestinal caeca and in intestine. Similarly traces of carbohydrate digestion were recorded in the extracts from all the parts of gastrointestinal tract of *S. silondia* while the protein and fat were digested in the stomach and in the intestine of this species.

The present observations indicate that the gastrointestinal tract of the omnivorous fish *R. corsula* is equipped with an array of

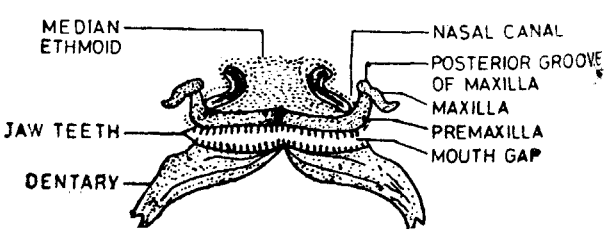

Figure 2 Upper jaw and lower jaw bones of *Silonia silondia* showing the arrangement of teeth

Table 3 p*H in the different parts of gastrointestinal tract of* Rhinomugil corsula

Bucco-pharynx	Oesoph-agus	C Sto-mach	P Sto-mach	Intesti-nal caeca	Intes-tine
7.1	6.9	6.7	6.7	6.9	7.4
7.2	6.7	6.6	6.8	6.8	7.5
7.0	6.9	6.5	6.5	6.8	7.3
7.1	6.8	6.7	6.6	6.9	7.5
7.1	6.7	6.6	6.5	6.7	7.3
Average *p*H 7.1	6.8	6.6	6.6	6.8	7.4
Nature of Medium	NN	NN	WA	WA	WA NN

NN=Nearer Neutrality; WA=Weakly acidic.

Table 4 p*H in the different parts of gastrointestinal tract of* Silonia silondia

Bucco-pharynx	Oesoph-agus	C Sto-mach	P Sto-mach	Intestine	Rectum
6.9	6.4	6.2	6.0	6.4	7.0
6.8	6.3	6.1	6.1	6.5	6.9
6.8	6.3	6.2	6.1	6.2	6.8
6.9	6.2	6.0	6.0	6.3	7.0
7.0	6.3	6.1	6.1	6.6	6.9
Average *p*H 6.9	6.3	6.1	6.0	6.4	6.9
Nature of medium	N	WANN	DA	WANN	N

N=Neutral; WANN=Weekly acidic nearer neutrality; DA=Distinctly acidic

digestive enzymes where carbohydrates are more active while the gastrointestinal tract of the carnivorous fish *S. silondia* is equipped with active proteases and lipase.

Discussions

A review of the literature regarding the food of mullets shows that there is a diversity of opinion among workers. Gunther (1880) mentioned that the diet of *Mugil* is sand mixed with organic material. Hornell (1911) and Jacot (1920) stated that *Mugil* feeds on the shoals of microcrustaceans. Mullets have been reported as omnivorous, Kyle (1926), carnivorous, Orton (1926), and herbivorous, (Hora 1938 and Pillay 1948). Pillay (1953) described *Mugil tade* as an iliophage. Mookerjee et al. (1946) stated *Mugil parsia* as omnivorous. Sarojini (1951) reviewed the plankton feeding nature of mullets.

Similarly the variations in the food of catfishes have been reported. Kapoor (1953) reported that *Wallago attu* is carnivorous. Khanna (1964) has stated that *Clarius batrachus* is omnivorous and predatory in habit. Khanna and Pant (1964) have mentioned that *Mystus seenghala* is carnivorous and predatory while Agrawal and Sharma (1966) have reported that *Mystus vittatus* is omnivorous.

The present observations on the food components of *R. corsula* during different months (table 1), reveal that the fish does not consume a particular type of food throughout the year. The variations observed in the food components in different months may be due to variations in the availability of different items in the habitat. The presence of mud together with decayed vegetation, algae, diatoms and crustaceans in the gut contents of the fish examined indicate the omnivorous feeding habit of the species. Aquarium experiments have shown that the fish takes whatever is available at the bottom of the aquarium by taking a dive perpendicular to the water surface, showing its bottom feeding habit. Morphological adaptation of its mouth supports such a conclusion. The present observations agree with the observations of Gunther (1880), Kyle (1926), and Mookerjee et al. (1946).

The observations of the diet components of *S. silondia* show that the fish consumes fish fry, fingerlings and macrocrustaceans, which indicates its carnivorous habit. Aquarium observations have shown that the fish attacks and feeds on fingerlings, and other food of animal origin. It also proves its carnivorous and predaceous nature. Khanna and Pant (1964) and Kapoor (1953) have also reported the predatory feeding

Table 5 *Biochemical qualitative analysis of digestive enzymes in the different parts of the gastrointestinal tract of* Rhinomugil corsula *and* Silonia silondia

Enzymes	Substrate & their concentration	Reaction of Substrate in the extract of different parts of gastrointestinal tract of 24 hrs (incubated on adjusted *p*H)											
		R. corsula						*S. silondia*					
		Bucco-pharynx	Oesophagus	Stomach		Intestinal caeca	Intestine	Buccpharynx	Oesophagus	Stomach		Intestine	Rectum
				Cardiac	Pyloric					Cardiac	Pyloric		
*p*H		7.1	6.8	6.6	6.6	6.8	7.4	6.9	6.3	6.1	6.0	6.8	6.9
Amylase	2% starch	—	—	—	—	+	+	—	—	—	±	—	—
Glycogenase	Saturated glycogen	+	+	+	+	+	+	—	±	±	±	±	±
Invertase	5% Sucrose	—	±	—	—	—	—	—	—	—	—	—	—
Inulinase	1% Inulin	—	—	—	—	—	—	—	—	—	—	—	—
Lactase	2% Lactose	±	±	+	—	—	+	—	—	±	—	±	—
Lipase	10% Condensed milk coloured with 2% Bromophenol Blue	—	±	±	—	+	+	—	—	+	—	+	—
Maltase	2% Maltose	—	—	±	±	±	±	±	±	±	±	±	—
Protease	Coagulated egg albumen	—	—	±	—	±	±	—	—	+	+	+	—
Raffinase	1% Raffinose	—	—	—	—	—	—	—	—	—	—	—	—
Salicinase	1% Salicin	—	—	—	—	—	—	±	±	±	—	±	—
Trypsin	Blood fibrin coloured with 1% Ruthenium red	—	—	—	—	—	—	—	—	—	—	—	—

habits of other cat fishes. Determination of *p*H and digestive enzymes is essential to understand the physiology of digestion in fishes. Al-Hussaini (1949) has reported that the *p*H in the intestine of *Rutilus, Gobeo* and *Cyprinus* ranges from 6.1–7.7. Agrawal and Tyagi (1963) have mentioned the *p*H range between 6.5 and 6.9 in the alimentary canal of *Mastacembelus pancalus*. They have further reported a slightly acidic medium in buccal cavity, stomach, intestinal caeca, in the intestine and towards neutrality in the pharynx, in the oesophagus and in the rectum of this fish. Agrawal and Bala (1967) have mentioned the *p*H range between 6.1 and 8.2 in different parts of alimentary canal of *Mugil corsula*. They have mentioned an acidic medium in oesophagus, nearly neutral medium in pyloric caeca and in intestine and a weakly acidic medium in cardiac stomach of the species.

In the present study, the range of *p*H in the different parts of the gastrointestinal tract of *R. corsula* is observed between 6.6 and 7.4, while in *S. silondia* it is between 6.0 and 6.9. Nearly neutral medium is found to be present in buccopharynx, in oesophagus and in intestine and weakly acidic medium in the stomach and in intestinal caeca of *R. corsula*. In the gastrointestinal tract of *S. silondia*, the medium is neutral in buccopharynx and in rectum. It is weakly acidic (nearer neutrality) in the oesophagus and in intestine. It is distinctly acidic in the stomach of the fish.

Regarding the activity of the digestive enzymes, Younge (1937) has stated that there is definite correlation between the food of any animal and the nature and relative strength of its digestive enzymes. It is also true in omnivorous fish, *R. corsula* and carnivorous fish, *S. silondia*. Al-Hussaini (1949) has reported that the concentration of carbohydrases is highest in herbivorous and lowest in carnivorous forms and vice-versa. The observations of Al-Hussaini (1949) are in general agreement with the present enzymological findings in the gastrointestinal tract of *R. corsula* and *S. silondia* which are omnivorous and carnivorous respectively.

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