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Comparative study on the mouth morphology and diet of three co-occurring species of silverbellies along the Kerala coast

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Abstract

Three species of pony fishes, *Gazza minuta* Bloch, 1797, *Leiognathus brevirostris* Valenciennes, 1835 and *Secutor insidiator* Bloch, 1797, which co-occur in the same locality along Kerala coast use resource at different levels in the water column, for which their feeding apparatus is suitably modified. The highest degree of jaw protrusion in an upward direction, smallest mouth tube opening measurements, small teeth and greater number of gill rakers in *S. insidiator* is associated with planktivorous diet (81.46%) whereas, intermediate degree of jaw protrusion in a downward direction fewer number of gill rakers and small teeth in *L. brevirostris* enable consumption of 59.75% plankton along with benthos and other food items. *G. minuta* has the least jaw protrusion in a horizontal direction, the lowest number of gill rakers but the highest mouth tube opening with a pointed curved teeth on both jaws, which facilitate predation on larger prey taxa including fish and cuttlefish (48.04%) and almost equal percentages of plankton and benthos.

Keywords: *Gazza minuta*, *Leiognathus brevirostris*, *Secutor insidiator*, feeding apparatus, jaw protrusion, gill rakers

Introduction

Fishes of the family Leiognathidae, popularly called as silverbellies, pony fish, slimys or slipmouths are important demersal (benthopelagic) fishes contributing to the fisheries of Indo-West Pacific region. Silverbellies are very specific in their nature of food intake with a protrusible mouth tube either in upward, forward or downward direction (Woodland *et al.*, 2001; Sparks *et al.*, 2005) and search for prey using the protruding pipette-like mouth or by sieving potential food through their gill rakers (Liu Jing, 1997).

Most of the studies on the diet of *Gazza minuta* (Rao, 1964; Jayabalan and Ramamoorthi, 1985), *L. brevirostris* (James and Badrudeen, 1975), and *Secutor insidiator* (Kuthalingam and Chellam, 1970; Divino *et al*., 1972; Kuthalingam *et al*., 1978) are from the southeast coast of India and there are no studies from Kerala coast.

Fish are notably opportunistic feeders and knowledge on where and how they feed will often provide insight into their ecology than simply knowing the actual components of their diet (Humphries, 1993). Accordingly, morphological comparisons of feeding apparatus among co-occurring species provide important information to ecologists searching for the mechanisms that determine resource utilization and animal community structure (Wikramanayaka, 1990; Wainwright, 1991). Humphries (1993) and Labropoulou and Eleftheriou (2005) conducted a comparative study on the mouth morphology of three co-occurring species of atherinids, and two pairs of congeneric demersal fish species respectively to examine the effect of the morphological differences on the food intake apparatus and resource partitioning among co-occurring fish species. The slipmouths are usually found feeding in schools containing several other co-existing species on the shallow coastal sea beds

(Liu Jing, 1997; Seah *et al*., 2009). Hence the study on morphological peculiarities of the food gathering apparatus in three co-occurring species of pony fishes, *Gazza minuta* Bloch, 1797, *Leiognathus brevirostris* Valenciennes, 1835 and *Secutor insidiator* Bloch, 1797 which live in a community is specially relevant to understand the community organisation.

Liu Jing (1997) has worked on the morphological comparison of feeding apparatus among co-occurring leiognathids distributed in the South China Sea. No such work is ever reported for the slipmouths distributed in the seas around India. The objective of the study is to determine relationships between feeding apparatus and diet of three co-occurring species of silverbellies, *Gazza minuta*, *Leiognathus brevirostris* and *Secutor insidiator* along the Kerala coast.

Material and Methods

Fortnightly collections for *G. minuta*, *L. brevirostris* and *S. insidiator*, were made for a period of two years (March 2005 to February 2007) from the commercial trawl landings at Neendakara, Alappuzha, Cochin, Azhikkode and Chettuwa along the Kerala coast. Specimens were brought to the laboratory in fresh condition packed with ice. A total of 645 specimens of *L. brevirostris* (280 males, 327 females and 38 indeterminates) with length range of 38.5 mm to 142.8 mm TL; 556 specimens of *G. minuta* (278 males, 215 females and 63 indeterminates) ranging from 38.7 mm to 158.2 mm TL and 734 specimens of *S. insidiator* (350 males, 286 females and 98 indeterminates) ranging from 14.5 mm to 128.6 mm TL were collected. Total length (TL) and head length (HL) were measured to the nearest 1mm; the length of the mouth tube (tube length - Tu L) when the jaws were fully extended, the horizontal and vertical length of mouth tube opening (mouth gape) were measured using a vernier caliper. The ratio of the tube length to head length (TuL/HL) and other characters associated with feeding, such as number of gill rakers and the size of teeth were also examined.

The fishes were dissected out and stomachs were removed, weighed and preserved in 4% formaldehyde solution. Each stomach was emptied in a petridish and its contents scrutinized under a binocular microscope (Jimmy *et al*., 2003). Attempts were made to identify the food items up to the possible taxonomic level depending on the state of digestion. The food contents were assigned semi-digested matter status, when the process of digestion made identification difficult. The quantitative analysis was made following numerical method by evenly spreading all contents from each gut in the counting cell chamber and examining under microscope. The numerical percentage of each item of food in different months was determined by finding the percentage of that item in the total number of occurrence of all items. The month-wise data for two years were pooled and various dietary items were broadly categorized as plankton, benthos and others items.

Results and Discussion

Among the three species of pony fishes, TuL/HL ratio was the lowest (0.43 ± 0.01) for *G. minuta* and the highest (0.71 ± 0.08) for *S. insidiator*. The measurement of the protracted mouth tube opening (mouth gape) is maximum in *G. minuta* and minimum in *S. insidiator* (Table 1). This variation in the mouth morphology is related to the diet components of each species. The diet of *G. minuta* consists of fish (*Stolephorus devisi*, *Pseudorhombus* sp., *Cynoglossus* sp., *Apogon* sp. and *Thryssa* sp.) and small quantity of cuttlefish (*Sepia* sp.) which together constitute 48.04% while the benthos [polychaetes *Nereis* sp. and *Eunice* sp., nematodes and young shrimps (*Peneaus indicus*, *P. monodon* and *Parapenaeopsis stylifera*)] and plankton (copepods *Calanus* sp. and *Acartia* sp., diatoms *Coscinodiscus* sp. and *Asterionella* sp., *Squilla* sp. and algae) constitute 27.80% and 24.16% respectively. For *L. brevirostris*, the main dietary component was plankton constituted by copepods *Calanus* sp. and *Eucalanus* sp., amphipods *Melita* sp., *Eriopisa* sp., *Podoceros* sp., diatom *Coscinodiscus* sp. and *Squilla* sp. which formed 59.75% of the diet whereas the benthos (nematodes, polychaetes *Nereis* sp. and *Eunice* sp. and foraminiferans) and others (shell pieces, sand, mud, fish scales) formed 22.05% and 18.19% respectively. The predominance of plankton food (81.46%) constituted by copepods *Calanus* sp., *Eucalanus* sp., *Acartia* sp. and *Oithona* sp., *Mysis*

Table 1. Morphological measurements (mm) of three species of silverbellies; TL - total length; HL - head length; TuL - mouth tube length; the values are mean ± SD

Species	TL	HL	TuL	TuL/HL	Mouth tube opening measurements Vertical length	Horizontal length
Gazza minuta	116.5 ± 1.85	36.4 ± 0.31	15.55 ± 0.51	0.43 ± 0.01	12.83 ± 0.12	7.4 ± 0.61
Leiognathus brevirostris	110.8 ± 0.81	32.12 ± 0.47	19.20 ± 0.91	0.60 ± 0.12	6.62 ± 0.42	5.85 ± 0.16
Secutor insidiator	102.5 ± 0.87	24.6 ± 1.01	22.1 ± 0.67	0.71 ± 0.04	6.14 ± 0.43	4.71 ± 0.26

sp., *Lucifer* sp., *Sagitta* sp., algae, amphipods *Eriopisa* sp., diatoms *Coscinodiscus*, cladocerans, fish egg, and microphytoplankton *Pleurosigma* sp. and *Nitzchia* sp. was specific in the diet of *S. insidiator* while the benthos (polychaetes *Nereis* sp. and foraminiferans) and others (sand, detritus, and fish scales) form 8.30 % and 10.24 % respectively (Table 2 and 3). The least protrusible, horizontally directed and the widest mouth tube opening of *G. minuta* is designed to handle large sized prey like small fish, cuttlefish and juvenile shrimps. An increase in the mouth gape size helps the fish to ingest large sized prey (Olsen *et al*., 2000). The highest degree of jaw protrusion in an upward direction and smallest mouth tube opening in *S. insidiator* is associated with planktivorous diet. The protracted mouth acts like an upwardly directed tube to ingest in water along with small food particles. The intermediate degree of jaw protrusion in *L. brevirostris* facilitates consumption of about 50% of plankton and an equal proportion of benthos and other food components. Those fish which are mostly plankton feeders tend to have more protrusible jaws, as they pick food from water column, or winnowed on the substrate while the species with less protrusible jaws are found to bite their prey (Clifton and Motta, 1998).

The teeth structure discussed is considered as an important adaptation resulting from evolutionary processes mediated by the nature of food (Vereginia, 1990; Blaber *et al.*, 1994). *L. brevirostris* and *S. insidiator* have very small or rudimentary teeth. The food consumed by both the species, basically plankton, does not require the presence of well developed teeth, since they do not need structures to ingest or hold the food. Vereginia (1990) stated in this context that a common adaptation for

Table 2. Percentage composition of diet components (combined as benthos : B, plankton: P; others: O) of silverbellies pooled for two years from March 2005 to February 2007

Month	*G. minuta*			*L. brevirostris*			*S. insidiator*		
	B	P	O	B	P	O	B	P	O
March	24.97	29.01	43.84	28.36	59.59	27.66	06.3	80.15	01.2
April	30.94	18.35	43.04	13.99	62.09	10.26	09.16	75.36	13.65
May	25.72	22.65	52.79	14.36	69.37	19.96	05.3	78.36	15.40
June	25.83	22.98	56.63	12.69	67.88	21.81	06.9	82.56	10.65
July	26.28	25.36	54.10	21.65	71.1	24.36	12.6	85.96	10.32
August	26.07	28.13	52.54	22.65	56.69	12.36	09.16	83.45	12.36
September	20.39	20.36	55.48	14.66	54.00	20.15	10.25	82.65	12.20
October	29.46	23.65	45.46	25.36	52.45	16.32	10.25	83.54	12.65
November	30.33	22.31	45.26	31.65	54.98	19.32	06.15	81.00	15.26
December	34..51	27.36	42.69	34.62	54.78	15.90	08.01	80.96	06.36
January	33.18	26.15	41.40	26.32	55.98	19.61	06.3	80.96	07.63
February	25.93	23.65	43.31	18.34	58.11	19.63	09.23	82.56	05.23
Avg.	27.80	24.16	48.04	22.05	59.75	18.19	08.30	81.46	10.24

Table 3. The dietary components of silverbellies during the years 2005-2007 along Kerala coast

Food items	*G. minuta*	*L. brevirostris*	*S. insidiator*
Plankton	Copepods: *Calanus* sp., *Acartia* sp., diatoms: *Coscinodiscus* sp., *Asterionella* sp., algae, *Squilla* sp.	Copepods: *Calanus* sp., *Eucalanus* sp., larval and post larval shrimps, amphipods: *Melita* sp., *Eriopisa* sp., *Podoceros* sp., *Squilla* sp., algae: *Coscinodiscus* sp.	Copepods: *Calanus* sp., *Eucalanus* sp., *Acartia* sp., *Oithona* sp., *Mysis* sp., *Lucifer* sp., *Sagitta* sp., algae, cladocera, amphipods: *Eriopisa* sp., fish eggs, *Pleurosigma* sp., *Nitzchia* sp., *Coscinodiscus* sp., *Fragalaria* sp.
Benthos	Juvenile shrimps: *Penaeus indicus*, *P. monodon*, *Parapenaeopsis stylifera*, Nematodes, polychaetes: *Nereis* sp., *Eunice* sp.	Polychaetes: *Nereis* sp., *Eunice* sp., nematodes, foraminifera	Polychaetes : *Nereis* sp., foraminifera
Others	Fish and other items: *Stolephorus devisi*, *Pseudorhombus* sp., *Cynoglossus* sp., *Apogon* sp. and *Thryssa* sp. cepahalopods: *Sepia* sp.	Sand, mud, fish scales, shell pieces	Sand, fish scales and detritus

planktophagus feeding regime is the partial reduction of the teeth. The small rudimentary teeth found in the lower jaw of *L. brevirostris* must also function to scrape the bottom sand before the food is sucked in while feeding the benthic prey. Its downwardly directed mouth tube opening is obviously an adaptation for bottom grazing as observed in other species like *Iheringichthys labrosus*, *Synodontis* sp. and *Scatophagus argus* by Fugi and Hahn (2001), Kone *et al.* (2008) and Wongchinawit and Paphavasit (2009) respectively. *G. minuta* is characterised by larger, pointed and curved canine teeth, which together with tongue, prevent the prey's escape from the buccopharyngeal cavity. This finding is similar to ichthyophagous species such as *Salminus* sp. (Rodrigues and Menin, 2006).

Gill rakers are another important determinant of feeding niche species. Although their function is respiration, they are important food filtering organ. The selective retention of food by the gill rakers has been mentioned by Liu Jing (1997), Labropoulou and Eletheriou (2005) and Tanaka *et al*. (2006). In the present study, it was observed that the type of food ingested is related to the number of gill rakers. *S. insidiator* has the greatest number of gill rakers as compared to the other two, which facilitates consumption of plankton. Numerous closely placed rakers on the first branchial arch prevent the loss of food through the gill opening. This is similar to the reports of Fugi *et al.* (1996), Palacios *et al.* (2006) and Wongchinawit and Paphavasit (2009) in other planktophagous species like *Coregonus* sp., *Chirostoma estor estor* and *Scatophagus argus*. The presence of very few gill rakers in *G. minuta* is related to consumption of large prey taxa like fish, cuttlefish and shrimps and less amount of plankton as observed in *Salminus* sp. by Rodrigues and Menin (2006). One exemption to this general pattern was the members of the family Syngnathidae and Fistulariidae, which have totally degenerated gill rakers, but their chief food components are plankton and benthic diatoms (Kramer and Bryant, 1995). This is suggested as a potential advantage for species that live close to the substrate and stir up the mud. If the gill raker slits close tightly, the suspended particles would be swallowed, otherwise, they would be eliminated easily. Table 4 shows the number of gill rakers, size of teeth, and direction of protracted mouth tube and the major dietary categories of three silverbelly species.

Table 4. Number of gill rakers, size of teeth, direction of protracted mouth tube and major diet categories of silverbellies

Species	*G. minuta*	*L. brevirostris*	*S. insidiator*
No. of gill rakers on first gill arch	19.33 ± 0.17	23.7 ± 0.22	25.1 ± 0.23
Size of teeth on lower jaw	Large, curved Canine like	Small, vestigial	Small, vestigial
Direction of protracted mouth tube	Horizontal	Downwards	Upwards
Major diet	Plankton 24.16 % Benthos 27.80 % Fishes and 48.04 % other items	Plankton 59.75 % Benthos 22.05 % Others 18.19 %	Plankton 81.46 % Benthos 08.30 % Others 10.24 %

The morphology of the three species is similar. They were caught at the same trawl grounds along the Kerala coast which shows that despite dietary differences, these species occur together. Their co-occurrence along the Kerala coast was previously reported by Sekharan and Nair (1975) and Jacob *et al*. (1985).

It may be concluded that the three silverbelly species, which co-occur along the Kerala coast, use resource at different levels in the water column, which is facilitated by their feeding apparatus. Given general morphological similarities between congeners, differences in feeding are mainly attributed to resource sharing, thus minimizing competition and allowing multiple species co-existence (Platell *et al.*, 1998).

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