MORPHOLOGICAL OVERLAP OF FISH COMMUNITY IN VAMANAPURAM RIVER, SOUTH KERALA

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ABSTRACT

The morphological characteristics and overlap of fish community in Vamanapuram River have been studied in detail. In the 12 study sites, 19 fish species were encountered. Based on the body shape, four different types are apparent. The elongate bodied fishes (RBD $<$ 1.5) like *Hemiramphus xanthopterus* and *Xenentodon cancila* are grouped under one category. The deep bodied fishes (RBD $>$ 3.5) like *Puntius filamentosus*, *P. ticto, P. vittatus, P. melanampyx, P. sarana, Etroplus maculatus* and *E. suratensis* come under a separate category. Fishes with round to square cross section like *Garra mullya* and *Glossogobius giuris* form a separate group. All the other species are grouped as generalized bodied fishes. The morphological overlap studied for the Vamanapuram fish community showed that out of 190 combinations, 30 combinations have high overlaps ($\geqq$ 67). *P. melanampyx* has maximum number (6) of high overlaps. *Puntius* spp., which constituted 49.5% of the total population, have a mean morphological overlap of 52%. The morphological overlap of fish species in relation to the trophic structure is discussed in detail.

Keywords: Vamanapuram River, morphology, fish community, morphological overlap, competition

INTRODUCTION

Morphological variations of fish community provide information on the ecological adaptations it has acquired to suit the environment and overcome the competition for food and space. In lotic environments like rivers, morphology plays an important role since the fish community has to undergo adverse conditions of stress during the dry season and the high-flowing monsoon season. The community has to adapt to the extreme conditions morphologically and maintain its population. Morphologically adaptive species are more selective naturally. Such natural selection leads to imbibing beneficial characters like faster growth, hardy nature, capacity to tackle extreme situations, etc. This study has been undertaken with a view to understand the morphological adaptations the fish community underwent and to know the overlap of the characters to overcome competition.

MATERIAL AND METHODS

Twelve sites were chosen for sampling throughout the Vamanapuram River from the lowlands to the mouth of the river. For morphological studies, fishes were collected using monofilament gill nets. Depending on the habitat, depth of water column and availability of fishes, gill nets of varying mesh sizes were used. A uniform effort of 20 minutes was set for the operation of all the nets at all habitats. Soon after the net was hauled, fishes were removed and anaesthetized in 50 ppm benzococaine. Then, the fishes were transferred to 4% formalin for preservation. Large fishes were injected with formalin using a hypodermic syringe and then preserved with 4% formalin in jars made of polyethylene terephthalate. A sample of 15 individuals was measured for each fish species. If sufficient number of individuals in each species were not available (<15), all the fishes caught were used for the measurements.

Morphological measurements of each species were quantified using selected measurements from Gatz (1979a). Most of the length measurements (>40 mm) were made with a millimetre scale to the nearest 0.5 mm. Some of the measurements (<40 mm) were made with vernier calipers to the nearest 0.1 mm. The ecomorphological features measured were: (1) standard length (straight line distance from the most anterior part of the head to the terminus of the vertebral column), (2) relative head length (straight line distance from the most anterior part on the upper lip to the posterior margin of the opercular membrane divided by standard length), (3) flatness index (maximum body depth divided by maximum body width), (4) relative body depth (maximum body depth divided by the standard length), (5) caudal span (the span of the caudal fin divided by the maximum body depth), (6) pectoral fin length (distance from the base of the pectoral fin to the extreme tip of the fin at its largest point divided by the standard length), (7) pelvic fin length (distance from the base of the pelvic fin to the extreme tip of the fin at its largest point divided by the standard length), (8) pectoral fin shape (coded and rated based on the subjective evaluation as A - rounded; B - intermediate or C - pointed), (9) relative eye size (the diameter of the eye between the fleshy orbits along an anterio-posterior axis divided by the standard length), (10) eye position (rated as A - lateral, B - slightly dorso-lateral or C - bulging on the top of the head), (11) relative mouth width (the interior lateral dimension of the opening when the mouth was fully opened, divided by the standard length), (12) mouth position (coded according to the position of the opening of the mouth when closed as A - supraterminal, B - terminal, C - subterminal, D - inferior or E - ventral), (13) number of barbells), (14) number of gill rakers (total number of rakers which were visible after staining with alizarin on both ascending and descending limbs of the lateral surface of the first arch) and (15) gill raker structure (rated and coded as A - absent, B - short and stubby, C - intermediate or D - long and narrow).

The amount of overlap between each pair of species was determined using the index of Gatz (1979b). By this method, the number of morphological features not significantly different between two species, when expressed as a percentage of the total number of features measured, was taken as an index of percentage morphological overlap of the two species. Therefore, the morphological overlap is simply the percentage of the characters with overlapping ranges between co-existing interspecific pairs.

RESULTS AND DISCUSSION

Morphological Characters and Variations

The fish species of Vamanapuram River were separated on the basis of morphological features mainly related to trophic adaptations. The morphological characteristics of the fish species of Vamanapuram River are given in Table 1. The abbreviations for the different fish species is provided in Appendix 1.

Table 1: Means of morphological characteristics of 19 fish species of Vamanapuram River

	PA	PF	DA	RD	PT	PV	PM	GM	PS	BB	EM	ES	MA	AP	LD	AL	GG	XC	HX
HL(X10)	2.96	2.95	2.60	2.90	2.80	2.80	3.00	2.39	2.80	2.70	3.66	3.93	2.70	2.88	2.90	2.93	3.55	4.12	3.57
FI	1.93	2.22	2.46	1.73	2.44	2.05	1.83	1.28	1.92	2.13	2.87	2.72	1.40	2.22	1.64	1.36	1.14	1.06	1.20
BD(X10)	3.25	3.80	3.46	2.66	4.05	3.62	3.71	2.52	3.86	3.13	5.57	5.53	2.38	2.78	2.72	2.20	1.73	0.80	1.07
CS	1.11	0.99	0.91	1.07	0.95	0.87	1.03	1.18	0.93	1.15	0.63	0.43	1.46	1.08	1.14	4.47	1.02	1.09	1.71
Pr(X10)	2.00	2.14	2.46	1.79	1.88	1.46	1.98	2.09	1.63	2.28	2.77	2.63	2.00	1.91	2.05	2.00	2.03	0.81	1.04
Pv(X10)	1.78	2.12	1.65	1.47	1.97	1.69	1.82	1.82	1.74	1.38	1.88	2.12	1.67	1.54	1.62	1.98	1.75	0.40	0.70
D(X10)	0.82	0.91	0.80	0.69	0.88	0.82	0.76	0.54	0.79	0.83	1.02	0.93	0.62	0.68	0.70	0.73	0.53	0.40	0.50
W(X10)	0.51	0.58	0.62	0.79	0.43	0.50	0.72	0.78	0.73	0.67	0.66	0.48	0.79	0.59	0.40	1.03	1.13	2.76	0.40
B	2	2	0	0	0	0	4	4	4	0	0	0	8	0	4	0	0	0	0
GR	22	14	10	2	18	2	8	18	12	3	11	9	18	16	22	7	9	0	45
GRS	C	C	C	D	B	C	B	B	B	B	D	B	D	C	B	C	B	A	D
MP	C	B	A	B	C	B	C	E	B	A	B	B	B	B	D	B	B	B	A
EP	A	A	A	A	A	A	A	A	A	A	A	A	B	A	A	B	C	A	A
SPr.	B	B	C	B	B	B	B	A	B	B	C	C	B	B	B	A	A	C	C

RHL – Relative head length
FI – Flatness index
RBD – Relative body depth
CS – Caudal span
RLPr. – Pectoral fin length
RLPv – Pelvic fin length
ED – Eye diameter
RMW – Relative mouth width
B – Number of barbels
GR – Number of gill rakers
GRS – Gill raker structure
MP – Mouth position
EP – Eye position
SPr. – Pectoral shape

Appendix 1

AL	*Aplocheilus lineatus*	MA	*Mystus armatus*
AP	*Amblypharyngodon microlepis*	PA	*Puntius amphibius*
BB	*Barilius bakeri*	PF	*P. filamentosus*
DA	*Danio aequipinnatus*	PM	*P. melanampyx*
EM	*Etroplus maculatus*	PS	*P. sarana*
ES	*E. suratensis*	PT	*P. ticto*
GG	*Glossogobius giuris*	PV	*P. vittatus*
GM	*Garra mullya*	RD	*Rasbora daniconius*
HX	*Hemiramphus xanthopterus*	XC	*Xenentodon cancila*
LD	*Labeo dero*		

Relative head length

High relative head length was recorded for XC (4.12), ES (3.93), EM (3.66), HX (3.57) and GG (3.45). The highest ratio recorded for XC is due to the extension of its mouth forming a beak-like structure.

Flatness index

The flatness index indicates the degree of compression and is more related to the habitat and water velocity (Gatz, 1979a). Dorsally compressed species like XC (1.06), GG (1.14) and HX (1.20) have the lowest flatness indices. The index of GM (1.28), AL (1.36) and MA (1.40) are low due to the dorsolateral compression. More laterally compressed species like EM, ES, DA, and PT form another group with their values ranging from 2.44 (PT) to 2.87 (EM).

Relative body depth

The variations in relative body depth are quite distinct between species. EM and ES, which have maximum body depth, are the best examples for laterally compressed bodied species. The lowest relative body depth is for XC (0.80).

Caudal span

Caudal span is more associated with the locomotion of the fish which provides better hydrodynamics for the fish to swim fast and balance itself in water. High span of caudal fin was observed in species like HX (1.71) and MA (1.46). High values in caudal span indicate fast swimmers. Other species having relatively high caudal span are PA, GM, BB, LD and AL.

Pectoral and pelvic fin length

Pectoral fin length was assumed to increase as a function of low speed manouvering in the behaviour of the fish (Gray, 1968; Starck and Schroeder, 1970; Kanep, 1971). High relative pectoral fin length was recorded in EM and ES which helps the fish to manoeuvre its position in the water with its laterally compressed body. The lowest relative pectoral fin length was observed in XC (0.81). The shape of pectoral fin is an important character and round fins are characteristic of fishes which remain motionless in midwater (Aleev, 1969). According to Watson and Balon (1984), larger and more rounded pectoral fins are characteristic of benthic oriented fishes. The presence of round pectoral fin in GM and GG indicates their benthic feeding nature and most of the other species have an intermediate type of pectoral fin in between rounded and pointed types.

Eye size and the presence/absence of barbels

Eye size is more related to the visual capabilities of the fish (Protasov, 1970) and is more important in sight feeding fishes (Evans, 1950). XC and HX had the smallest eye diameter (0.40 and 0.50, respectively). Among the other species, the eye diameters of GM (0.54) and GG (0.53) are small. Maximum eye diameter was observed in EM (1.02).

Relative mouth width

Relative mouth width is high (>1) in species like XC (2.76), GG (1.13) and AL (1.03). The high mouth orientation in XC is due to the protrusion of jaws into a beak-like structure. AL and GG have wide mouths because of their flattened head which enable them to have more access to the prey. Narrow mouths were observed in species like HX and LD. In HX, the lower jaw is extended forwards leaving upper jaw, making the mouth less wide. The mouth of LD is very narrow. PT has relatively small mouth width (0.43) and its mouth position is subterminal, which is an adaptation to feed on the bottom.

Number of gill rakers

The number of gill rakers is assumed to be inversely related to the presence of larger and more benthic prey in the diet (Nilsson, 1958; Himberg, 1970; Kliewer, 1970). The number and structure of gill rakers are important cues to distinguish between filter feeders and predators. The insectivores like DA, BB and AL have less number of gill rakers compared to herbivores. XC which is a carnivore mainly based on the mouth structure has no gill rakers. The bottom-feeding herbivores like PA, PT, PV and GM have more number of gill rakers. LD is a bottom feeder on chironomids and has high gill raker count (22). A major percentage of fishes in this assemblage have short and stubby gill rakers showing their relative benthic feeding nature. The morphological differences observed between the species show that there is segregation among them and are separated on the basis of trophic adaptations and body shape.

Based on the body shape, four different types are apparent. The first type is the elongate bodied fishes (RBD <1.5). HX and XC come under this category. Among them, XC has a long snout full of sharp teeth. The nature of the body shape and structure show that this species is a predator. The absence of barbels and gill rakers further confirm this. Another conspicuous group is the deep bodied fishes (RBD >3.50). PF, PT, PV, PM, PS, EM and ES come under this category. The terminal mouth, presence of barbels and intermediate structured gill rakers categorise PF as a generalist. Among this, PT and PV are separate with the absence of barbels and presence of more gill rakers. These are herbivores, but based on the subterminal mouth, PT is a bottom feeder. The cichlids EM and ES are more deep bodied herbivores. PM and PS have more similar characters. The presence of more number of gill rakers in PS (12) than PM shows that PM is a generalist.

GM and GG come under the group of species that are round to square in cross section. The presence of barbels, low eye diameter, ventral mouth and the presence of more gill rakers clearly place GM morphologically as a herbivorous bottom specialist. The position of eye, bulging on the top of head, and low flatness index group GG as a species confined to the bottom region.

A larger group of species come under the category of generalised body shape. Of them, PA is a bottom feeder based on the presence of barbels and subterminal mouth. The presence of more number of gill rakers shows that its feeding habit is more towards herbivory. The absence of barbels, less number of gill rakers and a supraterminal mouth group DA as a surface feeding carnivore. Based on the presence of barbels, and narrow and inferior mouth position, LD is categorised as a bottom feeder.

Morphological Overlap

The overlap of the 19 species observed in Vamanapuram River is given in Table 2. Out of the 190 combinations, 30 had high overlaps ($\geqq$ 67.0) which constitute 16% of the total overlap. In

Table 2: Morphological overlap (Gatz, 1979b) for the fish species of Vamanapuram River

	X	HX	CX	GG	LA	DL	PA	AM	SE	ME	BB	SP	MG	MP	VP	TP	DR	AD	FP
CX	52	75																	
GC	14	92	34																
LA	34	12	12	17															
DI	94	12	41	63	05														
PA	45	92	12	63	34	75													
AM	04	92	7	63	46	46	05												
SE	75	92	63	05	12	41	12	41											
ME	93	63	63	63	92	12	92	92	97										
BE	45	92	12	63	63	34	46	63	68	63									
SE	65	41	12	34	34	17	46	34	63	34	97								
MC	44	12	92	05	75	46	75	46	92	12	05	05							
ME	45	41	41	34	34	97	46	63	63	63	17	68	75						
VE	25	92	92	63	34	05	97	63	63	63	05	46	92	75					
TE	35	92	12	34	63	17	46	63	34	63	46	46	05	17	97				
DE	65	92	92	34	75	46	97	17	12	05	17	97	75	46	17	34			
AI	15	92	12	63	05	37	97	12	05	46	17	05	92	46	17	75	34		
XI	72																		
AE	25	12	41	82	34	97	97	63	12	92	75	46	34	17	46	97	46	46	68
FE	45	41	12	34	34	63	46	34	34	05	46	68	34	17	68	46	05	17	

general, there is high morphological overlap between the dominant fish species PA, PF, DA, RD and PT. PM has the maximum number of high overlaps (6). PA has high overlaps with five species, all of them are bottom-oriented species. PF has high overlaps with one surface-oriented fish, DA and four bottom-oriented fishes, PA, PV, PM and PS. Morphologically, it is separated from the surface-feeding fishes. The generalist RD has more overlap with bottom-oriented fishes like PV, PS, MA and AP.

The morphological features of PM are more overlapping with those of species like PA, PF, PT, PS, LD, and the surface-oriented fish BB. The benthic-feeding fish GM has low overlap with all other fishes in the community. Similarly, XC and HX have low overlaps with all other species. The surface-oriented fish BB has high overlap with DA, RD, PM, PS and ES.

Based on the morphological features, more species show characters most suitable for bottom-feeding nature. The overall mean overlap calculated for the different species was 46.3 ± 9.2. The mean overlap calculated for individual species varied between 25.4 and 55.6. The mean overlap observed in this assemblage is low when compared to the overlaps observed in temperate stream fish assemblages (Gatz, 1979b). However, the range of individual mean overlap is wide indicating high morphological diversity. Such morphological diversity is generally considered to reflect co-evolution to reduce competition for limited resources (Gatz, 1979b). The mean morphological overlap of fish assemblages in three streams in the Piedmont of North Carolina ranged from 64 to 66% (Gatz, 1979b). On the other hand, the mean morphological overlap of the tropical hill stream fish community (19 species) in Srilanka was 34% (Moyle and Senanayake, 1984). In the present study, cyprinids dominated the fish community (79.8%) and have a mean morphological overlap of 47%. *Puntius* spp., which constituted 49.5% of the total population, have a mean morphological overlap of 52.0%. The high morphological similarity among the *Puntius* spp. shows that they are co-evolved species. In general, the morphological overlap observed in this assemblage is low indicating high segregation between the members (mean overlap 27%, high overlap 16%). In the present study, the highest mean overlap was observed for ES (57) and the lowest mean overlap for XC (25). However, there is strong overlap (53.0%) between the five most abundant species and this indicates that competition between the dominant species is likely.

The morphological attributes in relation to feeding are closely related to the trophic structure of fish species. Watson and Balon (1984) observed vertical partitioning of habitat according to morphological attributes in Borneo fish taxocenes. They identified the major niche types as surface, pelagic, benthic and substratum. In the present study, such vertical partitioning of habitat is observed mainly based on the mouth position and the presence of barbels. Das Gupta (2000) compared the morphology of the alimentary tract of four *Channa* species. Similarly, Das Gupta (2001) studied the morphological adaptation of the alimentary canal of four *Labeo* species in relation to their food and feeding habits, and found that *L. gonius* is more herbivorous in nature. In the present study, DA, BB and HX with no barbels and supraterminal mouth can be classified as surface types. The pelagic type includes species with no barbels and terminal mouth (RD, PV, EM, ES, AP, AL, GG and XC). The benthic niche type includes species with barbels and subterminal, inferior and/or ventral mouths. Species like PA, PF, PM, GM, PS, MA and LD come under this category. As per this classification of niche types, fishes which are included in the pelagic niche type may occur in the bottom region occasionally for feeding on the benthic substrate. This assumption mainly stems from the presence of more detritus in the stomachs of some of the fishes included in the pelagic niche type. Under such circumstances, more competition is expected for the benthic niche type.

The range of morphological overlap of fish species constituting the assemblage is wide indicating a diverse use of resources and this morphological diversity may be a product of interspecific competition and co-evolution. In Srilankan hill stream fish assemblages, Moyle and Senanayake (1984) documented that interspecific competition is an important force behind structuring of fish assemblages.

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