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Research Article

Food partitioning of five cyprinid fish species in the Chittar River, South Western Ghats, India

Sahul Hameed SAJEN, Radhakrishnan PALANIKANI, Kumaresan SABAI SORNA DEVI, Sakthi Vadivel SELVANAYAGI, Abdul Asan Sathali MOHAMED SHAKILA, Ramaiah SORANAM*

Sri Paramakalyani Centre for Excellence in Environmental Sciences, Manonmaniam Sundaranar University, Alwarkurichi – 627 412, Tirunelveli, Tamil Nadu, India.

Email: soranamr@gmail.com

Abstract: The diet and feeding ecology of cyprinid fish species *Devario aequipinnatus*, *Rasbora daniconius*, *Puntius bimaculatus*, *Dawkinsia filamentosa* and *Garra mullya* were studied exploring the dietary breadth and overlaps of the species in the Chittar River, Southern Western Ghats, India. The diets of *D. aequipinnatus*, and *R. daniconius* were specialized animal matter and terrestrial arthropods whereas *P. bimaculatus* and *D. filamentosa* consumed large composition of algae and small portion of detritus respectively. Meanwhile the smaller portion of animal matter was present in the gut of *P. bimaculatus* while *G. mullya* fed on only algae and detritus with higher amount of plant matter. Levin's index diet breadths analyses showed major overlaps between *R. Daniconius* and *D. aequipinnatus* and between *G. mullya* and *P. bimaculatus* in all the seasons. In the confluence site, generalist such as *D. filamentosa* and *P. bimaculatus* had an overlap with *R. daniconius* in four taxa food items and animal matter category. *D. aequipinnatus* and *R. daniconius* fall in specialist group. This *D. aequipinnatus* and *R. daniconius* species fed mainly on terrestrial arthropods from the surface. *Garra mullya* get a narrow feeding range in all seasons. Among co-existing species, diet overlaps were noticeably low in all seasons. Among the five cyprinids species high diet breath value and highest food overlapping was observed in the intermediate and south-west monsoon seasons. These results suggest that the diets of the fish assemblages had a distinct similarity and dissimilarity between and within surface and bottom feeding guilds. The results revealed a co-existence of five cyprinid fishes in the study area of Chittar River where a highly structured stream assemblage was observed.

Keywords: Stream fishes, Feeding ecology, Diet breadth, Diet overlap, Co-existence.

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Introduction

Fishes are used as indicators of ecosystem health and environmental damages in streams (Radinger et al. 2019). In ecological research, knowledge of diet composition is important. There are numerous approaches to determine the aspects of diet composition of fishes (Hyslop 1980; Da Silveira et al. 2020; Hojat Ansari et al. 2020; Khaleel et al. 2020). Although there is no firm evidence that any running water fish species is limited by food supply; it is clear that the availability of suitable food must be a factor of considerable ecological importance, and diets of fishes have received much attention (Chapman 1966). Feeding ecology of organisms is an important means to understand biotic interactions amongst co-existing species and indicates an indirect community energy flux (Atabak 2011), which allows us to infer competition and predation effects on community structure.

Many reports are available on food and feeding behaviours of fishes in tropical and temperate regions. Studies of fish diet show that a wide range of foods are used, both of animal and vegetable origin (Dudgeon 1999; Alhazzaa et al. 2019). Welcomme (1979) mentioned that the allochthonous food is a major component in the forest environment and river

Table 1. Study locations – river Chittar, Southern Western Ghats, India.

Site	Name	Co-ordinates
Old falls	S1	8°54'52.6"N 77°18'29.5"E
Near honey falls	S2	8°55'02.6"N 77°15'50.3"E
Near shenbagadevi falls	S3	8°55'21.2"N 77°15'58.7"E
Orchard falls	S4	8°55'39.3"N 77°13'56.0"E
Gundar	S5	8°56'37.5"N 77°12'50.8"E
Hanumannadhi upstream	S6	9°04'49.1"N 77°13'57.1"E
Near hanuman nadhi dam	S7	9°04'18.0"N 77°14'06.0"E
Karuppanadhi upstream	S8	9°09'09.7"N 77°17'44.3"E
Near karuppanadhi dam	S9	9°08'15.4"N 77°18'30.0"E
Confluence	S10	8°47'59.5"N 77°48'26.0"E

flood plains. The fact that species share resources such as food, space and time with co-existing species results in problems pertaining to resource partitioning (Johnson & Arunachalam 2012). Ross (1986) concluded that in an aquatic environment food is the most common factor, so that partitioning occurs within the community followed by space and time. As a result, species with similar feeding habits are grouped into similar trophic guilds within the community. Most resource partitioning studies on hill stream fishes have been conducted in North American, Australian and European streams (Pusey & Bradshaw 1996; Lucena et al. 2000; Oscoz et al. 2005; Baumgartner 2007). Such studies have found that resource partitioning could be related to high dietary overlap among competing species or could result from interactive competition (Ross 1986; Lucena et al. 2000).

In India, there have been several studies on fish diversity, distribution patterns and assemblage structure ofthe Western Ghats (Arunachalam 2000; Dahanukar et al. 2004; Johnson & Arunachalam 2009). Mostly, head water streams of the Western Ghats are poor in primary production, and the organisms living in this environment depend mainly on allochthonous resources as their major food (Johnson & Arunachalam 2012). With over 300 species, of which ~65% are endemic, the freshwater fish fauna of the Western Ghats mountain ranges is one of the richest and unique in the tropical world (Joshi et al. 2017).

River Chittaris a major river of Courtallam hills of Tamil Nadu. The Chittar River joins with the Tamiraparani River, 25km of north-east of the Tirunelveli which after a south-westerly course of about 115km empties itself into Gulf of Mannar. However, there is very little information regarding resource partitioning, trophic organization and feeding ecology of fishes in River Chittar, Southern Western Ghats. Therefore, the present work was carried out to study feeding habits of selected cyprinids species within various streams of river Chittar, and to examine the degree of diet overlap among fishes within the community. In addition, this study proceeds to address about ecosystem function and wealth of river Chittar.

Materials and Methods

Study area: The study was carried out in Chittar River, Southern Western Ghats, India that lies within 8º50´ and 9º0´ latitude and 77º10´ and 77º20´ longitude. Geographically the areas lies a few km to the south of Achankoil and Aryankavu part of the Western Ghats, which connects the portion of the country to the state of Kerala on the Western side, Papanasam and extension of reserve forests of Kadyanallur ranges in Tirunelveli district on the Southern side and the plains of Tenkasi and Shencottahtaluks on the eastern and northern sides. The Present study was achieved in 10 selected sites of river Chittar (Table 1, Fig. 1). The sampling was carried out during June 2018 to May 2019. Sample collection was done on four seasons such as south-west and north-east monsoon, intermediate and dry

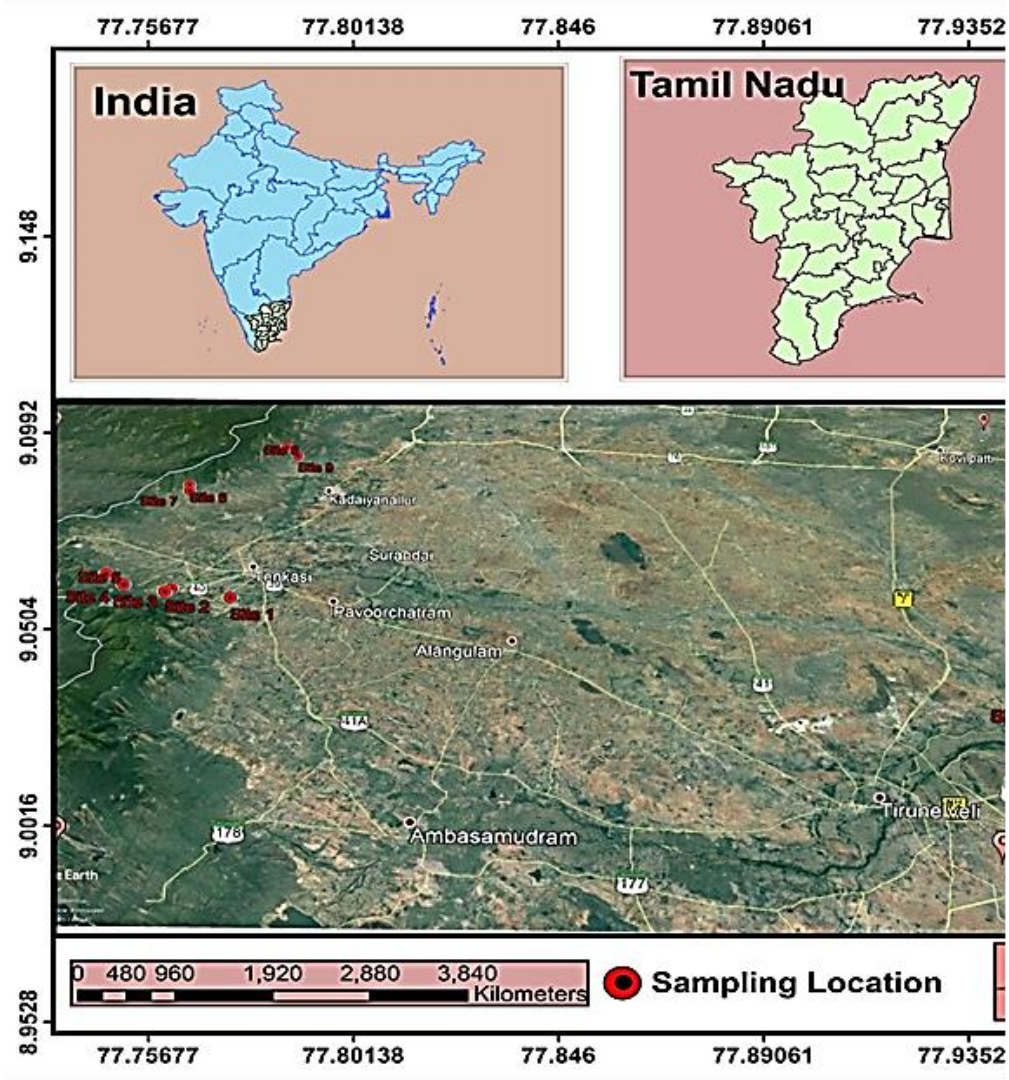

Fig.1. Location of the study stream in river Chittar Southern Western Ghats, India.

seasons.

Fish collection: Monofilamentous gill nets of various mesh sizes (32, 26, 22 and 13mm) were used to collect fishes (Johnson & Arunachalam 2012) from the selected study sites. The fish species of *Rasbora daniconius*, *Devario aequipinnatus*, *Dawkinsia filamentosa*, *Puntius bimaculatus*, *Garra mullya* were selected for dietary analyses. Specimens were identified following key to classification of fishes (Talwar & Jhingran 1991; Jayaram 1999).

Fish sampling: 10 individuals of each species were selected representing near to the same standard length (SL) and size classes in every season. The fish sample was treated individually for dietary analyze, dissected and the gut was removed. For each gut, the contents of stomach /or intestine up to the first bend were removed to a glass slide and examined under a microscope (Olympus model: CX21Ifs1). The entire food items were immediately identified and estimated to the percentage volumes through biovolume method (Hynes 1950).

Dietary analysis: In the laboratory, we carried out the gut analysis in five cyprinids species only, because due to their species dominants in the river Chittar (Johnson 1999). Relative abundance of algae, higher plant material, animal material and detritus were determined (Hynes 1950). Components of animal matter were categorized into Ephemeropteran larvae,

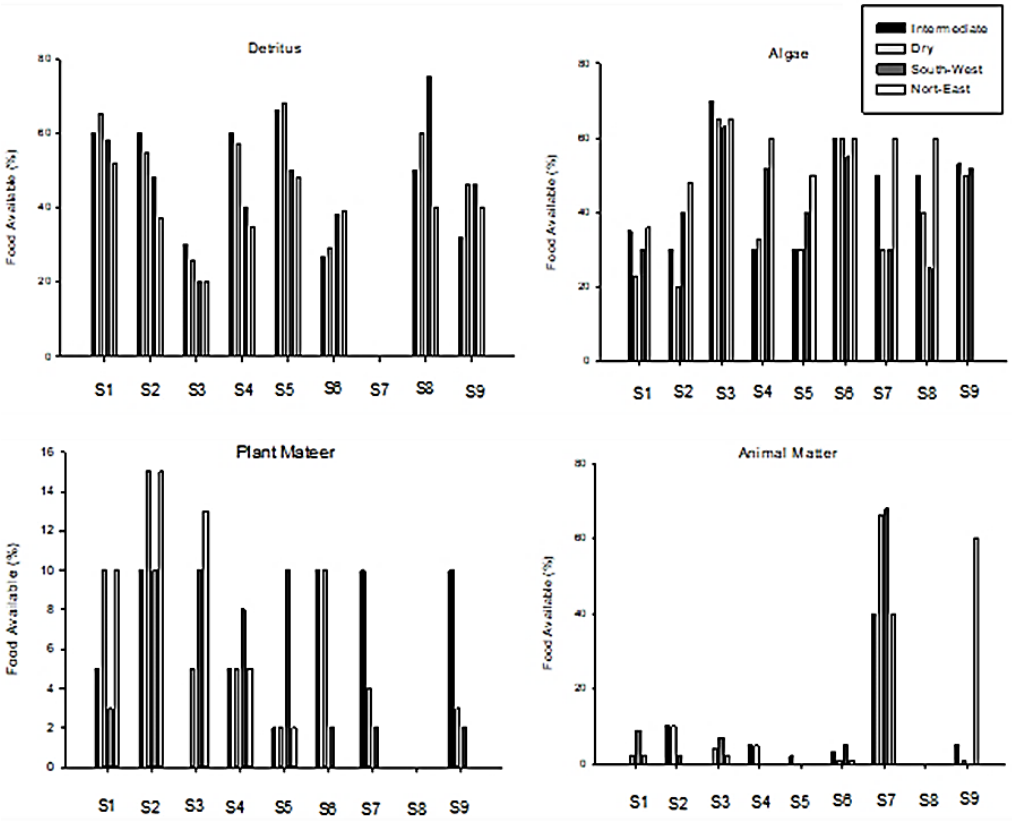

Fig.2. Location of the study stream in river Chittar Southern Western Ghats, India.

dipteran larvae, coleopteran, acari, terrestrial arthropods and rest group by using the point method. Diet overlap was estimated by comparing the proportion of diet for pair wise species (Schoener 1970).

$$Diet\ Overlap = 1 - 0.5(\frac{\Sigma ni - 1}{Pki - Pyi})$$

Where, Pki = Proportion of food used by species K, Pyi = Proportion of food used by species y and n = number of resource categories. Cyprinids diet breadths were determined using following formula (Levin's 1986): $B = \Sigma pij \log pij$, Where, pij is the proportion of resource in each category.

Results

Diet composition in the solely represented cyprinid in sites S1 and S2, *G. mullya*, showed only algae and detritus with fewer amounts of higher plant matter and animal matter in the diet composition and a negligible seasonal variation was also observed. In site S3, considerably, high proportion of algae was noted. The varying composition of algae and detritus was noted in diets of *G. mullya* but with slight seasonal variation. In site S1, S2 and S3 obtained algae, and detritus ranges were in less seasonal changes. In site 9, diet of *G. mullya* were mainly algae and detritus (Fig. 2A, B).

Dietary composition of *R. daniconius* in site S2 was largely of animal matter in all the seasons, with a slightly decreasing trend during intermediate and monsoon seasons. Among the studied fish, *R. daniconius* preferred terrestrial arthropods especially ants (Formicidae) in almost all the seasons, whilst Ephemeropteran larva was in small proportion.

In site S3, there were a significant value of animal and plant matters were obtained in all the seasons. During dry season, the proportion of animal matter was high (70%). Diets of *R. daniconius* was mainly composed of terrestrial arthropods and small amount

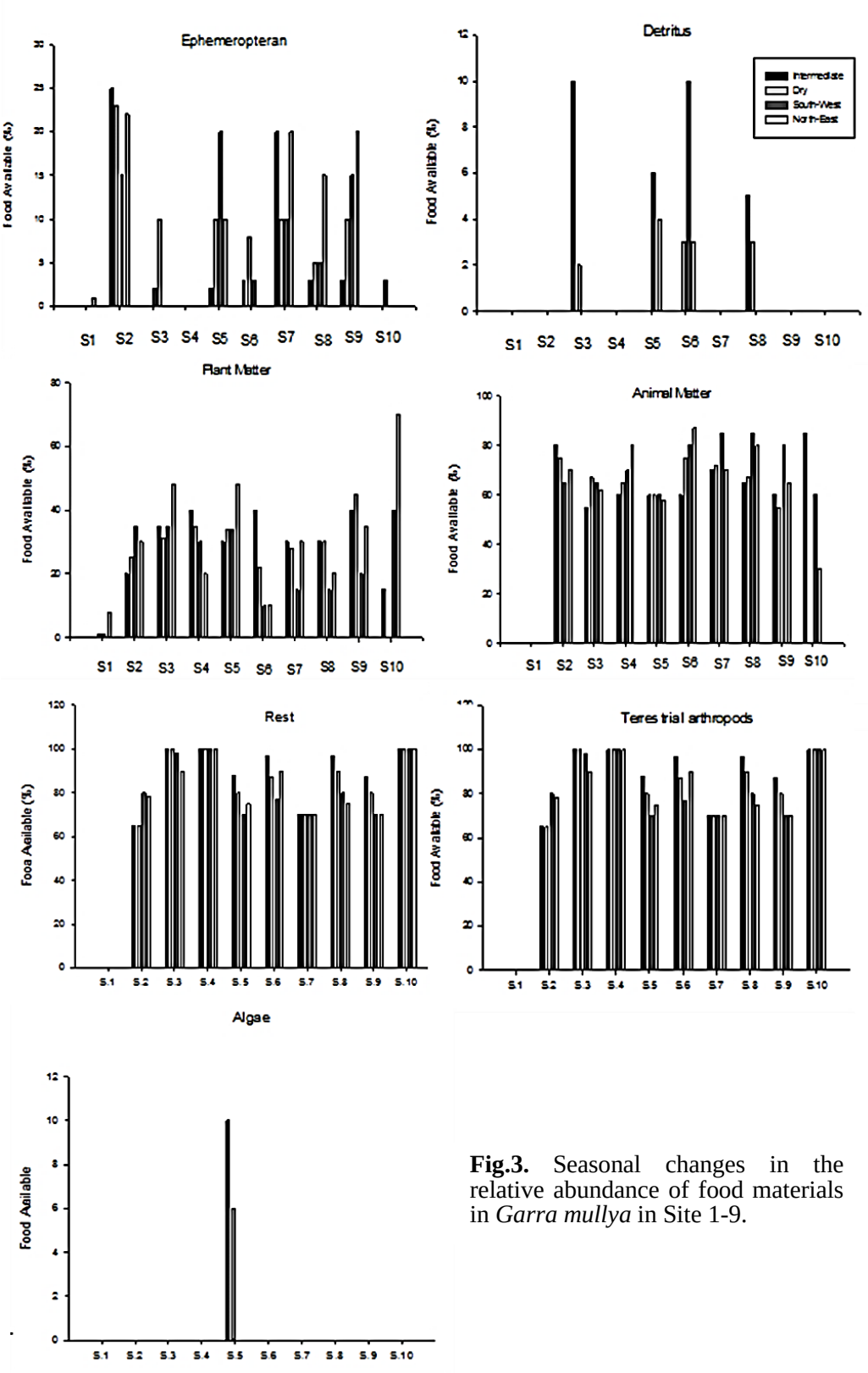

Fig.3. Seasonal changes in the relative abundance of food materials in *Garra mullya* in Site 1-9.

of Ephemeropteran larvae in all the seasons. Although, the said value is not observed in north-east monsoon. *Rasbora daniconius* in sites S4, S6 and S9 composed predominantly of animal matter and the rest group consisted of higher plant material. In site S5, dietary composition of *R. daniconius* was

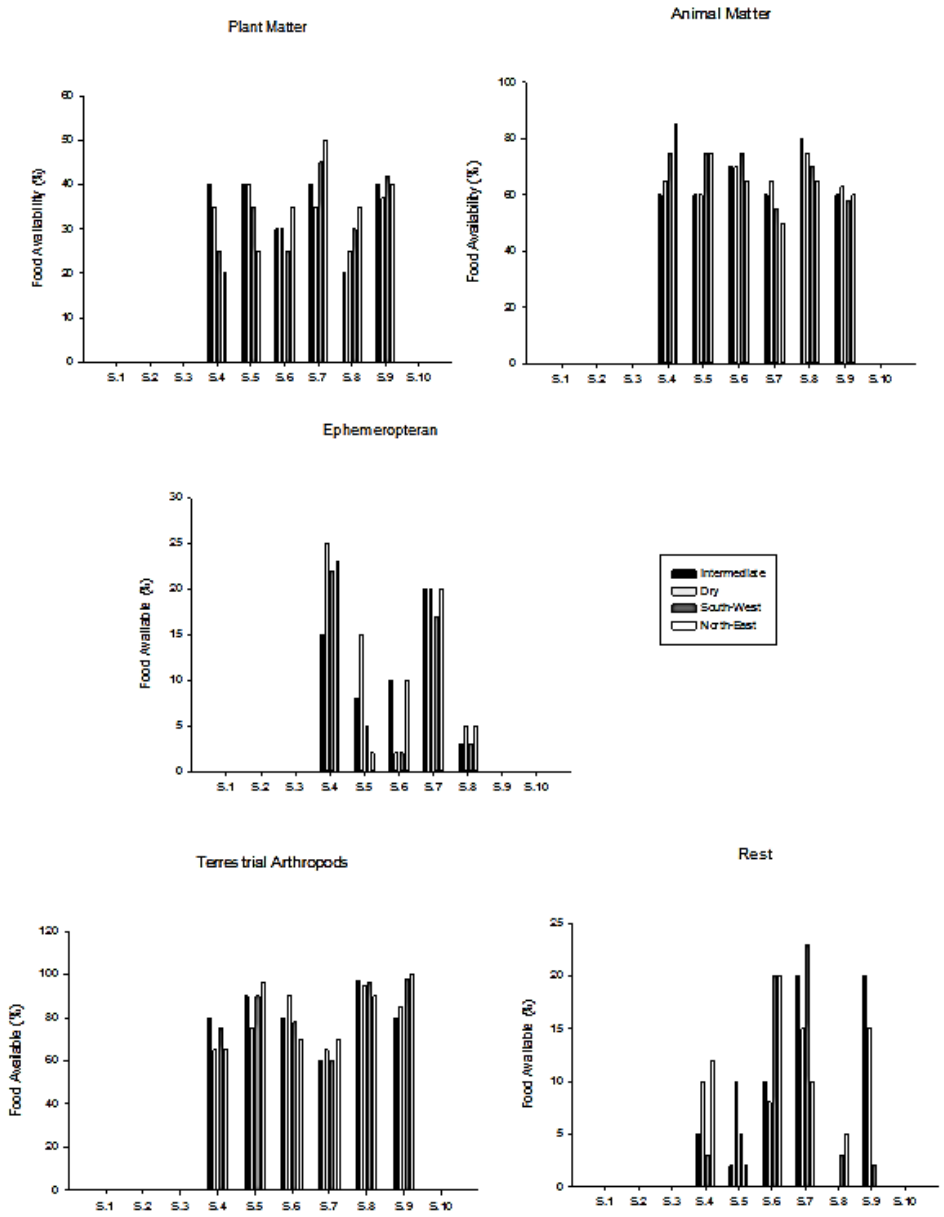

Fig.4. Seasonal changes in the relative abundance of food materials in *Rasbora daniconius* in site 2-10.

consistently represented by animal components and small portion of plant material. In site S7, dietary composition of *R. daniconius* was consistently represented by animal matter, however, 10 to 35% of higher plant material in different seasons was encountered. Gut content of *R. daniconius* were similar to that of *D. aequipinnatus* except in different ratios of Ephermeroptera and the rest group. During the south-west monsoon period, *R. daniconius* fed almost, completely on terrestrial arthropods and during other seasons the animal matter and plant matter were in different ratios. Diets of *R. daniconius* composed mainly of terrestrial arthropods during intermediate and dry seasons and other seasons, Ephemeropteran larvae and the rest group were in small portions. In site 10, dietary composition of *R. daniconius* was completely of animal matter except during south-west monsoon period (Fig. 3D).

In sites S4, S6 and S9, diets of *D. aequipinnatus* composed predominantly of animal matter and the rest group consisted of higher plant material. In site S5, dietary composition of *D. aequipinnatus* was

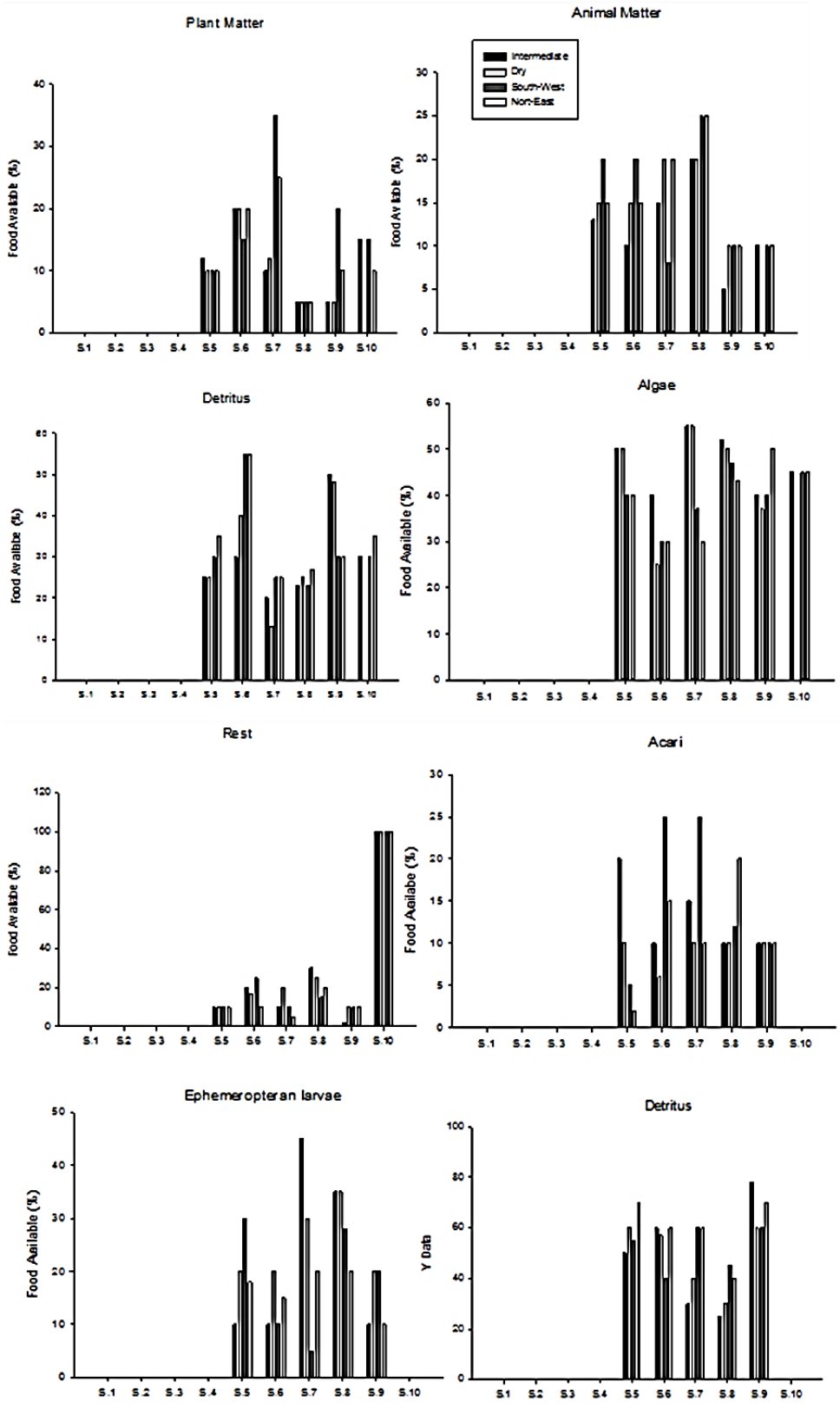

Fig.5. Seasonal changes in the relative abundance of food materials in *Devario aequipinnatus* in site 4-9.

largely of animal matter. *Devario aequipinnatus* and *R. daniconius* preferred terrestrial arthropods in

Table 2. Diet breadths values of cyprinids fishes in four major food items (Algae, detritus, higher plant matter and animal matter).

Site	Species	Intermediate season	Dry Season	South-west monsoon	North-east monsoon
1	*Garra mullya*	0.42	0.38	0.48	0.39
2	*Rasbora daniconius*	0.42	0.36	0.39	0.43
	Garra mullya	0.30	0.27	0.22	0.27
3	*Rasbora daniconius*	0.27	0.43	0.39	0.29
	Garra mullya	0.41	0.29	0.30	0.27
4	*Devario aequipinnatus*	0.29	0.23	0.27	0.21
	Rasbora daniconius	0.29	0.27	0.21	0.21
	Garra mullya	0.42	0.40	0.27	0.42
5	*Devario aequipinnatus*	0.29	0.28	0.27	0.21
	Rasbora daniconius	0.40	0.29	0.35	0.30
	Garra mullya	0.42	0.34	0.40	0.27
	Puntius bimaculatus	0.51	0.56	0.56	0.56
6	*Devario aequipinnatus*	0.27	0.27	0.21	0.29
	Rasbora daniconius	0.29	0.27	0.27	0.14
	Puntius bimaculatus	0.56	0.58	0.56	0.56
	Garra mullya	0.45	0.39	0.37	0.19
7	*Devario aequipinnatus*	0.28	0.22	0.21	0.20
	Rasbora daniconius	0.28	0.21	0.14	0.27
	Puntius bimaculatus	0.53	0.47	0.56	0.58
	Garra mullya	0.41	0.34	0.27	0.19
8	*Devario aequipinnatus*	0.21	0.27	0.27	0.29
	Rasbora daniconius	0.41	0.27	0.14	0.21
	Puntius bimaculatus	0.53	0.56	0.56	0.57
	Garra mullya	0.55	0.44	0.24	0.30
9	*Devario aequipinnatus*	0.29	0.27	0.28	0.27
	Rasbora daniconius	0.24	0.28	0.29	0.29
	Puntius bimaculatus	0.44	0.56	0.56	0.31
	Garra mullya	0.49	0.38	0.30	0.27
10	*Rasbora daniconius*	0.41	-	0.21	0.28
	Dawkinsia filamentosa	0.54	-	0.56	0.56
	Puntius bimaculatus	0.54	-	0.56	0.52

(Note; - No data)

almost all the seasons. In site S7, dietary composition of *D. aequipinnatus* was largely of animal matter but the proportion was decreasing in the south-west and north-east monsoon seasons. The portion of ants and terrestrial coleopterans in gut contents of *D. aequipinnatus* was high whilst Ephemeropteran larvae and the rest group occupied the rest of the portion. In site S8, gut content of *D. aequipinnatus* constituted mainly of animal matter throughout the period, despite a slight fall during north-east monsoon period. Gut contents of *D. aequipinnatus* constituted mainly of terrestrial arthropods with a slight fall during north-east monsoon period (80%) and during the dry season (90%). Diets of *D. aequipinnatus* were consistently represented by animal components; however, a noticeable portion of plant material was also encountered. Gut contents of *D. aequipinnatus* constituted mainly of terrestrial arthropods with a slight fall during dry and intermediate seasons (Fig. 4D).

In site S5, dietary composition of *P. bimaculatus* was higher proportion of algae in all the seasons and the animal matter was too much less. A smaller portion of animal matter in *P. bimaculatus* showed dipteran larvae, Ephemeropteran larvae, acari, water mites and the rest group. In site S6, algae and detritus were the major portions in the gut of *P. bimaculatus* in all the seasons but a slight decrease in algal content was noted during dry season. The composition of animal matter in the guts of *P. bimaculatus* was

Table 3. Diet breadth values for cyprinid fishes in animal matter.

Site	Species	Intermediate season	Dry season	South-west monsoon	North-east monsoon
2	*Rasbora daniconius*	0.27	0.40	0	2.10
3	*Rasbora daniconius*	0	0	0	0
4	*Rasbora daniconius*	0	0	0	0
	Devario aequipinnatus	0	0.40	0.22	0.27
5	*Rasbora daniconius*	0.14	0.28	0.27	0.27
	Devario aequipinnatus	0	0.40	0.22	0.27
	Puntius bimaculatus	0.54	0.41	0.47	0.28
6	*Rasbora daniconius*	0	0.14	0.22	0
	Devario aequipinnatus	0.41	0.27	0.0	0.50
	Puntius bimaculatus	0.47	0.34	0.56	0.47
7	*Rasbora daniconius*	0.21	0.27	0.27	0.22
	Devario aequipinnatus	0.28	0.0	0.22	0.35
	Puntius bimaculatus	0.56	0.56	0.30	0.47
8	*Rasbora daniconius*	0.0	0.40	0.35	0.35
	Devario aequipinnatus	0.41	0.27	0.38	0.30
	Puntius bimaculatus	0.57	0.56	0.57	0.58
9	*Rasbora daniconius*	0.40	0.28	0.41	0.37
	Devario aequipinnatus	0.0	0,40	0.0	0.27
	Puntius bimaculatus	0.28	0.47	0.47	0.41
10	*Rasbora daniconius*	0.23	-	0	0.19
	Puntius bimaculatus	0.21	-	0.28	0.23
	Dawkinsia filamentosa	0.37	-	0.5	0.41

(Note; - No data)

Ephemeropteran larvae, acari and the rest group.In site S7 and S8, diets of *P. bimaculatus* were mainly consisted of algae. In site S9, quantity of algae in the diets of *P. bimaculatus* was always high throughout the period with less proportion of detritus, plant material and animal matter. In site S10, the gut content of *P. bimaculatus* varied in the composition of algae, detritus, plant matter and animal matter (Fig. 5A, B, C, D).

In site S10, the higher portion of algae was noted in gut contents of *D. filamentosa* in all the seasons and a small portion were filled by detritus, plant matter and animal matter. Gut content of *D. filamentosa* composed of dipteran larvae, Ephemeropteran larvae, acari and the rest group (Fig. 6).

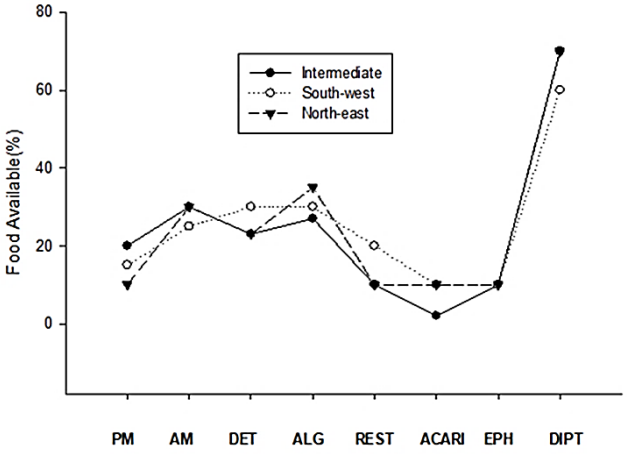

Fig.6. Seasonal changes in the relative abundance of food materials in *Puntius bimaculatus* in Site 5-10.

Diet breadth: Diet breadth values (Tables 2, 3) indicated that the assemblage members had a distinct pattern of specialization and generalization. *Devario aequipinnatus* and *R. daniconius* fall in specialist group. These species fed mainly on terrestrial arthropods from the surface. *Garra mullya* showed a similar degree of specialization as benthivore. *Puntius bimaculatus* and *D. filamentosa* fall into the category of generalist as they feed on plant and animal matter. High diet breath value was observed in the intermediate season, followed by the south-west monsoon and north-east monsoon seasons get second and third places. Dry season get a lowest diet breadth value. Same while, north-east monsoon

Table 4. Seasonal variations in diet overlap index among cyprinids fishes in four major food categories (Algae, detritus, higher plant material and animal matter).

Site	Species	Intermediate season	Dry season	South-west monsoon	North-east monsoon
4	D. a × R. d.	0.90	0.93	0.90	0.94
5	D. a × R. d.	0.90	0.95	0.90	0.70
	D. a × P. b.	0.20	0.30	0.40	0.30
	R. d × P. b.	0.30	0.30	0.40	0.30
	P. b × G. m.	0.75	0.75	0.65	0.70
6	D. a × R. d.	0.70	1.00	0.90	0.90
	D. a × P. b.	0.30	0.40	0.30	0.30
	R. d × P. b.	0.30	0.40	0.30	0.30
	P. b × G. m.	0.90	0.53	0.75	0.70
7	D. a × R. d.	0.95	0.90	0.60	0.80
	D. a × P. b.	0.30	0.30	0.40	0.70
	R. d × P. b.	0.30	0.30	0.40	0.50
	P. b × G. m.	0.70	0.75	0.60	0.55
8	D. a × R. d.	0.80	0.90	0.80	0.90
	D. a × P. b.	0.40	0.45	0.35	0.30
	R. d × P. b.	0.30	0.20	0.30	0.40
	P. b × G. m.	0.51	0.60	0.48	0.43
9	D. a × R. d.	1.00	0.80	0.95	0.93
	D. a × P. b.	0.44	0.40	0.30	0.30
	R. d × P. b.	0.30	0.30	0.40	0.45
	P. b × G. m.	0.50	0.60	0.65	0.60
10	R. d × D. fil.	0.45	-	0.35	0.35
	R. d × P. b.	0.40	-	0.50	0.35
	D. fil × P. b.	0.50	-	0.50	0.45

(Note; - No data)

season obtain a higher value in animal matter, followed by dry and south-west monsoon seasons get second and third places. Intermediate season get a last vale of animal matter.

Dietary overlap: Diets of the assemblage members had a distinct similarity and dissimilarity between and within surface and bottom feeding guilds (Tables 4, 5). The percentage overlap values ranged between 30% and 100%. *Rasbora daniconius* and *D. aequipinnatus* had major overlap with each other with the comparison of both for four major food items and animal diets spatially and temporally. Both food categories overlap between the surface feeders such as *R. daniconius*, *D. aequipinnatus* and *P. bimaculatus* was at a less significant level in all seasons. *Garra mullya* also had overlap with *P. bimaculatus* in all the seasons. In the confluence site S10 generalist such as *D. filamentosa* and *P. bimaculatus* had an overlap with *R. daniconius* in four taxa food items and animal matter category. Among the five cyprinids fishes, highest food overlapping was done in south-west monsoon season. Respectively, intermediate season and north-east monsoon season get second and third places in the food overlapping. Lowest food overlapping was occurred in dry season. Same while, highest animal matter overlapping was occurred in south-west monsoon season, followed by north-east and intermediate seasons among the all cyprinids fishes. Respectively, lowest animal matter overlapping was present in dry season.

Discussion

Analysis of gut content and dietary overlap index exhibited that fish assemblages have distinguished feeding niches. In general, the stream ecosystems are typically poor in nutrients, and fish species presenting in streams are depend heavily on

Table 5. Seasonal variations in diet overlap index among cyprinids fishes in animal matter.

Site	Species	Intermediate season	Dry season	South-west monsoon	North-east monsoon
4	D. a × R. d.	0.81	0.87	0.92	0.83
5	D. a × R. d.	0.79	0.90	0.91	0.88
	D. a × P. b.	0.41	0.38	0.31	0.34
	R. d × P. b.	0.39	0.37	0.36	0.38
6	D. a × R. d.	0.79	0.83	0.71	0.79
	D. a × P. b.	0.31	0.29	0.38	0.37
	R. d × P. b.	0.36	0.34	0.39	0.35
7	D. a × R. d.	0.84	0.91	0.93	0.89
	D. a × P. b.	0.28	0.36	0.37	0.31
	R. d × P. b.	0.21	0.32	0.31	0.29
8	D. a × R. d.	0.80	0.73	0.84	0.83
	D. a × P. b.	0.43	0.38	0.41	0.39
	R. d × P. b.	0.39	0.21	0.19	0.21
9	D. a × R. d.	0.71	0.76	0.81	0.82
	D. a × P. b.	0.31	0.29	0.36	0.34
	R. d × P. b.	0.21	0.28	0.36	0.37
10	R. d × P. b.	0.28	-	0.27	0.42
	R. d × D. fil.	0.38	-	0.39	0.14
	D. fil × P. b.	0.49	-	0.54	0.57

(Note; - No data)

allochthonous food resources (Atkinson et al. 2018). Analysis of food use and food overlap allowed characterization of the fish assemblage in to three guilds, surface feeding fishes which feed predominantly on terrestrial insects and allochthonous matter, in which *R. daniconius* and *D. aequipinnatus* are included in this category; bottom feeding fish guilds consists of *G. mullya* and the intermediary guilds which feeds both in water column and on bottom substrates are *P. bimaculatus* and *D. filamentosa*. The present study revealed the diet preference of *G. mullya* as algae and detritus foods in south-west and intermediate season. In addition, it is consuming less animal matter in all sites of north-west monsoon season. Moreover, *R. daniconius* gives high food preferences to the animal matter and terrestrial arthropods, rather than plant matter. It is broadly accepted simplification that streams fishes are mostly adaptable in their feeding habits because of the highly adjustable nature of habitat and resources. This above statement is clearly associated with past freshwater fish study (Johnson & Arunachalam 2012; Baumgartner 2007). Meanwhile, segregation patterns are obvious between the guilds. Generalist or intermediary guild species have a major degree of dietary overlap with surface feeding species like *D. aequipinnatus* and bottom dwelling species such as *G. mullya*. A similar phenomenon has been observed elsewhere between fish guilds (Yoshiyama 1981).

The consistent pattern of surface feeders such as *D. aequipinnatus* and *R. daniconius*on animal food is similar to other reports available in Sri Lankan streams (De Silva et al. 1979). In this research finding, *D. aequipinnatus* gives the high food pretenses to terrestrial arthropods followed by animal matter and plant matter. This indicates a consistency in feeding habits of these species to a level of specialized morphological features for such type of feeding.

Garra mullya was probably the best studied stream fish species (Bose et al. 2019). For this species, a diet comprising detritus and algae has been reported by several workers (Somvanshi & Bapat 1979; Arunachalam et al. 1997). This disagrees well with our findings in which detritus and algae are common in gut contents of *G. mullya* in all sites throughout the seasons. This species exhibits a degree of food

specialization. Moreover, the stream ecosystem has in depends on the allochthonous food resources due to the lack of primary. This statement was in near to the previous researches (Dudgeon 1999; Herder & Freyhof 2006). In addition, the top feeder of five cyprinidae species was occupied in the surface portion of stream water for efficient utilization of allochthonous resources it is well-known in the Southern Western Ghats. This statement was given addition support to the previous studies (Johnson 1999).

Dietary composition also exhibits differences for certain species. Previous research finding stated that, the diets of *D. filamentosa* mainly consist of higher plant materials (Sobhana & Nair 1976; Johnson and Arunachalam 2009), while in the present study, the diet of *D. filamentosa* comprises mainly in dipterian larvae. This benthic species generally exhibits an opportunistic feeding behaviour rather than a highly specialized one. This is particularly true for *D. filamentosa* which, in the phytoplankton rich lakes and reservoirs of the low lands, it switches from a benthivorous feeding to pelagic feeding and to feeding on water plants in the littoral zone (Vijayakumar et al. 1985).

*Puntius bimaculatus*is the food specialization of algae and detritus in study sites of S5-10 at intermediate and dry seasons. Moreover, basically stream ecosystem consists of poor in primary nutrient production. So, the fish species heavily depends upon the self-movement food resources. There is a considerable disagreement over the major processes affecting assemblage organization in stream fishes (Grossman & Freeman 1987). Some investigators maintain the coexistence among stream fishes can be attributed to partitioning of resource on food and space (Mookerji et al. 2004). In particular, it has been suggested that spatial resource partitioning is very important for coexistence of fishes (Resende Manna et al. 2020). Other investigators, however, maintain that resource partitioning may not be general importance to the community structure of stream fishes but is due to the frequency of natural disturbances such as floods and droughts (Boix et al. 2010). The present study emphasizes the importance of spatial segregation rather than food segregation; similar findings are reported in fish communities in rainforest-streams of Sri Lanka (Moyle & Senansyke 1984).

Huge number of diet overlap was occurred in *D. aequipinnatus* and *R. daniconius* at the south-west monsoon season, followed by intermediate season, and north-east monsoon seasons (Herder & Freyhof, 2006). *Rasbora daniconius* and *P. bimaculatus* get a lowest diet overlap in dry season. In addition, south-west monsoon season get a higher range of dietary overlap in animal matter at *D. aequipinnatus* and *R. daniconius* followed by north-east and intermediate seasons. Meanwhile, lowest overlap reading was observed in dry season. The seasonal food changes were observed in cyprinids. These finding results were in near to the previous studies (Matthews 1998; Oueda et al. 2008). Most studies on feeding habitats of tropical stream fishes have found a large amount of dietary overlap and have a reliance on allochthonous food, mainly terrestrial arthropods and detritus of terrestrial origin (Lowe McConnell 1975). The present study suggests that, surface feeding fishes are more overlapped with other fishes. The column dwelling fishes have overlap with surface feeding and bottom dwelling fishes.

Conclusions

This study has shown that the diets of the selected fish assemblage members had a distinct similarity and dissimilarity between and within the surface and bottom feeding guilds. Our present study aimed to explain the fish food habits of the freshwater. Dietary overlap indicates that surface feeding fishes have more overlap. The column dwelling fishes have overlap with surface feeding and bottom dwelling fishes in the river Chittar of Western Ghats. The present study provides knowledge about Cyprinidae fish family food abundance and their feeding habits in the stream ecosystem.

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مقاله پژوهشی

تقسیم‌بندی تغذیه‌ای پنج گونه کپورماهی در رودخانه چیتار، جنوب غربی قاتس، هند

ساهول حمید ساجن، رادهاکریشنان پالانیکانی، کومارسان سابای سورنا دوی، ساکتی وادیول سلوانیاگی، عبدل آسان ساتالی، محمد شکیلا، رامایا سورانام*

مرکز عالی علوم محیطی سری پاراماکالیانی، دانشگاه مانون مانیام، الوارکوریچی، تیرونلولی، تامیل نادو، هندو.

چکیده: رژیم غذایی و اکولوژی تغذیه‌ای گونه‌های کپورماهی *Devario aquipinnatus*، *Rasbora daniconius*، *Puntius bimaculatus*، *Dawkinsia filamentosa* و *Garra mullya* به منظور بررسی پهنای آشیان غذایی و همپوشانی آن‌ها در رودخانه چیتار، جنوب غربی قاتس، هند مورد مطالعه قرار گرفت. رژیم‌های غذایی گونه‌های *D. aquipinnatus* و *R. daniconius* مواد جانوری و بندپایان خشکی‌زی بودند، در حالی که *P. bimaculatus* و *D. filamentosa* به‌ترتیب ترکیب بالایی از جلبک‌ها و بخش کوچکی از مواد پوده‌ای را مصرف می‌کردند. در ضمن قسمت اندکی از مواد جانوری در روده *P. bimaculatus* وجود داشت در حالی که *G. mullya* فقط از جلبک‌ها و مواد پوده‌ای با مقادیر بیشتری از مواد گیاهی را تغذیه می‌کرد. تحلیل پهنای آشیان غذایی براساس شاخص لون در تمام فصل‌ها همپوشانی بالایی بین گونه‌های *R. Daniconius* و *D. aquipinnatus* و بین *G. mullya* و *P. bimaculatus* را نشان داد. در محل تلاقی مکانی، گونه‌های عام‌گرا نظیر *D. filamentosa* و *P. bimaculatus* همپوشانی در چهار رده غذایی و دسته مواد جانوری را با گونه *R. daniconius* نشان دادند. گونه‌های *D. aquipinnatus* و *R. daniconius* در گروه تخصص‌گرا قرار می‌گیرند. گونه‌های *D. aquipinnatus* و *R. daniconius* نیز عمدتاً از بندپایان خشکی‌زی از سطح آب تغذیه می‌کنند. *Garra mullya* دامنه تغذیه‌ای کمی در تمام فصول دارد. در میان گونه‌های همزیست، همپوشانی‌های غذایی به طور محسوسی در همه فصل‌ها کم بود. در میان پنج گونه کپورماهی مورد مطالعه، بالاترین پهنای آشیان غذایی و بیشترین همپوشانی غذایی در فصول میانه و موسمی جنوب-غرب مشاهده شد. این نتایج پیشنهاد می‌کند که رژیم غذایی اجتماع ماهی‌های مورد مطالعه، شباهت و عدم شباهت مشخص در بین صنف‌های تغذیه‌ای سطحی و کفزی داشتند. نتایج، همزیستی پنج گونه کپورماهی مورد مطالعه در منطقه مورد بررسی از رودخانه چیتار که در آن یک اجتماع نهری بسیار ساختار یافته مشاهده می شود را آشکار ساخت.

کلمات‌کلیدی: ماهیان نهری، بوم‌شناسی ماهیان، پهنای آشیان غذایی، همپوشانی غذایی، همزیستی.