7. SUMMARY

Niche is a useful measure in modern ecology to describe resource utilization and interspecific interaction in communities. Resource partitioning in fish communities is an interesting topic and the studies date back to early 50’s. The studies on resource partitioning and niche structure are very few in tropical countries. The present investigation on niche segregation in fish communities at different habitat types of a river is first of its kind in India. The niche segregation pattern in fish communities are usually studied on macrohabitat, microhabitat, diet and ecomorphological variables.

Physical, chemical and biotic features of the macrohabitat were measured seasonally at selected study sites in Kallar River. The microhabitat measures like depth, velocity and substrate categories were estimated at all study sites for each individual fish. The feeding habits of each fish species at each habitat type during different seasons were estimated by dietary analysis for one year. Measurements of morphological characters which reflect the niche specialisations were done on each fish species.

Physical and chemical features were useful in characterising the nature of habitat types, but these variables never influenced the distribution of fish species in the river system. The important chemical variables for characterising the habitat types were dissolved oxygen, hardness, alkalinity, silicate and total organic carbon. Of the total 16 fish species encountered in Kallar River, 8 were (Danio aequipinnatus, Barilius bakeri, Rasbora daniconius, Garra mullya, Labeo dero, Puntius amphibiuss, P. filamentosus and P. melanampyx) common and abundant and rest were (P. sarana, P. ticto, Mystus armatus, M. montanus, Xenentodon cancila, Glossogobius giuris, Tor khudree and Channa gachua) uncommon and less abundant. Most of the common and abundant fish species were homogeneously distributed in all habitat types, but some less abundant and uncommon species were selective in their habitat type choices. P. sarana and X. cancila were found only at river habitats, while P. ticto was present only at lowland streams. L. dero was absent at lowland streams but T. khudree was present only in hill streams.
Niche segregation pattern in fish communities of Kallar River was assessed through the following niche metrics: (1) Relative depth (2) Focal point velocity (3) Water column depth (4) Mean water column velocity (5) Substrate categories - constituting microhabitat variables and (6) food. Among the microhabitat variables, relative depth was the most important one in determining the resource partitioning pattern. This variable clearly determined the pattern of vertical segregation of fish species to surface, high, middle, low or bottom positions in water column. The next important variable was water column depth which determined the horizontal segregation pattern of fish species to shallow, moderately deep or deep waters of the habitat. The association of fish with the substrate categories indicated the preference to a particular substrate category mainly for feeding necessities. Hence this variable was also considered as the third important metric in niche segregation assessment. Mean water column velocity and focal point velocity were relatively less important and were the poorest discriminators in resource partitioning estimates. Microhabitat breadth values indicated the extent of utilisation of a particular microhabitat variable by each fish species. High value reveals the maximum utilisation of different microhabitat variables and the least value, the minimum usage. This leads to the pattern of generalisation or specialisation of fish species to microhabitat parameters. In general, *P. filamentosus* was found to be the most generalised and *G. mullya* the most specialised on microhabitat resource axes among the common and abundant fish species in Kallar River. Mean overlap values showed that fish species are highly segregated on relative depth (low mean overlap value) followed by water column depth and substrate types. This reveals the degree of sharing of each resource variable and the extent of interspecific interactions.

Food is another most important niche metric which determined the pattern of segregation in fish communities of Kallar River. Based on the feeding habitats, the fishes were categorised as surface feeders, bottom feeders and column feeders. In general the most used food bases in Kallar River were terrestrial arthropods by surface feeders, small and filamentous algae by column and bottom feeding fishes and chironomids and other microinvertebrates by bottom feeding and column feeding fishes.

A possible high interaction for food resources was noted among *Danio aequipinnatus*, *Barilius bakeri* and *Rasbora daniconius* and between *P. filamentosus* and *P. amphibius*. The
Surface feeders interact much less with column feeders or bottom feeders than column feeders with bottom feeders. Moreover, diet shift was noted especially amongst surface feeders with spatial variations and scarcity of preferred food resources. But temporal changes never influenced the dietary composition of fish species at any habitat type. Low diet breadth values of surface feeding fishes and bottom feeding fishes indicated their specialised feeding habits on terrestrial arthropods and algal resources respectively. High diet breadth values of *Puntius* spp. showed that these fish species were food generalists.

The ecomorphological variables like mouth position, eye position, number of barbels, number of gill rakers and mouth width indicated the nature of feeding of fish species from surface, bottom or water column. The other morphological variables measured reflected the specialisation for microhabitat choices like high flow regime (pectoral and pelvic fins, stream lined body) or low flow regime and deep habitats (dorsolateral eyes, dorsolaterally flattened body).

Generally the fish species are assigned to different guilds like surface, bottom or column based on the analysis of all niche variables and ecomorphological structure. The surface guild includes *D. aequipinnatus*, *B. bakeri* and *R. daniconius* and was partitioned either horizontally or vertically. Bottom guild consists of *G. mullya*, *L. dero* and *P. amphibius* segregated mainly by substrate categories and/or food. The water column guild contains *P. filamentosus* and *P. melanampyx* and are mainly partitioned through water column depth. The segregations on a microlevel is also evident among surface feeders by partitioning through water column depth and relative position. *D. aequipinnatus* occupied surface position in deep areas and *B. bakeri* at high position in deep areas. But *R. daniconius* preferred shallow areas at high/surface position. Moreover, the overlap calculation, which is a measure on the degree of interaction/competition between species pairs, shows that the segregation was prominent on food, relative depth, water column depth and substrate type variables. Again from the entire significant overlaps (≥0.67), the meaningful pair wise combination were identified from relative depth and water column depth. This included the following combinations: *P. filamentosus* × *P. amphibius*, *L. dero* × *P. filamentosus*, *G. mullya* × *P. amphibius*, *B. bakeri* × *R. daniconius*, *D. aequipinnatus* × *B. bakeri* and *P. aequipinnatus* × *R. daniconius*. These overlaps were again separated among fish species belonging to different guilds or substrate type associations and this in turn resulted in the most important combinations of fish species on all niche variables like
D. aequipinnatus X B. bakeri, D.aequipinnatus X R. daniconius, B. bakeri X R. daniconius and P. amphibius X P. filamentosus. Among these combinations, a high morphological overlap was noted between P. amphibius and P. filamentosus.

Based on the results on the niche structure, the present study proposes a hypothesis namely empty niche hypothesis. This suggests the possible inclusion or accommodation of more fish species of generalist nature in the community without affecting the stability or sensibility of the structure under optimal environmental conditions.

Furthermore, the fish communities in Kallar River are generally structured by biotic (= deterministic) forces except for two or three sites in high land area (hill stream) which are expected to be structured by abiotic (= stochastic) forces.

Finally, the usefulness and implications of the study on the structure and function of fish communities in Kallar River are suggested in the light of various hypotheses like river continuum concept, stream ecosystem theory, patch dynamics, competition crunch hypothesis and niche diversification hypothesis. Predictions on ecological/evolutionary perspective are made on four-dimensional scale on the structure and function of fish communities in Kallar River. The implementation of biomonitoring of running water with fish community structure and composition in tropical conditions based on index of biotic integrity and the need for the revision and suitable modifications of the existing theories and hypotheses in community ecology and lotic ecology are suggested.