Impact of riparian land use on stream insects of Kudremukh National Park, Karnataka state, India

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Abstract

The impact of riparian land use on the stream insect communities was studied at Kudremukh National Park located within Western Ghats, a tropical biodiversity hotspot in India. The diversity and community composition of stream insects varied across streams with different riparian land use types. The rarefied family and generic richness was highest in streams with natural semi evergreen forests as riparian vegetation. However, when the streams had human habitations and areca nut plantations as riparian land use type, the rarefied richness was higher than that of streams with natural evergreen forests and grasslands. The streams with scrub lands and iron ore mining as the riparian land use had the lowest rarefied richness. Within a landscape, the streams with the natural riparian vegetation had similar community composition. However, streams with natural grasslands as the riparian vegetation, had low diversity and the community composition was similar to those of paddy fields. We discuss how stream insect assemblages differ due to varied riparian land use patterns, reflecting fundamental alterations in the functioning of stream ecosystems. This understanding is vital to conserve, manage and restore tropical riverine ecosystems.

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Introduction

The Western Ghats, running parallel to the west coast of India between 8° N and 21° N is a prominent landscape feature of the peninsular India (see Map). This 1600 km long chain of mountains along with Sri Lanka is one of the biodiverisity hotspots for terrestrial and freshwater organisms (Myers et al., 2000; WCMC, 2000). Insects are the most diverse group of organisms in freshwater streams and rivers. Aquatic insects of riverine ecosystems, comprising some well-known groups such as mayflies (Ephemeroptera), dragonflies (Odonata) and caddies flies (Trichoptera) are important organisms in stream ecosystem function (Merrit et al., 1984; Wallace and Jackson, 1996). In addition to significant ecosystem function, aquatic insects are reliable indicators of human impact on freshwater ecosystem. Biological monitoring methods using aquatic insects have been developed and reliably tested in both temperate and tropical aquatic systems (Resh, 1979; Armitage et al., 1983, Trivedi, 1991 and Sivaramakrishnan et al., 1996).

The terrestrial drainage basin and the stream channel, with its associated physical heterogeneity determine the spatial variation of the stream ecosystem (Schlosser, 1991). The nature of streams and rivers reflects the physical and biological processes occurring in the catchment (Johnson and Gage, 1997; Allan, 2004). Studies have addressed the linkage between the stream and its valley from ecological, geomorphic and hydrological perspective. However, the relationship between biotic community structure and in-stream processes is little understood (Johnson and Gage, 1997).

Anthropogenic activities such as the river valley projects have drastically transformed the riverine ecosystems all over the world. In addition to the river valley projects, the landscape transformations are probably responsible for the most widespread damage to the rivers and streams (Allan, 1995; Dudgeon, 2000; and Allan, 2004). In tropical Asian countries, catchment deforestation and agricultural expansion are important factors for deterioration of the riverine ecosystem (Dudgeon, 1992). In temperate streams it is very well documented that the changes in catchment land use results in the loss or a change in diversity of invertebrates and fishes (Corkum, 1989; Allan, 1995; Vinson and Hawkins, 1998). Similarly, in tropical Asia, though it is known that deforestation of the catchment affects fish populations (Dudgeon, 1992, Dudgeon, 1999) the impact of catchment land use on the stream insect communities is poorly understood. In freshwater biodiversity hotspots like the Western Ghats, no information is available on this topic. Such information is very important to understand the impact of ongoing landscape transformations on the biodiversity of rivers in general and insect communities in particular. This information will also aid in developing conservation strategies for the riverine ecosystems of tropical biodiversity hotspots such as the Western Ghats. We address the impact of riparian land use on stream insect communities by studying the change in diversity and composition of aquatic insects in streams with different riparian land use types at Kundremukh National Park, Karnataka state in the central Western Ghats. Here we define the riparian land use as the most predominant land use type within the stream catchment.

Materials and Methods

Study Site

The study on the stream insect communities, within a landscape of 305 km^2 was carried out in Kudremukh National Park. This study area with an average annual rainfall of 5500 mm is located between latitudes 13° 9' and 13° 19' N and longitudes 75° 5' and 75° 15' E. The altitude ranges from 60 m in the western slopes to 1666 m in the eastern plateau. This region forms the catchment for the Tunga, Bhadra (Krishna basin) and Swarna Rivers of peninsular India (see Map).

The dominant vegetation types in the study area are tropical wet evergreen and semi-evergreen forests. The central, northern and eastern parts of the study area comprise a formation of rolling hills with a mosaic of grasslands and montane evergreen forests (Pascal, 1988). The forest formation in the western slopes below 300 m is human influenced and is semi evergreen in nature. A mosaic of landscape element types replaces natural vegetation below 200 m. Plantations of various kinds especially the areca nut (*Areca catechu*) dominate this landscape. An important environmental problem of the region is the iron ore mining in the crest lines of the mountains. The river Bhadra flows eastwards after draining the mining area. On the western slopes, just below the iron ore mines, the river Swarna drains a portion of Kudremukh National Park. Aquatic insects were

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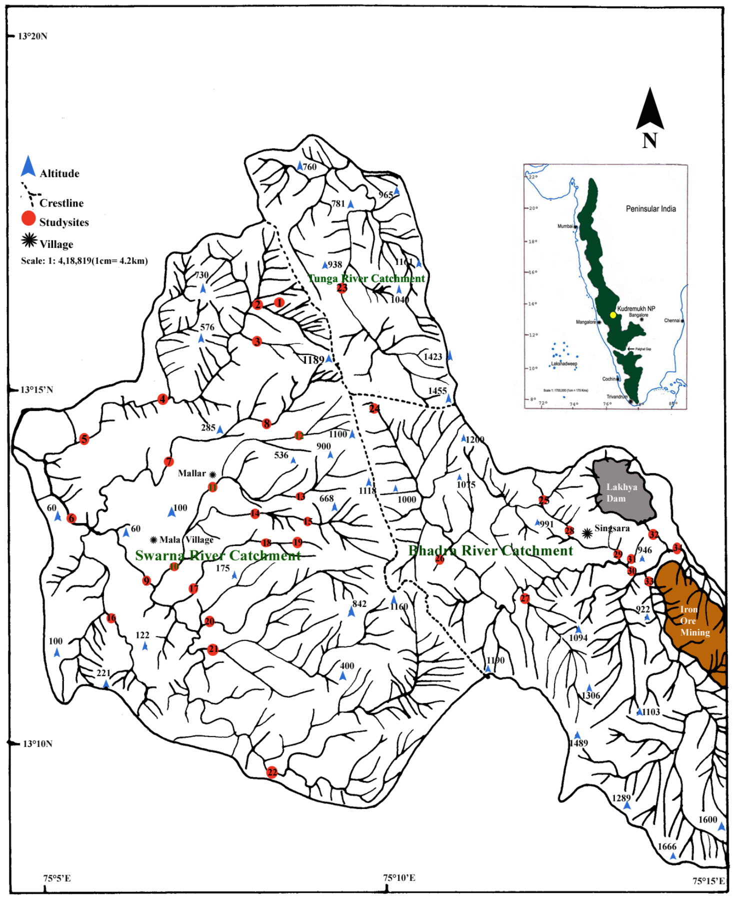
Map: Location of study sites within Kudremukh National Park. Inset: Location of Kudremukh National Park in the Western Ghats.



sampled in Tunga, Bhadra and Swarna catchments. These catchments together represent all the important landscape element types of the Western Ghats (Nagendra and Gadgil, 1998).

Sampling Design

Data on stream insect communities were collected from August 1999 to December 2001. Previous studies have shown that aquatic insects are best sampled in the Western Ghats during post monsoon period from August to December (Sivaramakrishnan et al., 2000). Aquatic insects were collected from 34 study sites in 83 sampling sessions (Map, Appendix-1). At each study site, a stretch of approximately 100-150 m was selected for collection of samples from the three target habitats, for example cascades, low gradient riffles and pools. The stream habitats were classified according to McCain et al. (1990). In addition to biological sampling, eight environmental variables were also recorded for each sampling session (Table 1).

Table 1. Environmental variables recorded for the samples.

Sl.No	Variable	Measure	Description
1	Altitude	Meters	Meters above Sea Level
2	Substrate	Richness	Sum of presence of substrates: mud, sand, gravel, cobble, boulder, bedrock, leaf litter and peat
3	Width	Centimeters	Average stream width
4	Depth	Centimeters	Average stream depth
5	Canopy Cover	Percent canopy cover	Percent area shaded by riparian vegetation
6	Temperature	°Celsius	Mid column water temperature
7	pH	pH	Using Qualigens narrow range pH paper
8	Turbidity	Ranking 0-3	Rank-0 is the least and 3 is the most turbid

In cascades an 'all out search' method was used to collect the aquatic insects. The effort in sampling in cascades was standardized by restricting the collection of aquatic insects from an area of 10 m^2 for one hour. Within the sampling area, aquatic insects were searched and collected from substrata such as bedrocks, boulders, cobbles, leaf litter and dead wood. In low gradient riffles, aquatic insects were sampled by taking three, 1-minute kick-net samples (mesh opening: 180 µm; area 1 m^2).

Aquatic insects on water surface of the pools were collected using a nylon pond net (mesh opening: 500 µm; diameter: 30 cm; depth: 15 cm). The all out search method was employed to collect aquatic insects from the substratum in the pools.

Collected samples were preserved in 70% ethanol and assigned to family and genus using taxonomic keys for that particular group (Dudgeon, 1999; Fraser, 1933-36; Morse et al., 1994; Thirumalai, 1989, 1999, Wiggins, 1996). All the genera encountered during the study were assigned a habit and functional feeding group category (Merritt and Cummins, 1996; Sivaramakrishnan, 1992). The study landscape was classified into 9 riparian land use types (Nagendra and Gadgil, 1998; Ghate et al., 1998).

Analysis

A total of 6,755 individuals belonging to 72 genera and 46 families were collected from 83 sampling sessions. One sample had unusually high abundance of a genus (Helicopsychidae: *Helicopsyche*) with 2052 individuals. This sample was dropped from the analysis. Since the sample sizes were unequal (Figs. 1 and 2), rarefied family and generic richness at 0.01 confidence interval was estimated using an unbiased version of the rarefaction formula (Hurlbert, 1971). In addition to this, alpha or point diversity and beta or differentiation diversity were measured using Shannon and Jaccard's indices (Magurran, 1988). The cluster analysis was used to examine similarity in community composition across streams with different riparian land use types. 1-Jaccard's index was subjected to simple linkage Euclidean distances and results were plotted as dendrogram (STATISTICA, 1999). The environmental correlates of family and generic richness were investigated using Spearman rank order correlation (STATISTICA, 1999).

Results

Diversity

The rarefied family and generic richness, and Shannon's index was highest for the streams with semi evergreen forests as riparian vegetation. The rarefied family and generic richness of streams with two other natural riparian vegetation type, for example evergreen forests and grasslands, were lower than of stream with human habitations and areca nut plantations as riparian land use type. The stream with paddy cultivation and iron ore mining as riparian land use type had the lowest rarefied richness (Table 2, Appendix 2).

Fig. 1. Generic accumulation curves across streams flowing through natural riparian land use types. Each point indicates one sampling locality.

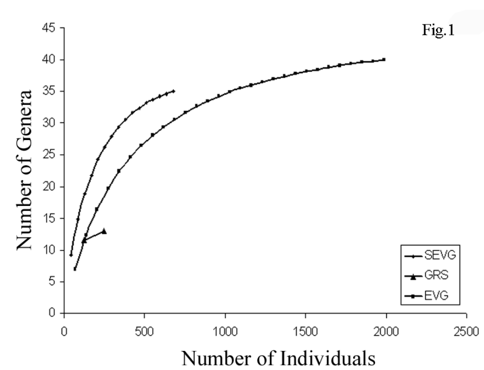
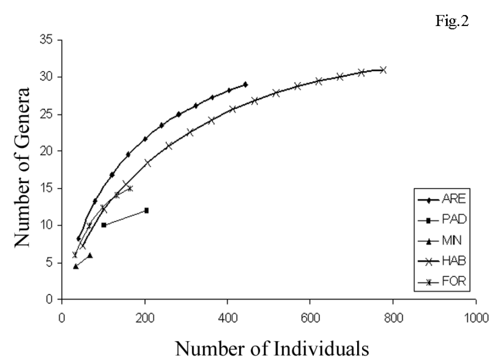


Fig. 2. Generic accumulation curves across streams flowing through human influenced riparian land use types. Each point indicates one sampling locality.



The family and genera turnover across the streams with different riparian land use types shows that, at the level of genera and family, the evergreen, semi evergreen forests, human habitations and areca nut plantations are similar. The aquatic insect families of the streams with grasslands, paddy fields, forestry plantations and iron mines as riparian land use type clustered into two groups. The grasslands and paddy fields formed the first group and the forestry plantations and mines the second group. At the level of genera, the forestry plantations grouped with grasslands and paddy fields, and mines did not cluster with any of the groups. The streams with scrubs as riparian land use type had distinct community composition both at family and generic level (Figs. 3 and 4).

Table 2. Alpha diversity of family and genera across streams draining different RLU types.

		RLU Types								
		EVG	SEVG	HAB	ARE	GRS	PAD	SCR	FOR	MIN
	Number of Individuals	1989	679	775	444	250	205	126	166	69
Family	Rarefied richness	16	23	20	21	12	12	12	12	8
	Shannon	1.566	2.641	2.52	2.481	1.984	1.876	1.814	1.892	1.558
Genera	Rarefied richness	20	29	25	26	15	15	14	16	9
	Shannon	1.703	3.028	2.854	2.875	2.166	2.024	1.906	2.152	1.772

Fig. 3. Similarity in family composition across streams flowing through different riparian land use types.

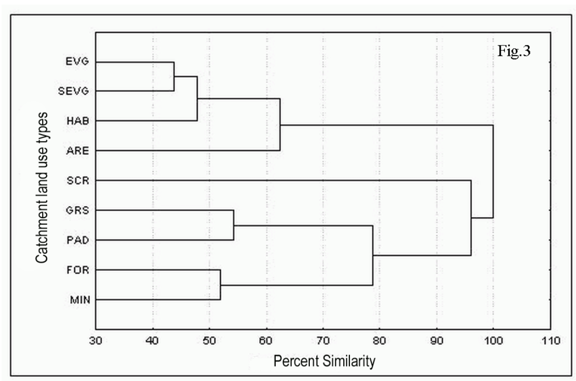
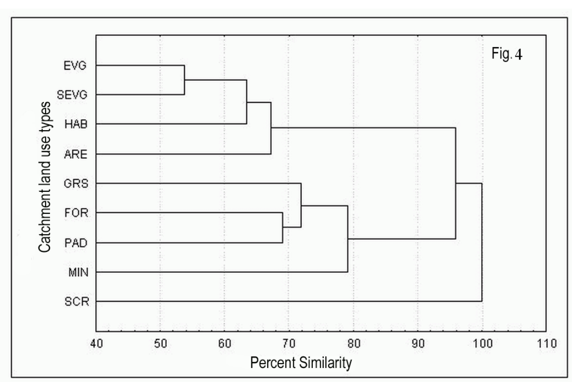


Fig. 4. Similarity in generic composition across streams flowing through different riparian land use types.



The genera such as *Helicopsyche* (Trichoptera: Helicopsychidae) *Dineutus* (Coleoptera: Gyrinidae), *Enithares* (Hemiptrea: Notonectidae), *Notoplebia* (Ephemeroptera: Leptophlebiidae), *Limnogonus* (Hemiptrea: Gerridae), *Hydropsyche* (Trichoptera: Hydropsychidae), *Petersula* (Ephemeroptera: Leptophlebiidae) *Agapetus* (Trichoptera:Glossosomatidae) and *Blaberidae* (Blattodea) characterize the streams with riparian evergreen and semi evergreen forests, areca nut plantations and human habitations. The insect communities in streams with natural riparian grasslands, forestry plantations and paddy fields were entirely different. The genera such as *Choroterpes* (Ephemeroptera: Leptophlebiidae), *Epeorus* (Ephemeroptera: Heptageniidae), *Eubrianax* (Coleoptera: Psephinidae), *Baetis* (Ephemeroptera: Baetidae) and *Simulium* (Diptera: Simuliidae) characterize these streams.

The streams with mining or scrub as riparian land use types were characterized by genera such as *Choroterpes* (Ephemeroptera: Leptophlebiidae), *Epeorus* (Ephemeroptera: Heptageniidae) *Baetis* (Ephemeroptera: Baetidae) and *Wormaldia* (Trichoptera: Philopotamidae). Family and generic richness were not significantly correlated ($P > 0.05$) with any of the environmental variables tested (Table 3).

Table 3. Correlates of family and generic richness with environmental variables (Spearman Rank Order Correlation; N=79, P ≥ 0.05)

	Altitude (m)	Width (m)	Depth (m)	MHR	CNC	Temperature (°C)	pH	TUR
Family richness	0.02	-0.04	-0.14	0.27	-0.12	0.06	0.13	0.04
Generic richness	0.07	-0.02	-0.14	0.28	-0.13	0.04	0.09	0.03

Habit and functional group organization

The distribution of proportional abundance of habits and functional groups shows that the number of stream insect habits remains unchanged across riparian land use types. However, the proportion of habit classes change. In the streams with evergreen forests as riparian vegetation, clingers and skaters contribute about 49 and 43 per cent of total individuals. The clingers and sprawlers dominated the streams with other riparian land use types. However, in the streams with paddy fields, habitations and mines as riparian land use types, 10 per cent of the individuals were swimmers. The divers and climbers were not represented in the sample (Table 4).

The proportional abundance of functional groups in the streams with different riparian land use types

Table 4. Proportional abundance of aquatic insect habits in the streams flowing across RLU types.

	RLU TYPES								
Habits	**EVG**	**SEVG**	**SCR**	**GRS**	**FOR**	**ARE**	**PAD**	**HAB**	**MIN**
Burrowers	0	0.05	0.2	0	0	0.04	0	0.08	0
Climbers	0	0	0	0	0	0	0	0	0
Clingers	0.49	0.72	0.6	0.71	0.5	0.69	0.75	0.61	0.61
Divers	0	0	0	0	0	0	0	0	0
Skates	0.44	0.08	0.01	0	0	0.1	0	0.08	0
Sprawlers	0.04	0.11	0.14	0.2	0.45	0.1	0.13	0.13	0.28
Swimmers	0.03	0.05	0.06	0.09	0.05	0.07	0.11	0.1	0.11

shows that the macrophyte piercers, though at a very low abundance were present only in the streams with scrub, areca nut plantations and human habitations as riparian land use type. The predators dominate the streams with evergreen forests as riparian vegetation. On the other hand, the collectors dominate the streams with the human influenced riparian land use types such as scrub, areca nut plantations and paddy fields. The streams with natural riparian vegetation had relatively low proportional abundance of collectors. The scrapers dominated the streams with grasslands, forestry plantations and mines as riparian land use type. The shredders were present only in the streams with evergreen, semi evergreen forests and habitations as riparian land use type, and the proportional abundance was very low (Table 5).

Discussion

The present study shows that, within a landscape, the diversity and community composition changes with riparian land use pattern. However, it has been argued that in tropical Asia it is difficult to distinguish changes due to human impact from changes resulting from natural variability at various spatial and temporal scales (Dudgeon, 1999). In the current study, lack of any significant correlation of family and generic richness with environmental variables (Table 3) indicate that riparian land use may be very important in determining stream insect community structure at a landscape level in the Kudremukh National Park.

Within a landscape at Kudremukh National Park, the family and generic richness was higher in the streams with natural riparian vegetation than with the human modified ones (Table 2). An exception to this was the streams with riparian grasslands, where the diversity was comparable to that of the stream with riparian paddy fields. However, the rarefied family and generic richness in the two human modified riparian land use type, for example areca nut plantations and habitations, were higher than that of the evergreen forests. The streams with riparian evergreen forests in Kudremukh are mostly shaded first order streams. On the other hand, the streams with riparian semi evergreen, habitations and areca nut plantations are partially shaded second order streams. The high diversity in partially shaded streams was expected as it represents transition zone from the heterotrophic to autotrophic ecosystem (Vannote et al., 1980). The high diversity of heterotrophic - autotrophic transition zone was expected, as taxa evolved in both systems can co-exist. The low diversity in the streams with the natural riparian grasslands may be due to reduced detritus input from the surrounding landscape. The detritus from the riparian zone is an important source of food for the stream insects and also plays a significant role in determining the diversity (Allan, 1995). The low diversity in streams with human modified riparian land use type is attributed to change in habitat brought out by decreased detritus input, increased sedimentation and runoff (Hershey and Lamberti, 1998). Similar results were also reported from the river Cauvery in southern India, where the streams with natural riparian vegetation had higher richness than the ones with the agriculture (Sivaramakrishnan, 1992).

Table 5. Proportional abundance of aquatic insect functional groups in the streams flowing across RLU types.

	RLU TYPES								
Functional Group	**EVG**	**SEVG**	**SCR**	**GRS**	**FOR**	**ARE**	**PAD**	**HAB**	**MIN**
Collectors	0.12	0.32	0.63	0.21	0.3	0.43	0.56	0.36	0.35
Macrophyte Piercers	0	0	0.12	0	0	0.02	0	0.05	0
Predators	0.47	0.19	0.06	0.04	0.12	0.22	0.06	0.19	0.04
Scrapers	0.4	0.48	0.19	0.76	0.58	0.3	0.37	0.39	0.61
Shredders	0.01	0.01	0	0	0	0.03	0	0.01	0

The family and generic turnover across streams with different riparian land use types shows that the evergreen forest and semievergreen forest habitations and areca nut plantations are similar in taxa composition (Figs. 1 and 2). The streams with these riparian land use types are either completely or partially shaded and are spatially very close. This indicates the spatial proximity of riparian land use types could also influence the stream community composition. The similarity of grasslands and paddy fields in taxa composition could be due to their low allochthonous (non-indigenous) input. The differences in allochthonous input may also explain the distinctiveness of taxa composition of the streams with scrubs and mine as riparian land use types.

The turn over of aquatic insect genera in the streams with different riparian land use type shows that taxa composition changes with the riparian land use. Taxa such as *Hydropsyche* (Hydropsychidae), *Macronema* (Hydropsychidae), *Baetis* (Baetidae), *Isca* (Leptophlebiidae), *Choroterpes* (Leptophlebiidae) and *Neoperla* (Perlidae), with tolerance to disturbance, characterize streams flowing through human influenced riparian land use types. The taxa with high sensitivity to human disturbance such as *Helicopsyche* (Helicopsychidae), *Dineutus* (Gyrinidae), *Enithares* (Notonectidae), *Limnogonus* (Gerridae), *Goera* (Goeridae), *Blaberidae* (Blattodea) and *Notoplebia* (Leptophlebiidae) are present in the streams with the natural riparian semievergreen and evergreen forests. Similarly, in the river Cauvery, the presence of pollution tolerant or intolerant taxa represented the riparian land use pattern (Sivaramakrishnan et al., 1995). Human disturbances such as riparian deforestation, opening the canopy, decrease shading and increases in sedimentation in the streams. This change in riparian land use alters allochthonous streams to autochthonous, facilitating colonization of aquatic insects adapted to autochthonous streams (Vannote et al., 1980; and Hershey and Lamberti, 1998). In the present study the stream with natural riparian grasslands were dominated by genera with tolerance to disturbance. This could be due to the fact that the genera dominating such streams may be adapted to autochthonous (indigenous) streams with open canopy and decreased detritus input.

A change in the riparian land use alters stream habitat and water quality, and is reflected in the macroinvertebrate communities (Hershey and Lamberti, 1998). The change in abundance of aquatic insect habits and functional groups across the streams with different riparian land use types strengthens the earlier observation that human modification alters the community structure in the streams. In the streams with human modified riparian land use types, the proportional abundance of collectors and scrapers is higher (Table 5). The river continuum concept predicts that the collectors and scrapers dominate autochthonous streams (Vannote et al., 1980). The higher dominance of the collectors and scrapers such as *Hydropsyche* (Hydropsychidae), *Macronema* (Hydropsychidae), *Baetis* (Baetidae), *Isca* (Leptophlebiidae) and *Choroterpes* (Leptophlebiidae) strongly indicates autochthonous food source of streams with human modified riparian land use types. Similar change in the community composition of macroinvertebrates in response to riparian land use change was also reported from many temperate streams (Hershey and Lamberti, 1998).

Earlier studies on other Western Ghats stream fauna such as freshwater fishes and amphibians did not address how the riparian land use influences the diversity and community structure (Esa and Shaji, 1997; Bhatta, 1997; Arunachalam, 2000; Vasudevan et al., 2001; Bhat, 2002). On the other hand, the present study shows that the distribution and abundance of aquatic insect families and genera are influenced by the riparian land use. Change in functional groups and habits reflect that human influence in the riparian zone alters the stream insect community structure and could be related to a change in nature of the nutrient input into the streams. This change in functional groups and habits of stream insects could fundamentally alter the stream ecosystem function. This in turn could directly affect the diversity and distribution of other fauna such as fishes which depend upon stream insects for their survival. This study also indicates that in the Western Ghats, riverine ecosystems with natural riparian vegetation may also nurture high biodiversity. However this needs to be investigated in detail. This study also shows that a riparian land use based approach to study stream fauna could provide valuable insights into aspects of stream ecosystem function. In this context, we propose a riparian land use based approach to identify and conserve biodiversity of tropical riverine ecosystems.

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Appendices

Appendix 1. Sampling localities and their physical attributes.

Sampling Localities	Altitude (m)	Max.Width (m)	Max.Depth (m)	RLU TYPE
1	410	5	0.2	EVG
2	350	4	0.4	EVG
3	300	3	0.15	EVG
4	160	15	0.4	SEVG
5	60	2	0.15	HAB
6	210	4	0.3	EVG
7	150	6	0.8	ARE
8	325	3	0.15	EVG
9	130	5	0.3	HAB
10	370	4	0.25	EVG
11	100	4	0.3	HAB
12	150	2	0.15	ARE
13	100	8	0.6	ARE
14	100	20	0.5	HAB
15	150	10	0.3	HAB
16	550	5	0.25	EVG
17	270	2	0.3	HAB
18	150	13	0.2	EVG
19	110	6	0.25	SEVG
20	350	8	0.5	EVG
21	90	2	0.15	SCRB
22	360	1	0.3	EVG
23	790	15	0.3	EVG
24	1100	1	0.1	EVG
25	710	8	0.4	FOR
26	910	4	0.15	EVG
27	725	30	0.2	FOR
28	750	4	0.7	HAB
29	710	8	50	PAD
30	800	5	0.2	GSL
31	650	15	0.2	HAB
32	725	2	0.15	FOR
33	725	8	0.4	MIN
34	760	15	0.5	FOR

Appendix 2. Distribution of family and genera across riparian land use types.

Sl.No:	Order	Family	Genera	EVG	SEVG	SCR	GSL	FOR	ARE	PAD	HAB	MIN
I	**Ephemeroptera (Mayflies)**											
1		Baetidae	*Baetis*	+	+	+	+	+	+	+	+	+
2		Caenidae	*Caenis*	-	+	-	+	-	-	-	+	-
3		Ephemerellidae	*Teloganodes*	+	+	-	+	-	+	+	+	-
4		Heptageniidae	*Epeorus*	+	+	-	+	+	+	+	+	+
5		Heptageniidae	*Thalerosphyrus*	+	+	-	-	+	-	+	+	-
6		Leptophlebiidae	*Choroterpes*	+	+	+	+	+	+	+	+	+
7		Leptophlebiidae	*Indialis*	-	-	-	-	-	+	-	+	-
8		Leptophlebiidae	*Isca*	+	-	-	-	+	-	+	-	-
9		Leptophlebiidae	*Petersulla*	+	+	-	-	+	+	-	+	+
10		Leptophlebiidae	*Notophlebia*	+	+	+	+	-	+	-	+	-
11		Neoephimeridae	*Neoephimeridae**	+	-	-	-	-	-	-	-	-
12		Oligoneuridae	*Isonychia*	-	-	-	-	-	+	-	-	-
13		Potamanthidae	*Rheonanthus*	+	-	-	-	-	-	-	+	-
14		Trichorythidae	*Neurocaenis*	-	-	+	-	-	-	+	-	-
II	**Odonata (Dragonflies and damselflies)**											
15		Chlorocyphidae	*Rhynocypha*	+	-	-	-	-	+	-	-	-
16		Cordulidae	*Cordulidae**	-	-	-	-	-	-	-	+	-
17		Euphaeidae	*Euphaea*	+	+	+	+	+	+	+	+	+
18		Gomphidae	*Gomphidae**	+	+	-	-	-	-	-	+	-
19		Gomphidae	*Lamelligomphus*	-	-	-	-	-	+	+	-	-
20		Libellulidae	*Libellulidae**	-	+	-	-	-	+	-	+	-
21		Protoneuridae	*Protoneuridae**	+	+	-	-	+	-	-	-	-
III	**Plecoptera (Stoneflies)**											
22		Perlidae	*Neoperala*	+	+	-	+	+	+	+	+	+
IV	**Blattodea (Cockroaches)**											
23		Blaberidae	*Blaberidae**	+	+	-	-	-	-	-	-	-
V	**Orthoptera (Grasshoppers)**											
24		Tetrigidae	*Scelimena*	-	-	-	-	-	-	-	+	-
VI	**Hemiptera (Aquatic Bugs)**											
25		Corixidae	*Micronecta*	-	+	+	-	-	+	-	-	-
26		Gerridae	*Amemboa*	+	-	-	-	-	-	-	+	-
27		Gerridae	*Aquarius*	+	-	-	-	-	+	-	+	-
28		Gerridae	*Cylindrostethus*	+	+	-	-	-	-	-	-	-
29		Gerridae	*Gerridae**	-	-	-	-	-	-	-	+	-
30		Gerridae	*Limnogonus*	+	+	-	-	-	+	-	-	-
31		Gerridae	*Metrocoris*	+	+	-	+	-	+	-	+	-
32		Gerridae	*Ptilomera*	+	+	-	-	-	-	-	-	-
33		Gerridae	*Tenagogonus*	+	-	-	-	-	-	-	+	-
34		Hebridae	*Timasius*	+	+	-	-	-	-	-	-	-
35		Naucoridae	*Naucoris*	+	+	-	-	-	-	-	+	-
36		Notonectidae	*Enithares*	+	-	-	-	-	-	-	-	-
37		Notonectidae	*Nychia*	+	-	-	-	-	-	-	-	-
38		Velidae	*Velidae**	+	-	-	-	-	-	-	-	-
39		Veliidae	*Rhagovelia*	+	+	+	-	-	+	-	+	-
VII	**Coleoptera (Beetles)**											
40		Curculionidae	*Curculionidae**	+	-	-	-	-	-	-	-	-
41		Dytiscidae	*Cybester*	-	+	-	-	+	+	-	+	-
42		Dytiscidae	*Hydaticus*	+	-	-	-	-	-	-	-	-
43		Dytiscidae	*Laccophilus*	-	-	-	-	-	-	-	+	-
44		Dytiscidae	*Sandracottus*	+	-	-	-	-	-	-	-	-
45		Elmidae	*Leptelmis*	+	+	-	-	-	+	+	+	-
46		Elmidae	*Stenelmis*	+	+	-	-	-	-	-	-	-
47		Gyrinidae	*Dinutus1*	+	-	-	-	-	+	-	+	-
48		Gyrinidae	*Dinutus2*	+	-	-	-	-	-	-	-	-
49		Hydrophilidae	*Laccobius*	-	-	+	-	-	+	-	+	-
50		Noteridae	*Noteridae**	-	+	-	-	-	-	-	-	-
51		Psephenidae	*Eubrianax*	+	+	+	+	+	+	+	+	+
52		Psephenidae	*Psephenidae**	-	+	-	-	-	-	-	-	-
VIII	**Trichoptera (Caddisflies)**											
53		Calamoceratidae	*Anisocentropus*	+	+	-	-	-	-	-	+	-
54		Glossosomatidae	*Agapetus*	+	-	-	+	-	-	-	-	-
55		Glossosomatidae	*Glossosoma*	+	+	-	-	-	+	-	+	-
56		Goeridae	*Goera*	+	+	-	-	-	-	-	-	-
57		Helicopsychidae	*Helicopsyche*	+	+	-	+	-	-	-	+	-
58		Hydropsychidae	*Hydropsyche*	+	+	+	+	+	+	+	+	-
59		Hydropsychidae	*Leptonema*	+	+	-	+	+	+	+	+	-
60		Hydropsychidae	*Macronema*	-	-	+	-	+	+	-	+	-
61		Hydropsychidae	*Moselyana*	+	+	-	-	+	+	-	+	-
62		Hydroptilidae	*Hydroptilidae**	-	-	-	-	-	+	-	-	-
63		Lepidostomatidae	*Goerodes*	+	+	-	-	-	+	-	-	-
64		Philopotamidae	*Chimarra*	+	+	-	-	+	+	-	+	-
65		Philopotamidae	*Wormaldia*	+	+	+	-	-	+	-	-	+
66		Polycentropodidae	*Polycentropus*	-	-	-	-	-	+	-	-	-
IX	**Lepidoptera (Moths)**											
67		Pyralidae	*Alacodes*	-	+	+	-	-	+	+	-	-
X	**Diptera (Flies)**											
68		Blephariceridae	*Philorus*	+	+	-	-	-	-	-	+	-
69		Chironomidae	*Chironomidae**	+	+	-	-	-	+	-	+	-
70		Ephydridae	*Ephydridae**	+	+	+	-	-	+	-	+	-
71		Simuliidae	*Simulium*	+	+	-	+	+	+	+	+	+
72		Tipulidae	*Tipulidae**	+	+	-	-	-	-	-	+	-

*= Identification only up to the family