A comparison of hill stream anuran diversity across two habitats in Kalakad-Mundanthurai Tiger Reserve: a pilot study

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India, one of the most populous countries, with an estimated population of 1.1 billion, also has the greatest amphibian species richness (321), endemics (180) and threatened species of all countries in the Indo-Malayan realm (Bain et al. 2005). According to the Global Amphibian Assessment (GAA) almost one-third of the worlds 6,638 known amphibian species are listed as threatened or extinct. These declines are attributed to two major factors, habitat loss and fungal disease with possible contributions from introduced species, climate change and pollution (Beirne 2009). In the Western Ghats, one of the 34 global biodiversity hotspots (Mittermeier et al. 2005), endemic anurans are also at risk due to their specialised diet, habitat preferences and limited vagility (Gururaja 2002). While much focus still lies on bringing about clarity in the taxonomic aspects of this class of vertebrates, there exists a dearth of research centred around their ecology, behaviour, species assemblages and for some species, natural history.

In the neotropics, species diversity and abundance have been found to vary under the influence of varied factors such as differences in litter fall rates, mast fruiting, heterogeneity within regions, breeding habitat constraints, and geological history (Allmon 1991) and also due to altitude, topography, and rainfall (Duellman 1999). Given that factors relating to environmental and habitat variation; both at a micro and macro level can influence the nature of anuran assemblages, our study aims at investigating the diversity and composition of anuran assemblages in hill streams within and across habitats in one mountain range of the southern Western Ghats. Questions that we put forth: (i) How do anuran assemblages vary across hill streams in two habitats with respect to species richness and diversity (ii) What

Image 1. Tea plantation stream

Image 2. Primary forest stream

factors are likely to influence variations in these hill stream anuran assemblages within and across the two habitats?

Methods: This study was conducted in Kakachi, within the Kalakad-Mundanthurai Tiger Reserve (KMTR) spread over 895km^2 located in the Agasthyamalai ranges of Tamil Nadu. It is one of the most diverse among the protected areas in southern Western Ghats (Ganesh et al. 2009). A total of eight species of stream anurans are known to exist in the Agasthyamalai range (Vasudevan et al. 2004).

The two habitats chosen for the study were at a similar elevation of around 1200m but differed in other aspects such as vegetation, canopy cover, and average ambient temperature.

Forest stream (Image 1): The stream was located in a primary evergreen forest of the *Cullinia, Aglaia, Palaquium* type (Ganesh et al. 1996), with an average canopy height of 30m with dense canopy cover (mean ambient temperature 22^{0}C). The stream had an average width of 5m and was characterized by a sandy stream bed embedded with large boulders and rocks. Presence of fallen logs and rapids were also a regular feature of the stream.

Tea plantation stream (Image 2): This stream had an average width of 3m and ran alongside a road with tea plantations bordering it on either side. The vegetation adjoining the stream was composed of tall grasses and reeds on one side and overhanging *Ochlandra travancorica* thickets on the other side for nearly 70% of the stretch sampled (mean ambient temperature 24^{0}C).

Field Survey: We surveyed for stream anurans towards the tail end of the south west monsoon in the month of August, 2010 over a period of three consecutive days. Time constrained surveys were carried out using the line transect method (Parris et al. 1999). Two 450m long transects were selected, one in each habitat type. Two observers on either side of each stream transect for 2hr twice a day. This resulted in a total of 48 man hours of sampling. At every detection spatial variables (orientation of an individual from the surface of the water) and substrate (ferns, grass, green leaves, dead leaves, dead leaf packs, fallen logs, mossy rocks, crevices, rocks) were recorded. Species were identified using field keys by Daniel (2002), Dinesh et al. (2008); nomenclature after Dinesh et al. (2010).

Data Analysis & Results: Analysis of all the data collected was done using Microsoft Excel (Office 2007) and the statistical analysis software – PAST 2.00 (Hammer 2010).

Species richness and diversity across habitats: During 24hr of observation, a total of seven species were recorded in both the streams with a total of 160 individuals (Table 1). One-hundred-and-twelve individuals belonging to four genera (*Micrixalus,*

Image 3. *Hylarana temporalis*

Image 4. Goolge Earth image of the primary forest stream

Table 1. Checklist of anurans encountered during the survey

	IUCN Status
Bufonidae	
Duttaphrynus melanostictus	LC
Micrixalidae	
Micrixalus saxicola	VU
Micrixalus fuscus	NT
Nyctibatrachidae	
Nyctibatrachus aliciae	EN
Nyctibatrachus vasanthi	EN
Ranidae	
Hylarana temporalis	NT
Ranixalidae	
Indirana beddomii	LC

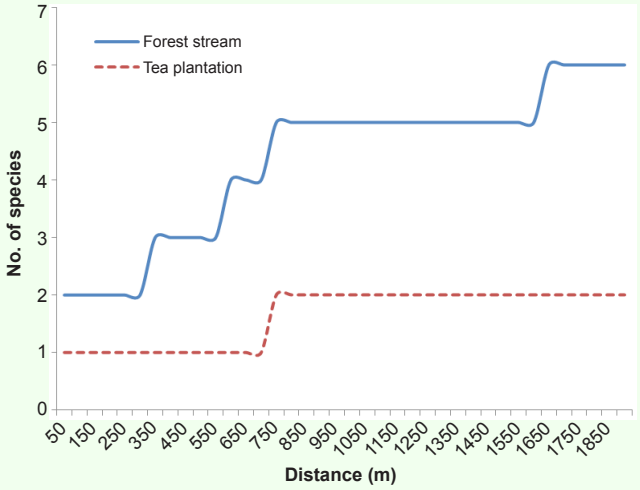

Figure 1. Species accumulation curve for the forest stream and tea plantation with sampling effort (distance sampled).

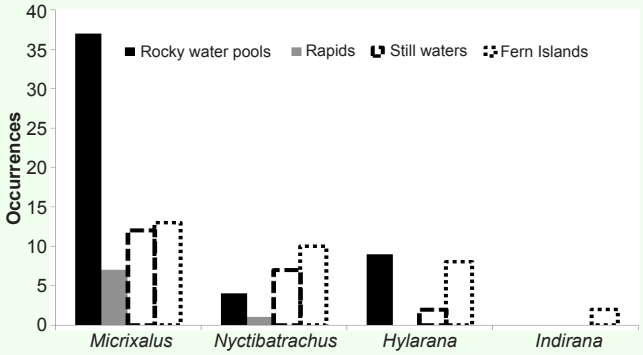

Figure 2. Habitat use across genera in the forest stream

Nyctibatrachus, Hylarana and *Indirana)* were recorded from the forest stream while only 48 individuals belonging to two genera (*Hylarana and Duttaphrynus)* were recorded from the tea plantation stream. Only one of the seven species, *Hylarana temporalis* (Image 3) was found to be common to both the habitats.

The species accumulation curve for sampling effort (Fig. 1) has not reached an asymptote for the forest stream as opposed to a distinct plateau for the plantation stream after encountering just two species. The absence of a distinct asymptote in the forest stream suggests sampling was inadequate for this habitat.

Jaccard's Index was used to test for similarity in the two streams showed that the sites were 42% similar based on substrate availability (C_j = 0.428571).

Indices used to compare the two habitats for species richness showed that the forest stream not only had a higher species richness and diversity as compared to the tea plantation but also had a more evenly distributed community structure (Table 2).

Anuran assemblages: (a) Forest stream (Image 4): Anuran assemblages were quantitatively assessed in terms of habitat use by grouping them under broad habitat classes namely fern islands, still waters, rapids and rocky water pools (Fig. 2). Although *Micrixalus* (Image 5) was found to occur in all the habitat classes, it was most seen in rapids. *Nyctibatrachus* (Image 6) on the other hand was found to occur more in still waters and fern islands.

Further, a comparison between the four genera in the forest stream showed that rocks and dead leaf litter were used most often as compared to the rest of the substrate types available, namely fallen logs, soil, ferns , rocks etc.

Box plots were drawn to depict distance from the edge of water and vertical height above the surface of water for individuals of each genus. Most of the individuals were found to occur within 1m from the edge of the water with a few exceptions of individuals of *Hylarana* and *Micrixalus* occurring further inland. While individuals of *Nyctibatrachus* were found either submerged or at water level, *Micrixalus* and *Hylarana* were found at varied heights up to 1.5m from the surface of water (Figs. 3a & 3b).

(b) Tea plantation stream (Image 7): Only two genera *Duttaphrynus, Hylarana* were found in this habitat of which only one individual of *Duttaphrynus* was found. Among the 47 individuals of *Hylarana* 44% of them used grass and 35% used soil as their substrates over others.

Effect of disturbance in the Tea plantation: High levels of

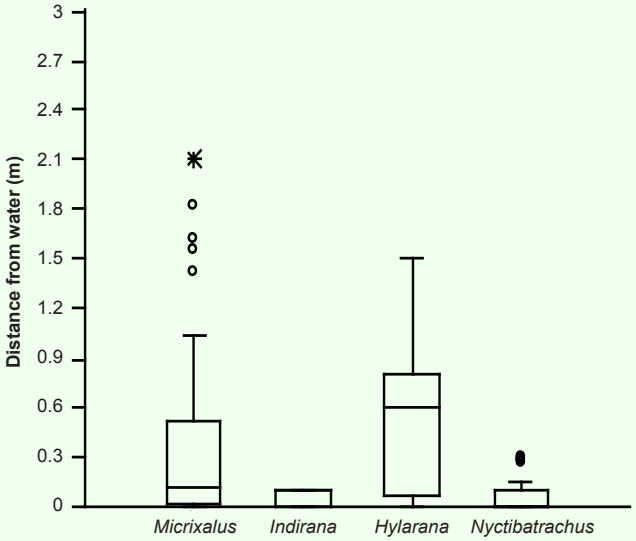

Figure 3a. A box plot showing the distance of individuals of each genus from the edge of the water

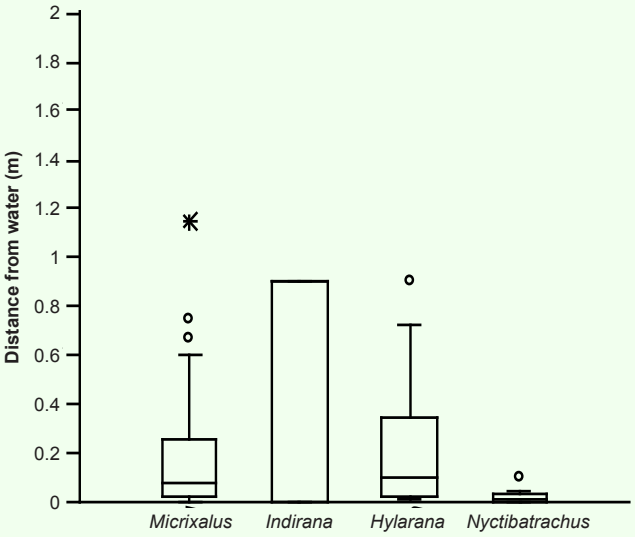

Figure 3b. A box plot showing the assemblage of individuals of each genus with respect to vertical distance above the surface of the water.

Image 5. *Micrixalus fuscus*

human activity like washing clothes, vehicles & livestock and letting in grey water from neighbouring households in and around the start point of the transect had been qualitatively considered as a source of disturbance. A linear model was used to see the influence of these disturbances on species abundance. It showed a high correlation between species abundance and their distance from the source of disturbance ($y = ax+b$ where slope $a = 0.056921$; intercept $b = -8.8969$; $r^2 = 0.075754$), the p value (0.4735) however was not significant.

Table 2. Diversity Indices showing a significant difference between the two habitat types.

Indices	Forest stream	Tea plantation stream
Species richness	6	2
Individuals	112	48
Shannon_H	1.423	0.1013
Simpson_1-D	0.7132	0.0408
Evenness_e^H/S	0.6913	0.5533

Discussion: Of the two habitats studied, the stream running through the primary forest had a higher species richness, species abundance and evenness, resulting in higher species diversity (Table 2). In this study we hypothesised there to be a difference in the diversity between the tea plantation (TP) and forested area (FP) however one this drastic is surprising.

Another study done in KMTR showed the amphibian

Image 6. *Nyctibatrachus* cf. *aliciae*

Image 7. Goolge Earth image of the tea plantation stream

assemblages in evergreen streams to be considerably different between two hills, separated by <2 latitude in the same mountain range (Vasudevan et al. 2004). Our study however shows a considerable difference between assemblages in two streams in the same latitudinal area with varying land use.

It is interesting to note that individuals of *Hylarana* and *Duttaphrynus* encountered in the tea plantation area were not fully grown adults as in a similar study done on stream

amphibians which showed that juveniles of these species remain along the stream only for a brief period. They eventually disperse into the forests, which are their feeding grounds, and adults therefore, are rarely found along the streams (Krishna et al. 2005) had we conducted the survey one or two months earlier or after the time period chosen, even these individuals may not have been found in the plantation. Fluctuations in pH as well as other physical parameters of the water have known to influence the biology of amphibians (Warner et al. 1998). In this case however we can consider fluctuations arising as a result of the human induced disturbance only a possible explanation for the poor diversity in the stream as they were not quantified in the study.

Another possible factor to explain the difference in species diversity could be the substrate availability along the streams. Modifications in the microhabitat have known adverse effects on amphibians (Gururaja 2002). Changes in substrate availability could compromise on the availability of shelter, prey and egg laying sites. In this study we qualitatively assessed the variety of substrates used by the anurans at a microhabitat level. Of the 13 substrates that we identified 77% of them (leaf litter, ferns, moss, boulders etc) were present in the forest stream while only 38% (grass, rocks, soil, etc.) were present in the tea plantation stream. A clear indication that land-use change has not only affected the vegetation but also changed the stream characteristics.

The short duration and scale at which the study was carried out can be considered as its short-coming. However, observations from our study give us reason to look at conservation and management of lotic water systems not just at a regional scale but at a more local one as well.

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