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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 world’s 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
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 895km² 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°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°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,
Table 1. Checklist of anurans encountered during the survey

<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
<th>IUCN Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bufonidae</td>
<td>Duttaphrynus melanostictus</td>
<td>LC</td>
</tr>
<tr>
<td>Micrixalidae</td>
<td>Micrixalus saxicola</td>
<td>VU</td>
</tr>
<tr>
<td></td>
<td>Micrixalus fuscus</td>
<td>NT</td>
</tr>
<tr>
<td>Nyctibatrachidae</td>
<td>Nyctibatrachus aliciae</td>
<td>EN</td>
</tr>
<tr>
<td></td>
<td>Nyctibatrachus vasanthi</td>
<td>EN</td>
</tr>
<tr>
<td>Ranidae</td>
<td>Hylarana temporalis</td>
<td>NT</td>
</tr>
<tr>
<td>Ranixalidae</td>
<td>Indirana beddomii</td>
<td>LC</td>
</tr>
</tbody>
</table>

Image 3. *Hylarana temporalis*

Image 4. Google Earth image of the primary forest stream

© Sandeep Das
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 (Cj = 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
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.

**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...
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.

References


Gururaja, K.V. (2002). Effect of Habitat Fragmentation on Distribution and Ecology of Anurans in Some Parts of


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The Indian Alliance for Zero Extinction

Pinpointing and conserving epicenters of imminent extinctions in India

The Alliance for Zero Extinction prioritises species assessed as Critically Endangered and Endangered and found restricted to a single location, which receive no formal protection and are continuing habitat loss and degradation. These sites are extremely vital to ensure the existence of the AZE species. In addition, a new study shows that the value of ecosystem services such as water filtration, soil retention, and carbon sequestration of these sites far outweighs their destruction (on the order of billions of dollars).

The Indian AZE is intended to fulfil the following objectives:

COLLABORATION – Build a national network of biologists, conservation groups, land management experts, and nature tourism operators to help identify critical places using the AZE criteria (see www.zeroextinction.org/selection.htm).

IDENTIFICATION – Identify all the ZERO EXTINCTION sites in the country; work with the global AZE network to include these sites on the global list.

RECOGNITION – Highlight those ZERO EXTINCTION sites that are already publicly protected, and consider extending official status to private reserves that include these sites.

PROTECTION IN PARTNERSHIP – Work with conservation groups and the private sector to create protected areas and develop carbon, watershed protection, and/or ecotourism projects at unprotected ZERO EXTINCTION sites to protect species and generate revenues.
First record of Charpa Tree Frog *Polypedates occidentalis* from Karnataka State

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A new Tree Frog *Polypedates occidentalis* was first described by Das & Dutta (2006) under the family Rhacophoridae from Kerala State. It was collected from Charpa forest range, Vazhachal forest division, Thrissur District of Kerala State, southern India on 25 July 1986 by Carl Gans. The description was based on three adult males and a metamorph from Kerala. No reports were available on the occurrence of this species from Karnataka State (Dinesh et al. 2009).

On 22 October 2008 one example of *Polypedates occidentalis* was collected from wet land near a banana plant from an arecanut plantation in Kadatoka Village (14°22′11″N & 74°27′45″E) in Honavar Taluka of Uttara Kannada District in Karnataka State. The distance between these two locations, first from where the species was first described and the present location is nearly 480 km in a straight line. The general topography of this area is low lying and flat area having two big water reservoirs on the east as well as on the west side. The climate is warm almost throughout the year except for a few days in the months of December and January in the winter season. During the annual monsoon Uttara Kannada the western water body is connected to the paddy fields and during the summer season (April and May) this water body dries up.

We could determine the specific identity of *Polypedates occidentalis* Das & Dutta, 2006 based on the following diagnostic characters. *Polypedates occidentalis* is a medium sized
Table 1. Morphometric data of *Polypedates occidentalis*

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snout-Vent length</td>
<td>46mm</td>
</tr>
<tr>
<td>Width of body behind shoulder</td>
<td>15mm</td>
</tr>
<tr>
<td>Head length</td>
<td>15mm</td>
</tr>
<tr>
<td>Head width</td>
<td>17mm</td>
</tr>
<tr>
<td>Eye diameter</td>
<td>06mm</td>
</tr>
<tr>
<td>Diameter of Tympanum</td>
<td>04mm</td>
</tr>
<tr>
<td>Eye-Snout tip distance</td>
<td>09mm</td>
</tr>
<tr>
<td>Eye-Nostril distance</td>
<td>06mm</td>
</tr>
<tr>
<td>Tibia length</td>
<td>24mm</td>
</tr>
</tbody>
</table>

tree frog with SVL of adult males 47.5-55.1 mm and females unknown. It possesses a rounded snout, fingers free, unpigmented nuptial pads on the dorsal surface of fingers I and II, vomerine teeth oblique between choanae, fingers with rudimentary webbing, no dermal fold along the forearm. Webbing in toe II extending to the base of the discs, skin of forehead free, skin lacking dermal flap, heel lacking a cutaneous spur, dark hour glass-shaped mark on dorsum (Image 1).

The specimen collected is deposited in the national collection of amphibia section of Zoological Survey of India, Kolkata (Reg.No: A10949) and its morphometric data are given in Table 1.

Our collection of *Polypedates occidentalis* constitutes the first record from Karnataka State.

References


Acknowledgement

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About this book

This book covers 66 species of amphibians and reptiles found in the hill state of Uttarakhand, India. With attractive photographs, the book provides its readers with an insight into the lives of these intriguing and lesser known creatures. This book dwells on their life cycles, behaviour, habits, habitats and a host of other interesting details. Through this book, we hope to create an interest in amphibians and reptiles amongst all.

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Amphibian fauna of Katerniaghat Wildlife Sanctuary, Uttar Pradesh, India

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There are some scattered works on the amphibian fauna of Uttar Pradesh, but the state has not been explored extensively for amphibians. However, a few places of undivided Uttar Pradesh were surveyed when Uttarakhand was a part of U.P. (Waltner 1974; Tilak & Hussain 1977; Tilak & Ray 1985; Ray, 1989, 1992, 1995, 1999; Ray & Tilak, 1995; Hussain 2003, 2004). A perusal of literature reveals that all the districts earlier surveyed are now under the jurisdiction of Uttarakhand state. Recently Khanna & Kumar (2006) and Sarkar & Tiwari (2006) studied the amphibian fauna of Corbett Tiger Reserve and Dudhwa Tiger Reserve respectively. This paper deals with the amphibian fauna of Katerniaghat Wildlife Sanctuary.

Methods

Study Area: Katerniaghat Wildlife division is on the India-Nepal border in Behraich District of Uttar Pradesh State. This forest division has a total area of 551.64km², wherein combinations of grasslands, wetlands and dense forests are found. Part of the wildlife division was declared a Wildlife Sanctuary in 1976 having an area of 400km². Sometimes elephants and rhinoceros from Nepal also visit the area of the Katerniaghat range. The fauna of the sanctuary includes Tiger, Leopard, Rhinoceros, Hyena, Bear, Wild Boar, Blackbuck, Hog Deer, Porcupine, Otter, Monitor Lizard, Langur etc. The Gerua River flows through the division, and has Gharial, Mugger, many species of fishes and turtles. During June to October generally it rains and the sanctuary then has a humid climate. The present collection of amphibians was mainly done in the wildlife sanctuary.

Survey: The present paper is based on the field work carried out in different parts of the sanctuary in the month of August 2007 in the evenings, during the monsoon. Visual encounters and random-sampling methods were adopted for collecting amphibians. The calls during the nights were helpful in locating some species.

Survey were made near water bodies and micro-habitats such as on the floor, on the rocks, on leaves, on moss or algae, under leaf litter, under logs, under the soil, at the edge of the water bodies, among dried leaves, among weeds, and near termite mounds etc. as explained in Daniels (1995). The amphibians were identified at ZSI, Kolkata using the diagnostic characters given by Daniel (1963 a,b, 1967, 1975) and Dutta (1997). The common species available throughout the sanctuary were caught, observed and released in the same place. Other species collected were deposited in the Amphibia Section, Fire Proof Spirit Building, Zoological Survey of India, Kolkata and registered.

Results

This sanctuary contains 10 species belonging to nine genera and four families under the order Anura. *Fejervarya teraiensis* is a new record for Uttar Pradesh (Hegde et al. 2009). The toads were common all over the sanctuary. *Euphlyctis cyanophlyctis* tadpoles were also found in almost all the water bodies. The calls from *Polypedates maculatus* were common during evenings. Since the weather in the sanctuary was very humid, the young ones of toads and bull frog were found during the day on the roads also.
**Duttaphrynus melanostictus** (Schneider, 1799) - Common Indian Toad.

Material Examined: Since it was common throughout the sanctuary some toads were caught, observed and released in the same place.

Adult size: Medium to large.

Description of the adult: Yellow to olive brown, red or black. Marbled or plain. White-grey below with fine marblings. Throat in mature males yellow orange. Cornified parts black or tipped black. Tympanum as large as eye. Two rows of paired dorsal warts on hind neck considerably enlarged. Toes ½ webbed.

Habits: Commensal of humans. Attracted to light within human environs and on roadsides.

Habitat: Urban. Cultivation to dense evergreen forests.


Remark: One of the commonest toads throughout the sanctuary.

**Duttaphrynus stomaticus** (Lutken, 1863) - Marbled Toad.

Material Examined: Since it was common throughout the sanctuary some toads were caught, observed and released in the same place.

Adult size: Medium.

Description of the adult: Yellow-olive brown with or without bold marblings. Upper lip and underparts white. Skin smoother than *D. melanostictus*. Parotid glands not cornified. Tympanum about as large as the eye.

Habits: A rather docile toad capable of burrowing into soil.

Habitat: Urban to forests.

Call: Described as ‘higher pitched and shriller’ than *D. melanostictus*.

Remark: Very common near human settlement, under the street lights.

**Euphlyctis cyanophlyctis** Schneider, 1799 – Skipper Frog (Image 1).


Adult size: Medium.

Description of the adult: Brown–olive (sometimes greenish or black) with distinct black spots on back and limbs. White below. A white stripe along sides and on rear side of thighs distinct. Pale mid-dorsal stripe absent. Skin generally smooth. Tympanum distinct. Toes fully webbed. Eyes rather dorsally placed. This differs from *Rana hexadactyla* in having thinner thighs. The first finger not longer than the second.

Habits: Aquatic. Floats on surface with all four limbs often folded close to the body; a rather characteristic posture of the species. Skips on surface when disturbed.

Habitats: Urban to hill streams. Just any place where there is water.

Remark: Quite common in water bodies and floats on water. Feeds on floating aquatic insects. Tadpoles were common throughout the sanctuary.

**Fejervarya limnocharis** Boie in Gravenhorst, 1829 – Streaked or Paddy Field or Cricket Frog.

Material Examined: Since it was common throughout the sanctuary some toads were caught, observed and released in the same place.

Adult size: Small-medium.


Habits: Rather terrestrial. Frequently found in grass.

Habitat: Urban. Cultivation to dense forests. Streams.

Call: Aggressive. ‘Creak; creaka-creaka-creaka….’ in quick series. In chorus after rains and around fields

Remark: Found on the water edges, paddy fields. Matching colour with the background, usually conceals its presence. More terrestrial.
**Fejervarya teraiensis** (Dubois, 1984) - Terai Cricket Frog (Image 2).


Adult size: Small.

Description of the adult: Having a maximum SVL of 56.00mm in females and 51.00mm in males. It is the largest species of Fejervarya found in Nepal with an ovoid, stocky body. The development of a middorsal line is highly variable. The dorsum has more or less patches of orange, red or green and males have characteristic W-shaped dark marking on the throat (Schleich & Kastle 2002). The forelimbs are more or less darkly spotted. The hindlimbs have no stripes but have oval spots. The toe webbing is faintly marbled. The males have a thickened metacarpal tubercle at the base of the first finger. The finger tips are rounded. The relative finger length is 2=4<1<3 with the first finger longer than the second and fourth.

Habits: Solitary, active during evening.

Habitat: Forest floor, water bodies, channels and hill sides.

Remark: First record not only for the sanctuary but also for Uttar Pradesh. Found on the India-Nepal border. Few in number.

**Hoplobatrachus tigerinus**

Daudin, 1802 - Indian Bull Frog (Image 3).

Material Examined: 1, 09.viii.2007, coll. V.D. Hegde and party (Reg. No. ZSIA...
Adult size: Large. The largest Indian frog.


Habits: Solitary. Sedentary resting for long in the same place and day after day. Pounce feeds (vs. active search).

Habitat: Open forests to dense forests. River and stream beds. Hill cultivation and suburbs. Along hill roads and channels.

Call: A loud and low pitched ‘bong’ or ‘oong-awang’.

Remark: The largest Indian frog, essentially an aquatic amphibian always found near water bodies or in the water. Gets a beautiful colouration during breeding season.

*Sphaerotheca breviceps* (Schneider, 1799) - Indian Burrowing Frog (Image 4).

Material Examined: Since it was common throughout the sanctuary some toads were caught, observed and released in the same place.

Adult size: Small-medium.


Habits: Fossorial.

Habitat: Open forests and agricultural areas.

Call: a loud ‘awang’.

Remark: It is seen when it comes out for feeding and breeding. Its powerful hind legs with dagger-like metatarsal...
tubercle helps it to burrow deep in loose soil.

*Uperodon systoma* (Schneider, 1799) – Lesser or Marbled Baloon Frog (Image 5).

Material Examined: 3, 09.viii.2007, coll. V.D. Hegde and party (ZSIA 11011).

Adult size: Medium.

Description of the adult:
Olive green-yellow with black marblings. White below. Black throat in breeding males. Smaller size and distinctly marbled colour pattern separate from *Uperodon globulosus*. Metatarsal tubercles less developed.

Habits: Sluggish, Burrowing. Feeds more or less entirely on winged termites.

Habitat: Scrub, cultivation and deciduous forests.

Remark: Found during breeding season and can be located near wooded water lodged in the sanctuary.

*Microhyla ornata* Dumeril & Birbon, 1841 – Ornate Narrow-mouthed Frog.


Adult size: Very small to small.

Description of the adult:
Golden to earth brown with darker symmetrical markings on back (frequently arrow-shaped). Legs cross barred. White below. Throat black in breeding males. Narrow head and broader trunk is the characteristic. Fingers and toes without dilated tips. Toes without web. Metatarsal tubercles very small.

Habits: Active. Leaps powerfully and high for its size.

Habitat: Urban. Agriculture. Deciduous to evergreen forests.

Call: A shrill long drawn ‘breeep’ resembling a finger nail being drawn across a plastic comb. Often in loud choruses after the first rains. Sometimes heard during overcast days, on the forest floor and from under logs and stones.

Remark: Most common ornate frog in moist places during the night. Calls were common in the sanctuary.

*Polypedates maculatus* (Gray, 1833) – Chunam or Common Tree Frog.

Material Examined: 1, 09.viii.2007, coll. V.D. Hegde and party (ZSIA 11997).

Adult size: Medium.

Description of the adult:
Colour variable from almost plain white-fawn to yellowish-brown with darker markings. Dark line from snout through eyes and along the sides. Rear side of hind limbs marbled yellow and brown. White below. Toes ½ webbed. Web extends till about half length of fourth toe. Tympanum distinct (more than ½ diameter of eye).

Habits: A commensal of humans entering living quarters frequently.

Habitat: Urban to secondary forests.


Remark: Common in the sanctuary. Collected on a small bush while calling.
References


Acknowledgement

We thank Sri Ramesh Pandey, Divisional Forest Officer, Behraich District, Sri Ganesh Bhat, D.F.O., and Sri. Choudhary, range officer, Nishangadha, range officer, for their support extended while conducting the amphibian survey in this sanctuary and the Principal Chief Conservator of Forests (PCCF) and Wildlife Warden of Uttar Pradesh for permission. We are very much indebted to the Director, Zoological Survey of India, Kolkata for facilities and all the other staff of ZSI for encouragement.
Predator avoidance mechanism of the Sri Lankan Shrub Frog
Pseudophilautus sarasinorum (Muller, 1887) (Anura: Rhacophoridae)

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Amphibians show various predator avoidance mechanisms. These include morphological, physiological and behavioral adaptations (Duelman & Trueb 1986). Cryptic coloration (Noris & Lowe 1964), apomistic coloration, mimicry and cryptic structure are some of the well known morphological adaptations of amphibians (Dodd 1976). Physiological adaptations include the development of noxiousness and toxicity (Di Giovanni & Brodie 1981).

Although death feigning and Unken response are interesting behavioral adaptations shown by amphibians to avoid predation, the commonest is the escape behavior (Duelman & Trueb 1986). This involves sensing of the predator by the prey and rapid movement and hiding, or both, before predation occurs. Anurans are very well adapted for escape behavior due to the presence of rapid saltatorial movement. This movement is very useful for frogs in escaping from predators that use chemical cues to detect prey, because jumping leaves an interrupted chemical trail. Anurans employ several strategies for saltatorial movement (Duelman & Trueb 1986). One of these, a single long leap that carries the frog to shelter is a characteristic saltatorial movement displayed by many species of aquatic Anurans that leap from land to water (Duelman & Trueb 1986).

Observation and Discussion
On an informal field visit made by us to the Tangappuwa area (7°21’49.1”N & 80°49’59.1”E, elevation 1295m) in the Knuckles region in the Central province of Sri Lanka, on the 29 July 2008, we observed about 11 individuals of P. sarasinorum from 1100 to 1400 hr along a single stream. Some of the individuals we observed were hiding among the decaying leaf litter and other debris collected among the boulders of the stream. When disturbed, the individuals leaped into the stream directly. Then they swam fast through the water column using their fully webbed hind limbs. Their movement in the water was jerky and resembled a jumping rather than a swimming action.
None of them used their forelimbs while swimming and kept them steady. Following this they quickly hid themselves in submerged rotting debris and leaf litter at the bottom of the stream and that camouflaged them very well. Consequently, they moved slightly backwards or into the debris by moving their forelimbs to further conceal themselves at the bottom. In this posture they were well camouflaged with the benthic substrate. Typically they swam about two meters in the water before hiding themselves at the bottom. Generally, they remained under water from about 08 minutes up to 20 minutes. The average depth of the water in the stream where individuals hid ranged between 30-40 cm.

This kind of behavior is commonly observed in species that are closely associated with water such as species of aquatic *Rana*. This has been never been reported in a *Pseudophilautus* species in Sri Lanka and it is very rare in terrestrial and arboreal species of frogs. This species also have completely webbed hind feet. This is very unlikely for a species that completes their life cycle entirely on land (Bahir et al. 2005). Therefore the webbing must be aiding them in swimming. The cryptic body color of the frogs also aid in concealing the frogs in leaf litter at the bottom of the stream. The diagonal marks on the hind limbs (Image 1) further helps in camouflaging the frog by breaking up the outline of the frog’s body (Image 2). This is known as disruptive coloration (Duelman & Trueb 1986). Interestingly they are capable of staying underwater for an impressively long time. While they were underwater they kept their eyes slightly open all the time. Our observations and other reported observations (Manamendra-arachchi & Pethiyagoda 2005) indicate that this species is habitat specific and prefers
lotic habitats in primary and secondary forests.

The combination of escape behavior, cryptic coloration and habitat specificity of *P. sarasinorum* gives an ideal survival strategy. Disturbance and loss of this habitat will increase the predation risk of this species in their natural habitat. Therefore conservation of habitat will ensure the survival of this endangered habitat specific species of frog in Sri Lanka.

References


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