Herpetofaunal survey in rainforest remnants of the Western Ghats, India

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ABSTRACT - We undertook amphibian and reptile surveys in six rainforest remnants of the Anamalai Hills in the Western Ghats, India. Over a two-month period, 36 species of herpetofauna were recorded from these remnants, including one species of caecilian, 19 frog species, 8 lizard species and 8 species of snake. Six species were either critically endangered or endangered. We also recorded one species of frog (*Nyctibatrachus acanthodermis*) outside of its type locality for the first time since its original description. The study demonstrated the presence of several threatened species of herpetofauna in these small forest remnants, the protection and restoration of which are important for the conservation of biodiversity in the Western Ghats.

INTRODUCTION

With increasing fragmentation of tropical forests and conversion to other land uses, there has been an increased interest in the conservation of biodiversity in fragmented landscapes (Wade et al., 2003; Harris & Silva-Lopez 1992; Chazdon et al., 2009). This is especially relevant in areas of high biological diversity, such as tropical rainforests. The Western Ghats of India, a biodiversity hotspot, has lost most of its original habitat due to land-use conversion related to human activities (Bhupathy et al., 2016). Despite this, recent studies indicate that even in their fragmented and degraded state, remnants of forests in the Western Ghats can sustain high levels of biodiversity (Balaji et al., 2014; Anand et al., 2010; Sridhar et al., 2008; Karanth et al., 2016).

The Anamalai Hills in the southern Western Ghats is rich in herpetofaunal biodiversity and endemism, having at least 83 species of amphibians and 82 species of reptiles and is an important area for conservation of biodiversity in this region (Smith, 1935 & 1943; Kumar et al., 2002; Deepak et al., 2009; Deepak et al., 2016; Subramanian et al., 2013; Frost, 2018). Approximately 45 % of amphibian species in the Anamalai area are either Data Deficient or Not Assessed, while 35 % are considered critically endangered or endangered (IUCN, 2017). Many species are known only from original descriptions or anecdotal records (Ishwar, 2000; Biju & Bossuyt, 2009). Lack of fine-scale information on species distribution and abundance within the landscape hampers reliable conservation status assessments of most of these species.

Surveys conducted between 1995 and 2003 in tea plantations and 14 rainforest fragments in the Valparai Plateau recorded 40 species of amphibians and 40 species of reptiles (Kumar et al., 2002; Daniels, 2003). The diversity and abundance of amphibians and reptiles were higher in rainforest remnants compared to modified habitats such as plantations (Murali & Raman, 2012; Venugopal, 2010). In the last decade, there have been significant changes in our understanding of the diversity of herpetofauna in the Western Ghats. Many species previously considered as widespread, with better taxonomic understanding, are now considered local endemics with small, restricted distribution ranges (Garg & Biju, 2017; Biju & Bossuyt, 2009; Biju et al., 2014b; Garg et al., 2017; Biju et al., 2011; Biju et al., 2014a). The number of frog species known from the Western Ghats have increased from 104 in 2001 to 220 in 2018 (Biju, 2001; Frost, 2018). Many of the new species descriptions were from forest remnants in human-modified landscapes such as tea plantations (Myers, 1942; Biju et al., 2011; Zachariah et al., 2011; Vijayakumar et al., 2014). Further surveys and ecological studies across this region are required to understand the distribution and abundance patterns of herpetofauna. For a period of two months, we undertook herpetofaunal surveys in six rainforest remnants on the Valparai Plateau of the Anamalai Hills, a landscape dominated by tea plantations.

MATERIALS AND METHODS

Valparai is an undulating plateau (area 220 km^2) located between 800 – 1500 m above mean sea level (hereafter asl) (10.32° N, 76.95° E), in the Anamalai Hills in Tamil Nadu, India (Fig. 1). This region receives mean annual rainfall of over 2800 mm (Rathod & Aruchamy, 2010). Natural vegetation of Valparai Plateau is mid-elevation tropical wet evergreen forest of the *Cullenia exarillata – Mesua ferrea – Palaquium ellipticum* type (Pascal, 1988). Valparai has lost over 75 % of the original tropical rainforest to tea, coffee, and other commercial privately owned plantations. The current land-cover in the plateau is a mixture of plantations and forest remnants. There are numerous rainforest remnants in the Valparai Plateau (Kapoor, 2008; Mudappa & Raman, 2007; Mudappa et al., 2014). Anamalai Tiger Reserve surrounds the plateau on its north, east and south, while Vazhachal Reserved Forest occurs to the west. Valparai has several perennial streams, rivers (mainly, Sholayar and Nirar), and a single large reservoir (Upper Sholayar Dam). Though there

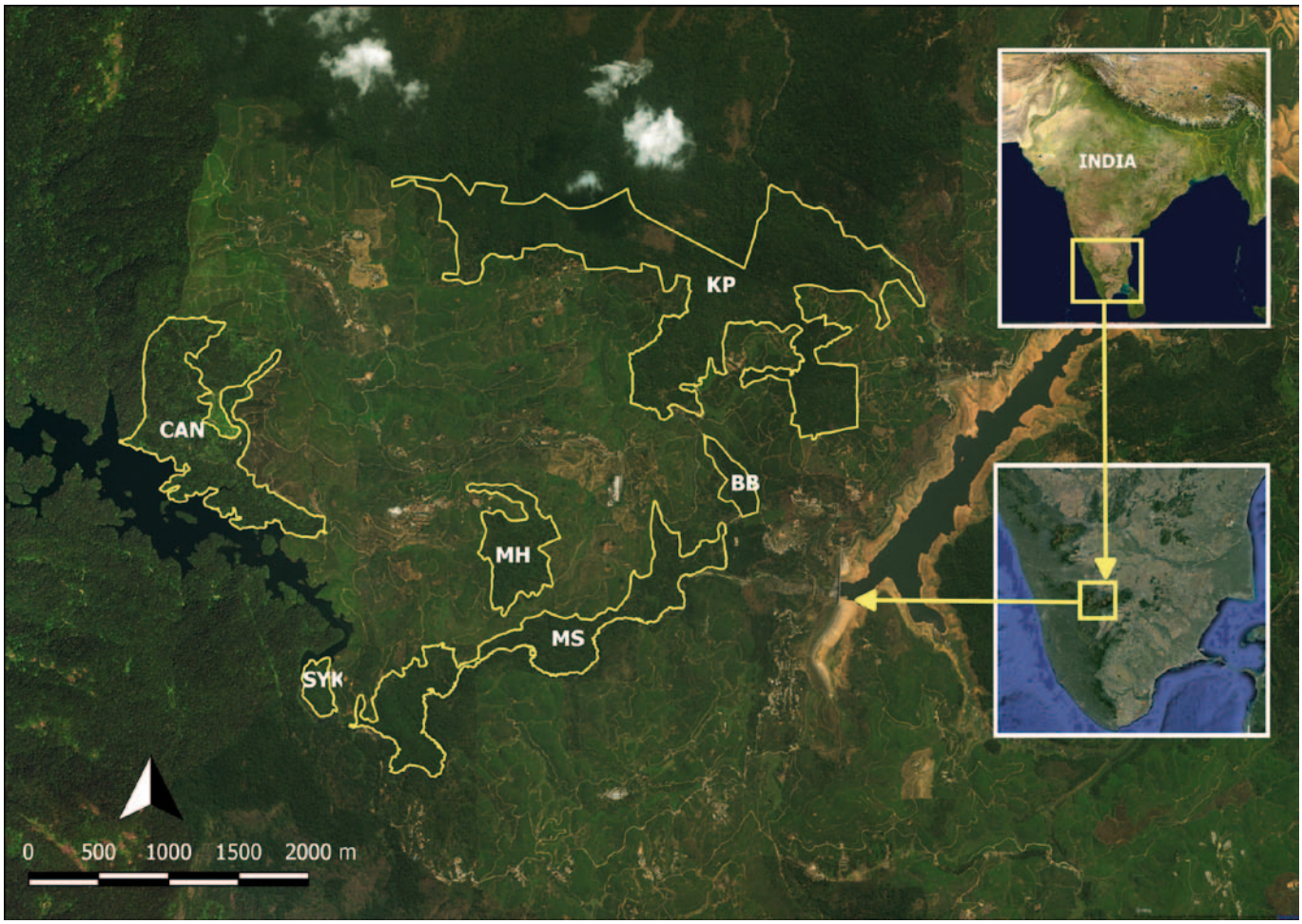

Figure 1. Six rainforest remnants surveyed for herpetofauna in the western part of the Valparai Plateau: KP - Kalyanapandal-Pudukadu, CAN - Candura, MS - Murugalli Sholayar, MH - Murugalli Hospital, BB - Murugalli Black Bridge, and SYK - Murugalli Sykes

are many human settlements spread throughout the plateau, most people live near the Valparai town.

We surveyed six rainforest sites on the western part of the Valparai Plateau (Fig. 1). In order of size, these were Kalyanapandal-Pudukadu (KP, 200 ha, 909-967 m asl), Candura (CAN, 103.3 ha, 845-1019 m asl), Murugalli-Sholayar (MS, 102 ha, 835-893 m asl), Murugalli-Hospital (MH, 38 ha, 929-1028 m asl), Murugalli-Black Bridge (BB, 16 ha, 834-924 m asl), and Murugalli-Sykes (SYK, 9 ha, 826-838 m asl). Two of the larger rainforest remnants, CAN and KP, adjoin contiguous rainforest, separated only by small boundary clearings. The Sholayar River separates the MS and SYK remnants from contiguous rainforest areas. All of these remnants have had human disturbances in the past. MH remnant was the closest to a human settlement and consequently the most disturbed, though we have not quantified the disturbance levels for this preliminary survey. All remnants other than the MH remnant have perennial streams or a river flowing through them or along the edge. The sites surveyed were all between 800 – 1050 m asl.

To record the species richness in the selected rainforest remnants we used time-constrained visual encounter surveys (VES) (Crump & Scott Jr, 1994; Doan, 2003). Each survey was of 1 h duration, during which two observers walked a trail through the sites, actively searching all potential habitats (e.g., leaf-litter, tree buttresses, fallen logs etc.) and recording all specimens sighted. We selected these trails to represent the general habitats and microhabitats present, maximise detections, while taking into account logistics and accessibility. To avoid pseudo-replication, we chose a new trail for each survey. We conducted surveys during day (07:00-12:00 h) and night (18:00-19:00 h) but due to logistical difficulties there were no night-time surveys in Murugalli-Sholayar and Murugalli-Sykes fragments. All surveys were undertaken from 9 September to 29 October 2017, coinciding with the retreating south-west monsoon and early north-east monsoon rains.

The survey effort varied between remnants (Table 1). We

Table 1. Visual encounter survey effort (excluding three opportunistic records) and observation rates for six rainforest remnants on the Valparai Plateau in the Anamalai Hills. For site name abbreviations, see Figure 1.

Site	No. surveys (Day/Night)	Person-hours	No. specimens	No. species
KP	7 (5/2)	14	64	17
CAN	12 (6/6)	24	145	17
MS	8 (8/-)	16	70	19
MH	4 (2/2)	8	23	10
BB	5 (2/3)	10	70	15
SYK	4 (4/-)	8	33	10
All sites	40 (27/13)	80	405	33

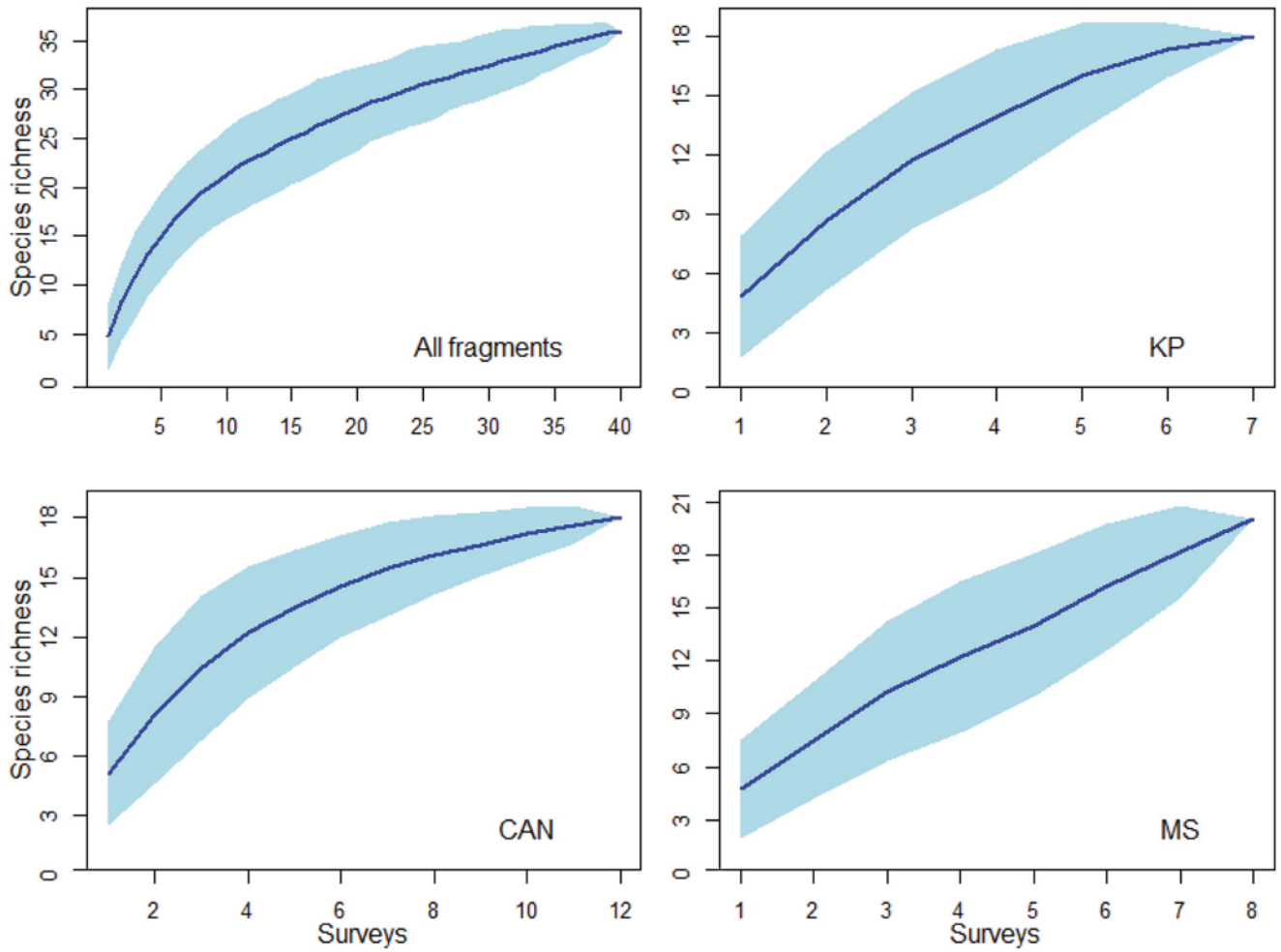

Figure 2. Species accumulation curves for all remnants combined and three largest remnants (KP, CAN, and MS). The feather area indicates 95 % confidence intervals.

calculated encounter rates as number of specimens recorded per person-hour of survey effort. To compare the efficacy of day and night time surveys, we compared mean (expressed as mean ± standard deviation) and median numbers of specimens and species recorded per survey during day and night surveys. Since the data was not-normally distributed, we used the non-parametric Wilcoxon rank sum tests for these comparisons. To examine the extent of survey completeness, we plotted species accumulation curves using a random addition of samples (number of species against number of surveys) for each remnant surveyed, using the VEGAN package in program R (R Core Team, 2017).

We identified most specimens based on examination of diagnostic morphological characters as described in relevant taxonomic literature. These were mainly Biju et al. (2011) for frogs of the genus *Nyctibatrachus*; Biju et al. (2014a) for frogs of the genus *Micrixalus*; Biju et al. (2014b) for frogs of the genus *Indosylvirana*; Biju & Bossuyt (2005 & 2009) and Bossuyt (2002) for Rhacophorid frogs currently in the genera *Raorchestes* and *Pseudophilautus*; Dahanukar et al. (2016) and Garg & Biju (2016) for frogs of the genus *Indirana*; Garg & Biju (2017) for frogs of the genus *Minervarya*; Manamendra-Arachchi et al. (2007) for geckos of the genus *Cnemaspis*; and Smith (1935 & 1943) in general for lizards and snakes. The nomenclature used follows Frost (2018) and Uetz et al. (2018) for amphibians and reptiles respectively. We identified specimens that could not be closely examined, some juveniles, and populations whose taxonomic status was unclear only to genus level. Unidentified specimens were not included in estimations of species richness and relative abundance. We did not collect voucher specimens during this survey, as our research permit from the state Forest Department did not include permission to collect biological specimens. In addition, we wanted to avoid invasive methods given the sensitivity and rarity of many species and the already disturbed status of these forest remnants. Field identification based on diagnostic characters and photo-documentation was sufficient for the purposes of this survey. Voucher photos of all species recorded were deposited in the biodiversity database India Biodiversity Portal (Vattakaven et al., 2016).

RESULTS

We undertook 40, one-hour-long visual encounter surveys (VES) in the six rainforest remnants (Table 1). Species accumulation curves reached asymptote only in the CAN remnant (Fig. 2). Other remnants and data pooled across all sites did not reach an asymptote, indicating that additional sampling may reveal the presence of more species in these

Table 2. Number of specimens recorded (encounter rates as specimens/ person-hour in brackets) of amphibians and reptiles in six rainforest remnants on the Valparai Plateau, Anamalai Hills. Species names are followed by their IUCN conservation status: NA – Not Assessed, DD – Data Deficient, LC – Least Concern, VU – Vulnerable, NT – Near Threatened, EN – Endangered, CE – Critically Endangered. For site name abbreviations, see Figure 1. * indicates opportunistic encounters not part of VES.

Species	All sites	MS	CAN	KP	BB	SYK	MH
Amphibians							
Duttaphrynus melanostictus (LC)	19 (0.24)	1	4 (0.17)	3 (0.25)	3 (0.30)	7 (0.88)	1
D. microtympanum (VU)	3 (0.03)	-	-	-	3 (0.20)	-	-
M. keralensis (LC)	40 (0.50)	8 (0.50)	11 (0.46)	3 (0.25)	13 (1.30)	5 (0.63)	-
Minervarya sp.	18 (0.23)	1	6 (0.25)	6 (0.50)	1	-	4 (0.50)
I. brachytarsus (EN)	7 (0.09)	-	4 (0.17)	2 (0.17)	1	-	-
I. semipalmata (LC)	1	-	-	-	1	-	-
Clinotarsus curtipes (NT)	24 (0.30)	6 (0.38)	-	-	13 (1.30)	5 (0.63)	-
M. nelliyampathi (NA)	19 (0.24)	4 (0.25)	14 (0.58)	-	1	-	-
N. acanthodermis (NA)	28 (0.35)	-	18 (0.75)	8 (0.67)	2 (0.20)	-	-
N. anamallaiensis (NA)	1	1	-	-	-	-	-
I. sreeni (NA)	71 (0.89)	20 (1.25)	25 (1.04)	5 (0.42)	13 (1.30)	6 (0.75)	2 (0.25)
I. doni (NA)	14 (0.18)	1	5 (0.21)	7 (0.58)	-	-	1
R. ponmudi (CE)	16 (0.20)	-	11 (0.46)	-	3 (0.30)	-	2 (0.25)
R. akroparallagi (LC)	1	-	1	-	-	-	-
R. anili (LC)	8 (0.10)	-	-	-	8 (0.80)	-	-
P. wynaadensis (EN)	66 (0.81)	9 (0.50)	37 (1.54)	7 (0.58)	3 (0.30)	1	9 (1.13)
Polypedates pseudocruciger (LC)	1	-	-	1	-	-	-
R. calcadensis (EN)	6 (0.08)	-	-	6 (0.50)	-	-	-
R. pseudomalabaricus (CE)	4 (0.50)	-	-	4 (0.33)	-	-	-
U. cf. oxyurus (DD)	1	-	1	-	-	-	-
Reptilia							
Cnemaspis sp.	14 (0.18)	10 (0.63)	2 (0.08)	1	1	-	-
C. wynadensis (EN)	9 (0.11)	1	-	1	5	1	1
E. macularia (NA)	10 (0.13)	1	1	3 (0.25)	-	5 (0.63)	-
E. carinata (LC)	1	*	*	*	-	1	-
R. cf. travancorica (DD)	1	-	-	-	-	1	-
Draco dussumieri (LC)	5 (0.06)	1	2 (0.08)	2 (0.17)	-	-	-
Monilesaurus ellioti (LC)			2 (0.08)	3 (0.25)	-	-	1
C. nemoricola (LC)	*	*	-	-	-	-	-
U. cf. nitida (DD)	-	-	-	-	*	-	-
U. cf. ocellata (LC)	-	-	-	-	*	-	-
L. travancoricus (LC)	1	1	-	-	-	-	-
Dendrelaphis ashoki (LC)	1	1	-	-	-	-	-
A. nasuta (NA)	3 (0.04)	1	-	1	-	-	1
Hebius beddomei (LC)	1	-	-	-	-	-	1
H. monticola (LC)	2 (0.03)	1	*	-	-	1	-
X. piscator (NA)	2 (0.03)	1	1	-	-	-	-

remnants (Fig. 2). We recorded 405 specimens and 33 amphibian and reptile species in the VES surveys (Table 1, Figs. 3-7). This included 12 families and 22 genera. We recorded 1 species of caecilian, 19 frog species, 7 lizard species, and 6 species of snakes (Table 2). Additionally, we had opportunistic encounters of the Nilgiri forest lizard *Calotes nemoricola* in MS remnant, and road-kills of two shield-tailed snakes (*Uropeltis* cf. *ocellata* and *U.* cf. *nitida*) on the road bordering BB remnant (Table 2).

The mean species richness per survey was higher in night-time surveys (5.6±1.7 species/survey, median = 4, N = 13 surveys) compared to daytime surveys (4.3±1.6 species/

Figure 3. Amphibians recorded from rainforest remnants: **(a)** *D. microtympanum* (juvenile; BB) **(b)** *D. melanostictus* (CAN) **(c)** *Minervarya* sp. (CAN) **(d)** *M. keralensis* (SYK) **(e)** *I. brachytarsus* (CAN) **(f)** *I. semipalmata* (BB) **(g)** *M. nelliyampathi* (CAN) **(h)** *I. sreeni* (CAN)

Figure 4. Amphibians recorded from rainforest remnants: **(a)** *I. doni* (KP) **(b)** *C. curtipes* (MS) **(c)** *N. acanthodermis* (CAN) **(d)** *N. anamallaiensis* (MS) **(e)** *P. wynaadensis* (CAN) **(f)** *R. anili* (BB) **(g)** *R. akroparallagi* (CAN) **(h)** *R. ponmudi* (BB)

survey, median = 6, N = 27 surveys, Wilcoxon rank sum test $W = 100$, $p = 0.027$). Significantly more specimens were recorded during night-time surveys (15.6±9.4 specimens/survey, median = 14, N =13 surveys) than during daytime surveys (7.7±4.4 specimens/survey, median = 6, N = 27 surveys, Wilcoxon rank sum test $W = 73$, $p = 0.003$).

The most species-rich group was the largely arboreal amphibian family Rhacophoridae (seven species), followed by the snake family Colubridae (five species). Despite differences in survey effort, species richness was similar in the three larger sites (Table 1). Across all sites, *Indosylvirana sreeni* (Fig. 3h) was the most commonly encountered amphibian species, averaging 0.89 specimens/person-hour of survey, while a diminutive diurnal gecko *Cnemaspis* sp. (Fig. 5f) was the most commonly encountered reptile species (Table 2). Single specimens represented six species of amphibian and five species of reptile. Several species were unique to single remnants, such as the tree frog *Rhacophorus pseudomalabaricus* (Fig. 5c), located only in KP remnant. The MS remnant had the highest number of such unique species despite not having night surveys. Even the smallest remnant (SYK) supported a unique species, *Ristella* cf. *travancorica* (Fig. 5g).

We recorded two amphibian species that are listed as critically endangered—*Raorchestes ponmudi* (Fig. 4h) and *R. pseudomalabaricus* (Fig. 5c), and three as endangered—*Indirana brachytarsus* (Fig. 3c), *Pseudophilautus wynaadensis* (Fig. 4e), and *R. calcadensis* (Fig. 5b). There were five species of amphibian that were 'Not Assessed' for threat levels—*Micrixalus nelliyampathi* (Fig. 3g), *I. sreeni*, *I. doni* (Fig. 4a), *Nyctibatrachus acanthodermis* (Fig. 4c), *N. anamallaiensis* (Fig. 4d), and one Data Deficient species—*Uraeotyphlus* cf. *oxyurus* (Fig. 5d) (IUCN Redlist, 2017). Among reptiles there was one species listed as endangered —*Cnemaspis wynadensis* (Fig. 5e), three species that have not been assessed for their conservation status —*Eutropis macularia* (Fig. 5h), *Ahaetulla nasuta* (Fig. 6g), and *Xenochrophis piscator* (Fig. 6h), and two Data Deficient species—*R.* cf. *travancorica* (Fig. 5g) and *U.* cf. *nitida* (IUCN Redlist, 2017).

Comments on identity of some species

Minervarya sp. – Daniels (2003) reported both *Fejervarya limnocharis* (Gravenhorst, 1829) and *Minervarya nilagirica* (Jerdon, 1854) (as *Limnonectes limnocharis* and *L. nilagirica* respectively) from Valparai. *Fejervarya limnocharis* is currently considered a South-east Asian species (type locality probably in Java). *Minervarya nilagirica* was described by Jerdon from the Nilgiris, north of Palghat gap (Frost, 2018). While the specimens from Valparai, located mostly near swamps and streams in fairly open habitats, resembled *M. nilagirica*, it was impossible to assign these specimens to that or any other known species with certainty.

Nyctibatrachus acanthodermis – This species was described from Kaikatti in Nelliyampathi, Palakkad District, Kerala (Biju et al., 2011). This current record is the first report of this species outside of the vicinity of its type locality. The straight-line distance between the sampled locations in Valparai and the type locality is not more than 27 km. We used the following key diagnostic features to identify the species: medium to large sized frogs; skin on dorsum strongly wrinkled with spiny projections which are more prominent on posterior body; an inverted 'Y' shaped ridge on snout; toes almost fully webbed with the webbing reaching the base of the fourth toe disc; finger discs without dorso-terminal groove; toe discs with dorso-terminal grooves and rounded dorsal skin flaps.

Nyctibatrachus anamallaiensis – This species was originally described from 'Puthuthottam Estate', a small, privately owned rainforest fragment in Valparai (approximate elevation 1100 m asl) (Myers, 1942). All known specimens (published records) are from the Anamalais. We found a single specimen in leaf litter in MS remnant.

Uraeotyphlus. cf. *oxyurus* – The specimen was tentatively identified as *U.* cf. *oxyurus*. The taxonomy of this group is unclear, but the specimen definitely belongs to the 'oxyurus' group (Gower & Wilkinson 2007): eye distinct, surrounded by a pale ring; tentacles below the nostrils; middle groove between two nuchal collars only visible laterally and ventrally; 190 annuli on the body; seven distinct secondary annuli on neck, but primary and secondary annuli indistinguishable throughout the rest of the body; four annuli on tail after the posterior end of cloaca. Gower et al. (2008) also mentioned specimens from Valparai, which they placed in *U.* cf. *oxyurus*.

Cnemaspis sp. – This small, slender, semi-arboreal species was common in most sites. In possessing prominent spine like tubercles on the flanks, it belongs to group II in Smith (1935). However, this species has keeled ventral scales (thoracic region, abdomen, and underside of thighs) and postmentals separated by a single scale, resembling the description of *C. australis* Manamendra-Arachchi, Batuwita & Pethiyagoda, 2007. However, it differs from that species in having smooth subcaudal scales and presence of spine-like tubercles on flanks.

DISCUSSION

The species accumulation curves (Fig. 2) suggest that the 36 amphibian and reptile species recorded from the six rainforest remnants in this survey are almost certainly an underestimate. This in part may be due to the use of the VES methodology which is inherently biased towards the detection of species that are more easily seen (Doan, 2003). This probably explains the absence/non-detection of several groups such as the amphibian genera *Ichthyophis*, *Uperodon*, *Sphaerotheca*, *Nasikabatrachus* and *Melanobatrachus*, alongside reptiles belonging to the families *Typhlopidae*, *Gerrhopilidae*, and more several species of *Uropeltidae*. All these groups are burrowing species that spend most of their life underground and are known to be present in the Anamalai Hills (Smith, 1943; Rajendran, 1985; Ishwar, 2000; Biju, 2001; Kumar et al., 2002; Biju & Bossuyt 2003; Dutta et al., 2004; Subramanian et al., 2013; Pyron, 2016; Garg et al., 2018). Additionally, we conducted most surveys during daytime, and there were no night-time surveys at two sites. The faster species accumulation during night-time surveys, higher encounter rates, and lack of asymptotes in species accumulation curves suggest that additional night-time surveys may reveal more species in these remnants. Some species encountered during daytime surveys were nocturnal species that had taken refuge under rocks, fallen logs, and leaf litter (e.g. *Lycodon travancoricus*, *P. wynaadensis*). Locating these species during the night when they are active will also allow better observations of natural history and behaviour.

Seasonal activity of amphibians and reptiles is a factor that could have influenced the results of this survey. The surveys were conducted during the retreating monsoon and early north-east monsoon rains (September-October).

Figure 5. Amphibians and reptiles recorded from rainforest remnants: **(a)** *P. pseudocruciger* (KP) **(b)** *R. calcadensis* (KP) **(c)** *R. pseudomalabaricus* (KP) **(d)** *U.* cf. *oxyurus* (CAN) **(e)** *C. wynadensis* (SYK) **(f)** *Cnemaspis* sp. (MS) **(g)** *R.* cf. *travancorica* (SYK) **(h)** *E. macularia* (CAN)

Figure 6. Reptiles recorded from rainforest remnants: **(a)** *E. carinata* (CAN) **(b)** *D. dussumieri* (KP) **(c)** *M. ellioti* (KP) **(d)** *C. nemoricola* (MS) **(e)** *L. travancoricus* (MS) **(f)** *D. ashoki* (MS) **(g)** *A. nasuta* (KP) **(h)** *X. piscator* (CAN)

Figure 7. Reptiles recorded from rainforest remnants: **(a)** *H. beddomei* (MH) **(b)** *H. monticola* (MS)

Surveys at the beginning of south-west monsoon may add several more species from these forest remnants. Yet another factor that could affect abundance and species richness of herpetofauna is past management practices in these forest remnants, although this survey was not designed to assess these effects.

Although not quantified systematically, observations suggest that the presence of perennial streams and ponds increased the abundance and species richness of herpetofauna. The MH remnant, the only site without either of these, had the lowest encounter rates of amphibians and reptiles (3 specimens/person-hour). Amphibian abundance was generally higher around water bodies (streams, ponds, marshes). In the Anamalai Hills, most amphibians other than members of the genus *Raorchestes* are dependent on specific microhabitats associated with water bodies for breeding. We recorded *M. nelliyampathi* and *I. sreeni* males on rocks in perennial streams. We found *R. pseudomalabaricus* and *R. calcadensis* breeding in dammed pools with over-hanging vegetation. *I. doni* was mostly located in swamps associated with streams, and *N. acanthodermis* in rock pools in fast flowing streams. Tadpoles of *Indirana* spp. occurred on wet rock faces and boulders. We also recorded *Minervarya* sp. and *M. keralensis* males calling from puddles created by elephant footprints. Identifying these breeding habitats and associated species is important for long-term monitoring of populations of threatened species.

Of the 36 species recorded in this survey, 32 are endemic to the Western Ghats, and a quarter of the amphibian species recorded are listed as critically endangered or endangered (IUCN, 2017). The Anamalai Hills exhibit high endemism, species richness, and turnover of amphibians among sites, drainages, and elevations (Vasudevan et al., 2006; Biju & Bossuyt 2009; Vijayakumar et al., 2014). Past surveys conducted in other rainforest remnants in the Valparai Plateau have provided baseline information on species presence and distribution (Vijayakumar et al., 2001; Kumar et al., 2002). However, for an improved understanding of the diversity and taxonomy of species from this region, further surveys and ecological studies are required, especially in forest remnants outside protected areas.

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