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A preliminary study on the herpetofaunal diversity and distribution in Madurai hills across the Vaigai basin, southern India

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ABSTRACT. We studied the herpetological assemblage and community structure in and around Madurai, targeting a biogeographically complex crossroad at the intersection of the Western Ghats, the Eastern Ghats, and the Vaigai River. Based on a short, three-month-long survey, amounting to 210 hours of fieldwork, we recorded a total of 391 sightings representing 43 species of herpetofauna, consisting of ten species of amphibians, one species of turtle, 15 species of lizards, and 17 species of snakes. Among the 43 species, the 10 commonest species with sighting frequency > 10, including five species each of amphibians and lizards, alone accounted for 321 out of the overall 391 sightings, i.e., 82.0%. Five out of ten amphibian species, ten out of 15 lizards, all 17 snakes, and one turtle species were all represented by < 10 sightings each. These 391 sightings were distributed across eight microhabitat categories spanning fossorial, terrestrial, arboreal, and aquatic guilds. Our analysis revealed a non-random distribution of herpetofauna, where many species were found in water bodies, largely attributable to dicroglossid frogs. The encounter rates of species ranged between 0.005 and 0.324, with the snakes and chelonian being rare species with low encounter rates. Further surveys during rainy season will reveal greater diversity in the study areas.

KEYWORDS. Sirumalai, species richness, species evenness, Srivilliputhur hills

Introduction

Unlike the better-studied ectotherms, less vagile taxa like herpetofauna with lower dispersal and higher endemism (Vitt and Caldwell 2013) occurring in complex biogeographic crossroads (Spector 2002) are best suited to test out questions on diversity and distributions. In the Indian Peninsula, Madurai is one such complex region where the Eastern Ghats (Sirumalai) closely abuts the Western Ghats (Meghamalai-Srivilliputhur hills) and is provided with a riverine barrier — the Vaigai (Chellasamy and Balasubramanian 1991). There have been a few herpetofaunal studies focused on this landscape. One of the earliest works was conducted by Malhotra and Davis (1991) who surveyed the Srivilliputhur hills. Additionally, Hutton and David (2009) revisited their older collection of snakes from here, deposited at the Natural History Museum, London. Chandramouli and Ganesh (2010) reported on the herpetofauna of the Cardamom Hills (Meghamalai plus Srivilliputhur hills). Later, Srinivas and Bhupathy (2013) and Bhupathy and Kumar (2013) reported on the amphibians and reptiles of Meghamalai, respectively. Ganesh et al. (2014) combined the aforementioned works and presented a detailed overview of the ophiofaunal diversity of

Meghamalai. Subsequently, Chaitanya et al. (2019) presented an updated checklist of the Meghamalai herpetofauna.

Likewise, a few studies have also been done in the Eastern Ghats, in Sirumalai on the other side of the Vaigai river. Vanak et al. (2001) reported on the herpetofaunal checklist of the Khandige Estate in Sirumalai. Later, a series of studies by Ganesh and Arumugam (2015, 2016) shed new light on the herpetofauna of Sirumalai and a few other ranges in the adjacent parts of the Eastern Ghats. Thus, compared to the myriad studies conducted on the Western Ghats biodiversity, very few studies exist for the Eastern Ghats, here represented by Sirumalai and surrounding massifs. Perhaps the only one of the past studies that had generally enumerated on the reptile diversity of Madurai district is the brief work by Murthy and Chandrasekar (1996). In addition to being brief and patchy, this study has not been revisited since, in almost three decades. Barring these, the only other mention of herpetofauna includes a few new gecko descriptions (Sayyed et al. 2023a-c). Therefore, detailed and updated information on the herpetological diversity in the hills and drainage systems in Madurai is still needed. Therefore, we conducted a study on the herpetofauna of the hills near Madurai city, on either side of the Vaigai river.

Study Area

Three hill ranges, namely Elumalai, Nagamalai, and Alagarmalai, were selected for this survey as they represented areas situated on the west and east banks and along the Vaigai river, aligning with the aim of this study. Elumalai (9.89ºN 77.64ºE; 790 m asl) is to the west of Vaigai, closer to the Western Ghats where it dovetails with the Srivilliputhur hills to the southwest. Nagamalai (9.95ºN, 78.02ºE; 390 m asl) is part of a long, linear hill range that runs along the Vaigai river next to Madurai, situated in the middle. Alagarmalai (10.10ºN 78.23ºE; 800 m asl) is to the east of Vaigai, closer to the Eastern Ghats where it meets Sirumalai and Karanthamalai to the northeast. These hills are typically covered with dry thorn forests in the foothills (< 200 m asl), dry deciduous forests in mid-elevation (200–600 m asl), and moist deciduous forests in the higher slopes and summits (> 600 m asl). Some of these hills are also intersected by a few rivulets and water bodies (Pauline et al. 2006; Jayakumar et al. 2009). All the study sites are Reserved Forests under statutory protection.

Methodology

Fieldwork was conducted for three months from January to March 2023, by a two-member team. About one month was spent surveying each range, with around 21 field days, for 3 or 4 hours of survey per day. All hill ranges were surveyed during all the months to avoid seasonal bias in sighting records. A total of 210 hours of fieldwork was conducted, roughly corresponding to 70 hours per hill range. Field surveys were conducted following the diurnal time-constrained search method (Ribeiro-Junior et al. 2008) and the nocturnal visual encounter method (Crump and Scott 1994). Most of the surveys (70%) were done during daytime and some hours of surveys (30%) were done at night, especially the surveys closer to human habitations. Individuals thus sighted were identified, maturity and sex externally determined (wherever possible), and photographed in situ. This was a visual study and did not involve any voucher specimen collection and deposition in museums. Taxon identifications were based on consultation of the following literature — amphibians (Daniel 2002; Daniels 2005; Gururaja 2012; Ganesh 2015) and reptiles (Das 2002; Daniel 2002; Whitaker and Captain 2008; Ganesh 2015). These were further updated using (Sayyed et al. 2023 a-c; Agarwal et al. 2016, 2024; Mallik et al. 2020).

Results

Overall, a total of 43 species of herpetofauna, consisting of 10 species of amphibians and 33 species of reptiles, were recorded in this study. The reptile fauna in turn consisted of one species of turtle, 15 species of lizards, and 17 species of snakes. The following are quantified accounts of the herpetofauna sighted during the study, detailing the sighting frequencies and microhabitat associations.

Our records (Table 1) revealed that five frogs, 10 lizards, all 17 snakes, and one turtle species, equating to 33 species (76.7%), had less than 10 sightings each. Only two lizard species were present in the next category (11–20 sightings per species). To draw further inferences, we categorised the dataset into frogs, lizards, snakes

Table 1. Break-up of herpetofaunal taxa – frogs (F), lizards (L), snakes (S), and turtle (T) detailing the no. of species (sp.) and encounter rate (ER) in each abundance category.

No. of sightings	F sp.	F ER	L sp.	L ER	S sp.	S ER	T sp.	T ER
1–10	5	0.005–0.021	10	0.005–0.021	17	0.005	1	0.005
11–20	0	0	2	0.065–0.082	0	0	0	0
21–30	0	0	3	0.115–0.137	0	0	0	0
31–40	2	0.192	0	0	0	0	0	0
41–50	3	0.225–0.269	0	0	0	0	0	0
51–60	1	0.324	0	0	0	0	0	0

and turtles. We then found that only six species of amphibians were present in categories that included species with > 31 sightings. Since the highest number of sightings of any species in this study is 59 (*D. melanostictus*), the cut-off value 31 forms almost 50% of the maximum value.

Of the fauna represented by > 10 sightings, five were amphibian species and five were species of lizards. The values range from 12 to 59 sightings, or 3.0 to 15.0% of total sightings (Table 2). The total number of species sighted more than 10 times (n = 10) among the overall species sighted (n = 43) was 23.2%, or roughly between one fifth and one fourth, which collectively constituted 321 out of 391 sightings, i.e. 82.0% of the total number of sightings. It is noteworthy to mention here that, surprisingly, a few species that are highly habitat specific and do not tolerate human-mediated disturbances also featured in this list. Examples include two species of agamid lizards — *Psammophilus cf. blanfordanus* and *Sitana ponticeriana* — which are highly specific to rocky outcrops and open grasslands, respectively.

Table 2. Sighting frequency and relative abundance (%) of species with > 10 sightings

Scientific Name	No. sightings	% of total
Amphibia		
Duttaphrynus melanostictus	59	15.0
Euphlyctis cyanophlyctis	46	11.7
Minervarya agricola	44	11.2
Sphaerotheca breviceps	41	10.4
Hoplobatrachus tigerinus	35	8.9
Reptilia		
Hemidactylus frenatus	25	6.3
Calotes versicolor	23	5.8
Psammophilus cf. blanfordanus	21	5.3
Sitana ponticeriana	15	3.8
Hemidactylus leschenaultii	12	3.0

The 43 species of herpetofauna occupied several categories of microhabitats (see Table 3). The greatest number of sightings were in the water bodies, viz. 202 (51.7%). This was followed by rocks, viz. 49 (16.8%), followed by an equal number on tree branches 38 (9.7%) and building walls 38 (9.7%), followed by leaf litter 36 (9.2%), tar road 11 (2.8%), grass 10 (2.5%) and lastly, bare ground 6 (1.5%). Assuming a non-random distribution, the number of sightings in each of the eight categories of microhabitats were 48.8 (12.5%). Only two categories, namely tree branches and building wall with 9.7% comes the closest to this hypothesised ideal mean value. As for the taxonomic break-up of the number of sightings, in the various families, the values ranged from 1 (0.2%) (geoemydid turtle, typhlopid, erycid, pythonid snakes) to as much as 166 (42.4%) (dicroglossid frogs).

Discussion

The present study revealed the occurrence of 43 species of herpetofauna in the study area. However, there are still some species that are known from the region (Daniel 2002; Das 2002; Whitaker and Captain 2004), but remain undetected in the present work. Examples include two Chelonians; flapshell turtle (*Lissemys punctata*) and star tortoise (*Geochelone elegans*). As for the lizards, scaly gecko (*Hemidactylus scabriceps*), Erode ground gecko (*Cyrtodactylus* cf. *speciosus*), supple skinks (*Riopa punctata, R.*

Table 3. Family-wise break-up of sightings of taxa among the various microhabitat types (spp – no. of species; grd – ground; ltr – litter; grs – grass; sight – no. of sightings)

Taxa (Families)	Spp	Water	Wall	Tree	Grd	Ltr	Grs	Rock	Road	Sight
Bufonidae	1	32	0	0	0	27	0	0	0	59
Microhyldiae	3	1	0	0	0	0	3	0	1	5
Rhacophoridae	1	0	1	2	0	0	0	0	0	3
Dicroglossidae	5	166	0	0	0	0	0	0	0	166
Geoemydidae	1	1	0	0	0	0	0	0	0	1
Gekkonidae	7	0	37	7	1	0	1	5	0	51
Scincidae	2	0	0	0	0	7	0	1	1	10
Lacertidae	1	0	0	0	0	0	0	4	0	4
Agamidae	4	0	0	22	3	0	1	36	0	62
Chameleonidae	1	0	0	2	0	0	0	0	0	2
Typhlopidae	1	0	0	0	0	0	0	0	1	1
Erycidae	1	0	0	0	0	0	0	0	1	1
Pythonidae	1	0	0	0	0	0	0	0	1	1
Viperidae	2	0	0	0	1	0	1	1	0	3
Elapidae	2	0	0	0	0	0	1	0	1	2
Natricidae	3	2	0	0	0	1	1	0	3	7
Colubridae	7	0	0	5	1	1	2	2	2	13

albopunctata), Dravid skinks (*Dravidoseps* sp.), Bibron's skink (*Eutropis* cf. *bibronii*) and Bengal monitor lizard (*Varanus bengalensis*) are such examples (Vanak et al. 2001; Ganesh and Arumugam 2016; Karthik 2017; Agarwal et al. 2016). Among snakes, beaked worm snake (*Grypotyphlops acutus*), common sand boa (*Eryx conicus*), banded kukri snake (*Oligodon arnensis*), Russell's wolf snake (*Lycodon fasciolatus*), common bridal snake (*Dryocalamus nympha*), common trinket snake (*Coelognathus helena*), Joseph's racer (*Platyceps josephi*), common cat snake (*Boiga trigonata*) and slender coral snake (*Calliophis melanurus*) remain undetected in this work.

Some unrecorded species of snakes are truly rare ones (Daniel 2002; Das 2002; Whitaker and Captain 2004). Similarly, one species that was seen, the black-headed snake (*Sibynophis subpunctatus*) is rare among other snakes seen in the area. Also, a few range-restricted snake species such as shieldtail snakes (*Uropeltis* sp.), bamboo pitviper (*Craspedocephalus gramineus*), green keelback (*Rhabdophis plumbicolor*), Indian reed snake (*Gongylosoma calamaria*), flying snakes (*Chrysopelea taprobanica, C. ornata*), Boulenger's bronzeback (*Dendrelaphis bifrenalis*), Forsten's cat snake (*Boiga forsteni*), yellow-green cat snake (*Boiga flaviviridis*) and Travancore wolf snake (*Lycodon travancoricus*) could potentially occur in the hill forest tracts of the study areas based on their published records nearby (Ganesh and Arumugam 2016; Chaitanya et al. 2019; Aengals et al. 2022; Agarwal et al. 2024). Much longer-term sampling, including road-cruising, preferably during the wet season would certainly yield these snake sightings in the study area.

This study's record of 43 species (33 reptiles) is much higher when compared to the 15 reptile species reported by Murthy and Chandrasekar (1996). All species reported by them were also sighted in the present study, except for one species *Uropeltis pulneyensis*, which is a high-elevation Shola forest species that is absent in the study area (Whitaker and Captain 2004; Ganesh et al. 2023). Literature specifically mentions Alagarkoil hills in the distribution of the brown vine snake (*Ahaetulla sahyadrensis*) (Whitaker and Captain 2004 read with Mallik et al., 2020).

However, that species was not sighted during the present study. The relatively range-restricted, non-commensal reticulated gecko (*Hemidactylus reticulatus*), which was recorded by Murthy and Chandrasekar (1996), was also sighted in this work. But, another lizard, the scaly gecko (*Hemidactylus scabriceps*) that was recorded in the nearby Pasumalai (Ganesh et al. 2017) could not be recorded in this study. Regarding the unrecorded species of herpetofauna, it is hypothesised that the survey undertaken during the hot and dry summer months is a major reason for the incomplete dataset at present.

As for the amphibians, the frog fauna of this region is similar to that prevailing in any plains country in southern India (Daniels 2005; Gururaja 2012). The frog species recorded in this work is comparable to those reported in Puducherry (Seshadri et al. 2012) and in Kalpakkam (Ramesh et al. 2013). Apart from those reported here, only a few species of amphibians might still be present in the current study sites. Such examples include the two species of toads *Duttpahrynus scaber* and *D. peninsularis* (Ganesh et al. 2020 read with Bisht et al. 2021). Another possible species occurrence in this region is the rock toad (*Duttaphrynus hololius*) that has been seen in the northerly Pudukottai hills (Rameshwaran and Sayyed 2018). The recently studied burrowing frogs (*Sphaerotheca pluvialis* and *S. rolandae*) might also be occurring here (Dahanukar et al. 2017). Given that the study was carried out during the dry season, future surveys during the monsoon might record these above-mentioned species. Future surveys will likely yield the presence of all these frogs in the study sites. However, the proportional number of amphibian species recorded vs. reported from the study area, fared much better than that of reptiles, even though the study was conducted during the dry season.

Sighting endangered species like the Indian rock python (*Python molurus*) is also an encouraging prospect. The presence of another such species, the Bengal monitor lizard (*Varanus bengalensis*), would have further enriched this dataset. The presence of the endangered marsh crocodile or mugger (*Crocodylus palustris*) in the area is questionable. This species has been reported from places north (Moyar, fide Whitaker and Srinivasan 2020) and south (Neyyar, fide Jayson et al. 2006) of the Vaigai basin. Since the focus of the survey was more in the hilly terrestrial ecosystems and not the actual Vaigai river, we were unable to record this species. Another similar case is with the Leith's softshell turtle (*Nilssonia leithii*) that is also known to occur in Tamil Nadu's rivers (Das et al. 2014). Surveys

Figure 1. Map of study area showing the sampled hill ranges viz., Elumalai, Nagamalai and Alagarmalai, the course of the river Vaigai, Palani hills (Western Ghats), and Sirumalai (Eastern Ghats). Map rendered from Google Earth.

targeting the lotic aquatic ecosystems around Madurai might yield the aforementioned species. Future works should target the aforesaid microhabitats to fully unravel the diversity of the biogeographically-composite Madurai region.

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Appendix 1. Encounter rate of herpetofauna in Vaigai Basin Hills during the study

S. no	Scientific name	Sighting frequency	Encounter rate
1	*Duttaphrynus melanostictus*	59	0.3241
2	*Uperodon systoma*	3	0.0164
3	*Uperodon taprobanicus*	1	0.0054
4	*Microhyla ornata*	1	0.0054
5	*Polypedates maculatus*	3	0.0164
6	*Hoplobatrachus tigerinus*	35	0.1923
7	*Hoplobatrachus crassus*	4	0.0219
8	*Sphaerotheca breviceps*	41	0.2252
9	*Minervarya agricola*	44	0.2417
10	*Euphlyctis cyanophlyctis*	46	0.2692
11	*Melanocelys trijuga*	1	0.0054
12	*Hemidactylus leschenaultii*	12	0.0659
13	*Hemidactylus frenatus*	25	0.1373
14	*Hemidactylus parvimaculatus*	3	0.0164
15	*Hemidactylus triedrus*	3	0.0164
16	*Hemidactylus multisulcatus*	1	0.0054
17	*Hemidactylus reticulatus*	1	0.0054
18	*Cnemaspis reticulata*	3	0.0164
19	*Eutropis carinata*	4	0.0219
20	*Eutropis macularia*	4	0.0219
21	*Ophisops leschenaultii*	4	0.0219
22	*Sitana ponticeriana*	15	0.0824
23	*Calotes versicolor*	23	0.1263
24	*Calotes calotes*	2	0.0109
25	*Psammophilus cf. blanfordanus*	21	0.1153
26	*Chamaeleo zeylanicus*	2	0.0109
27	*Indotyphlops braminus*	1	0.0054
28	*Eryx johnii*	1	0.0054
29	*Python molurus*	1	0.0054
30	*Daboia russelii*	2	0.0109
31	*Echis carinatus*	1	0.0054
32	*Naja naja*	2	0.0109
33	*Bungarus caeruleus*	1	0.0054
34	*Fowlea piscator*	4	0.0219
35	*Atretium schistosum*	2	0.0109
36	*Amphiesma stolatum*	1	0.0054
37	*Sibynophis subpunctatus*	1	0.0054
38	*Lycodon striatus*	1	0.0054
39	*Lycodon aulicus*	2	0.0109
40	*Oligodon taeniolatus*	1	0.0054
41	*Ptyas mucosa*	4	0.0219
42	*Dendrelaphis tristis*	4	0.0219
43	*Ahaetulla oxyrhynca*	1	0.0054