Journal of Threatened Taxa

Building evidence for conservation globally

www.threatenedtaxa.org

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

Communication

Species composition and abundance estimates of reptiles in selected agroecosystems in southern Western Ghats, India

Abhirami Mini Jayakumar & Paingamadathil Ommer Nameer

26 September 2018 | Vol. 10 | No. 10 | Pages: 12328–12336
10.11609/jott.3652.10.10.12328-12336

COMMUNICATION

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 September 2018 | 10(10): 12328–12336

ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

Species composition and abundance estimates of reptiles in selected agroecosystems in southern Western Ghats, India

Abhirami Mini Jayakumar [1] & **Paingamadathil Ommer Nameer** [2]

[1,2] Centre for Wildlife Studies, College of Forestry, Kerala Agricultural University, Thrissur, Kerala 680656, India
[1] abhirami.mj@gmail.com, [2] nameer.po@kau.in (corresponding author)

OPEN ACCESS

Abstract: Species composition and abundance of reptiles in selected agroecosystems in Thrissur plains, near Palghat Gap, southern Western Ghats in India, was studied from January 2017 to May 2017. The agroecosystems surveyed were coconut, cashew & rubber plantations, home garden, paddy field, and botanical garden. Time-constrained visual encounter surveys of a total effort of 360 man-hours were done in the field. Coconut and cashew plantations reported the highest species richness with 11 species each, while the highest number of sightings (159) were recorded from botanical garden. Bronze Grass Skink *Eutropis macularia* was the most abundant species in agroecosystems. Correspondence analysis was done to compare the reptilian diversity in the agroecosystems. The reptile fauna of home garden and paddy field were found to be more distinct than the rest of the agroecosystems. A total of 17 species of reptiles were recorded during the study, thus highlighting the significance of agroecosystems in acting as important buffer landscapes for reptiles.

Keywords: Cashew plantation, coconut plantation, botanical garden, home garden, Important Bird Area, Kole wetlands, paddy field, Ramsar site, rubber plantation.

Malayalam Abstract

മദ്ധ്യകേരളത്തിലെ വിവിധ കാർഷിക ആവാസവ്യവസ്ഥകളിലുള്ള ഉരഗജീവികളുടെ ജൈവവൈവിധ്യം കണ്ടെത്തുന്നതിനായി ജനുവരി 2017 മുതൽ മെയ് 2017 വരെ നീണ്ടുനിന്ന ഒരു പഠനം നടത്തുകയുണ്ടായി. കശുമാവ് തോട്ടം, തെങ്ങിൻതോപ്പ്, പുരയിടകൃഷി, റബ്ബർ തോട്ടം, നെൽപ്പാടം തുടങ്ങിയ കാർഷിക ആവാസവ്യവസ്ഥകളിൽ പലതരത്തിലുള പഠന രീതികൾ പ്രയോഗിച്ച്, 17 വിവിധ ഇനം ഉരഗജീവികളെ കണ്ടെത്തുവാൻ കഴിഞ്ഞു. പശ്ചിമഘട്ടത്തിലെ തദ്ദേശീയ ഇനങ്ങളായ ബെട്ടോമീ പൂച്ചയരണ (*Ristella cf. beddomii*), കാട്ടരണ (*Sphenomorphus dussumieri*) എന്നീ ഇനങ്ങളെയും പ്രസ്തുത പഠനത്തിന്റെ ഭാഗമായി കാർഷിക ആവാസവ്യവസ്ഥകളിൽ നിന്നും രേഖപ്പെടുത്തുവാനായി സാധിച്ചു. തിരഞ്ഞെടുക്കപ്പെട്ട കാർഷിക ആവാസവ്യവസ്ഥകളും ഉരഗജീവികളുടെ സമൃദ്ധിയും തമ്മിൽ അഭേദ്യ ബന്ധം ഉണ്ടെന്നു ഈ പഠനം ചൂണ്ടികാണിക്കുന്നു. പശ്ചിമഘട്ടത്തിലെ തദ്ദേശീയ ഇനങ്ങളായ ഉരഗജീവികളുടെ സംരക്ഷണത്തിൽ പശ്ചിമഘട്ടത്തോട് ചേർന്നു കിടക്കുന്ന കാർഷിക ആവാസവ്യവസ്ഥകൾക്കുള്ള പങ്ക് ഈ പഠനത്തിലൂടെ വ്യക്തമാവുന്നു.

DOI: https://doi.org/10.11609/jott.3652.10.10.12328-12336 | **ZooBank:** urn:lsid:zoobank.org:pub:860DCCC7-66AB-4A46-A362-5EC56D844488

Editor: Pritpal S. Soorae, Environment Agency Abu Dhabii, United Arab Emirates. **Date of publication:** 26 September 2018 (online & print)

Manuscript details: Ms # 3652 | Received 14 July 2017 | Final received 02 August 2018 | Finally accepted 12 September 2018

Citation: Jayakumar, A.M. & P.O. Nameer (2018). Species composition and abundance estimates of reptiles in selected agroecosystems in southern Western Ghats, India. *Journal of Threatened Taxa* 10(10): 12328–12336; https://doi.org/10.11609/jott.3652.10.10.12328-12336

Funding: Kerala Agricultural University.

Competing interests: The authors declare no competing interests.

Author Details: Abhirami M. Jayakumar is a PG research scholar, whose interest include taxonomy and ecology of reptiles of Western Ghats. P.O. Nameer is a Professor and his research interest include the taxonomy, biogeography and ecology of the vertebrates except fishes.

Author Contribution: Both the authors contributed equally to the design of the study, field work, morphometric data collection, analysis and manuscript preparation.

Acknowledgements: We thank Neelesh Dahanukar, IISER, Pune for his assistance with data analysis. Abhin M. Sunil, Bharath M. R., Habeel Sahal, Nibin Antony K., Francis Scaria, Al Ameen A., Sreekumar E. R., Prajeesh P., Syamili M. S., Dilgith Surendran and Amal U. S. assisted us with the field work. The Dean, College of Forestry, Kerala Agricultural University is acknowledged for the encouragement and support. We also thank the anonymous reviewers and the Subject Editor for their critical comments.

INTRODUCTION

Nearly two-thirds of the terrestrial environment of the world is made up of managed ecosystems with natural, undisturbed habitats accounting for only a meagre five percentage. These managed ecosystems include agricultural systems, forestry systems, and human settlements (Gamage et al. 2008). Herpetofauna makes up 48% of the terrestrial vertebrates that are threatened by agroforestry and forestry activities (Palacios et al. 2013).

Despite the fact that herpetofauna makes up half of vertebrate species, they are very much understudied in their response to change in habitats from natural forests to plantations. The review done by Palacios et al. (2013) on the herpetofauna of agroecosystems on a global scale found just 27 studies pertaining to amphibians and reptiles. Very few studies on the reptilian diversity of agroecosystems have been done in southern India too. Perhaps the only study on the reptiles of human-modified habitats is the one by Venugopal (2010), who studied the agamids of human-modified habitats in the Western Ghats.

In a time when more and more forest areas are being converted into plantations and agricultural lands for meeting the growing needs of human populations, it is important to evaluate the reptile diversity in these modified ecosystems. It is important to assess whether these agroecosystems are capable of supporting and sustaining reptile biodiversity, particularly that of habitat specialists and endemic species.

STUDY AREA

The study was conducted in selected agroecosystems in Thrissur District, southern Western Ghats, Kerala (10.53–10.55^{0}N & 76.27–76.28^{0}E, 20–70 m). The agroecosystems chosen included cashew, coconut & rubber plantations, home garden, paddy field, and botanical garden (Fig. 1). The study area chosen mostly comes within the main campus of Kerala Agricultural University in Kerala. The campus has a total area of 391.44ha and is located very close to Peechi-Vazhani Wildlife Sanctuary. The major habitats include gardens, botanical gardens, plantations of rubber, coconut, plantain & cocoa, and orchards of mango, jackfruit, sapota & guava. The whole area must have been under forests about one and a half centuries ago and was subsequently converted mostly into rubber plantations. Later, in 1971, the land was handed over to the Kerala Agricultural University (KAU), and the KAU developed these areas into different land uses as explained above. The 14-year mean minimum temperature is 23.3^{0}C and the 10-year mean maximum is 31.9^{0}C. The area receives southwest and northeast monsoons, the greater portion of the rainfall, however, is received from the southwest monsoon between June and September. The mean

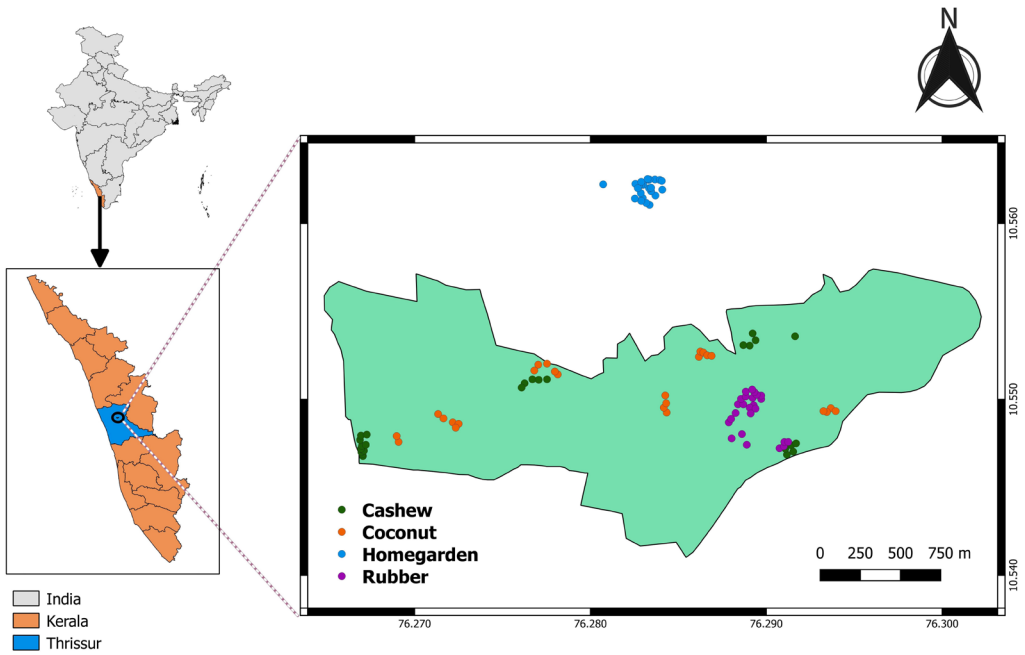

Figure 1. Location map of different study locations, Thrissur

annual rainfall is 2803.4mm. The mean number of rainy days per year is 112 (Manohar et al. 2017). The paddy field selected was located at the Kole Wetlands in central Kerala, which incidentally is a Ramsar site and an Important Bird Area (IBA) (Islam & Rahmani 2004, 2008).

METHODS

The method followed was time-constrained visual encounter survey of a two-hour duration in each of the agroecosystems in the morning (08:00–10:00 hr) and evening (19:00–21:00 hr). Each location was covered on foot and whenever a species was sighted, observations such as the name of the species, the number of sightings, time, and GPS location were recorded following Ishwar et al. (2001). At each agroecosystem, the survey was carried out for five days. Thus, the total effort spent during the entire course of the study was 360 man -hours. Additionally, micro-habitat parameters such as canopy height, canopy cover, leaf litter depth, leaf litter cover, shrub cover, herb cover, and number of fallen logs were recorded at each of the agroecosystems. Litter depth was measured using a steel scale (Elora) and canopy height was measured using Haga altimeter (Durga Enterprises). The rest of the measurements were visually estimated (see Vasudevan et al. 2001; Kanagavel et al. 2013). Weather data like maximum temperature, minimum temperature, and relative humidity for the study period was obtained from the Kerala Agricultural University Weather Station located in Thrissur District, Kerala. The study was carried out from January to May 2017 in the pre-monsoon season.

For confirming the identification of the species, the following literature were consulted: Das (2002), Whitaker & Captain (2004), Mahony (2011), Agarwal & Karanth (2015), Agarwal et al. (2016), Lajmi et al. (2016). The distribution range of the species was verified using Ganesh et al. (2013) and Palot (2016).

Statistical Analysis

Chi-square analysis of association was performed to understand whether the reptile fauna had a preference for any plantation types (coconut, cashew, rubber, home gardens, botanical gardens, or paddy fields). Patterns of relationship between species abundance across nine environmental parameters (canopy cover, canopy height, litter depth, litter cover, shrub cover, herb cover, maximum temperature, minimum temperature, and relative humidity) in different plantation types were investigated using canonical correspondence analysis (CCA), a multivariate constrained ordination technique (Legendre & Legendre 1998). A triplot of observations grouped for plantation types, species, and eigenvectors of environmental variables was plotted to understand the species distribution along the plantation types and environmental variables. A scree plot of eigenvalues and cumulative inertia explained by each canonical axes was plotted to understand the contribution of each axes. The significance of the canonical axes was tested using permutations test (Legendre et al. 2011). Statistical analysis was performed in PAST 3.19 (Hammer et al. 2001).

RESULTS AND DISCUSSION

A total of 594 sightings of 17 species (Table 1) was encountered from the agroecosystems during the study period, with an average pooled encounter rate of 1.27 reptiles/man-hour. The species richness was the highest in coconut and cashew plantations, with 11 species each (Table 2; Images 1–14). The abundance of the reptiles, however, was greatest in botanical gardens (159 sightings). Bronze Grass Skink *Eutropis macularia* was the most encountered species in the agroecosystems of Thrissur District with 220 sightings, followed by (Murray's) House Gecko *Hemidactylus* cf. *murrayi* totalling 87 sightings.

The variation in the number of sightings of the reptiles between day and night are given in Fig. 2. As expected, it can be seen that most of the reptiles were more active during night hours. Out of the six species of geckos seen during the study, all four species of *Hemidactylus* geckos, as well as *Cyrtodactylus* cf. *collegalensis*, were nocturnal in habit. The Day Geckos *Cnemaspis* spp., however, as its common name suggests, were observed mainly during morning hours. Among skinks, *Ristella* cf. *beddomii* was primarily a nocturnal species, while *Sphenomorphus dussumieri* was spotted only during day hours. *Eutropis macularia*, *E. carinata*, and the agamid lizard *Calotes versicolor* were observed during both morning and night hours. *Calotes versicolor* was observed to be sleeping when spotted during night hours. All the seven species of snakes observed were spotted during night hours (Fig. 2).

There was a significant association between plantation types and abundance of different reptile species (chi square = 1006.3, df = 80, $P < 0.0001$), indicating that the reptile fauna had a differential preference for the plantation type. The complex pattern of reptile species distribution across the plantation types

Table 1. Reptiles of selected agroecosystems in Thrissur District

	Common name	Scientific name	Family	IUCN status	Image
1	(Murray's) House Gecko	*Hemidactylus* cf. *murrayi*	Gekkonidae	NE	Image 1
2	Common House Gecko	*Hemidactylus frenatus*	Gekkonidae	LC	Images 2 & 3
3	Termite Hill Gecko	*Hemidactylus triedrus*	Gekkonidae	NE	Image 4
4	Day Gecko	*Cnemaspis* cf. *gracilis*	Gekkonidae		Images 5 & 6
5	Kollegal Ground Gecko	*Cyrtodactylus collegalensis*	Gekkonidae	NE	Image 7
6	Dussumier's Litter Skink*	*Sphenomorphus dussumieri*	Scincidae	LC	Image 8
7	Bronze Grass Skink	*Eutropis macularia*	Scincidae	NE	Image 9
8	Common Keeled Skink	*Eutropis carinata*	Scincidae	LC	Image 10
9	(Beddome's) Cat Skink*	*Ristella* cf. *beddomii*	Scincidae	LC	Image 11
10	Oriental Garden Lizard	*Calotes versicolor*	Agamidae	NE	Image 12
11	Common Indian Krait	*Bungarus caeruleus*	Elapidae	NE	
12	Beddome's Cat Snake	*Boiga beddomei*	Colubridae	LC	
13	Common Wolf Snake	*Lycodon aulicus*	Colubridae	NE	
14	Common Trinket Snake	*Coelognathus helena*	Colubridae	NE	
15	(Common) Vine Snake	*Ahaetulla* cf. *nasuta*	Colubridae	NE	Image 14
16	Russell's Kukri Snake	*Oligodon taeniolatus*	Colubridae	LC	Image 13
17	Checkered Keelback	*Xenochrophis piscator*	Natricidae	NE	

Table 2. Species diversity and abundance of reptiles in selected agroecosystems in Thrissur District

	Species	Coconut Plantation	Cashew Plantation	Rubber Plantation	Home garden	Botanical Garden	Paddy field	Total
		Number of sightings						
1	*Hemidactylus* cf. *murrayi*	47	20	3	2	10	0	82
2	*Hemidactylus frenatus*	40	6	16	4	3	0	69
4	*Hemidactylus triedrus*	0	2	0	0	0	0	2
5	*Cnemaspis* spp.	10	1	8	3	19	0	41
6	*Cryodactylus collegalensis*	7	6	18	2	11	0	44
7	*Sphenomorphus dussumieri*	0	0	0	13	0	0	13
8	*Eutropis macularia*	21	45	82	2	70	0	220
9	*Eutropis carinata*	1	9	0	0	14	0	24
10	*Ristella* cf. *beddomii*	0	11	5	0	28	0	44
11	*Calotes versicolor*	16	11	9	3	3	0	42
12	*Bungarus caeruleus*	0	0	0	1	0	0	1
13	*Boiga beddomei*	1	0	1	0	0	0	2
14	*Lycodon aulicus*	1	1	0	0	0	2	4
15	*Coelognathus helena*	1	0	0	0	0	0	1
16	*Ahaetulla* cf. *nasuta*	0	0	1	0	0	0	1
17	*Oligodon taeniolatus*	0	0	0	0	0	3	1
18	*Xenochrophis piscator*	0	0	0	0	1	0	3
	Total	145	112	143	30	159	5	594

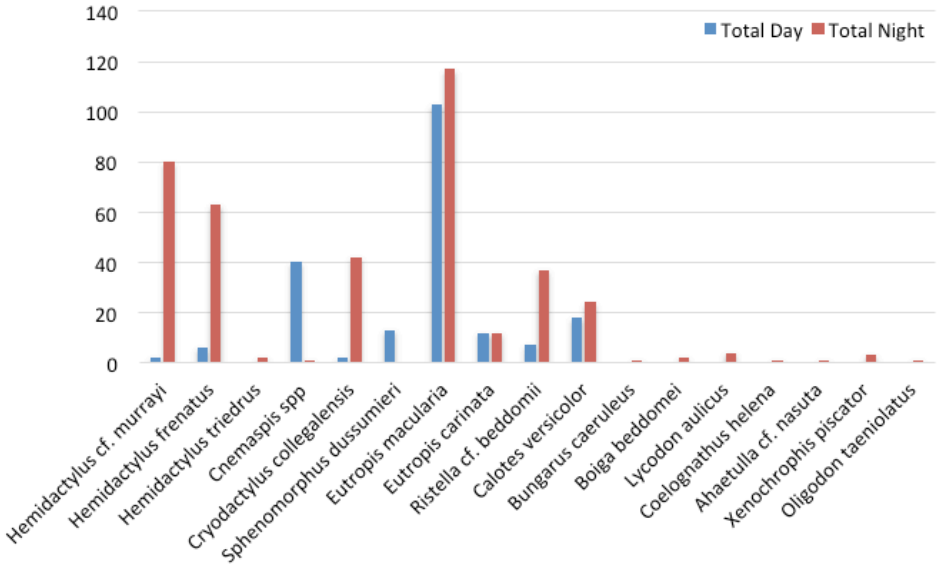

Figure 2. Number of sightings for each species of reptile recorded during morning and night hours

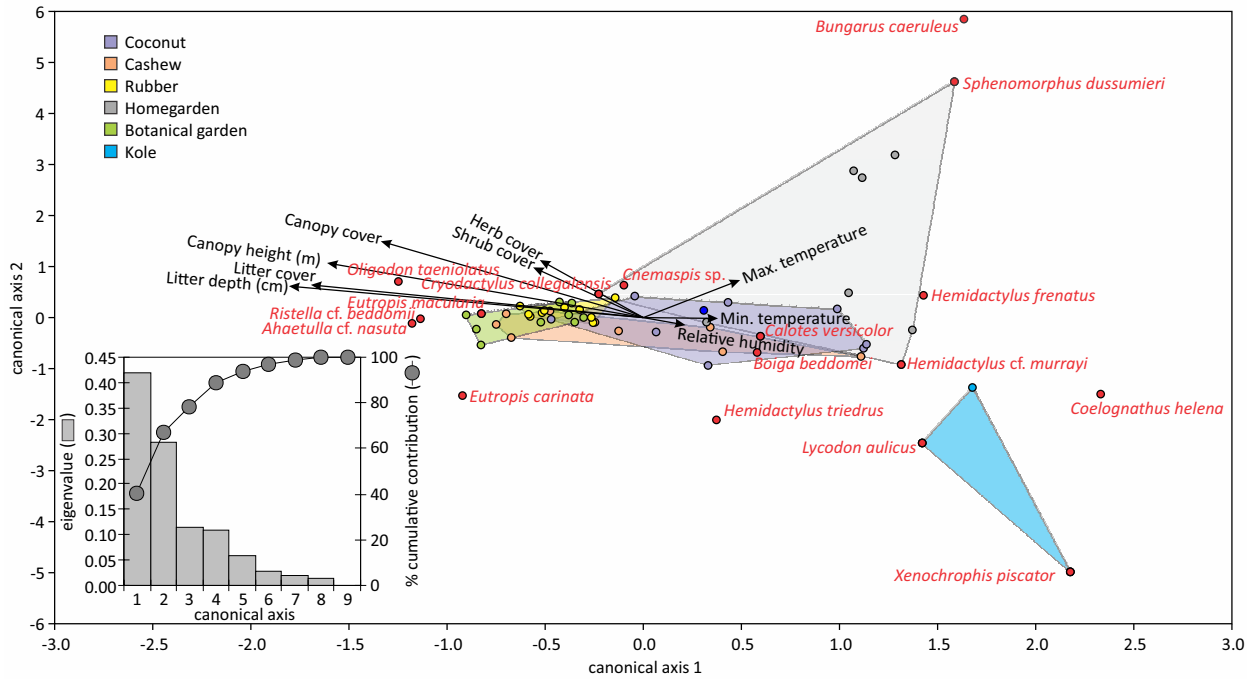

Figure 3. Canonical correspondence analysis triplot. Species are shown in red font and red circles. Observations are grouped for plantation type and a convex polygon was plotted to delineate observations for each plantation type. Eigen vectors of environmental variables are shown in black. Screen plot depicting the contribution explained by each canonical axis is shown in inset.

and environmental variables are depicted in the CCA triplot (Fig. 3). The first two CCA axes were significant (permutations 999, trace = 1.047, P = 0.001; canonical axis 1, eigen value = 0.4199, P = 0.001; canonical axis 2, eigenvalue = 0.2819, P = 0.001) and together they explained 67% total inertia in the data. Both species composition and environmental parameters of the different plantation types were different with no overlap for paddy fields, indicating that paddy fields are not only distinctly different in the environmental parameters but has a different reptile fauna. *Xenochrophis piscator* was unique to the paddy field habitat while *Lycodon aulicus* was more abundant in the paddy field as compared to other habitats and both these factors

could be correlated to the relatively higher humidity and temperature of paddy field habitats and lower canopy cover, canopy height, litter depth, litter cover, shrub cover, and herb cover (Fig. 3). In general, species such as *Boiga beddomei*, *Bungarus caeruleus*, *Calotes versicolor*, *Coelognathus helena*, *Hemidactylus frenatus*, *H.* cf. *murrayi*, *H. triedrus*, *Sphenomorphus dussumieri*, *Lycodon aulicus*, and *Xenochrophis piscator* preferred relatively higher humidity and temperature and lower canopy cover, canopy height, litter depth, litter cover, shrub cover, and herb cover. As a result, these species mainly favoured home gardens and paddy fields in Kole Wetlands, followed by cashew and coconut plantations and, rarely, rubber plantations or botanical gardens. On the other hand, *Ahaetulla* cf. *nasuta*, *Cnemaspis* sp., *Cryodactylus collegalensis*, *Eutropis macularia*, *Eutropis carinata*, *Oligodon taeniolatus*, and *Ristella* cf. *beddomii* preferred higher canopy cover, canopy height, litter depth, litter cover, shrub cover, and herb cover and favoured rubber plantations and botanical gardens, followed by cashew and coconut plantations (Fig. 3).

While this is a preliminary, pooled analysis consisting of resource use frequencies of both active and dormant sightings, it gives at least a preliminary picture of probable impacts on resultant species records. We mention this with a caution that more studies with better sample size and discerning active and dormant sightings are needed to fully understand the impacts of these abiotic variables on species composition and assemblage structure. We believe that our work will pave the way for future studies to take a deeper look into this subject (also see Vijayakumar et al. 2006).

Palacios et al. (2013), who reviewed studies on the herpetofauna in human-modified habitats across the world, found that in 81% of the cases plantations supported more herpetofauna than natural forests. They also found that human-modified habitats support even some endemic species in agroecosystems. Two species of reptiles endemic to the Western Ghats, *Ristella* cf. *beddomii* and *Sphenomorphus dussumieri*, were recorded from the agroecosystems of central Kerala. The present sighting of the *Ristella* cf. *beddomii* from the agroecosystem at an elevation of 50m is lower than the known altitude range of 400–1300 m (Srinivasulu et al. 2014) of this species.

Apart from addressing reptile conservation in managed landscapes, our study also fills in a major gap in herpetological studies in southern India – their community assemblage structure. Very few studies have elaborated on this topic. Studies from Western Ghats rainforests (Inger et al. 1987), the Western Ghats dry forests (Vijayakumar et al. 2006), Eastern Ghats wet forests (Ganesh & Arumugam 2015; & Ramesh & Arumugam 2016), and the Coromandel coastal plains scrub forests (Ramesh et al. 2013) are available. The current paper provides a first-hand data on reptile assemblage structure from a central Kerala plains site, that too from the little-studied Palghat Gap region.

This documentation is important as it highlights the significance of agroecosystems in conserving and maintaining the reptilian fauna of the region, including some of the Western Ghats endemic species.

REFERENCES

Aengals, R., V.M.S. Kumar & M.J. Palot (2011). *Updated Checklist of Indian Reptiles*. Southern Regional Centre, Zoological Survey of India, Chennai. Accessed on 10 November 2015; http://zsi.gov.in/checklist/Checklist%20of%20 Indian%20Reptiles.pdf.

Agarwal, I. & K.P. Karanth (2015). A phylogeny of the only ground-dwelling radiation of *Cyrtodactylus* (Squamata, Gekkonidae): diversification of *Geckoella* across peninsular India and Sri Lanka. *Molecular Phylogenetics and Evolution* 82: 193–199; https://doi.org/10.1016/j.ympev.2014.09.016

Agarwal, I., Z.A. Mirza, S. Pal, S.T. Maddock, A. Mishra & A.M. Bauer (2016). A new species of the *Cyrtodactylus (Geckoella) collegalensis* (Beddome, 1870) complex (Squamata: Gekkonidae) from western India. *Zootaxa* 4170(2): 339–354; https://doi.org/10.11646/zootaxa.4170.2.7

Bhupathy, S. & N. Sathishkumar (2013). CEPF Western Ghats special series: status of reptiles in Meghamalai and its environs, Western Ghats, Tamil Nadu, India. *Journal of Threatened Taxa* 5(15): 4953–4961; https://doi.org/10.11609/JoTT.o3595.4953-61

Das, I. (2002). *A Photographic Guide to the Snakes and Other Reptiles of India*. New Holland Publishers (U.K.) Ltd., London, 144pp

Gamage, S.N., A. Gunawardena, D.K. Weerakoon & W.K. Liyanage (2008). A comparative study of the leaf litter herpetofauna and physical parameters in different agro-eco systems (tea, rubber and oil palm) and natural rain forest in the south-western wet-zone of Sri Lanka. *Journal of Environmental Research and Development* 2(3): 285–294.

Ganesh, S.R. & M. Arumugam (2015). Microhabitat use and abundance estimates of under storey herpetofauna in the highlands of southern Eastern Ghats, India, with observations on roadkill mortalities. *Asian Journal of Conservation Biology* 4(2): 143–150.

Ganesh, S.R. & M. Arumugam (2016). Species richness of montane herpetofauna of southern Eastern Ghats, India: a historical resume and a descriptive checklist. *Russian Journal of Herpetology* 23(1): 7–24.

Ganesh, S.R., S.R. Chandramouli, R. Sreekar & P.G. Shankar (2013). Reptiles of the central Western Ghats, India - a reappraisal and revised checklist, with emphasis on the Agumbe Plateau. *Russian Journal of Herpetology* 20(3): 181–189.

Gardner, T. A., J. Barlow & C.A. Peres (2007). Paradox, presumption and pitfalls in conservation biology: the importance of habitat change for amphibians and reptiles. *Biological Conservation* 138(1): 166–179; https://doi.org/10.1016/j.biocon.2007.04.017

Gibbons, J.W., D.E. Scott, T.J. Ryan, K.A. Buhlmann, T.D. Tuberville, B.S. Metts, J.L. Greene, T. Mills, Y. Leiden, S. Poppy & C.T. Winne (2000). The global decline of reptiles, deja vu amphibians. *BioScience* 50(8): 653–666.

Hammer, Ø., D.A.T. Harper & P.D. Ryan (2001). PAST-PAlaeontological STatistics, version 1.89. *Palaeontologia electronica* 4(1): 1–9.

Inger, R.F., H.B. Shaffer, M. Koshy & R. Bakde (1987). Ecological

Image 1. *Hemidactylus* cf. *murrayi*

Image 2. *Hemidactylus frenatus*

Image 3. *Hemidactylus frenatus* (in rubber plantation)

Image 4. *Hemidactylus triedrus*

Image 5. *Cnemaspis* cf. *garcilis* (female) from homegarden

Image 6. *Cnemaspis* cf. *gracilis* (male) from botanical garden

Image 7. *Cyrtodactylus collegalensis*

Image 9. *Eutropis macularia*

Image 11. *Ristella* cf. *beddomii*

Image 8. *Sphenomorphus dussumieri*

Image 10. *Eutropis carinata*

Image 12. *Calotes versicolor*

Image 13. *Oligodon taeniolatus*

Image 14. *Ahaetulla* cf. *nasuta*

structure of a herpetological assemblage in south India. *Amphibia-Reptilia* 8(3): 189–202.

Ishwar, N.M., R. Chellam & A. Kumar (2001). Distribution of forest floor reptiles in the rainforest of Kalakad-Mundathurai Tiger Reserve, south India. *Current Science* 80(3): 413–418.

Islam, M.Z. & A.R. Rahmani (2004). *Important Bird Areas in India. Priority Sites for Conservation*. Indian Bird Conservation Network: Bombay Natural History Society, BirdLife International, xviii+1133pp.

Islam, M.Z. & A.R. Rahmani (2008). *Potential and Existing Ramsar Sites in India*. Indian Bird Conservation Network: Bombay Natural History Society, BirdLife International and Royal Society for the Protection of Birds. Oxford University Press, 592pp.

Kanagavel, A., S.M. Rehel & R. Raghavan (2013). Population, ecology, and threats to two endemic and threatened terrestrial chelonians of the Western Ghats, India. *ISRN Biodiversity* 2013: 1–8.

Lajmi, A., V.B. Giri & K.P. Karanth (2016). Molecular data in conjunction with morphology help resolve the *Hemidactylus brookii* complex (Squamata: Gekkonidae). *Organisms Diversity & Evolution* 16(3): 659–677.

Legendre, P. & L. Legendre (1998). *Numerical Ecology*, *2nd English edition*. Elsevier, 853pp.

Legendre, P., J. Oksanen & C.J. ter Braak (2011). Testing the significance of canonical axes in redundancy analysis. *Methods in Ecology and Evolution* 2(3): 269–277.

Mahony, S. (2011). Taxonomic revision of *Hemidactylus brookii* Gray: a re-examination of the type series and some Asian synonyms, and a discussion of the obscure species *Hemidactylus subtriedrus* Jerdon (Reptilia: Gekkonidae). *Zootaxa* 3042(1): 37–67.

Manohar, K.A., A. Ramachandran, M.S. Syamili, E.R. Sreekumar, N. Mohan, J. Anjali, A. Reddy & P.O. Nameer (2017). Birds of the Kerala Agricultural University campus, Thrissur District, Kerala, India - an update. *Journal of Threatened Taxa* 9(8): 10585–10612; https://doi.org/10.11609/jott.2455.9.8.10585-10612

Palacios, C.P., B. Aguero & J.A. Simonetti (2013). Agroforestry systems as habitat for herpetofauna: is there supporting evidence? *Agroforestry Systems* 87(3): 517–523.

Palot, M.J. (2015). A checklist of reptiles of Kerala, India. *Journal of Threatened Taxa* 7(13): 8010–8022; https://doi.org/10.11609/jott.1999.7.13.7961-7970

Ramesh, T., K.J. Hussain, K.K. Satpathy & M. Selvanayagam (2013). Community composition and distribution of herpetofauna at Kalpakkam Nuclear cCampus, southern India. *Herpetology Notes* 6: 343–351.

Srinivasulu, C., B. Srinivasulu & S. Molur (Compilers) (2014). *The Status and Distribution of Reptiles in the Western Ghats, India. Conservation Assessment and Management Plan (CAMP).* Wildlife Information Liaison Development Society, Coimbatore, Tamil Nadu, 150pp.

Vasudevan K., A. Kumar & R. Chellam (2001). Structure and composition of rainforest floor amphibian communities in Kalakad-Mundathurai Tiger Reserve. *Current Sci*ence 80(3): 406–412.

Venugopal, P.D. (2010). Population density estimates of agamid lizards in human-modified habitats of the Western Ghats. *The Herpetological Journal* 20(2): 69–76.

Vijayakumar, S.P., A. Ragavendran & B.C. Choudhury (2006). Herpetofaunal assemblage in a tropical dry forest mosaic of Western Ghats, India: Preliminary analysis of species composition and abundance during the dry season. *Hamadryad* 30(1/2): 40–53.

Whitaker, R. & A. Captain (2004). *Snakes of India. The Field Guide*. Draco Books. Chengalpattu, Tamil Nadu, xiv+479pp.

Journal of Threatened Taxa

www.threatenedtaxa.org

ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

September 2018 | Vol. 10 | No. 10 | Pages: 12299–12442
Date of Publication: 26 September 2018 (Online & Print)
DOI: 10.11609/jott.2018.10.10.12299-12442