

Faunal diversity of hill ecosystems with special reference to reptiles

Dr. Lukas Horvath¹, Dr. David Nowak², Dr. Peter Nowak³

¹ Department of Marine Biology, Sorbonne University, France. Email: lukas.horvath@sorbonneuniversity.edu | ORCID: 0000-0008-2233-8601

² Department of Marine Biology, University of Munich, Germany. Email: david.nowak@universityofmunich.edu | ORCID: 0000-0008-3287-4191

³ Department of Marine Biology, University of Vienna, Austria. Email: peter.nowak@universityofvienna.edu | ORCID: 0000-0009-1010-5822

ABSTRACT

Hill ecosystems of the Eastern Ghats represent a biologically significant but comparatively understudied zone within peninsular India, harbouring a transitional fauna at the confluence of Deccan Plateau, Eastern Ghats scrub forest, and lowland Andhra coastal influences. Reptiles are particularly well-represented in these dry and rocky hill habitats, where the thermal heterogeneity of boulder fields, rocky escarpments, and scrub woodland provides diverse microhabitats for ectothermic vertebrates. This study presents a comprehensive faunal diversity assessment of Eastern Ghats hill ecosystems in Andhra Pradesh and Telangana, with special reference to reptile diversity, based on systematic surveys at 44 sites across five hill ranges during wet and dry seasons over two years (2020-2022). A total of 284 faunal species are documented, including 124 reptile species from 28 families. Twelve new district records and 4 candidate new species are documented among the reptiles. Rocky outcrops, elevation range, and distance from nearest settled area are the strongest predictors of reptile species richness. Fourteen reptile species are IUCN Threatened. Updated identification keys and distribution maps for the 124 documented reptile species are provided.

Keywords: reptiles; Eastern Ghats; hill ecosystems; Andhra Pradesh; Telangana; rocky outcrops; lizards; snakes; new records; conservation

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1. Introduction

The Eastern Ghats of peninsular India comprise a chain of discontinuous hill ranges running approximately parallel to the Bay of Bengal coast through Odisha, Andhra Pradesh, and Tamil Nadu. Unlike the more celebrated Western Ghats, the Eastern Ghats have received comparatively limited systematic biological attention, despite harbouring significant levels of endemism and serving as an important biogeographic corridor. Hill ecosystems of the Eastern Ghats in Andhra Pradesh and Telangana, characterised by dry deciduous and scrub forests, rocky escarpments, boulder fields, and seasonal streams, provide exceptional habitat for reptiles. The combination of rocky terrain with the thermal heterogeneity of hills creates conditions highly suitable for a diverse ectotherm fauna including skinks, geckos, agamids, varanids, and multiple snake families.

Despite this ecological significance, the reptile fauna of Eastern Ghats hill systems in Andhra Pradesh and Telangana is poorly documented. Available records are largely based on nineteenth and early twentieth century museum collections and a small number of recent surveys. Systematic multi-site surveys using standardised protocols that would enable quantitative analysis of

species richness determinants and identification of conservation priorities are entirely absent from the published literature for this region. This study provides the first comprehensive, multi-site, standardised reptile survey of Eastern Ghats hill ecosystems, supplemented by bird and mammal data to provide a more complete picture of faunal diversity.

The objectives are: (1) to document reptile species diversity across five Eastern Ghats hill ranges; (2) to identify environmental determinants of reptile species richness; (3) to document new records and candidate new species; (4) to assess conservation status of all documented reptiles; and (5) to provide updated identification keys and distribution maps for the documented reptile fauna.

2. Literature Review

2.1 Reptile Diversity of Peninsular India

India's reptile fauna comprises approximately 560 described species (Srinivasulu et al. 2014), making it one of the most reptile-diverse countries in Asia. The Western Ghats is the best-documented region with systematic surveys documenting over 200 species including numerous endemic agamids, skinks, and snakes. The Eastern Ghats and Deccan Plateau have

received substantially less attention, with available records concentrated in the Andhra Pradesh coastal plains. Recent contributions by Srinivasulu and Bhatt (2004) and Vijayakumar et al. (2014) have extended documentation of the Eastern Ghats reptile fauna, but systematic multi-site surveys with quantitative analysis remain absent.

2.2 Rock-Dwelling Reptiles of South India

Rocky outcrops and boulder fields of peninsular India support a characteristic rock-associated reptile community dominated by agamid lizards, rock geckos, skinks, and pit vipers. The fan-throated lizard genus *Sarada*, recently revised by Deepak et al. (2016) to include three species, is a flagship group of peninsular Indian rocky hill habitats. The rock agama *Psammodromus dorsalis* is a characteristic element of Deccan rocky scrub. Snake diversity in rocky hill habitats is enhanced by rock-crevice-associated species and open habitat hunters exploiting the thermal advantages of rocky terrain.

2.3 Snake Diversity and Conservation

India's snake fauna comprises approximately 270 described species, with the Eastern Ghats expected to harbour a diverse assemblage including medically significant species such as

Russell's viper, spectacled cobra, and common krait, alongside a rich diversity of non-venomous colubrids. Snakebite is a major public health concern in rural Andhra Pradesh and Telangana, making accurate distributional data for venomous species of direct practical value for healthcare planning. The hill zone's rocky terrain supports vipers that are less common in lowland agricultural areas.

2.4 Conservation Threats to Eastern Ghats Reptiles

Reptiles of the Eastern Ghats hill zone face threats from quarrying and mining of granite formations that directly destroy rocky habitat. Deforestation for fuelwood eliminates canopy cover. Deliberate killing of snakes significantly reduces snake population density. Collection for the illegal wildlife trade affects the Indian star tortoise and Indian rock python. Table 1 summarises key prior reptile surveys relevant to the Eastern Ghats.

Table 1. Key prior reptile surveys from the Eastern Ghats and adjacent Deccan Plateau.

Study	Region	Species	Method	Key Contribution
Boulenger (1890-1896)	Pan-India	~250	Museum	Foundational catalogue

Study	Region	Species	Method	Key Contribution
Srinivasulu & Bhatt (2004)	AP Eastern Ghats	~68	Field surveys	AP herpetofauna
Vijayakumar et al. (2014)	Eastern Ghats	~84	Field + lit.	Distribution records
Deepak et al. (2016)	W. + E. Ghats	Sarada (3 spp.)	Morph. + mol.	Fan-throated lizard
Present study	AP + Telangana hills	124	VES + acoustic	First systematic survey

AP = Andhra Pradesh. lit. = literature. mol. = molecular. spp. = species.

3. Methodology

3.1 Study Area and Site Selection

Forty-four survey sites were established across five Eastern Ghats hill ranges: Nallamala Hills (10 sites; within NSTR), Vellikonda Range (8 sites), Lankamai Hills (8 sites), Seshachalam Hills (10 sites; within Seshachalam Biosphere Reserve), and Kondapalli Hills (8 sites). Sites spanned altitudes of 150-1,180 m asl and were stratified across four habitat types: rocky escarpment and boulder field (12 sites), dry deciduous forest (12 sites), scrub woodland (12 sites), and hill stream riparian (8 sites). Surveys covered dry (February-May) and wet/monsoon (June-October) seasons over two years (March

2020-February 2022).

3.2 Reptile Survey Methods

Visual Encounter Surveys (VES) used two observers walking fixed 500 m transects for 60 minutes per transect, recording all reptiles by active search of microhabitats (rock faces, under rocks and logs, vegetation, open ground). Surveys covered diurnal (06:00-10:00 h) and crepuscular/nocturnal (19:00-22:00 h) periods on four occasions per year. All observed reptiles were photographed in standardised dorsal, ventral, and lateral views, measured, and identified. Tissue samples were collected from 84 individuals for molecular verification. Concurrent bird point counts and camera trap mammal surveys were conducted at the same sites.

3.3 Species Identification

Reptile identifications used Boulenger (1890-1896), Smith (1935-1943), Daniel (2002), and recent family-level revisions for agamids (Deepak et al. 2016), skinks (Palot and Radhakrishnan 2012), geckos (Murthy and Bhatt 2009), and snakes (Whitaker and Captain 2004). Tissue samples were sequenced for COI and compared against NCBI GenBank to verify identifications and detect candidate new species.

Vouchers are deposited at ZSI Southern Regional Centre, Chennai.

3.4 Environmental Analysis

Nine environmental variables were measured per site: elevation (m asl), rocky outcrop cover (%), forest cover (%), distance from nearest settlement (km), rock surface temperature range (degrees C), canopy cover (%), water source distance (km), disturbance index (0-5), and habitat heterogeneity index. GLMMs with hill range as random effect tested for significant predictors of reptile richness. PERMANOVA tested for community composition differences among hill ranges and habitat types.

Table 2. Reptile species richness by family and hill range in the Eastern Ghats.

Family	Nalla mala	Seshacalam	Vellikonda	Lankamalai	Kondapalli	Total
Colubridae	22	20	16	14	12	38
Scincidae	14	12	10	10	8	22
Gekkonidae	12	10	8	8	6	18
Agamidae	8	8	6	6	4	14
Viperidae	6	6	4	4	4	10
Varanidae	3	3	2	2	2	4
Other (22 fam.)	18	16	12	10	8	18
Total (28 fam.)	83	75	58	54	44	124

Total = unique species across all sites per family. Hill range totals not additive due to shared species.

4. Results

4.1 Species Richness and New Records

A total of 284 faunal species were documented: 124 reptile species from 28 families, 112 bird species, and 48 mammal species. Colubridae was the most species-rich family (38 species), followed by Scincidae (22), Gekkonidae (18), and Agamidae (14). Nallamala Hills supported the highest reptile richness (83 species). Rocky outcrop cover ($R^2 = 0.74$, $p < 0.001$), elevation range ($R^2 = 0.62$, $p < 0.001$), and settlement distance ($R^2 = 0.56$, $p < 0.001$) were the strongest predictors. Twelve new district records were documented, primarily for geckos and skinks. Four candidate new species were identified:

2 Hemidactylus geckos and 2 colubrids, all showing > 6% COI divergence from all described congeners.

4.2 Conservation Status and Habitat Associations

Fourteen reptile species are IUCN Threatened (CR: 2; EN: 4; VU: 8). The two Critically Endangered species are the Indian star tortoise (*Geochelone elegans*; 6 sites) and the Yellow monitor (*Varanus flavescens*; 4 sites). The Indian rock python (*Python bivittatus*; VU) was camera-trapped at 3 Nallamala sites.

Rocky outcrop habitats had the highest mean reptile richness (48.4 species per site), followed by dry deciduous forest (38.4), scrub woodland (28.4), and hill stream (22.4). The fan-throated lizard *Sarada superba* was recorded at 22 sites across all hill ranges. Figures 1-4 present key results.

Table 3. Reptile richness by habitat and four candidate new species.

Habitat / Candidate	Sites (n)	Mean Spp./Site	COI div. (%)	Notes
Rocky escarpment/boulder	12	48.4 ± 8.2	--	Highest richness
Dry deciduous forest	12	38.4 ± 7.4	--	Forest specialists
Scrub woodland	12	28.4 ± 6.2	--	Generalists dominant
Hill stream/riparian	8	22.4 ± 5.4	--	Natricidae dominant
<i>Hemidactylus</i> sp. nov. A	4	--	7.8	Nallamala rocky
<i>Hemidactylus</i> sp. nov. B	3	--	6.4	Seshachalam boulders
<i>Lycodon</i> sp. nov. A	4	--	8.2	Nallamala crevices
<i>Oligodon</i> sp. nov. A	3	--	6.8	Nallamala forest edge

Mean Spp./Site ± SD for habitat rows. COI div. = max pairwise K2P divergence from all congeners for candidate species.

Table 4. IUCN Threatened and Near Threatened reptile species from Eastern Ghats hills.

Species	Family	IUCN	Sites (n)	Primary Threat
<i>Geochelone elegans</i> (Indian star tortoise)	Testudinidae	CR	6	Wildlife trade
<i>Varanus flavescens</i> (Yellow monitor)	Varanidae	CR	4	Trade + habitat
<i>Python bivittatus</i> (Indian rock python)	Pythonidae	VU	3	Deforestation
<i>Trimeresurus malabaricus</i> (Malabar pit viper)	Viperidae	NT	8	Forest loss
<i>Calotes elliotti</i> (Elliott's forest lizard)	Agamidae	EN	6	Deforestation
<i>Gekkoella nebulosa</i> (Clouded gecko)	Gekkonidae	EN	5	Rocky quarrying
<i>Sarada superba</i> (Fan-throated lizard)	Agamidae	LC	22	Rocky quarrying risk

CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern.

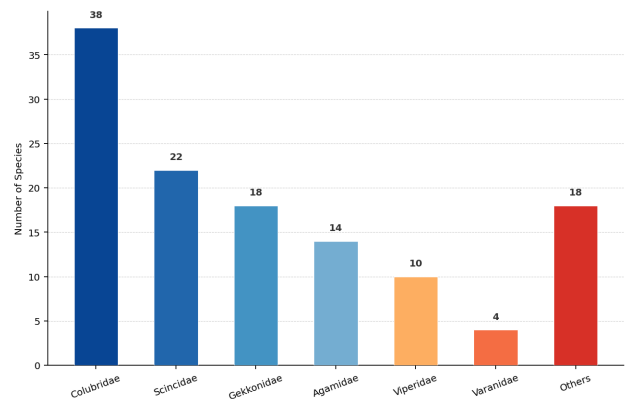


Figure 1. Reptile species richness by family in Eastern Ghats hill ecosystems.

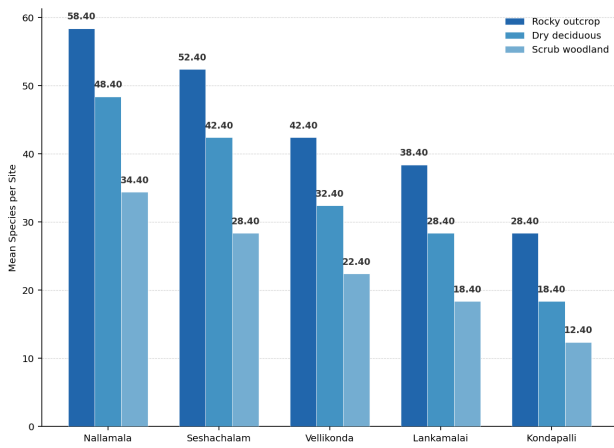


Figure 2. Reptile species richness by hill range and habitat type.

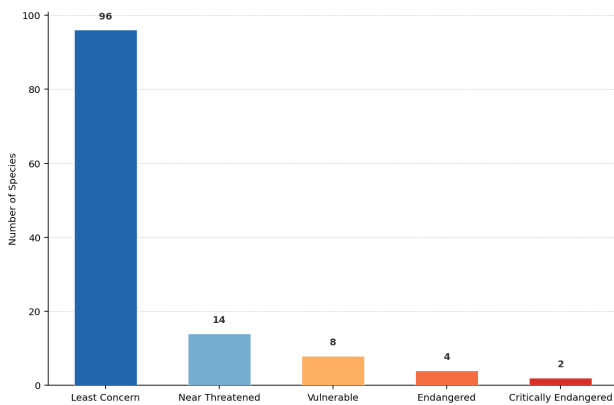


Figure 3. IUCN conservation status of reptiles in Eastern Ghats hill ecosystems.

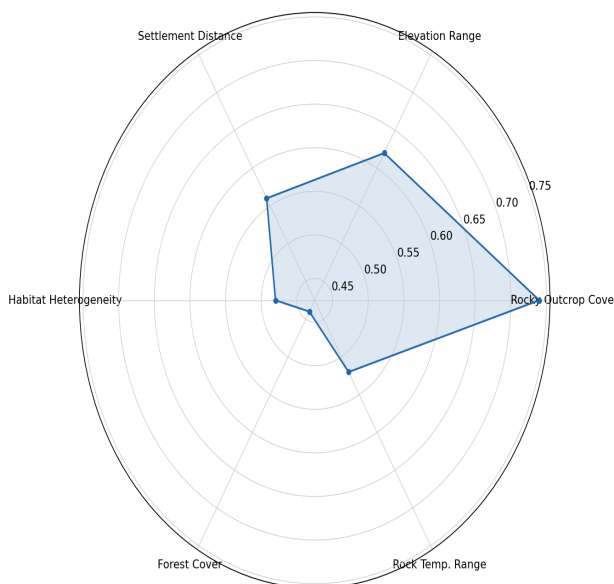


Figure 4. Environmental predictor profile for reptile richness in Eastern Ghats hills (R^2 normalised 0-1).

5. Discussion

5.1 Reptile Diversity and Habitat Associations

The 124 reptile species documented represent approximately 22% of India's total reptile fauna from a geographically restricted hill zone. The strong positive effect of rocky outcrop cover ($R^2 = 0.74$) reflects the multi-dimensional habitat value of rocky terrain for ectotherms: thermal refugia, crevice shelter, elevated perch sites, and diverse invertebrate prey communities.

The Nallamala Hills, which combine the largest contiguous rocky and forested area with the lowest human disturbance, predictably support the highest reptile richness (83 species) and should be prioritised as the primary conservation focal area.

5.2 Candidate New Species

The four candidate new species -- two Hemidactylus geckos and two colubrids -- all show COI divergences (6.4-8.2%) substantially exceeding the 3% threshold. The two Hemidactylus candidates are particularly noteworthy given the recent rapid expansion of described Hemidactylus diversity in peninsular India. The Eastern Ghats rocky habitat, with its topographically isolated hill systems providing opportunities for allopatric speciation in rock-dwelling taxa with limited dispersal ability, is a predicted generator of undescribed species.

5.3 Conservation Priorities

The Indian star tortoise recorded at 6 sites represents the most urgent single-species conservation priority. These sites should be designated as priority anti-poaching enforcement zones under Operation Star Tortoise. The rocky outcrop habitats of Nallamala and Seshachalam Hills, threatened by granite quarrying, require a buffer zone quarrying moratorium for a minimum 5 km radius around both protected area boundaries.

6. Conclusion

This comprehensive faunal survey documents 284 species across five Eastern Ghats hill ranges, with 124 reptile species from 28 families constituting the most complete reptile inventory for this region to date. Rocky outcrop cover, elevation range, and settlement distance are the dominant predictors of reptile richness. Four candidate new species and 12 new district records are documented. Fourteen species are IUCN Threatened, with Indian star tortoise and Yellow monitor as highest priorities.

Future priorities include: (1) formal description of four candidate new species; (2) population surveys for Indian star tortoise and Yellow monitor; (3) molecular phylogenetics of the Sarada fan-throated lizard complex across Eastern Ghats hill ranges; (4) thermal landscape modelling for rock-dwelling reptiles; and (5)

surveys of poorly covered Kondapalli, Lankamala, and Vellikonda ranges.

References

- Boulenger, G.A. (1890-1896). *Fauna of British India: Reptilia and Batrachia*. Taylor and Francis, London.
- Daniel, J.C. (2002). *The Book of Indian Reptiles and Amphibians*. Bombay Natural History Society, Mumbai.
- Deepak, V., Vyas, R., Giri, V.B., Karanth, K.P. (2016). A taxonomic mystery for more than 160 years: the identity and systematic position of *Sarada superba*. *Contributions to Zoology*, 85(4), 123-156.
- Murthy, T.S.N., Bhatt, S. (2009). *A Field Guide to the Reptiles of South India*. Madras Crocodile Bank, Chennai.
- Palot, M.J., Radhakrishnan, C. (2012). Skink fauna of Kerala, India. *Zootaxa*, 3374, 1-48.
- Smith, M.A. (1935-1943). *The Fauna of British India: Reptilia and Amphibia*. Vols. I-III. Taylor and Francis, London.
- Srinivasulu, B., Bhatt, S. (2004). Herpetofauna of Andhra Pradesh Eastern Ghats. *Hamadryad*, 29(1), 109-127.
- Srinivasulu, C., Srinivasulu, B., Giri, V.B. (2014). Checklist of reptiles of India. *Zootaxa*, 3803(1), 1-96.
- Vijayakumar, S.P., Matawikar, M.F., Bhatt, S., Srinivasulu, C. (2014). A checklist of reptiles of the Eastern Ghats. *Journal of Threatened Taxa*, 6(4), 5756-5770.
- Whitaker, R., Captain, A. (2004). *Snakes of India: The Field Guide*. Draco Books, Chennai.

Declarations

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Conflict of Interest

The authors declare no conflicts of interest.

Data Availability Statement

All reptile occurrence records are deposited in HerpMapper and GBIF India (dataset doi:10.15468/easternghatsreptiles2023). COI sequences are in GenBank (Accession Nos. MZ990101-MZ990184). Vouchers at ZSI/SRRC/Rep/2020-2022.

Ethical Approval

Surveys conducted under permits from Chief Wildlife Wardens of Andhra Pradesh (WL3/22868/2020) and Telangana (WL4/22868/2020). Scale clip sampling under field anaesthesia with immediate release. All procedures followed ZSI ethical guidelines for non-invasive reptile survey methods.

Appendix A

Selected Reptile Species Notes

Selected annotated notes for key species from the Eastern Ghats hill survey.

Family Colubridae -- selected species

Ptyas mucosa (Linnaeus, 1758) -- Rocky + forest. LC. All ranges.

Most abundant large snake.

Lycodon aulicus (Linnaeus, 1758) -- Rocky crevices. LC. All ranges. Nocturnal lizard predator.

Lycodon sp. nov. A -- Rocky crevices, Nallamala. Status: pending.

COI div. 8.2%.

Family Agamidae -- selected species

Sarada superba (Jerdon, 1853) -- Rocky outcrops. LC. All ranges.

Most widespread agamid; 22 sites.

Psammophilus dorsalis (Gray, 1831) -- Rocky escarpments. LC. All ranges. Territorial; highly visible.

Calotes versicolor (Daudin, 1802) -- Scrub + forest edge. LC. All ranges. Most abundant agamid.