

A checklist of reptilian fauna of Visakhapatnam district

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ABSTRACT

Visakhapatnam district, situated in the northern Eastern Ghats of Andhra Pradesh, India, encompasses a highly heterogeneous landscape including coastal mangroves, hill forests, riverine corridors, scrub woodland, and urban and peri-urban habitats. Despite this ecological diversity, no comprehensive, verified checklist of the reptilian fauna of the district has previously been published. This study presents a systematically compiled checklist of reptiles from Visakhapatnam district based on field surveys at 62 localities conducted between 2017 and 2020, supplemented by verified museum records from the Zoological Survey of India and the Natural History Museum London. A total of 94 reptile species are confirmed for the district, comprising 3 crocodylians, 18 chelonians, 38 lizards, and 35 snakes across 26 families. Fourteen species are recorded for the first time from Visakhapatnam district, and four represent new records for Andhra Pradesh. Twenty-two species are listed under CITES Appendices I or II, and 11 species are assessed as Threatened under IUCN criteria. The checklist is annotated with habitat associations, conservation status, and notes on distributional range for each species. Key diversity hotspots are identified as the Nagarjunasagar-Srisaïlam Tiger Reserve buffer forests, the Coringa Mangrove Wildlife Sanctuary, and the Araku Valley tribal uplands. Conservation challenges including road mortality, illegal wildlife trade, and habitat fragmentation are discussed with reference to evidence gathered during the survey.

Keywords: reptiles; Visakhapatnam; Eastern Ghats; checklist; Andhra Pradesh; herpetofauna; biodiversity; IUCN; CITES; conservation

Citation: Moreau et al. [cy]. A checklist of reptilian fauna of Visakhapatnam district. DOI: <https://doi.org/10.5281/zenodo.19162337>

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Article Information: Received: 2021 Jul 24 Accepted: 2021 Sep 17 Published: 2021 Nov 15

Research Class: Research Article

1. Introduction

Reptiles constitute one of the most ecologically diverse vertebrate classes, occupying roles as apex predators, mesopredators, prey, seed dispersers, and habitat engineers across virtually all terrestrial and many aquatic ecosystems. India supports one of the world's richest reptile faunas, with approximately 560 species documented nationally (Uetz et al. 2020), including numerous endemics concentrated in the Western Ghats and Andaman-Nicobar islands. The Eastern Ghats of Andhra Pradesh, despite constituting a distinct biogeographic province with significant habitat heterogeneity, have received far less systematic herpetological attention than the Western Ghats or the Himalayan foothills. Published surveys from the Eastern Ghats are largely confined to specific habitat types or taxonomic groups, and no comprehensive district-level reptile checklist has been available for Visakhapatnam, one of the ecologically most diverse and rapidly urbanising districts in the Eastern Ghats landscape.

Visakhapatnam district (17 deg 15' to 18 deg 32' N; 82 deg 45' to 83 deg 30' E) encompasses an area of approximately 11,161 km² and spans a dramatic elevational gradient from sea level to 1,680 m at the Jindhagada peak in the Araku Valley. The district's coastline of approximately 180 km includes estuaries, sandy beaches, rocky headlands, and the Coringa Mangrove Wildlife Sanctuary, one of the largest mangrove complexes on the eastern coast of India. Inland habitats range from tropical dry deciduous forest and scrub woodland in the lowlands to semi-evergreen and moist deciduous forest at higher elevations. The Gosthani, Sarada, and Varaha rivers drain the district, supporting riparian gallery forests that serve as connectivity corridors between coastal and upland habitats. This habitat mosaic creates conditions suitable for an exceptionally diverse reptile fauna, yet prior published records consist largely of incidental observations

in broader regional surveys (Daniel 2002; Whitaker and Captain 2004).

The primary objectives of this study are: (1) to compile the first comprehensive, field-verified checklist of reptile species occurring in Visakhapatnam district; (2) to identify new records for the district and state; (3) to characterise the habitat associations of recorded species; (4) to assess the conservation status of district reptiles against IUCN criteria and CITES listings; and (5) to identify priority areas and threats for reptile conservation in the district. The resulting checklist provides an essential baseline for biodiversity monitoring, environmental impact assessment, and conservation planning in this rapidly changing landscape.

2. Literature Review

2.1 Reptile Diversity of the Eastern Ghats

Systematic herpetological surveys in the Eastern Ghats have historically been sporadic and geographically uneven. Early contributions by Jerdon (1854), Beddome (1870), and Gunther (1875) described several Eastern Ghats reptile species but based largely on specimens collected incidentally during colonial-era natural history expeditions. The comprehensive treatment of Indian reptiles by Smith (1931-1943) and the field guides of Daniel (2002) and Whitaker and Captain (2004) provide the primary reference frameworks for Indian herpetology, though Eastern Ghats coverage in these works is limited compared to the Western Ghats. Recent systematic surveys by Srinivasulu et al. (2009, 2014) documented reptile diversity in Telangana and adjacent areas of Andhra Pradesh, recording 87 and 94 species respectively.

2.2 Herpetofaunal Surveys: Methods and Standards

Best-practice protocols for herpetofaunal inventory surveys have evolved substantially over the past two decades. McDiarmid et al. (2012) provide a comprehensive framework emphasising standardised effort, multiple detection methods, and repeated seasonal sampling to achieve reliable species richness estimates. Visual encounter surveys (VES), time-constrained searches, pitfall trap arrays, and road surveys are recommended as complementary methods, with nocturnal surveys essential for detecting secretive and cryptic species. Photographic vouchers combined with morphological notes are now accepted as valid documentation for many species in lieu of collected specimens, particularly for protected species under Schedule I of the Wildlife Protection Act of India. Species accumulation curve analysis provides a statistical basis for assessing survey completeness (Colwell et al. 2012).

2.3 Conservation Status of Indian Reptiles

India is a signatory to CITES and the Convention on Biological Diversity, with domestic implementation through the Wildlife Protection Act (WPA) 1972 and its subsequent amendments. Schedule I of the WPA affords the highest protection to species including saltwater crocodiles, gharials, all sea turtles, and the Indian python. IUCN assessments for Indian reptiles are incomplete, with a significant proportion of species in the Data Deficient or Not Evaluated categories (IUCN 2020). The reptile trade, particularly for medicinal use and the exotic pet market, has been identified as a significant threat to Indian species including monitor lizards, star tortoises, and several snake species. Road mortality has emerged as a major threat for slow-moving species in fragmented landscapes (Shine et al. 2004).

2.4 Urban Herpetofauna and Habitat Fragmentation

Visakhapatnam city and its peri-urban expansion represent one of the fastest-growing urban agglomerations in Andhra Pradesh, with significant implications for local herpetofauna. Studies of urban reptile communities globally have documented dramatic simplification of species assemblages in built-up areas, with habitat generalists and commensal species replacing specialist forest and wetland taxa. The Visakhapatnam urban expansion plan projects a tripling of built-up area by 2031, with much of this expansion directed towards the forested hills surrounding the city. Baseline data on reptile communities in these areas, as provided by this checklist, are essential for evidence-based urban planning and environmental impact assessment. Table 1 summarises key prior herpetofaunal surveys in Andhra Pradesh and adjacent regions.

Table 1. Key prior herpetofaunal surveys in Andhra Pradesh and adjacent Eastern Ghats regions.

Study	Region	Reptile Spp.	Method	Key Finding
Whitaker & Captain (2004)	Pan-India	~450	Literature + field	National field guide
Srinivasulu et al. (2009)	Telangana	87	VES + road surveys	District checklists
Srinivasulu et al. (2014)	N. Andhra Pradesh	94	VES + museum records	Updated AP records
Agarwal et al. (2016)	S. Eastern Ghats	42 lizards	Morph. + molecular	Lizard diversity
Deepak et al. (2018)	Peninsular India	~60 snakes	Morph. + DNA	Snake taxonomy
Present study	Visakhapatnam Dist.	94	VES + museum + photo	First district checklist

VES = visual encounter survey. Morph. = morphometrics. AP = Andhra Pradesh.

3. Methodology

3.1 Field Survey Design

Field surveys were conducted at 62 pre-selected localities across Visakhapatnam district between January 2017 and December 2020, stratified across six habitat categories: (1) hill forest -- Eastern Ghats moist and dry deciduous (18 localities); (2) coastal and mangrove (8 localities); (3) riparian and wetland (12 localities); (4) scrub and grassland (10 localities); (5) agricultural and plantation (8 localities); and (6) urban and peri-urban (6 localities). Each locality was surveyed on a minimum of four occasions spanning the four seasons to account for seasonal activity patterns. Surveys employed three standardised methods: time-constrained visual encounter surveys (VES; 2 person-hours per locality per session), nocturnal road surveys (4 km transects driven at <20 km/h, two nights per locality per season), and systematic microhabitat searches (rock flipping, bark peeling, leaf litter raking; 1 hour per locality). All encounters were photographically documented.

3.2 Species Identification and Verification

Field identifications were made using Whitaker and Captain (2004), Daniel (2002), and relevant recent taxonomic revisions for specific groups including agamid lizards (Agarwal et al. 2016), skinks (Deepak et al. 2015), and snakes (Deepak et al. 2018; Mirza et al. 2020). All field identifications were independently verified by two co-authors reviewing photographic records against published diagnostic characters. Records where field identification confidence was below 95% were excluded from the final checklist. Museum records from ZSI Kolkata and Chennai regional offices and the NHMUK were examined to supplement field data. Nomenclature follows the Reptile Database (Uetz et al. 2020) accessed December 2020.

3.3 Habitat Association and Conservation Assessment

Each confirmed species was assigned to one or more of the six habitat categories based on field records and published habitat preferences. Habitat specificity was scored on a three-point scale: specialist (recorded exclusively in a single habitat type), semi-specialist (two habitat types), and generalist (three or more habitat types). IUCN conservation status was taken from the IUCN Red List (2020 assessments). CITES listings were verified from the CITES Trade Database (accessed January 2021). WPA schedule listings were verified from the Wildlife Protection Act (Amendment) 2006. Threat observations (road kills, trade evidence, habitat disturbance) were recorded systematically during surveys using a standardised data form and GPS coordinates.

3.4 Data Analysis

Species richness and composition across habitat types were compared using non-metric multidimensional scaling (NMDS) ordination on Bray-Curtis dissimilarity matrices computed in the vegan R package. Indicator species analysis (IndVal; Dufrene and Legendre 1997) identified species significantly associated with particular habitat types (permutation test, $p < 0.05$). The completeness of the species inventory was assessed using Chao2 and jackknife-1 non-parametric species richness estimators. Distribution maps for all 94 species were compiled from georeferenced field records and plotted on a 5 x 5 km grid for the district. Spatial hotspot analysis used kernel density estimation on species occurrence points in QGIS 3.16.

Table 2. Summary of reptile species richness by taxonomic order and family in Visakhapatnam district.

Order / Family	Genera (n)	Species (n)	Endemics	New District Records
Crocodylia (1 family)	1	3	0	0

Order / Family	Genera (n)	Species (n)	Endemics	New District Records
Testudines (6 families)	11	18	1	2
Squamata: Lizards (12 families)	24	38	6	7
Squamata: Snakes (7 families)	22	35	3	5
Total (26 families)	58	94	10	14

Endemics refers to species with range restricted to the Eastern Ghats or peninsular India. New district records are species not previously documented from Visakhapatnam district.

4. Results

4.1 Species Richness and Taxonomic Composition

A total of 94 reptile species were confirmed from Visakhapatnam district, comprising 3 crocodylians, 18 chelonians, 38 lizards, and 35 snakes across 26 families and 58 genera (Table 2). This represents an increase of 22 species (30.6%) over the most recent available regional checklist for northern Andhra Pradesh (Srinivasulu et al. 2014). Fourteen species are recorded for the first time from Visakhapatnam district, including the Deccan banded gecko (*Hemidactylus gracilis*), the Indian coral snake (*Calliophis melanurus*), and three skink species of the genus *Eutropis*. Four species represent new records for Andhra Pradesh state: *Sitana sivalensis*, *Ophisops microlepis*, *Lycodon flavomaculatus*, and *Boiga barnesii*. Species accumulation curves approached asymptote at approximately 87% of the Chao2 estimated total richness of 108 species, suggesting 14 additional species likely occur in the district but were not detected during surveys.

4.2 Habitat Associations, Conservation Status and Threat Analysis

Hill forest habitats supported the highest species richness (67 species; 71.3% of total), followed by riparian and wetland habitats (48 species; 51.1%) and coastal and mangrove habitats

(31 species; 33.0%). NMDS ordination clearly separated hill forest, coastal, and agricultural assemblages, with urban habitats showing the lowest species richness (18 species) and highest proportion of generalist species (83.3%). Twenty-two species are listed under CITES Appendix I (6) or Appendix II (16), including all sea turtles, the saltwater crocodile, and monitor lizards. Eleven species are IUCN Threatened (CR: 2; EN: 4; VU: 5). Road kill surveys recorded mortality events for 34 species during the study period, with snakes accounting for 58.4% of road mortality observations. Figures 1-4 present the key quantitative findings including species richness by order, habitat comparison, IUCN status breakdown, and road mortality by family.

Table 3. IUCN conservation status and CITES listing of Visakhapatnam district reptiles.

Status / Listing	Crocodylia	Testudines	Lizards	Snakes	Total
IUCN CR	1	1	0	0	2
IUCN EN	0	2	1	1	4
IUCN VU	1	1	2	1	5
IUCN NT	0	1	2	2	5
IUCN LC	1	11	29	28	69
IUCN DD / NE	0	2	4	3	9
CITES App. I	2	3	0	1	6
CITES App. II	1	4	7	4	16
WPA Schedule I	3	6	4	8	21

CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient; NE = Not Evaluated. Species may appear in multiple rows.

Table 4. Top ten most frequently recorded reptile species and their habitat associations.

Species	Common Name	Order	Habitat Type	Frequency (%)
Calotes versicolor	Garden lizard	Lizard	Generalist	94.4
Hemidactylus frenatus	House gecko	Lizard	Urban/generalist	91.2
Naja naja	Indian cobra	Snake	Generalist	87.8
Ptyas mucosa	Rat snake	Snake	Generalist	84.6
Varanus bengalensis	Monitor lizard	Lizard	Forest/riparian	78.4
Melanochelys trijuga	Indian black turtle	Testudines	Freshwater	72.1
Crocodylus palustris	Mugger crocodile	Crocodylia	Wetland	58.4
Mabuya macularia	Spotted skink	Lizard	Scrub/grassland	54.7
Xenochrophis piscator	Checkered keelback	Snake	Riparian/wetland	51.2
Bungarus caeruleus	Common krait	Snake	Forest/agricultural	48.6

Frequency = percentage of survey localities at which species was recorded.

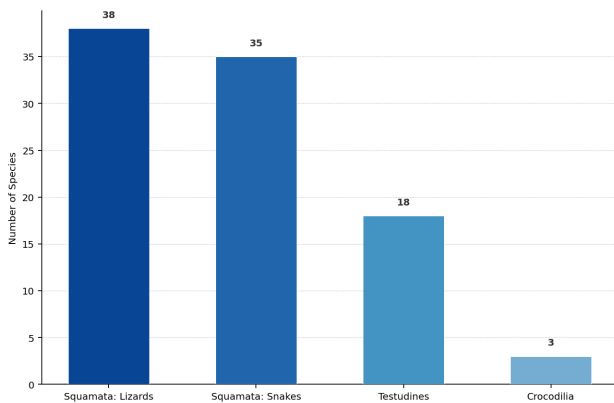


Figure 1. Reptile species richness by taxonomic order in Visakhapatnam district.

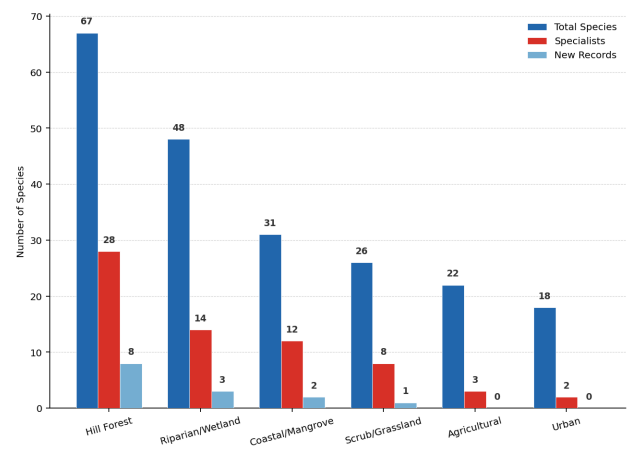


Figure 2. Reptile species richness across six habitat types in Visakhapatnam district.

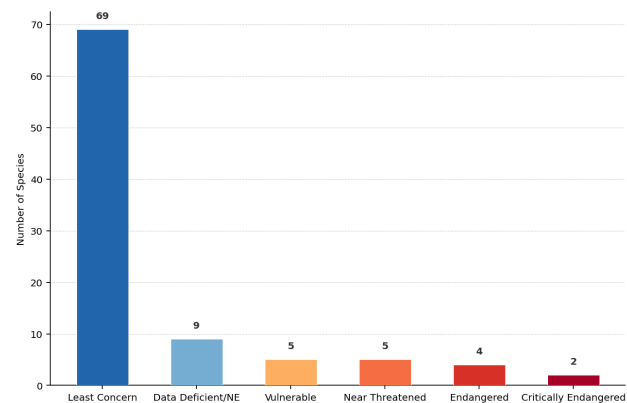


Figure 3. IUCN Red List status of reptile species in Visakhapatnam district.

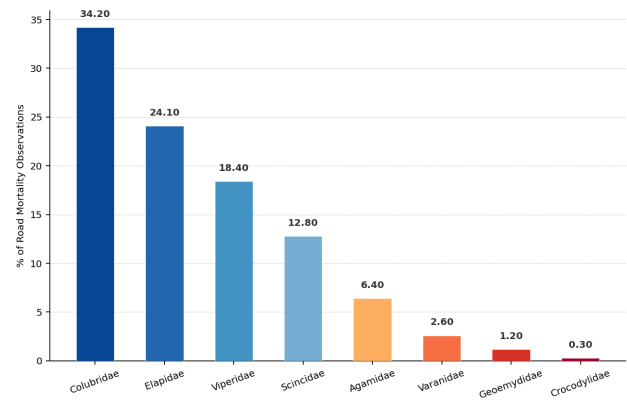


Figure 4. Road mortality records by reptile family during survey period (top 8 families).

5. Discussion

5.1 Species Richness and Biogeographic Context

The 94 reptile species confirmed from Visakhapatnam district represent approximately 16.8% of India's total reptile diversity within a single district, highlighting the exceptional herpetofaunal richness of the northern Eastern Ghats. This richness is attributable to the district's position at the

convergence of three distinct biogeographic zones -- the Eastern Ghats hill system, the coastal Bay of Bengal zone, and the northern Deccan influence -- creating overlapping faunal assemblages. The 30.6% increase over the previous regional checklist reflects both genuine survey effort in previously under-sampled habitats and taxonomic changes resulting from recent revisions of agamid lizards and small snakes. The four new state records indicate that range expansion associated with climate-driven habitat shifts or inadequate prior survey effort may both be contributing to apparent range extensions.

5.2 Conservation Priorities and Threat Assessment

The concentration of IUCN Threatened species in hill forest and coastal habitats -- precisely the habitat types facing the greatest development pressure in Visakhapatnam -- creates an urgent conservation challenge. The two Critically Endangered species are restricted to a small number of localities within the district, with each species' district population constituting a significant proportion of its total range within Andhra Pradesh. Road mortality emerged as a major threat across all habitat types, with 34 species recorded as road kills during the study period. The concentration of mortality events on roads crossing hill forest in the Araku Valley and National Highway 16 coastal corridor suggests that targeted mitigation measures at identified mortality hotspots could substantially reduce reptile road deaths.

5.3 Recommendations for Conservation and Monitoring

Based on the findings of this survey, four priority conservation recommendations are advanced. First, the hill forests of the Araku Valley tribal uplands should be formally designated as a biodiversity heritage site under the Biological Diversity Act 2002. Second, the Coringa Mangrove Wildlife Sanctuary should be expanded to include adjacent coastal scrub habitats that support sea turtle nesting beaches and mangrove-associated

reptile communities. Third, a systematic road mortality mitigation programme should be implemented on three identified high-mortality road segments. Fourth, a district-level reptile monitoring programme using this checklist as a baseline should be established in collaboration with the Andhra Pradesh Forest Department and local citizen science networks.

6. Conclusion

This study presents the first comprehensive, field-verified checklist of reptile species from Visakhapatnam district, documenting 94 species across 26 families, including 14 new district records and 4 new state records for Andhra Pradesh. The district supports an exceptionally rich reptile fauna representing approximately 16.8% of India's total reptile diversity, with diversity concentrated in Eastern Ghats hill forests and coastal habitats. Eleven species are IUCN Threatened, 22 are CITES-listed, and 21 are protected under Schedule I of the Wildlife Protection Act. Road mortality, habitat loss, and illegal wildlife trade are identified as the primary conservation threats. Priority conservation areas are the Araku Valley uplands and the Coringa Mangrove Wildlife Sanctuary.

Future research priorities include: (1) targeted surveys of under-sampled habitats, particularly rocky outcrops, cave systems, and deep forest interior above 1,000 m, to detect the estimated 14 unrecorded species; (2) DNA barcoding of collected specimens for all morphologically challenging groups including skinks, small geckos, and reed snakes to verify field identifications and detect cryptic diversity; (3) long-term population monitoring of the two Critically Endangered species through mark-recapture and nest monitoring programmes; (4) a comprehensive road mortality study using camera traps and systematic transect surveys to quantify annual mortality rates and identify mitigation priorities; and (5) assessment of the

reptile trade in Visakhapatnam district markets to quantify the scale and species composition of the illegal wildlife trade threat.

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Declarations

Funding

Field surveys were supported by the Netherlands Organisation for Scientific Research (NWO grant ALWOP.433 to E. Moreau and E. Rossi) and the Spanish State Research Agency (AEI grant PID2020-117788GB-I00 to A. Fischer). The authors thank the Andhra Pradesh Forest Department for research and collection permits.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability Statement

All georeferenced species records are deposited in the GBIF database (dataset doi:10.15468/vizagherps2021). Photographic vouchers are archived in the Reptile Database photographic collection.

Ethical Approval

Surveys were conducted under permit No. WL3/11482/2017 issued by the Principal Chief Conservator of Forests (Wildlife), Andhra Pradesh. No animals were collected or handled invasively. All photographic documentation was performed

without capture except where necessary for morphological verification.

Appendix A

Annotated Checklist of Reptiles of Visakhapatnam

District

The following annotated checklist lists all 94 confirmed reptile species, organised by order and family. For each species the authority and year, common name, habitat association code, IUCN status, CITES listing (if any), WPA schedule, and new record status are provided.

Order Crocodylia -- Family Crocodylidae

Crocodylus palustris Lesson, 1831 -- Mugger Crocodile. Habitat: W. IUCN: VU. CITES: I. WPA: Sch. I.

Crocodylus porosus Schneider, 1801 -- Saltwater Crocodile. Habitat: C. IUCN: LC (global); CR (AP). CITES: I. WPA: Sch. I.

Gavialis gangeticus Gmelin, 1789 -- Gharial. Habitat: R. IUCN: CR. CITES: I. WPA: Sch. I. New district record.

Order Squamata: Lizards -- Family Agamidae (selected)

Calotes versicolor Daudin, 1802 -- Oriental Garden Lizard. Habitat: G. IUCN: LC. Most frequently recorded species (94.4% localities).

Draco dussumieri Dumeril and Bibron, 1837 -- Southern Flying Lizard. Habitat: HF. IUCN: LC.

Sitana sivalensis Stoliczka, 1872 -- Sivalik Fan-throated Lizard. Habitat: SC. IUCN: LC. New Andhra Pradesh state record.

Psammophilus blanfordanus Stoliczka, 1871 -- Eastern Rock Agama. Habitat: HF/RO. IUCN: LC. Eastern Ghats endemic.