

Research Article

Distribution of the Green Forest Lizard *Calotes calotes* (Linnaeus, 1758) (Squamata: Agamidae) in India

R. Aengals¹ and S.R.Ganesh^{2*}

¹Zoological Survey of India, Southern Regional Station, Chennai, India

²Chennai Snake Park, Rajbhavan Post, Chennai, India

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ABSTRACT

We analysed the distribution pattern in India, of the agamid lizard *Calotes calotes* based on localities of the many voucher specimens that we examined, direct field observations by us and literature records. Our preliminary MaxEnt analysis run based on 48 localities revealed that hilly terrain of the Western Ghats and Eastern Ghats are the most ideal regions (>70% prediction) within its range. We also elaborate on the morphology of examined specimens, especially from the eastern parts of its Indian range, viz. the Coromandel Coastal Plains and the Eastern Ghats, so as to categorically confirm its occurrence in eastern parts of Southern India, where its presence had remained equivocal and contentious at best.

Key words: agamid, Coromandel Coastal Plains, distribution, Eastern Ghats, MaxEnt, morphology.

INTRODUCTION

The green forest lizard *Calotes calotes* (Linnaeus, 1758) is a species of draconine agamid lizard distributed in Sri Lanka and Southern India (Das, 2002; Daniel, 2002). This species was first described as *Lacerta calotes* based on a syntype series of two preserved specimens UUZM Reptilia 33 (Uppsala, Sweden), NRMN 106 (Stockholm, Sweden) and three drawings featured in the work of Albertus Seba (Amarasinghe *et al.*, 2009). Geographical reference associated with the figure captions of Seba's drawings is 'ceilonica' and that of Linnaeus (1758) is 'Zeylona' both of which allude to Sri Lanka, (Amarasinghe *et al.*, 2009). Two subjective junior synonyms *Agama ophiomachus* Merrem, 1820 and *Agama lineata* Khul, 1820 exist. The type locality of *Calotes calotes* is Sri Lanka (Smith, 1935). Its distribution in the island is fairly clear in that it is almost found throughout the island except the high montane zones (Somaweera & Somaweera, 2009). But its distribution in Southern India is rather general and unclear. Daniel (2002) and Das (2002) generally state that it occurs in Southern India. However, its occurrence in Southern India is patchy and unequivocal, requiring an ensemble of precisely-reported locales to accurately understand its distribution here. In the following, we sketch an overview of the distribution of *C. calotes* in southern India.

Merrem (1820) while describing a synonym *Agama ophiomachus* stated the geographic provenance as "India orientali et Insulis Moluccensibus" which is perhaps the first explicit report of this species from India. Subsequently Duméril & Bibron (1837) stated the

distribution as Philippine Islands, Ceylon and the mainland of India, from which countries specimens were collected by Leschenault, Dussumier and Raynaud. Gray (1845) in his British Museum catalogue mentioned both adults and young ones from "India" obtained through Thos. Bell Esq. and Mr. Argent's collection. Jerdon (1854) reported this species from "Dharwar" alluding to Elliot's collecting. Blyth (1846) was the first to state Nicobar Islands in the distribution of this species. Günther (1864), Theobald (1876) and Boulenger (1885, 1890) and Smith (1935) mention its distribution as Ceylon, Southern India and Nicobars. Smith (1935) explicitly attributed the Nicobar record to Blyth's collection ZSI 6543. Taylor (1922) listed *C. calotes* under erroneous records of Philippine lizards and remarked that there is a specimen in the Santo Tomas Museum, but it is very probably not of Philippine origin. Only lately was it understood that the records from Nicobar and Philippines might perhaps refer to the equally long-tailed *Bronchocela* spp. and subsequently, *C. calotes* was considered absent in these islands (Das, 2002; Daniel, 2002).

As stated earlier, the precise distribution of *C. calotes* was always better known in Sri Lanka, compared to Southern India. For example, Boulenger (1885) lists many specimens in the British museum collection, all of which were only from Ceylon (= Sri Lanka), obtained through A. Paul Esq., R. Templeton Esq., Messers v. Schlagintweit and Col. Beddome collections. Beddome in Grigg (1888) stated this species to occur in all the slopes of the Nilgiri hills. Annandale (1909) stated recording a small male taken at Kulathupuzha near Agasthyamalai in the Southern Western Ghats. Roux (1928) recorded this species from Attakatti in Anamalai

*Corresponding Author's E-mail: snakeranglerr@gmail.com

hills. As for the Indian distribution, only Smith (1935) stated two precise localities – Travancore and Shevaroy. Mathew (1944) while stating about its egg-laying habit, states its presence in Trivandrum. Inger *et al.* (1984) listed it from Ponmudi foothills. Prasad & Jayanthi (1991) report this species from Bandipur based on a roadkill observed en route to Mudumalai-Nilgiris border. Karthikeyan (1993) reported this species again from Yercaud, atop Shevaroy hills, in the Eastern Ghats (also see Smith, 1935). Ajith (2000) reported it from Chinnar Sanctuary in drier forests of the Southern Western Ghats. Zachariya (1997) listed it from Periyar Tiger Reserve, Southern Western Ghats.

Apart from the Western Ghats, *C. calotes* has also been known from the Eastern Ghats and some parts of the Coromandel Coastal Plains. Kalaiarasan & Kannan (1994) reported this species from Maraiyur and Mannampandal (near Mayiladuthurai) in the Cauvery delta. Subsequently, this species has again been reported from the same place by Ganesh & Chandramouli (2007) and Nath *et al.* (2012). In the Eastern Ghats (also see Murthy & Aengals, 2008), *C. calotes* has been reported from Jawadi hills (Daniels & Ishwar, 1994), Kolli Hills (Daniels & Kumar, 1998; Kumar & Daniels, 1999) and Sirumalai hills (Vanak *et al.*, 2001). Ganesh & Arumugam (2016) reported this species from Jawadi, Shevaroy, Kolli and Sirumalai hills. Ganesh *et al.* (2018) reported this species from Gingee and Tiruvannamalai hills. Of late it was stated that *C. calotes* is distributed in low and medium elevation (1000 m asl) dry forests of the Western Ghats, Eastern Ghats and across Sri Lanka (Pal *et al.*, 2018). Coromandel Coastal Plains was not mentioned probably due to the lack of vouchered records and published evidence detailing the presence of this species there. To fill this lacuna, we here elaborate on the presence of *C. calotes* based on voucher specimens from the Western Ghats, the Eastern Ghats and the Coromandel Coastal Plains. We map its distribution based on literature reports plus examined museum specimens and also conduct species distribution modelling (SDM) for *Calotes calotes*.

MATERIALS AND METHODS

This work is based on examination of preserved specimens (n=15) of the target species in the following museums: Chennai Snake Park (CSPT), Madras Govt. Museum (MAD), Salim Ali Centre for Ornithology and Natural History, Coimbatore (SACON) and Zoological Survey of India, Chennai (ZSIM). Morphological examination protocols, definitions and terminologies follow Smith (1935). For mapping analysis, point localities were assembled based on provenance records of the examined material, wild sightings during fieldwork by the authors, literature records sourced from publications and lastly from geo-referenced photo-voucher entries in citizen science platforms viz. iNaturalist, India Biodiversity Portal and Herp Mapper. A total of 48 distinct localities were assembled by pooling up the data points sourced from all the aforesaid ways. Data point geo-coordinates were in decimal degree format, correct up to 4 decimal places, sourced from GoogleEarth software when unavailable. Species Distribution Modelling (SDM) was conducted using Maximum Entropy algorithm run on MaxEnt software (Philips *et al.*, 2004). We

used all the bioclimatic variables downloaded from WorldClim Database (Hijmans *et al.*, 2005), following Joshi & Karanth (2012), though others recommend choosing correlated set of variables (e.g. Schnase *et al.*, 2021). The output map files (GRD and GRI files) were rendered from MaxEnt using DIVA-GIS software. We rounded off the logistic values of the predictions to the nearest increment of 5 so as to get better defined spatial distribution predictions.

RESULTS

Calotes calotes (Linnaeus, 1758) (Figs.1-3)

Specimens examined (n=17, India; Figs.1-2): CSPT/L-3 adult female from Mayiladuthurai, Nagapattinam, Tamil Nadu, coll. and date unknown; MAD no number from Sirumalai, Dindigul, Tamil Nadu, coll. and date unknown; SACON/VR-17a from Srivilliputhur hills, from Virudunagar, Tamil Nadu; VR-17b from Meghalmai, Theni, Tamil Nadu and VR-17c-d from Anai-katti, Coimbatore, Tamil Nadu, coll. and date unknown; ZSIM/VRL-18 from Anaimalai-Parambikulam Road, Kerala, coll. G.V. Kurup and party on 5/6/1973; ZSIM/VRL-19 from Kulathupuzha, Thenmala, Kerala, coll. T.S.N. Murthy and party on 10/12/1973; ZSIM/VRL-20 from Agali, Attapadi, Kerala, coll. G.M. Kurup and party on 17.10.1974; ZSIM/VRL-161 from Thattapara, Sabarigiri, Kerala, coll. R. S. Pillai and party on 7/5/1981; ZSIM/VRL-211 from Pachaiyar, Thalattyanai, KMTR, Tamil Nadu, coll. M. Vasanth and party on 12/2/1986; ZSIM/VRL-357 from Courtallam Five Falls, Tirunelveli, Tamil Nadu, coll. M.B.R and party on 14/4/1995; ZSI/M-823 from Injukadu, Alagiyapandipuram, Kanyakumari district, Tamil Nadu, coll. S. Prabhakaran and party, on 17/3/2008; ZSI/M/VRL-824 from Alagiyapandipuram, Samikuchi, Kanyakumari district, Tamil Nadu, coll. S. Prabhakaran and party on 12/6/2007; ZSIM/VRL-752 from Kootathur Aaru, Jamunamarathur, Tamil Nadu, coll. R. Aengals and party on 23/6/2008; ZSI/M-734 from Mozhalai Aru, Singarapaettai Range, Tamil Nadu, coll. R. Aengals and party on 26/6/2008; ZSI/M-753 from Karumanthurai, Chinna Kalrayan Malai, Aruna RF, coll. K. Ilango and party on 6/10/2010; ZSIM/VRL-820 from Amaravathy dam, Anamalai, Tamil Nadu, coll. R. Aengals and party on 16/7/2013; ZSIM/VRL-821 from Alagiapandipuram-Kalikesam, Kanyakumari, Tamil Nadu, coll. S. Prabhakaran and party on 11/11/2013; ZSIM/VRL-822 from Karumandi Amman Koil, Sengaltheri, KMTR, Tamil Nadu, coll. R. Babu and party on 21/2/2014.

Morphology: The voucher specimens presented with the following morphological features, characteristic of *C. calotes*: very long tail that is over 300% of snout to vent length; mild fold in front of shoulder; scales on body postero-dorsally oriented, homogenous, imbricate, slightly keeled near apex; ventral scales larger than dorsal / costal scales, keeled, mucronate; scale rows around midbody 30–35; crest present, well developed in adult males; continuous nuchal and dorsal crest; long lanceolate spines above nape; crest on back made of smaller spinules, decreasing in size as it progresses posteriorly; supratympanic spines, in two clusters, made of 8–9 spines; postmentals, paired, 1st pair separated by 1–2



Figure 1. Preserved specimens of *Calotes calotes* from the Western Ghats, Southern India



Figure 2. Preserved specimens of *Calotes calotes* from Eastern Ghats and Coromandel Coastal Plains, Southern India



Figure 3. Adult and juvenile colouration (top panel) of *Calotes calotes* and the respective habitat profiles (bottom panel) from Mayiladuthurai (Cauvery Basin) and Kolli hills (Eastern Ghats)

scales; 4th toe subdigital lamellae 29–30; labial scales 9–12 on upper and lower lips; overall colouration verdant grass green in life turning to dark grey in preservation, with 5 or 6 off-white cross bars across trunk and anterior part of tail, this pattern being obscure or absent in young ones and subadults; eye with a brick red ocular streak, ashy grey in preservation; tail ending brownish grey; ventral, gular and subcaudal regions fluorescent green in life, ashy grey in preservation. Measurements in mm: snout to vent length 80–120; tail length 320–390; head length 22–33; head width 13.5–25; head depth 12–22.5; axilla-groin distance 48–68; body width 14–25.5; upper arm length 16–20; lower arm length 15–21; hand length 16–23.5; thigh length 24–31; shank length 24–29; foot length 31–39.5; eye diameter 6.5–9.5; inter-orbital distance 8.5–14.

Distribution Range and MaxEnt Modelling (Figs. 3-4): Our mapping indicates that in southern India, *C. calotes* is known from the Western Ghats, the Malabar Plains, the Eastern Ghats and the Coromandel Coastal Plains. This species has been reported from near sea-level (< 10 m asl) in Ambalappuzha (West Coast) and Cuddalore (East Coast) to up to 1600 m asl in Asankodai in Palni hills (Western Ghats) and in Yercaud, Shevaroy (Eastern Ghats). Hence, understandably, this species inhabits many forest types including moist, dry and mixed deciduous forests and semi-evergreen forests (in hilly tracts) as well as riverine /riparian forests (in coastal plain deltas). As far as the MaxEnt modelling is concerned, the highest (> 70%) prediction envelope of patches (red) were in the hill country – the Western Ghats of lower Nilgiris, eastern fringes of Anaimalai, Cardamom hills and all of the Agasthyamalai hills as well as the Eastern Ghats of Shevaroy, Kalrayan malai, Kolli malai and Sirumalai. Tiny isolated high prediction patches occur in Chitteri and Jawadi hills of the Eastern

Ghats. In the next grade, lies moderate (50-70%) prediction patches (orange). These patches cover large areas in the Travancore coastal Plains, all the way south of Palghat Gap (except big wetlands), Chitteri-Shevaroy and large parts of Yelagiri and Jawadi hills in the Eastern Ghats and the Cauvery Delta areas in between Pondichery and Mayiladuthurai along the East Coast. Next, the low (35-50%) prediction patches (yellow) are dispersed over the eastern fringes of the Western Ghats, along the foothills, the Palghat Gap abutting the southern edge, the peripheries of the Eastern Ghats along the foothills and lastly in the Vedaranyam Bay on the East Coast, towards the southern edges of Cauvery Delta. From the distribution modelling MaxEnt analysis, it is clear that *C. calotes* predictions are in line with wetter areas like the hills and the riverine tracts of Deltas in the plains. Rest of the plains country that are dry, covered with thin scrub were predicted to be unsuitable areas (< 35%; green shades).

DISCUSSION

The present work aims to fill the voids of lack of morphologically described, illustrated and voucher-based records of *C. calotes* from eastern parts of southern India, especially in the Coromandel Coastal Plains and the Eastern Ghats. Some literature unfortunately, maintained that *C. calotes* occurs in the Western Ghats and Shevaroy following Smith (1935) (Manthey, 2008) though they corrected later on (Manthey, 2010). As stated earlier, despite reports of *C. calotes* from the East Coast in literature (Mannampandal, see Kalaiarasan & Kanakasabai, 1994; Ganesh & Chandramouli, 2007; Nath *et al.*, 2012) as well as in India Biodiversity Portal, Pal *et al.* (2018) could not feature the complete

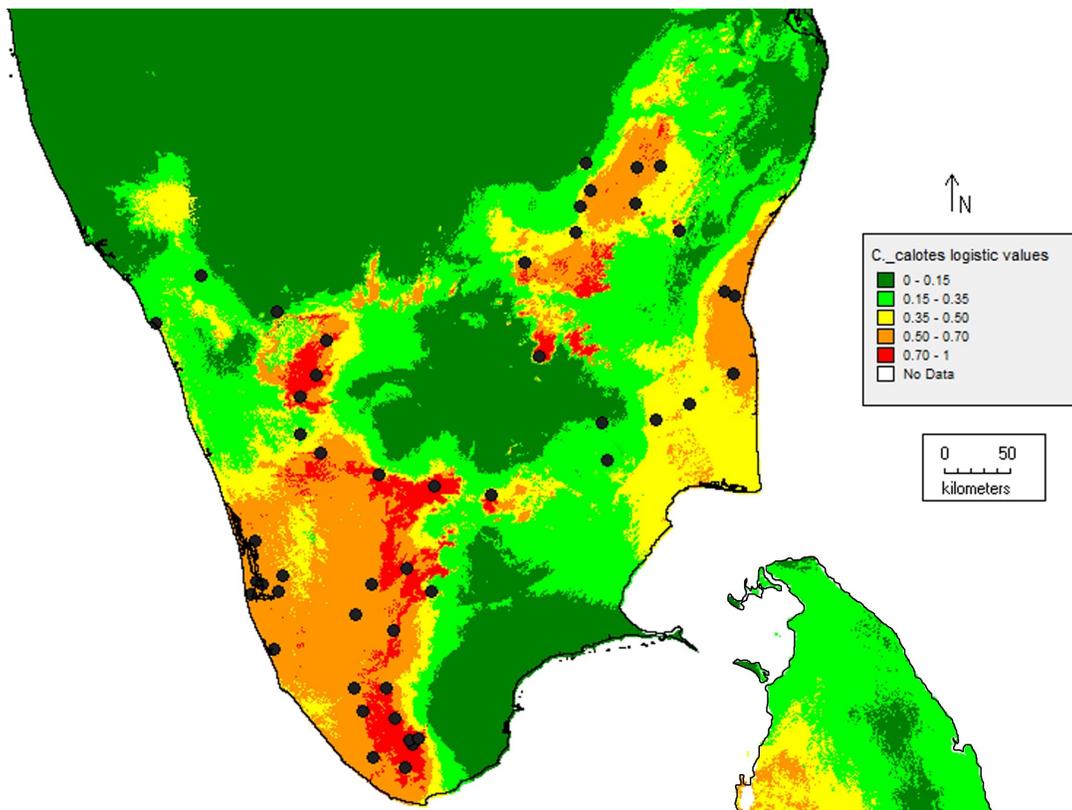


Figure 4. Map of Southern India, showing the preliminary MaxEnt modeling predictions; black dots represent records of *Calotes calotes*

range of *C. calotes*, by excluding the Eastern Coastal Plains sites in toto. Additionally, though they mentioned the Eastern Ghats, precise information on the ranges harbouring *C. calotes* did not feature in their work. Moreover, their work was limited to the Western Ghats and hence did not feature any material of *C. calotes* from other ecoregions in India. So to supplement them, we described and illustrated preserved voucher specimens of *C. calotes* from the Eastern Coast and Eastern Ghats.

Also, the moderate to high (>50%) prediction envelopes revealed by our MaxEnt modelling indicate that further surveys in suitably wet, riparian tracts of the Eastern Coast could fetch novel records of *C. calotes*. Therefore, informed by our SDM exercise, we advocate for further surveys in wet, riparian tracts along the Coromandel Coastal Plains to better document the range of *Calotes calotes*. This is a unique species that has a distribution in both the dry and wet zones of Sri Lanka, but in India is restricted to predominantly wet landscapes such as hill forests tracts and riparian zones alongside large river deltas. While many agamid lizards display restricted distribution ranges revealing montane endemism, *C. calotes* represents a curious case—one that has very few parallels among herpetofauna. Hump-nosed pitviper *Hypnale hypnale* (Merrem, 1820) is a species distributed in the Western Ghats and Sri Lanka (dry and wet zones) (Maduwage *et al.*, 2009). But in Southern India, this species is not known outside the Western Ghats (Whitaker & Captain, 2004). Some species such as *Chrysopelea taprobanica* *Oligodon arnensis* and *Dendrelaphis bifrenalis* have such shared distributions (Guptha *et al.*, 2015; Bandara *et al.*, 2022; Aengals *et al.*, 2022).

After a spate of recent research on agamid lizards, it is clear that no range restricted genus or species of agamid co-occurs in both India and Sri Lanka (Pal *et al.*, 2018; Achyuthan *et al.*, 2021; Gowande *et al.*, 2021). When this being the case, the wider distribution of another range-restricted species from this region is unusual. Gowande *et al.* (2022) split *C. versicolor* complex in India and Sri Lanka into *C. versicolor* s. str. – inhabiting Sri Lanka and Southern India (sporadically eastern India) and *C. vultuosus* (Harlan, 1825) – inhabiting the rest of India. Seen in light of Gowande *et al.* (2021), *C. calotes* could potentially be postulated to have an approximately similar distribution in being present in Southern India and Sri Lanka, but absent in the Deccan plus Northern India. Pal *et al.* (2018) after their genetic studies involving both Sri Lankan and Indian populations concluded that they indeed represent one same species.

Recently, such new records and range extensions were reported for agamids in southern India, including *Draco dussumierii* (see Balachandran & Pittie, 2000) and *Monilesaurus rouxii* (see Daniels & Ishwar, 1994). Thereafter, further fine-scale sampling and targeted long-term surveys revealed the presence of both these species in many nearby localities from where they were previously unknown (Ganesh & Arumugam, 2016; Ganesh *et al.*, 2018). Given that the forested zones of southern India have not had thorough bioinventories for agamids in the past, like in Sri Lanka (Erdelen, 1984; Manamendra-Arachchi & Liyanagae, 1994; Pethiyagoda & Manamendra-Arachchi, 1998), such new knowledge on the diversity and distribution of agamids are understandably expected in India. As emphasized previously (Ganesh & Arumugam, 2016),

targeted surveys in wet forest enclaves outside the Western Ghats is indispensable to get a complete understanding of India's reptile diversity. Given the kind of species with idiosyncratic distribution that it is, further novel information on occurrence records of this taxon from India will help plug in the gaps, if any.

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