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REPTILES OF THE CENTRAL WESTERN GHATS, INDIA — A REAPPRAISAL AND REVISED CHECKLIST, WITH EMPHASIS ON THE AGUMBE PLATEAU

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We examined the species richness and distribution patterns of reptiles inhabiting the Central Western Ghats Mountains of southwestern India. In the past few years, field work by us as well as our colleagues resulted in a steady stream of several new regional records of species of day geckos (*Cnemaspis*), skinks (Scincidae), shieldtail snakes (Uropeltidae), bronzeback tree snakes (*Dendrelaphis*) and coral snakes (*Calliophis*). Based on our past extensive sampling in the region as a whole and intensive, long-term sampling in the central part, i.e., the Agumbe plateau, we continue to add several additional species of geckos (Gekkonidae), agamids (*Calotes*), skinks and snakes in this paper. We take a more holistic approach here and revise the checklist of reptiles inhabiting the Central Western Ghats not only by adding all our past and present new regional records but also by deleting some dubious "records" of agamids (*Salea*) and pitvipers (*Trimeresurus*) not based on voucher specimens pending the availability of reliable, soundly identified vouchers. As a result, a total of 71 species of reptiles, comprising of 4 chelonians, 24 lizards and 43 snakes are reported here. Our literature review shows that only 11 (out of 71) species were originally described from this region. Our preliminary analysis of area cladogram delineated that despite the many range extensions of "southern" Western Ghats species, the Central Western Ghats reptile fauna is still more similar to the Northern Western Ghats. Our analysis of distribution patterns revealed that half the species are Western Ghats endemics (47%), many are also widespread species (30%) and that the Eastern Ghats and Sri Lankan fauna were only scarcely represented.

Keywords: latitude; species richness; *Calotes*; *Dendrelaphis*; *Salea*; *Trimeresurus*; Uropeltidae.

INTRODUCTION

The Western Ghats Mountain range of southwestern India is one of the last remaining stretches of the biodiverse tropical wet evergreen rainforests in Peninsular India and is home to a unique endemic radiation of biota which makes it a global biodiversity hotspot (Myers et al., 2000). This mountain range extending 1000 miles northwest to southeast along the west coast of India, from 8° – 21° N, is geologically heterogeneous and is separated thrice by intervening low-altitude "gaps." These three gaps, namely the Sencottah gap (8° – 9° N), the Palghat gap (10° – 11° N) and the Goa gap (14° – 15° N) divide the range into southern (8° – 11° N), central (12° – 15° N) and northern (16° – 21° N) Western Ghats (Robin et al., 2010; Bocxlaer et al., 2012). These three segments are rather natural entities that are characterized by differing geoclimatic factors including annual rainfall, average mountain height, relief features and dominant forest types.

Consequently the faunal composition greatly varies between the segments. Reptiles are no exception. As early as the time of T. C. Jerdon, R. H. Beddome, H. S. Ferguson, F. Wall and A. F. Hutton, all the way to the more modern workers such as Inger et al. (1984), Das and Whitaker (1990), Malhotra and Davis (1991), Zachariah (1997), Ishwar et al. (2001), Hutton and David (2009), and Chandramouli and Ganesh (2010), Bhupathy and Nixon (2011), Bhupathy et al. (2012); the Southern Western Ghats that had been given prominence when it comes to reptile studies. Chief among the hill ranges are the Nilgiris, Anamalais, Palnis, High Wavy Ranges, Tirunelveli and Travancore hills.

Likewise, several herpetological surveys have been conducted in the Northern Western Ghats (Daniel and Shull, 1963; Nande and Deshmuk, 2007; Mirza and Pal, 2008) and new species of reptiles were also described (Giri, 2008; Giri and Bauer, 2008). But, barring our own

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previous account that dealt with the herpetofaunal species richness of the Central Western Ghats with some basic ecological data (Ganesh et al., 2007), this is the region that has experienced a lull in reptile inventories. This is evidenced by the fact that out of the 71 reptile species reported from Central Western Ghats (see below), only 11 (i.e., 15%) species were originally described from this region. Even here, only four were during the British period.

List of reptiles described from the Central Western Ghats and their type localities:

1. *Geckoella albofasciata* (Boulenger, 1885) from South Canara;

2. *Pseudoplectrurus canaricus* (Beddome, 1870) from Kudremukh;

3. *Hemidactylus prashadi* Smith, 1935 from Jog, North Canara;

4. *Calliophis beddomei* Smith, 1943 from Koppa [apart from Shevaroys];

5. *Cnemaspis goaensis* Sharma, 1969 from Goa;

6. *Eryx whitakeri* Das, 1991 from Mangalore;

7. *Coelognathus helena monticollaris* (Schulz, 1992) from Mangalore;

8. *Cnemaspis indraneildasi* Bauer, 2003 from Gund, North Canara;

9. *Cnemaspis heteropholis* Bauer, 2003 from Gund, North Canara;

10. *Dendrelaphis girii* Vogel et Rooijen, 2011 from Castle Rock;

11. *Calliophis castoe* Smith, Ogale, Deepak et Giri, 2012 from Karwar [apart from Amboli, Maharashtra].

Nonetheless, recently, significant additional species have been reported (e.g., *Calotes nemoricola*, *Kaestlea beddomii*, *Dasia subcaeruleum*, *Melanophidium wynaudense*, *Dendrelaphis chairecacos*, *Calliophis bibroni*) and furthermore, others have been reconfirmed when their earlier records have either remained implicit or doubtful (e.g., *Dendrelaphis grandoculis*, *D. ashoki*, and *Oligodon affinis*) (see Naniwadekar and Deepak, 2008; Ganesh and Gowrishankar, 2009; Gowrishankar and Ganesh, 2009; Chandramouli and Ganesh, 2012; Harikrishnan et al. 2012; Ganesh et al., 2012b; this work). These additions apart, noteworthy new observations on the natural history of some little known species have also been reported (e.g., *Cnemaspis heteropholis*, *Hemidactylus prashadi*, *Rhabdops olivaceus*; see Giri and Bauer, 2006; Naniwadekar and Deepak, 2010; Ganesh et al., 2011; Ganesh et al., 2012a).

On the other hand, there are also some cases of erroneous, dubious and unsubstantiated reports of certain species. Examples include the two species of montane agamid lizards (*Salea anamallayana* and *S. horsfieldii*, both of which were included in a checklist of reptiles from Kudremukh National Park by Radhakrishnan and Palot (2007) based only on a web-page (http://www.wildindia.org/wiki/Kudremukh_checklist_reptiles) as pointed out by Ganesh and Aengals (2011). *Ahaetulla perroeti*, a montane species restricted to the higher hills of Nilgiris has been reported based on a subjective junior synonym *Leptophis canarensis* Jerdon (1854). This issue was highlighted in a recent publication dealing with the nomenclature of this species (Ganesh and Chandramouli, 2011). Lobo (2001) and Whitaker and Captain (2008) reported *Trimeresurus macrolepis* from Bondla Wildlife Sanctuary in Goa and Southern Karnataka respectively. A recent study on pitvipers of Goa by Sawant et al. (2010) did not report *T. macrolepis*, a species that is definitely known only from the high elevations (>1000 m a.s.l.) of the Western Ghats south of Palghat gap (personal observation) and considered to be an ecological equivalent of its parapatric, drier zone dwelling congener T. gramineus (see Ganesh et al., 2008). The imprecise record of *Trimeresurus strigatus* from "North Canara" and "Deccan" based on Phipson (1888) and Vidal (1890), respectively, is another such example.

Meanwhile, some species, such as *Vijayachelys sylvatica*, *Sphenomorphus dussumierii*, and *Calliophis beddomei*, are known in Central Western Ghats only from historical collections. As the principal herpetologists involved in surveying this region, it became apparent to us that these sizable new additions to the Central Western Ghats warrants a reappraisal of its reptilian fauna. In this work, we list all the reptile species that either we have so far documented in the Central Western Ghats or reliably reported in literature and also advocate deletion of some species dubiously/erroneously reported from this region, pending reliable, soundly-identified vouchers.

STUDY AREA

The study area (Fig. 1) extends along the narrow western coastal plains and the adjoining Western Ghats Mountains of the southwestern Indian State of Karnataka, covering six different districts, namely Talakaveri, South Canara, Udupi, Shimoga, Chikmagalur and North Canara. The study sites were on the foothills (<300 m a.s.l.), elevated plateaus (300 – 700 m a.s.l.) and the hilltops (>700 m a.s.l.). Along a north-south axis, the study sites ranged from Talakaveri (12° N) in the south, through Kudremukh, Someshwara, Mookambika, Agumbe, Jogigundi, and Tirthahalli (all 13° N) till Gersoppa and Sharavathy (14° N) to the north.

The sites in the 13° N block, i.e., the central part of the Central Western Ghats, particularly the Agumbe plateau, was intensively surveyed. In this block, forests in

the lowlands, plateaus, and hilltops, riparian and non-riparian habitats, hill-slopes on the windward and leeward sides, were subjected to long-term sampling. Since new locality records and range extensions were predominant, extensive surveys in further northern and southern latitudes to this region were also considered important and hence included.

The dominant natural climax vegetation of the study area is the tropical wet evergreen rainforest. Apart from this, some patches of tropical semi evergreen and tropical moist deciduous forests were present along lower altitudes of the leeward slopes. These formations apart, the surveyed habitat types also included man-made plantations such as areca nut, coconut, vanilla, coffee and silver oak. As far as climate is concerned, the area receives southwest monsoon during June – September, when the moist trade winds from the Arabian Sea crash over the Ghats. The mean annual temperature ranges from 20 – 35°C in the day and 15 – 20°C in the night. Soil of the region is largely lateritic (Champion and Seth, 1968).

MATERIAL AND METHODS

The present work is based on several spells of field work between the years 2005 and 2011. We here define the three blocks of the Western Ghats as: Southern Block — Hill ranges from Mahendragiri in the tip of the southern Peninsula, through the Agasthyamalais, Ashambu, High Wavys, Anamalais and Palnis till the Nilgiri Hills across the Palghat gap; Central Block — from Brahmagiri Hills including Pushpagiri, Talakaveri, Kudremukh, Agumbe Hills and the Sharavati River Valley till the Goa Gap; Northern Block — Hills north of Goa including Amboli, Koyna, Sindudurg, Mahabaleshwar and further north up to Surat Dangs. Nilgiris is herein provisionally placed in the Southern Western Ghats owing to its reptilian fauna, particularly the montane endemics, reminiscent of similar peaks in the Western Ghats south of Palghat.

Habitat types surveyed were evergreen forests as well as areca, vanilla and coffee plantations. We performed *ad hoc*/random active searches during both day and night, across all seasons, by inspecting prospective microhabitats such as under fallen logs, rocks, leaf litter, tree holes, buttress interspaces and rock crevices. Accidental/chance encounters, those brought to us either alive or dead by local inhabitants as well as road-killed specimens were all included. Barring our long-term sampling in and around Agumbe, our survey duration and search effort varied randomly with respect to the availability of forest cover across the many study sites.

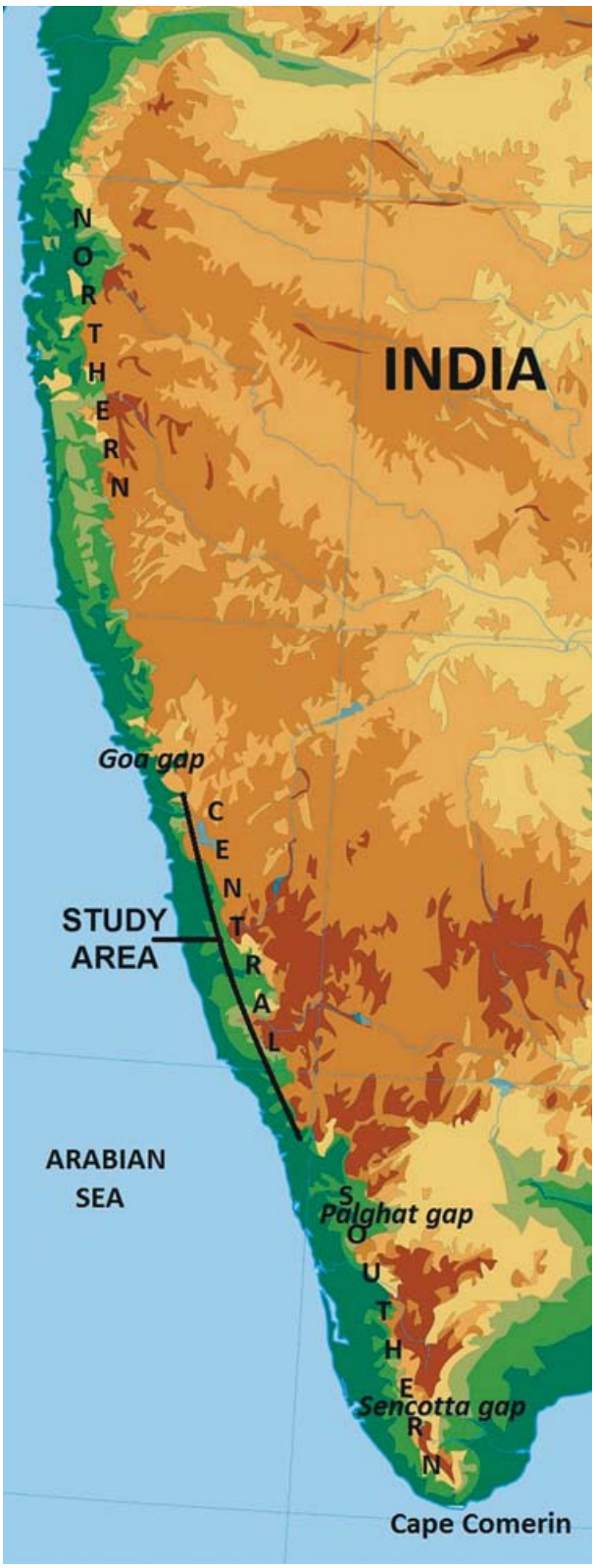

Fig. 1. Map of southwestern India showing the different regions of the Western Ghats.

Individuals sighted were examined, photographed in-situ and released. Owing to lack of collection permits, no voucher specimen was preserved/deposited. Instead most data, particularly the new records are supported with photographic vouchers that are also reproduced here. In the checklist, an asterisk "*" indicates species endemic to the Western Ghats. Taxa that stand unresolved down to the species level are mentioned here either as "sp." or with a prefix "cf." before their most-conferring nominate species. Those with "cf." are excluded from the chresonymy and distribution of their respective nominate taxa. Some erroneous and/or doubtful literature records that need reconfirmation with soundly identified vouchers for being formally included in the Central Western Ghats reptilian fauna are listed separately. Statistical analyses were performed in the software package PAST (Hammer et al., 2001) and Jaccard's index of similarity was used as the measure to construct the cladogram, with single linkage algorithm.

REVISED LIST OF REPTILES OF THE CENTRAL WESTERN GHATS

Class: Reptilia
Order: Chelonii
Family: Geoemydidae

1. *Melanochelys trijuga* (Schweigger, 1812)
2. *Vijayachelys silvatica* (Henderson, 1912)*

Family: Trionychidae

3. *Lissemys punctata* (Bonnaterre, 1789)

Family: Testudinidae

4. *Indotestudo travancorica* (Boulenger, 1907)*

Order: Squamata
Family: Gekkonidae

5. *Cnemaspis heteropholis* Bauer, 2002*
6. *Cnemaspis* sp.
7. *Cnemaspis indraneildasi* Bauer, 2002*
8. *Hemidactylus frenatus* Schlegel, 1836
9. *Hemidactylus* cf. *brookii* (Gray, 1845) sensu Mahony, 2011
10. *Hemidactylus prashadi* Smith, 1935*
11. *Geckoella albofasciata* (Boulenger, 1885)*

Family: Agamidae

12. *Calotes versicolor* (Daudin, 1803)
13. *Calotes rouxii* Duméril et Bibron, 1837*
14. *Calotes nemoricola* Jerdon, 1853*
15. *Calotes grandisquamis* Günther, 1875*
16. *Draco dussumierii* Duméril et Bibron, 1837*
17. *Psammophilus blanfordanus* (Stolizcka, 1871)

Family: Scincidae

18. *Dasia subcaeruleum* (Boulenger, 1891)
19. *Eutropis carinata* (Schneider, 1801)
20. *Eutropis allapallensis* (Schmidt, 1926)
21. *Eutropis beddomei* (Jerdon, 1870)
22. *Eutropis macularia* (Blyth, 1853)
23. *Kaestlea beddomii* (Boulenger, 1887)*
24. *Lygosoma guentheri* (Peters, 1879)
25. *Ristella beddomei* (Boulenger, 1887)*
26. *Sphenomorphus dussumierii* (Duméril et Bibron, 1839)*

Family: Lacertidae

27. *Ophisops beddomei* (Jerdon, 1870)

Family: Varanidae

28. *Varanus bengalensis* (Linnaeus, 1758)

Family: Typhlopidae

29. *Ramphotyphlops braminus* (Daudin, 1803)

Family: Uropeltidae

30. *Melanophidium punctatum* Beddome, 1871*
31. *Melanophidium wynaudense* (Beddome, 1863)*
32. *Pseudoplectrurus canaricus* (Beddome, 1870)*
33. *Uropeltis ceylanica* Cuvier, 1829*
34. *Uropeltis elliotti* (Gray, 1858)
35. *Rhinophis sanguineus* Beddome, 1863*

Family: Pythonidae

36. *Python molurus* (Linnaeus, 1758)

Family: Boidae

37. *Eryx whitakeri* Das, 1991*

Family: Colubridae

38. *Ahaetulla* cf. *nasuta* (Bonnaterre, 1790) sensu Chandramouli and Ganesh, 2010
39. *Ahaetulla pulverulenta* (Duméril, Bibron et Duméril, 1854)
40. *Boiga beddomei* (Wall, 1909)
41. *Boiga ceylonensis* (Günther, 1858)
42. *Boiga forsteni* (Duméril, Bibron et Duméril, 1854)
43. *Boiga nuchalis* (Günther, 1875)
44. *Boiga trigonata* (Schneider, 1802)
45. *Chrysopelea ornata* (Shaw, 1802)
46. *Coelognathus helena monticollaris* (Schulz, 1992)*
47. *Dendrelaphis ashoki* Vogel et Rooijen, 2011*
48. *Dendrelaphis chairecacos* (Boie, 1827)*
49. *Dendrelaphis girii* Vogel et Rooijen, 2011*
50. *Dendrelaphis grandoculis* (Boulenger, 1890)*
51. *Lycodon aulicus* (Linnaeus, 1758)
52. *Lycodon travancoricus* (Beddome, 1870)

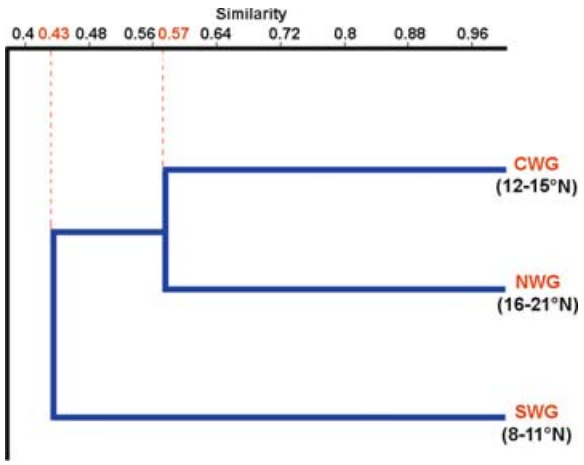

Fig. 2. Preliminary area cladogram showing similarity between the reptilian fauna of Southern, Central and Northern Western Ghats (red dotted lines indicate similarity values; see Table 1).

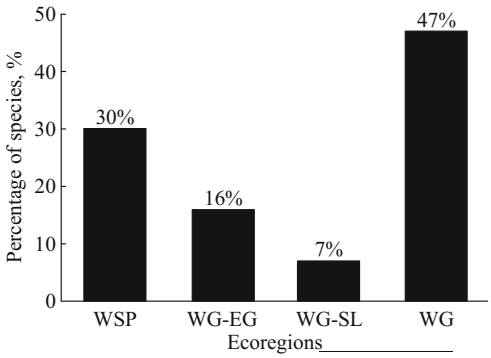

Fig. 3. Distribution patterns of reptiles across the ecoregions prevailing in southern India: WSP, widespread; WG-EG, Western and Eastern Ghats endemics; WG-SL, Western Ghats-Srilankan endemics; WG, Western Ghats endemics.

53. *Oligodon affinis* (Günther, 1862)*
54. *Ptyas mucosa* (Linnaeus, 1758)
55. *Rhabdops oilvaceus* (Beddome, 1863)*

Family: Natricidae

56. *Amphiesma beddomei* (Günther, 1864)*
57. *Amphiesma monticola* (Jerdon, 1854)*
58. *Amphiesma stolatum* (Linnaeus, 1758)
59. *Atretium schistosum* (Daudin, 1803)
60. *Macrophisthodon plumbicolor* (Cantor, 1839)
61. *Xenochrophis piscator* (Schneider, 1799)

Family: Elapidae

62. *Bungarus caeruleus* (Schneider, 1801)
63. *Calliophis nigrescens* Günther, 1862*
64. *Calliophis beddomei* Smith, 1943
65. *Calliophis bibroni* (Jan, 1858)*
66. *Calliophis castoe* Smith, Ogale, Deepak et Giri, 2012
67. *Naja naja* (Linnaeus, 1758)
68. *Ophiophagus hannah* (Cantor, 1836)

Family: Viperidae

69. *Hypnale hypnale* (Merrem, 1820)
70. *Trimeresurus gramineus* (Shaw, 1802)
71. *Trimeresurus malabaricus* (Jerdon, 1854)*

ERRONEOUS SPECIES REPORTS NOW DELETED

Order: Squamata

Family: Agamidae

1. *Salea anamallayana* (Beddome, 1878)*
2. *Salea horsfieldii* Gray, 1845*

Family: Colubridae

3. *Ahaetulla* perroteti (Duméril, Bibron et Duméril, 1854)*

Family: Viperidae

4. *Trimeresurus macrolepis* Beddome, 1862*
5. *Trimeresurus strigatus* Gray, 1842*

DISCUSSION

The above list of 71 species reveals that there have been significant additions to the reptile fauna now known from the Central Western Ghats when compared to what was reported earlier (ie. 41 in Ganesh et al., 2007). Of these, the identity of *Cnemaspis* sp. remains currently uncertain and warrants further samples for a precise identification. There have been a few misidentifications of cryptic taxa in the past (e.g., *Cnemaspis indraneildasi* as *C. indica*; *Geckoella albofasciata* as *G. dekkanensis*; *Dendrelaphis chairecacos* as *D. tristis*; *D. ashoki* as *D. pictus* by Ganesh et al. (2007)) which are herein corrected, in light of recent taxonomic changes/advancements (Bauer and Giri, 2004; Manamendra-Arachchi et al., 2007; Chandramouli and Ganesh, 2012). The Western Ghats population of vine snake is being referred to as

TABLE 1. Jaccard's Coefficient of Similarity Values of Reptile Faunal of Southern, Central, and Northern Blocks of the Western Ghats, Southwestern India

	Southern (8 – 11° N)	Central (12 – 15° N)	Northern (16 – 21° N)
Southern (8 – 11° N)	1.00000		
Central (12 – 15° N)	0.43636	1.00000	
Northern (16 – 21° N)	0.31792	0.57426	1.00000

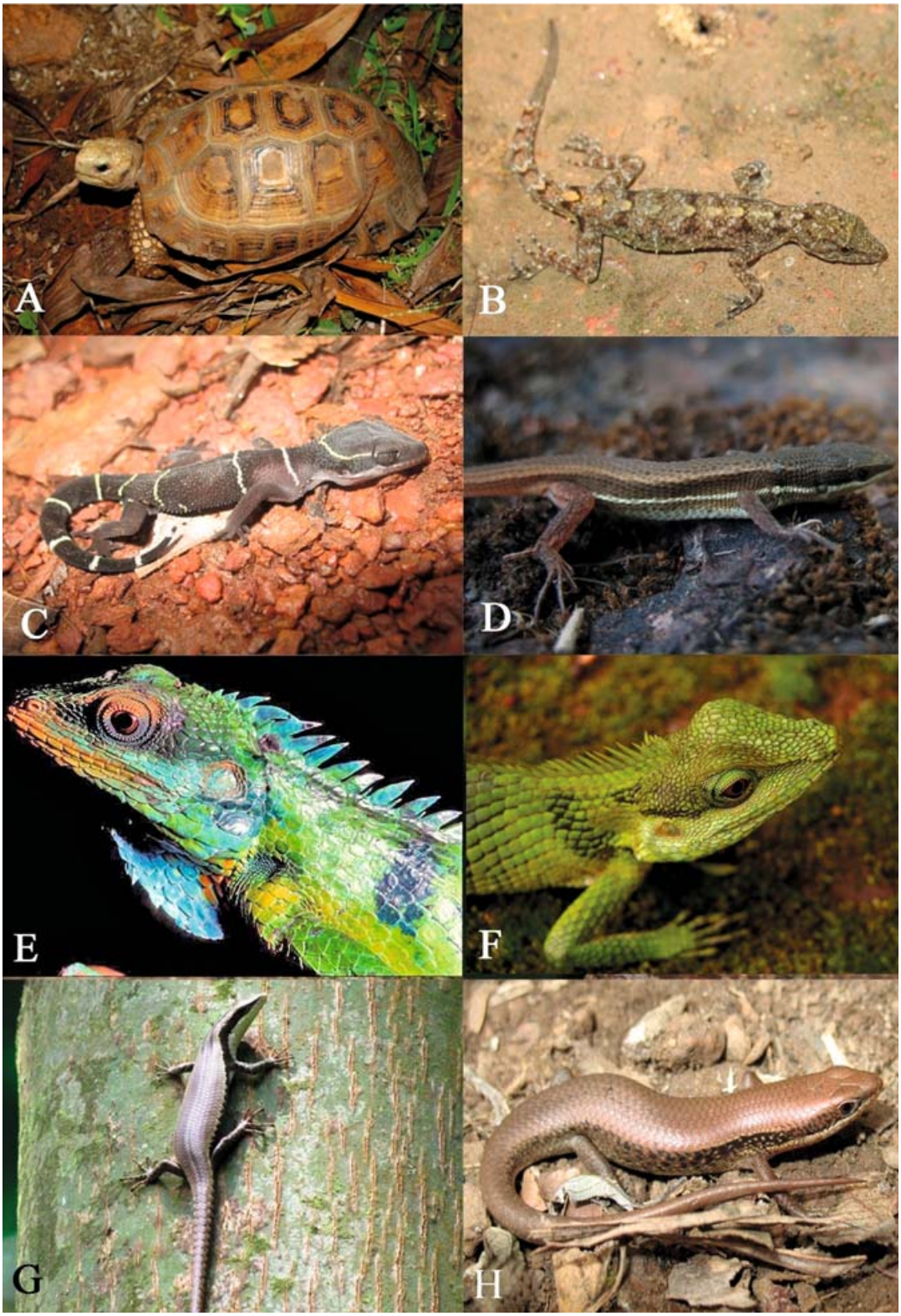

Fig. 4. Travancore tortoise and some lizards of the Central Western Ghats (top left to bottom right): A, *Indotestudo travancorica*; B, *Cnemaspis indraneildasi*; C, *Geckella albofasciata*; D, *Ophisops beddomei*; E, *Calotes grandisquamis*; F, *Calotes nemoricola*; G, *Dasia* cf. *subcaeruleum*; H, *Eutropis allapallensis*.

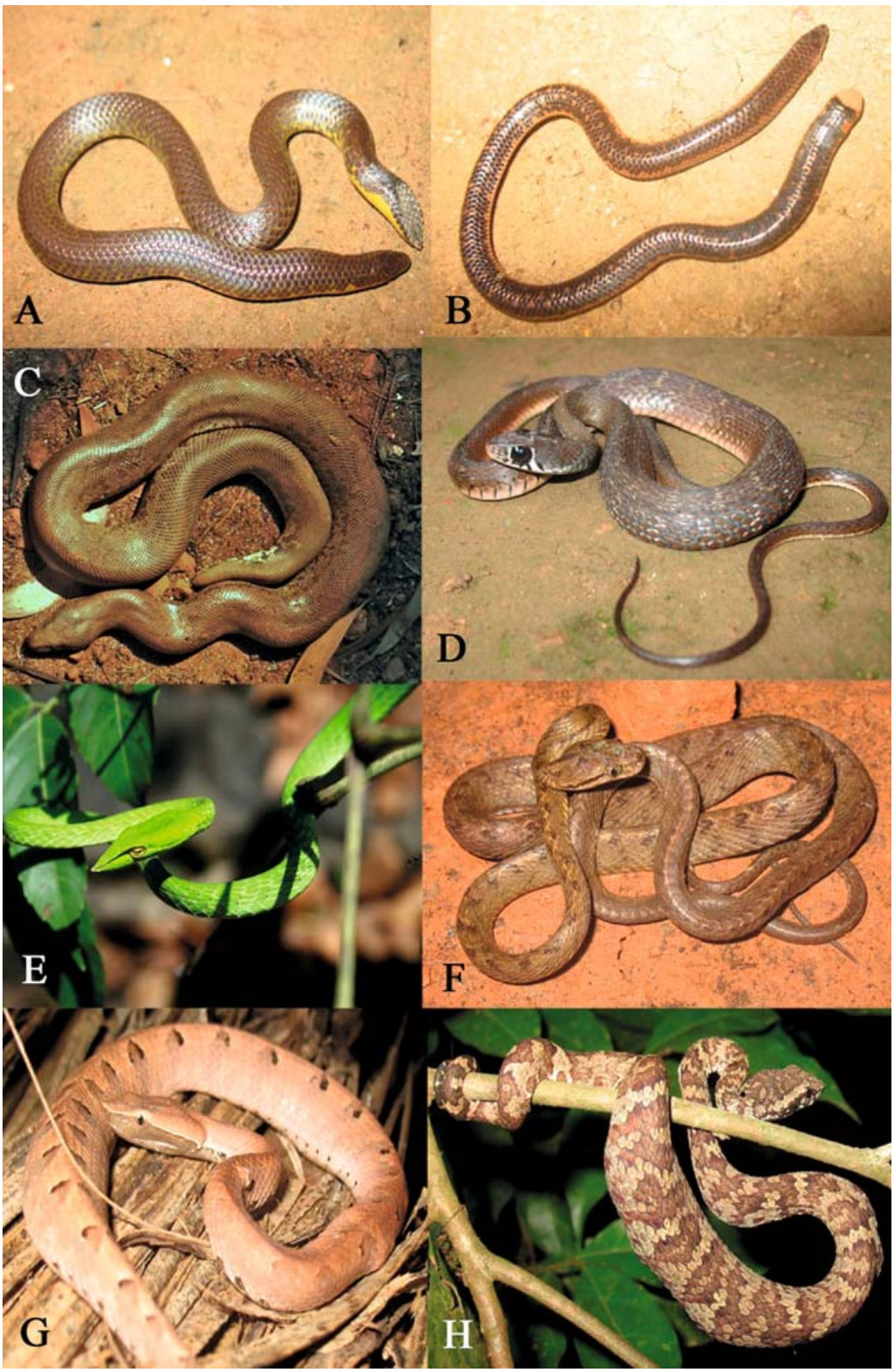

Fig. 5. Some snakes of the Central Western Ghats (top left to bottom right): A, *Uropeltis ceylanica*; B, *Rhinophis sanguineus*; C, *Eryx whitakeri*; D, *Amphiesma monticola*; E, *Ahaetulla nasuta*; F, *Boiga nuchalis*; G, *Hypnale hypnale*; H, *Trimeresurus malabaricus*.

Ahaetulla cf. *nasuta* after Chandramouli and Ganesh (2010). Furthermore, through this work we also report species such as *Geckoella albofasciata*, *Calotes grandisquamis*, *Eutropis allapallensis*, and *Rhinophis sanguineus* from the Agumbe region of the Central Western Ghats for the first time.

A preliminary, coarse-level area cladogram (Fig. 2, Table 1) constructed based on the occurrence of reptilian taxa across the Southern, Central and Northern Western Ghats reveals the relative similarity of the Central Western Ghats reptile fauna with the Northern and Southern blocks. It is noteworthy to highlight here that despite the many "range-extensions" of Southern Western Ghats species, Central Western Ghats reptile fauna shows a greater similarity with that of the Northern block. We believe that this situation could be attributed to the much higher levels of species richness and endemism of reptiles of the Southern Western Ghats, consequent on its wetter average climate and higher average elevation compared to that prevailing in the Central and Northern Western Ghats (Champion and Seth, 1968).

Coming to the distribution patterns (Fig. 3) of the reptiles in the Central Western Ghats, out of the total 71 species of reptiles (Figs. 4 and 5), nearly half of them, i.e., 47% are Western Ghats endemic elements; followed by 30% of widespread, pan-Indian species. Other categories such as those that are endemic to the Western and Eastern Ghats (n = 11; 16%) and those that are endemic to the Western Ghats and Sri Lanka (n = 5; 7%) were few and far between. This indicates the contribution of pan-Indian widespread species towards the observed species richness as well as the dilution of the observed level of endemism of the Central Western Ghats reptile fauna.

Based on these significant additions of species to the existing picture, we further emphasize the prioritization of these forests from a conservation perspective. We also suggest the identification of suitable, pristine habitats to be amalgamated to the existing Protected Areas Network in this region, given its paucity of large mammals like elephants that promoted a better conservation of Southern Western Ghats landscape as a whole.

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