

## A CONSERVATION ASSESSMENT OF THE SRI LANKAN AGAMIDAE (REPTILIA: SAURIA)

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**ABSTRACT.** – The conservation status of Sri Lanka’s agamid-lizard fauna is assessed, based on a 1998–2004 survey by the Wildlife Heritage Trust of Sri Lanka, supported by historical data. A total of 17 species are recorded from the island, 14 of them endemic. This fauna comprises species of the genera *Calotes*, *Otocryptis*, *Ceratophora*, *Cophotis* and *Lyriocephalus*, the last three of which are endemic to Sri Lanka. The assessment concludes that among the endemic species, 3 are Critically Endangered, 5 Endangered, 3 Vulnerable and 3 Least Concern. The regional status in Sri Lanka of the non-endemic species is assessed as Least Concern. The populations of all Critically Endangered and Endangered species are restricted to montane habitats, emphasizing the need for increased conservation focus on these habitats in Sri Lanka. All three Critically Endangered species are more or less restricted to a single 10 km<sup>2</sup> site, Morningside Forest, the conservation status of which is not clear. Habitat fragmentation and loss, rainwater acidification, pesticides and the effects of climate change are perceived as the principal threats to this fauna. These preliminary assessments will be fed into the Global Reptile Assessment, currently underway by IUCN-SSC.

**KEY WORDS.** – Agamidae, Red List, conservation, Sri Lanka.

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### INTRODUCTION

The Indian Ocean continental island of Sri Lanka (65,230 km<sup>2</sup>) is, together with the Wetsern Ghats of India, considered to be a global Biodiversity Hotspot (Myers et al., 2000). Despite Sri Lanka having had a terrestrial connection with India for much of the past 500,000 years, ending only with the end of the last glacial maximum ~ 10,000 ybp, its herpetofauna shows a high degree of endemism: 92 of the 182 reptile species recognized at present are considered endemic (Bahir & Maduwage, 2005; Bahir & Silva, 2005; Bossuyt et al., 2004; Das, 1996; Pethiyagoda & Manamendra-Arachchi, 1998). Sri Lanka’s agamid lizards are especially interesting, given that three genera (*Lyriocephalus*, *Cophotis* and *Ceratophora*) and 14 of the 17 species are endemic to the island. These lizards have also benefited from studies of their taxonomy, distribution, ecology, molecular phylogeny and evolution (Erdelen, 1984, 1986; Manamendra-Arachchi & Liyanage, 1994; Macey et al., 1998; Schulte et al., 2002). However, only two species (*Ceratophora tennentii* and *Calotes liocephalus*) have hitherto been assessed for the IUCN *Red List* (IUCN, 2004). We hope that this treatment of the agmid-lizard fauna will be a starting point for a conservation assessment of all the Sri Lankan reptiles.

IUCN (1999) assessed the conservation status of the Sri Lankan Agamidae, concluding that four species were “Highly Threatened” and a further eight “Threatened”. It is not possible however, to translate these categories to those of IUCN (2001), and so a fresh review is called for. Here we assess the conservation status of all the species of Sri Lankan Agamidae applying the quantitative criteria of IUCN (2001), basing our analysis on the results of a country-wide survey of the Sri Lankan Sauria involving ~ 120 sampling sites, undertaken by the Wildlife Heritage Trust of Sri Lanka (WHT) from 1998–2004 (other saurian groups however, have not been studied in the same depth as the Agamidae). The results of parallel WHT surveys of the island’s freshwater crabs (Bahir et al., 2005) and amphibians (Stuart et al., 2004; IUCN, 2004) have already resulted in conservation assessments of these faunas. The results of this preliminary assessment will be fed into the formal process of the Global Reptile Assessment of the IUCN, which is now getting underway.

Eleven of Sri Lanka’s 17 agamid-lizard species are restricted to the ‘wet zone’ (rainfall more than 2,000 mm yr<sup>-1</sup>)—the formerly rain-forested south-western quadrant of the island, including the central and Knuckles hills—only three being restricted to the ‘dry zone’ (rainfall less than 2,000 mm yr<sup>-1</sup>).

This pattern is also largely true also for other well-studied groups such as the angiosperms, land snails and amphibians (Dassanayake & Fosberg, 1980–2004; Naggs & Raheem, 2000; Naggs et al., 2005; Dutta & Manamendra-Arachchi, 1996; Manamendra-Arachchi & Pethiyagoda, 2005). We were prompted to make this assessment in part because of the massive loss of habitat Sri Lanka's wet zone has seen: only ~ 5 percent of the original extent of rain forest now survives; even this is heavily fragmented; and habitat loss continues apace in an environment of steadily increasing demand for agricultural land from a rapidly growing human population in what is already the most populous of the world's 25 Biodiversity Hotspots (Cincotta et al., 2000).

## MATERIALS AND METHODS

The 17 species of Sri Lankan agamid lizards were evaluated against the IUCN Red List Categories and Criteria (2001: Version 3.1) to assess their risk of extinction. A species can fall into any one of the following categories: Extinct, Extinct in the Wild, Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened, Data Deficient or Least Concern (LC). A species is considered to be threatened with extinction at the global scale if it meets the criteria for Critically Endangered, Endangered or Vulnerable (for the non-endemic species, these assessments are, however, for the Sri Lanka region only). Inferred or estimated trends in population size and/or geographic range are used to assess species for inclusion into one of the Red List categories.

This assessment is based primarily on the 1998–2004 national survey of saurian fauna conducted by the Wildlife Heritage Trust of Sri Lanka (WHT) and the voucher collection resulting therefrom. Distribution data were also extracted from the collections of The Natural History Museum, London (BMNH) and the National Museum of Sri Lanka (NMSL), which include all 17 species of Sri Lankan agamids. We also recognized as reliable the records of Deraniyagala (1953), Erdelen (1988) and Taylor (1953). As no population data are available except qualitatively (e.g. 'locally common', 'rare'), the assessments were made using the geographic range criteria of the IUCN Red List. Presence/absence was determined for each of the 17 species at each sampling station, together with estimates of geographic range.

The IUCN (2001) criteria allow for geographic range to be estimated using either Extent of Occurrence (i.e. the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the sites of present occurrence) or Area of Occupancy (i.e. the area of habitat within its Extent of Occurrence that is in fact occupied by the taxon). We have chosen to use Area of Occupancy for the species known from only one or a few discrete, isolated (e.g. mountain-top) populations, because this—usually being a protected area—is quantifiable. In such cases, Extent of Occurrence is likely to yield misleading results as the species are often known from small areas that are widely separated, there being no suitable habitat in the intervening spaces. In

other, widely distributed species however, Extent of Occurrence was clearly more appropriate. Thus, *Calotes liocephalus*, *C. ceylonensis*, *C. liolepis*, *C. nigrilabris*, *C. desilvai*, *Cophotis ceylanica*, *Ceratophora stoddarti*, *C. tennentii*, *C. aspera*, *C. karu*, *C. erdeleni*, *Otocryptis nigristigma* and *Lyriocephalus scutatus* were assessed using Area of Occupancy, and *Calotes calotes*, *C. versicolor*, *Sitana ponticeriana* and *Otocryptis wiegmanni* were assessed using Extent of Occurrence. The assessments in respect of *Calotes calotes*, *C. versicolor* and *Sitana ponticeriana* are purely regional, not global, in scope: their global status should be determined after assessment also elsewhere in their range.

A species is assessed as threatened under the geographic range criteria of the IUCN Red List if it meets the quantitative thresholds for either Extent of Occurrence—20,000 km<sup>2</sup> (VU), 5,000 km<sup>2</sup> (EN) or 100 km<sup>2</sup> (CR)—or Area of Occupancy—2,000 km<sup>2</sup> (VU), 500 km<sup>2</sup> (EN) or 10 km<sup>2</sup> (CR). Additionally, the species' habitat must be severely fragmented or it is known to exist at only a few locations—10 (VU), 5 (EN), 1 (CR)—and there is continuing decline or extreme fluctuations in the any of the following: extent of occurrence; area of occupancy; area, extent and/or quality of habitat; number of locations or subpopulations; or number of mature individuals. Continuing decline in Extent of Occurrence, Area of Occupancy and/or quality of habitat was inferred if the habitat was not a protected area, or it was a protected area subject to anthropogenic impacts such as pollution or encroachment. Least Concern status was awarded to taxa that were evaluated against the criteria and did not qualify for CR, EN, VU or NT status—in general such taxa are widespread (Extent of Occurrence greater than 20,000 km<sup>2</sup> or largely in protected areas) and abundant with continuous distribution.

The terminology for habitat types follows the 2001 IUCN Red List Categories & Criteria (version 3.1) ([http://www.redlist.org/info/categories\\_criteria2001.html](http://www.redlist.org/info/categories_criteria2001.html)), accessed 01 Jan. 2005.

## RESULTS

The results of the application of the IUCN Red List criteria to Sri Lanka's agamid lizards are presented in Table 1, which is a checklist of the Sri Lankan Agamidae, showing available data responsive to the IUCN (2001) Red List criteria. The assessment shows that three species are Critically Endangered: they are all restricted to an Area of Occupancy of less than 10 km<sup>2</sup> at Morningside Forest, in the eastern part of Sinharaja World Heritage Site. Five species are Endangered, all of them confined to mountaintops in the central hills and Knuckles mountains. Three are Vulnerable, occurring mainly in the lowland rainforests of the island's south west. The six Least Concern species, include the three non-endemic species *Calotes versicolor*, *Calotes calotes* and *Sitana ponticeriana*. No species fall into the categories Near Threatened, Extinct, Extinct in the Wild or Data Deficient. All the threatened agamids of Sri Lanka are forest-dwelling species, those restricted to montane cloud forests apparently being at higher risk of extinction as a result of severe fragmentation of their habitat.

Table 1. Checklist of the agamid lizards of Sri Lanka, showing conservation status derived using the IUCN (2001) Red List criteria. CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern. Extent of Occurrence ('extent') is based on available habitat; 'number of sites' is the number of discrete (discontiguous) sites from which the species is known; or Area of Occupancy ('area') is the area of habitat within the Extent of Occurrence that is occupied by the taxon; 'site', largest single site associated with each Threatened species; 'protection' estimates the degree of protection offered to the largest single site associated with the species: 'P', protected area (PA); 'N', site not protected; 'F', PA administered by Forest Department; 'W', PA administered by Department of Wildlife Conservation; 'T', PA subject to degradation because of direct human impacts; B1 = Extent of Occurrence, B2 = Area of Occupancy; 'frequency', a qualitative estimate of the abundance of the species as v[ery] common, common, uncommon, rare and very rare. Note that the assessments for the non-endemic species *Calotes versicolor*, *C. calotes* and *Sitana ponticertiana* are only regional in scope, not global.

species	conserv- ation status	extent (km <sup>2</sup> )	number of sites	protection	site	applicable criteria	abundance
<i>Calotes calotes</i> (Linnaeus, 1758)	LC	~43,800	> 30	P F W	—	—	v. common
<i>Calotes versicolor</i> (Daudin, 1802)	LC	~37,700	> 35	P F W	—	—	v. common
<i>Otocryptis wiegmanni</i> Wagler, 1830	LC	~10,000	> 30	P F T	—	—	common
<i>Sitana ponticertiana</i> Cuvier, 1829	LC	~15,000	> 20	P W	—	—	common

  

species	conserv- ation status	area (km <sup>2</sup> )	number of sites	protection	site	applicable criteria	abundance
<i>Calotes ceylonensis</i> (Müller, 1887)	LC	~10,900	15	P F W	—	—	uncommon
<i>Calotes liocephalus</i> Günther, 1872	EN	~400	7	P F T	Knuckles	B2ab(iii)	rare
<i>Calotes desilvai</i> Bahir & Maduwage, 2005	CR	< 10	1	N T	Morningside	B2ab(iii)	very rare
<i>Calotes liolepis</i> Boulenger, 1885	VU	~1,100	20	P F W T	Sinharaja	B2ab(iii)	uncommon
<i>Calotes nigrilabris</i> Peters, 1860	EN	~300	5	P W F T	Horton Plains	B2ab(iii)	common
<i>Cophotis ceylanica</i> Peters, 1861	EN	~60	4	P F W T	Horton Plains	B2ab(iii)	rare
<i>Ceratophora aspera</i> Günther, 1864	VU	~700	> 10	P F T	Sinharaja	B2ab(iii)	uncommon
<i>Ceratophora erdeleni</i> Pethiyagoda & Manamendra-Arachchi, 1998	CR	< 10	2	P F T	Morningside	B2ab(iii)	rare
<i>Ceratophora karu</i> Pethiyagoda & Manamendra-Arachchi, 1998	CR	< 10	2	N F T	Morningside	B2ab(iii)	rare
<i>Ceratophora stoddarti</i> Gray, 1835	EN	~200	> 10	P F W T	Horton Plains	B2ab(ii, iii, iv)	uncommon
<i>Ceratophora tennentii</i> Günther & Gray, 1861	EN	~130	3	P F T	Knuckles	B2ab(iii)	uncommon
<i>Lyriocephalus scutatus</i> (Linnaeus, 1758)	VU	~800	> 10	P F T	Sinharaja	B2ab(iii)	uncommon
<i>Otocryptis nigristigma</i> Bahir & Silva, 2005	LC	~20,000	> 10	P F W	—	—	common

## DISCUSSION

Compared with the 44 agamid species (Das, 1996) known from India, the land area of which is 48 times that of Sri Lanka's, the latter's agamid diversity and endemism are remarkable. Nevertheless, several agamid genera present in south India (e.g. *Draco*, *Psammophilus*, *Salea*) do not occur in Sri Lanka. It appears that much of the agamid-lizard diversity observed in Sri Lanka's wet zone is the result of insular radiations, there having been little biotic exchange during the Pleistocene (Bossuyt et al., 2004). In particular, the endemic Sri Lankan species of *Calotes* and the lyriocephaline genera *Lyriocephalus*, *Ceratophora* and *Cophotis* appear to represent ancient insular radiations (Macey et al., 1998; Schulte et al., 2002).

The three Critically Endangered agamids, *Ceratophora karu* (900–1070 m elevation), *C. erdeleni* (900–1070 m elevation) and *Calotes desilvai* (~1080 m elevation) are confined to Morningside, a tropical moist montane forest area at the eastern border of the Sinharaja World Heritage Site, near Rakwana. This small (~10 km<sup>2</sup>) forest has endemic to it also several other species, including seven frogs, three crabs and a gecko (Bahir & Ng, 2005; Batuwita & Bahir, 2005; Fernando

& Siriwardana, 1996; Manamendra-Arachchi & Pethiyagoda, 2001, 2005; Meegaskumbura & Manamendra-Arachchi, 2005; Ng & Tay, 2001), and contains also an unusual flora (Gunatilleke et al., 2005). The conservation status of Morningside however, is unclear: indeed, although the Forest Department has custody of a section of this forest, part of it has been replaced with tea, and most of it under-planted with cardamom. A significant (but un-assessed) part of this small extent of forest belongs to the Land Reform Commission of the government, which in 2004 sought (fortunately abortively, from the standpoint of biodiversity conservation) to lease out this section for the purpose of clearing the forest and planting tea. Establishment of title to this forest and the adjacent properties and securing these lands for conservation is therefore a matter of the highest priority.

The Endangered species are all restricted to Tropical Moist Montane Forests: *Ceratophora stoddarti* to Horton Plains, Hakgala, Namunukula, Galaha, Pidurutalagala and Peak Wilderness (1,200–2,200 m elevation); *C. tennentii* to the Knuckles hills (700–1,300 m elevation); *Cophotis ceylanica* to Horton Plains and Hakgala (1,300–2,200 m elevation); *Calotes liocephalus* to Knuckles, Agra-Bopath and Peak Wilderness (800–1,900 m elevation); and *C. nigrilabris* to

Horton Plains, and grasslands around Nuwara Eliya and Hakgala (1,000–2,400 m elevation). Among these, *C. nigrilabris* is the only species to occur also in tropical high altitude grasslands, at Horton Plains National Park.

All the species assessed as Vulnerable are from the lowlands: *Ceratophora aspera* (60–900 m elevation), *Lyriocephalus scutatus* (below ~ 1,650 m elevation) and *Calotes liolepis* (below ~ 1,220 m elevation). These occur chiefly in tropical moist lowland forests. The Endangered status of highland species, against the Vulnerable status of lowland ones, appears to be the result of montane habitats having suffered greater loss to agriculture than lowland habitats.

Of the species assessed as being of Least Concern, *Otocryptis wiegmanni* (up to ~ 1350 m elevation), occupies tropical moist lowland forests, tropical moist scrublands, and also plantations, rural gardens and tropical heavily degraded former forest. *Otocryptis nigristigma* (up to 450 m elevation) and *Calotes ceylonensis* (up to 400 m elevation), on the other hand, were recorded only from tropical dry forests and tropical dry scrublands. *Sitana ponticeriana* dwells primarily on shingle or pebble shores (sandy habitats in the dry zone) and in open areas of tropical dry forests and tropical dry scrublands. *Calotes calotes* is found mainly in anthropogenic habitats, including plantations and rural gardens, but was also recorded from tropical dry scrublands, tropical moist scrublands and tropical heavily degraded former forests. Less commonly, the species was also recorded from tropical dry forests and tropical moist forests. In general, it is widespread throughout the island from sea level to ~ 1,500 m altitude. On the other hand, *C. versicolor* was almost never recorded from undisturbed forest, being found only in anthropogenic habitats such as plantations and rural gardens, tropical heavily degraded former forest and tropical scrublands within the altitude range sea level to approximately 1,400 m elevation.

*Calotes liolepis* was earlier thought to be a species restricted to the wet zone (Manamendra-Arachchi & Liyanage, 1994), but the present survey served to uncover isolated populations in several moist-forest ‘islands’ in the dry zone (e.g. Ritigala, Moneragala, and riparian forest in Yala). Erdelen (1984: 515) noted the restriction of this species to undisturbed rain forest, but we have found it even in relatively disturbed tropical moist forest in several parts of the dry zone. Deraniyagala (1953) recorded *C. liocephalus*, *C. ceylonensis* and *C. nigrilabris* from Peradeniya, records not confirmed by our own observations in that locality.

Of the endemic agamids, only three species (*Otocryptis nigristigma*, *Calotes ceylonensis* and *C. liolepis*) occur in the dry zone. The former two species are restricted to the dry zone, whereas *C. liolepis* occurs in both. All three species however, are dependent on relatively moist (e.g. riparian), closed-canopy forest, for which reason their populations are now scattered and discontinuous.

Clearance of the wet zone’s former tropical moist forest cover for the plantation of cinchona, coffee, tea and rubber during the past two centuries has led to less than five percent of

relatively undisturbed habitat remaining in this biodiversity rich region of Sri Lanka. Even this remaining habitat is severely fragmented, with three fragments (Peak Wilderness, 250 km<sup>2</sup>; the Knuckles Hills, 175 km<sup>2</sup>; and the Sinharaja World Heritage Site, 90 km<sup>2</sup>) accounting for ~ 65% of the remaining forest, the remainder being represented by more than 100 discrete fragments. Population density in the wet zone—740 km<sup>2</sup>—is exceptionally high, and demand for agricultural land has led to increasing pressure of encroachment on the remaining forest estate.

With 11 of the 17 agamid species (65%) being threatened with extinction, Sri Lankan agamids are clearly in need of conservation attention. For instance, the only available habitat of the three Critically Endangered species, the Morningside forest at the eastern edge of the Sinharaja World Heritage Site, is under immediate threat. The protection status of this tropical moist montane forest is not clear, as is the title to much of the land in this vicinity. This poses a significant risk of encroachment, a process that has already begun. Much of this forest (including the area that is nominally protected) has been under-planted with cardamom (Pethiyagoda & Manamendra-Arachchi, 1998). Morningside represents all or most of the remaining habitat for three species of Critically Endangered agamid species, in addition to several amphibians (Stuart et al., 2004; Manamendra-Arachchi & Pethiyagoda, 2005; Meegaskumbura & Manamendra-Arachchi, 2005) and freshwater crabs (Bahir et al., 2005) that needs to be absorbed into the conservation planning process, especially in the biodiversity-rich wet zone.

*Ceratophora tennentii* is restricted to the higher elevations of the Knuckles range, together with an important population of *Calotes liocephalus*. Much of the Knuckles has no protection status and is not subject to conservation management. Large extents of the forest understorey have been cleared for under-planting with cardamom, with only the canopy vegetation being retained for shade. This disturbance could have severe long-term consequences given that succession has been disrupted for several decades already. The populations of *Ceratophora stoddarti*, *Calotes nigrilabris* and *Cophotis ceylanica* are all now in effect mountaintop isolates, as is to a degree also the central hills population of *Calotes liocephalus*. Tropical moist montane (“cloud”) forest has been decimated in Sri Lanka as a result of tea cultivation, with only ~ 200 km<sup>2</sup> still remaining (Werner, 2001; pers. obs.). There is also evidence, especially in the tropical moist montane forests of the Knuckles and Horton Plains, of large-scale forest dieback (Werner, 2001), which could be the result of rain and cloud-water acidification (Gunawardena et al., 1998). Because they occupy an extreme climatic niche, tropical montane biotas are also at risk from climate change, especially warming. Indeed, long-term data from Nuwara Eliya, a 2,000 m elevation montane site in central Sri Lanka, show that average temperature has increased by almost 1.5° C in the course of the past 120 years, while rainfall has decreased by more than 20 percent (Schaefer, 1998).

The threats to Sri Lanka’s agamid lizards would appear to stem largely from habitat fragmentation. Studies elsewhere in

the tropics (e.g. Bierregaard et al., 2001) have shown that fragmentation can have negative impacts on faunas even in the decadal time frame. Thus, it is imperative that threatened populations restricted to small forest fragments be continuously monitored so as to assess population trends, and captive-breeding methodologies and capacity developed if necessary. This need is underlined by the finding that many mountaintop isolates (e.g., of *Ceratophora* and the shrub-frog genus *Philautus*) have been genetically separated from one another in the time-frame of hundreds of thousands or millions of years (Schulte et al., 2002; Meegaskumbura & Manamendra-Arachchi, 2005) and show significant morphological divergence (Pethiyagoda & Manamendra-Arachchi, 1998), which may lead in the future to their being recognized as distinct taxonomic entities. Each of these populations therefore warrants conservation in its own right.

The impacts of fragmentation could also be exacerbated by the fact that many important montane forest fragments (e.g. Hakgala, Pedro, Agra-Bopath) are surrounded by vegetable cultivations. The lack of clearly demarcated boundaries and buffer areas has resulted in significant encroachment into these forests. Worse still, vegetable cultivation in Sri Lanka involves the intensive and indiscriminate application of pesticides: no assessments have been made in Sri Lanka to date on the susceptibility of non-target organisms to these chemicals; and studies made elsewhere (e.g. Hayes et al., 2002, for amphibians) have shown that even minute concentrations of some herbicides could have devastating impacts on non-target species.

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