

# NATURAL HISTORY AND CURRENT DISTRIBUTION PATTERNS OF *CALOTES LIOLEPIS* BOULENGER, 1885 (REPTILIA: AGAMIDAE: DRACONINAE) IN SRI LANKA

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**Abstract:** *Calotes liolepis* is an endemic agamid lizard distributed in the lowland wet zone, intermediate zone and some wetter areas in the dry region of Sri Lanka. This species is categorized as 'Vulnerable' under the 2007 IUCN Global Red List. Although it is a relatively common species of lizard in Sri Lanka, general behavior, feeding and reproductive habits and the genetic and morphological variation within the species are poorly known. Hence, we report some observations made on the dry zone population of *C. liolepis*, observations on feeding and ovipositioning made on the wet zone population and further notes on the overall distribution of the species in Sri Lanka. We speculate that *Calotes liolepis* in Sri Lanka may be a species complex.

**Key words:** Anthropogenic disturbances, ecology, feeding, oviposition, sympatric species, species complex.

**Resumen:** M.D.C. Asela, K.D.B. Ukuwela, I.N. Bandara, H.K.D. Kandambi, T.D. Surasinghe y D.M.S.S. Karunaratna. "Historia natural y patrones de distribución actual de *Calotes liolepis* Boulenger, 1885 (Reptilia: Agamidae: Draconinae) en Sri Lanka". *Calotes liolepis* es un lagarto agámido distribuido en la zona húmeda de tierras bajas, zona intermedia y algunos bolsones húmedos en la región seca de Sri Lanka. Esta especie está categorizada como "Vulnerable" en la lista roja global de la UICN, 2007. Aunque es una especie de lagarto relativamente común en Sri Lanka, su comportamiento general, alimentación y hábitos reproductivos, así como la variación genética y morfológica dentro de la especie son poco conocidos. Por consiguiente, reportamos algunas observaciones hechas en la población de *C. liolepis* de la zona seca, observaciones en alimentación y ovoposición en la población de la zona húmeda y notas adicionales sobre la distribución general de la especie en Sri Lanka. Especulamos que *Calotes liolepis* en Sri Lanka puede constituir un complejo de especies.

**Palabras clave:** Perturbaciones antropogénicas, ecología, alimentación, oviposición, especies simpátricas, complejo de especies.

## INTRODUCTION

The agamid genus *Calotes* is one of the most widespread lizard genera in South and Southeast Asia and is distributed from Iran to the Indo-Australian Archipelago. Some species are distributed widely while others have highly localized ranges. The genus is represented by seven species in Sri Lanka, of which five are endemic to the island (Somaweera and Somaweera 2009). Among the endemics, *Calotes liolepis* is the most widely distributed species occurring in the lowland wet and intermediate zones and also in 'wet pockets' of the lowland dry zone of Sri Lanka, in an area of 1100 km<sup>2</sup> (Bahir and Surasinghe 2005). This species was categorized as 'Threatened' in the IUCN Sri Lanka Red List (2000) and later was listed as 'Vulnerable' (Bahir and Surasinghe 2005; IUCN-SL

and MENR-SL 2007) after re-evaluation, according to the IUCN Global Red List Criteria.

Despite being a widespread species, little information is available on its natural history (e.g. Asela *et al.* 2007, Karunaratna *et al.* 2009) and more research is needed on its biology, ecology, systematics and biogeography. Here we present new distributional records, further notes on habitat preference and other observations.

## MATERIALS AND METHODS

The notes in this account are based on opportunistic field observations made by the authors in different regions of the island of Sri Lanka over the course of the last decade (Fig. 1). All authors were experienced and familiar with the identification of *Calotes* species. Species identifications (e.g. scale counts, measurements,

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body characters and color patterns) were based on Bahir and Maduwage (2005), Boulenger (1885, 1890), Das and de Silva (2005), Deraniyagala (1953), Manamendra-Arachchi (1990), Smith (1935), Somaweera and Somaweera (2009) and Taylor (1953). Live specimens were captured and examined carefully to record scale patterns, scale counts and external measurements, and photographed before releasing back into the same habitat. Scales were observed using a 10X hand lens and external measurements were taken to the nearest 0.1 mm using a digital vernier caliper (accuracy  $\pm 0.05$  mm) and a 1 m measuring tape. We took head

length, snout to vent length, axial-groin length, midbody count and ventral count.

A thermometer and a hygrometer were used to record the temperature and relative humidity during our observations. The plant nomenclature is based on Senaratna (2001) and identifications are based on Ashton *et al.* (1997). The vegetation types and forest category were delineated based on Gunatilleke and Gunatilleke (1990).

## RESULTS AND DISCUSSION

### Observations in Ritigala Strict Nature Reserve. Ritigala Strict

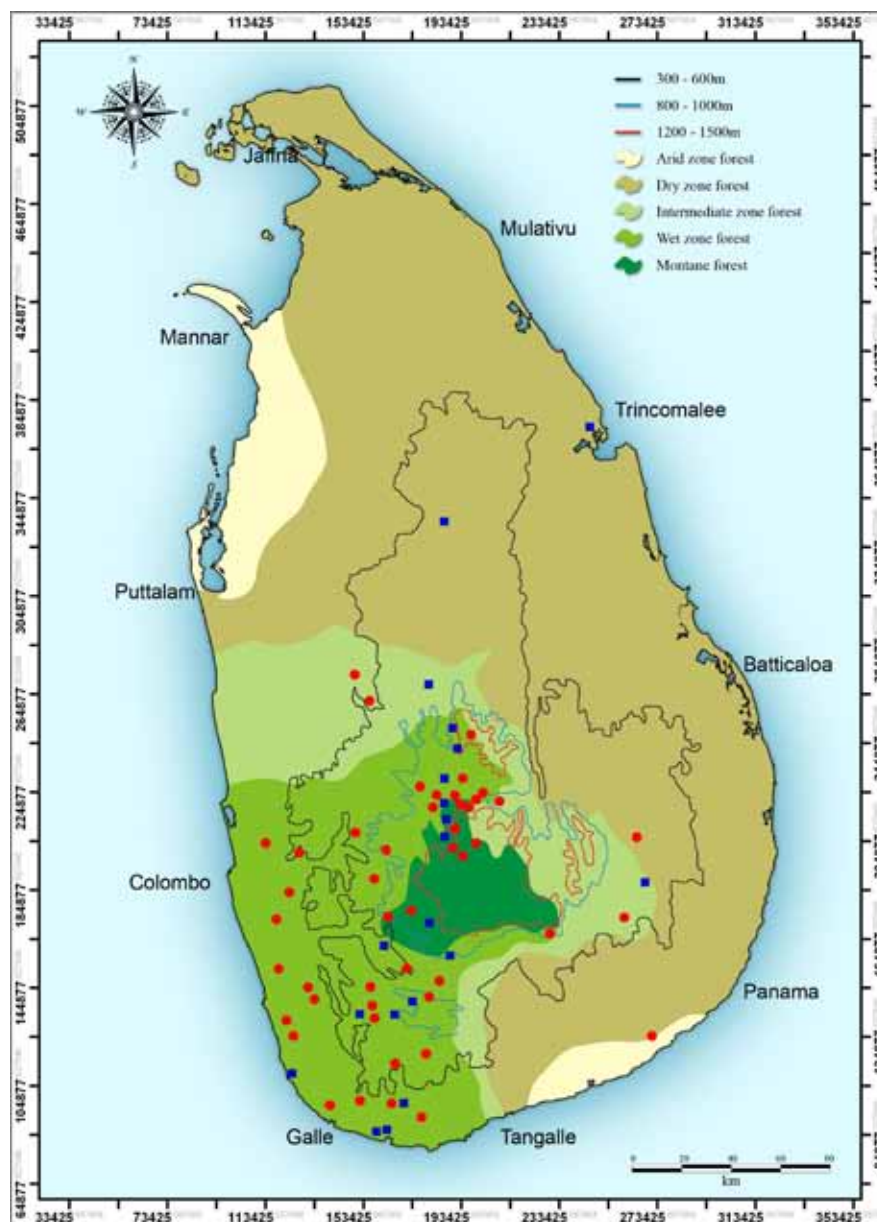


FIG. 1. Current distribution patterns of the *Calotes liolepis* complex in Sri Lanka (Red circles: Locations recorded in the current study, Blue squares: Locations reported in previous studies).

*Patrones de distribución actual del complejo de Calotes liolepis en Sri Lanka (Círculos rojos: Localidades registradas en el presente estudio, Cuadrados azules: Localidades reportadas en estudios previos).*

Nature Reserve (SNR) is an isolated hill in the dry zone plains and is situated in the Anuradhapura District of North Central Province, about 27 km north of Dambulla and 36 km Southeast of Anuradhapura (8°05'26.18" - 8°08'47.32"N and 80°37'47.88" - 80°41'30.54"E). The area is about 1528 ha and the altitude ranges from 125 to 766 m.a.s.l. The steep slopes are highly eroded, and covered with boulders, and the plains have an alluvial upper layer. The area is covered with Tropical Dry Mixed evergreen forests (Fig. 2a) dominated by a *Manilkara* (palu) community mixed *Chloroxylon* (buruta), *Vitex* (nabada), *Berrya* (hal-milla) and *Schleichera* (kon) divisions (Gunatilleke and Gunatilleke 1990). Weather data from the closest weather station (Mahailuppallama; 24 km NE of Ritigala) show a mean annual temperature of 27.1 °C and a mean annual rainfall of 1483 mm (Jayasooriya 1984, Priyadarshana and Fernando 1996).

We observed *Calotes liolepis* four times in the Ritigala SNR. Each observation was made approximately 1.2 km away from the entrance toward the Kalu Ebea village. The first observation was made on 3 June 2003 at about 11:30 h. The canopies of the surrounding forests where the observations were made were about 25-35 m in height, and the undergrowth was about 5-10 m above ground. The lizard was observed at a height of 6 m on a ~30 m tree, basking at a spot with moderate shade. The lizard was observed for about 5 minutes in the same position during which time it changed its colors from a pale green with whitish stripes to a dark color during the observed time period and subsequently it moved to the top of the tree (Fig. 2b).

The second observation was made on 15 July 2004 at about 16:00 h, approximately 250 m away from the first observation. A male and a female were observed on the trunk of a huge tree. At the time of observation the sky was clear with an air temperature of 30.4 °C. The tree was about 30 m in height and the lizards were observed at a height of 5 m above the ground. Both male and the female were spotted together on the same tree and both had dark colors. After a few seconds they moved to the top of the tree.

The third observation was made on 28 December 2004 around 15:45 h, approximately 200 m away from the first site and 100 m from the second site. A subadult male measuring 45.6 mm SVL was spotted moving vertically down on a tree vertically to a height of 2 m. This specimen was observed within the closed canopy forest in a shady area. Once the lizard was captured for closer examination it opened its mouth and made a slight whistling sound which is peculiar to this species (Das and de Silva 2005). Prior to capture the lizard had a dark brown body color with pale colored marks. Upon capture it changed its color rapidly to a paler shade (Fig. 2c).

The fourth observation was made on 10 October 2011 around 11:00 h, approximately 300 m away from the first site; an adult pair of lizards were perched on the branches of two shrubs under the shade of the canopy. The pair was 2 m apart from each other. The weather was windy with bright sunlight. Possibly due to the very dry conditions, the creatures did not move from the shade, staying in the same position for 30 minutes. The shrubs are in the shade of dry semi-deciduous forest that has a canopy of 15-20 m in height. At the locations of our observations *C. liolepis* was

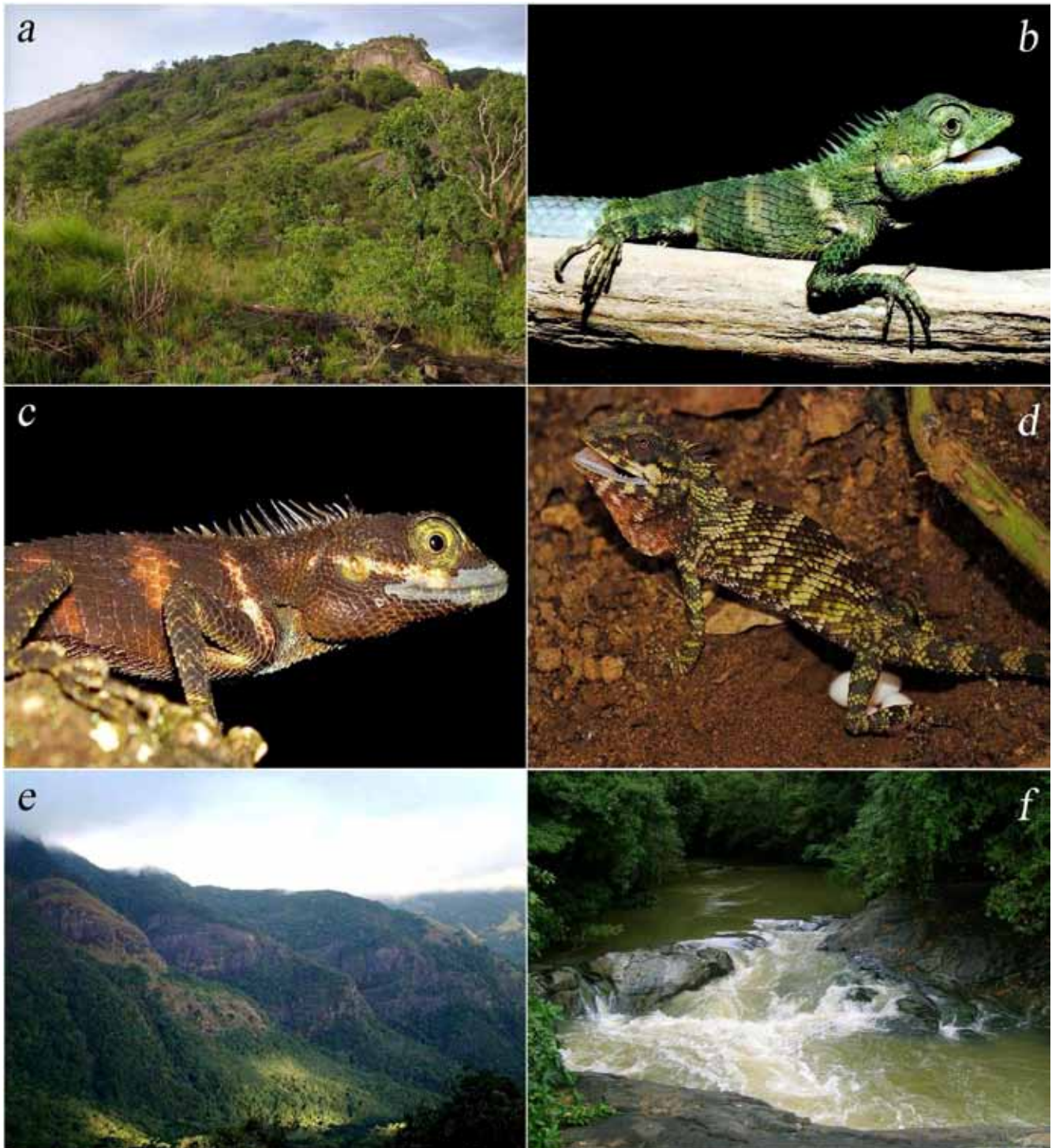
sympatric with *C. ceylonensis*, *Otocryptis nigristigma*, *Cnemaspis retigalensis*, *Cyrtodactylus* sp., *Hemidactylus frenatus*, *H. depressus*, *H. leschenaulti*, *H. lankae* and *Geckoella yakhuna*.

**Observations in Kelani Valley, Kithulgala, Kegalle District.** We observed 6 individuals of the species in this reserve in an opportunistic survey done between April 2003 and December 2005. Kelani Valley Proposed Forest Reserve is located in the southwestern lowland wet zone of Sri Lanka (7°00'02.01" - 7°01'11.98"N and 80°26'35.95' - 80°28'51.48"E). The Reserve lies in the lowland plains of the island and adjoins the foothills of the central mountains, in particular the foothills of the Peak Wilderness (IUCN and FAO 1997). We conducted field trips in both the core forest and the home gardens of the surrounding villages. We found all the 6 individuals on canopy trees, at an average height of 2-3 m, in the core forests where there is a high canopy cover and minimal anthropogenic disturbances. We did not find any individuals in the home gardens or in the forests peripheral to the villages. All the observations were made during daytime (09:30-17:00 hrs). At this location, *C. liolepis* was sympatric with *C. calotes*, *C. versicolor*, *Otocryptis wiegmanni*, *Ceratophora aspera*, *Lyriocephalus scutatus*, *Eutropis carinata*, *E. macularia*, *Lankascincus gansi*, *Hemidactylus parvimaculatus*, *H. frenatus*, *H. pieresii*, *Cyrtodactylus cracens*, *Gehyra mutilata*, *Geckoella triedrus* and *Cnemaspis silvula*.

**Observations in Elkaduwa, Matale District.** An ovipositional event of *Calotes liolepis* was observed in Elkaduwa (7°25'05.21"N and 80°41'02.26"E) in Matale District, along the Hunasgiriya – Elkaduwa nature trail on 22 March 2006 between 15:00 – 17:30 h. This was a completely different habitat used for ovipositioning when compared to the previous observations on egg laying in this species (Asela *et al.* 2007, Karunarathna *et al.* 2009). The ground was covered with a ~25 mm thick dry litter layer composed of pine needles (*Pinus caribaea*). There was no canopy cover at all and sunlight fell directly into the nest hole. The nest hole was made 50 cm away from the footpath which is surrounded by 'patana' grassland on one side and a *Pinus* plantation on the other side with very few bushes in the vicinity. The weather was moderately windy and sunny with a temperature of 28.0 °C and a humidity of 60%. The cloud cover was 25%. The nest hole was dug in dry hard soil. The female roughly removed the pine needles from around the pit (Fig. 2d).

This well grown adult female faced away from the sun when laying eggs. The color of the female's body was dark greenish-brown when she was laying eggs. About two and a half hours were spent for the egg laying process and four eggs were laid. At this location, *C. liolepis* was sympatric with *Cnemaspis kallima*, *Cyrtodactylus soba*, *Ceratophora tennentii*, *Calotes* cf. *liocephalus*, *C. calotes*, *C. versicolor*, *Lyriocephalus scutatus*, *Hemidactylus frenatus* and *H. pieresii*. The few previous observations of oviposition in *C. liolepis* were made in cool shady places (Asela *et al.* 2007, Karunarathna *et al.* 2009), unlike the open habitat recorded here.

**Observations in Sinharaja Forest Reserve, Kudawa, Ratnapura District.** We observed 12 individuals of this species in Sinharaja



**FIG. 2.** (a) Forest habitat in Ritigala Strict nature reserve (archeological site); (b) Green colored *Calotes liolepis* with whitish stripes in Ritigala Strict nature reserve; (c) Brown colored *Calotes liolepis* with reddish stripes in Ritigala Strict nature reserve; (d) Egg laying behaviour of *Calotes liolepis* in Elkaduwa, with four eggs; (e) Mountains and forest view in Knuckles massif from the Central hills; (f) Riverine forest in Kalugala proposed forest reserve in the wet season.

(a) Hábitat forestal en la reserva de naturaleza Ritigala Strict (sitio arqueológico); (b) *Calotes liolepis* verde con bandas blancuzcas en la reserva de naturaleza Ritigala Strict; (c) *Calotes liolepis* pardo con bandas rojizas en la reserva de naturaleza Ritigala Strict; (d) Comportamiento de deposición de huevos en *Calotes liolepis* en Elkaduwa, con cuatro huevos; (e) Vista de montañas y bosques en el macizo Knuckles de las Central hills; (f) Bosque ripario en Kalugala proposed forest reserve en la estación húmeda.

(Man and Biosphere Reserve) during an agamid survey conducted in January-May 2004. We made all the observations between 09:30-13:00 and 14:00-17:00 hrs. The area is located in the lowland wetzone, and the vegetation can be classified as tropical evergreen rainforests. Our survey was conducted in the lowlands of the northwestern section within latitudes - 6°23'04.58" to 6°34'59.44"N and 80°15'24.38" to 80°38'11.48"E. The elevation of the forest is generally in the range of 200-400 m. The annual rainfall of the forest ranges from 3750 to 5000 mm. Much of the precipitation comes during periods of the southwest (May-July) and the northeast (November-January) monsoons.

Our survey included four habitat types located in and around the reserve: the unlogged forests, selectively logged forests (lumbered for commercial timber production during 1971-1977 (Ishwaran and Erdelen, 1990), clear-cut areas that are covered by invasive fern *Dicranopteris linearis* and other herbaceous species, and pine plantations. We found 8 individuals in the unlogged forests and 4 individuals in the selectively logged forests. We did not find any of the above species in the pine plantations or clear-cut areas. All 12 individuals were found on tree trunks, about 2-3 m from the ground. At this location, *C. liolepis* was sympatric with *C. calotes*, *Otocryptis wiegmanni*, *Lyriocephalus scutatus*, *Ceratophora aspera*, *Hemidactylus parvimaclatus*, *H. frenatus*, *H. pieresii*, *Cyrtodactylus cracens*, *Gehyra mutilata*, *Geckoella triedrus*, *Cnemaspis melligodai* and *C. silvula*.

**Observations in Ampitiya, Kandy District.** We also observed the feeding behavior of an adult male *Calotes liolepis*. It predated on large black ants (Family Formicidae) on a *Caryota urens* Palm tree (Kithul) at a height of 3.5 m above the ground. The observation was made around 09:30 h in a densely planted home garden (7°19'47.47"N and 80°39'39.66"E). The lizard was positioned vertically on the tree and it pounced on the moving ants, grabbing them one by one and swallowing them. The ants that the lizard fed on, measured about 12 mm in length. The lizard fed on a total of five ants within 80 seconds. According to Manamendra-Arachchi and Liyanage (1994) and Manthey (2008) the feeding behavior of *C. liolepis* has not been reported previously. We have also observed adult *Calotes versicolor* feeding on arboreal black ants and juveniles on small red ants on the ground, elsewhere in dry zone. At this location *C. liolepis* was sympatric with *Calotes calotes*, *Lyriocephalus scutatus*, *Otocryptis wiegmanni*, *Hemidactylus parvimaclatus*, *H. frenatus*, *H. pieresii*, *Cyrtodactylus fraenatus*, *Gehyra mutilata* and *Geckoella triedrus*.

**Distribution and habitat of *Calotes liolepis*.** *Calotes liolepis* is known to be mainly distributed throughout the southwestern lowland wet zone and intermediate zone (Manamendraarachchi and Liyanage 1994) and humid regions of the lowland dry zone (Bahir and Surasinghe 2005) of Sri Lanka. Erdelen (1984) stated that the range of this species extends up to 800 m above sea level, but subsequent studies have recorded it even at elevations of 1300 m above sea level. The *C. liolepis* populations recorded in humid regions of the lowland dry zone (e.g. Monaragala, Ritigala

and Nilgala) and high elevations (e.g. The Knuckles, Adams Peak, and Rakwana Range) are reproductively isolated with disjunction of suitable habitats and in absence of dispersal corridors. Therefore, given that these populations are larger than the effective population size, such isolates can radiate into different species, or genetically distinct races seems to be several different species (T. Amarasinghe, *pers. comm.*). Distribution of this species in the rest of the wet zone has been recorded and reviewed by Erdelen (1984), Surasinghe and Bahir (2005), Gamage *et al.* (2006), WCSG (2009), Karunaratna and Amarasinghe (2012), and Manamendra-Arachchi and Liyanage (1994).

According to Manamendra-Arachchi *et al.* (2006) the lowlands below 500 m elevation along the valley of the Mahaweli River, which separates the Knuckles Hills from the Central Mountains (Fig. 2e), appears to have served as a barrier to the dispersion of highland species between the two mountain ranges. Therefore, character displacement and genetic divergence of *C. liolepis* populations in lowland rainforests and the Knuckles region should be closely examined as underscored by de Silva *et al.* (2005) and Karunaratna *et al.* (2009). In all the occasions, this species was recorded from the tropical wet evergreen rainforests that are relatively undisturbed by anthropogenic activities. These species seem to be deterred by human-induced disturbances such as logging, clear-cutting, and firewood extraction (Surasinghe and Wijesinghe 2005). Therefore, these species are highly susceptible to habitat loss.

We believe there may be more distinct species than we expected, like the sympatric population of early *Calotes liolepis* complex named as *C. desilvai* Bahir and Maduwage (2005). Proper taxonomic studies have shown that many of the animals recorded from Sri Lanka are in fact distinct species different from Indian populations and endemic to Sri Lanka. Moreover, we contend that there might be highly differentiated faunal elements between the dry zone and the wet zone as well as low country and highlands of Sri Lanka, given marked geo-climatic differences prevailing across these ecotones within the island (Helgen and Groves 2005). Therefore, here we highlight the importance of taxonomic and phylogenetic studies of this species complex.

The habitat of *C. liolepis* ranges from patches of dense, close-canopy natural forests to densely planted home gardens. They are mainly found in humid and shaded locations, both in natural and anthropogenic habitats. We have observed this species from anthropogenic habitats such as roadsides bordering forests, tea estates, teak plantations, home gardens and wooded pastures and lawns individuals have been observed from the ground level up to a height of 6 m from ground. As mentioned above, the population of this species is restricted to discrete "land islands" in Sri Lanka. The extent and quality of their natural habitat (Fig. 2f) are threatened by deforestation (Erdelen 1978, Manamendra-Arachchi and Liyanage 1994, Asela *et al.* 2007). Further field-based investigations on distribution, ecology, breeding and population dynamics are required to verify the conservation status of this species. The persistence of the populations of this species found within the wet pockets of the dry zone is highly questionable since such isolated populations could have undergone genetic bottleneck.

Such species might suffer from inbreeding depression and could

already be trapped in the extinction vortex. On the other hand, if such populations have numbers greater than the effective population size, then such populations can serve as founders which have genetically distinct variation from the original source population, and with time such populations can evolve into a different species. Amarasinghe *et al.* (2009) observed many dead sub-adults of *Calotes liocephalus* after very cold nights in December and January on the branches of trees in the Knuckles range, but reason for mortality was unknown. Therefore similar threats can imperil *Calotes liolepis* (Karunaratne and Amarasinghe 2011) in the Knuckles, where both species are sympatric.

We strongly recommend that IUCN conservation assessment of this species be based on the contiguous populations only in the wet and intermediate zone, since the isolated populations recorded in the dry zone might inflate the realized distribution of these species. Such isolated populations should be continuously monitored, followed by population-level studies to ensure the longevity of such populations in order to include such records into status re-evaluations. Here we present the distribution of *Calotes liolepis* complex according to the different geographic region and highlight the possibility of they being different from the typical form.

**Known localities of *Calotes liolepis*:** Kottawa, Kanneliya, Galle, Nakiyadeniya, Beraliya (Fig. 3a), Elpitiya, Rumassala, Sinharaja, Haycock, Koggala, Wakwella (Galle District); Dediya, Wilpita, Mulatiyana, Panilkanda, Viharakale (Matara District); Maliboda (Fig. 3b), Kithulgala, Deraniyagala (Kegalle District); Kuruwita, Balangoda, Koskuluna, Singharaja, Delwala, Kukulugala (Rathnapura District); Beruwala, Dombagaskanda, Madakada, Kalugala, Pahiyangala (Kaluthara District); ***Calotes liolepis* (1):** Raththota, Puwakpitiya, Menikdena, Manigala (Matale District); ***Calotes liolepis* (2):** Kotagala, Rojersongama, Kothmale (Nuwara Eliya District); ***Calotes liolepis* (3):** Nilgala, Monaragala (Monaragala District); Ritigala (Anuradapura District); Trincomalle (Trincomalee District); ***Calotes liolepis* (4):** Gampola, Peradeniya, Dothalugala (Kandy District). These locations were based on Asela *et al.* (2007), Bahir and Maduwage (2005), Bahir and Surasinghe (2005), Bauer and de Silva (2007), Botejue and Wattavidanage (2012), Das and de Silva (2005), de Silva *et al.* (2005), Janzen and Bopage (2012), Karunaratne and Amarasinghe (2010, 2011, 2012); Karunaratne *et al.* (2009), Peabotuwage *et al.* (2012), Rajapaksha *et al.* (2006), Samarawickrama *et al.* (2012), Somaweera and Somaweera (2009), Somaweera *et al.* (2001), WCSG (2008, 2009).

**New localities of *Calotes liolepis*:** Neluwa, Thawalama, Batapola, Imaduwa, Wanduraba, Hiniduma, Elpitiya, Nakiyadeniya, Beraliya, Dellawa (Galle District); Deniyaya, Matara, Makandura, Morawaka, Kotapola, Akuressa, Kamburupitiya, Ellakanda (Matara District); Bathalegala (Bible rock), Nelundeniya, Bulathkohupitiya (Fig. 3c), Rambukkana, Yatiyanthota, Pindenya (Kegalle District); Nittambuwa, Weliveriya, Mirigama, Kiridivala, Ganemulla (Gampaha District); Ratnapura, Gilemale, Bambarabotuwa, Walankanda, Kukulugala, Karawita, Batadombalena (Rathnapura District); Atweltota, Horana, Baduraliya, Bulathsinhala, Boralugoda,

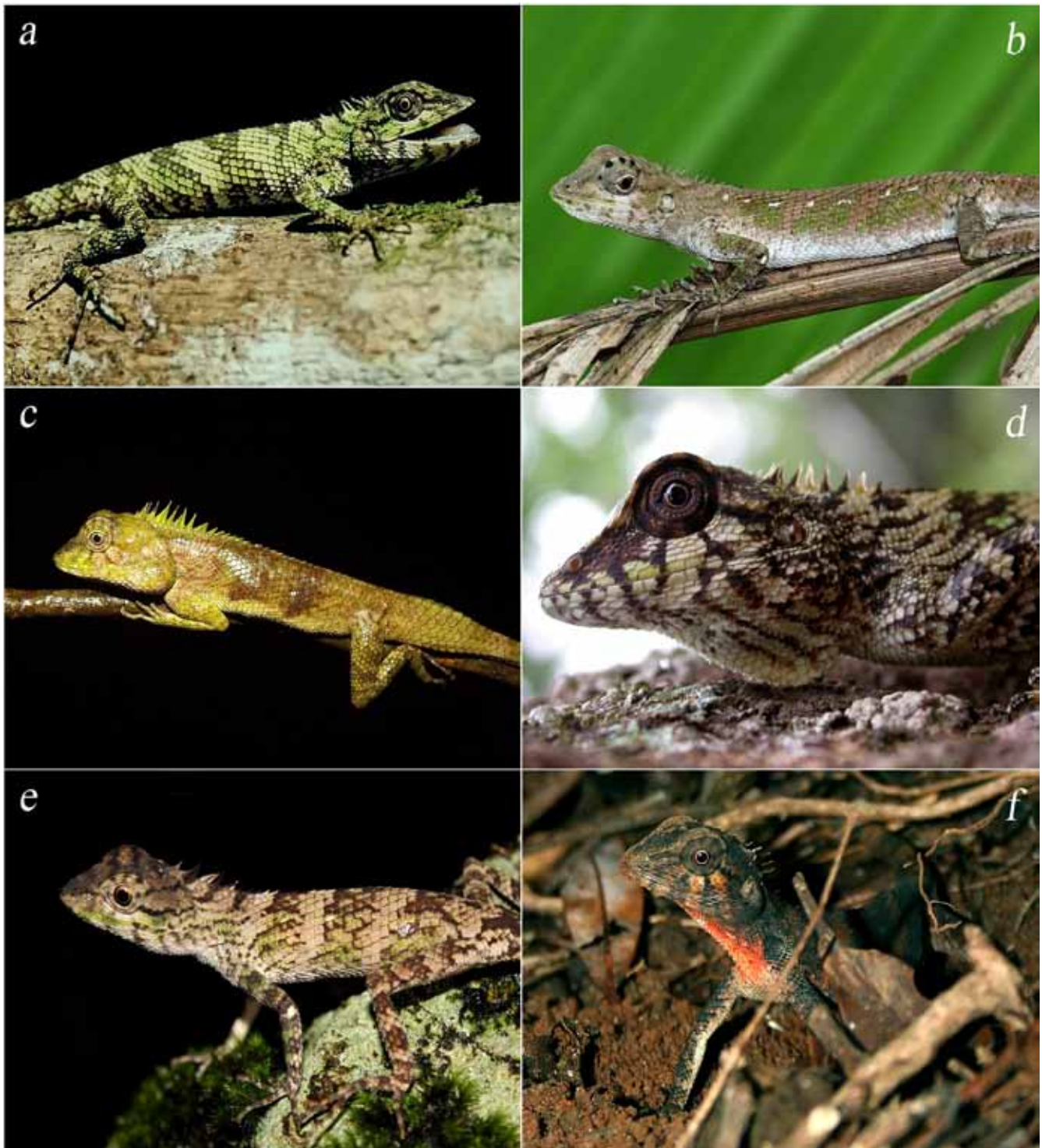
Maggon (Kaluthara District); ***Calotes liolepis* (1):** Pitawalapathana, Illukkumbura (Fig. 3d), Kalupahana (Matale District); ***Calotes liolepis* (2):** Hanguranketha, Ramboda, Hatton, Bambarakanda, Sri padaya (Fig. 3e), Lookandura (Nuwara Eliya District); Beragala (Badulla District); ***Calotes liolepis* (3):** Buttala, Badalkumbura, Namunukula, Maragala (Monaragala District); Yala (Hambanthota District); ***Calotes liolepis* (4):** Wattagama, Teldeniya, Hunnasgiriya, Nawalapitiya, Ampitiya, Meewathura, Menikdiwela, Wakarawatta, Gannoruwa, Kalugala, Udawattekele, Rangala, Galaha, Delthota, Ratemulla, Dolosbage (Fig. 3f) Narangamuwa, Meemure (Kandy District); ***Calotes liolepis* (5):** Alawwa, Ethagala, Veuda (Kurunegala District). These locations were based on our own observations during the last decade.

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**FIG. 3.** (a) Adult male of *Calotes liolepis* threat expression, Beraliya forest; (b) Sub-adult *Calotes liolepis* resting on a *Caryota urens* tree, Maliboda forest; (c) Adult male of *Calotes liolepis* sleeping at the night, Bulathkohupitiya; (d) Mature female of *Calotes liolepis* (1) displaying gular sac, Illukkumbura; (e) Juvenile *Calotes liolepis* from Sri-Padaya sanctuary in October; (f) Threat expression (red throat) of a female *Calotes liolepis* from Dolosbage.

(a) Expresión de amenaza de macho adulto de *Calotes liolepis* en el bosque Beraliya; (b) *Calotes liolepis* Sub-adulto descansando en un árbol de *Caryota urens*, bosque Maliboda; (c) Macho adulto de *Calotes liolepis* durmiendo en la noche, Bulathkohupitiya; (d) Hembra adulta de *Calotes liolepis* (1) mostrando el saco gular, Illukkumbura; (e) *Calotes liolepis* Juvenil del santuario Sri-Padaya en octubre; (f) Expresión de amenaza (garganta roja) en una *Calotes liolepis* hembra de Dolosbage.

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