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Taxonomic and biological study on *Calotes ceylonensis* Müller, 1887 (Reptilia: Agamidae) of Sri Lanka

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Abstract. *Calotes ceylonensis* Müller, 1887 is an endemic, rare and vulnerable, arboreal agamid lizard species of Sri Lanka, which is found only at the low country dry and intermediate zones below 500 m a.s.l. This work is mainly based on examination of type specimens as well as published literature and our observations of ecological and conditions and threats on *Calotes ceylonensis*. The analysis of habitat data has shown that this species is widely spread within the well shading riverine-forested areas and poorly in the home gardens. The results of this survey indicate that *C. ceylonensis* lays about 4–12 eggs from August to October. Hatchlings come out from November to December. These lizards' natural predators are arboreal Colubrid snakes, Hornbills and Civet cats. The current habitat destruction poses a huge threat to this species.

Keywords. Agamidae, *Calotes ceylonensis*, Taxonomy, Natural history, Ecology, Biology, Behaviour, Sri Lanka.

INTRODUCTION

There are eighteen species of agamid lizards in Sri Lanka and fifteen (83.33%) of them are endemic to the island (DE SILVA 2006; MANAMENDRA-ARACHCHI et al. 2006). These eighteen species are classified under sub family Draconinae (MACEY et al., 2000). According to BAHIR & SURASINGHE (2005), MANAMENDRA-ARACHCHI et al. (2006) and IUCN & MENR (2007) four species are Critically Endangered; five species Endangered; three species Vulnerable and six Least Concern. The genus has a pit or fold in front of shoulder or none; body is compressed; supra ocular scales generally enlarged; dorsal scales are usually regular; dorsal crest and gular sac are more or less developed; tail is elongated, slender and sub cylindrical (DERANIYAGALA 1953).

The genus *Calotes* extends throughout southern Asia, most of the East Indian Archipelago (TAYLOR 1953). There are seven species in the genus *Calotes*. Five of them (*C. ceylonensis* Müller, 1887; *C. liocephalus* Günther, 1872; *C. liolepis* Boulenger, 1885; *C. nigrilabris* Peters, 1860; *C. desilvai* Bahir & Maduwage, 2005) are endemic to Sri Lanka. The remaining two *Calotes* species (*C. calotes* [Linnaeus, 1758]; *C. versicolor* [Daudin, 1802])

are probably widespread throughout South East Asia. According to the published literature *Calotes ceylonensis* is a largely arboreal species found only from the low country dry and intermediate zones below 500 m a.s.l (DAS & DE SILVA 2005; MANAMENDRA-ARACHCHI & LIYANAGE 1994). Its conservation status is Rare and Vulnerable (MANAMENDRA-ARACHCHI & LIYANAGE 1994; IUCN & MENR 2007). The information available on this species is marginal, and therefore further studies on their behaviour and ecology, which may be very important for the conservation of the species, are needed. Hence it is essential to gather information on the *C. ceylonensis* in different areas of the country as a first step towards conservation of this lizard species.

MATERIALS AND METHODS

The material examined is deposited at the NMB, Naturhistorisches Museum Basel, Switzerland and WHT, Wildlife Heritage Trust of Sri Lanka, Colombo, Sri Lanka. Diagnoses and descriptions are based on external morphology. This work is mainly based on examination of type

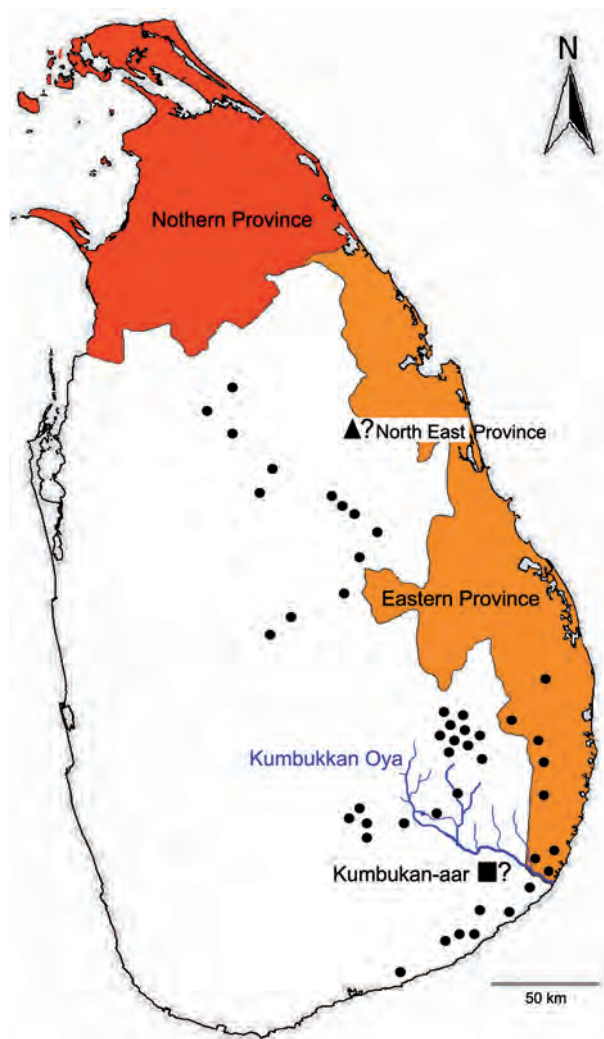


Fig. 1. Distribution map of *C. ceylonensis* (Square, Holotype; Triangle, Paratype; Circle, Other).

specimen and WHT specimens as well as published literature and our observations on their ecological and behavioural conditions and threats. The locality records for each species include WHT specimen data, published locality records as well as our observations during past decade. We have examined 45 localities (March 2002 to April 2006)

Table 1. Measurements of *C. ceylonensis* hatchlings.

	Measurement given in mm											
	1	2	3	4	5	6	7	8	9	10	11	Average
SVL	34.1	32.8	35.0	34.5	34.6	35.1	33.9	34.8	33.4	34.2	32.9	34.11
TL	65.5	66.8	67.2	64.8	66.1	63.4	66.2	64.5	63.9	66.5	65.8	65.51

throughout 7 districts (Anuradapura: 5 / Monaragala: 13 / Ampara: 8 / Hambantota: 7 / Badulla: 4 / Matale: 3 / Polonnaruwa: 5) (fig. 1). A total of 68 individuals (males: 37; females: 18; juveniles: 13) were recorded during the study period. The collected species were examined, measured and noted down carefully before released back to the same habitats (tab. 1 & 2). The diagnostic keys given by DERANIYAGALA (1953), MANAMENDRA-ARACHCI (1990), MANAMENDRA-ARACHCI (1998), MANAMENDRA-ARACHCI & LIYANAGE (1994), SMITH (1935) and TAYLOR (1953) were used for species identification. Principal components analysis of preferred habitats was done using Pcord4 and each number of males, females and juveniles against the preferred habitat type were used in this analysis.

All the photographs and line drawings displayed with the photographer's and artist's initials; ES (Edi Stöckli), TA (Thasun Amarasinghe) and SK (Suranjan Karunaratna).

All measurements were taken to the nearest 0.1 mm with dial calipers.

Scale counts. **SUP**, Supralabials were counted from the first scale anterior to that at angle of gape, not including the median scale (when present); **INF**, infralabials were counted from first scale posterior to mental, to angle of gape; **DS**, dorsal spines were counted from first spine to last of mid-dorsal row; **CR**, canthus rostralis (counted from rostral scale along scale row passing over nostril to posterior end of supraciliary ridge); **MDS**, mid dorsal scales (counted from scale behind rostral to posterior margin of the thigh); **MBS**, mid body scales were counted from center of mid-dorsal row forwards and downwards across ventrals (this count is, however, made unreliable by the unequal size and uneven arrangement of the lateral scales); **MVS**, mid ventral scales were counted from first scale posterior to mental, to last scale anterior to vent; **SAT**, Spines around tympanum were counted from first spine to last above tympanum.

External measurements. **SVL**, snout-vent length (distance between tip of snout to anterior margin of vent); **HL**, head length (distance between posterior edge of mandible and tip of snout); **HW**, head width (maximum width of head); **DHL**, dorsal head length (distance between posterior edge

Table 2. Measurement of *C. ceylonensis* Eggs.

No.	Egg length	Egg width
1	16.5	8.6
2	16.8	8.4
3	14.3	7.9
4	15.6	8.5
5	15.2	8.7
6	17.1	8.8
7	16.9	7.8
8	17.1	7.6
9	14.6	8.5
10	15.7	7.8
11	14.8	7.9
12	14.4	8.3
13	15.5	8.8
14	16.1	8.9
15	16.7	7.9
16	16.2	8.5
17	13.8	8.1
18	14.5	8.6
19	15.3	8.4
20	13.9	8.1
21	13.5	8.9
22	17	7.9
23	16.8	8.3
24	16.4	8.7
25	15.8	8.1
26	15.5	8.8
27	13.6	7.9
28	13.5	8.6
29	15.3	8.9
30	16.7	7.8
31	16.2	8.3
32	16.6	8.8
Mean	15.55	8.34

of cephalic bone and tip of snout); **NFE**, nostril – front eye length (distance between most anterior point of orbit and middle of nostril); **UAL**, upper-arm length (distance between axilla and angle of elbow); **LAL**, lower-arm length (distance from elbow to wrist with both upper arm and palm flexed); **FL**, finger length (distance between tip of claw and the nearest fork); **FEL**, femur length (distance between groin and knee); **TBL**, tibia length (distance between knee and heel, with both tibia and tarsus flexed); **TL**, toe length (distance between tip of claw and nearest fork); **AG**, axilla–groin length (distance between axilla and groin); **SA**, snout–axilla length (distance between tip of snout and axilla); **TAL**, tail length (measured from anterior margin of vent to tail tip); **PAL**, palm length (tak-

en from posterior most margin of palm and tip of longest finger); **FOL**, foot length (distance between heel and tip of longest toe, with both foot and tibia flexed); **TBW**, width of tail base (most distance of the tail base); **IOW**, inter orbital width (least distance between the upper margins of orbits); **ED**, eye diameter (horizontal diameter of orbit); **SFE**, snout–front eye length (distance between anterior most point of orbit and tip of snout); **SBE**, snout–back eye length (distance between posterior most point of orbit and tip of snout); **SFT**, snout–front tympanum length (distance between anterior most point of tympanum and tip of snout); **TD**, Tympanum diameter (least distance between the inner margins of tympanum).

RESULTS

Calotes ceylonensis Müller, 1887

English Name: Painted-lip Lizard

Sinhala Name: Thola – wisithuru Katussa

Calotes mystaceus, var. ceylonensis Müller, 1887 (MÜLLER 1887: 8, 292–293, pl. 3.).

Calotes ceylonensis (BOULENGER 1890; DERANIYAGALA 1931; SMITH 1935; TAYLOR 1953).

Calotes kelaartii Nevil, 1887 (HALY 1887: 2, 133. [Species described but not named]; NEVIL 1887: 2, 134, pl. 5 [Species named but not described]).

Calotes saleoides Werner, 1896 (WERNER 1896: 46, 7).

Holotype (fig.2). Male (81.9 mm SVL); *Cat. no.* NMB 3340; *Loc.* Kumbukan-aar: South East Ceylon (= Kumbukkan Oya?: Sri Lanka [“aaru” in *Tami l*= “Oya” in *Sinhala*]); *Coll.* P. Sarasin & F. Sarasin; *Date.* 1886.

Paratype (in NMB catalogue labeled as Syntype). Male



Fig. 2. *C. ceylonensis*, NMB 3340; Holotype, male; lateral aspect of head (ES).



Fig. 3. *C. ceylonensis*, NMB 3341; Paratype, male; lateral aspect of head (ES).

(67.6 mm SVL); *Cat. no.* NMB 3341; *Loc.* North East province: Ceylon (= Northern Province ? / Eastern Province ?; Sri Lanka); the same coll. & same date (fig. 3).

Other materials examined. WHT 7397, male, 59.1 mm, Wasgamuwa; WHT 7514, male, 74.8 mm, Giritale; WHT 1427A, male, 79.6 mm, Wasgamuwa; WHT 1427B, male, 75.0 mm, Wasgamuwa; WHT 1427C, female, 76.7 mm, Wasgamuwa; WHT 1427D, female, 61.6 mm, Wasgamuwa; WHT 1428, male, 80.3 mm, Tatugala-Bulupitiya; WHT 0515, male, 72.9 mm, Pallegama; WHT 1625A, male, 77.2 mm, Wasgamuwa; WHT 1625B, male, 71.9 mm, Wasgamuwa; WHT 0511, male, 82.5 mm, Konketiya-Buttala; WHT 0521, female, 72.1 mm, Konketiya-Buttala; WHT 0522, male, 73.2 mm, Konketiya-Buttala; WHT 0519, male, 73.0 mm, Yala; WHT 0520, male, 73.4, Yala. WHT 1624A, male, 65.1 mm, Wasgamuwa

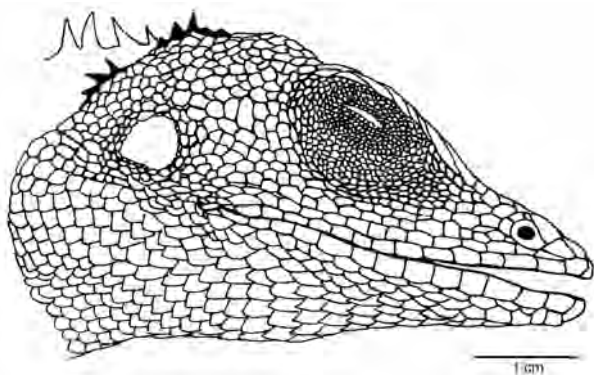


Fig. 4. *C. ceylonensis*, WHT 0511; male; lateral scalation of head (TA).

Diagnosis. Two well-separated spines above the tympanum, the anterior and upper lateral pointing backwards and upwards, the other straight backwards, an oblique fold in front of the shoulder runs across throat covered with small granular scales. Dorsal crest formed of 7 to 13 small spines. In a fully-grown male the head is larger and the base of the tail more swollen.

Description. (Based on MÜLLER 1887; Holotype (NMB 3340); Paratype (NMB 3341) and WHT collection). Length of head one and a half times its breadth; snout a little longer than the orbit; forehead concave; cheeks swollen in the adult male; upper head scales unequal, smooth; canthus rostralis and supraciliary edge sharp; two well separated spines above the tympanum, the upper and anterior one mid way between it and the nuchal crest; diameter of the tympanum half that of the orbit; Supralabi-

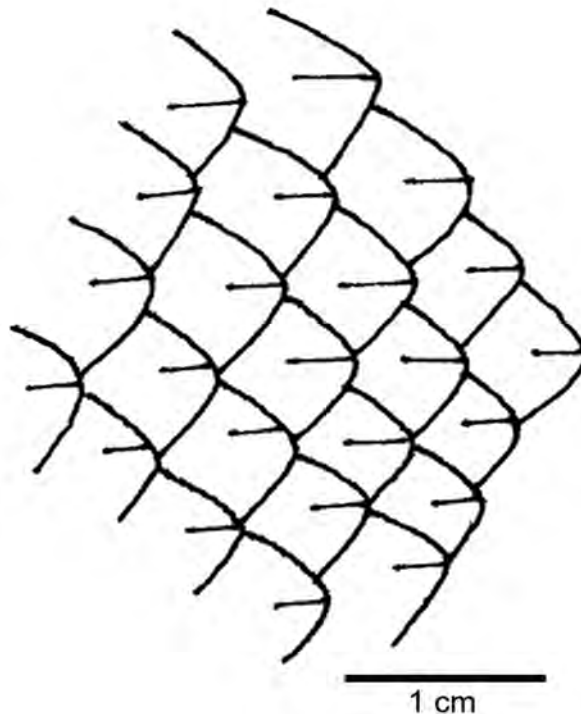


Fig. 5. *C. ceylonensis*, WHT 0511; male; mid body lateral scales (TA).

als, 10–14; Infralabials, IX–XIII (fig. 4). Body compressed; dorsal scales rather small, smooth or faintly keeled, the anterior and upper ones pointing backwards and upwards (fig. 5); the others straight backwards, larger than the ventrals, which are strongly keeled and mucronate; 53 to 76 scales round the body. No trace of a gular sac; gular scales strongly keeled, as large as the ventrals; an oblique fold in front of the shoulder runs across throat covered with small granular scales. Dorsal crest



Fig. 6. *C. ceylonensis* Mature Male (lateral aspect) (SK).

formed of 7 to 13 small spines; no dorsal crest. Limbs moderate; third and fourth fingers are sub equal; Relative length of fingers; $1 < 5 < 2 < 4 < 3$. Fourth toe distinctly longer than third. Relative length of toes; $1 < 2 < 5 < 3 < 4$. The hind limb reaches to the tympanum or beyond. Tail long and slender; in the adult male it is markedly swollen at the base, with large, thick, keeled scales, those of the upper median row forming a slight serrated ridge.

Remarks. (Based on MÜLLER [1887] and observations on living specimens). The body color is changeable from grayish brown to light blue or dark brown, back of the head and anterior part of back pale brownish, divided in to more or less distinct spots by dark transverse bars; hinder part of back and tail with dark cross bars; upper lip with a pale strongly defined stripe, which extends to beyond the ear; sides of neck and chest black or white with black reticulations; gular region grayish or blackish; belly pale brown with more or less distinct angular bands (figs. 6 & 7).

Scale counts and External measurements (in mm) of Holotype. SUP, 10; INF, 10; DS, 9; CR, 14; MBS, 59; MDS, 78; MVS, 101; SAT, 2; SVL, 81.9; HL, 31.2; HW, 18.6; DHL, 20.6; NFE, 6.7; UAL, 12.3; LAL, 14.7; FLI, 4.3; FLII, 7.0; FLIII, 10.1; FLIV, 9.6; FLV, 6.6; FEL, 20.3; TBL, 22.7; TLI, 4.2; TLII, 7.5; TLIII, 11.6; TLIV, 14.1; TLV, 9.9; AG, 33.9; SA, 37.7; TAL, 185; PAL, 12.2; FOL,



Fig. 7. *C. ceylonensis* Mature Male (dorsal aspect) (TA).

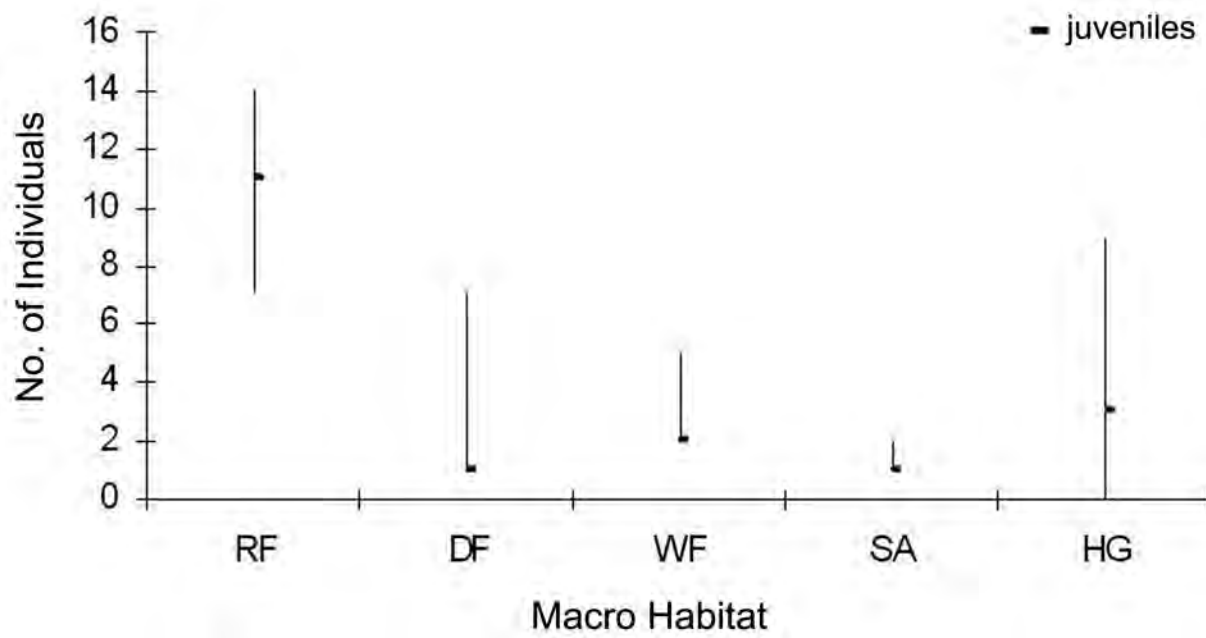


Fig. 8. PC analysis of preferred macro habitats (RF, Riverine Forests; DF, Dry-mixed Forest; WF, Wet-mixed Forest; SA, Savannah; HG, Home Gardens).

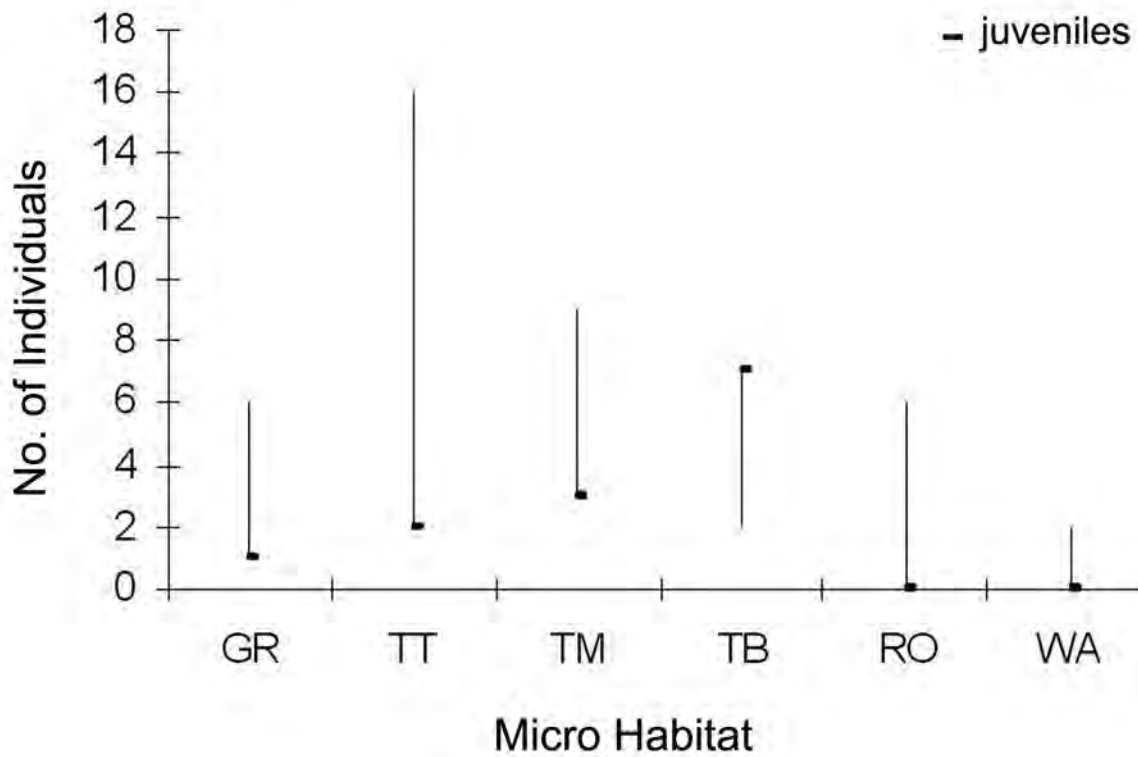


Fig. 9. PC analysis of preferred micro habitats (GR, Ground; TT, Tree Top - >10m height; TM, Middle of Tree 5 to 10m height; TB, Base of Tree 1 to 5m height; RO, On Rocks; WA, On Walls).

22.2; TBW, 10.2; IOW, 12.4; ED, 8.3; SFE, 10.8; SBE, 18.8; SFT, 23.5; TD, 2.8.

Scale counts and External measurements (in mm) of

Paratype. SUP, 11; INF, 11; DS, 8; CR, 14; MBS, 53; MDS, 73; MVS, 84; SAT, 2; SVL, 67.6; HL, 19.9; HW, 11.6; DHL, 16.2; NFE, 4.7; UAL, 9.7; LAL, 11.2; FLI, 4.0; FLII, 6.4; FLIII, 7.5; FLIV, 7.3; FLV, 5.1; FEL, 16.3; TBL, 16.0; TLI, 3.5; TLII, 6.0; TLIII, 10.2; TLIV, 10.6; TLV, 8.6; AG, 27.5; SA, 25.1; TAL, 156; PAL, 10.6; FOL, 17.9; TBW, 6.3; IOW, 9.0; ED, 6.0; SFE, 8.1; SBE, 13.5; SFT, 11.6; TD, 2.6.

Distribution and Habitat. *Calotes ceylonensis* is recorded only from the semi evergreen monsoon forests, plantations and home gardens of the dry and intermediate zones up to 500 m a.s.l. within the well shading riverine-forested areas and poorly in the home gardens (DAS & DE SILVA 2005; ERDELEN 1984; MANAMENDRA-ARACHCHI & LIYANAGE 1994). According to our observations a large number of individuals of this species mostly favour shady riverine forests over the other macro habitats (fig. 8) and we also could locate a great number of individuals from top of the trees rather than the other microhabitats (fig. 9).

According to our survey the female sex ratio is low comparatively to the males except in Ampara district. The highest number of males was recorded from Monaragala district and least numbers from Matale and Badulla dis-

tricts and also the number of females, juveniles, hatchlings as well as eggs were low in these two districts (fig. 10 and tab. 3).

Reproduction. There have been only few attempts to use hemipenis morphology as a taxonomic tool for agamid lizards although there is a considerable amount of structural diversity (McCANN 1949, BÖHME 1988). The hemipenis of *C. ceylonensis* (fig. 11) seems less differentiated as compared to *C. nigrilabris* and *C. liocephalus* (see also the descriptions and fig. 18 in BÖHME 1988). The pedicel is considerably longer than the head; below the head, it is broadened out in to two shallowly concaved shoulders; there are no spines. The head is quadrangle in shape. It is shallowly divided longitudinally in to four lobes, two being very slightly larger than the others. The surface of the head is reticulatedly pitted, the pits being larger on the outside and diminishing in size towards the divisions between the lobes (fig. 11).

The female digs a nest hole in the ground and deposits about 4–12 eggs in August to October on shady places near from tree bases. While laying eggs the females change their body color to black. The eggs are 13.5 mm–17.1 mm long and 7.8 mm–8.9 mm wide. Hatchlings come out from November to December (DERANIYAGALA 1953).

Behaviour. This species is largely arboreal and active during the day, widely spread within the well shading riverine-forested areas and poorly in the home gardens. They

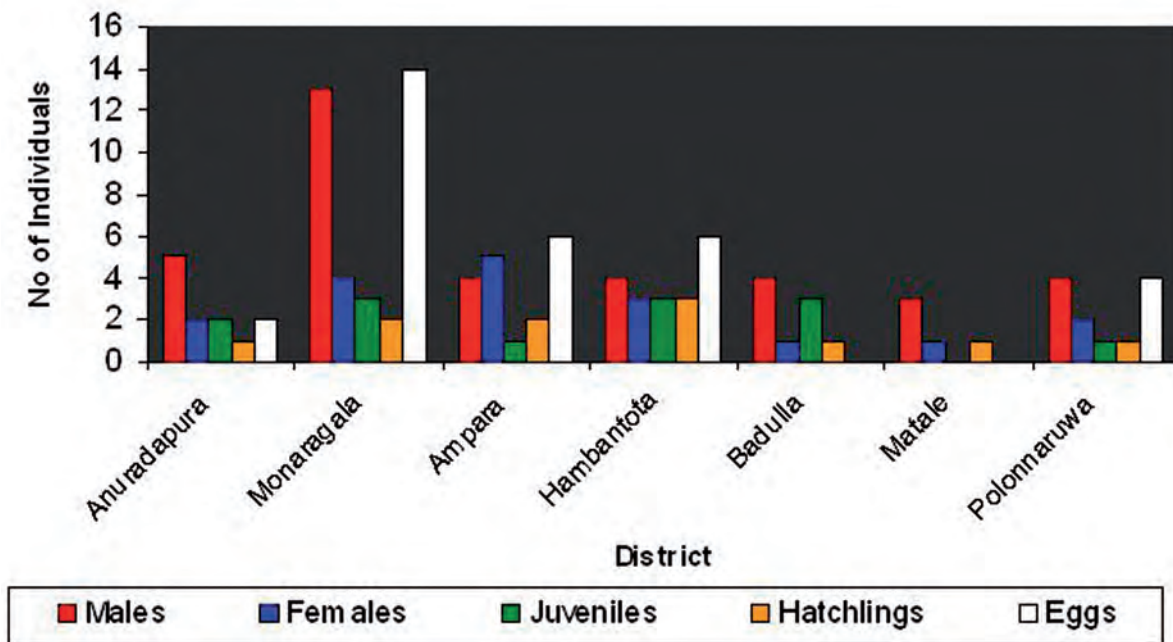


Fig. 10. No. of individuals recorded in each district.

Table 3. Observed locations and individual details of *C. ceylonensis*.

District	Location	No. of Males	No. of Females	No. of Juveniles	No. of Eggs	No. of Hatchlings
Monaragala	Pitakumbura	1	0	1	2	1
	Wellavaya	1	1	0	0	0
	Puwakpale	1	0	0	2	0
	Bulupitiya	1	1	0	2	0
	Monaragala	1	0	1	2	0
	Hangala	0	1	0	0	1
	Yakunhela	0	0	0	0	0
	Buttala	1	0	0	2	0
	Nilgala	3	1	0	0	0
	Ulhela	1	0	1	2	0
	Rathugala	1	0	0	2	0
	Pihibiyamukalana	1	0	0	0	0
	Hamapola	1	0	0	0	0
Ampara	Hulannuge	0	1	0	2	0
	Buddangala	0	1	0	0	1
	Kumana	0	1	0	0	0
	Galoya	1	0	1	0	0
	Yala	1	1	0	0	1
	Makara	1	0	0	2	0
	Aravila	1	0	0	0	0
	Manakanda	0	1	0	2	0
Hambantota	Palatupana	0	1	0	2	1
	Kataragama	0	1	1	2	1
	Weeravila	0	1	0	2	0
	Hambantota	1	0	1	0	1
	Akasachihthiya	1	0	0	0	0
	Tissamaharama	1	0	0	0	0
Polonnaruwa	Yala	1	0	1	0	0
	Maduruoya	0	1	1	0	0
	Giritale	1	0	0	2	0
	Polonnaruwa	1	0	0	2	1
	Wasgomuwa	1	0	0	0	0
Badulla	Minneriya	1	1	0	0	0
	Koslada	1	0	0	0	0
	Udadiyaluma	1	0	1	0	1
	Akkaraseya	1	1	1	0	0
Matale	Nikapotha	1	0	1	0	0
	Ilukkumbura	1	0	0	0	0
	Wasgomuwa	1	1	0	0	1
Anuradapura	Narangamuwa	1	0	0	0	0
	Galkulama	1	1	0	0	0
	Padaviya	1	0	1	0	0
	Ritigala	1	1	0	0	1
	Anuradapura	1	0	1	0	0
Kekirawa	1	0	0	2	0	

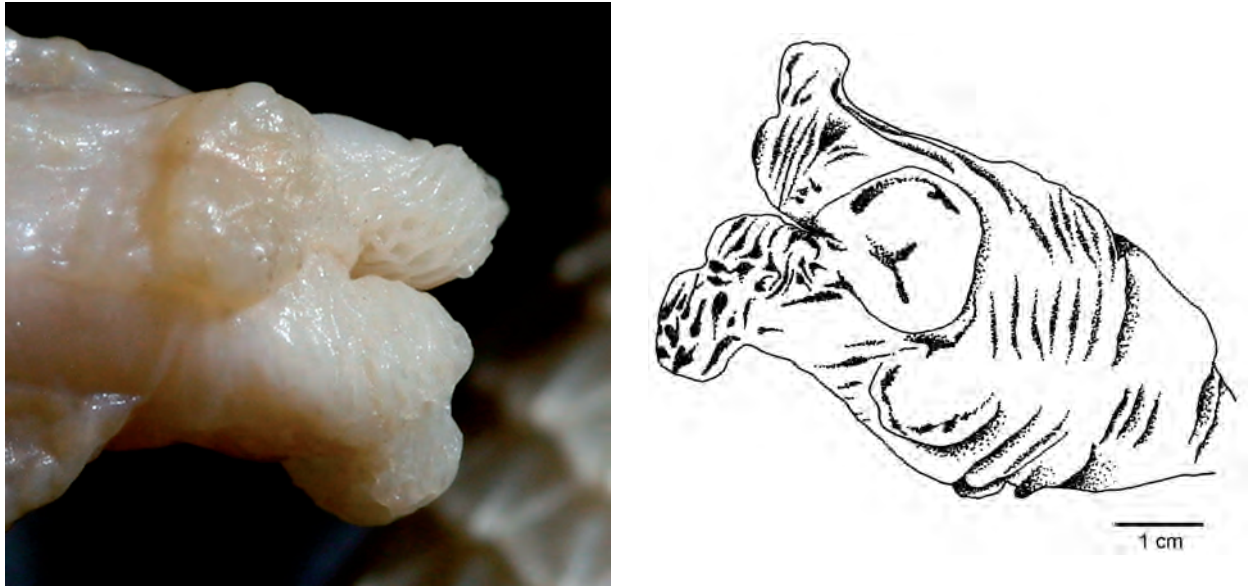


Fig. 11. *C. ceylonensis*, WHT 1428; male, 80.3 mm SVL; lateral aspect of left hemipenis (TA).

specially feed on butterflies, honeybees and other insects. These lizards' natural predators are arboreal colubrid snakes, hornbills and civet cats. Being in danger this lizard suddenly climbs into a tree to an average height of 15 m and then glides to another tree, which is 1 m away till the danger disappears. If there is no other tree to glide, they just jump down to the ground and stay a few minutes without moving, and then suddenly run on another tree. Hatchlings are mostly waiting for their preys on *Lantana camara* trees (an invasive plant to Sri Lanka) while camouflaging their snout color into pink (the flowers of *L. camara* are also pink). Their prey are insects which feed on *L. camara*.

Conservation status. Rare (MANAMENDRA-ARACHCHI & LIYANAGE 1994), Least Concern (BAHIR & SURASINGHE 2005) and Vulnerable (IUCNSL & MENR 2007).

DISCUSSION

The holotype of *Calotes ceylonensis* (NMB 3340) was collected from "Kumbukan-aar: South East Ceylon" by P. & F. Sarasin. Today there is known no area or river basin as "Kumbukan-aar" in South East Sri Lanka. However there is a river basin called "Kumbukkan Oya". In Sinhala "Oya" means a small river/large stream. In Tamil "aaru" is the same meaning for "Oya or River". There are several rivers in East and North parts of Sri Lanka named as "aaru" in Tamil. However there is no evidence that name used for "Kumbukkan Oya". Somehow the Tamil people live in that area used to call this river as "Kumbukkan

aaru". Therefore we believe that the person who gave this information to P. & F. Sarasin might have been a Tamil person. In addition now there is also a considerable population of *C. ceylonensis* inhabiting this area. Therefore we assume the name for holotype locality as "Kumbukkan Oya", which is currently used in Sri Lanka.

In addition the paratype of (NMB 3341), was collected from "North East province: Ceylon" by the same collectors. Actually nowadays there is no district as "North East province" in Sri Lanka and this province considered as two provinces called Northern Province and Eastern Province. Therefore it is difficult to place the exact location and also *C. ceylonensis* is distributed throughout these two provinces of the country.

The ecological and behavioural status of *C. ceylonensis* has not been investigated up to now. *C. ceylonensis* is an endemic, rare and vulnerable species. Therefore many published literature on their ecological status will have to be done for the conservation of this species. And also captive breeding methods may be needed for ex-situ conservation of these species. A major portion of the primary forests of Sri Lanka has undergone considerable destruction during the past 150 years. As a result: most of the agamid lizards that inhabit in these primary forests now live in degraded or altered habitats. According to DE SILVA (1996) *C. ceylonensis* is distributed in primary forest where a considerable amount of destruction and alteration of the forest by human activities have taken and are still taking place. As a consequence only 5% to 25% of primary or secondary forest / scrub jungle still exist with the

greater extent being anthropogenic vegetations. *C. ceylonensis* is sympatric with *Calotes liolepis* in Ritigala, Nilgala, and the eastern slope of the Knuckles region; with *C. versicolor*, *Otocryptis nigristigma*, *Lyriocephalus scutatus* and *Sitana ponticeriana* in many habitats throughout the intermediate and dry zones.

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