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Microhabitat preferences and associated behavior patterns of endemic pigmy lizard: *Cophotis ceylanica* in Horton plains, Sri Lanka

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Abstract

The pigmy lizard (*Cophotis ceylanica*) is an endangered and rare lizard species endemic to Sri Lanka, yet no studies exist on its microhabitat preferences. Therefore, the present study was carried out in the Cloud Forests of the Horton Plains National Park (HPNP) with the aim of addressing this knowledge gap in their ecology. Microhabitat variables were measured placing 1x1 m quadrates marking the point of each lizard sighting as the center and microhabitat details including perch plant characteristics, soil characteristics and environmental parameters were recorded. Highest number of individuals were seen on *Sarcococca brevifolia* (1.167±0.937) plant species. Total of 78.13%, *C. ceylanica* were observed perching on branches rather than on trunks or leaves. Highest percentage of pigmy lizards (48.87%) was recorded in the branches where the moss cover was between 50% - 75% and the lowest of 12.50% was recorded where the moss cover was less than 25%. Highest percentage of 71.88% of *C. ceylanica* were recorded perching in the height category of 2-3 m of perching plants. No individuals were recorded up to 1m from ground level. Most of the pigmy lizards (71.87%) were recorded where branch diameter was between 1- 2cm. *C. ceylanica* preferred microhabitat where mean ambient temperature was 20.36±3.68 °C and mean substrate temperature 16.89±2.67 °C. Relative humidity ranged from 61.40% to 100.00. The mean number of *C. ceylanica* encountered at different sampling time periods of the day varied significantly. Mean number of encounters were greater in Mid-Day time period and the lowest number of individuals were recorded in Evening time period. *C. ceylanica* showed prominent behaviors in each time period. Highest average time percentage was spent for resting (47.22%) in the morning, for basking (38.88%) in the mid-day and for sleeping (50.00%) in the evening. Courtship was only observed in evening time period. Overall results show that very few time is spent by *C. ceylanica* for locomotion and feeding. With these very important findings this study highlights the need for further studies on this endangered species to ensure its survival.

Keywords: The pigmy lizard, endemic, microhabitat, perch plant characters, activity patterns

Introduction

The reptile fauna of Sri Lanka comprises of 210 species ^[1]. Reptile fauna includes lizards that are categorized under the suborder Sauria ^[2]. There are 96 species of native saurians in Sri Lanka ^[3, 4]. Saurians are further grouped in to families including family Agamidae. Agamids are day-active lizards, usually with a crest along the middle of their backs ^[5]. There are 21 native agamid species in Sri Lanka. They belong to the subfamily Draconinae which consist of six genera, Calotes; Ceratophora; Cophotis; Lyriocephalus; Otocryptis and Sitana ^[6-9]. Previously the agamid lizard genus *Cophotis* included two species (Peters, 1861). One *Cophotis ceylanica*, distributed in Sri Lanka and the other *Cophotis sumatrana* Hubercht distributed in Indo-Australian Archipelago ^[4]. Later it became a monotypic genus when new genus *Pseudocophotis* was described ^[10]. That resulted in *Pseudocophotis sumatrana* ^[11] and *Cophotis ceylanica* being the only species included in it ^[12]. Recently a second new species was described of the genus *Cophotis*, *Cophotis dumbarae* distributed in Dumbara (Knuckles) Hills in Sri Lanka ^[12]. *Cophotis ceylanica* is an endangered and rare endemic species ^[13]. It is known as Pigmy Lizard or 'Kandukara Kurukatussa'/'Kuru Bodiliya' in Sinhala. It is a slow-moving lizard with a compressed body, narrow head, well-developed dorsonuchal crest, enlarged dorsal scales, laterally compressed gular sac, prehensile tail and an absent tympanum ^[5]. Its distribution in Sri Lanka is limited to high altitude, relatively undisturbed patches of tropical montane cloud forests in central mountainous regions ^[4, 12]. Horton Plains National Park (HPNP) and its environs are considered to be the home of best-known population of

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Cophotis ceylanica [4]. Microhabitat generally refers to habitat features in a finer scale. Previous studies have revealed that microhabitat use may effect several traits such as individual physiology [14], population dynamics [15], interspecific competition and size & morphology of the lizard [16]. Vegetation structure is one of the main factors which determine the microhabitat use in lizards [17]. This appears to be related with microclimatic conditions associated with vegetation [18]. Although the knowledge of Sri Lankan herpetofauna has significantly improved recently, the absence of basic ecological information at both population and individual levels for most reptilian taxa is an enigma¹⁹. Absence of adequate researches and information about any particular species, make it challenging to accomplish their conservation. There are very few published literature on *C. ceylanica*. Our knowledge of this species and its habitat preference, microhabitat utilization or behavior patterns are very limited. Therefore, the aim of this research is to broaden the current knowledge of *C. ceylanica* which could facilitate their conservation.

Materials and Methods

Microhabitat variables were measured by placing 1x1 m quadrates making the point of each lizard sighting as the center. Following data were recorded at each lizard occupied quadrate.

Perch plant characteristics

Perch type where the lizard was sighted was broadly classified in to ground, leaf litter, shrub, tree trunk, tree branch and tree leaf. Perching plant species was recorded²⁰. Perch branch circumference was recorded using a measuring tape and then the diameter was calculated. Percentage lichen cover was calculated using a grid which was drawn in a hard polythene paper (Length = 20cm, Width = 5cm) and by placing it around the branch circumference when possible where lizard was originally observed. All squares that cover 50% with lichens were counted and percentage values were calculated.

Soil characteristics

Soil pH and soil moisture content was recorded using soil pH meter [Kelway soil acidity (pH) and moisture tester. Leaf litter depth was recorded using a metal ruler. Soil penetration was recorded using a soil penetrometer [Land penetrometer INC].

Environmental parameters

Ambient temperature at chest height above ground to the nearest 0.10 °C was recorded using Krestrel 4000 pocket weather meter, USA [21]. Relative humidity at chest height above ground using Krestrel 4000 pocket weather meter, USA [22].

Behavioral data collections

During the census, lizards' behavior was observed and recorded. An ethogram was constructed describing those observed distinct behaviors. Following behaviors were observed; resting, feeding, foraging, locomotion, alert, sleeping and courtship.

Behavioral data were collected by observing the individuals throughout the day from 08.00h to 18.00h with 30 minute breaks between two hour time periods. Diet assessments were made during observation of their foraging period. Gut content

obtained from a dead lizard due to a road kill was analyzed to observe prey items.

Results & Discussion

The present study revealed that *C. ceylanica* was selective in their use of microhabitats. They were only observed in few plant species. Highest number of individuals were encountered on *Sarcococca brevifolia* (1.167±0.937) plant species. Least number of individuals were encountered on *Elaeocarpus montanus* (0.167 ±0.389) plant species. Preferred plant species of *C. ceylanica* are presented in Table 1.

Table 1: Preferred perch plant species of *C. ceylanica* averaged for all sampling days

Plant Species	Mean number of individual encountered (Mean ± SD)
<i>Sarcococca brevifolia</i>	1.167±0.937
<i>Hedyotis lessertiana</i>	0.500 ±0.674
<i>Toddalia asiatica</i>	0.500 ± 0.798
<i>Cinnamomum ovalifolium</i>	0.333 ± 0.651
<i>Elaeocarpus montanus</i>	0.167 ±0.389

All the plant species where it was encountered, *Sarcococca brevifolia*, *Hedyotis lessertiana*, *Toddalia asiatica*, *Cinnamomum ovalifolium*, *Elaeocarpus montanus* are endemic species which grows up to more than 5m height and *Sarcococca brevifolia* is restricted to Horton Plains in Sri Lanka. According to past literature these are not the most common plant species found in HPNP thus highlighting *C. ceylanica* is selective regarding the perching plant species. Therefore, preservation of these plant species in their original habitat is of utmost importance for the survival of this endemic lizard species.

Average of 71.88% of *C. ceylanica* were recorded perching in the height category of 2-3 m of perching plants. 15.63% was recorded in the height category of 1-2m heights. 12.50% was recorded perching in the height category of more than 3m. No individuals were recorded up to 1m from ground level. Perch height preference of *C. ceylanica* are presented in Figure 1.

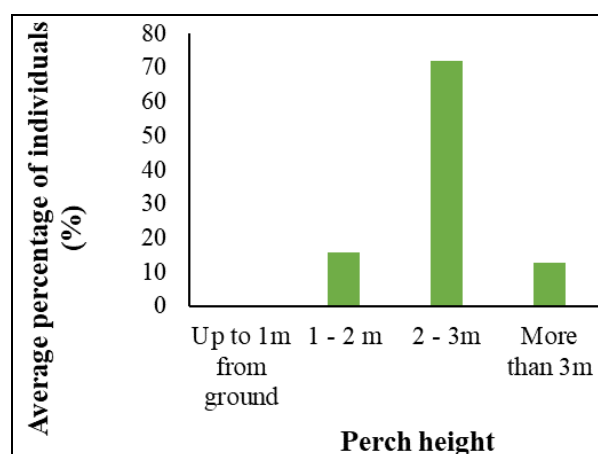


Fig 1: Perch height preference of *C. ceylanica*

Total of 25 (78.13%) *C. ceylanica* were recorded perching on branches. Only 02 (6.25%) were observed perching on leaves, 03 (9.38%) on trunks and 02 on the ground. No *C. ceylanica* were observed perching on shrubs (Figure 2). Furthermore 72% of *C. ceylanica* were recorded where branch diameter was between 1-2cm. 12% *C. ceylanica* was recorded in

branches where diameter was between 2 -3cm. Where branch diameter was more than 3cm and less than 1cm, observed percentage of *C. ceylanica* were 8%. The preferred branches with diameters between 1 -2 cm. When the diameter increased over 3cm they usually did not occupy them (Figure 3). It was observed that they only perched branches where they could hold the branch completely with the digits in their limbs. In the harsh environments of upper montane cloud forests, they are constantly faced with high winds and heavy rains. Therefore, it is possible that the branches with diameters between 1 -2 cm provide them with a strong grasp to avoid being carried away by strong winds or associated rains.

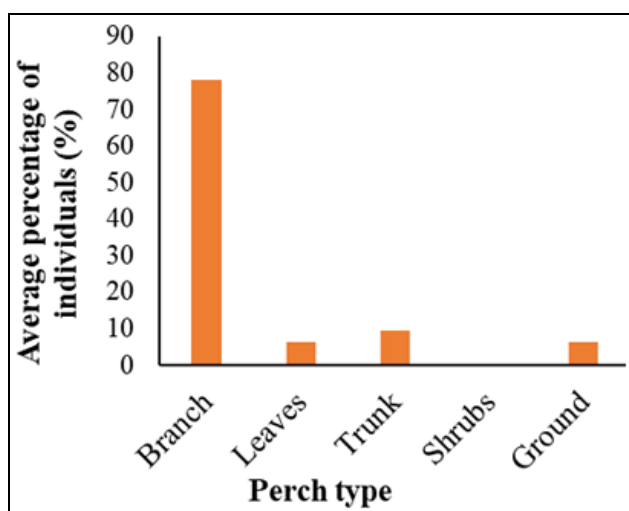


Fig 2: Perch type preference of *C. ceylanica*

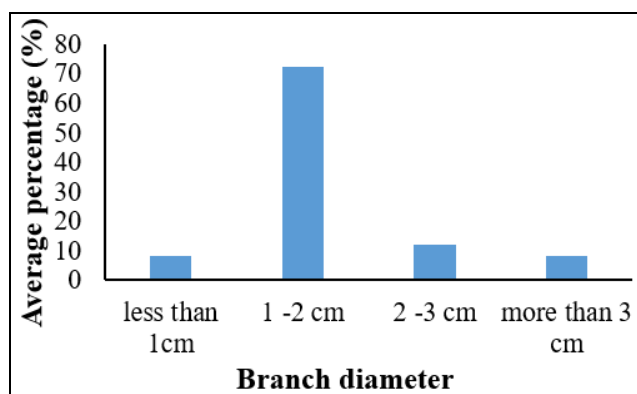


Fig 3: Preferred branch diameter of *C. ceylanica*

Table 2: Mean values for the microhabitat soil characteristics and physical parameters of *C. ceylanica* occupied quadrats

Soil characteristic variable	Mean ± SD	Environmental variable	Mean±SD
Soil Penetration (cm)	15.68±1.256	Ambient Temperature (°C)	20.359±3.688
Soil pH	6.35±0.2199	Substrate Temperature (°C)	16.897±2.678
Leaf Litter Depth (cm)	2.75±0.4704	Relative Humidity (%)	86.35±14.01
Soil Moisture (%)	23.75±6.35		

Principal Component Analysis (PCA) of microhabitat variables suggests that some of these factors are more influential in selection of the preferred microhabitat of *C. ceylanica* than others in cloud forest habitat. According to PCA results ambient temperature, branch diameter, lichen cover and perch height significantly affect the microhabitat conditions. Hence it can be concluded that perch plant characteristics are more significant in microhabitat preference of *C. ceylanica*. Table 3 and 4 respectively indicate the

When the branches that they occupy were further studied, highest average percentage of 48.87% was recorded where the lichen cover is 50% - 75% and second highest average 25.00% was recorded between 25% - 50%. Average percentage where lichen cover is >75% was 15.62% and the lowest average percentage 12.50% was recorded where moss cover is < 25%. Lichen cover preference of *C. ceylanica* are presented in Figure 4. It is probable that they preferred lichen as they offered a far better camouflage. Lichens are prominent in majority of the trees in Horton Plains [23]. There are various types of lichens at the Horton Plains National Park. However, *C. ceylanica* were mostly observed with the lichen species *Usnea barbata*. Therefore, this lichen species is of high importance to this slow moving lizard species for camouflage.

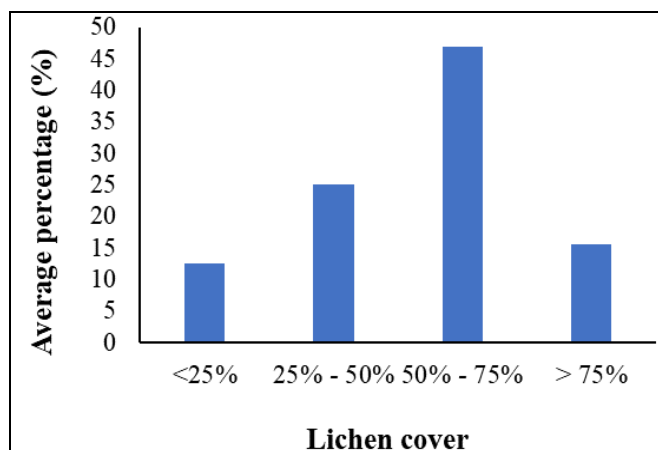


Fig 4: Percentage lichen cover preference of *C. ceylanica*

These endemic species preferred microhabitats where soil penetration was average 15.688±1.256 cm and soil pH ranges from 6.1 to 6.9. Leaf litter depth ranges from 1.5 to 3.2 cm and the mean soil moisture percentage recorded as 23.75±6.35. Furthermore they also preferred microhabitats where mean ambient temperature was 20.359±3.688 °C and mean substrate temperature 16.897±2.678 °C. Relative humidity ranged from 61.40% to 100.00%. Since environmental temperature frequently fluctuate in these montane cloud forests, it is likely that *C. ceylanica* utilize these specific microhabitats which provide appropriate temperature conditions. Microhabitat soil conditions and preferred physical parameters of *C. ceylanica* are presented in Table 2.

Eigenanalysis of the correlation matrix and Factor loadings for the first five principal component (PC) axes of occupied microhabitat variables.

Table 3: Eigenanalysis of the Correlation Matrix

	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5
Eigenvalue	2.6860	0.9924	0.8416	0.7611	0.6272
Proportion	0.448	0.165	0.140	0.127	0.105
Cumulative	0.448	0.613	0.753	0.880	0.985

Table 4: Factor loadings for the first five principal component (PC) axes of occupied microhabitat variables

Variable	PC1	PC2	PC3	PC4	PC5
Ambient Temperature (°C)	0.559	0.161	0.237	-0.016	-0.245
Substrate Temperature (°C)	0.521	0.127	0.437	-0.009	-0.294
Relative Humidity	-0.404	-0.148	0.072	-0.461	-0.771
Perch height (m)	0.329	0.081	-0.840	0.164	-0.372
Lichen Cover Percentage (%)	-0.348	0.292	0.190	0.803	-0.334
Branch Diameter (cm)	0.153	-0.919	0.076	0.340	-0.098

Behavior associated with microhabitat utilization revealed that the highest number of encounters were recorded in mid-day time period from 12.00h to 15.00h. The mean number of *C. ceylanica* encountered at different sampling time periods of the day varied significantly ($p < 0.05$). They were rarely detected in the morning and evening time periods on the field. The diurnal variation in their activity pattern may also aid in the thermoregulation since highest exposure to the sunlight can be achieved at this time period. Hence, it was apparent that they preferred to perch in filtered sunlight.

Figure 5 present the diurnal variation of *C. ceylanica* encounters. *C. ceylanica* showed prominent behaviors in each time period. Highest average time percentage was spent for resting (47.22%) in the morning, for basking (38.88%) in the mid-day and for sleeping (50.00%) in the evening. Courtship was only observed in evening time period. *C. ceylanica* displayed variety of behavioral patterns throughout the day. However, the study of the organism throughout the day establish the fact that it is a slow- moving, less active agamid. Highest amount of time in the morning and mid-day was spent basking and resting. Most of the evening time percentage was spent sleeping. An interesting observation was

that with the gradually losing sunlight, they habitually moved to more leaves or lichen covered position in the same perching plant from where they perched in the day time and spend the night time more sheltered. In the morning they were observed returning back to their usual perching position. Diurnal behavior pattern variation of *C. ceylanica* are presented in Figure 6.

C. ceylanica tend not to spend much time foraging and they perch near flowers of their perching plants. They feed on insects which are attracted to the flowers rather than actively chase after them. Movement of *C. ceylanica* was very protracted and deliberate that insects cannot sense it approach. Their insectivorous dietary pattern was well demonstrated in their gut content analysis where whole undigested insects, insect wings, mouth parts and leg parts were observed.

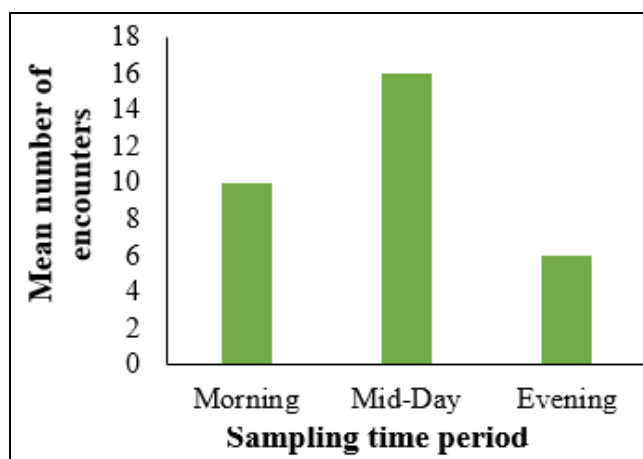


Fig 5: Diurnal variation in mean number of *C. ceylanica* encounters

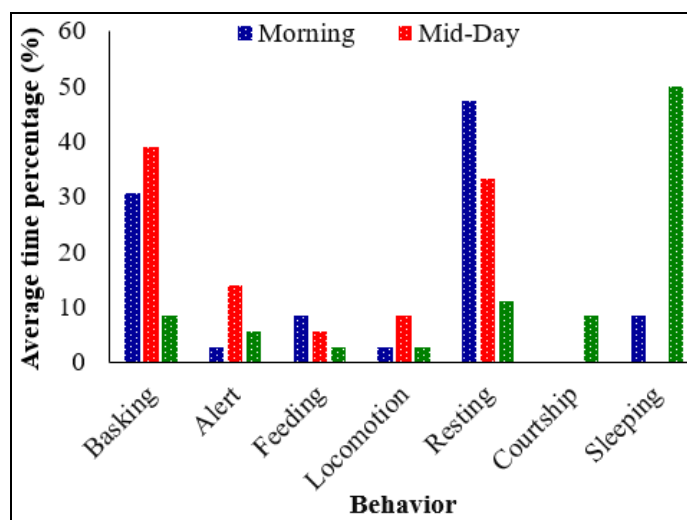


Fig 6: Diurnal behavior pattern variation of *C. ceylanica*

Conclusion

It was observed that these lizards prefer the cloud forest habitat over the other habitat types available at the HPNP. It was also observed that they prefer the endemic plants with suitable branch sizes, high with lichen or moss cover as their perching places. Most preferred plant species is restricted to the HPNP. The study also observed that this could be a monogamous species which is extremely rare in lizard species. Observations in the field also indicate the ovoviviparity in these species. With these very important findings, this study highlights the need for further studies on this endangered species to ensure its survival.

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