Montane lizard in a mosaic landscape: Effect of tea plantations on Anamalai Spiny Lizard (*Salea anamallayana*)

Dissertation submitted to Saurashtra University, Rajkot in Partial Fulfillment of the Master of Science Degree in Wildlife Science

Submitted by

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DECLARATION

I, **Anjitha Devarajan**, hereby declare that the research work entitled **"Montane lizard in a mosaic landscape: Effect of tea plantations on Anamalai Spiny Lizard (*Salea anamallayana*)"**, carried out in partial fulfilment of M.Sc. (Wildlife Science) degree of Saurashtra University, Rajkot is an original piece of research work. This research work was carried out under the supervision of **Dr. C. Ramesh, Dr. Abhijit Das and Dr. Deepak Veerappan**, at the Wildlife Institute of India from January 2021 to July 2021. I hereby declare that this work has not been submitted for any other degree of any university.

Date: 13th August 2021

Place: Dehra Dun

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This is to certify that Ms. Anjitha Devarajan has carried out original research titled **"Montane lizard in a mosaic landscape: Effect of tea plantations on Anamalai Spiny Lizard (*Salea anamallayana*)"** in partial fulfilment of Master's Degree in Wildlife Science from Saurashtra University, Rajkot. This study was carried out under our supervision from January 2021-July 2021. We hereby certify that this work has not been submitted for any other degree to any other university.

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Project summary

The Anamalai Spiny Lizard (*Salea anamallayana*), an agamid lizard endemic to southern Western Ghats is reported to use shola and tea plantations of Kannan Devan hills of high ranges of Kerala. The Western Ghats has experienced extensive habitat destruction and modification since a very long time and the lizards are highly affected by habitat modification which in turn affect their fitness and survival.

In this study we investigated the effect of habitat modification on morphology, population and habitat association in *Salea anamallayana* in the shola forests of Eravikulam National Park and surrounding tea plantations. The study was conducted from February 2021 to May 2021.

Line transect method was used to study density and Visual encounter surveys for collecting data for basking habitat use and morphology. Surveys were conducted from 9 am to 2 pm since the lizard was more active during the time period.

Shola and plantation are structurally very different. Shola was divided into shola close to plantations and shola away from plantation. Plantation was classified according to the proximity to shola and presence of shade trees.

The density was found to be more in shola (27.59±6.79/ha) compared to plantation (8.63 ±2.21/ha). In plantations, the density was influenced by proximity to shola and presence of shade trees. Density is more in plantations in close proximity to shola (20.91±4.51/ha) compared to plantations away from shola (2.85±1.37/ha) and the lizard was present only where the shade trees were planted.

The sex ratio was biased towards male in plantations (100:14) and it improves in shola close to plantations (100:33) and further improves in shola away from plantations (100:50). The body condition of male lizards was poor in plantations compared to shola away from plantations ($t = 2.57$, $df = 14.17$, p-value = 0.021). The males do not differ in other morphological variables across the habitats. Body condition of males is better than females ($t = -2.19$, $df = 23.80$, p-value = 0.037).

The basking habitat use is in proportion to habitat availability. The microhabitat use varies across shola and plantation. Average perch height and perch diameter is more in plantation and average canopy cover is more in shola. More diverse perch surface is available and used in shola compared to plantation. The average body temperature is high in plantation compared to shola and the body temperature is directly proportional to atmospheric temperature and substrate temperature.

There is no significant difference in Flight Initiation Distance (FID) between shola and plantation. FID is inversely correlated to substrate temperature.

1. Introduction

1.1 Background

Western Ghats is one of the 36 biodiversity hotspots in the world (Myers et al., 2000). The Western Ghats spread over 0.14 million sq.km in the six southern states of Gujarat, Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala (Nair, 1991; "Western Ghats," 2021). The southern Western Ghats has the best preserved and most extensive climax vegetation in peninsular India (Nair, 1991). Mountains are very important in terms of biodiversity because it contain disproportionate number of species relative to its geographic area (Rahbek et al., 2019).

Western Ghats has a vast geographic area and is extending over many degrees of latitudes. It is highly variable in topography and climatic zones and is located at the junction of many Biogeographic regions and sub regions. All these factors contributes to its rich biodiversity (Nair, 1991). But this landscape has undergone extensive human interferences and consequently lost much of its biodiversity (Nair, 1991).

Western Ghats is rich in diversity and endemism of reptiles especially lizards. 254 species of squamates are reported from Western Ghats of which 189 species are endemic to India and 167 species are endemic to Western Ghats (Srinivasulu et al., 2021).

Human interventions have the capacity to alter the biotic and abiotic features of a landscape. It has been found that large human interventions in general has a negative impact on biodiversity (Johnson, 2001). The extension of agriculture, especially cash crops in the Western Ghats, over a short span of time has caused destruction of natural habitats and biological diversity in most of the settled areas (Nair, 1991).

Like other organisms, reptiles are also largely impacted by the human interventions leading to land use changes due to habitat loss and degradation (Driscoll, 2004). The decrease in diversity and richness due to human interventions can cause reduced fitness of the lizards (Battles et al., 2013).

Habitat modification can cause depletion and fragmentation of the habitat and homogenization of the floral and faunal community (Driscoll, 2004; Battles et al.,2013). The alteration of community structure through homogenization cause changes in the biotic interactions of the species especially the prey and predators (Battles et al.,2013). Thus a particular species can be affected directly by the disturbance through habitat loss or indirectly through altering the community structure (Battles et al.,2013).

The effects of habitat modification is well studied in the larger scale but its effects are less studied in the local scale (Crooks & Soulé, 1999). The effect of habitat modification can be different in different species depending on the home range of the species (Crooks & Soulé, 1999). Even though the home range of a lizard is small, it can be affected by habitat modification.

Salea anamallayana is an endemic lizard of southern Western Ghats and this study is focused on the effect of habitat modification on the population, body condition and behavior of the lizard. Studies on body condition, morphology, escape behaviour and thermal profiling are not available on *Salea anamallaya* till now.

1.2 Literature review

1.2.1 Body condition

A study done on Green Anole lizards (*Anolis carolinensis*) in Southeastern United States shows that body condition of the lizards is affected by higher human land use (Battles et al.,2013). The body condition of females was lower in disturbed habitat compared to natural habitat in the Green Anole lizards. This difference in body condition was not due to difference in prey availability since the prey abundance did not differ across the habitats (Battles et al.,2013).

Habitat degradation can increase the perceived risk of predators and the lizard may adjust their movement pattern to differences in risk (Amo et al., 2007). The speed of movement of the lizards in degraded habitats can be high since the predator risk is high (Amo et al., 2007). This difference in speed can affect the body condition of the lizards.

In reptiles, one significant component of the daily energy expenditure is the cost of locomotion (Christian et al., 1997). The frequent movements and high speed are costly and can increase the daily energy expenditure (Gleeson & Hancock, 2002). Since the energy expenditure is more in disturbed habitats, the body condition will be poor in degraded habitat compared to undisturbed habitat (Amo et al., 2007). Thus it can be said that behavioral strategies to cope with increased predation risk, may affect the body condition of the lizards (Amo et al., 2007).

A study comparing the body bcondition of the lizards in high and low tourism areas in Common wall lizards has found that, in high tourism areas tourism (high frequent visits of tourists), the lizards have lower body condition compared to lizards inhabiting places with low tourism (less frequent visits of tourists). This difference is due to the physiological costs due to high predatory risks in high tourism areas (Amo et al., 2006). There are also evidences from the laboratory studies which support that costs associated with frequent fleeing episodes alone can cause a decrease in body mass of lizards (Amo et al., 2007).

Poor body condition in breeding season can affect the reproductive fitness of the lizards especially in females (Cooper, 1985). Poor body condition may cause poor immune system which can make the individual more susceptible to parasites and thus negatively affect the reproductive fitness (Cooper, 1985).

In cold regions, the body condition of the lizards is also influenced by thermoregulation. The lizards which have an opportunity to reach their preferred body temperature can thermoregulate accurately and can maintain their daily activity. This can help to improve the body condition (Herczeg et al., 2006). But at the same time lizards which do not get the opportunity to reach their preferred body temperature, becomes thermoconformers and causes reduced daily activity and poor body condition (Herczeg et al., 2006).

Even though high risk to predation causes poor body condition, habituation to low risk predation stimuli may act beneficial for the lizards (Rodríguez-Prieto et al., 2010). The lizards living in areas with frequent encounters with low-risk predators when get exposed to high risk, can improve their body condition compared to lizards that are not habituated (Rodríguez-Prieto et al., 2010).

A study on *Anolis nebulosus* suggests that predation and competition can affect body condition of the lizards even if the food availability is the same (Siliceo-Cantero & García, 2014).

Lizard body condition does not always differ between sexes (Jenssen et al., 1995). The body condition difference between sexes can be affected by the energy expenditure of individuals at the time of capture (Siliceo-Cantero & García, 2014). During reproductive season, males will have to spend extra energy for attracting mates and defending territories and thus their body condition can decrease (Schlaepfer, 2006). But in females, the body condition will decrease after egg laying due to the energy expenditure for reproduction (Cox & Calsbeek, 2010).

Many lizards consider humans as potential predators and they respond in such a way that they readily escape to refuges (Amo et al., 2006). The increased antipredatory responses in response to increased predation risk can cause reduced body condition and consequently short and long term consequences on the fitness of the lizard (Amo et al., 2006).

Body condition of the lizard is also associated with its immune response. Poor body condition can cause lower cell mediated immune responses in lizards (Amo et al., 2006). Effect of tourism on the common wall lizards, *Podarcis muralis* shows that high tourism levels can cause poor body condition and increased parasite load on the lizard (Amo et al., 2006).

Even though increased frequency of exposure to humans can increase the frequency of escape behaviors, the escape behaviour of the lizard need not be get affected (Amo et al., 2006).

1.2.2 Morphology

As a group, lizards occupy a vast range of habitats worldwide, yet there remain relatively few cases where habitat use and morphology of the lizards are clearly related (Goodman et al., 2008). There is a close link between the habitat of an organism and its morphology, performance and behavior.

Arboreal lizards will have a unique microhabitat structure which makes them to has several functional demands for the locomotion including steep inclines, narrow round perches and cluttered, obstacle-filled pathways. Increased inclines increase energetic cost of locomotion (Spezzano & Jayne, 2004). Studies done on the lizard

Anolis sagrei shows an influence of perch diameter and inclines on the hind limb kinematics (Spezzano & Jayne, 2004).

Different ecological requirements will lead to different organismal designs (morphology) which is explained by the ecomorphological theory (Tulli et al., 2011). Limb length, hooks, claws, adhesive pads, etc. are the specialized traits of the locomotor system which can have an influence on the locomotion of the lizard (Tulli et al., 2009). Organisms can expand their ecological niche by using these specialized traits. Thus, variation in habitat use and locomotor performance should be correlated with morphology (Tulli et al., 2009). Arboreal lizards will have higher and more sharply curved claws compared to lizards that occur in sandy soils (Tulli et al., 2009). Claw height and length are important morphological variables related to microhabitat use. Claw height helps to increase the frictional grip on arboreal substrates and thus helps in exploring arboreal niche (Tulli et al., 2009).

1.2.3 Flight Initiation Distance

Predation is one of the important threats to the survival of any organisms. Thus different organisms including lizards have evolved different antipredatory strategies to minimize the risk of mortality (Batabyal et al., 2017). The most typical response in animals in response to an approaching predator is to flee. Flight initiation distance (FID) is defined as the distance between a potential threat and the prey at the onset of escape (Batabyal et al., 2017). Thus FID is a widely used measure of antipredator responsiveness (Batabyal et al., 2017). Escape strategies of animals are economic decisions, and it varies as a function of both intrinsic and extrinsic factors (Ydenberg & Dill, 1986).

FID is an economic decision and it depends on the cost of fleeing. FID will increase as predation risk increases and will decrease as the cost of escape increases (Ydenberg & Dill, 1986). If the prey behaves optimally, it is expected that the FID will increase with predation risk (Cooper & Frederick 2007). Also it is found that frequent exposure to low-risk threats can result in habituation of escape responses through learning (Frid & Dill, 2002; Engelhardt & Weladji, 2011).

FID is generally greater in modified habitats for lizards, and it is also found that inmodified habitats the sprint speed is significantly faster than lizards in natural habitats (Prosser, Hudson, & Thompson, 2006). In open habitats, lizards will be more exposed to predators and this will be compensated by longer FID or faster escape speeds (Prosser, Hudson, & Thompson, 2006). FID can be influenced by approach direction and gaze. In the lizard *Psammophilus dorsalis*, FID is influenced by gaze and approach direction. It is because the lizard modulate its escape behaviour assessing the relative risk. It is also found that the FID of the lizards can be influenced by the sex and age class of the lizards (Sreekar & Quader, 2013).

1.2.4 Thermal profiling

It is found that in the lizard *Crotaphytus collaris* FID is negatively correlated with substrate temperature (Braun et al., 2010). The locomotory abilities of ectotherms are diminished at lower ambient temperatures (Braun et al., 2010). Thus compared to other animals, ectotherms are more vulnerable to predation.

1.3 Anamalai Spiny Lizard (*Salea anamallayana*)

Draconine agamid lizard *Salea anamallayana* is endemic to Western ghats (Das et al., 2019). *Salea anamallayana*, was first described as *Lophosalea anamallayana* by Beddome (1878) from the Anamalai hills. Boulenger (1885) assigned this species to the genus *Salea*. *Salea anamallayana* is found in Western Ghats, south of the Palghat gap (Das, 2002; Srinivas, Bhupathy, & Madhivanan, 2008). It has so far been recorded from Meghamalai, Palni, Anaimalai and Travancore hill ranges (Das, 2002; Srinivas, Bhupathy, & Madhivanan, 2008). It is found between the altitude range of 1700–2500m asl(Bhupathy & Kannan, 1997; Srinivasulu *et al.* 2014).

The lizard is found in the shola forests and tea plantations of Munnar region of kerala (Deepak & Vasudevan, 2008). Density of the species is almost the same in tea plantations and its original habitat, shola forest of Eravikulam National Park, Kerala (Deepak & Vasudevan, 2008). The lizard was not recorded from mid-elevation evergreen forests and Eucalyptus plantations of areas surrounding Eravikulam national park.

Salea anamallayana is a slow moving, arboreal, insectivorous lizard which and is active during the daytime (Das 2002). It is a spectacularly ornamented lizard (Ord & Stuart-Fox, 2006) but are having cryptic coloration (Deepak & Vasudevan, 2008). The lizard is sexually dimorphic (Smith, 1935). Males are characterized by a large crest that extends to the tail while females have a small crest (Deepak & Vasudevan, 2008). The juveniles are small and lack a crest (Deepak & Vasudevan, 2008) (Fig.1).

The egg laying season is April (Bhupathy & Kannan, 1997). The female produces up to 3 clutches with each clutch consisting of 3–5 eggs (Bhupathy & Kannan, 1997; I. Das, 2002).

The microhabitat variables like perch tree height, perch height, perch thickness, moisture, altitude, temperature and canopy opening does not affect the sightings of the lizard in the age - sex classes (Deepak & Vasudevan, 2008).

Head bobbing and push up behaviors were observed in male lizards as display when they come near to female lizards during breeding season. The males also extend their gular fold and arrange sitting position in such a way they become more visible to predators. Male and female pairs were sighted during the month of March both in shola (three pairs) and plantation (three pairs). Juveniles and gravid females were sighted in April. One pair was sighted in a shola close to plantation for three consecutive days in the same location. The total movement of the pair in three days was restricted within five meter radius. The male displayed head bobbing and push up behaviors and approached the female but breeding was not reported (personal observation).

In the high altitudes of the study area, above 1600m, *Salea anamallayana* was the only arboreal lizard observed. But at altitudes around 1500m asl in the western side of the Western Ghats it is found to share habitat with *Moniliesaurus ellioti*. The lowest recorded altitude for *Salea anamallayana* in the study area was 1477m asl and highest recorded elevation is 2199 m asl. On the eastern aspect of Western Ghats around 1500m asl, *Salea anamallayana* was absent (personal observation).

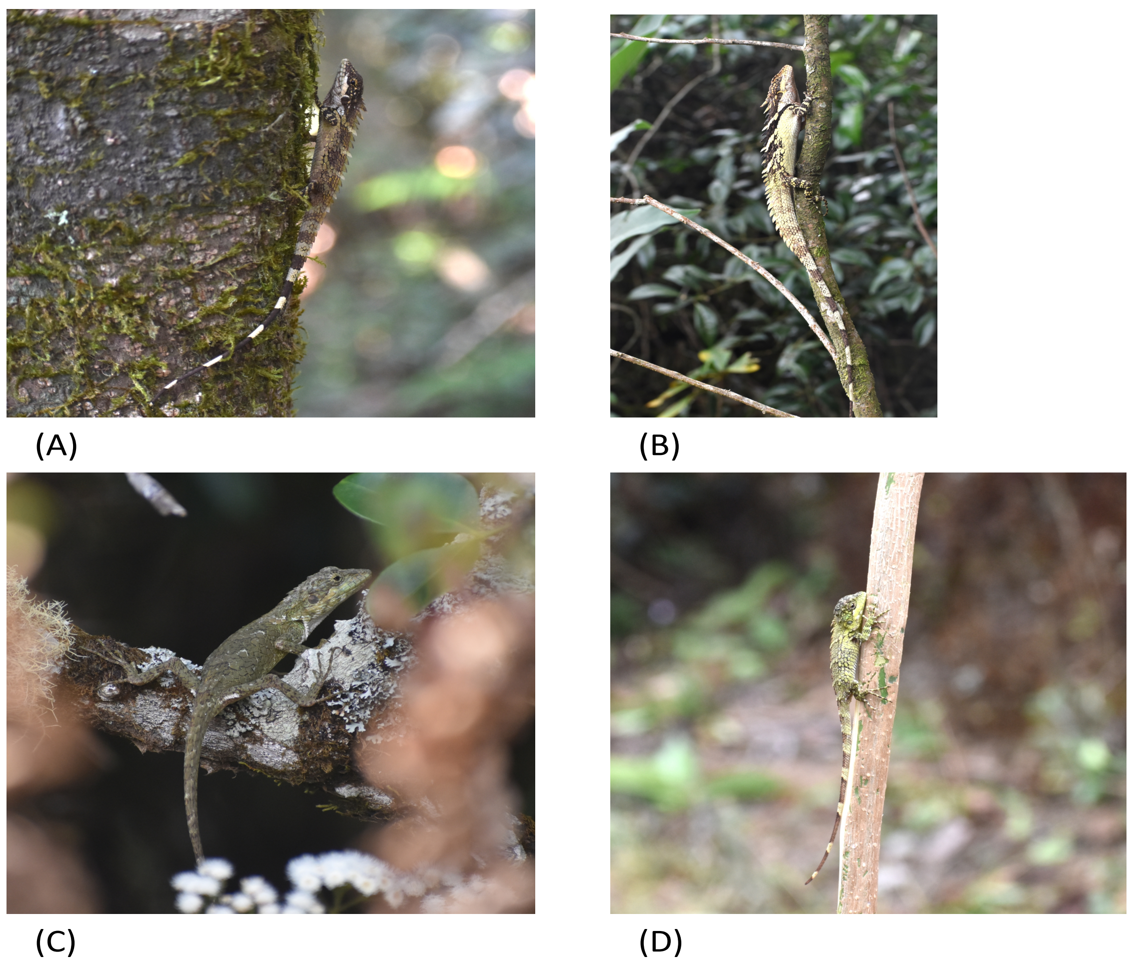


Figure 1. Different age-sex classes of *Salea anamallayana* (A- Adult male, B- Adult male, C- Adult female, D- Juvenile)

1.4 Aim

The study investigates effect of habitat modification on morphology, population and habitat association in endemic *Salea anamallayana* in a mosaic landscape in southern Western Ghats

1.5 Objectives

1. To study the effect of modified habitat on body condition, sex ratio and thermal profiling of Anamalai Spiny Lizard
2. To determine the factors influencing density of Anamalai Spiny Lizard across a disturbance gradient
3. To determine the microhabitat use of Anamalai Spiny Lizard in the modified and unmodified habitats
4. To determine the effect of habitat modification on escape behaviour

1.6 Hypothesis

1. Density will be more in shola and plantation near shola compared to tea plantations
2. Body condition and sex ratio will be poor in tea plantations compared to shola forests away from plantations
3. Habitat use will be in proportion to habitat availability
4. Flight Initiation Distance will be more in plantations compared to shola

1.7 Research questions

1. Does density of the lizard in plantation vary in response to proximity to shola and presence of shade trees?
2. Does habitat modification influence body condition of Anamalai Spiny Lizard?
3. Does basking habitat use vary in the modified and unmodified habitats?
4. Does Flight Initiation Distance vary with habitat modification?

2. Methodology

2.1 Study design and field methods

Two different habitats, natural shola and tea plantations were selected for the study. The shola was further classified into shola close to plantations and shola away from the plantations. Due to the unique land use pattern of the study area, shola and tea plantations were found very close to each other outside the protected area and inside the protected area, the shola is very far from the plantations. Outside the protected area, the shola and plantations are found on the same elevations (1470 - 1900 msl) and the shola inside the protected area is higher in elevation (1890 - 2200 msl).

2.1.1 Density comparison

Distance sampling using the transect surveys and visual encounter surveys were used for detecting the lizard. Sampling was carried out from 24 January 2021 to 27 April 2021 during the day time within the time frame 10 am to 2 pm. Line transect methodology was used to estimate the density of the lizard (Deepak & Vasudevan, 2008). Line transects of length 100m were laid randomly in each of the three habitats. Total 35 transects were laid in plantations and 22 in shola forests.

The plantation was categorized into two groups according to the proximity to shola forests. The first category included plantations within 300m away from shola forests and the second category includes plantations 300 to 600m away from shola.

Only those transects that were laid in plantations with silver oak is considered for the analysis. Total 13 transects in plantations close to shola and nine transects in plantations away from shola is used for the study.

The plantation was further classified into those with shade trees (Silver Oak) and those without shade trees to study the influence of shade trees on the lizard density. Ten transects were in plantations without silver oak and 25 transects in plantation with silver oak.

To find the density, the shola forests were classified into shola away from plantations and shola close to plantations. Thirteen transects were laid in shola close to plantations and nine transects in shola away from plantations.

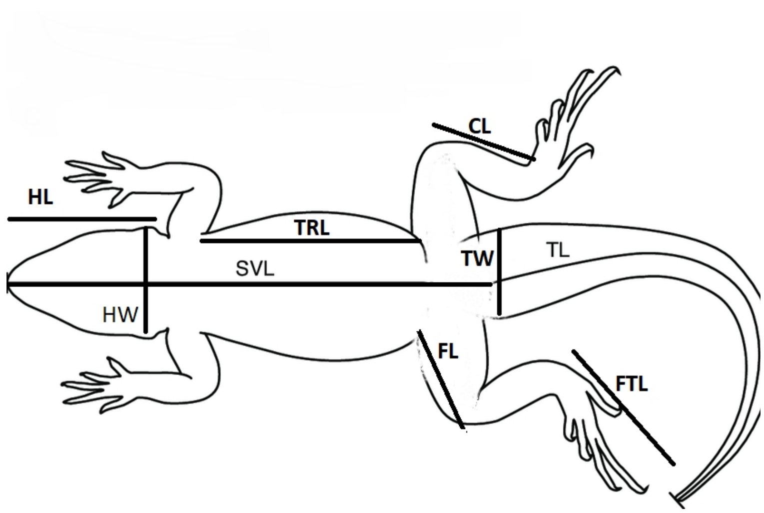
The line transects were laid in such a manner that it is distributed in all the habitat categories. Sampling was carried out from 31 January 2021 to 27 April 2021 during the day time within the time frame 10 am to 2 pm. Three to five pseudo-replications were done for each transect.

2.1.2 Morphology and basking habitat use

Diurnal visual encounter surveys were conducted for collecting morphology and habitat data. Sampling was done from 9 am to 2 pm which is the basking time for the lizard and is easier to be sighted. Every time a lizard is encountered the sex and age class is noted along with habitat variables including canopy cover, perch height, perch surface and height and girth of the tree and climatic variables including atmospheric temperature and humidity. Surface temperature and body temperature is also measured using digital psychrometer (Extech RH401).

For measuring morphological variables, the lizards were caught either by hand or using a noose. After taking the measurements the lizards were released in the same location. The lizard were marked using a permanent marker to avoid recapture of the same individual.

The parameters measured include: Weight, Snout to vent length (SVL), Tail Length, Tail width (base of tail), Trunk Length, Head length, Head width, Ocular diameter (eye socket), Femur Length, Crus Length, Foot Length and 5thToe length (Fig. 2).



SVL – Snout to vent length	HW - Head width
TL - Tail Length	FL - Femur Length
TW - Tail width	CL - Crus Length
TRL - Trunk Length	FTL - Foot Length
HL - Head length	

Figure 2. Morphological variables of the lizard collected for the study

Body condition (mass/SVL ratio) was compared between lizards of plantations, shola close to plantations and shola away from plantations. Only males from three habitats were compared for body condition analysis.

2.1.3 Habitat characterization

To understand the structural difference of the two habitats (shola and plantation), vegetation sampling was done in each habitat using vegetation plots of 10 × 10 m size.

The variables measured include number of trees, height of trees, Girth at breast height of trees, number of shrubs, height of shrubs, number of herbs, number of liana, number of rocks, percentage grass cover, percentage litter cover, canopy cover and tree pruning.

2.1.4 Flight initiation distance

To determine the effect of habitat modification on the behaviour of the Anamalai Spiny Lizard, we looked at the escape behaviour of the lizard in response to a simulated predator attacks by the observer.

To find out the FID, only lizards that are initially 5 m away from the observer was selected for simulated predator attacks (Batabyal et al., 2017). The individuals were first sighted using binoculars. Then the lizard was approached slowly and the distance at which the species starts moving is recorded. All predator attacks was simulated by the same observer wearing the same colored clothes and approached each lizard at an approximate speed of 1.5 m/s directly in a straight line. Other variables recorded include: Atmospheric temperature, Humidity, age class, Sex, Time of the day and Activity.

2.2 Analytical methods

The density data was analyzed using DISTANCE (version 7.3) software. The data was run separately for each category and the model with least AIC value was chosen from each category. Confidence interval s expressed in standard error.

To differentiate between the two habitats (tea plantations and shola forests) based on biotic habitat variables, Principal Component Analysis method (PCA) was used. PCA was also used for comparing the morphology between males and females, morphology between males of the two habitats and the biotic microhabitat variables between the two habitats. It was performed with R (version 1.4.1717) using the package ggbiplot (version 0.55).

Morphological variables were directly used for PCA when males of two habitats were compared since there was no significant difference between Snout to Vent lengths of the two population. When the morphology of males and females were compared using PCA, the ratio of morphological variables to SVL was used to avoid correlation between morphological variables and SVL since there was significant difference between SVL of males and females.

To compare the basking habitat use, different microhabitat variables were classified into different groups and compared between habitats. Perch height was classified into classes of 50 cm, perch diameter into classes of 10 cm and canopy cover into classes of 10 percent canopy cover. Perch surface was classified into Tree trunk, Tree branch, Shrub, herb, liana and ground.

Body temperature distribution was compared between shola and plantation using R (version 1.4.1717) and correlation with substrate temperature and atmospheric temperature is tested.

To compare between habitat use and availability, tree height and tree GBH were considered as the variables. Perch tree height was compared between the general tree height and perch GBH to the general tree GBH of the plot used for habitat characterization. Only trees with height more than 3m and GBH more than 15 cm was considered for the analysis. Tree height was classified into classes of 5m and Tree GBH into classes of 15cm for the analysis.

Flight Initiation Distance was compared between the modified and unmodified habitats using Wilcoxon rank sum and correlation of FID with substrate temperature is also tested.

R (version 1.4.1717) was used for all the analyses. Shapiro Wilk test and QQ plots were used to test the normality of the data. If the data was normal parametric tests (Welch Two Sample t-test) and when the data was non-normal, non-parametric test (Wilcoxon rank sum test) was done to compare between two datasets. Confidence interval is expressed in standard deviation. Significance was tested with 95%

confidence interval. And all graphical representations were prepared using the R (version 1.4.1717) software and package ggplot2 (version 3.3.3)

3. Study area

The study areas include Eravikulam National Park (ENP) in Idukki district of Kerala along with tea plantations in Munnar which is part of the Western Ghats (Fig. 3).

ENP is located in the High Ranges of the Southern Western Ghats in the Devikulam Taluk of Idukki district, Kerala State between 10º 05' - 10º 20' N Latitude and 77º 0' - 77º 10' E Longitude. ENP covers an area of 97 km^2. The national park is mostly consisting of high altitude grasslands that are interspersed with sholas.

The high ranges of Kerala is divided into three subregions, the Kannan Devan Hills, eastern Anjanad valley and Pooyamkutty – Idamalayar valleys. The study area falls under Kannan Devan Hill region of southern Western Ghats (Nair, 1991).

The Park experiences tropical montane climate. The influence of altitude over tropical latitude brings about the characteristic climate. The monsoon is a dominant season in the region. The year consists of four seasons: winter (December to February), summer or pre-monsoon (March to May), South – West monsoon (June to August) and North - East monsoon (September to November).

From January till May, the mean daily maximum temperature rises but drops abruptly with the onset of monsoon in June. The maximum temperature is the lowest during the monsoon, which is caused by the lack of penetration of solar radiation in the sholas. After the monsoon the maximum temperature rises again slightly. The lowest minimum temperatures are during the winter. The winter is from December till February. Frost is a common during winter.

Anamudi is the highest peak in Southern Western Ghats. Eravikulam National Park is situated around this peak (Nair, 2001). The National Park is a biologically rich area and is sheltered on all sides by rocky cliffs. This region contains many relict plants such as *Rhododendron* and animals such as Nilgiri Tahr. High altitude regions of the park is characterised by grassland and sholas vegetation (Nair, 2001). Sholas are generally found in sheltered valleys, hollows and depressions. Tea and cardamom plantations in this tract has caused discontinuity in forest (Nair, 2001).

Shola forests are seen as isolated patches interspersed with stretches of grasslands in Eravikulam National Park. Elevation of the region goes up to 2600 m. The vegetation of the region is a mixture of grassland and Southern montane temperate forest (Nair, 2001). Major plant communities found in the park are grasslands, shrub land and shola forests. Shrub lands are seen along the bases of the cliffs (Management plan ENP, 2012). Around 60% of the area is covered by grasslands, 25% by shola forests, 8.45% by southern sub tropical hill forest and 7.5% constitute the shrubs (Menon, 1997). Sholas are evergreen forests characterized by stunted trees with dense crown, closed canopy and small coriacious leaves.The patch size of shola in Eravikulam ranges between 1-300 ha. (Babu, 1998).

The major tree species of the shola of Eravikulam includes *Chionanthus ramiflorus, Cinnamomum sulphuratum, Cinnamomum wightii, Glochidion neilgherrense, Gomphandra coriacea, Ilex gardneriana, Lasianthus accuminatus, Litsea bourdillonii, Litsea wightiana, Microtropis ramiflora, Neolitsea scrobiculata,* *Pavetta breviflora, Psychotria elongata,Isonandra perrottetiana, Saprosma foetens and Syzygium densiflorum* (Nair, 2001) .

49 species of mammals, 132 species of birds, 20 species of amphibian and 101 species of Butterflies, 13 species of reptiles and four species of fishes have been recorded from the Park (Management plan ENP, 2012).

Many streams passes through the landscape. Almost all the streams are perennial. They become tributaries of Periyar and Chalakudiyar in the west and Pambar in the east. Bheemanauda, an artificial lake is created before the formation of the National Park (Management plan ENP, 2012.).

Shola inside the national park is very far from plantation (>500m) but there are shola outside the boundary of national park which is very close to shola. These two shola have been classified as shola away from plantation and shola close to plantation in the study.

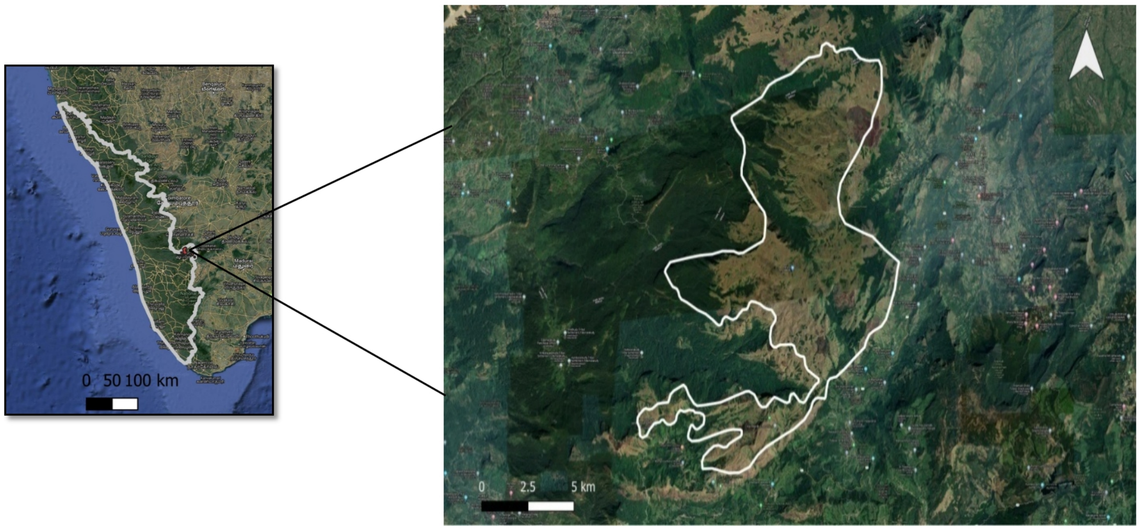


Figure 3. Map showing the study area- Eravikulam National Park and surrounding tea plantations, Kerala

The hills surrounding the National Parks are used for cultivation of tea since past 90 years (Deepak & Vasudevan, 2008). The Kannan Devan Hills and surrounding areas are the largest tea producing area in south India (14,000 ha) (Karunakaran et al., 2015). *Camellia sinensis* is the tea species growing in these plantations. In most of the plantations, surrounding the Eravikulam National Park where the study was conducted, they have maintained fragmented patches of shola in every 200-300m of tea plantation. Silver Oak (*Grevillea robusta*) is planted as shade trees and wind breaks in plantations. Silver Oak is periodically pruned and maintained at a height of around eight meters.

Tea gardens retain several interspersed forest fragments which act as corridor or sheltered habitat for many plant and animal groups of the landscape (Karunakaran et al., 2015). The management practices in the tea garden also have negative impact to the biodiversity of the area (Karunakaran et al., 2015).

The tea gardens are one of the most used habitats by wild animals. The presence of shola patches in the tea gardens provide excellent cover for many animals. Hence both large and small including elephants are commonly found in many of these estates. They move very frequently through the estates and sometime the chemically intensive tea industry pose problem for the proper habitat utilization of these species (Karunakaran et al., 2015). The gardens are also used by herpetofauna and Fourteen species of anurans were recorded from tea plantations of Munnar (Eluvathingal, 2016).

The study was conducted in four divisions of Kannan Devan Hills Plantations (KDHP) named Rajamala, Nemakkad, Thenmalai and Kadalar divisions.

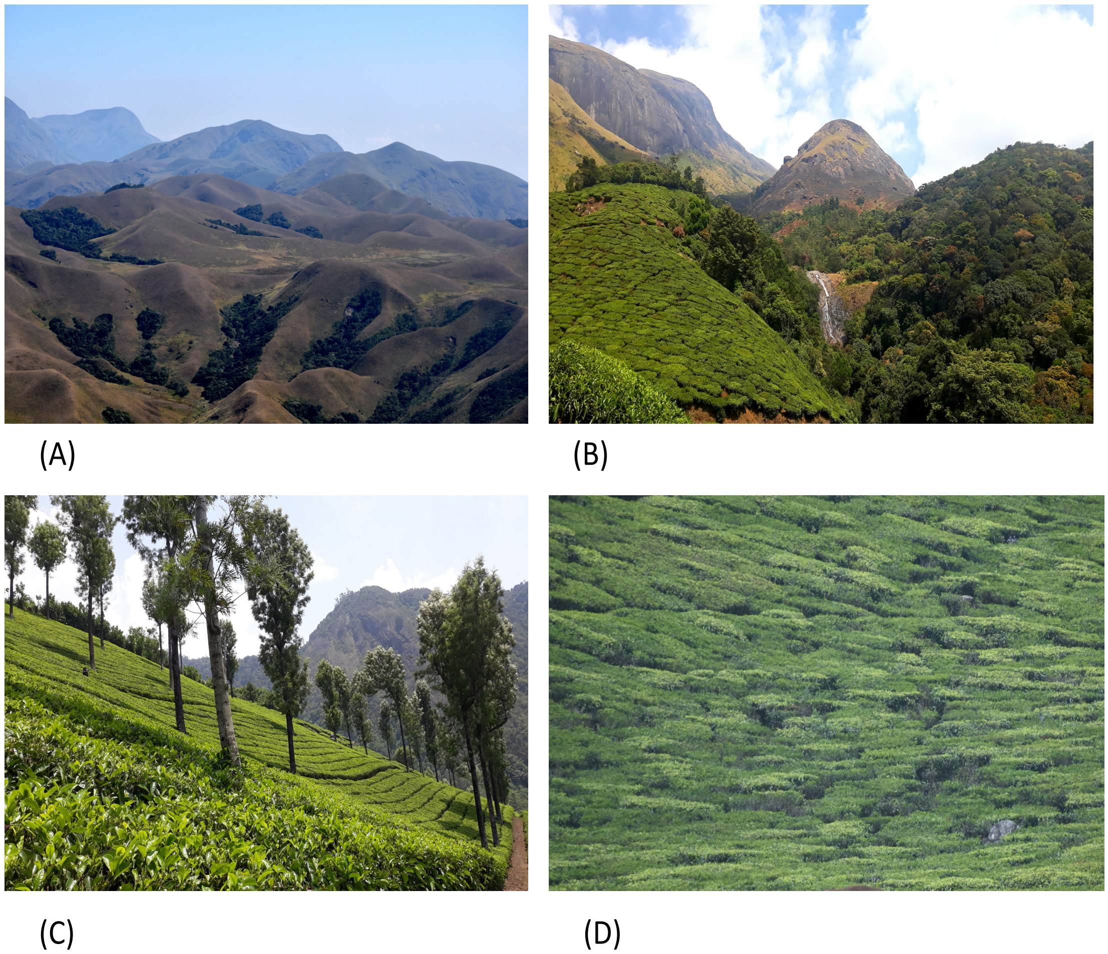


Figure 4. Study area showing different habitats (A – Shola away from plantation, B – Shola close to plantation, C – Tea plantation with shade trees, D – Tea plantation without shade trees

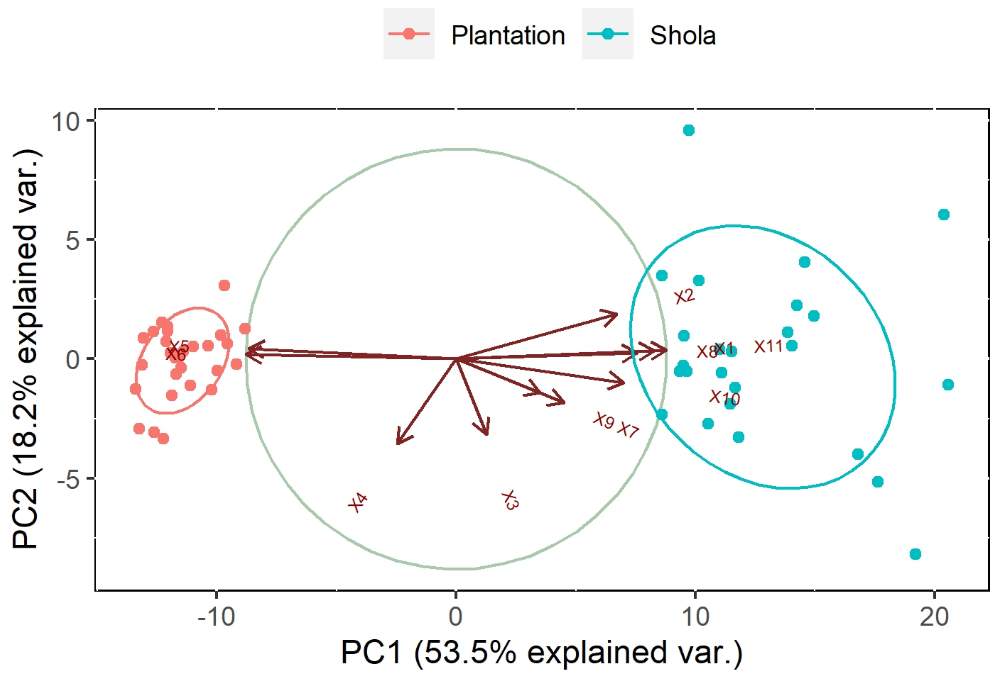
4. Results

4.1 Habitat characterization

Principal Component Analysis done between habitat variables of shola forest and tea plantation shows that the two habitats are distinct since there is no overlap between the two in the graph (Fig. 5). PC1 explains 53.3 percent of variance and PC2 explains 18.2 percent variance.

Tree pruning and high shrub density are the plantation characters, while herb number, canopy cover, litter percentage, Tree density, grass cover, and average shrub height characterizes shola forests. Liana is present only in shola forests. Average tree height and average tree GBH doesn't fit properly in either of the two categories.

Canopy cover, tree number, tree pruning, shrub number, herb number and grass and litter percent explains the distribution of the data well which is indicated by the length of the arrow.



1 - Canopy cover	2 - Tree number	3 - Tree height	4 - Tree GBH
5 - Tree pruning	6 - Shrub number	7 - Shrub height	8 - Herb number
9 - Liana number	10 - Grass percent	11 - Litter percent	

Figure 5. Principal Component Analysis graph between habitat variables of Shola and Plantation

4.2 Sex ratio

A total of 160 individuals of Anamalai Spiny Lizard were sighted during the entire study period. Out of it, sex was identified for 147 individuals, and age class identified for 149 individuals. Individuals of all three age classes, including adult, sub-adult and juveniles, were sighted.

Maximum number of individuals sighted was in the adult category (94 percent). The number of sub adults (five percent) and juveniles (one percent) were comparatively less (Table 1).

Adults and sub-adults were observed in both habitats, but juveniles were observed only in plantations. Both juveniles were sighted in the month of April.

	Adult	Subadult	Juvenile	Age class unidentified	Total
Male	114	7	0	0	121
Female	26	0	0	0	26
Sex unidentified	0	0	2	11	13
Total	140	7	2	11	160

Table 1. Number of individuals sighted in different sex and age classes

The sex ratio is skewed towards males in both habitats. However, it is better in shola (100:33) compared to plantations (100:14). Within the shola habitat, the sex ratio was higher in shola away from plantations (100:50) than shola close to plantations (100:29) (Fig. 6).

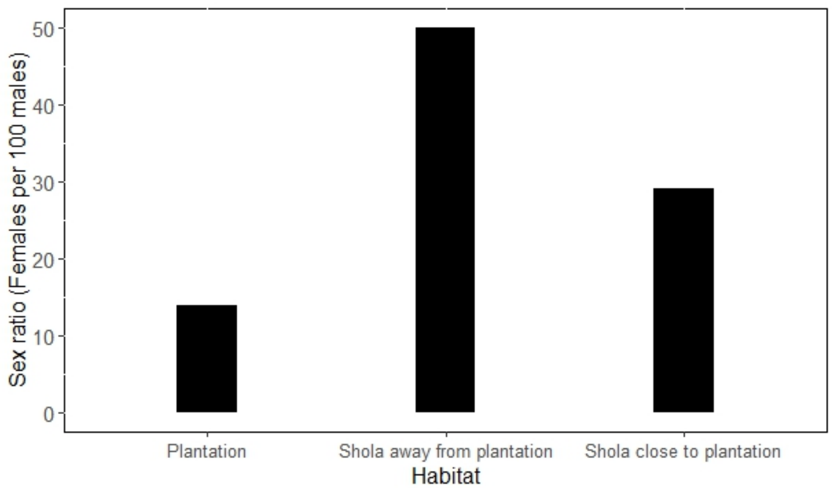


Figure 6. Graph showing sex ratio (females per 100 males) in different habitats

4.3 Density

4.3.1 Density comparison between the habitats

Compared to plantations (8.63±2.21/ha), shola (27.59±6.79/ha) has a higher density of lizards. Nevertheless, within shola, the density varies between shola close to plantations (26.37±4.93/ha) and shola away from plantations (12.29±4.45/ha) (Fig.7). The detection probability in plantations is 12.2, and in shola, it is 71.3. Within shola, it is more in shola close to plantations (53.6) than shola away from plantations (40.9).

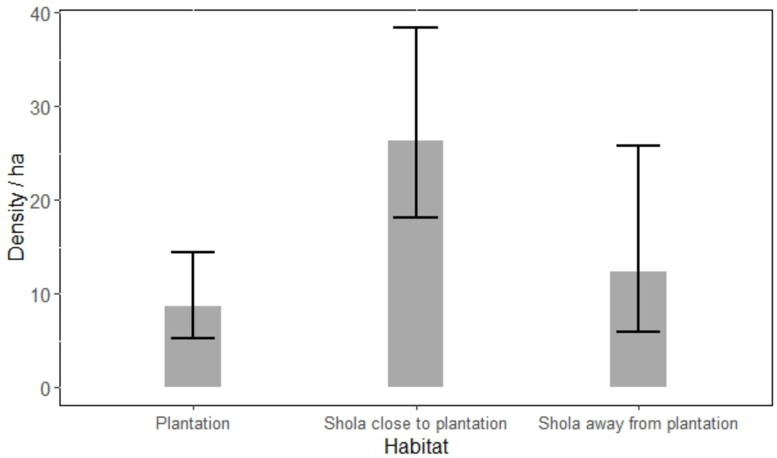


Figure 7. Density (Number of individuals per hectare) comparison between habitats

4.3.2 Influence of proximity to shola on the density of lizards in plantations

In plantations that are close to shola (within 300m), the density is more (20.91±4.51/ha) than plantations away (300 to 600m) from shola (2.85±1.37/ha) (Fig.8). Detection probability is more in plantations between 300 and 600m (28.3) than plantation within 300m (20.3) to shola.

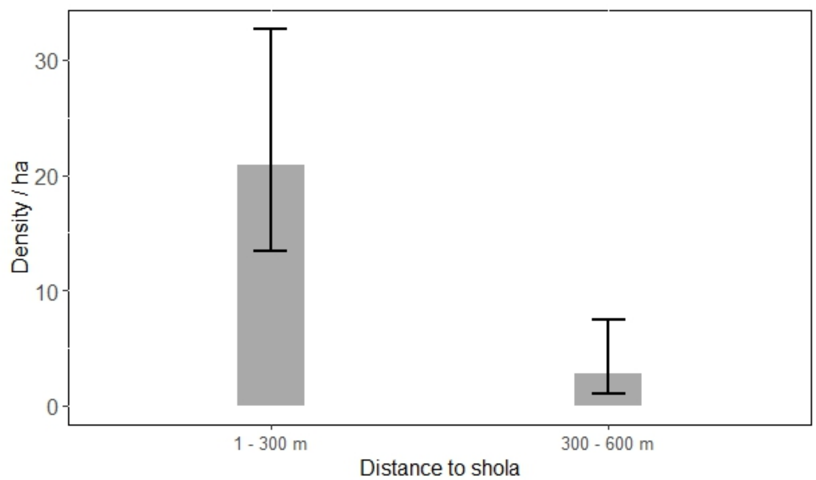


Figure 8. Density of the lizard in plantation with respect to proximity to shola (within 300m from shola and from 300 to 600m from shola)

4.3.3 Influence of shade trees on the density of the lizards in plantations

When only plantations with shades trees were considered, the density of the lizard is 12.08±2.82/ha, but in plantations without silver oak, it is zero (Fig.9).

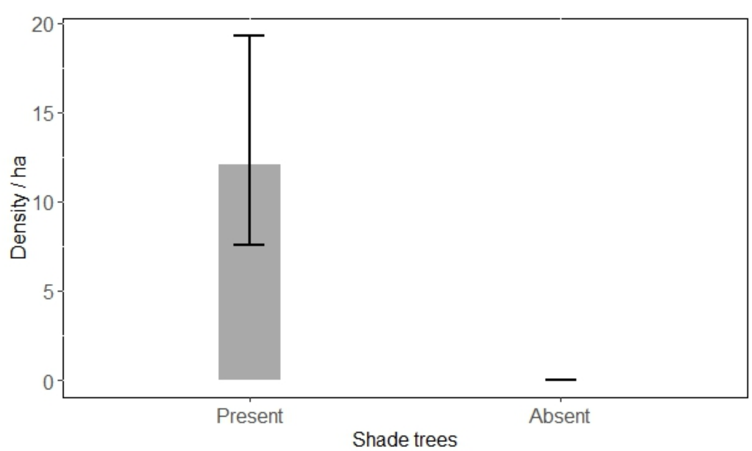


Figure 9. Density of the lizard in plantation where shade trees are present and absent

Transect	Density (per hectare)	standard error	No. of observations	No. of transects	Detection probability	Effective Strip Width (cm)
PLANTATION						
Plantation – all transects combined	8.6289	2.2122	57	35	12.2	943.67
Plantation with Silver Oak	12.081	2.8205	57	25	14.7	943
Plantation with Silver Oak within 300m from shola	20.909	4.5086	48	13	20.3	882.95
Plantation with Silver Oak between 300m to 600m away from shola	2.8499	1.3668	12	9	28.3	1315.9
Plantation without silver oak	0		0	10		
SHOLA						
Shola – all transects combined	27.589	6.7928	37	22	71.3	304.8
Shola close to plantations	26.373	4.9349	27	13	53.6	393.76
Shola far away from plantations	12.286	4.4473	10	9	40.9	452.2

Table 2 Density of the lizard with respect to different habitat classifications calculated using DISTANCE software

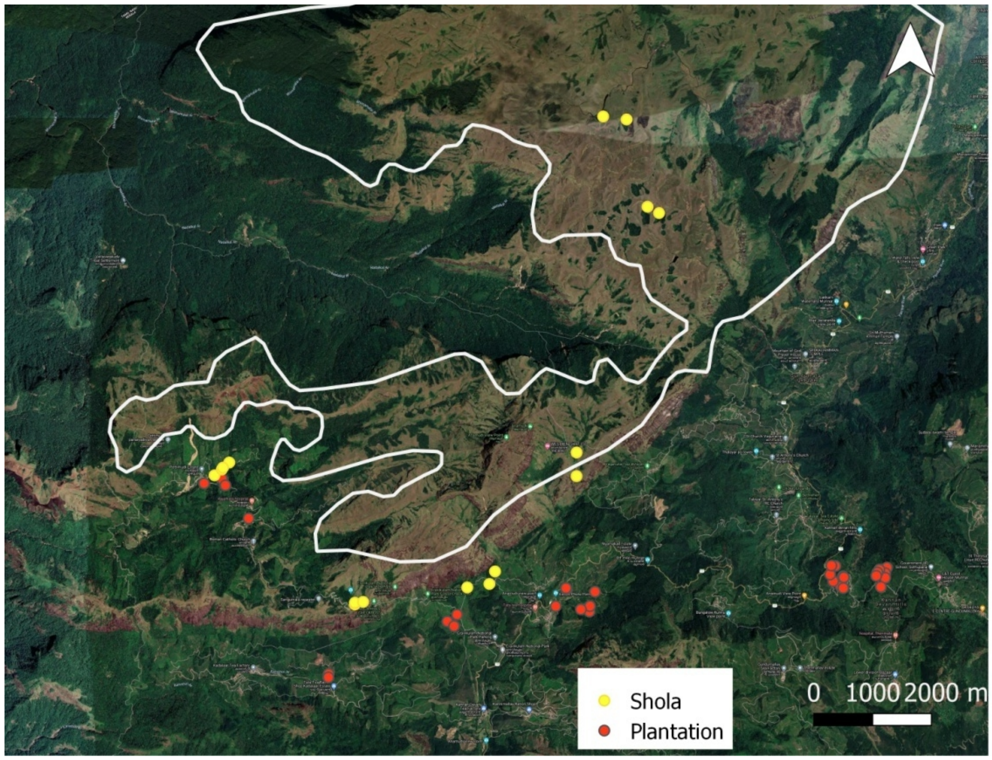


Figure 10. Map showing distribution of transects in shola and plantation

4.4 Body condition and morphology

4.4.1 Body condition comparison between habitats

Welch Two Sample t-test done using body condition data suggests a significant difference in the body condition of males between lizards of plantation and shola away from plantations (t = 2.57, df = 14.17, p-value = 0.021) and between lizards of shola close to plantation and shola away from plantation (t = -2.72, df = 23.14, p-value = 0.011). But there is no significant difference between plantation and shola close to plantations (t = 0.68, df = 38.25, p-value = 0.49).

The body condition of shola away from plantations (N=10, mean=0.21, SD=0.04) is significantly higher compared to plantation (N=16, mean=0.18, SD=0.03) and shola close to plantation (N=26, mean=0.17, SD=0.06) (Fig.9).

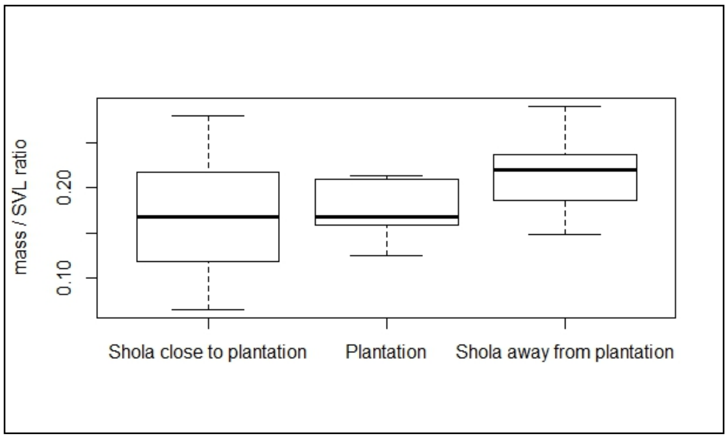


Figure 11. Body condition (Weight/SVL ratio)comparison between habitats

4.4.2 Body condition comparison between sexes

Welch Two Sample t-test shows that body condition of males (N=48, mean=0.15, SD=0.03) is significantly higher (t = -2.19, df = 23.80, p-value = 0.037) compared to body condition of females (N=11, mean=0.18, SD=0.05) (Fig.12).

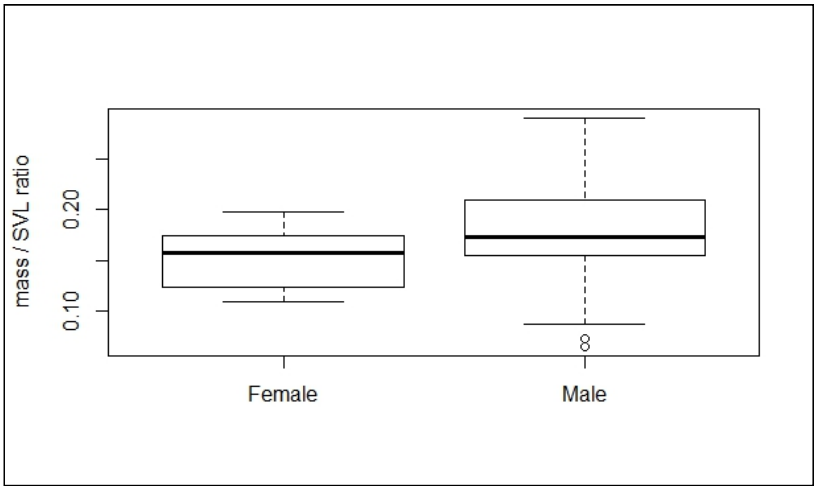


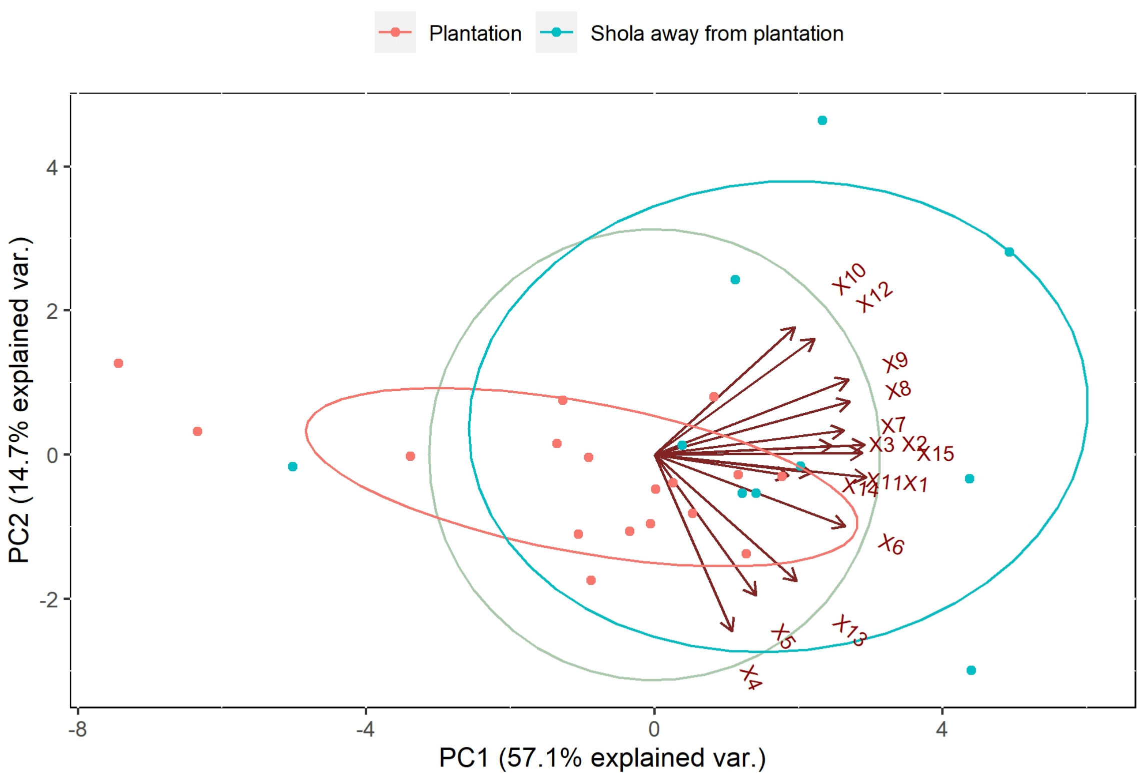
Figure 12. Body condition comparison between adult males and females

4.4.3 Morphological difference of male lizards between habitats

All morphological variables are positively correlated to SVL and there is no significant difference between SVL of plantation and shola away from plantation (Wilcoxon rank sum test with continuity correction, W = 61.5, p-value = 0.24).

PCA graph shows that there is high overlap between morphological variables of lizards of plantations and shola away from plantations. And there are no specific variables that can be used for differentiating between the two populations morphologically since all variables are directed towards one side (Fig.13).

PC1 explains 57.1 percent variance while PC2 explains 14.7 percent variance.



1 - Head Length	2 - Head width	3 - Head height	4 - Gular length	5 - Trunk length
6 - SVL	7 - Femur length	8 - Crus length	9 - Foot length	10 - 5th toe length
11 - Tail length	12 - Tail width	13 - Tail Height	14 – Ocular diameter	15 - Weight

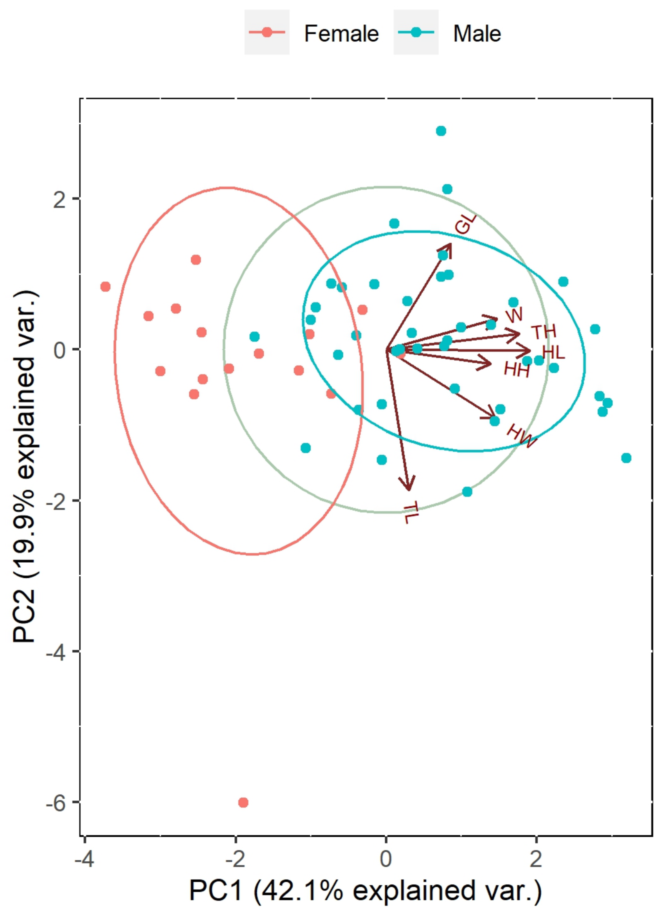
Figure 13. Principal Component Analysis graph between morphological variables of males of plantation and shola away from plantation

4.4.4 Sexual differences in morphology

All morphological variables are positively correlated to SVL. Wilcoxon rank sum test with continuity correction shows that there is significant difference between SVL of male and female lizards (W = 540, p-value = 0.00017).

When the ratio of different morphological variables to SVL was considered, it is found that Head length/SVL ratio ($t = 167.94$, $df = 64$, p-value $< 2.2e-16$), Head width/SVL ratio ($W = 592$, p-value $= 0.0018$), Head height/SVL ratio ($t = 3.15$, $df = 36.63$, p-value $= 0.0032$), Tail length/SVL ratio ($W = 455$, p-value $= 0.02$), Tail height/SVL ratio ($t = 8.07$, $df = 42.16$, p-value $= 4.332e-10$), Gular length/SVL ratio ($W = 581$, p-value $= 0.003$) and Body weight/SVL ratio ($t = 3.64$, $df = 28.91$, p-value $= 0.0010$) are significantly different for male and female lizards (Fig.12) (Refer Table 2 in appendix).

Trunk Length/SVL ratio ($t = -0.53$, $df = 27.45$, p-value $= 0.59$), Femur Length/SVL ratio ($W = 435$, p-value $= 0.52$), Crus length/SVL ratio ($W = 468$, p-value $= 0.25$), Foot length/SVL ratio ($W = 334.5$, p-value $= 0.51$), 5th toe length/SVL ratio ($t = -1.73$, $df = 24.57$, p-value $= 0.094$), Tail width/SVL ratio ($W = 466$, p-value $= 0.15$)and Ocular diameter/SVL ratio ($t = -1.047$, $df = 31.74$, p-value $= 0.30$) didn’t show any significant difference between the sexes.



HL - Head Length / SVL	HW - Head width / SVL	HH - Head height / SVL	GL - Gular length / SVL
TL - Tail length / SVL	TH - Tail Height / SVL	W – Weight / SVL	

Figure 14. Principal Component Analysis graph of morphological variable to SVL ratio between sexes

4.5 Thermal profiling

Body temperature range of the lizard is wider in shola (17 to 29.5 degree) compared to plantation (21.2 to 28.5 degree). Also Welch Two Sample t-test shows that the body temperature is significantly higher in plantation compared to shola ($t = -2.11$, $df = 39.28$, p-value = 0.040) (Fig.15).

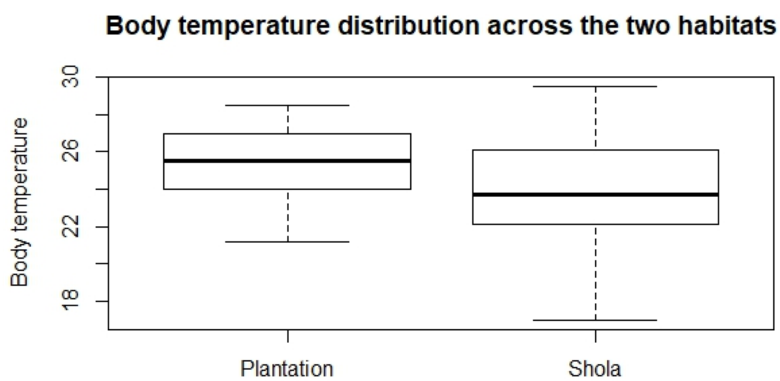


Figure 15. Body temperature distribution across plantation and shola

Body temperature is positively correlated to substrate temperature (cor - 0.38, $t = 3.04$, $df = 52$, p-value = 0.003) and atmospheric temperature (cor -0.47, $t = 3.56$, $df = 43$, p-value = 0.0008) (Fig.16).

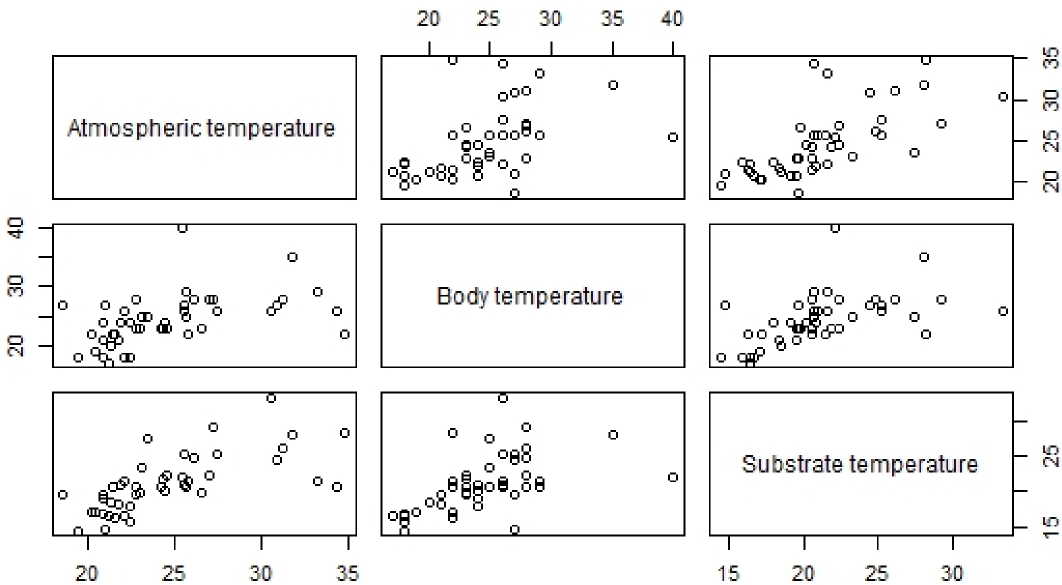


Figure 16. Graph showing correlation between body temperature, substrate temperature and atmospheric temperature

4.6 Basking habitat use

PCA shows an overlap between basking microhabitat use in shola and plantation. Shola is characterized by canopy cover and plantation is characterized by perch diameter. PC1 Explains 50.1 percent and PC2 explains 29.0 percent variance (Fig.17).

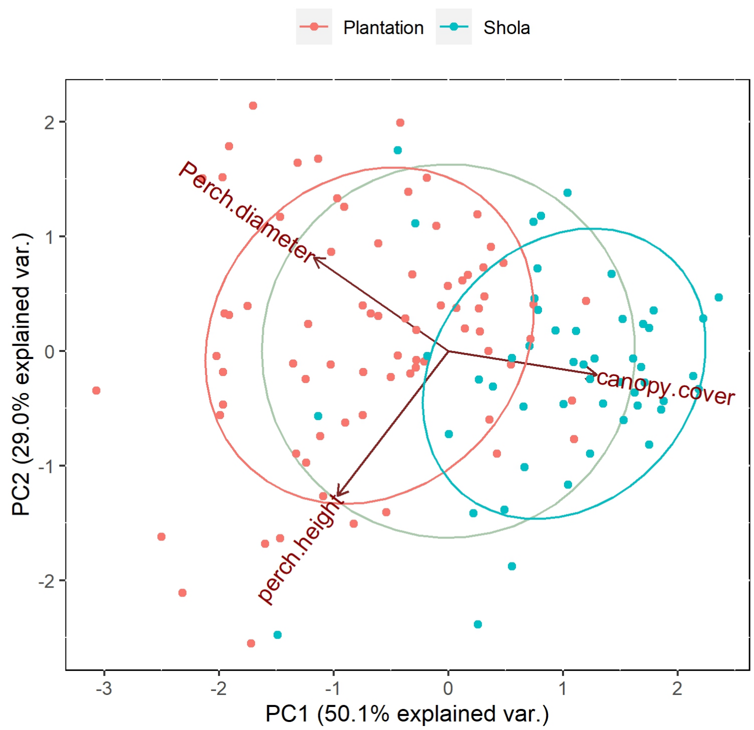


Figure 17. PCA graph between basking microhabitat variables in shola and plantation

4.6.1 Perch height

In shola, the maximum number of lizards sighted at a height between 101 and 150 cm above ground (24.6 percent), after which sightings decrease with height. In plantations, maximum sightings are from 150 cm to 200 cm above the ground (23.8 percent) and then decrease (Fig.19).

The average perch height is higher in tea plantations (mean=266; SD=147.88; N=84), compared to shola forests (mean=197; SD=133.56;N=69). Wilcoxon rank sum test with continuity correction shows a significant difference in perch height between the two habitats (W = 3756, p-value = 0.0016) (Fig.18).

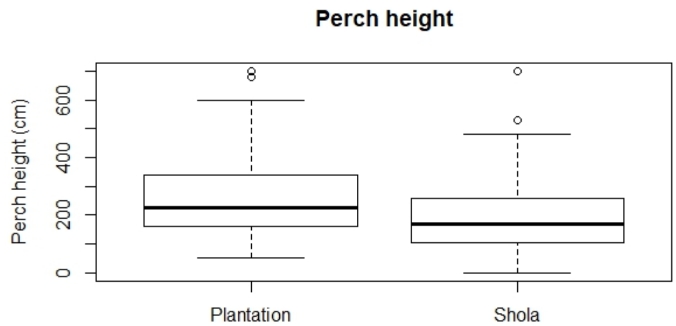


Figure 18. Basking perch height use between plantation and shola

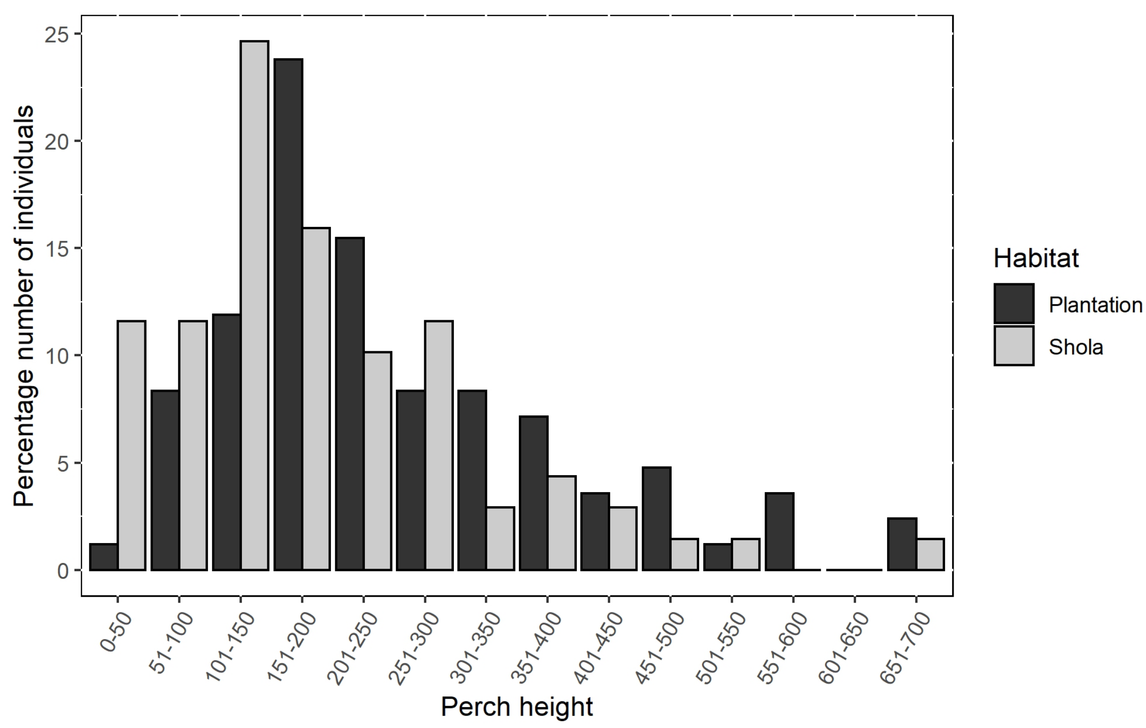


Figure 19. Basking perch height use between plantation and shola with perch height is classified into groups of 50 cm

4.6.2 Perch Diameter

The perch diameter of the lizard varied from 4 cm to 180 cm. In shola, a maximum number of lizards were sighted with perch diameter 1 to 10 cm (44 percentage), and then the number decreases with an increase in perch diameter. More than 75 percent of individuals were sighted with a perch diameter less than 30 cm in shola.

In plantations, a maximum number of individuals were found occupying the perch diameter 40 to 50 cm. more than fifty percent of the individuals occupy perch diameter from 40 to 80 cm (Fig.21).

Wilcoxon rank sum test with continuity correction shows a significant difference in perch diameters between the two habitats (W = 4186, p-value = 2.448e-12) (Fig.20).

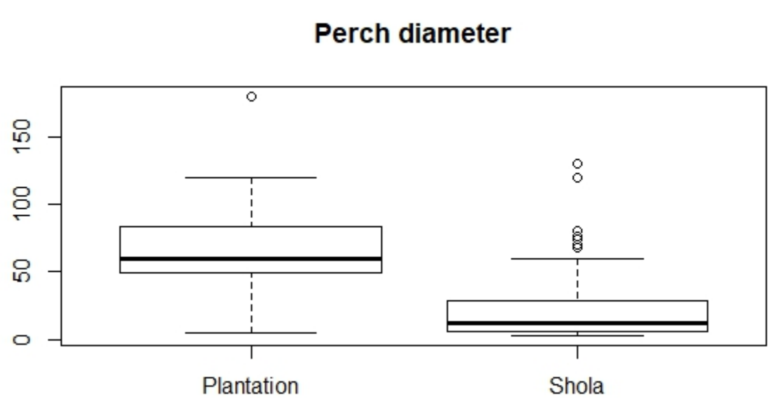


Figure 20. Basking perch diameter use between plantation and shola

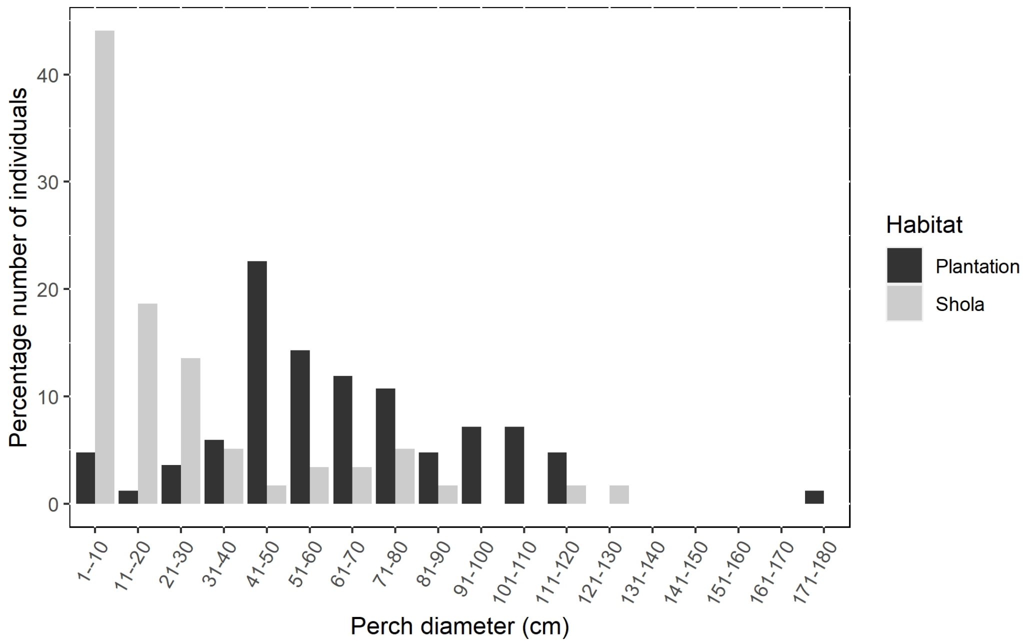


Figure 21. Basking perch diameter use between plantation and shola when perch diameter is classified into groups of 10 cm

4.6.3 Perch surface

Within plantations, more than 95 percent of the individuals were seen on the silver oaks. 93 percent of lizards were on a tree trunk and only one individual on the ground and tea plant. There was more diversity for perch surfaces in shola forests and are well represented than plantations, where only tree trunk is the dominant perch surface (Fig.22).

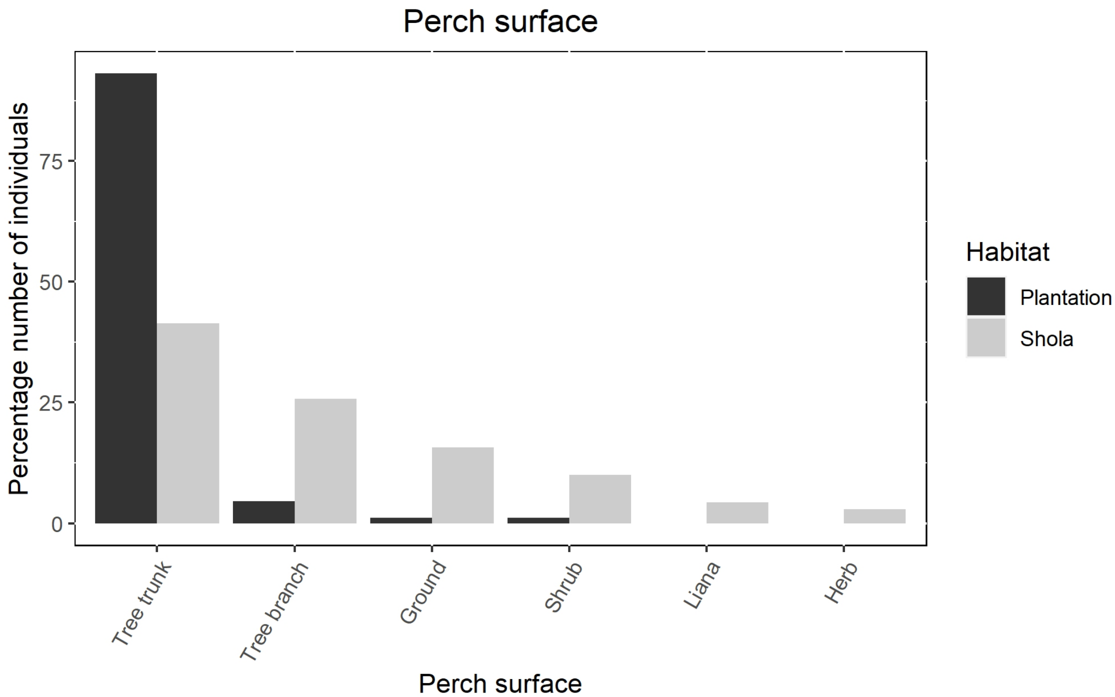


Figure 22. Basking perch surface use between plantation and shola

4.6.4 Canopy cover

In shola, more than fifty percent of individuals were found where canopy cover is more than eighty percent, and the number of individuals observed increases with an increase in canopy cover. More than sixty percent of individuals were found where canopy cover is between fifty and seventy percent in the plantation (Fig.23).

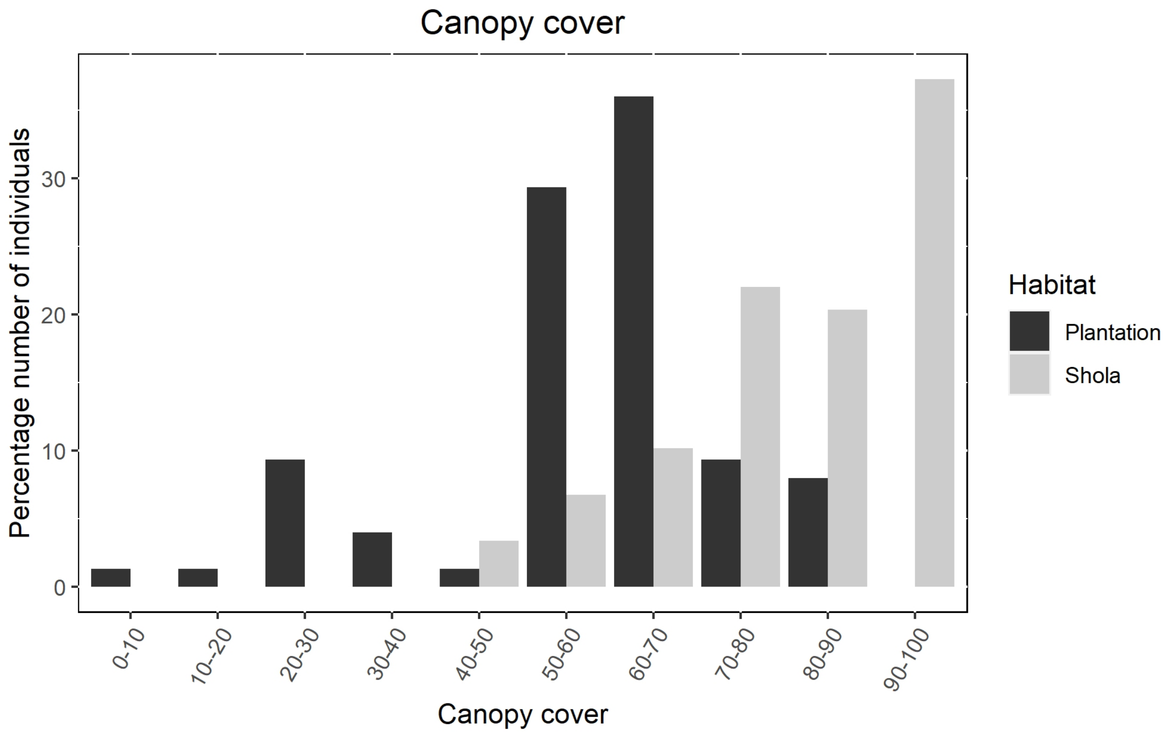


Figure 23. Basking canopy cover use between plantation and shola when canopy cover is classified into groups of 10 percent

4.7 Habitat availability and use

Habitat availability and habitat use follow a similar trend in both the habitats. There is no significant difference in use and availability of Tree height and Tree GBH in both the habitats (Fig.24).

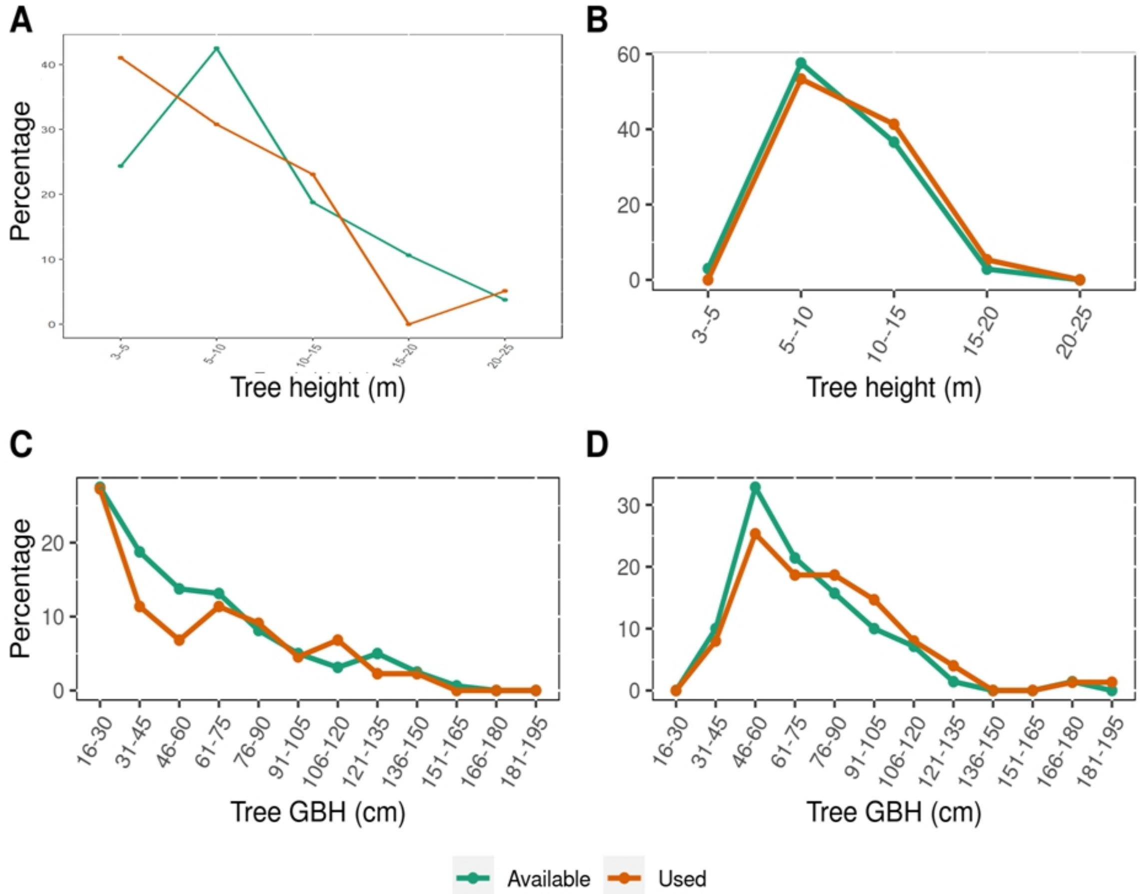


Figure 24. Habitat (Tree height and Tree GBH) use and availability comparison in shola and plantation. A – Shola, B – Plantation, C – Shola, D - Plantation

4.8 Flight initiation distance

Flight Initiation Distance and substrate temperature are negatively correlated (cor -0.45, t = -2.26, df = 20, p-value = 0.03). From Wilcoxon rank sum test with continuity correction, there is no significant difference between habitat type and FID (W = 76.5, p-value = 0.72) (Fig.25).

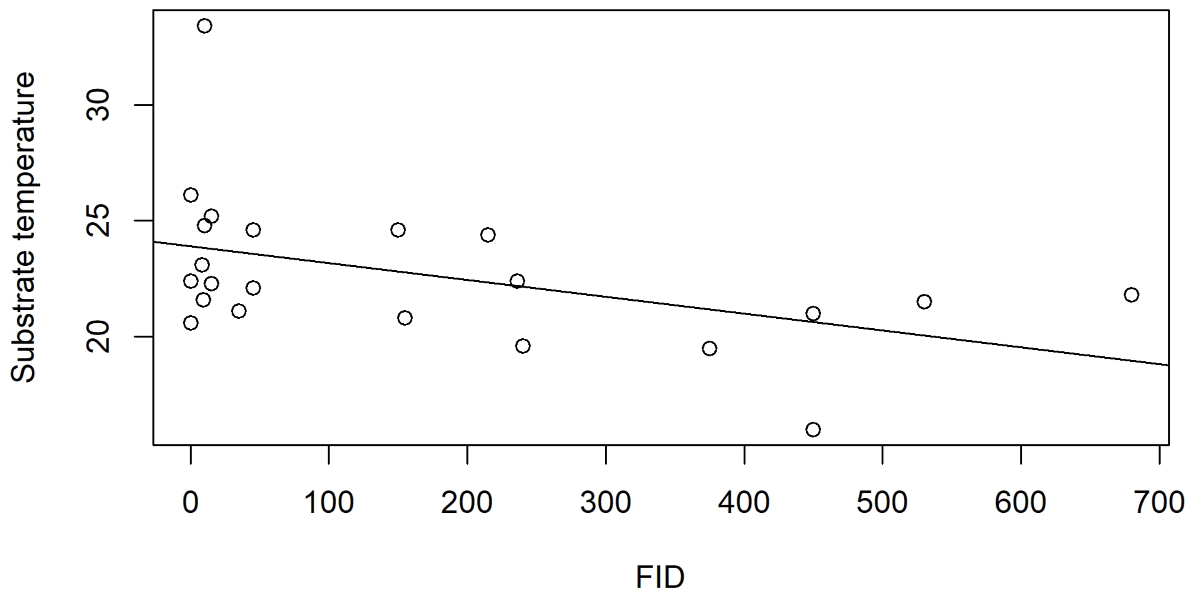


Figure 25. Graph showing correlation between Substrate temperature and Flight Initiation Distance

5. DISCUSSION

Tea plantation and shola forests are structurally very distinct habitats. Due to the unique landscape structure of the Munnar – Eravikulam region, these two habitats are found very close to each other. Shola forests are very complex in structure while tea plantations have a uniform structure with tea plants of upto 1m height and shade trees (silver Oak) planted in uniform distances. Herb number, canopy cover, litter percentage, Tree density, liana and grass cover are more in shola forests compared to plantations. In tea plantations, the shade trees are periodically pruned which further reduces the complexity of the habitat.

The lizard density when compared between shola and plantation, it is found that the density is high in shola, compared to plantations. But, within shola, density is high in shola close to plantations than shola away from plantations.

It is found that the density of the lizard in plantation is influenced by the proximity to shola forests. The density is high in plantation close to shola than plantation away from shola. Due to the high density of the lizard in shola close to the plantation, the lizards might be getting pushed to the plantations and they might be occupying the plantations close to shola or it is also possible that the lizards are moving between shola and plantation. This could be the reason why the lizard density decreases with increase in density from shola. more studies in the movement pattern and home range size has to be done to clearly state if the population in the plantations are restricted to shola or are moving between the plantation and shola.

Density in plantation is also influenced by the presence of shade trees. The lizard is sighted only where the shade trees are present. In plantations without shade trees, the density was found to be zero. The lizard was sighted on a tea plant for once, but it was close to a shade tree. In shola, where highly complex habitats are available, the lizard was found to use mostly trees. This preference of the lizard to the trees could be the reason why the lizard is using only tea plantations with shade trees.

Density estimation of *Salea anamallayana* in the same landscape thirteen years before using the same methodology but different sampling effort estimated the density to be 55 individuals/ha in shola and 65 individuals/ha in plantations (Deepak & Vasudevan, 2008). The current study estimates the density as 27.6/ha in shola and 8.6/ha in plantations. The result shows that there was a drastic decline in population density of the lizard in past thirteen years in both shola and plantations.

Even though the density is low, the body condition is high in shola away from plantation. In shola close to plantation, the density is high while body condition is low. But in plantations, both the density and body condition is low. Measurements of body condition are typically used to assess an individual's quality, health, or energetic state (Warner et al., 2016).

The shola close to plantations are very fragmented and are mostly seen as narrow stretches in between the plantations. But the tree density is high and the canopy is mostly closed. So the predation risk from aerial predators will be less compared to plantations. There was no direct sighting of raptors predating on Anamalai Spiny Lizard. But escape response was observed in the lizard when raptors flew over the canopy. The arboreal snake, Large-scaled Pit Viper (*Trimeresurus macrolepis*) was observed in the shola frequently. Even though there was no direct evidence that the snake predate in the lizard, it could be a potential predator in the shola.

In shola close to plantations, the density of the lizard is high, this can lead to high intra-specific competition which has to be studied. Intra specific competition is one factor that causes decrease in body condition in lizards (Siliceo-Cantero & García, 2014).

Body condition of the lizard is negatively influenced by competition and predation risk (Amo et al., 2007; Siliceo-Cantero & García, 2014). But if the lizards get habituated to low risk, it can positively influence body condition (Rodríguez-Prieto et al., 2010). Plantations have a more open canopy and the chances of predation risk will be high, thus the lizard will have to spend more energy to flee from the predator thus reducing the body condition.

In the shola away from plantations, the density was low but body condition was high. Low predation risk and low density might be the reason for high body condition in shola away from plantations.

The body condition of males is higher than females. Earlier studies shows that lizard body condition does not always differ between sexes (Jenssen et al., 1995), and is affected by the energy expenditure of individuals at the time of capture (Siliceo-Cantero & García, 2014). During reproductive season, male body condition can decrease due to the energy expenditure for attracting mates and defending territories (Schlaepfer, 2006). At the same time in females the body condition can decrease after egg laying due to the energy expenditure for reproduction (Cox & Calsbeek, 2010).

On contrary our results shows an opposite trend. The lizards were captured during the breeding season and egg laying season. And the results show that there is clear difference in body condition between males and females and the male body condition is higher than females. The study has also found that head length, head width, head height, tail length, tail height and gular length are larger for males than females when adjusted to SVL (explained in the next paragraph). This must have contributed to the higher body condition in males. Further studies will be required to understand if there is any seasonal difference in body condition of the lizard.

For making more conclusive statements on body condition difference between habitat and sex, studies need to be done on the diet pattern, food availability and movement pattern of the species. These studies will also help to explain the distribution of the lizard.

Even though there was difference in body condition of males between the habitats, there is no significant difference in other morphological variables including

SVL. The tea plantations were established only around 90 years back (Deepak & Vasudevan, 2008) and also there is chances that the populations from the shola and plantations are interacting there is no clear separation between the two habitats.

There is significant difference in morphological variables between the sexes. All morphological variables measured including Weight, Snout to vent length (SVL), Tail Length, Tail width (base of tail), Trunk Length, Head length, Head width, Ocular diameter (eye socket), Hind limb length, Heel length and 5thToe length shows significant difference between the sexes.

Since there was significant difference in SVL between the sexes, and other morphological variables being highly correlated to SVL, the ratio of morphological variable to SVL was compared between the sexes and it was found that Head length/SVL, Head width/SVL, Head height/SVL, Tail length/SVL, Tail height/SVL, Gular length/SVL and Body weight/SVL are significantly higher on males than females.

The adult sex ratio of the lizard is skewed towards males in all the habitats. The sex ratio is very low in plantations. It improves when it comes to shola close to plantations and further improves in shola away from plantations.

The sex ratio can vary widely among species, and studies suggest that variations in sex ratio will impact behaviour, ecology and life history of the species (Székely et al., 2014). In populations with male biased sex ratio, the male aggression will be high and male-male competition intensifies (Székely et al., 2014). The sex ratio can influence mate choice behaviour, social behaviour and mating competition (Székely et al., 2014).

Three breeding pairs were observed in plantations in the month of march and it suggests that the lizards are using plantations for breeding. And since the sex ratio is more biased towards males in plantations, it can be expected that the male-male competition is more in plantations.

The population in shola away from plantations, even though the density is less, due to the high body condition and high sex ratio, it can be said that the population is more stable compared to other two populations under study.

The study period (February to May) was the breeding season of the lizard. This could be the reason why more males were sighted during the study period. And also the males are larger in size and have larger spines on the body making them easier to sight. Females on the other hand are smaller in size and more cryptic in nature. Also during a focal sampling it is observed that the males move more than females in a breeding pair (personal observation, sample size =1), making it easier to sight males. This might have contributed to the male biased sex ratio of the lizard. But, since the study was conducted simultaneously in all the habitats, no bias was expected between the habitats.

Basking microhabitat use shows significant difference between both the habitats with respect to perch height, perch diameter, canopy cover and perch surface. Average perch height is significantly higher in plantations compared to shola.

The perch diameter is smaller in shola compared to plantations. In plantations, 93 percent of individuals were found on tree trunk whereas, in shola, only 41 percent of individuals were found using tree trunk. Perch diameter of tree trunk is larger compared to other surfaces and plantations are lacking other perch surfaces which are available in shola. This must be contributing to the high perch diameter in plantations.

Lizards are using high canopy cover areas in shola than plantations. Shola due to its high tree density, average canopy cover is high compared to plantations, where tree density is less. Use of high canopy cover areas might also be helping the lizards to escape from the predators.

Shola has all six categories of perch surfaces including tree trunk, tree branch, shrub, herb, liana and ground. But plantation does not have liana and herb. In both the habitats, maximum number of lizards was found on tree trunk, followed by tree branch. Thus it is clear that the lizard prefer tree as basking habitat.

Thus the difference in use of perch diameter, perch surface and canopy cover can be attributed to difference microhabitat availability between the habitat even though quantitative analysis of microhabitat availability is not done during the study.

Trees in plantations are pruned, thus they have branches only on the top. Thus if the lizards were approached by a predator, they can easily escape to the canopy if the perch height is high. Also due to high human activity in plantations, the lizards could be avoiding lower perch surfaces. Along with this, the lack of availability of perch surfaces other than trees can be the reason for high perch surfaces in plantations.

It is found that the body temperature of the lizard is directly correlated with substrate temperature and atmospheric temperature. Plantations due to the open canopy, plantations have higher temperature compared to shola. Thus the average body temperature of the lizard is higher in plantations compared to shola. Since the body temperature have positive relationship to the atmospheric temperature, it can be said that the changes in atmospheric temperature can cause changes in body temperature and consequently physiological or behavioral changes in the lizard.

It is found that the FID is inversely proportional to substrate temperature. When the substrate temperature increases, body temperature increases and the lizard become more active and can move faster when approached by predator (Braun et al., 2010). Thus, when the substrate temperature increases, FID decreases. Earlier studies also supports that FID decreases with increase in substrate temperature (Braun et al., 2010). Thus compared to other animals, ectotherms are expected to be more vulnerable to predation when their locomotory abilities are diminished at lower ambient temperatures (Braun et al., 2010).

Measuring FID in response to an approaching predator was an attempt to understand the behavioural adaptations of the lizard when in a more open area. But due to high perch height and terrain and vegetation, the sample size was low.

A decrease in the density of the lizard is observed in the study in the past thirteen years. But it is not sure if it is because of the drastic decline in density or if some kind of cyclical events are affecting the population density of the lizard.

A limitation of the study was that it was conducted only during the breeding season of the lizard and no data on seasonal variation in body condition, habitat use and density could be collected. Also due to the biased sex ratio, sample size of the females was less compared to males. Due to the accessibility issues, data collection points were clustered in shola away from plantations. Also the shola away from plantations (1820-2100m asl) were at higher elevations compared to shola close to plantations 1470-2020 m asl) and plantations (1570-1905m asl), the effect of elevation could not be studied. In this study we couldn't study the movement pattern of the lizard thus establish whether the lizards are moving between the shola and plantations or whether they are two separate populations in the two habitats. Also we could not study the food availability and feeding habit of the lizard which can have direct impact on the body condition of the lizard.

FID was an important behaviour in understanding behavioural adaptations to land use change. But the lizard was very cryptic and mostly sighted when reaches very close to the animal. Also many times the lizard was sighted above the observer's height and it was difficult to walk in a straight line towards the lizard to test FID, due to the field situations. All these factors reduced the sample size and could not test the hypothesis with enough sample size.

6. CONCLUSION

Urbanization and changing land use patterns globally are affecting many species in different scales and even lead to local extinctions in some species. With the still continuing trend of changing land use patterns, it became important to find out how the lizards are able to adjust to the new habitats.

From the study it is clear that land use change has a deleterious effect on the Anamalai Spiny Lizard. It negatively affected the density, body condition and sex ratio. The reduction in body condition can have long term impact on the fitness and survival of the lizards.

From the study it is not clear whether the lizard population in plantations is a separate population or they are transients from the shola close to plantations. In either way, since the population of the lizard is less in plantation compared to shola, it can be said that they prefer shola over plantation. But, even though the plantation is not a preferred habitat, it has the capacity to accommodate a good population of lizards. The plantation can act as a sink of metapoppulation.

From the study it is clear that the lizards prefer trees over other perch surfaces for basking. Thus if the plantation could have more trees, it could accommodate more number of lizards. The recent move by the Kerala Government to diversify plantations is a ray of hope in this aspect. The project promotes cultivation of subsidiary crops, mainly fruit varieties such as rambutan, avocado, dragon fruit, and mangosteen, in plantations including tea plantations (Raman, 2021).

This study will aid in future conservation efforts of the species and similar species. Further studies have to be done on the diet patterns, food availability and movement pattern to have a more comprehensive idea about the impact of habitat modification.

References

Amo, L., López, P., & Martín, J. (2007). Habitat deterioration affects body condition of lizards: A behavioral approach with Iberolacerta cyreni lizards inhabiting ski resorts. *Biological Conservation*, *135*(1), 77–85. https://doi.org/10.1016/j.biocon.2006.09.020

Amo, L., López, P., & Martı´n, J. (2006). Nature-based tourism as a form of predation risk affects body condition and health state of Podarcis muralis lizards. *Biological Conservation*, *131*(3), 402–409. https://doi.org/10.1016/j.biocon.2006.02.015

Babu, S. (1998). *Vegetation mapping and analysis of Eravikulam national Park of Kerala using remote sensing techniques*.

Batabyal, A., Balakrishna, S., & Thaker, M. (2017). A multivariate approach to understanding shifts in escape strategies of urban lizards. *Behavioral Ecology and Sociobiology*, *71*(5), 83. https://doi.org/10.1007/s00265-017-2307-3

Battles, A. C., Whittle, T. K., Stehle, C. M., & Johnson, M. A. (n.d.). EFFECTS OF HUMAN LAND USE ON PREY AVAILABILITY AND BODY CONDITION IN THE GREEN ANOLE LIZARD, ANOLIS CAROLINENSIS. *Herpetological Conservation and Biology*, 12.

Bhupathy, S., & Kannan, P. (1997). Status of agamid lizards in the Western Ghats of Tamil Nadu, India. *Salim Ali Centre for Ornithology and Natural History, Technical Report*, *5*.

Braun, C. A., Baird, T. A., & LeBeau, J. K. (2010). Influence of substrate temperature and directness of approach on the escape responses of juvenile collared lizards. *Herpetologica*, *66*(4), 418–424.

Christian, K. A., Baudinette, R., & Pamula, Y. (1997). Energetic costs of activity by lizards in the field. *Functional Ecology*, *11*(3), 392–397.

Cooper, E. L. (1985). Comparative immunology. *American Zoologist*, *25*(3), 649–664.

Cox, R. M., & Calsbeek, R. (2010). Severe costs of reproduction persist in Anolis lizards despite the evolution of a single-egg clutch. *Evolution: International Journal of Organic Evolution*, *64*(5), 1321–1330.

Crooks, K. R., & Soulé, M. E. (1999). Mesopredator release and avifaunal extinctions in a fragmented system. *Nature*, *400*(6744), 563–566.

Das, I. (2002). *A photographic guide to snakes and other reptiles of India*. New Holland.

Das, S., Campbell, P. D., Deuti, K., Bag, P., & Raha, S. (2019). A contribution to the systematics of Salea anamallayana (Beddome, 1878) and S. horsfieldii Gray, 1845 (Squamata: Agamidae: Draconinae). *Zootaxa*, *4563*(3), 563–583.

Deepak, V., & Vasudevan, K. (n.d.). *Density and microhabitat association of Salea anamallayana in Eravikulam National Park, Western Ghats, India*. 7.

Driscoll, D. A. (2004). Extinction and outbreaks accompany fragmentation of a reptile community. *Ecological Applications*, *14*(1), 220–240.

Eluvathingal, L. M. (2016). *An Ecological Study of the Anurans in Tea Plantations in a Biodiversity Hotspot*.

Engelhardt, S., & Weladji, R. (2011). Effects of levels of human exposure on flight initiation distance and distance to refuge in foraging eastern gray squirrels (Sciurus carolinensis). *Canadian Journal of Zoology*, *89*(9), 823–830.

Frid, A., & Dill, L. (2002). Human-caused disturbance stimuli as a form of predation risk. *Conservation Ecology*, *6*(1).

Gleeson, T. T., & Hancock, T. V. (2002). Metabolic implications of a 'run now, pay later'strategy in lizards: An analysis of post-exercise oxygen consumption. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology*, *133*(2), 259–267.

Goodman, B. A., Miles, D. B., & Schwarzkopf, L. (2008). Life on the rocks: Habitat use drives morphological and performance evolution in lizards. *Ecology*, *89*(12), 3462–3471.

Herczeg, G., Gonda, A., Saarikivi, J., & Merilä, J. (2006). Experimental support for the cost–benefit model of lizard thermoregulation. *Behavioral Ecology and Sociobiology*, *60*(3), 405–414. https://doi.org/10.1007/s00265-006-0180-6

Jenssen, T. A., Congdon, J. D., Fischer, R. U., Estes, R., Kling, D., & Edmands, S. (1995). Morphological characteristics of the lizard Anolis carolinensis from South Carolina. *Herpetologica*, 401–411.

Johnson, M. P. (2001). Environmental impacts of urban sprawl: A survey of the literature and proposed research agenda. *Environment and Planning A*, *33*(4), 717–735.

Karunakaran, P., Sebastian, M. K., Uma, G., Gayathri, V., & Adhavan, E. (n.d.). *LANDUSE AND MANAGEMENT PLAN FOR PRODUCTION LANDSCAPE IN MUNNAR*.

Management plan ENP. (n.d.). *Management plan of Eravikulam National Park, Kerala*.

Megía-Palma, R., Jiménez-Robles, O., Hernández-Agüero, J. A., & De la Riva, I. (2020). Plasticity of haemoglobin concentration and thermoregulation in a mountain lizard. *Journal of Thermal Biology*, *92*, 102656. https://doi.org/10.1016/j.jtherbio.2020.102656

Myers, N., Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, *403*(6772), 853–858.

Nair, P. V. (n.d.). *Biodiversity mapping of Shola Forests through remote sensing and GIS techniques*. 70.

Nair, S. C. (1991). *The Southern Western ghats: A biodiversity conservation plan*. India National Trust for Art and Cultural Heritage.

Ord, T. J., & Stuart-Fox, D. (2006). Ornament evolution in dragon lizards: Multiple gains and widespread losses reveal a complex history of evolutionary change. *Journal of Evolutionary Biology*, *19*(3), 797–808. https://doi.org/10.1111/j.1420-9101.2005.01050.x

Prosser, C., Hudson, S., & Thompson, M. B. (n.d.). *Effects of Urbanization on Behavior, Performance, and Morphology of the Garden Skink, Lampropholis guichenoti*. 9.

Rahbek, C., Borregaard, M. K., Colwell, R. K., Dalsgaard, B., Holt, B. G., Morueta-Holme, N., Nogues-Bravo, D., Whittaker, R. J., & Fjeldså, J. (2019). Humboldt's enigma: What causes global patterns of mountain biodiversity? *Science*, *365*(6458), 1108–1113.

Raman, G. K. (2021, June 6). Diversification to benefit estates. *The Hindu*.

Rodríguez-Prieto, I., Martín, J., & Fernández-Juricic, E. (2010). Habituation to low-risk predators improves body condition in lizards. *Behavioral Ecology and Sociobiology*, *64*(12), 1937–1945. https://doi.org/10.1007/s00265-010-1004-2

Schlaepfer, M. A. (2006). Growth Rates and Body Condition in Norops polylepis (Polychrotidae) Vary with Respect to Sex but not Mite Load 1. *Biotropica: The Journal of Biology and Conservation*, *38*(3), 414–418.

Siliceo-Cantero, H. H., & García, A. (2014). Differences in growth rate, body condition, habitat use and food availability between island and mainland lizard populations of *Anolis nebulosus* in Jalisco, Mexico. *Journal of Tropical Ecology*, *30*(5), 493–501. https://doi.org/10.1017/S0266467414000297

Smith, M. A. (1935). *The fauna of British India, including Ceylon and Burma. Reptilia and Amphibia. Vol. 2. Sauria. London: Taylor and Francis. 440 pp*.

Spezzano, L. C., & Jayne, B. C. (2004). The effects of surface diameter and incline on the hindlimb kinematics of an arboreal lizard (Anolis sagrei). *Journal of Experimental Biology*, *207*(12), 2115–2131.

Sreekar, R., & Quader, S. (2013). Influence of gaze and directness of approach on the escape responses of the Indian rock lizard, Psammophilus dorsalis (Gray, 1831). *Journal of Biosciences*, *38*(5), 829–833. https://doi.org/10.1007/s12038-013-9378-8

Srinivas, G., Bhupathy, S., & Madhivanan, A. (2008). Occurrence of Salea anamallayana Beddome, 1878 in High Wavy Mountains, Western Ghats, India. *Journal of the Bombay Natural History Society*, *105*(3), 341–342.

Srinivasulu, A., Srinivasulu, B., & Srinivasulu, C. (2021). Ecological niche modelling for the conservation of endemic threatened squamates (lizards and snakes) in the Western Ghats. *Global Ecology and Conservation*, e01700.

Srinivasulu, C., Srinivasulu, B., & Molur, S. (2014). *The Status and Distribution of Reptiles in the Western Ghats, India: Conservation Assessment and Management Plan (CAMP)*. Wildlife Information Liaison Development Society.

Székely, T., Liker, A., Freckleton, R. P., Fichtel, C., & Kappeler, P. M. (2014). Sex-biased survival predicts adult sex ratio variation in wild birds. *Proceedings of the Royal Society B: Biological Sciences*, *281*(1788), 20140342.

Tulli, M. J., Abdala, V., & Cruz, F. B. (2011). Relationships among morphology, clinging performance and habitat use in Liolaemini lizards. *Journal of Evolutionary Biology*, *24*(4), 843–855.

Tulli, M. J., Cruz, F. B., Herrel, A., Vanhooydonck, B., & Abdala, V. (2009). The interplay between claw morphology and microhabitat use in neotropical iguanian lizards. *Zoology*, *112*(5), 379–392.

Warner, D. A., Johnson, M. S., & Nagy, T. R. (2016). Validation of Body Condition Indices and Quantitative Magnetic Resonance in Estimating Body Composition in a Small Lizard: MEASURING BODY COMPOSITION OF SMALL LIZARDS. *Journal of Experimental Zoology Part A: Ecological Genetics and Physiology*, *325*(9), 588–597. https://doi.org/10.1002/jez.2053

Ydenberg, R. C., & Dill, L. M. (1986). The Economics of Fleeing from Predators. In *Advances in the Study of Behavior* (Vol. 16, pp. 229–249). Elsevier. https://doi.org/10.1016/S0065-3454(08)60192-8

APPENDIX

VARIABLE	SEX		P- value
	MALE	FEMALE	
SVL	88.75 ± 11.07 (N=41)	76.4 ± 8.60 (N=16)	W = 540, p-value = 0.0001726
Head Length	28.29 ± 4.07 (N=49)	22.84 ± 2.44 (N=16)	W = 663, p-value = 3.797e-05
Head Width	15.22 ± 2.56 (N=49)	12.32± 1.35 (N=16)	W = 667, p-value = 2.909e-05
Head Height	12.28 ± 1.90 (N=49)	9.98 ± 1.22 (N=16)	t = 5.6096, df = 40.292, p-value = 1.635e-06
Gular Length	41.12 ± 6.28 (N=49)	33.78 ± 4.45 (N=16)	W = 656, p-value = 5.998e-05
Trunk Length	43.24 ± 5.84 (N=47)	38.00 ± 5.63 (N=16)	W = 578.5, p-value = 0.001424
Femur Length	18.59 ± 2.47 (N=49)	16.16 ± 1.69 (N=16)	W = 630.5, p-value = 0.0002894
Crus length	16.46 ± 2.13 (N=49)	14.21 ± 1.48 (N=16)	W = 639, p-value = 0.000174
Foot length	23.21 ± 2.89 (N=47)	20.92 ± 1.71 (N=16)	W = 606, p-value = 0.0002902
5th toe length	9.46 ± 1.29 (N=47)	8.65 ± 0.89 (N=16)	t = 2.8013, df = 37.86, p-value = 0.007973
Tail length	168.83 ± 24.52 (N=41)	143.12 ± 21.72 (N=16)	W = 513, p-value = 0.001047
Tail width	7.90 ± 1.79 (N=47)	6.41 ± 1.06 (N=16)	W = 589, p-value = 0.0007905
Tail Height	10.81 ± 2.54 (N=47)	6.92 ± 0.87 (N=16)	W = 664.5, p-value = 5.414e-06
Ocular diameter	4.17 ± 0.50 (N=49)	3.76 ± 0.41 (N=16)	t = 3.2892, df = 30.426, p-value = 0.002543
Weight	15.75 ± 5.97 (N=49)	9.75 ± 4.35 (N=16)	t = 4.343, df = 34.919, p-value = 0.0001149

Table 1 Morphological variables comparison between male and female with p-values

VARIABLE	MEAN	
	MALE	FEMALE
Head length/SVL	0.32 ± 0.01 (N=49)	0.30 ± 0.01 (N=16)
Head width/SVL	0.17 ± 0.02 (N=49)	0.16 ± 0.01 (N=16)
Head height/SVL	0.14 ± 0.01 (N=49)	0.13 ± 0.01 (N=16)
Tail length/SVL	1.90 ± 0.15 (N=41)	1.88 ± 0.29 (N=16)
Tail height/SVL	0.12 ± 0.02 (N=47)	0.09 ± 0.01 (N=16)
Gular length/SVL	0.47 ± 0.04 (N=49)	0.44 ± 0.03 (N=16)
Body weight/SVL	0.17 ± 0.05 (N=49)	0.12 ± 0.04 (N=16)

Table 2. Mean of morphological variable to SVL ratio between sexes

Treatment	**Sex**	**Age class**	**Substrate temperature**	**Starting distance**	**FID**
Plantation	Female	Adult	23.1	6	8
Plantation	Male	Adult	24.6	7	150
Plantation	Male	Adult	21.5	10	530
Plantation	Male	Adult	26.1	6	0
Plantation	Male	Adult	21.6	10	9
Plantation	Male	Adult	19.6	12	240
Plantation	Male	Adult	21.8	10	680
Plantation	Male	Adult	21.1	6	35
Plantation	Male	Adult	24.6	6	45
Plantation	Male	Adult	24.4	8	215
Plantation	Male	Adult	21	8	450
Plantation	Male	Adult	24.8	12	10
Plantation	Female	Adult	-	10	0
Plantation	Male	Adult	-	7	210
Shola	Male	Adult	19.5	5	375
Shola	Male	sub adult	33.4	5	10
Shola	Female	Adult	22.1	5.5	45
Shola	Male	Adult	20.6	5	0
Shola	Male	Adult	22.4	5	236
Shola	Male	Adult	25.2	7	15
Shola	Male	Adult	22.4	5	0
Shola	Male	Adult	20.8	5	155
Shola	Female	Adult	22.3	5	15
Shola	Female	Adult	16	5	450

Table 3. Flight Initiation Distance comparison between plantation and shola