SPECIES DIVERSITY AND COMMUNITY STRUCTURE OF REPTILES OF SELECTED AGROECOSYSTEMS IN THRISSUR, KERALA

by

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(2015 – 17 – 003)

THESIS

Submitted in partial fulfilment of the

requirement for the degree of

MASTER OF SCIENCE IN FORESTRY

Faculty of Forestry

Kerala Agricultural University

DEPARTMENT OF WILDLIFE SCIENCE

COLLEGE OF FORESTRY

VELLANIKKARA, THRISSUR -680 656

KERALA, INDIA

DECLARATION

I, hereby declare that this thesis entitled **"SPECIES DIVERSITY AND COMMUNITY STRUCTURE OF REPTILES OF SELECTED AGROECOSYSTEMS IN THRISSUR, KERALA"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Place: Vellanikkara

Date: 20-07-2017

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CERTIFICATE

Certified that this thesis **entitled "SPECIES DIVERSITY AND COMMUNITY STRUCTURE OF REPTILES OF SELECTED AGROECOSYSTEMS IN THRISSUR, KERALA"** is a record of research work done independently by Ms. Abhirami M. Jayakumar under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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Abhirami M. Jayakumar

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INTRODUCTION

INTRODUCTION

Reptiles have been living on the earth since prehistoric times. These cold blooded animals are divided into four orders, with India having representatives in three of them (except Rhyncocephalia). They are Crocodylia (crocodiles), Testudines (turtles and tortoises), and Squamata (lizards and snakes).

According to Aengals *et al.* (2011), 518 reptiles have so far been reported from India which includes three species of crocodiles, 34 species of turtles and tortoises, 202 species of lizards, and 279 species of snakes. Though a few more additions have happened after that, a new complete checklist of Indian reptiles is yet to be published.

Coming to reptilian diversity of the Western Ghats, the Conservation Assessment and Management Plan (CAMP) of IUCN (Srinivasulu *et al.,* 2014) accessed a total of 227 species of which 107 were endemic to the Western Ghats. Palot (2015) published the checklist of reptiles of Kerala with 173 species, including 87 species endemic to the Western Ghats and 10 endemic to Kerala. Out of this 36% belong to the categories, Not Evaluated and Data Deficient. This is clear evidence that there is dire lack of research on reptiles in Kerala.

Amphibians and reptiles have been found to be the highest threatened categories among vertebrates. They have more species at risk than both birds and mammals (Gardner *et al.,* 2007). There have been reports of strong declines in amphibians across the world. Though poorly documented, reptiles face the same threat and are equally, if not more, threatened as amphibians (Gibbons *et al.,* 2000). The major threats faced by reptiles are habitat loss and degradation, invasive species, environmental pollution, disease, unsustainable use and global climate change. Out of these, the leading cause for declines in reptile population is habitat loss and degradation and this where the role of agroecosystems comes into play.

Nearly two-third of the terrestrial environment of the world is made of managed ecosystems with natural, undisturbed habitats making only a mere five percentage. These managed ecosystems include agricultural systems, forestry systems and human settlements (Gamage *et al.,* 2008). Herpetofauna make up 48% of the terrestrial vertebrates which are threatened by agroforestry and forestry activities (Palacios *et al.,* 2013). In a time when more and more forest areas are being converted into plantations and agricultural lands for meeting the growing needs of the population it is important to evaluate the reptile diversity in these modified ecosystems. It is important to access whether these agroecosystems are capable of supporting and sustaining reptile biodiversity.

Despite the fact that herpetofauna make up half of the vertebrate species, they are very much under studied in their response to change in habitat from natural forests to plantations. On a review conducted on studies related to habitat change of vertebrates in plantations across the world, 146 articles were found to be published. Out of this only 27 (19%) referred to amphibians and reptiles (Palacios *et al.,* 2013). This clearly shows the lack of research on reptiles. And this applies especially to our state, where only one study has been undertaken so far on the reptiles of human-modified habitats. But that was only on the agamids. The present study is the first to study reptiles as a whole in agroecosystems.

The main objectives of the present study are:

1. To study the species diversity and the reptilian community structure of selected agroecosystems in Thrissur, Kerala
2. To assess the spatial variation of reptile distribution using Geographic Information System (GIS) tools

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The studies on Indian reptiles started with Russell in 18th century, who made an elaborate inventory of reptiles of south India. Albert Gunther based on the collections in the British Museum published the book 'The Reptiles of British India' in 1864. It has accounts of 180 species of snakes, 47 species of tortoises and turtles, five species of crocodilians, and 129 species of lizards. Beddome (1864, 1870 & 1886) named several new snakes from Kerala. Systematics of Herpetology gained much momentum in 1890 when Boulenger published several volumes on reptiles and batrachians in the form of Fauna of British India volumes. He was the first to develop a 'satisfactory' key for identification of snakes. The works of Gunther (1864), Boulenger (1890) and Smith (1933, 1935, 1943) are considered exceptional and laid the foundation for reptile study in India. Even now, these works are used as the basic keys in reptilian taxonomy. A photographic guide to reptiles of India was published by Das (2002). The books has illustrations of 243 species of reptiles consisting of 110 snakes, 98 lizards, 32 testudines and 3 crocodilians. A field guide to the sakes of India was brought out by Whitaker and Captain (2004). It has descriptions of 157 species of snakes.

518 reptiles have so far been reported from India (Aengals *et al.*, 2011) which includes three species of crocodiles, 34 species of turtles and tortoises, 202 species of lizards, and 279 species of snakes.

2.1 SPECIES RECORDS

In the recent decade there have been many records of new species across the reptilian taxa from India. Most of the discoveries belong to Family Gekkonidae.

2.1.1 Lizards

Giri and Bauer (2008) along with description of a new species *Hemidactylus satarensis* from Maharashtra brought out a key to the *Hemidactylus* of India. *Lygosoma vosmaerii* was rediscovered from Andhra Pradesh (Seetharamaraju *et al.*, 2009). Das and Vijayakumar (2009) discovered a new species of gecko *Ptychozoon nicobarensis* from the Nicobar archipelago. *Geckoella jeyporensis* was rediscovered after 135 years from the Eastern Ghats (Agarwal *et al.*, 2012).

New additions to the genus *Hemidactylus* include *Hemidactylus aaronbaueri* described from Pune (Giri, 2008), *Hemidactylus treutleri* described from Hyderabad (Mahony, 2009), *Hemidactylus gujaratensis* described from Gujarat (Giri *et al.*, 2009a), rediscovery of *Hemidactylus scabriceps* after 72 years from Eastern Tamil Nadu (Ganesh and Chandramouli, 2010), *Hemidactylus graniticolus* described from Karnataka (Agarwal *et al.*, 2011), *Hemidactylus acanthopholis* from Southern India (Mirza and Sanap, 2014) and *Hemidactylus yajurvedi* described from Chattisgarh (Murthy *et al.*, 2015). *Hemidactylus anamallensis*, an already described species, was reported from Chembra, Wayanad for the first time by Cyriac *et al.* (2011).

Manamendra-Arachchi *et al.* (2007) did a taxonomic revision of the Sri Lankan day-geckos. 11 new species were described from Sri Lanka in this study. Three new South Indian species were also described during the study. They were *Cnemaspis monticola, Cnemaspis australis* and *Cnemaspis nilagirica.* Other new species discovered in the genus *Cnemaspis* include *Cnemaspis kolhapurensis* (Giri *et al.*, 2009b) described from the northern Western Ghats of Maharashtra, *Cnemaspis heteropholis* from Agumbe (Ganesh *et al.*, 2011), *Cnemaspis girii* from the northern Western Ghats of Maharashtra (Mirza *et al.*, 2014), *Cnemaspis kottiyoorensis* from the hills of Kannur and Wayanad districts in Kerala (Cyriac and Umesh, 2014) and *Cnemaspis flaviventralis* from Maharashtra (Sayyed *et al.*, 2016).

Ganesh and Chandramouli (2013) brought out a note to distinguish between two very similar agamids, *Calotes nemoricola* and *Calotes grandisquamis*.

2.1.2 Snakes

Ajit (2000) rediscovered two rare *Typhlops*, *Typhlops thurstani* and *Typhlops tindalli* from Kerala. In 2007, a new species of wolf snake *Lycodon flavicollis* was described by Mukherjee and Bhupathy from the Anaikatti hills in Tamil Nadu. Gower and Winkler (2007) described taxonomy of genus *Xylophis* along with description of a new species *Xylophis captaini*. They also came up with a key to the genus *Xylophis* in India.

The Kerala Mud Snake *Enhydris dussumieri,* was recorded from Vellayani Lake (Kumar and Captain, 2011). Other records among snakes include a new species of coral snake *Calliophis castoe* from the west coast (Smith *et al.,* 2012), record of Wayanad Shieldtail *Melanophidium wynaudense* from the Central Western Ghats (Ganesh *et al.,* 2012), first record of *Chrysopelea taprobanica* from India (Guptha *et al.,* 2015) and a new species of racer snake *Wallaceophis gujaratensis* described from Gujarat (Mirza *et al.,* 2016). Gower *et al.* (2016) carried out a reassessment of the uropeltid genus *Melanophidium* from the Western Ghats and described a new species *Melanophidium khairei.*

2.1.3 Testudines

There was a record Leith's Softshell *Nilssonia leithi* Turtle from Kerala (Nameer *et al.,* 2007). The first record of Narrow-headed Softshell Turtle *Chitra indica* was reported from Kerala by Palot and Murthy (2015).

2.2 DIVERSITY STUDIES

Diversity studies on reptiles have been very less and are scattered throughout the country. Some of the studies done on the Western Ghats and Kerala region are discussed below. Ishwar *et al.* (2001) studied the reptiles of Kalakad–Mundanthurai Tiger Reserve, it was one study in which adaptive cluster sampling was used for surveying reptiles. They found a total of 55 species of reptiles in Kalakad–Mundanthurai Tiger Reserve. Ganesh *et al.* (2007) studied the herpetofauna of rainforests of Western Ghats in the Karnataka region. In this study along with species richness and abundance they also accessed the effect of anthropogenic pressure on the faunal diversity. They found that in areas altered or where there is high pressure from humans the species richness of the forest community is less and in such areas a dominant species which can adapt to these changes emerge. In the study among reptiles it was *Calotes rouxii* and among amphibians it was *Indirana beddomii.*

The herpetofauna of Cardamom Hills and Ponmudi Hills was investigated by Chandramouli and Ganesh (2010). In the four month survey they recorded 28 species of amphibians belonging to eight families and 46 species of reptiles belonging to nine families. Venugopal (2010a) published an annotated checklist of Indian lizards. It listed 196 species of lizards with valid distribution records in India. Family Gekkonidae has the highest number with 71 species followed by Scincidae with 58 and Agamidae with 47 species respectively.

Pit Vipers of Western Ghats of Goa were surveyed by Sawant *et al.* (2010). In this study three species of pit vipers *Trimeresurus malabaricus*, *Trimeresurus gramineus* and *Hypnale hypnale* were found. They showed clear differences in habitat preferences and season. The first two species were found to be primarily arboreal and *H. hypnale* terrestrial. *T. malabaricus* was found mostly in tropical semi-evergreen

forests while the other two were also found to inhabit cane brakes, wet bamboo brakes and moist deciduous forests.

Bhupathy and Nixon (2011) accessed reptiles in Upper Nilgiris in the Nilgiri Biosphere reserve. Reptiles of the Central Western Ghats were also accessed (Ganesh *et al.*, 2013). In this study which laid great emphasis on the Agumbe Plateau, 71 reptile species were found comprising 43 snakes, 24 lizards and four chelonians. This was a big development from the only 17 species that were previously described from the region. Reptiles of Meghamalai area (High Wavy Mountains) was surveyed by Bhupathy and Sathishkumar (2013). 90 species of reptiles with 30 of them endemic to the Western Ghats were reported in this study. Species richness, status and distribution of the snakes of High Wavy Mountains were published by Ganesh *et al.* (2014). 62 species and subspecies of snakes belonging to 8 families were reported with 25 of them endemic to Western Ghats. Most of the snakes in this area were found to have terrestrial nature. More than half of them belonged Near Threatened category. Most of the uropeltid snakes were classified as Data Deficient showing the lack of studies in the Uropeltidae family.

In 2014 the Conservation Assessment and Management Plan (CAMP) of IUCN brought out the status and distribution of reptiles in the Western Ghats (Srinivasulu *et al.*, 2014). Among the 107 species endemic to Western Ghats, 18 (16.82%) are assessed as threatened (CR, EN & VU), eight (7.47%) are assessed as Near Threatened species and 38 (35.51%) are assessed as Data Deficient. Coming to peninsular India an additional 50 species were added to the endemic category. Out of this 157, 14.64% species are threatened. Two species Jeypore Ground Gecko *Geckoella jeyporensis* and the Legless Skink *Barkudia insularis*, both endemic to the Eastern Ghats were accessed to be Critically Endangered.

The reptile studies in the state of Kerala has been very few. The first checklist on the reptiles of the State was published in 1997 by Radhakrishnan and contained 169 species (Palot, 2015). Taking into account new species findings and rediscoveries Palot (2015) published the most recent checklist of reptiles of Kerala. This checklist has listed 173 species of reptiles belonging to 24 families. Out of this 87 species are endemic to Western Ghats and 10 are endemic to Kerala. The list contains 2 crocodilians, 12 testudines, 12 agamids, 1 chamaeleon, 20 geckos, 2 lacertids, 18 skinks, 1 monitor lizard and 102 snakes.

2.3 MOLECULAR STUDIES

2.3.1 Testudines

In-depth studies of reptilian fauna have been very less. The first phylogenetic studies were carried out on the Testudines. Iverson *et al.* (2001) studied phylogenetic relationships between Asian tortoises of the genus *Indotestudo*. They recognized three nominal species of *Indotestudo, Indotestudo elongata* from the mainland of south eastern and southern India, *Indotestudo forstenii* from the islands of Halmahera and Sulawesi in eastern Indonesia and *Indotestudo travancorica* from the Western Ghats. DNA analysis study was carried out on Indian Star Tortoise *Geochelone elegans* for identification and relocation of the tortoises caught from trade into their natural habitat (Gaur *et al.*, 2006).

2.3.2 Snakes

Phylogeography study was carried out on the *Daboia russelli* complex in relation with changes in colour pattern and symptoms of envenoming (Thorpe *et al.*, 2007). Van Rooijen and Vogel (2009) investigated population systematics of *Dendrelaphis*

tristis and *Dendrelaphis schokari*. Analysis of morphological data revealed a third species that occurs sympatrically with *Dendrelaphis tristis* in south India, and its description matched with *Dendrelaphis chairecacos* and thus lead to the revalidation of *Dendrelaphis chairecacos*. They also brought out a key to *Dendrelaphis* of India.

2.3.3 Geckos

Bansal and Karanth (2010) carried out molecular phylogeny of *Hemidactylus* geckos which revealed a unique Indian radiation and origin for the *Hemidactylus* geckos of the Indian subcontinent.

2.3.4 Skinks

Phylogenetic study of the Asian skink genus *Eutropis* was carried out (Datta-Roy *et al.*, 2012). The study revealed an endemic radiation towards India that may have happened 5.5 – 17 million years ago giving rise to the members of the now endemic India radiation. Another skink genus *Lygosoma* yielded similar results with phylogenetic studies suggesting an *in situ* radiation with species distributed predominantly in India. But one of the Indian endemics *Lygosoma pruthi* was found to be not part of this clade thus making another suggestion that there may have been two dispersal events. One which brought *Lygosoma pruthi* and the next one which brought the rest of the skinks in the genus (Datta-Roy *et al.*, 2014).

Phylogeography of *Dasia* was described by Harikrishnan *et al.* (2012). They also described a new species *Dasia johnsinghi* based on morphological and molecular data. An updated key to the genus *Dasia* was also brought out by them.

2.3.5 Agamids

Brachysaura minor, a species which had remained a taxonomic mystery for more than 180 years was resolved into the genus *Calotes* after an in depth study taking into account nuclear and mitochondrial data, osteology, external morphology and hemipenial morphology (Deepak *et al.,* 2015).

Another study though not based on molecular data is worth mentioning. Mahony (2010) did systematic and taxonomic reevaluation of four little known agamid species, *Calotes kingdonwardi, Japalura kaulbacki, Salea kakhienensis* and the monotypic genus *Mictopholis.* Based on morphological examination the study suggested moving the first three into genus *Pseudocalotes.* Genus *Mictopholis* after comparison with other Draconine genera in Asia was found to be indistinguishable from *Pseudocalotes.*

One of the breakthrough studies of the decade is on the fan throated lizards. Earlier considered to be have two species *Sitana ponticeriana and Sitana deccanensis*, has been now split into seven species with five new additions and description of a new genus based on external morphology, osteology and molecular data (Deepak *et al.*, 2016). The new genus *Sarada* has two new species *Sarada darwini* and *Sarada superba,* and *Sitana deccanensis* has been changed to *Sarada deccanensis*. The new species in the *Sitana* genus are *Sitana visiri, Sitana laticeps* and *Sitana spinaecephalus.*

2.4 DISTIBUTION STUDIES

Distribution studies of species are also very less with studies done only on a handful of species. These include studies on *Hemidactylus albofasciatus* (Gaikwad *et al.,* 2009) and *Sespophis punctuatus* (Datta-Roy *et al.,* 2013). *Hemidactylus albofasciatus*, a poorly studied gecko known only from a few localities in Ratnagiri

district of Maharashtra was found in other localities as distant as 100km south thus enhancing its distribution. *Sespophis punctuatus,* the only species of the monotypic genus was earlier described from a single specimen from the Eastern Ghats 137 years ago. Datta-Roy *et al.* (2013) found more specimens of *Sespophis punctuatus* from Odisha and Andhra Pradesh thus bringing more light on its morphology, natural history, habitat and diet. In most of these studies the morphology and habitat of the species were also noted.

Density and microhabitat association of *Salea anamallayana* in Eravikulam National Park in the Western Ghats was studied by Deepak and Vasudevan (2008). Most of the individuals were found in shola. The density was calculated as 55 individuals per ha in shola. Mid-elevation evergreen forest, tea and eucalyptus plantation were also surveyed out of which the species was found only in tea plantations. Density in tea plantations were found to be 65 individuals per ha. This is an important information for conservation practices in a landscape dominated by different land uses.

Ecological studies have been done on the endemic chelonians *Indotestudo travancorica* and *Vijayachelys silvatica* (Kanagavel and Raghavan, 2012). The study was carried out in Vaazhachal and Chalakudy forest divisions of Kerala. Fire was found as the major threat to these threatened chelonians followed by human consumption. Out of the two species, *I. travancorica* was found to be more abundant. It was also the one more consumed and preferred for human consumption. These species are also the ones on which hunting as a threat to the species was accessed (Kanagavel and Raghavan, 2013). They concluded that consumption by indigenous communities can cause local extirpation around human settlements but not extirpation from the whole landscape as most wild chelonians were found far away from human inhabitation. But consumption need to be reduced to prevent more decline of these species.

2.5 STUDIES BASED ON AGROECOSYSTEMS

Coming to studies on agroforestry systems, the studies in the Western Ghats region have been primarily on birds and mammals. Study of small mammals in coffee farms in the Western Ghats was carried out by Caudill *et al.* (2014) and on the avian fauna in agroforests of Western Ghats by Karanth *et al.* (2016).

Some of the studies on the herpetaufauna in the human-modified landscape from around the world include: Herpetofauna of managed forest landscape in U.S.A. (Ryan *et al.*, 2002), comparative study of leaf litter herpetofauna in different agroecosystems and natural rain forest in Sri Lanka (Gamage *et al.*, 2008), herpetofauna of cacao agroforestry in Indonesia (Wanger *et al.*, 2009) and effect of land use change on community composition of reptiles and amphibians in Indonesia (Wanger *et al.*, 2010).

Palacios *et al.* (2013) published a review on agroforestry systems as suitable habitats for herpetofauna based on 72 case studies from 14 countries. They found from the studies that amphibian abundance is less in agroforestry systems than natural forests while the reverse is true for reptiles. Because of the severe lack of research on herpetofauna on plantations and other modified landscapes conclusions cannot be drawn entirely and it hinders the conservation of herpetofauna outside protected areas.

The one study in Western Ghats region on reptiles in human-modified habitats was carried out by Venugopal (2010b). He surveyed abandoned vanilla, abandoned rubber, vanilla and tea plantations and a degraded evergreen forest patch for agamid lizards and estimated their population densities. He found that modified habitats could support some endemic agamid lizards like *Calotes ellioti* which was the most common species in the study.

MATERIALS AND METHODS

MATERIALS AND METHODS

3.1 STUDY AREA

The main campus of Kerala Agricultural University is located at Vellanikkara, Thrissur. It lies between the latitudes $10^0$32'–$10^0$33'N and longitudes $76^0$16'–$76^0$17'E. Having a total area of 391.44 ha the university contains a wide array of habitats. These include orchards of mango, sapota, breadfruit, mangosteen, jack etc., plantations of coconut, arecanut, cocoa, cashew, rubber, and plantain, fodder grasses, arboretum, botanical garden and other garden lands. For the present study four different agroecosystems such as cashew plantation, coconut plantation, rubber plantation and botanical garden were selected. Additionally, two more habitats such as home garden and wetland, were also selected for the intensive study on the reptiles of these six different types of land uses. Home garden was chosen from an area near to the university while Wetland was chosen from Arimbur, Thrissur.

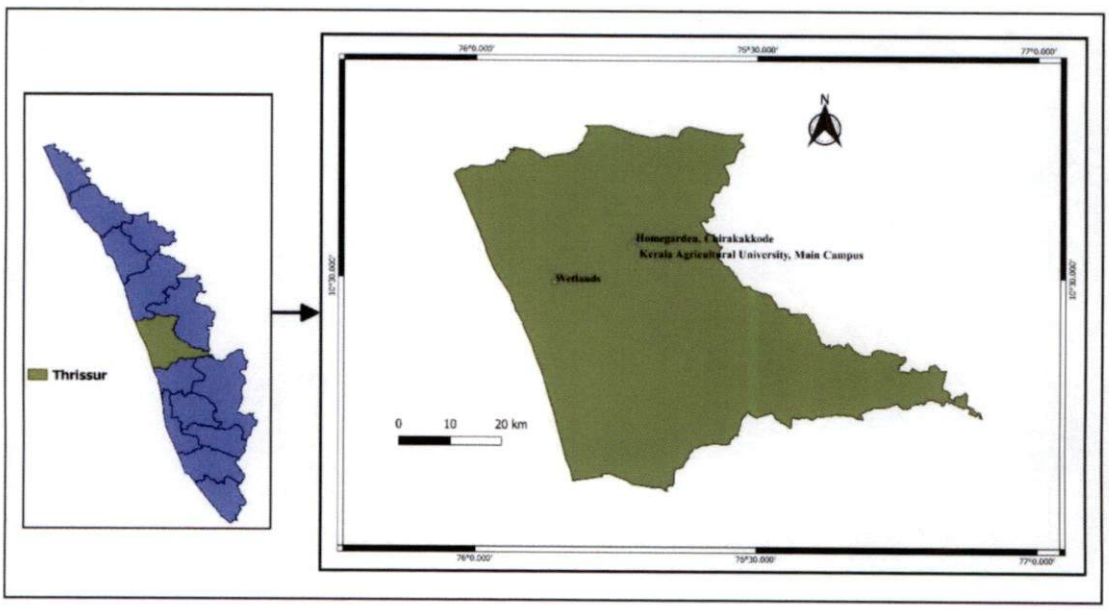

Figure 1. Location map of different study locations, Thrissur

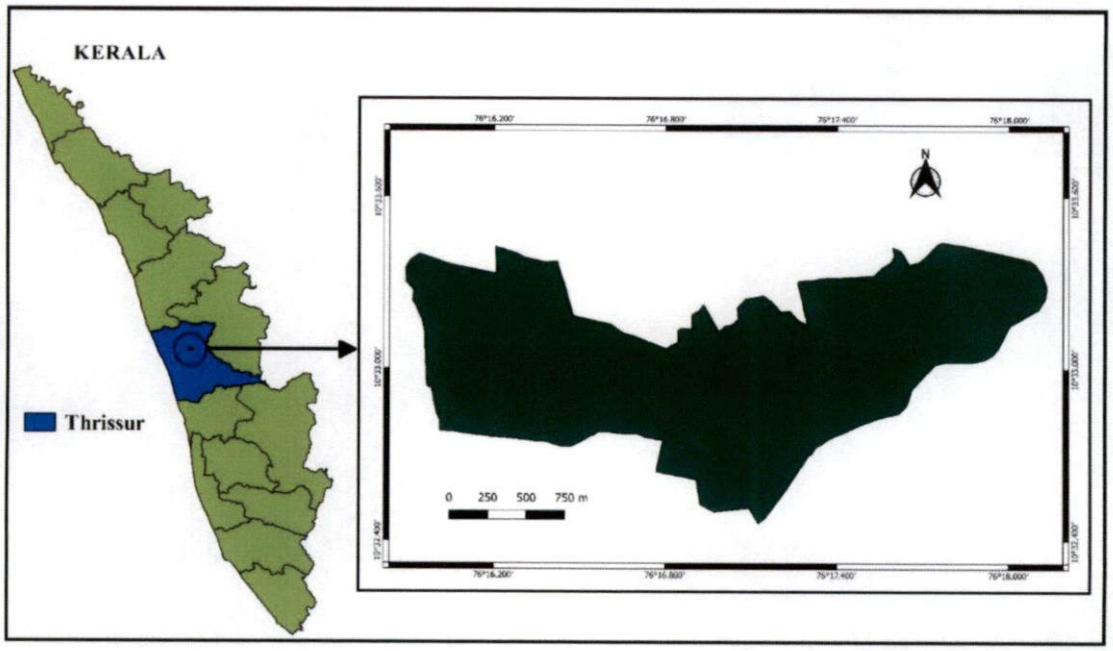

Figure 2. Location map of Kerala Agricultural University Main Campus

3.2 METHODS

The fieldwork was carried out from January 2017 to May 2017 in the different agroecosystems. A preliminary survey was done during the rainy season of 2016 in the Kerala Agricultural University main campus at Vellanikkara, Thrissur dist. Kerala.

3.2.1 Time-constrained Visual Encounter Survey

The study locations were covered on foot and the reptiles were recorded as soon as they were sighted. Whenever a species was sighted observations such as name of the species, number of individuals, latitude, longitude, time and elevation were recorded in the prescribed data sheet (Ishwar *et al.*, 2001). The method followed was time-constrained visual encounter survey with 2 hour duration, in the morning and in the night hours. The fieldwork was carried out between 8:00 to 10:00hrs. and 19:00 to

21:00hrs. at each of the habitats. Head lamps are used for doing the fieldwork at night. For each ecosystems the work was carried out for 5 days, comprising 10 field visits for each agroecosystem. Thus the total effort spent during the entire course of the study was 360 man hours (4hrs x 5days x 6 habitats x 3persons). The following micro-habitat parameters such as canopy height, canopy cover, leaf litter depth, leaf litter cover, shrub cover, herb cover and number of fallen logs were taken at each of the study locations. Litter depth was measured using a steel scale and canopy height was measured using haga altimeter. The rest of the measurements were visually estimated (Vasudevan *et al.,* 2001; Kanagavel *et al.,* 2013). Weather data like maximum temperature, minimum temperature, relative humidity etc. for the study period was obtained from the Kerala Agricultural University Weather Station.

3.2.2 Opportunistic records

Reptiles sighted incidentally across the campus were recorded to account for the diversity of the campus. Photographs were taken of the reptiles sighted using Canon SX50HS.

3.2.3 Laboratory studies

Voucher specimens were collected from the field. They were euthanized with diethyl ether and tissue was extracted from liver for further molecular analysis. The specimens after tissue extraction were injected with 4% formaldehyde solution and kept immersed in the same for 24 hours. After 24 hours the specimens were transferred to and kept in water for another 24 hours. After this they were preserved in 70% alcohol. The specimens were given tags which contain the common name, the scientific name, the date of collection, place, collector's name and specimen number.

According to species the standard morphological measurements were taken. For geckos snout-vent length, trunk length, body width, crus length, tail length, tail width, head length, head width, head height, forearm length, orbital diameter, nares to eye distance, snout to eye distance, eye to ear distance, internarial distance, interorbital distance are taken. Other morphological characters like lamellae, types of scales, femoral pores, cloacal pores were noted (Giri and Bauer, 2008). For skinks the number of supraoculars, scales around the body at mid body region, and subcaudal scales were noted. Additionally, the measurements mentioned above for geckos were taken for the skinks too (Datta-Roy *et al.*, 2013).

3.3 DATA ANALYSIS

The data analysis was carried out with the software PAST 3.15 (Hammer *et al.*, 2001). The following diversity indices (Magurran, 1988) were calculated:

3.3.1 Margalef's Diversity Index

This index uses species richness as a measure of diversity.

$$\text{Margalef's Diversity index } D_{Mg} = (S\text{-}1)/\ln N$$

S – the number of species recorded

N – the total number of individuals summed over all S species

3.3.2 Shannon's Diversity Index

This index is related to species richness but is also influenced by the abundance distribution of the underlying species.

$$\text{Shannon's Diversity Index } H' = -\Sigma pi \ln pi$$

p_i – the proportion of individuals found in the ith species

3.3.3 Evenness

Evenness, also called equitability shows how equally abundant the species are. The ratio of observed diversity to maximum diversity is taken as a measure of evenness and is calculated by dividing Shannon's Index by the logarithm of number of taxa.

$$\text{Evenness E} = H'/\ln S$$

H' – Shannon's Diversity Index

S – the number of species recorded

3.3.4 Berger-Parker Index

This index shows the abundance of the commonest species than providing a measure of species richness. It shows the proportional importance of the most abundant species.

$$\text{Berger-Parker Index } d = Nmax/N$$

N_{max} – the number of individuals in the most abundant species

N – the total number of individuals summed over all species

Apart from the indices the following analysis were carried out:

3.3.5 Correspondence analysis

Correspondence analysis is an ordination method for counted data. It is used for comparing associations (columns) containing counted taxa (Hammer *et al.*, 2001).

3.3.6 Canonical Correspondence analysis

This is a correspondence analysis in which environmental variables are given for each site in a site/species matrix. The gradient in environmental variables, which is known as a priori, is determined and species abundances are considered as responses to this gradient (Hammer *et al.*, 2001).

RESULTS

RESULT

4.1 SPECIES DIVERSITY OF REPTILES OF SELECTED AGROECOSYSTEMS IN THRISSUR

From the six selected agroecosystems (coconut plantation, cashew plantation, rubber plantation, home garden, botanical garden and wetland) a total of 18 species of reptiles were recorded from the visual encounter survey (Table 1). This includes six species of geckos, four species of skinks, one agamid and seven species of snakes. Two species, the Dussumier's Litter Skink *Sphenomorphus dussumieri* and Beddome's Cat Skink *Ristella beddomii* are endemic to Western Ghats.

Table 1: Reptiles of selected agroecosystems in Thrissur dist.

Sl. No.	Common Name	Scientific Name	Family	IUCN status
1.	Spotted House Gecko	*Hemidactylus brookii*	Gekkonidae	NE
2.	Common House Gecko	*Hemidactylus frenatus*	Gekkonidae	LC
3.	Bark Gecko	*Hemidactylus leschenaultii*	Gekkonidae	LC
4.	Termite Hill Gecko	*Hemidactylus triedrus*	Gekkonidae	NE
5.	Day Gecko spp	*Cnemaspis* spp	Gekkonidae	
6.	Kollegal Ground Gecko	*Geckoella collegalensis*	Gekkonidae	NE
7.	Dussumier's Litter Skink*	*Sphenomorphus dussumieri*	Scincidae	LC
8.	Bronze Grass Skink	*Eutropis macularia*	Scincidae	NE

9.	Common Keeled Skink	*Eutropis carinata*	Scincidae	LC
10.	Beddome's Cat Skink*	*Ristella beddomii*	Scincidae	LC
11.	Oriental Garden Lizard	*Calotes versicolor*	Agamidae	NE
12.	Common Indian Krait	*Bungarus caeruleus*	Elapidae	NE
13.	Beddome's Cat Snake	*Boiga beddomei*	Colubridae	LC
14.	Common Wolf Snake	*Lycodon aulicus*	Colubridae	NE
15.	Common Trinket Snake	*Coelognathus helena*	Colubridae	NE
16.	Common Vine Snake	*Ahaetulla nasuta*	Colubridae	NE
17.	Russell's Kukri Snake	*Oligodon taeniolatus*	Colubridae	LC
18.	Checkered Keelback	*Xenochrophis piscator*	Natricidae	NE

*Endemic to Western Ghats

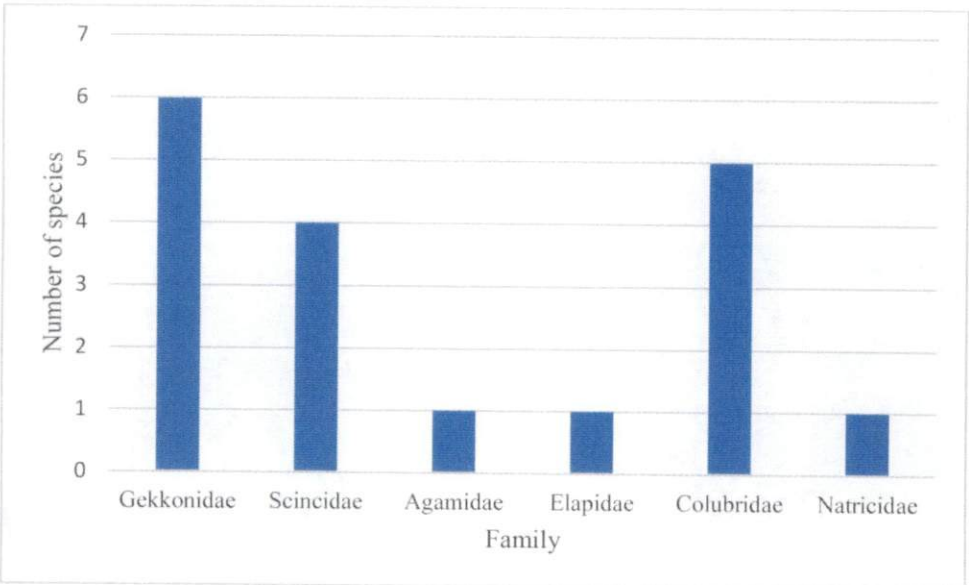

Figure 3. Family-wise distribution of reptiles in the selected agroecosystems in Thrissur dist.

4.2 DIVERSITY AND ABUNDANCE OF REPTILES IN EACH AGROECOSYSTEM

The species richness was the highest in the two habitats such as Coconut Plantation and Cashew Plantation, with each supporting 11 species each, while the species richness was the lowest in the Wetland habitat, with just two species (Table 2, Figure 4). The abundance of the reptiles, however was greatest in the Botanical Garden (159 individuals), followed by Coconut Plantation (145 individuals) and Rubber Plantation (143 individuals). The reptilian abundance was also the lowest in the Wetland habitat, which recorded just five individuals.

Eutropis macularia (Bronze Grass Skink) was the most abundant species of reptile with 220 individuals observed across the whole ecosystems followed by *Hemidactylus brookii* (Spotted House Gecko) with 87 individuals (Table 2).

Among geckos, *Hemidactylus brookii* (Spotted House Gecko) was the most abundant species with 82 individuals observed and *Hemidactylus triedrus* (Termite Hill Gecko) had the lowest count of two. Among skinks *Eutropis macularia* (Bronze Grass Skink) was the most abundant with 220 individuals observed and *Sphenomorphus dussumieri* (Dussumier's Litter Skink) was the least abundant with 13 individuals. Among snakes, *Lycodon aulicus* (Common Wolf Snake) was the abundant with four individuals observed.

In Coconut Plantation, *Hemidactylus brookii* (Spotted House Gecko) was the most abundant species with 47 individuals. In Cashew Plantation, Rubber Plantation and Botanical Garden *Eutropis macularia* (Bronze Grass Skink) was the most abundant species with 45, 82 and 70 individuals respectively. In Home garden *Sphenomorphus dussumieri* (Dussumier's Litter Skink) leads with 13 individuals and in Wetland it is *Xenochrophis piscator* (Checkered Keelback) with three individuals.

Table 2: Species diversity and abundance of reptiles in selected agroecosystems in Thrissur dist.

Sl. No.	Species	Coconut Plantation	Cashew Plantation	Rubber Plantation	Home garden	Botanical Garden	Wetland	**Total**
		Number of individuals						
1	*Hemidactylus brookii*	47	20	3	2	10	0	**82**
2	*Hemidactylus frenatus*	29	1	7	3	2	0	**42**
3	*Hemidactylus leschenaultia*	11	5	9	1	1	0	**27**
4	*Hemidactylus triedrus*	0	2	0	0	0	0	**2**
5	*Cnemaspis* spp	10	1	8	3	19	0	**41**
6	*Geckoella collegalensis*	7	6	18	2	11	0	**44**
7	*Sphenomorphus dussumieri*	0	0	0	13	0	0	**13**
8	*Eutropis macularia*	21	45	82	2	70	0	**220**
9	*Eutropis carinata*	1	9	0	0	14	0	**24**
10	*Ristella beddomii*	0	11	5	0	28	0	**44**
11	*Calotes versicolor*	16	11	9	3	3	0	**42**
12	*Bungarus caeruleus*	0	0	0	1	0	0	**1**
13	*Boiga beddomei*	1	0	1	0	0	0	**2**
14	*Lycodon aulicus*	1	1	0	0	0	2	**4**
15	*Coelognathus helena*	1	0	0	0	0	0	**1**
16	*Ahaetulla nasuta*	0	0	1	0	0	0	**1**
17	*Oligodon taeniolatus*	0	0	0	0	0	3	**1**
18	*Xenochrophis piscator*	0	0	0	0	1	0	**3**
	Total	**145**	**112**	**143**	**30**	**159**	**5**	**594**

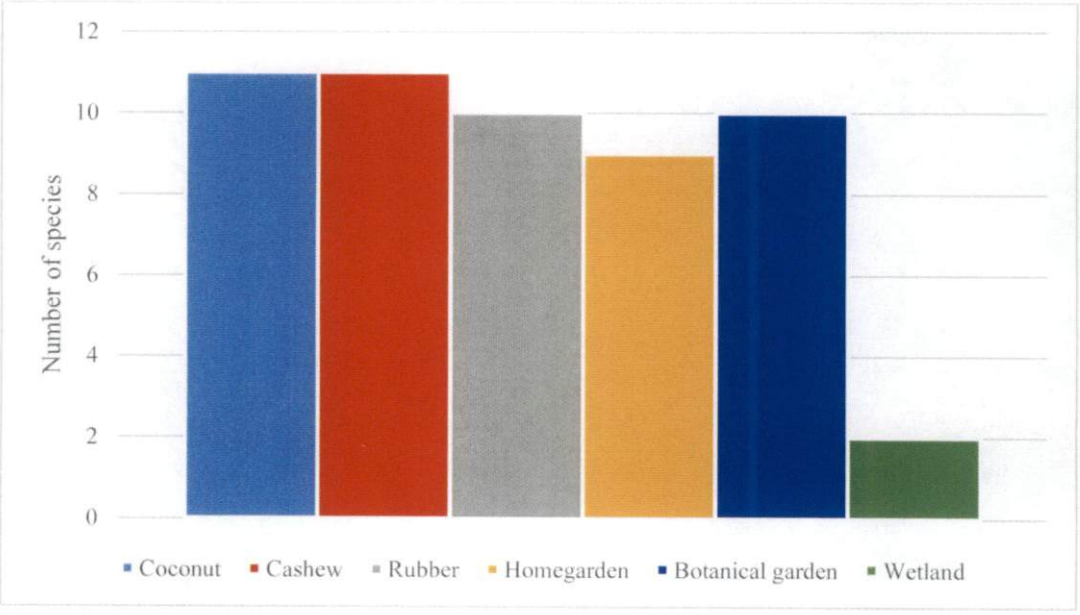

Figure 4. Number of species of reptiles in different agroecosystems in Thrissur dist.

4.3 THE VARIATION IN THE REPTILE SPECIES RICHNESS AND ABUNDANCE BETWEEN MORNING AND NIGHT HOURS

The fieldwork was carried out for two hours in the morning and two hours at night, which was repeated for five days in each of the six different agroecosystems. The number of species as well as number of individuals obtained for each species in the two time periods are given in Figure 5 and Figure 6 respectively.

Number of species are obtained is greater at night for all the habitats. There is clear difference between the number of species obtained for the habitats during morning and night. Coconut Plantation and Cashew Plantation recorded the highest number of species at night with 10 species each. For Wetland no species was observed during the morning hours (Figure 5).

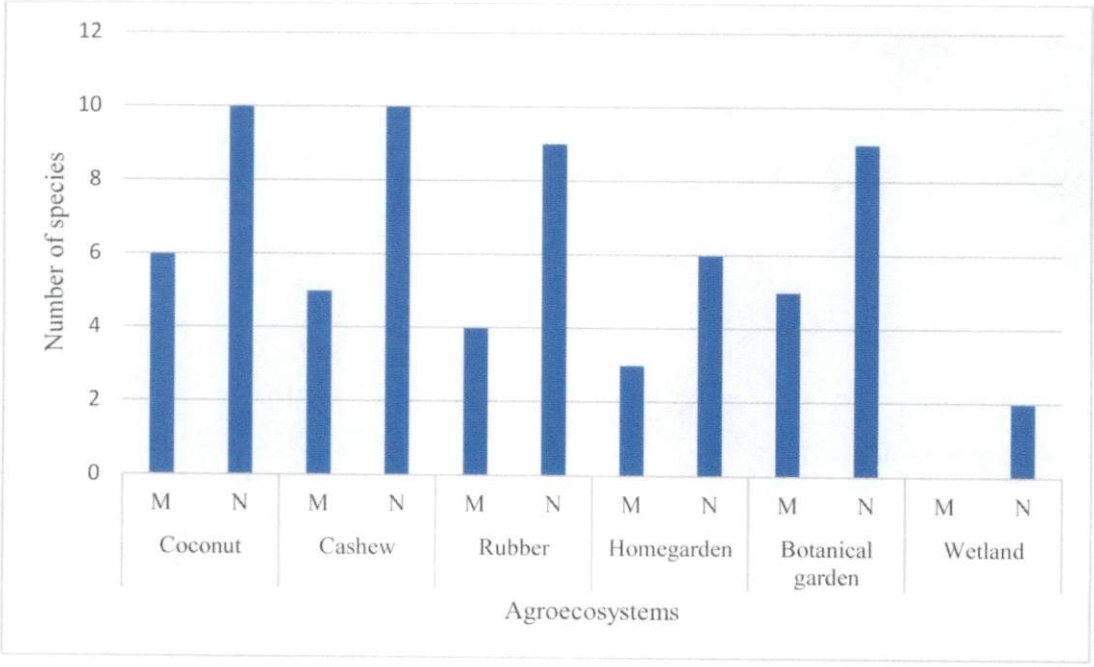

Figure 5. Number of species of reptiles recorded during morning and night hours in selected agroecosystems in Thrissur dist.

Most of the reptile species observed were nocturnal. Out of the four species of *Hemidactylus* geckos obtained, only two had a few individuals observed during the morning hours. They are predominantly nocturnal. *Geckoella collegalensis* (Kollegal Ground Gecko) also showed a similar habit as *Hemidactylus* geckos with only a few sighted during the morning hours (Figure 6).

Cnemaspis spp (Day Geckos), as its common name suggests was observed mainly during the morning hours with only a single specimen sighted at night. Among skinks, *Ristella beddomii* (Beddome's Cat Skink) was mostly seen at night while *Sphenomorphus dussumieri* (Dussumier's Litter Skink) was spotted only during the morning hours. Both the *Eutropis* species, *Eutropis macularia* (Bronze Grass Skink) and *Eutropis carinata* (Common Keeled Skink) and *Calotes versicolor* (Oriental Garden Lizard) was observed somewhat evenly during the morning and night hours.

All the seven species of snakes observed were observed during the night hours (Figure 6).

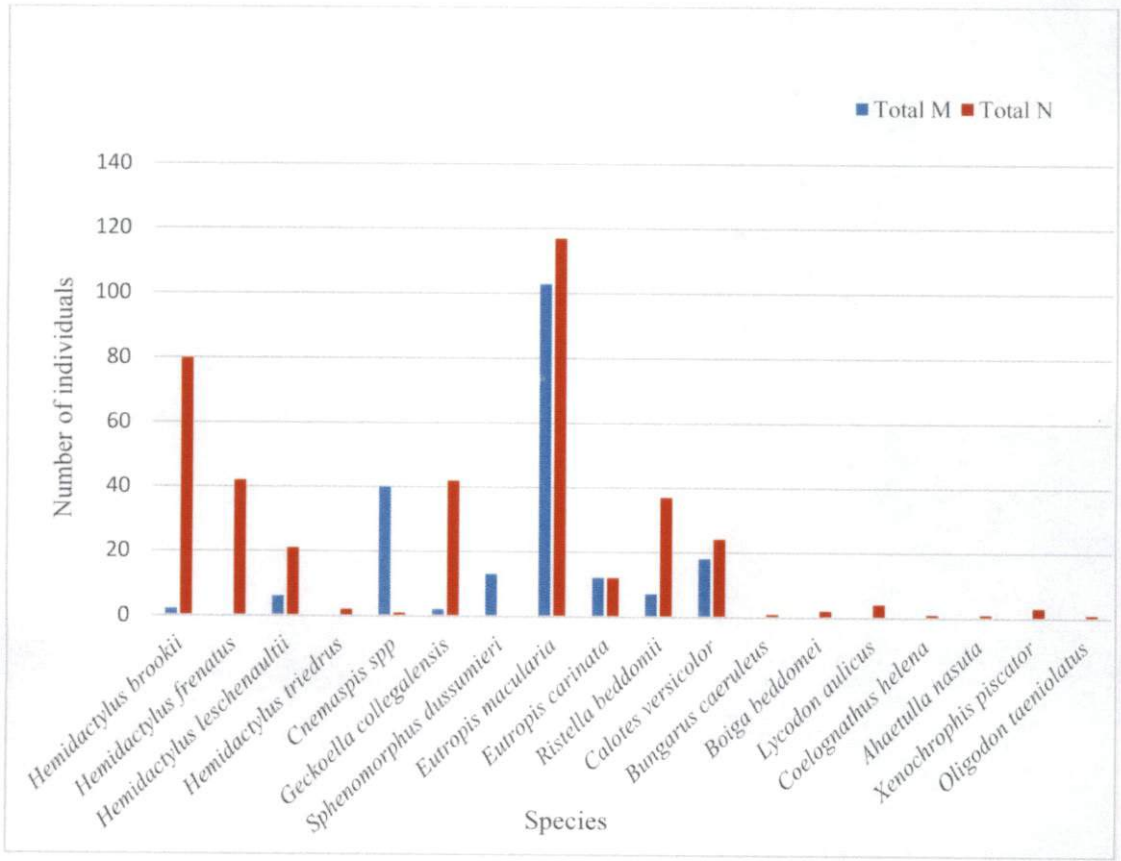

Figure 6. Number of individuals for each species of reptile recorded during morning and night hours

4.4 DIVERSITY OF REPTILES AT SELECTED AGROECOSYSTEMS

The different diversity indices such as Shannon's Diversity Index, Margalef's Diversity Index, Evenness and Berger-Parker Index were calculated to understand the reptilian diversity in the selected agroecosystems in Thrissur dist. The details of which is given in Table 3.

Shannon's Diversity Index is high for the three habitats, Coconut Plantation (1.87), Cashew Plantation (1.83) and Home garden (1.82) and lowest for Wetland (0.67).

Evenness is highest for Wetland (0.98) and lowest for Rubber Plantation (0.45). Berger-Parker Index which accounts for dominance is highest for Wetland and lowest for Coconut Plantation.

Table 3: Diversity of reptiles in the selected agroecosystems in Thrissur dist.

Diversity Index	Coconut Plantation	Cashew Plantation	Rubber Plantation	Home garden	Botanical Garden	Wetland
Taxa_S	11	11	10	9	10	2
Individuals	145	112	143	30	159	5
Shannon_H	1.87	1.83	1.51	1.82	1.69	0.67
Evenness_e^H/S	0.59	0.56	0.45	0.69	0.54	0.98
Margalef	2.0	2.1	1.81	2.35	1.78	0.62
Berger-Parker	0.32	0.40	0.57	0.43	0.44	0.60

4.5 COMPARING REPTILIAN DIVERSITY BETWEEN DIFFERENT AGROECOSYSTEMS IN THRISSUR DIST.

The diversity *t* test was done to compare between the reptilian diversity between each of the selected agroecosystems in Thrissur. The details of which are given in Table 4.

Reptilian diversity of Coconut Plantation as well as the Cashew Plantation have been found to be significantly different from the reptilian diversity of Rubber

Plantation. Reptilian diversity of has also shown significant difference with the reptilian diversity of Rubber Plantation. Wetland, a varied habitat from the other five habitats considered under the present study has been found to be significantly different from all the rest of the habitats under present study.

Table 4. Comparing the reptilian diversity between the selected agroecosystems in Thrissur dist.

Agroecosystems	**t**	**Df**	**p**
Coconut Plantation and Cashew Plantation	0.42	218.16	0.67
Coconut Plantation and Rubber Plantation	3.08*	251.8	0.00
Coconut Plantation and Home garden	0.28	39.02	0.78
Coconut Plantation and Botanical Garden	1.85	302.55	0.07
Coconut Plantation and Wetland	6.67*	6.74	0.00
Cashew Plantation and Rubber Plantation	2.40*	254.78	0.02
Cashew Plantation and Home garden	0.02	46.76	0.98
Cashew Plantation and Botanical Garden	1.18	239.96	0.24
Cashew Plantation and Wetland	6.07*	8.34	0.00
Rubber Plantation and Home garden	-1.56	50.63	0.16
Rubber Plantation and Botanical Garden	-1.46	273.65	0.14
Rubber Plantation and Wetland	4.28*	9.12	0.00
Home garden and Botanical Garden	0.70	41.53	0.49
Home garden and Wetland	4.71*	18.72	0.00
Botanical Garden and Wetland	5.54*	7.23	0.00

*Significant at 5%

4.6 CORRESPONDENCE ANALYSIS

Correspondence analysis was done to find out the affinity of the reptile species to the various agroecosystems in Thrissur dist., the details of which is given in Figure 7. Correspondence analysis shows that the reptilian community of the Home garden and Wetland habitats are quite distinct from that of other agroecosystems studied. It is also evident that the agroecosystems such as Coconut Plantation, Cashew Plantation, Rubber Plantation and Botanical Garden have a many common species among them.

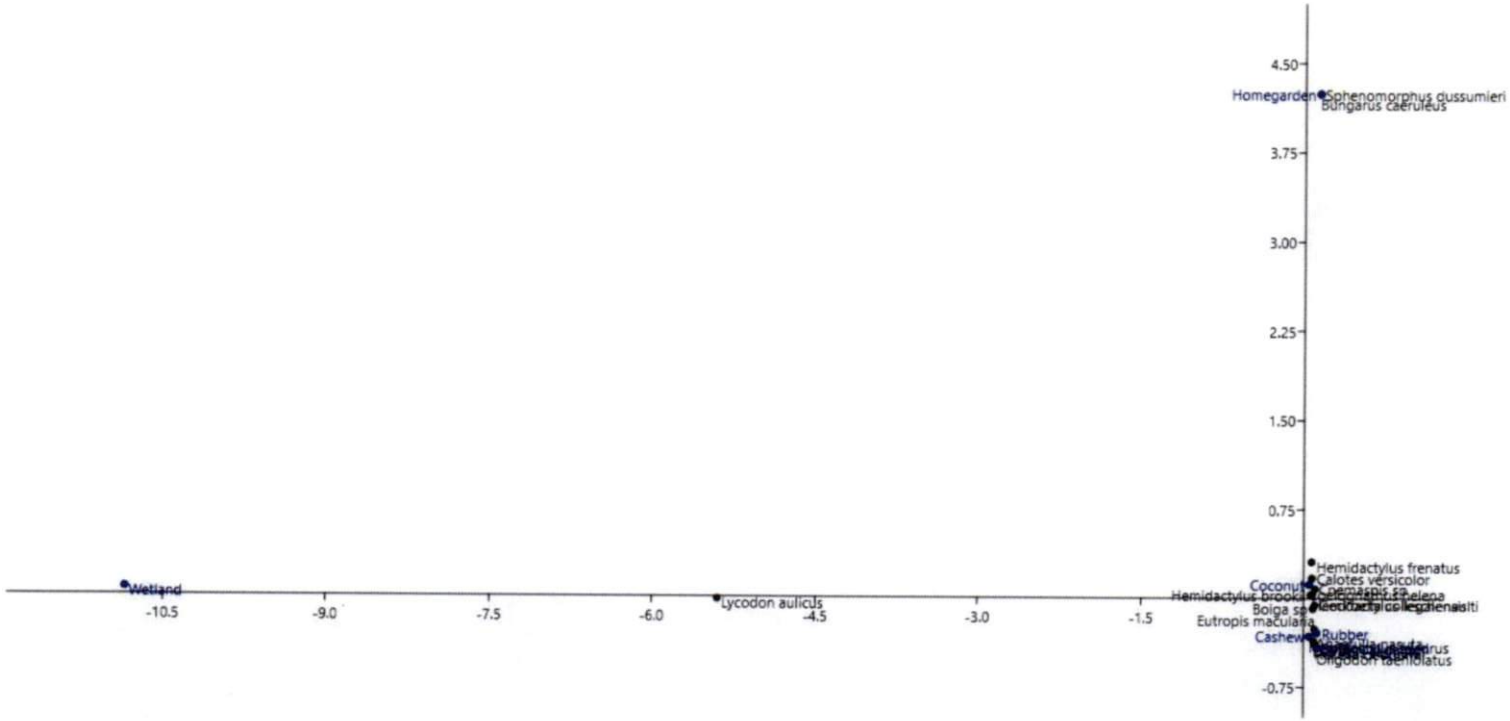

Figure 7. Correspondence analysis scatter plot of the reptiles of selected agroecosystems in Thrissur dist.

4.7 CANONICAL CORRESPONDENCE ANALYSIS

Canonical correspondence analysis was carried out to analyse the effect of habitat variables on the reptilian species distribution in the selected agroecosystems in Thrissur dt (Figure 8). Habitat variables taken into account for this analysis are canopy height, canopy cover, shrub cover, herb cover, maximum temperature, minimum temperature, mean relative humidity.

It has been observed that following habitats variables such as litter cover, litter depth, canopy height, canopy cover, shrub cover and herb cover have been found to be influencing the distribution of the three species of reptiles such as *Oligodon taeniolatus, Geckoella collegalensis* and *Cnemaspis* spp in the agroecosystems of Thrissur dist.

The habitat variables such as minimum temperature and mean relative humidity have been found to be slightly influencing the distribution of the reptiles such as *Calotes versicolor, Boiga beddomei, Hemidactylus triedrus, Hemidactylus brookii, Lycodon aulicus, Coelognathus helena* and *Xenochrophis piscator* in the selected agroecosystem in Thrissur.

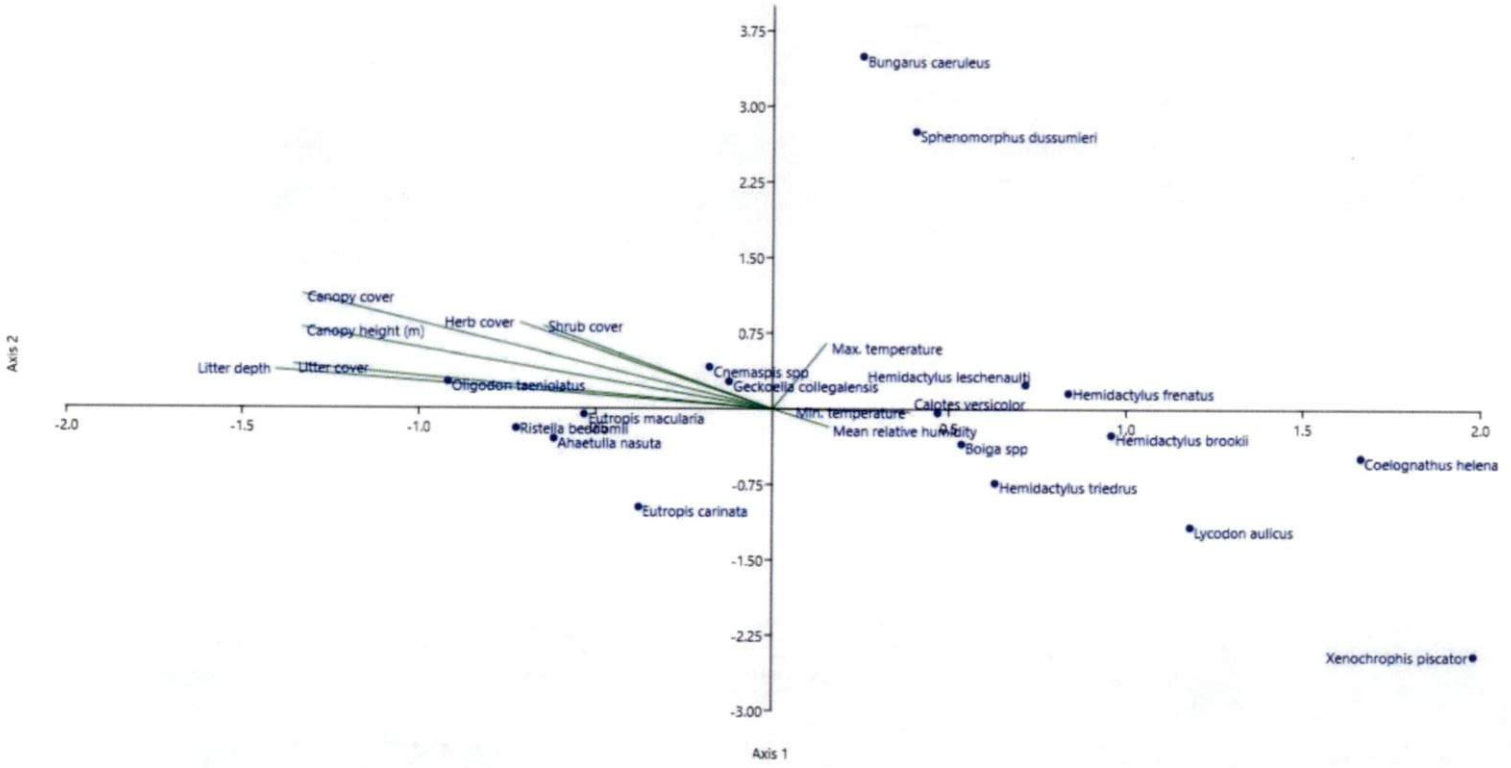

Figure 8. Canonical Correspondence analysis plot of the reptiles of selected agroecosystems in Thrissur dist.

4.8 MORPHOMETRY OF THE REPTILES IN THE AGROECOSYSTEMS OF THRISSUR DIST.

The following standard morphological measurements were taken for the specimens collected: snout-vent length, trunk length, body width, crus length, tail length, tail width, head length, head width, head height, forearm length, orbital diameter, nares to eye distance, snout to eye distance, eye to ear distance, internarial distance and interorbital distance. In the case of skinks additional measurements such as the number of supraoculars, scales around the body at mid body region, supralabials, infralabials and subcaudal scales were also noted.

Table 5. Morphological measurements for *Geckoella collegalensis*

	Specimens						
Measurements (mm)	1	2	3	4	5	Average	Standard Deviation
Snout-vent length	37.91	33.07	40.11	41.08	43.68	39.17	3.25754
Trunk length	15.19	15.21	18.24	17.91	18.95	17.10	1.44905
Body width	7.61	6.95	7.43	7.84	8.5	7.67	0.46499
Crus length	5.33	5.6	5.93	5.38	5.99	5.65	0.2489
Tail length	29.2	24.16	17.76	26.09	34.06	26.25	4.93579
Tail width	4.03	3.7	4.29	3.79	4.25	4.01	0.21636
Head length	12.6	12.98	12.99	13.62	14.11	13.26	0.48973
Head width	7.58	7.61	8.86	8.18	8.68	8.18	0.48258
Head height	5.18	5.23	6.03	6.05	6.24	5.75	0.40901
Forearm length	5.1	5.07	5.12	5.22	5.77	5.26	0.23907
Orbital diameter	2.53	2.52	2.97	2.53	3.17	2.74	0.24977
Nares to eye distance	2.36	2.97	2.83	2.98	2.75	2.78	0.20651
Snout to eye distance	4.12	4.42	4.44	4.4	4.66	4.41	0.15689
Eye to ear distance	3.15	3.18	3.17	3.43	3.28	3.24	0.09511
Internarial distance	2.02	2	2.06	2.09	1.93	2.02	0.05
Interorbital distance	5.34	5.39	6.01	5.93	5.56	5.65	0.25157

Table 6. Morphological measurements for *Hemidactylus leschenaultii*

Measurements (mm)	Specimens					Average	Standard Deviation
	1	2	3	4	5		
Snout-vent length	48.37	35.19	51.8	52.75	50.47	47.72	5.87
Trunk length	20.03	15.29	2.83	24.59	21.28	16.80	6.94
Body width	9.21	6.77	9.62	9.1	10.47	9.03	1.12
Crus length	5.91	4.62	6.96	6.4	5.51	5.88	0.73
Tail length	51.57	34.03	30.53	57.9	30.5	40.91	10.53
Tail width	4.64	3.47	5.22	5.17	3.85	4.47	0.64
Head length	16.18	12.84	17.69	16.38	16.7	15.96	1.50
Head width	10.04	7.61	10.75	10.53	9.83	9.75	1.02
Head height	5.63	5.48	6.68	6.46	5.85	6.02	0.43
Forearm length	5.48	3.46	5.58	5.35	5.41	5.06	0.73
Orbital diameter	3.08	2.67	3.77	3.22	3.11	3.17	0.32
Nares to eye distance	4.43	3.32	4.84	4.44	4.31	4.27	0.46
Snout to eye distance	5.59	4.65	6.24	5.55	5.6	5.53	0.46
Eye to ear distance	9.98	3.11	4.23	3.89	4.11	5.06	2.27
Internarial distance	1.91	1.53	1.71	1.93	1.96	1.81	0.15
Interorbital distance	5.77	4.52	6.01	5.04	5.32	5.33	0.48
Lamellae	10	10	9	10	9	0	
Types of Scales	Smooth	Smooth	Smooth	Smooth	Smooth		
Femoral pores	Absent	Absent	13	16	Absent		
Cloacal pores	Absent	6	Absent	Absent	Absent		

Table 7. Morphological measurements for *Hemidactylus brookii*

Measurements (mm)	Specimens					Average	Standard Deviation
	1	2	3	4	5		
Snout-vent length	50.53	49.07	49.86	39.56	41.13	46.03	4.28
Trunk length	22.94	22.93	22.69	17.97	17.33	20.77	2.34
Body width	11.61	10.94	10.59	7.66	7.46	9.65	1.59
Crus length	6.09	5.38	5.83	4.66	5	5.39	0.48
Tail length	42.5	55.29	36.37	29.31	38.35	40.36	7.85
Tail width	4.5	4.66	4.81	4.35	4.19	4.50	0.20
Head length	16.53	14.69	14.82	13.06	15.11	14.84	1.01
Head width	10.88	10.1	9.89	8.56	8.58	9.60	0.83
Head height	6.8	5.98	5.24	5	4.93	5.59	0.65
Forearm length	5.92	5.22	4.85	4.33	4.6	4.98	0.50
Orbital diameter	2.85	2.81	3	2.38	2.57	2.72	0.20
Nares to eye distance	4.31	3.96	3.99	3.56	3.29	3.82	0.33
Snout to eye distance	5.56	5.51	5.2	4.52	4.52	5.06	0.42
Eye to ear distance	4.34	4.49	4.04	3.33	3.51	3.94	0.41
Internarial distance	1.74	1.6	1.64	1.54	1.55	1.61	0.07
Interorbital distance	5.23	5.17	5.27	4.51	5.21	5.08	0.26
Lamellae	7	7	7	7	7		
Types of Scales	Keeled	Keeled	Keeled	Keeled	Keeled		
Femoral pores	11	11	0	0	10		

Table 8. Morphological measurements for *Eutropis macularia*

Measurements (mm)	Specimens					Average	Standard Deviation
	1	2	3	4	5		
Snout-vent length	49.41	50.97	50.35	49.62	46.56	49.38	1.38
Trunk length	25.07	25.51	24.93	26.31	22.58	24.88	1.14
Body width	11.67	11.4	10.41	13.24	10.77	11.50	0.89
Crus length	5.33	4.71	4.42	4.45	4.4	4.66	0.32
Tail length	61.25	76.02	74.8	59.94	59.56	66.31	6.81
Tail width	4.9	5.74	4.98	5.91	4.77	5.26	0.43
Head length	14.06	14.49	14.98	15.11	13.61	14.45	0.51
Head width	7.6	8.29	8.57	9.41	8.07	8.39	0.55
Head height	6.23	6.06	6.14	6.51	6.83	6.35	0.26
Forearm length	3.95	3.92	3.29	4.06	4.05	3.85	0.26
Orbital diameter	2.79	2.9	2.37	2.66	2.38	2.62	0.20
Nares to eye distance	2.31	2.48	2.46	2.04	2.26	2.31	0.15
Snout to eye distance	3.68	3.72	3.69	3.57	3.96	3.72	0.12
Eye to ear distance	2.79	3.07	2.7	3.2	2.83	2.92	0.17
Internarial distance	2.02	2.13	2.1	2.12	1.98	2.07	0.05
Interorbital distance	5.05	5.41	5.06	5.06	5.21	5.16	0.13

Table 9. Morphological measurements for *Ristella beddomii*

Measurements (mm)	Specimens					Average	Standard Deviation
	1	2	3	4	5		
Snout-vent length	30.73	31.53	31.14	31.93	33.18	31.70	0.77
Trunk length	16.16	17.37	17.52	18.01	18.4	17.49	0.69
Body width	5.25	5.01	5.56	6.53	6.75	5.82	0.63
Crus length	2.85	2.68	2.92	2.77	2.68	2.78	0.09
Tail length	38.51	46.69	36.08	47.04	32.3	40.12	5.34
Tail width	3.94	3.63	3.88	3.64	3.65	3.75	0.12
Head length	7.41	7.91	7.71	8.32	8.42	7.95	0.34
Head width	4.83	4.74	4.97	4.79	4.97	4.86	0.09
Head height	3.25	3.71	3.96	3.73	3.77	3.68	0.21
Forearm length	2.48	2.37	2.54	2.63	2.64	2.53	0.09
Orbital diameter	1.38	1.49	1.54	1.64	1.48	1.51	0.08
Nares to eye distance	1.52	1.4	2	1.51	1.56	1.60	0.19
Snout to eye distance	2.24	2.41	2.3	2.45	2.24	2.33	0.08
Eye to ear distance	2.21	2.48	2.3	2.53	2.32	2.37	0.11
Internarial distance	1.55	1.54	1.15	1.44	1.19	1.37	0.16
Interorbital distance	3.19	3.34	3.36	3.49	3.32	3.34	0.09

Table 10. Scale counts for *Eutropis macularia*

Scales	Specimens				
	1	2	3	4	5
Supraoculars	4	4	4	4	4
Loreal	2	2	2	2	2
Supralabials	6	6	6	6	6
Infralabials	6	6	6	6	6
Scales around the body at mid region	28	29	28	28	29
Dorsal	5 keeled	5 keeled	5 keeled	5 keeled	5 keeled
Subcaudal	55	69	73	63	52

Table 11. Scale counts for *Ristella beddomii*

Scales	Specimens				
	1	2	3	4	5
Supraoculars	5	5	5	5	5
Supralabials	5	5	5	5	5
Infralabials	4	4	4	4	4
Scales around the body at mid region	26	27	28	28	26
Dorsal	smooth	smooth	Smooth	smooth	Smooth
Subcaudal	53	62	48	65	44

4.9 DISRIBUTION MAPS OF SELECTED SPECIES OF REPTILES IN AGROECOSYSTEMS IN KERALA AGRICULTURAL UNIVERSITY MAIN CAMPUS

Distribution maps of the following species, *Calotes versicolor* (Figure 9), *Cnemaspis* spp (Figure 10), *Eutropis carinata* (Figure 11), *Eutropis macularia* (Figure 12), *Geckoella collegalensis* (Figure 13), *Hemidactylus brookii* (Figure 14), *Hemidactylus frenatus* (Figure 15), *Hemidactylus leschenaultii* (Figure 16) and *Ristella beddomii* (Figure 17) are shown below.

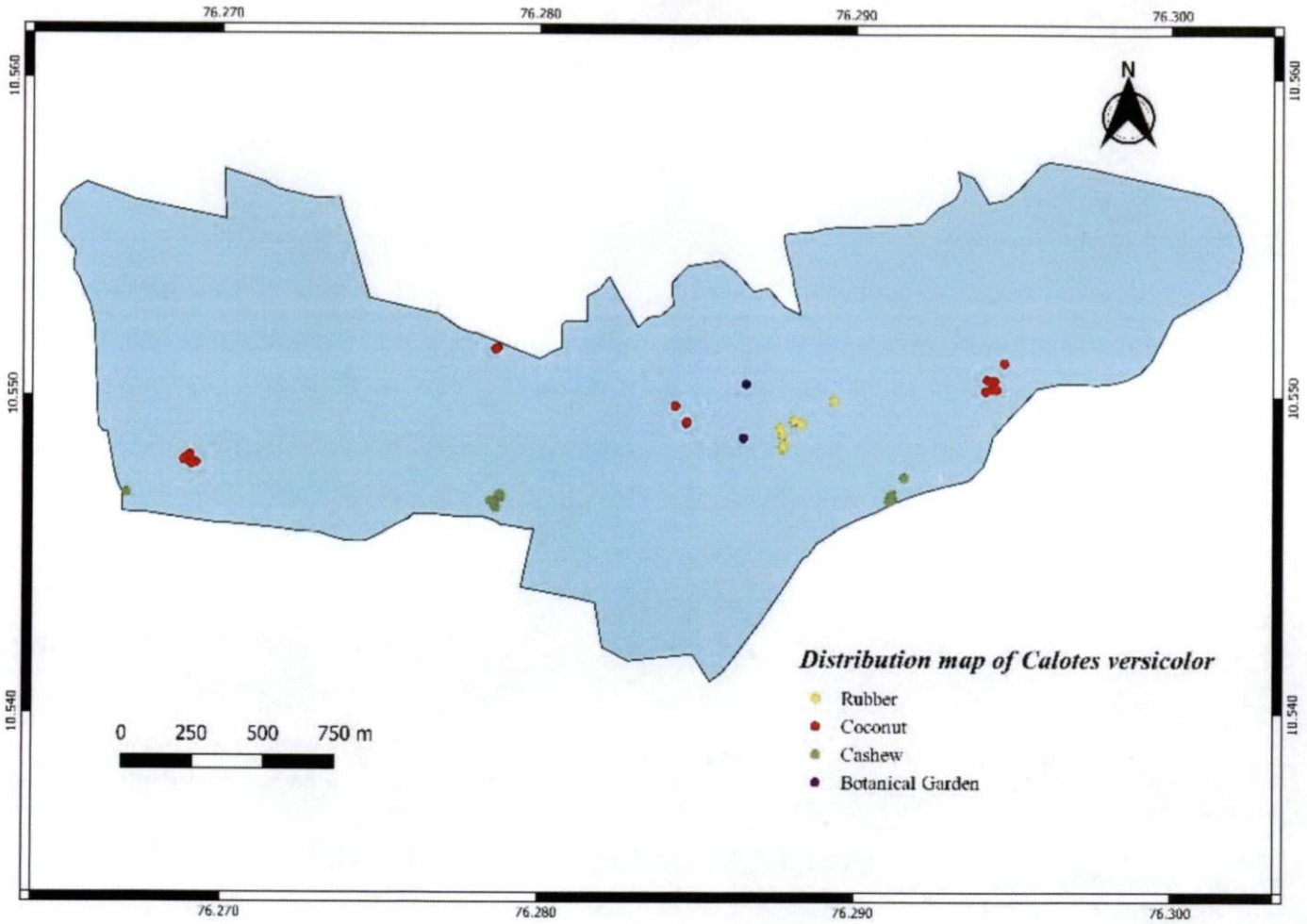

Figure 9. Distribution map of *Calotes versicolor* in agroecosystems in Kerala Agricultural University Main Campus

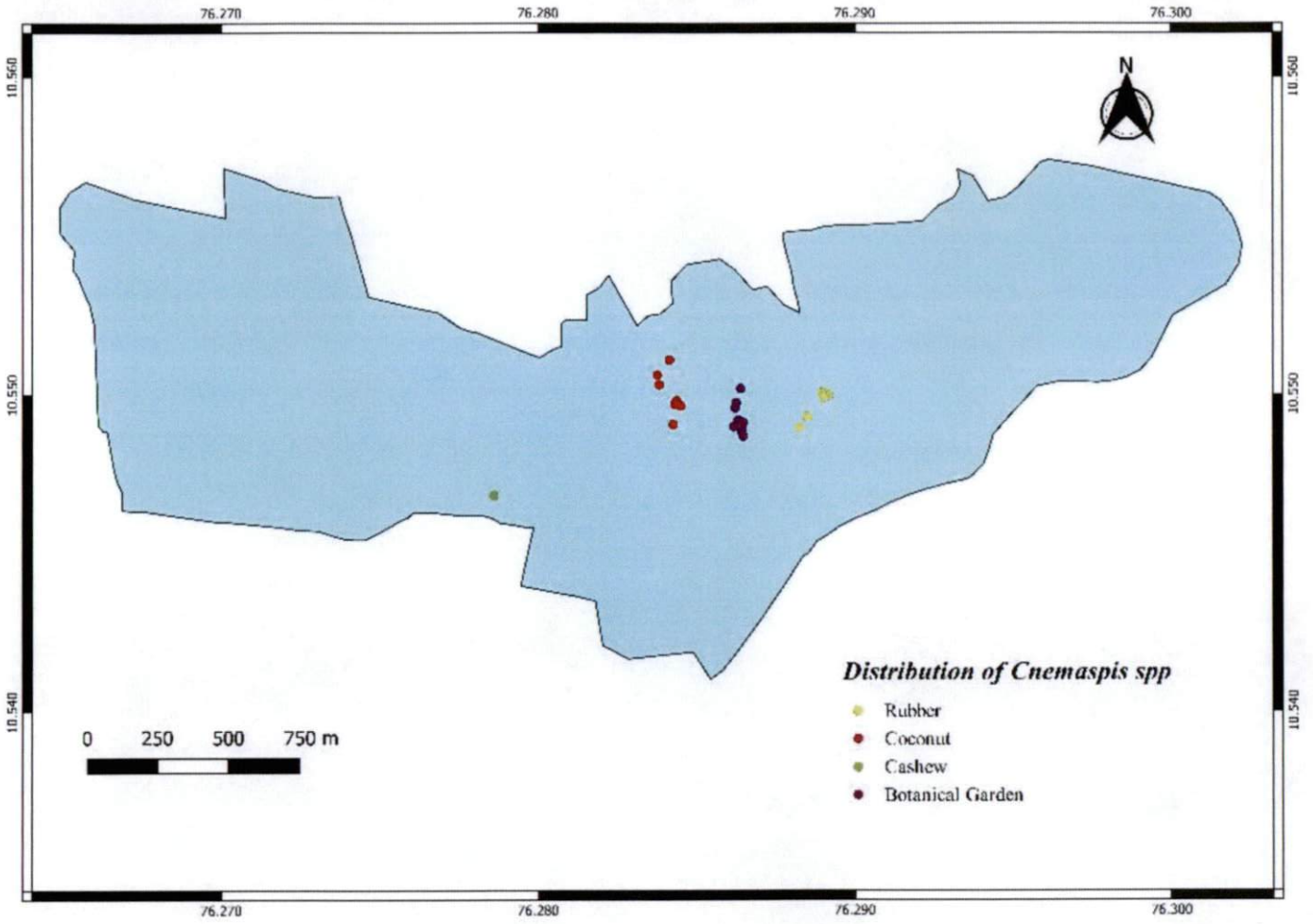

Figure 10. Distribution map of *Cnemaspis* spp in agroecosystems in Kerala Agricultural University Main Campus

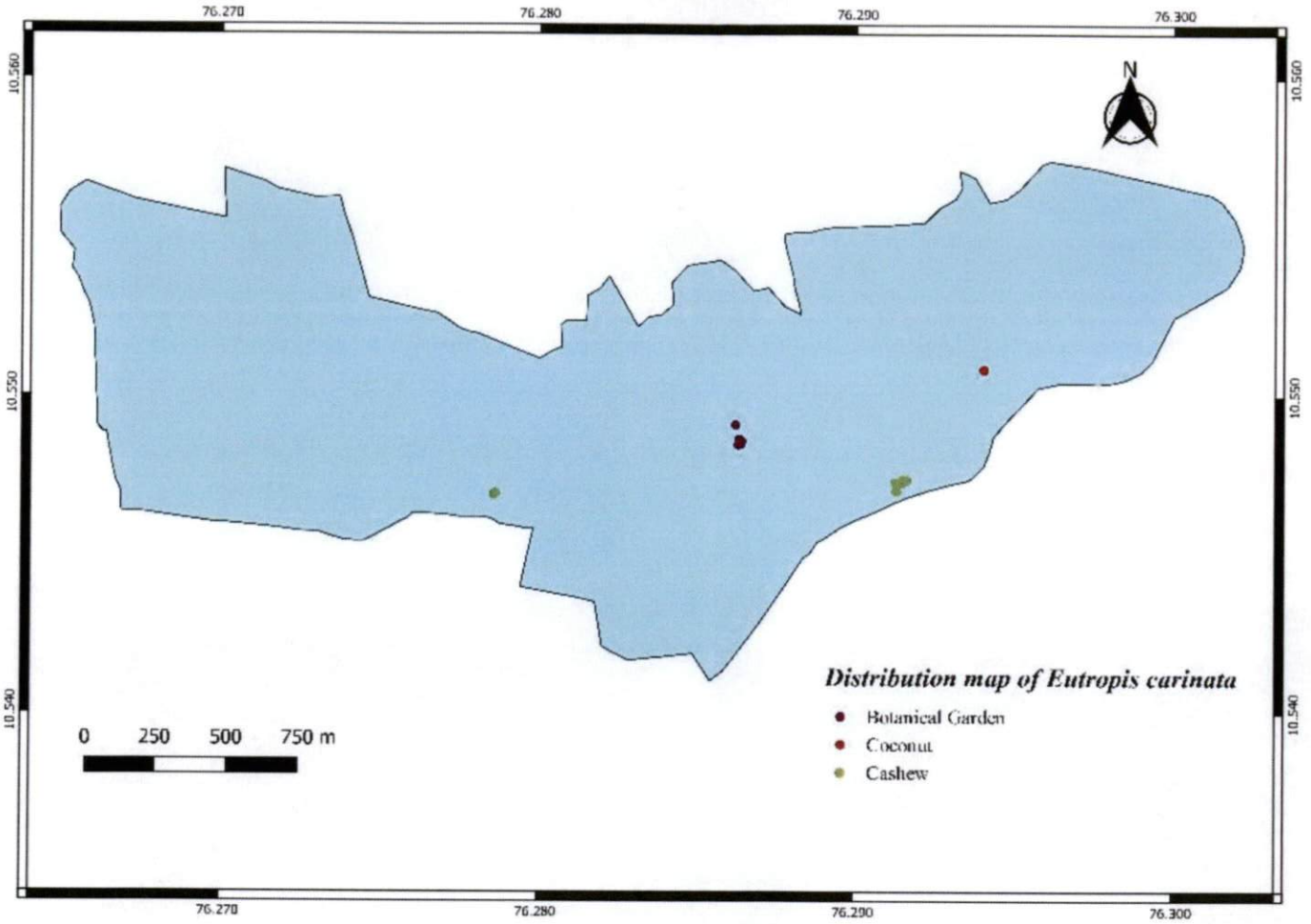

Figure 11. Distribution map of *Eutropis carinata* in agroecosystems in Kerala Agricultural University Main Campus

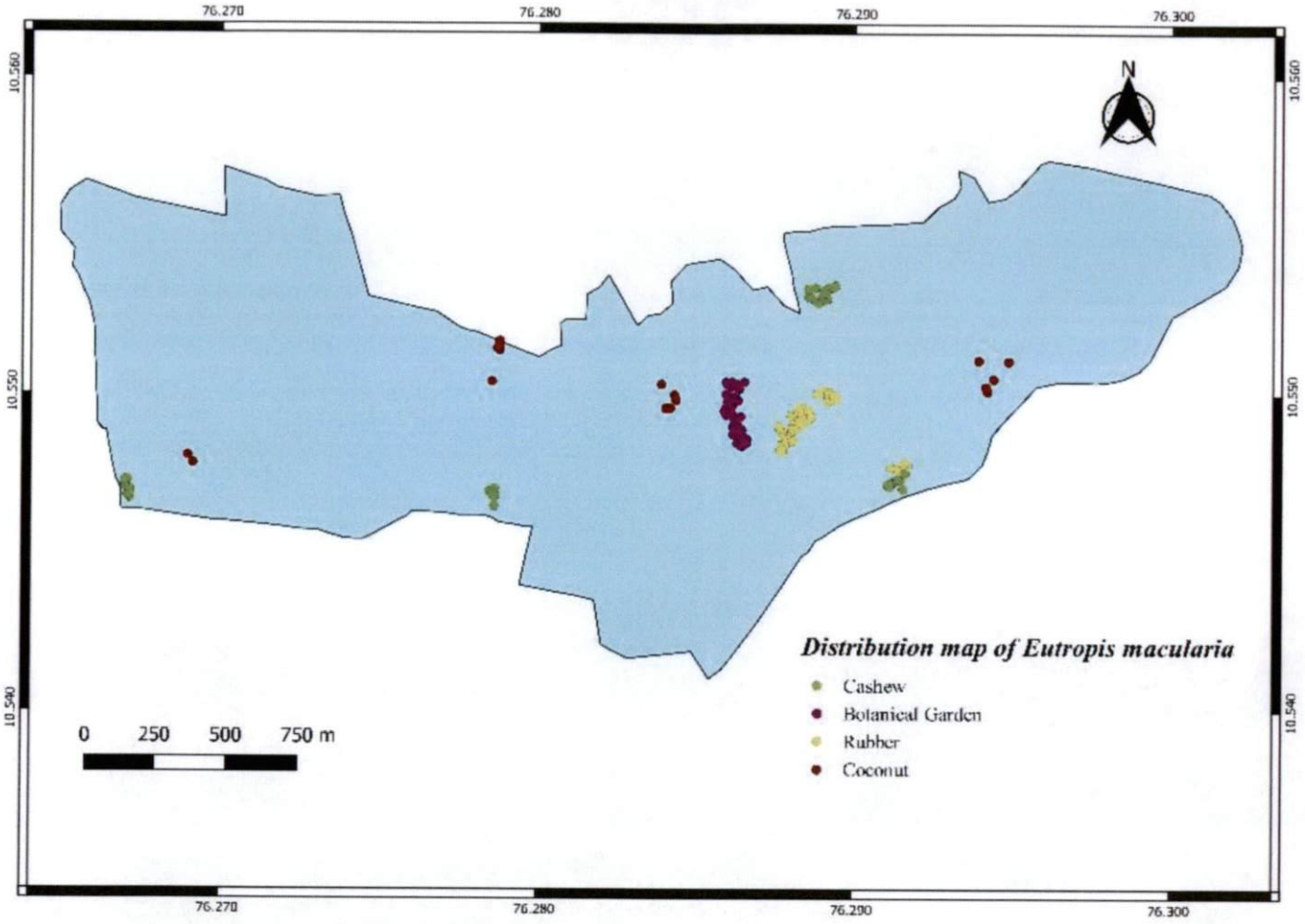

Figure 12. Distribution map of *Eutropis macularia* in agroecosystems in Kerala Agricultural University Main Campus

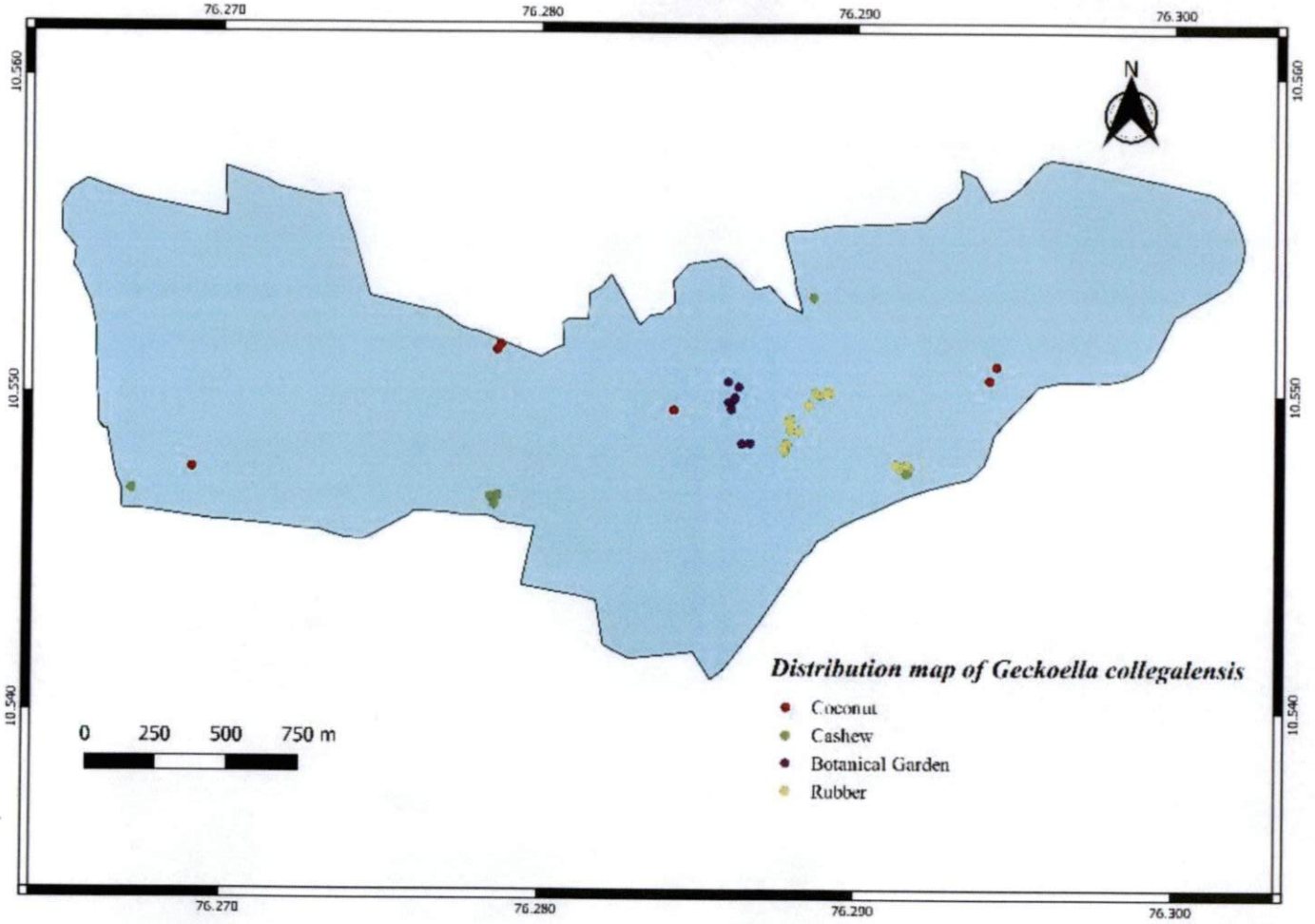

Figure 13. Distribution map of *Geckoella collegalensis* in agroecosystems in Kerala Agricultural University Main Campus

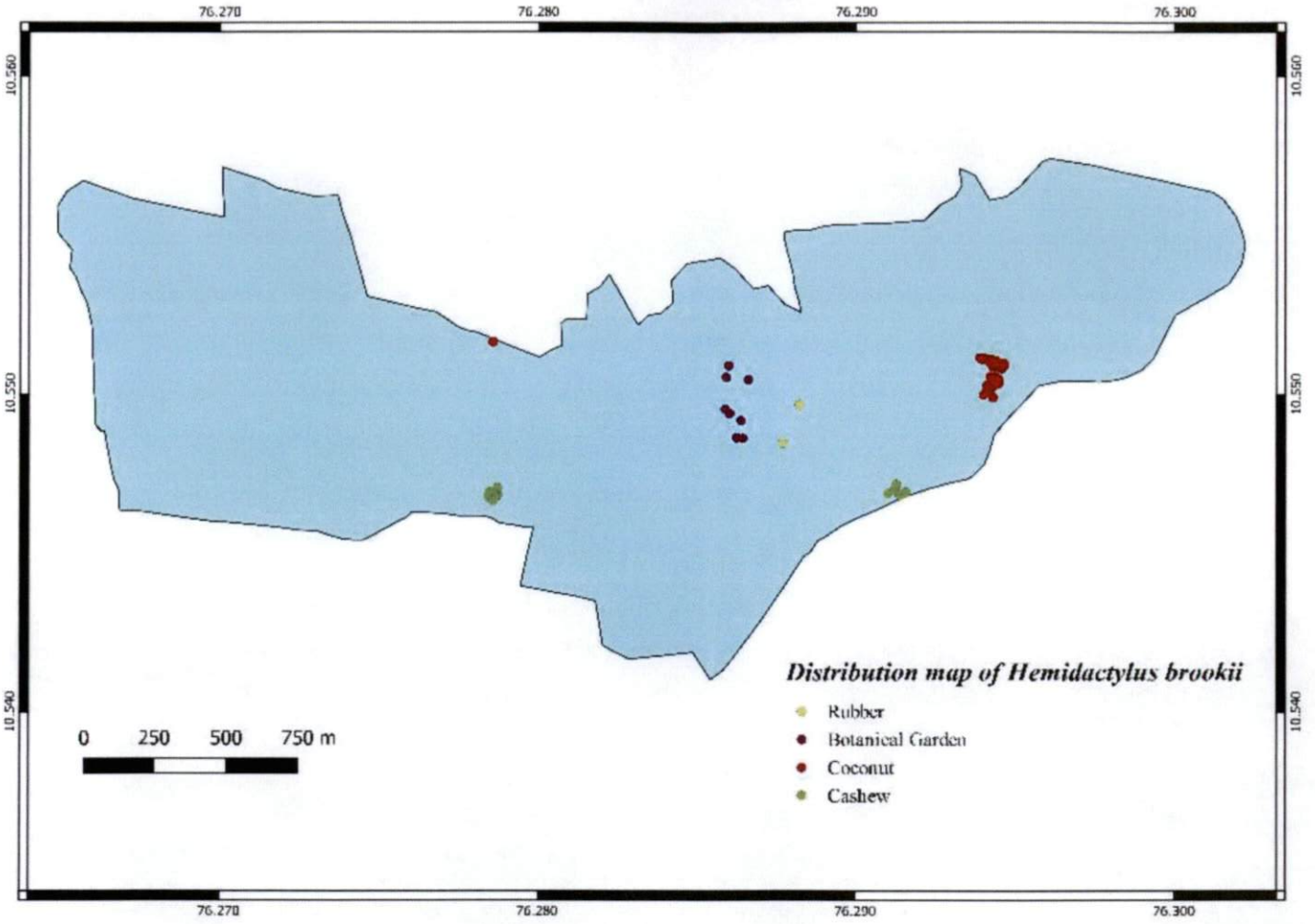

Figure 14. Distribution map of *Hemidactylus brookii* in agroecosystems in Kerala Agricultural University Main Campus

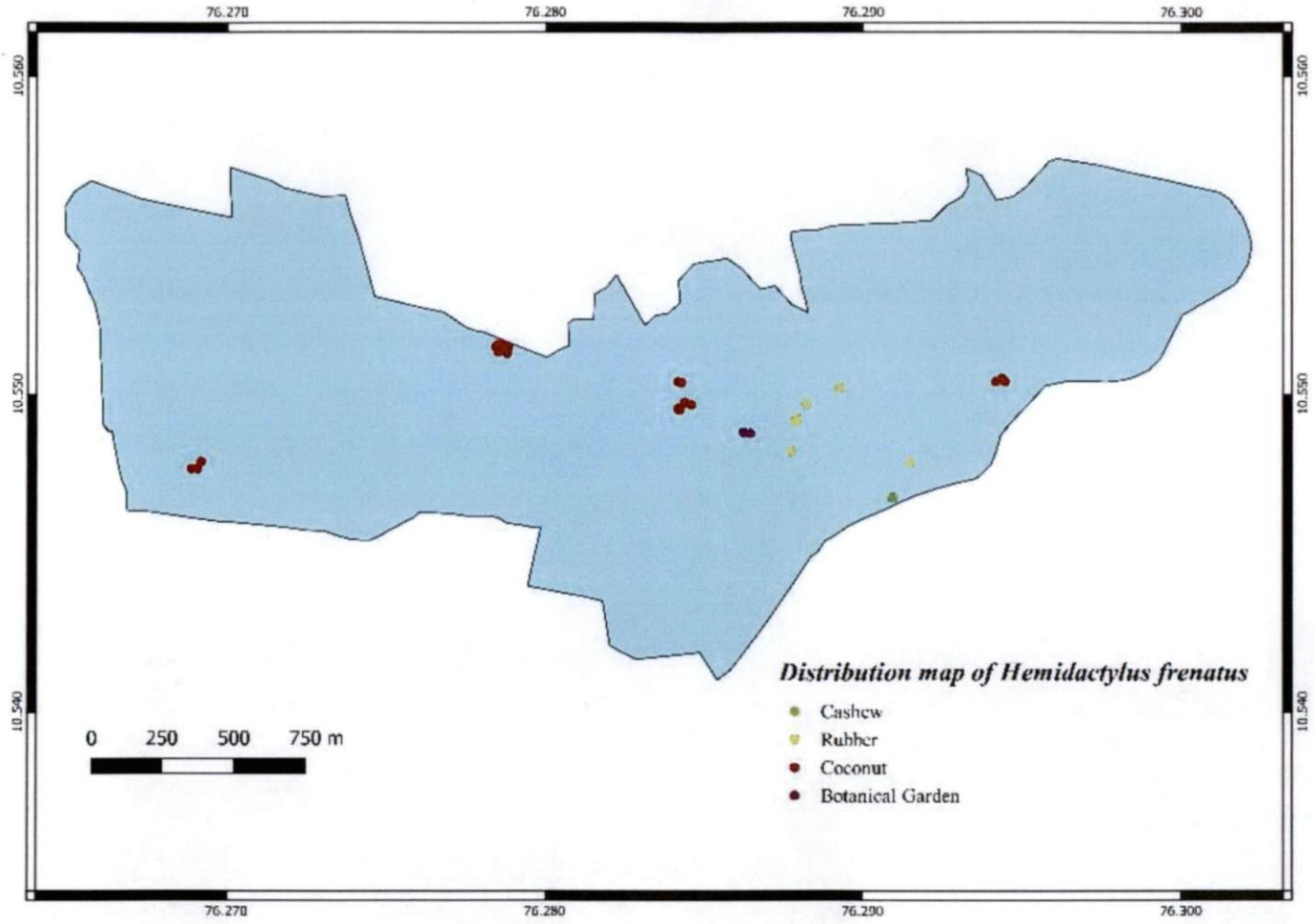

Figure 15. Distribution map of *Hemidactylus frenatus* in agroecosystems in Kerala Agricultural University Main Campus

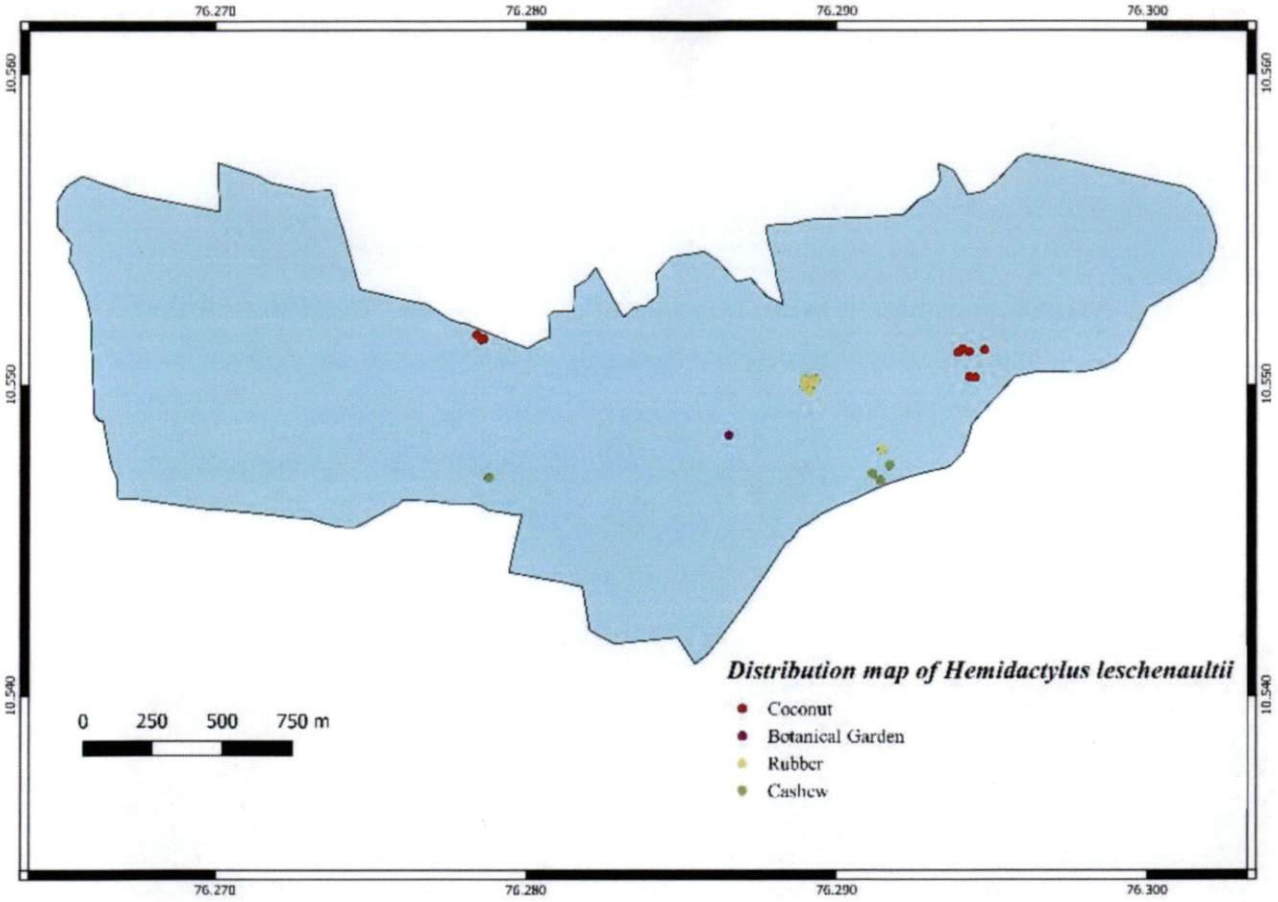

Figure 16. Distribution map of *Hemidactylus leschenaultii* in agroecosystems in Kerala Agricultural University Main Campus

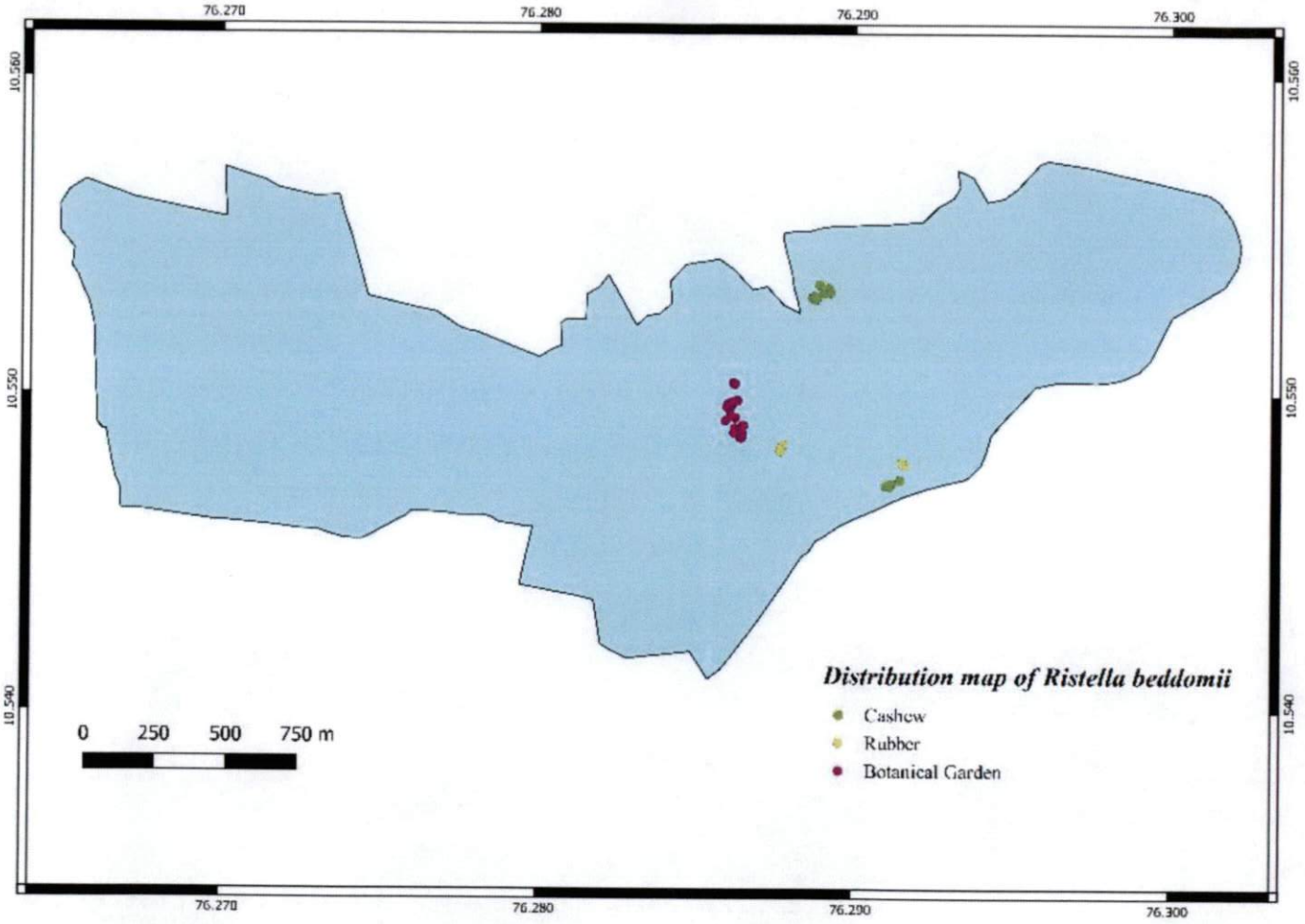

Figure 17. Distribution map of *Ristella beddomii* in agroecosystems of Kerala Agricultural University Main Campus

4.10 CHECKLIST OF REPTILES OF KERALA AGRICULTURAL UNIVERSITY CAMPUS, THRISSUR

The checklist of the reptiles of Kerala Agricultural University Main campus in the Thrissur district is given in Table 12. This includes the ones that was sighted as part of the Visual Encounter Survey as well as the opportunistic records.

Table 12. Checklist of the reptiles of Kerala Agricultural University campus in Thrissur dist.

Sl. No.	Common Name	Scientific Name	IUCN status
	ORDER TESTUDINES		
	Family Geoemydidae		
1	Indian Black Turtle	*Melanochelys trijuga*	NT
	ORDER SQUAMATA		
	Family Agamidae		
2	Common Green Forest Lizard	*Calotes calotes*	NE
3	Oriental Garden Lizard	*Calotes versicolor*	NE
	Family Gekkonidae		
4	Day Gecko spp	*Cnemaspis* spp	
5	Kollegal Ground Gecko	*Geckoella collegalensis*	LC
6	Spotted House Gecko	*Hemidactylus brookii*	NE
7	Common House Gecko	*Hemidactylus frenatus*	LC
8	Bark Gecko	*Hemidactylus leschenaultii*	LC
9	Termite Hill Gecko	*Hemidactylus triedrus*	NE
	Family Scincidae		
10	Common Keeled Skink	*Eutropis carinata*	LC
11	Bronze Grass Skink	*Eutropis macularia*	NE
12	Beddome's Cat Skink*	*Ristella beddomii*	LC
	Family Typhlopidae		
13	Brahminy Worm Snake	*Indotyphlops braminus*	NE
14	Beaked Worm Snake	*Grypotyphlops acutus*	LC
	Family Erycidae		
15	Common Sand Boa	*Eryx conicus*	NE
16	Red Sand Boa	*Eryx johnii*	NE

	Family Colubridae		
17	Common Trinket Snake	*Coelognathus helena*	NE
18	Indian Rat Snake	*Ptyas mucosa*	NE
19	Russell's Kukri Snake	*Oligodon taeniolatus*	LC
20	Common Kukri Snake	*Oligodon arnensis*	NE
21	Common Bronzeback Tree Snake	*Dendrelaphis tristis*	NE
22	Common Wolf Snake	*Lycodon aulicus*	NE
23	Common Cat Snake	*Boiga trigonata*	LC
24	Beddome's Cat Snake	*Boiga beddomei*	LC
25	Common Vine Snake	*Ahaetulla nasuta*	NE
	Family Natricidae		
26	Striped Keelback	*Amphiesma stolatum*	NE
27	Checkered Keelback	*Xenochrophis piscator*	NE
	Family Elapidae		
28	Common Indian Krait	*Bungarus caeruleus*	NE
29	Slender Coral Snake	*Calliophis melanurus*	NE
30	Spectacled Cobra	*Naja naja*	NE
	Family Viperidae		
31	Russel's Viper	*Daboia russelii*	NE

*Endemic to Western Ghats

DISCUSSION

DISCUSSION

5.1 SPECIES DESCRIPTIONS

5.1.1 Family Gekkonidae

5.1.1.1 Hemidactylus brookii Spotted House Gecko

It is found throughout India and in a wide variety of habitats ranging from dry deciduous forests, grasslands to moist evergreen forests. This species has been found to be highly adaptable and is also seen in and near human habitation (Srinivasulu *et al.*, 2014).

Identification key: A pale coloured gecko with a pattern dark spots or blotches on the dorsum (Plate 1 and Plate 2). It has strongly keeled dorsal tubercles, paired lamellae (except terminal) and males have 7-16 precloacal-femoral pores on each side (Das, 2002; Giri and Bauer, 2008).

Plate 1. *Hemidactylus brookii* in Cashew Plantation

Plate 2. *Hemidactylus brookii* in Rubber Plantation

5.1.1.2 Hemidactylus frenatus Common House Gecko

This gecko is most commonly found in houses. In addition to that it is also found in a wide range of natural habitats such as forests and savannahs. It is also quite vocal compared to other gecko species (Srinivasulu *et al.,* 2014).

Identification key: Dorsal tubercles are smooth or feebly keeled if present and not regularly arranged. It has 9-10 lamellae under the fourth toe and digit I is less than or equal to half the length of digit II of manus. It also has a weakly depressed tail and 26-36 continuous series of precloacal-femoral pores (Giri and Bauer, 2008).

Plate 3. *Hemidactylus frenatus*

5.1.1.3 Hemidactylus leschenaultii Bark Gecko

In India it is found across peninsular India, the Eastern and the Western Ghats. It has been found in both forested areas and in human habitation. It is an arboreal species (Srinivasulu *et al.,* 2014).

Identification key: It has pale grey dorsum with dark grey patterns across its back. The belly is cream and does not have any pattern. Dorsal tubercles are smooth or feebly keeled if present and not regularly arranged. It has 9-11 lamellae under the fourth toe and digit I is greater than half the length of digit II of manus (Das, 2002; Giri and Bauer, 2008).

Plate 4. *Hemidactylus leschenaultii*

5.1.1.4 Hemidactylus triedrus Termite Hill Gecko

It a largely terrestrial species found across India. It occurs in a wide range of habitats while include grasslands, dry deciduous forests, scrub forest and also in and near human habitation. It is sometimes found on termite mounds which led to its common name (Srinivasulu *et al.,* 2014).

Identification key: A gecko with large head and dorsal pattern of bands across its back. Dorsal tubercles are enlarged and trihedral. It has 7-10 lamellae under the fourth toe (Giri and Bauer, 2008).

Plate 5. *Hemidactylus triedrus*

5.1.1.5 Cnemaspis spp

These geckos are also known as dwarf geckos. They are diurnal as opposed to geckos of *Hemidactylus* genus which are primarily nocturnal. They have round pupils and are one of the most diverse genera in geckos (Smith, 1935).

Plate 6. *Cnemaspis* spp in Home garden

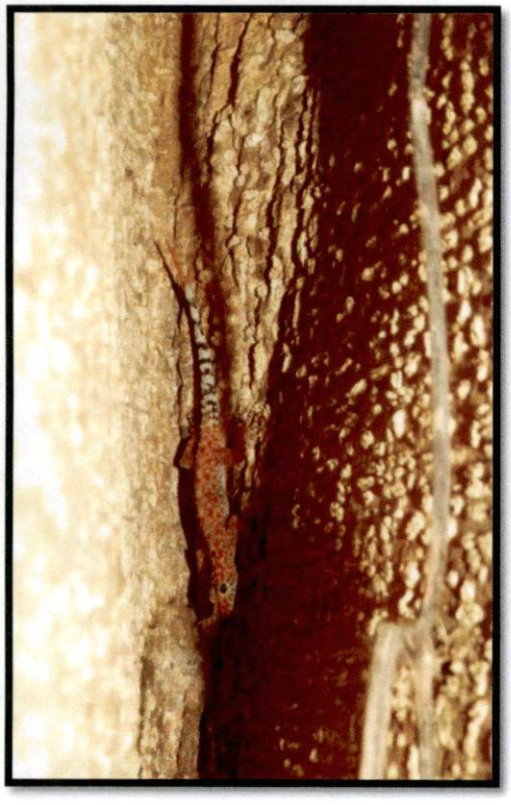

Plate 7. *Cnemspis* spp in Botanical Garden

5.1.1.6 Geckoella collegalensis Kollegal Ground Gecko

In India it has been reported from Kerala, Karnataka, Tamil Nadu, Gujarat, Madhya Pradesh and Maharashtra. It's found abundant in its range. It prefers habitats such as dry to moist deciduous forests. It is a terrestrial and crepuscular species (Srinivasulu *et al.,* 2014).

Identification key: Stout and cylindrical body covered with small granular scales. Body has dark brown spots on top (usually 5) and tail has dark brown bands (Das, 2002).

Plate 8. *Geckoella collegalensis*

5.1.2 Family Scincidae

5.1.2.1 Sphenomorphus dussumieri Dussumier's Litter Skink

It is endemic to Western Ghats and occurs at elevation 15-500 m above sea level. It can be seen in wet evergreen and moist deciduous forests. It has also been found in plantations and in home gardens. It is a terrestrial species (Srinivasulu *et al.,* 2014).

Identification key: Slender body with smooth dorsal scales. A light stripe extend from eyes to the sides of the body. A broad stripe with white below is also present on the side. Its belly is cream coloured and adults have reddish coloured tail (Das, 2002).

Plate 9: *Sphenomorphus dussumieri*

5.1.2.2 Eutropis macularia Bronze Grass Skink

It occurs across the country in India. It occurs in in tropical moist and dry deciduous forests, scrub forests and thorny scrub. It is also found near human habitation. It is a diurnal species (Srinivasulu *et al.,* 2014).

Identification key: It has a slender body with dorsum bronze coloured. Dorsal scales have 5-9 keels and has 28-30 scales round the body (Smith, 1935; Das, 2002).

Plate 10. *Eutropis macularia* dorsal view

Plate 11. *Eutropis macularia* side view

5.1.2.3 Eutropis carinata Common Keeled Skink

It also occurs across the country and is more common in southern parts of its range. It a diurnal species and found in evergreen to scrub forest (Srinivasulu *et al.*, 2014).

Identification key: It has scaly lower eyelids. Dorsum is bronze to brown, sometimes olive with a yellow lateral band. Dorsal scales have 3-7 keels and there are 30-34 scales around the body at mid region (Smith, 1935; Das, 2002).

Plate 12. *Eutropis carinata*

5.1.2.4 Ristella beddomii Beddome's Cat Skink

It is endemic to Western Ghats and widespread throughout its distribution. It is one of the most abundant species of *Ristella*. Mostly found among leaf litter and under rocks its main habitat is found to be wet evergreen forests (Srinivasulu *et al.*, 2014). In the present study it was seen in Botanical Garden, Cashew and Rubber plantations with good leaf litter coverage.

Identification key: Semi-fossorial with retractable claws. Dorsum reddish brown with indistinct dark lines and sometimes prominent yellow spots. Has 26-28 scales around the body at mid region (Smith, 1935; Das, 2002).

Plate 13. *Ristella beddomii*

5.1.3 Family Agamidae

5.1.3.1 Calotes versicolor Oriental Garden Lizard

It is found across the country and is common to abundant across its range. It is a highly arboreal species and inhabits rural gardens to urban areas (Srinivasulu *et al.*, 2014).

Identification key: Scales on the sides of the body pointing backwards and upwards and has no fold or pit in front of the shoulder. Two separated fines can be seen above the tympanum (Smith, 1935).

Plate 14. *Calotes versicolor* juvenile

Plate 15. *Calotes versicolor* adult

Plate 16. *Calotes versicolor* breeding male

5.1.4 Family Elapidae

5.1.4.1 Bungarus caeruleus Common Indian Krait

It is known throughout the country in India. It is nocturnal and found usually in scrub and sandy areas. It is also seen in plantations and agricultural fields (Srinivasulu *et al.*, 2014).

Identification key: Black with white bands. Loreal scale is absent. Ventral scales range from 200-217 and subcaudals from 33 to 52 (Whitaker and Captain, 2004).

Plate 17. *Bungarus caeruleus*

5.1.5 Family Colubridae

5.1.5.1 Boiga beddomei Beddome's Cat Snake

It is endemic to South Asia. It is found inhabiting moist and dry deciduous forests (Sriniasulu *et al.,* 2014). These are nocturnal snakes, named for their large eyes with cat-like pupil. The venom is mild and not enough to cause harm to humans (Whitaker and Captain, 2004).

Identification key: Vertebral scales distinctly enlarged and hexagonal in shape. Ventrals 248-266, subcaudals 111-129 (Whitaker and Captain, 2004.

Plate 18. *Boiga beddomii*

5.1.5.2 Lycodon aulicus Common Wolf Snake

This species is found across India except for the Andaman and Nicobar Islands and is common throughout its range. It is found in a diverse array of habitat including most forest types, agricultural plantations, urban areas and other similar disturbed areas except extremely arid areas (Srinivasulu *et al.,* 2014).

Identification key: Slender-bodied snake with entirely black eye. Glossy brown or black coloured above with 10-20 narrow white or yellow bands on the body. Scales in rows of 17:17:15. Ventrals 172-214. Subcaudals 57-80 (Whitaker and Captain, 2004).

Plate 19. *Lycodon aulicus* in Coconut Plantation

Plate 20. *Lycodon aulicus* in Wetland

5.1.5.3 Coelognathus helena Common Trinket Snake

This species is known throughout the country and is common in the Western Ghats. It is found in a variety of habitats from tropical dry deciduous forests to semi evergreen hill forest. It has also been observed near human habitation (Srinivasulu *et al.*, 2014).

Identification key: Slender bodied, chocolate brown or olive coloured snake with two black stripes on neck. Two prominent brown or black stripes run along till the tail on hindbody. Ventrals 210-244. Subcaudals 73-100. Scales along mid in 23-27 rows (Whitaker and Captain, 2004).

5.1.5.4 Ahaetulla nasuta Common Vine Snake

This species is known throughout peninsular India to the south of the Indo-Gangetic. It is also seen in West Bengal and Assam. This diurnal and arboreal snake has been found in a wide array of habitats including semi evergreen forests, dry deciduous forests and mangroves. It is also found near human habitation (Srinivasulu *et al.*, 2014).

Identification key: Long and slender snake with a highly pointed head, extended snout and large eyes. Usually green in colour with underside yellow or light green. Scales in rows 15: 15: 13. Ventrals 166-207. Subcaudals 156-180 males, 132-152 females (Whitaker and Captain, 2004).

Plate 21. *Ahaetulla nasuta*

Plate 22. *Ahaetulla nasuta* striking position

5.1.5.5 Oligodon taeniolatus Russell's Kukri Snake

This species is found across except the North East and the states of Himachal Pradesh and Jammu and Kashmir. Its habitats include deciduous forests, shrublands, coastal plantations etc. It is also seen in human habituated landscape (Srinivasulu *et al.*, 2014).

Identification key: The snake is brown in colour with body fully of patterns and blotches. The top of head and two dark brown, black-edged bow shaped marks, followed by a broad blotch on neck. Stripes can be found on the body. Scales in 15 rows at midbody. Ventrals 157-201 for males, 154-219 for females. Subcaudals 27-59 (Whitaker and Captain, 2004).

Plate 23. *Oligodon taeniolatus*

5.1.6 Family Natricidae

5.1.6.1 Xenochrophis piscator Checkered *Keelback*

It is widely distributed in India and is seen throughout the country. It's a species which is active both day and night. It is more habitat specific than the above mentioned and is found in an around freshwater bodies and paddy fields (Srinivasulu *et al.,* 2014).

Identification key: There are two black streaks on head, one below the eye and other from eye to mouth. The scales are keeled and body usually has a checkered pattern. Found in a variety of colours with glossy olive green, brown, yellow, black, gray forms seen. Scales in rows of 19 at midbody. Ventrals 122-158. Subcaudals 70-97 (Whitaker and Captain, 2004).

Plate 24. *Xenochrophis piscator*

5.2 AGROECOSYSTEMS

In most of the diversity studies carried out across the Western Ghats region the methods used are visual encounter surveys and quadrat sampling. The one study which used time constrained visual encounter survey was the study carried out by Bhupathy and Sathishkumar (2013) in the Meghamalai WLS in the High Wavy Mountains of Western Ghats. They found 3004 individuals of reptiles in 3600 hours of time constrained visual encounter survey. This is compared to the present study of agroecosystems of Thrissur were 594 reptiles were encountered in a time of 360 hours. In the first case the encounter rate is 0.83 reptiles/man hour and in the second case it is 1.65 reptiles/man hour. Here encounter rate is higher for modified habitats. A similar scenario was observed in the case of population density study of agamids in the Western Ghats (Venugopal, 2010b) where encounter rate of the commonly distributed species *Calotes ellioti* was found to be higher in vanilla and abandoned rubber plantations than rainforest fragments.

In this case we can see that the agroecosystems have fared better when compared to a natural forest ecosystem when it comes to reptile abundance. But a lot of factors need to be accessed before this can be concluded. The time periods are highly different for the two studies. One was carried out for a period of two years and the other only a few months. Also in Meghamalai the study was carried out only during the daylight hours thus omitting a wide variety of species, especially nocturnal species like *Hemidactylus* geckos, which may have been a reason for the less number obtained. One thing similar in both studies is the species *Eutropis macularia* which showed the highest abundance among species in both the studies, 34.7% and 37.3% in High Wavy Mountains and agroecosystems respectively.

Palacios *et al.* (2013) reviewed studies on human modified habitats across the world. From that study it was found that when it comes to reptile abundance, in 81%

of the cases studied plantations supported more individuals than natural forests. The species richness though was found to be slightly more in natural forests than plantations (57% of cases). They also found that reptile species which were abundant in the human modified habitats were of low conservation concern and the number of endemic species was less in agroecosystems than natural forests. This holds true for the present study also with six of the species being Least Concern. Most the species found in the present study have wide distribution ranges across India and are quite common in their range (Srinivasulu *et al.,* 2014). *Ristella beddomii*, is one of the two Western Ghats endemic species of reptile found during the study period from the selected agroecosystems of Thrissur dist., *Ristella beddomii* is also one of the most common *Ristella*'s and found widespread across its distributional range (Srinivasulu *et al.,* 2014). One of the interesting finding of the study is that Srinivasulu *et al.* (2014) had reported the altitudinal range of *Ristella beddomii* from 400m to 1300 m, but in the present study it was reported at a much lower altitude (50m) for the first time. *Sphenomorphus dussumieri*, the other Western Ghats endemic reptile species found during the present study, was found only from the home garden and were absent in the other habitats under study. Srinivasulu *et al.* (2014), had reported the *Sphenomorphus dussumieri* from the home garden. *Sphenomorphus dussumieri* is also found in the wet evergreen forests and moist deciduous forests. In the present study, however, it was only reported from Home garden.

Similar results were obtained for the population density study of agamids in modified habitats by Venugopal (2010b). *Calotes ellioti*, the species which was described to be commonly distributed was found to be most abundant in modified habitats while rainforest specialists like *Calotes nemoricola* was not found in modified habitats.

Coming to the six agroecosystems in the present study, the Correspondence Analysis Plot showed that the four agroecosystems Coconut Plantation, Cashew

Plantation, Rubber Plantation and Botanical Garden harbour the similar type of reptiles and are in very much relation to each other. No distinctiveness was observed in the reptile fauna among these four selected agroecosystems. This can explained by the fact that even though these agroecosystems have different flora, they are all part of the Kerala Agricultural University landscape. There could be free movement of the taxa happening between these closely located agroecosystems, which could also be the reason for the lack of distinctiveness of the reptilian fauna among these agroecosystems.

Home garden, though highly diverse in case of flora compared to the monoculture plantations showed very little reptile abundance compared to them (5.05%) (Table 2). This is in contrast to Palacios *et al.* (2013) review which said that species richness and abundance increased in structurally complex plantations than simpler ones. But this is based on just three studies and more research need to be conducted before this can be concluded. Home garden in the present study is also irrigated regularly on a daily basis keeping the habitat damp most of the year. Moreove, the highly dense shrub and herb cover allows less areas for reptiles to bask. The habitat also has high human interference. But being a unique ecosystem of its own, from the present study two species *Bungarus caeruleus* and *Sphenomorphus dussumieri* were reported only from Home garden. This may be due to the greater presence of soil moisture in the Home garden, which are preferred by these two species.

Wetland is another unique ecosystem compared to the other ecosystems in the study. The reptile count was very less probably due to the lack of cover. Only two species were found there, *Lycodon aulicus*, the wide-spread and commensal common wolf snake and *Xenochrophis piscator*, a snake commonly found in paddy fields.

SUMMARY

SUMMARY

Reptiles are one of the much neglected taxa and very less studies have been done on them especially in modified habitats. Very less is known about ecology, behaviour, and distribution of reptiles of Kerala. The only study on reptiles in human-modified habitats of Kerala was on the agamids of the Western Ghats by Venugopal in 2010. The present study is the first study incorporating reptiles as a whole. The objectives of the present study were to study the species diversity and the reptilian community structure of selected agroecosystems in Thrissur, Kerala and to assess the spatial variation of reptile distribution using Geographic Information System (GIS) tools. The method used for the study was Time-constrained Visual Encounter Survey. Six different agroecosystems viz. Coconut Plantation, Cashew Plantation, Rubber Plantation, Botanical Garden, Home garden and Wetland, were accessed for a span of five days each. The survey was carried out for two hours both at morning and night at each study locations. The salient findings of the study are summarized below:

1. A total of 594 individuals of reptiles, belonging to 18 species were observed during the study. This includes six species from Family Gekkonidae, four species from Family Scincidae, one species from Family Agamidae, one species from Family Elapidae, five species from Family Colubridae and one species from Family Natricidae.
2. The species richness was the highest in the two habitats such as Coconut plantation and Cashew plantation, with each supporting 11 species each, while the species richness was the lowest in the Wetland habitat, with just two species.
3. The abundance of the reptiles was greatest in the Botanical Garden (159 individuals) and lowest in the Wetland habitat with five individuals.
4. *Eutropis macularia* (Bronze Grass Skink) was the most abundant species of reptile with 220 individuals observed across the whole ecosystems followed by *Hemidactylus brookii* (Spotted House Gecko) with 87 individuals.

5. More reptiles were recorded during the night hours. 391 out of 594 individuals of reptiles were recorded during the night hours. All the seven species of snakes recorded were observed during night hours.
6. The reptilian community of the Home garden and Wetland habitats were found to be quite distinct from that of other agroecosystems studied. It is also evident that the agroecosystems such as Coconut Plantation, Cashew Plantation, Rubber Plantation and Botanical Garden have many common species among them.
7. Habitats variables were found to be influencing only certain species. Occurrence of Russell's Kukri Snake *Oligodon taeniolatus* was found to be influenced by variables such as litter cover, litter depth, canopy height, canopy cover, shrub cover and herb cover.
8. Occurrence of Oriental Garden Lizard *Calotes versicolor,* Beddome's Cat Snake *Boiga beddomei,* Termite Hill Gecko *Hemidactylus triedrus,* Spotted House Gecko *Hemidactylus brookii,* Common Wolf Snake *Lycodon aulicus,* Common Trinket Snake *Coelognathus helena* and Checkered Keelback *Xenochrophis piscator* was found to be influenced by relative humidity.
9. Occurrence of Common Krait *Bungarus caeruleus,* Dussumier's Litter Skink *Sphenomorphus dussumieri* and Bark Gecko *Hemidactylus leschenaultii* was found to be influenced by maximum temperature.
10. 31 reptiles reported from Kerala Agricultural University Main campus.

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SPECIES DIVERSITY AND COMMUNITY STRUCTURE OF REPTILES OF SELECTED AGROECOSYSTEMS IN THRISSUR, KERALA

by

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(2015 – 17 – 003)

ABSTRACT

Submitted in partial fulfilment of the

requirement for the degree of

MASTER OF SCIENCE IN FORESTRY

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Kerala Agricultural University

DEPARTMENT OF WILDLIFE SCIENCE

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ABSTRACT

Species diversity and community structure of reptiles of selected agroecosystems in Thrissur, Kerala was studied during January 2017 to May 2017. The agroecosystems chosen for the study were Coconut Plantation, Cashew Plantation, Rubber Plantation, Botanical Garden, Home garden and Wetland. Time-constrained visual encounter survey was the method used for the study, and a total effort of 360 man hours were spent in the field. The highest number of individuals were recorded from the Botanical Garden with 159 individuals of reptiles. While, the species richness was highest in the Coconut Plantation and Cashew Plantation with 11 species each. 18 species of reptiles belonging to six families were observed during the study. This include six species of geckos, four species of skinks, one agamid species and seven species of snakes. Bronze Grass Skink *Eutropis macularia*, was the most abundant species. More reptiles were recorded during night hours than morning hours.

Correspondence analysis was deployed to compare the reptilian diversity between the habitats. Home garden and Wetland were found distinct in reptilian species composition from the rest of the agroecosystems. The effect of habitat variables on the presence of reptile species was analysed using canonical correspondence analysis. Litter cover, litter depth, canopy height, canopy cover, shrub cover and herb cover were found to influence the presence of the species Russell's Kukri Snake *Oligodon taeniolatus*. Relative humidity was found to influence the presence of the reptiles such as Oriental Garden Lizard *Calotes versicolor,* Beddome's Cat Snake *Boiga beddomei,* Termite Hill Gecko *Hemidactylus triedrus,* Spotted House Gecko *Hemidactylus brookii,* Common Wolf Snake *Lycodon aulicus,* Trinket Snake *Coelognathus helena* and Checkered Keelback *Xenochrophis piscator.* Maximum temperature was found to influence the presence of reptiles such as Common Krait *Bungarus caeruleus*, Dussumier's Litter Skink *Sphenomorphus dussumieri* and Bark Gecko *Hemidactylus leschenaultii*.

Two species of reptiles that are endemic to Western Ghats such as Beddome's Cat Skink *Ristella beddomii* and Dussumier's Litter Skink *Sphenomorphus dussumieri* were recorded. Of these, the report of the *Ristella beddomii* from the KAU campus is of interest, as it has been reported from a lower altitude (50m) than the already known lowest altitude range (400m) for this species.

This documentation is important as it highlights the significance of agroecosytems in conserving the reptilian fauna of the region, including some of the Western Ghats endemic species.

APPENDICES

APPENDIX

Appendix No. I. Habitat parameters for each study location

Agroecosystems	Place	Canopy cover	Canopy height (m)	Litter depth (cm)	Litter cover	Shrub cover	Herb cover	Max. temperature	Min. temperature	Relative humidity
Coconut Plantation	A1	25	3.5	0	0	0	0	35.3	24.3	48.5
Coconut Plantation	A1	25	3.5	0	0	0	0	35.3	21.9	43.5
Coconut Plantation	A2	45	1.5	0	0	10	70	35.6	21.4	43.5
Coconut Plantation	A2	45	1.5	0	0	10	70	35.6	21.4	43.5
Coconut Plantation	A3	20	2	0	0	10	10	34.7	23	66.5
Coconut Plantation	A3	20	2	0	0	10	10	35.3	25	67.5
Coconut Plantation	A4	20	2	0	0	30	20	35.3	25	67.5
Coconut Plantation	A4	20	2	0	0	30	20	36.3	24.7	67.5
Coconut Plantation	A5	25	2.5	0	0	0	10	34.1	24.5	74.5
Coconut Plantation	A5	25	2.5	0	0	0	10	35.5	26.7	74
Cashew Plantation	B1	95	2	5.5	95	0	85	35.4	23	43.5
Cashew Plantation	B2	35	4	3	10	10	10	34.8	23.6	50.5
Cashew Plantation	B2	35	4	3	10	10	10	35.4	23	43.5
Cashew Plantation	B3	75	1.5	4.2	75	10	30	35.9	23.3	74
Cashew Plantation	B3	75	1.5	4.2	75	10	30	35	25.1	72.5
Cashew Plantation	B4	85	2	5.3	85	10	35	33	23.6	75.5
Cashew Plantation	B4	85	2	5.3	85	10	35	37.6	25.1	73
Cashew Plantation	B5	95	4	5.5	95	35	90	36.3	24.5	75
Cashew Plantation	B5	95	4	5.5	95	35	90	35.8	26	68

Rubber Plantation	C1	90	7	5.5	95	10	10	34.3	23.4	34
Rubber Plantation	C1	90	7	5.5	95	10	10	34.3	23.4	34
Rubber Plantation	C2	90	7	5.5	95	20	50	35	22.7	67
Rubber Plantation	C2	90	7	5.5	95	20	50	34.9	23.3	65.5
Rubber Plantation	C3	90	7	6	95	10	10	39.1	25.3	71.5
Rubber Plantation	C3	90	7	6	95	10	10	38.4	25.9	75.5
Rubber Plantation	C4	90	7	6	95	40	10	36	24.9	70.5
Rubber Plantation	C4	90	7	6	95	40	10	35.4	26.5	72
Rubber Plantation	C5	90	7	5	95	40	10	35.8	26	68
Rubber Plantation	C5	90	7	5	95	40	10	35.9	26.9	67.5
Homegarden	D1	90	4.5	1.1	50	20	90	37.2	23.7	41.5
Homegarden	D1	90	4.5	1.1	50	20	90	37.2	23.7	41.5
Homegarden	D2	95	4.2	2.8	40	50	70	38.8	25.3	68
Homegarden	D2	95	4.2	2.8	40	50	70	38.8	25.3	68
Homegarden	D3	65	4.3	2.4	80	50	30	39.1	25.3	71.5
Homegarden	D3	65	4.3	2.4	80	50	30	39.8	25.6	68
Homegarden	D4	70	4.4	2.1	10	30	85	34.9	27	71.5
Homegarden	D5	90	4.5	1.8	20	10	60	34.7	26.8	74
Homegarden	D5	90	4.5	1.8	20	10	60	34.8	26.2	69.5
Botanical Garden	E1	75	6.2	5.1	95	60	40	35.6	25.4	69
Botanical Garden	E1	75	6.2	5.1	95	60	40	34.8	25.4	67.5
Botanical Garden	E2	65	8	4.6	70	20	50	35.9	26.3	74
Botanical Garden	E2	65	8	4.6	70	20	50	34.8	25.4	67.5
Botanical Garden	E3	50	6.5	5.5	95	50	50	35.2	26	70.5
Botanical Garden	E3	50	6.5	5.5	95	50	50	34.8	25.4	67.5

Botanical Garden	E4	70	6.5	5.5	97	10	40	34.9	27	71.5
Botanical Garden	E4	70	6.5	5.5	97	10	40	33.8	24.6	74.5
Botanical Garden	E5	80	4.5	6	85	50	50	34.8	26.2	69.5
Botanical Garden	E5	80	4.5	6	85	50	50	33.8	24.6	74.5
Wetland	F1	0	0	0	0	0	0	36.0	26.0	74
Wetland	F2	0	0	0	0	0	0	36.0	26.0	74
Wetland	F3	0	0	0	0	0	0	34.8	25.4	70
Wetland	F4	0	0	0	0	0	0	34.8	25.4	70
Wetland	F5	0	0	0	0	0	0	34.8	25.4	70

For each locations morning and night data is given. As the survey during morning and night hours of a location was done during different days the weather data varies.