

**DIVERSITY, HABITAT PREFERENCE AND FEEDING HABITS OF
CHIROPTERANS IN WAYANAD WILDLIFE SANCTUARY**

NITHIN DIVAKAR

(13-MSVP-03)

**Abstract of Dissertation Submitted in Partial Fulfillment of the Requirement for the
Degree of**

MASTER OF SCIENCE

(Wildlife Studies)

**Faculty of Veterinary and Animal Sciences
Kerala Veterinary and Animal Sciences University**

2015

**CENTRE FOR WILDLIFE STUDIES
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
POOKODE, WAYANAD,
KERALA, INDIA**

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DISSERTATION

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POOKODE, WAYANAD, KERALA, INDIA**

DECLARATION

I hereby declare that this dissertation titled “**Diversity, Habitat Preference and Feeding Habits of Chiropterans in Wayanad Wildlife Sanctuary**” is a bonafide record of research work done by me during the course of my Master’s research program and that the dissertation has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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Certified that this dissertation, titled “**Diversity, Habitat Preference and Feeding Habits of Chiropterans in Wayanad Wildlife Sanctuary**” is a bonafide record of research work done independently by **Nithin Divakar (13-MSVP-03)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to him.

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Date

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CERTIFICATE

We, the undersigned members of the advisory committee of **Nithin Divakar (13-MSVP-03)**, a candidate for the degree of Master of Science in Wildlife Studies, agree that the dissertation titled, “**Diversity, Habitat Preference and Feeding Habits of Chiropterans in Wayanad Wildlife Sanctuary**” may be submitted by **Nithin Divakar (13-MSVP-03)**, in partial fulfillment of the requirement for the degree.

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EXTERNAL EXAMINER

ACKNOWLEDGMENTS

This thesis is a result of support, help and time put in by several people, without which this work would not have been possible.

*First and foremost, I thank **Sandeep Das** and **G Kumar**, who have nurtured my early interest in wildlife and had guided me throughout this work. I sincerely thank them for lending me the first hand in all the critical situations staying close to my hand as my own brothers. Without their support and help this work would never been possible.*

*I thank **Dr. George Chandy**, Course Director, Centre for Wildlife Studies, for his constant support, guidance and his bold decisions which helped me in this manuscript. I admire his patience, immense amounts of energy and time he had put in molding our course which has helped me not only develop confidence but also helped to polish my personality.*

*I thank my major guide **Dr. Arun Zachariah**, Assistant Professor, Centre for Wildlife Studies for love, care and encouragement throughout this work. I also thank him for his efforts and influences without which my sample collections and field works would not have been this easy.*

*I extended my sincere gratitude to **Mr. Jignasu Dolia**, Research officer, Centre for Wildlife Studies without whom I might not have successfully completed this work. I thank him for all the positive critical comments, patience, love and freedom he had given us. I also thank him for the tiresome work of my thesis correction. I extended my gratitude to **Divya Mam** for the moral support she had given me.*

*I also thank **Dr. Ashok Kumar** for his guidance, help and support. I extend my special thanks to him for attending all my enquiries and also for the night walks when he flushed my brain with knowledge. I would like to specially mention **Vivek Philip***

Cyriac with whom I had long night discussions which help me to design and execute my thesis.

I also thank **Mr.C K Vishnudas, Dr.Easa and Dr.SreejithRadhakrishnan** for their valuable suggestions and support. I'm also indebted to members of my advisory committee for their guidance in completion of my work; my co-guide **Dr. Abdul Azeez C P**, Assistant Professor, Centre for Wildlife Studies and **Dr. Chandramohan**, Senior Research Fellow for their guidance.

I would like to acknowledge the help and support given by **Kerala Forest Department** and it's **staff**.

Special thanks to **Sreehari, Rajkumar, Daneesh Baskar** for long phone calls and discussions which helped me to design and workout my project successfully. I also thanks to my seniors **Roshnath and Arjun C P** for their valuable suggestions and opinions that helped me throughout this work. I thank **Mr. George V.T.** for sanctioning my reimbursements and for the care and interest he had on us.

I thank all my **classmates, The Pack**, for their support, fun and fights which had maintained the ecstasy in our class. Together with them I thank my juniors, who had helped me with my thesis.

I thank **Krishna, Salil, Chithra, Soorya and Yadhu** for giving me mental support and for comforting me at the time of my peak tensions.

Finally I thank my Parents for all their moral support, for the freedom they had given me to pursuit my interest and for the comfort they had given in my needy times.

Nithin Divakar

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1. INTRODUCTION

Bats belong to the Order Chiroptera, which is the second largest order within Mammalia. Globally, there are 1117 species of bats belonging to 18 families (Mickleburgh *et al.*, 2003; Simmons, 2005). In South Asia, there are 128 species of bats belonging to eight families and 37 genera (Srinivasulu *et al.*, 2010) including 114 species from India (Nameer, 2008). In the Western Ghats, 52 species of bats have been recorded of which six species belongs to sub-order Megachiroptera and 46 species to sub-order Microchiroptera (Korad *et al.*, 2007).

Bats, the only true flying mammals, were traditionally classified into two suborders, *viz.* Megachiroptera and Microchiroptera. The Megachiroptera suborder includes large frugivorous bats, whereas the smaller insectivorous bats are included in Microchiroptera. However, molecular phylogenetic studies have recently proposed the order Chiroptera to be divided into two new suborders Yinpterochiroptera (includes the families Pteropodidae, Rhinolophidae, Megadermatidae and Rhinopomatidae) and Yangochiroptera (Teeling *et al.*, 2005). But the new classification is yet to gain acceptance, and thus the traditional classification is still followed.

Within the highly varied mammalian order, bats are the only mammals that are capable of sustained flight. Unlike other mammals, bats have conquered a wide variety of habitats and resources at night with the help of their ability to fly and echolocate.

The evolution of Megachiroptera and Microchiroptera was highly debated. The aid of echolocation in Microchiroptera and several other features promoted the idea of the two suborders being of independent evolutionary origin. Bio-chemical, molecular studies and certain morphological features were pointed out as supporting features for the monophyly of the two suborders while similarities in penal

morphology of mega chiropterans and primates indicated diphyly. The diphyly of the chiropteran orders suggests that at first (during the Cretaceous) insectivore-type mammals developed flight to capture the insects, eventually evolving into the Suborder Microchiroptera. The second event of evolution of flight in bats occurred when frugivorous, primate-like mammals developed flight to utilize the niche resources available and eventually paved way for the evolution of Megachiroptera. More recent molecular studies have revealed that echolocation evolved only once in the history of Chiroptera with the possibility of megachiropterans having lost the character eventually (Simmons *et al.*, 2008).

Bats live to about 25 to 30 year that is 3.5 times as long as non-flying placental mammals of similar body size. Bat lifespan is reported to significantly increase with hibernation, body mass and occasional cave use. The strong association of life span with both reproductive rate and hibernation suggests that bat longevity is strongly influenced by seasonal allocation of non-renewable resources (Gerald and Jason, 2002).

Most species of bats produce only one pup at a time, probably due to flight constraints. Bats often need to travel over long distances in search of food, during which they carry their pup with them. It thus seems reasonable for them to have a single pup at a time. Due to this bats have slow population growth rates. Like all other mammals, bats also show high maternal care including feeding their young ones with milk.

Bats mainly roost in caves, tree holes, buildings, tunnels, bridges, foliage etc. Roost selection is done mainly on areas where predation is less. Bats will often move between roosts as local conditions change, and to avoid parasite build up. Ectoparasites are common among colonial species of bats, and several of these species are known to change roosts in a manner that would decrease their exposure to

ectoparasites (Lewis, 1995; Wilkinson, 1985). Females of some species form large maternity roosts.

In winter, some species hibernate to escape from the cold temperatures. Hibernating bats typically reduce their body temperature from about 40°C to 6°C, and then maintain the basal temperature for several weeks at a time. As a consequence, the metabolic rate of a hibernating bat is about 5% of its resting metabolic rate at room temperature (Geiser, 1998).

Bats provide several ecosystem services. They eat insects and pollinate plants and play an important role by keeping a healthy and balanced ecosystem. For instance, Boyles *et al.* (2011) has reported that a single little brown bat (*Myotis lucifugus*) can consume 4-8 grams of insects each night during the active season. They have great potential as suitable environmental bio-indicators as well (Jones *et al.*, 2009).

Insectivorous bats are the main predators of nocturnal insects and they also consume numerous agricultural pest insects (Whittaker, 1995; Lee *et al.*, 2005). Hence, bats play an important role in keeping the insect population under control. For example, Boyles (2011) reported that a single colony of 150 big brown bats in Indiana consumes nearly 1.3 million pests each year, possibly contributing to the disruption of population cycles of agricultural pests. Other studies suggest that the big brown bats (*Eptesicus fuscus*) found in Florida consumes many insect pests that damage crops like corn, soya bean and cotton. Another species of bat, the Mexican free-tailed bat (*Tadarida brasiliensis*) in Texas consumes several species of moths that are agricultural pests. Recent research on an organic pecan orchard in Georgia indicates that these bats feed on several pests including the pecan nut case bearer moth, the hickory shuck worm moth and the corn earworm moth, which are major pests of the region (Boyles *et al.*, 2011).

Bats indirectly also help keep the human population healthy. Many medicines that we use are obtained from the plants that rely on bats for their survival and regeneration. They also help us to control diseases by feeding on mosquitoes, which carry the malaria virus (Champbell, 1925). For example, a study shows that one little brown bat can catch 600 mosquitoes or more in an hour (Boyles *et al.*, 2011).

Bats act as natural pollination agents. Many of the night flowers depend on them for pollination. Commercially-important plants like dates, coconut, vanilla, cloves, avocados and Brazil nuts are pollinated by bats (Kunz *et al.*, 2011).

The primary pollinator of *Agave tequilana*, which is used for the production of Tequila, is the Mexican long-nosed bat (*Leptonycteris nivalis*). These plants and their pollinators have co-evolved very closely such that the nose of the bat and the shape of the flower are complementary. *Agaves* flowers have a long stalk of up to 15 feet high, with candelabra-shaped flower clusters at the top. As these bats swoop in for nectar they get dusted with pollen, which they carry to other plants (www.bcu.com).

Bats effectively disperse the seeds of many plants across a wide area. Bats may carry off a piece of fruit, eat the fruit and drop the seeds some distance away from the original plant, or they might eat the seeds, which are then defecated. Almonds, cashews, cocoas and figs, which are regarded as keystone species, are some of the plants that are regenerated with the help of bats (Kunz *et al.*, 2011). Chocolate is made from the fruit pods of the cacao tree. Fruit bats eat the pulp of the cacao fruit and discard the cocoa bean, which subsequently grows into a new plant. This is especially important because the cacao seed will not fall from the fruit by itself (Maas *et al.*, 2013).

Bat guano, make a very rich fertilizer. Some regions in Texas have been known to produce 80 tons of guano annually. It is sold on the basis of its rich fertilizing constituents for which there is a ready market of florists and fruit growers.

One particular plant is very dependent on bat guano - peppercorns from which we make black pepper (Ober, 2008).

Although bats are said to act as reservoirs of many diseases like ebola, rabies etc, these diseases are considered as the natural control measures for checking and maintaining the population of various species in the ecosystem (Klimpel and Mehlhom, 2014).

In Kerala, there are 29 species of bats belonging to seven families and 17 genera (Nameer, 2015). There have been only a few bat-related studies in Kerala, some of which are faunistic surveys by Blanford (1891), a taxonomical and geographical distribution study by Das (1986) and a catalogue of bats in Kerala, with special reference to Thrissur district by Madhavan (1999). Most of the works done on bats in Kerala was by Nameer. The Wayanad Wildlife Sanctuary, specifically is home to about 45 mammal species (Easa and Sankar, 2001). However, there are no published studies with regard to bats from the sanctuary, and this study aimed to fill in this knowledge gap. The major objectives of this study were:

1. To study the species richness and abundance of bats in Wayanad Wildlife Sanctuary (WWS)
2. To study the roosting habitats of bats in WWS
3. To study the diet composition of three common bat species in WWS.

2. REVIEW OF LITERATURE

2.1. EVOLUTION

Teeling *et al.* (2005) revealed a molecular phylogeny for all the bat families. They suggested that mega bats share the same ancestries with four major micro bats which originated in the early Eocene period. The data shows that bats originated in Laurasia, North America.

Simmons *et al.* (2008) described a new bat fossil from Wyoming USA. Its forelimb anatomy supports the “first flight hypotheses” since their anatomy shows that it was capable of true flight. But their ear anatomy suggests that it lacked echolocation abilities. Their wings were shaped for gliding while the limb proportion shows that it had been an active climber, which later helped them in quadrupedal locomotion and under-branch hanging behaviour.

Pettigrew *et al.* (2008) revealed the retino-tectal pathway in the brain of the echo-locating mega bat *Rosettus aegyptiacus*. They found the same retino-tectal decussation that matched other mega bats and primates. They concluded that phylogenetically mega bats are sister group for primates. They also concluded that chiropteran evolution is diphyletic.

Almeida *et al.* (2009) deliberated the phylogenetic relationship of Cynopterinae fruit bats. Their results discovered the monophyly of Cynopterinae family and its Sundaland origin. They also recorded two monophyletic clades.

Fleming *et al.* (2009) did a phylogenetic study on the evolution of bat pollination. They discuss the adaptation of bats and their interaction in a plant phylogenetic perspective. They stated that bats deposit a large amount of pollen and travel a long distance.

2.2. DIVERSITY

2.2.1. Studies on the Chiropteran Diversity of South Asia

Blyth (1863) listed 55 bat species that belonged to 12 genera in the Catalogue of Mammalia in the Museum Asiatic Society.

A Chiropteran Action Management Plan (2002) workshop for South Asian chiroptera evaluated a total of 123 bat species found in South Asia in 2001 as per the IUCN Red List criteria. A conservation, research and management plan was prepared.

Srinivasalu *et al.* (2010) published a checklist along with identification characters of 128 species of bats known from South Asia. They also included the character matrices for families, genera and species. The statistics showed that India had more than 90% of the total bat diversity of South Asia.

Aul *et al.* (2014) carried out the first extensive bat survey in Andaman and Nicobar Islands during 2003 to 2006 to record the bat species, their habitat and distribution. They surveyed around 40 islands and recorded 28 bat species representing 13 Genera.

2.2.2. Studies on the Chiropteran Diversity of India

Numerous studies have been carried out on the chiropteran diversity of India. From the 1860s, the British Natural Historical Society of India surveyed numerous bat species and analyzed their ecological features. Mammalogists like Blyth, Dobson, Thomas and Wroughton (1860-1920) have studied the morphology of Indian Bats. During these years the principal objective of their work had been to measure the skull and dry skin of bats.

Slater (1891) catalogued 590 species of mammals including bats based on the 4872 specimens presented in the Indian Museum, Calcutta.

Bosset (1960a,b,c,d) directed his research towards systematic studies on the ecology and distribution of bats in Central and Western India. Through four series of publications, he provided a detailed account of the habit and habitats of 35 species of bats at 43 locations. His papers had two sections. In the first section he described their distribution in detail and included information on their ecology, food, field characters, reproduction, social life, hibernation and migration. The second section included biogeographical affinities and ecological factors that influenced their distribution, reproduction cycle, hibernation and migration.

Bates *et al.* (1994) revisited the ten localities surveyed by Bosset (1960a,b,c) and evaluated the fitness of bat populations observed 30 years back.

Bates and Harrison (1997) published a book on the chiropterans of Indian sub-continent, "Bats of the Indian Sub-Continent". They gave a comprehensive account of 119 species of bats from the entire sub-continent, including Andaman and Nicobar Islands and Maldives. The greatest asset of this book is the detailed anatomical drawings and description of every species. The rediscovery of the very rare and endangered *Latidens salimalli* and *Otomops wroughtoni* was also an important highlight of this book.

Srinivasulu and Srinivasulu (2001) recorded a total of 110 species of bats that belonged to 33 genera and eight families from India.

Nameer (2008) listed 114 bat species belonging to 8 families and 8 sub families from India. Seven species that were included in the previous checklist (Nameer, 2000) wasn't featured in the list while 10 new species were recorded and these were mainly due to new informations on distributions and taxonomic revisions.

2.2.3. Studies on the Chiropteran Diversity of Western Ghats

Nameer *et al.* (2001) published a checklist of the mammals of Western Ghats along with the States where the taxa occurred. They recorded Chiroptera as the largest mammalian order of Western Ghats comprising of 50 species that belonged to seven families.

Korad *et al.* (2007) studied the diversity and distribution of bats in the Western Ghats of India. They reviewed the existing literature for compiling the species checklist. They recorded 52 species of bats, which belonged to 25 genera and 5 families. The most abundant family was Vespertilionidae, which contributed to nearly 40% of the bat fauna of the region. They also reviewed the distribution pattern, habits, habitat specificity, threats and conservation measures.

Molur and Singh (2009) conducted an acoustic study in the modified landscapes of Coorg, Karnataka to understand the diversity and abundance of bat species. They recorded ultrasonic sounds of microchiropterans for accurately identifying the species. During the study they recorded 13 species of bats and they also computed the habitat association, species richness and diversity indices.

Wordley *et al.* (2014) did an acoustic sampling in the human-altered habitats of Western Ghats, Valparai. They recorded the echo-location calls of 15 species of bats and made a local acoustic call library. They suggested that the echo-location calls of 5 species differed from those used in other tropical habitats.

2.2.4. Studies on the Chiropteran Diversity of Kerala

Madhavan (2000) conducted an extensive survey in the Thrissur district and other regions in southern part of Kerala. He recorded 24 species of bats belonging to six families and 14 genera. The survey also aimed to understand the ecology, behavior and reproduction aspects in the bats.

Easa and Ramachandran (2005) documented 34 species of bats from Kerala.

Dineshan *et al.* (2006) published a hand book on mammals of Kerala. One hundred and nine mammals were reported in this book with the illustration of 94 of them including 28 bat species. They also provided a very well description about the morphological and morphometric data.

Nammer (2015) recently published a checklist of mammals of Kerala. In his publication, he listed 118 species of mammals which includes 29 species of bats belonging to seven families and 17 genera. Unless other checklists, it mentioned about the IUCN status and vernacular names of the species.

2.2.5. Studies on the Chiropteran Diversity of Wayanad

One study has been carried out specifically in Wayanad. Reshma (2013) studied two different roosts of Indian flying fox (*Pteropus giganteus*). The study revealed that food resources and break of monsoon rain played an important role in determining the population of bat colony.

2.3. ECHOLOCATION

Charles Jurine (1794) reported that bats use echolocation as an orientation system. He experimented by covering the ear canal of the bats by using wax and he observed that they collided with wires on the way.

Donald Griffin (1938) used piezoelectric crystals, which have the ability to transform ultrasound to audible frequencies and he was able to hear the ultrasonic echolocation calls of bats. Some of the signals produced by the bats exceeded 130 decibels in intensity.

Marimuthu and Neuweiler (1986) studied the application of acoustic signals for prey detection by the Indian False Vampire bat (*Megaderma lyra*). They observed *M. lyra* senses the prey on ground by listening to the noise of the moving target and not by echolocation. They differentiated the prey by touching with muzzle and by sensing some chemicals.

Schitzler and Kalko (2001) described that the echolocation behavior of bats changes with differing conditions such as habitat type, foraging mode and diet favour different signal types. They also confirmed the relationship among ecological conditions and echolocations.

Sripathi *et al.* (2006) studied the structure and characteristics of the echolocation calls of *Kerivoula picta* in Madhuri. The analysis showed that echolocation calls of *K.picta* were closer to the range of frequencies reported in other *Kerivoula* species found in Malaysia which had high strategy frequency ranges. It adopted this strategy for foraging in a mosaic habitat such as plantations. They also observed that these species roosted in the dry leaves of banana plants.

Teeling (2009) conducted phylogenetic studies on the basis of “Prestine” -the hearing gene in mammals and found that all echo-locating bats belonged to one clade. Nonecho-locating bats whereas belonged to a separate clade which was similar to

traditional classification. The study showed that Pteropodids had lost their echo-locating abilities and diverged from echo-locating bats nearly 58 million years ago. A rapid diversification had occurred in echo-locating bats about 52 million years ago.

Jones *et al.* (2014) studied two bat populations of *Trachops cirrhosis* in Panama and Costa Rica, where wild-caught bats were provided with different prey species to understand the seasonal variation in bat response to prey calls. The study showed that the bats captured during dry season were more responsive to frog species that bred in the dry season than other species.

2.4. ECOLOGY

McCracken and Bradbury (1980) observed a colony of *Phyllostomus hastatus* and studied their social organization. They observed that colonies were divided into a highly stable group of adult females and a less stable bachelor group of males. Harem males were highly territorial and defended their female groups from other intruding males. Some individuals roosted together for numerous years. They also radio-collared some individuals to study their foraging behaviour.

Kunz *et al.* (1983) observed a harem type of social organization among the cave roosting bat *Artibeus jamaicensis*.

Giral *et al.* (1991) studied the reproduction and social organization in *Peropteryx kappleri* in Colombo. They observed that females dominated the colonies and males did not exhibit territorial behavior. During the gestation period, females formed individual breeding territories. After weaning, the females returned to their position in the social group.

Helversen *et al.* (2002) revealed that bats were able to recolonize the echos of certain flowers since the echos of these flowers were different from the echos reflected by leaves or other objects from the surroundings.

Parris and Hazell (2005) studied the biotic effect of climate change and how it affected the roosting of Grey Headed Flying Fox *Pteropus policephalus*. They found that human activities had increased the ambient temperature and effective precipitation in central Melbourne which created a suitable climate for *Pteropus policephalus*.

Newman *et al.* (2011) published a manual that described bat biology, ecological importance, conservation and the emergence of zoonotic diseases in detail.

Sven Klimpel and Heinz Mehlhorn (2014) published a book on chiropteran morphology, feeding behaviors of different groups, their potential for and confirmed transmission of diseases and their endo- and ecto parasites.

2.5. IMPORTANCE OF BATS

Bats provide a lot of ecosystem services. A number of studies have been carried out on the importance of chiroptera.

Campbell (1925) published a book “Bats, Mosquitoes and Dollars”. In his book he described the role of bats in controlling malarial mosquito population in Texas.

Anthony *et al.* (1977) suggested that a single Little Brown bat (*Myotis lucifugus*) can consume 4 to 8g of insects each night during the active season.

Whitaker (1993) observed and estimated that a colony of Big Brown bats (*Eptesicus fuscus*) consumed 38000 cucumber beetles, 16000 june bugs, 19000 stink bugs and 50000 leaf hoppers in summer and substantially reduce pest-related expenditure for the agricultural industry of United States of America.

Keleher and Sara (1996) studied the importance of bat guano. They concluded that it was a good fertilizer rich in nitrogen and bio-remediation microbes.

Federico *et al.* (2005) studied the ecological and economical importance of Brazilian free-tailed bats (*Tadarida brasiliensis*) in non-transgenic cotton fields. They found that these bats assisted by saving US\$ 86 per hectare through the consumption of boll worms which led to the reduced utilization of insecticidal sprays.

Lee *et al.* (2005) observed that insectivorous bats were the main predators of nocturnal insects and that they consumed numerous agricultural pest insects.

Ober (2008) published that bat guano was a very nutrient-rich fertilizer. Texas is known to produce as much as 80 tonnes of guano. It is sold on the basis of its fertilizing constituents and there is a flourishing market of florists and fruit growers for it.

Jones *et al.* (2009) mentioned that bats have great potential as suitable bio-indicators.

Kunz *et al.* (2011) point out that bats acts as natural pollination agents. Many of the night flowers depend on them for pollination. Numerous other plants from which products such as dates, coconut, vanilla, cloves, avocados and Brazil nuts are derived are pollinated by bats.

Maas *et al.* (2013) revealed that frugivorous bats ate the cacao fruit pulp and effectively dispersed the cocoa bean across wide distances. This is especially important since the cacao fruit does not fall from the tree by itself.

2.6. DIETARY ANALYSIS

Mc Aney (1991) published a manual that details the analysis of bat droppings. It provides instructions on how to collect and prepare droppings for examination. The book also provides a detailed description of the anatomy of most insect orders with clear illustrations.

Jones *et al.* (1994) studied the interaction and frequency strategies of three species of leaf nosed bats. They observed that *Hipposideros ater* preferred small-sized terrestrial prey, *H.fulvus* preferred large-sized arboreal prey while *H.speoris* preferred large-sized insects from the tree line.

Corlett (1996) observed that the diet preference in bat was mainly based on the morphological characters of fruits.

Wilson and Don (1997) reported that the fruit preferred by most frugivorous bats were fleshy and sweet, but not particularly strong smelling or colorful.

Vendan (2003) studied the diet and roost site selection of *Pteropus giganteus* in Tamil Nadu.

Ramanujan and Verzhutski (2004a) studied the diet and prey spectrum of the Indian pipistrelle bat (*Pipistrellus coromandra*) in Pondicherry. They recorded that the basic food consist of insects from the Orders Lepidoptera and Coleoptera.

Ramanujan and Verzhutski (2004b) revealed the prey spectrum of *Hipposiderous ater*, from the droppings of *H.ater* as insects. They mainly fed on beetles and low-flying insects. The study clearly shows the bats ability to consume non flying prey on branches and the ground.

Siemers *et al.* (2004) observed that *Rhinolophus blassi* used echolocation to catch ground-dwelling insects. Echolocation is otherwise mostly used during aerial hawking among bats of the *Rhinolophus* genus. They compared the capture efficiency in three bats species and found no difference. They highlighted the innovative use of cumulative frequency echolocation and ground gleaning as an adaptation in *Rhinolophus blassi*.

Srinivasulu and Srinivasulu (2005) analyzed and studied the dietary composition of Black-bearded tomb bat (*Taphozous melanopogon*) through the

analysis of faecal pellets and found that about 11 insect orders and spiders contributed to their diet.

Food, foraging and flight heights of three pteropodid bat species (*Cynopterus sphinx*, *Rousettus leschenaultii* and *Pteropus giganteus*) were studied by Sudhakaran and Doss (2012). It was found that *C. sphinx* foraged at canopy level, *R. leschenaultii* foraged at upper canopy and *P. giganteus* at a height above the canopy area.

Sachin and Nameer (2014) studied the food and foraging habitat of bats in Peechi-Vazhani Wildlife Sanctuary at Thrissur (Kerala). He revealed that the Order *Lepidoptera* was the major diet of *Rhinolophus rouxii*, *Hipposideros speoris* and *Hipposideros ater*. He also noted the niche utility of these three bats.

Weterings *et al.* (2015) studied the dietary analysis of five insectivorous bat species from Kamphaeng Phet, Thailand. They analyzed a total of 151 pellets and identified the fragments of 11 insect orders. They found a large amount of Dipterians in the diet of those individuals sampled from urban areas and concluded that bats helped in the control of the vector mosquito population in Thailand.

3. MATERIAL AND METHODS

3.1. STUDY AREA

Wayanad Wildlife Sanctuary was established in 1973. There are 13 reserved forests in the sanctuary. The Sanctuary is made up of two discontinuous administrative patches (Fig 1); the first patch, which lies to the south comprises of Muthanga Range, Sulthan Bathery Range and Kurichiat Range of the South Wayanad Forest Division. Disconnected from these three ranges and further to the north, lies the Tholpetty Range of North Wayanad Forest Division. These two patches are connected only on the Karnataka side of the border. The dominant area on the Kerala side of the border consists of agricultural lands, coffee estates, settlements and also patches of Reserve Forest.

The Wayanad Wildlife Sanctuary is contiguous with Bandipur Tiger Reserve and Mudumalai Wildlife Sanctuary in the South and Southeast and Rajiv Gandhi National Park (also known as Nagarahole) in the North and Northeast. The total extent of area is about 520.78 km², of which 344.44 km² form the Wayanad Wildlife Sanctuary. Out of this, 242.954 km² are natural forest and 101.437 km² are plantations, mainly of teak.

As per the revised classification of forest types of India by Champion and Seth (1968), the natural vegetation of the Sanctuary is classified into West coast tropical semi-evergreen forests, South Indian moist mixed deciduous forests, Southern dry mixed deciduous forests and Bamboo brakes. Large extents of marshy grassland (swamps), locally known as Vayals, are also seen in the sanctuary. No silvicultural operations or extraction of timber are carried out in the sanctuary.

The moist deciduous forests are dominated by the *Tectona-Dillenia-Lagerstroemia* species composition. The other main species here are *Dalbergia latifolia*, *Pterocarpus marsupium*, *Terminallia paniculata* and *Bambusa arundinacea*. Semi-evergreen forests are dominated by tree species such as *Veteria indica*,

Lagerstroemialanceolata, *Terminalia paniculata* etc. About 110 km² (approximately 30%) of the sanctuary is under plantations of teak and eucalyptus.

Forty-five species of mammals have been reported from the sanctuary, which includes six Western Ghats endemics. Of the 203 species of birds, 10 are endemics, six range restricted and five globally threatened species. Thirteen of these are listed in the schedule I of the Indian Wildlife Protection Act (1972). Preliminary surveys indicate the presence of 45 species of reptiles, including eight Western Ghats endemics (Thomas *et al.*, 1997), 31 species of amphibians (Easa, 1998) and 54 species of fishes (Shaji and Easa, 1997).

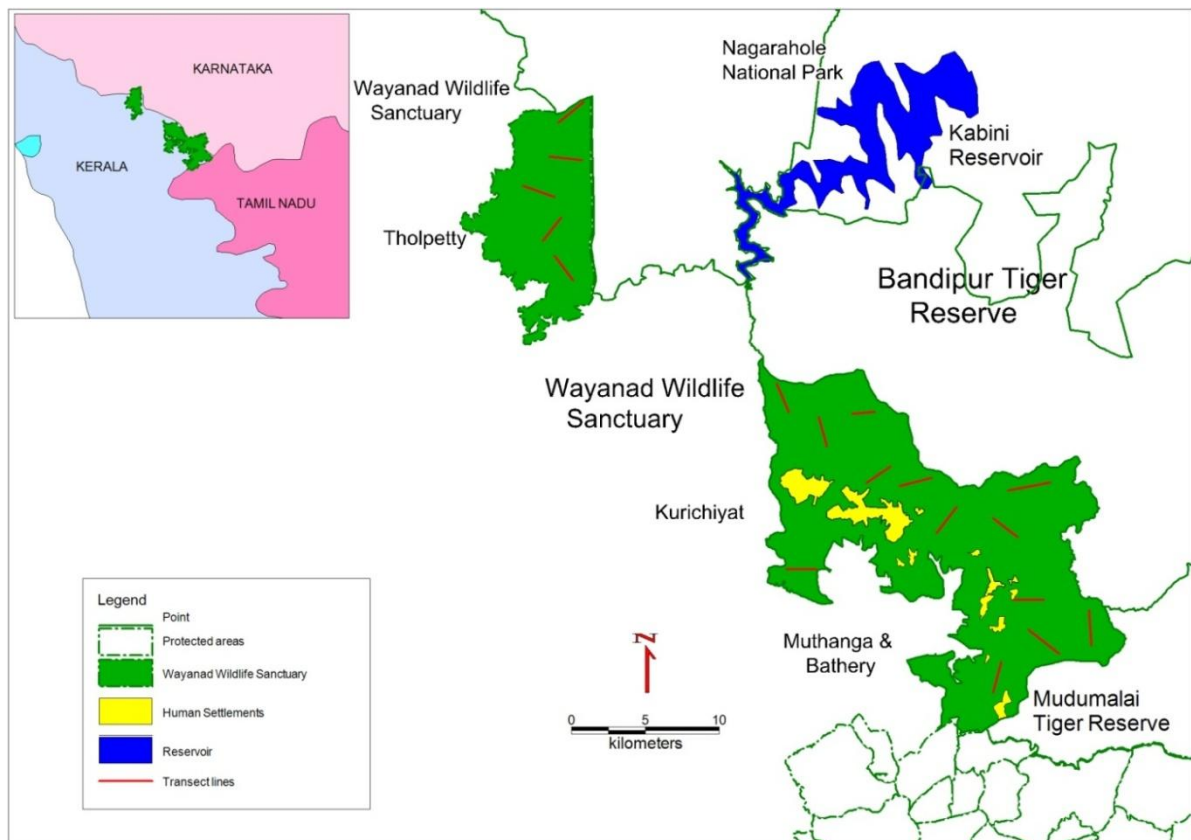


Fig 1: Map of Wayanad Wildlife Sanctuary

3.2. FIELD SAMPLING

The study was carried out within the Sanctuary and Reserve Forests adjoining it. Within the sanctuary, sampling for bats firstly involved visual encounter surveys (Chiarello, 2000) across 12 established paths (6km length, 8m width) in the Sanctuary. Tree holes, caves, bridges and other small buildings that were seen within the specified distances at each path were also surveyed for any direct or indirect signs of bats. Ten hours were spent on each path, searching visually for bat species which led to 120 hours of field observation. On identifying roosting colonies in the path, roost counts were also undertaken to estimate the bat population. Direct count and block counts were made to understand the population size of small ($n < 50$) and big roosting colonies ($n > 50$) respectively. Types of roost, height of roost from the ground, height of the tree were recorded to understand the habitat preference of bat species found in the area.

Mist netting was undertaken in the Reserve Forest and not within the Sanctuary. Two mist nets were placed at five sites where bat activity was found to be high by the local knowledge from forest guards and local tribes in that area.

3.3 DIET ANALYSIS

Three hundred and twenty guano samples were collected from roost sites. The pellets when collected in 2ml bottles filled with 10% formalin solution. In the laboratory, these pellets were powdered, dissolved in water and analyzed under a fluorescent microscope (Carl Zeiss AxioLab™ A1 Microscopes, 10X, 20mm E-PL, 10X/20mm) to understand the prey consumed by the bat species. Order-level identification of insects was carried out in consultation with entomologists at the Zoological Survey of India, Kozhikode.

4. RESULTS

4.1. SPECIES RICHNESS AND ABUNDANCE

A total of ten bat species were belonging to six families and eight genera were reported during the study period. *Pteropus giganteus* was the highest in abundance (538) followed by *Megaderma spasma* (70), *Rhinolophus rouxii* (24), *Cynopterus sphinx* (12), *Kerivoula picta* (9), *Hipposideros speoris* (1), *Rhinolophus sp.* (1), *Myotis sp.* (1), *Pipistrellus sp.* (4) and *Taphozous sp.* (11) belonging to the family Emballonuridae (11). Out of the nine species found in the present study two species were frugivorous and seven were insectivorous. Details on the number of species recorded and their taxonomic positions are listed in Table 1.

Table 1: Number of species recorded from the Wayanad Wildlife Sanctuary and adjoining areas during the study period

Family	Common Name	Scientific Name	No: of sighted individuals
Pteropodidae	Indian flying fox	<i>Pteropus giganteus</i>	538
	Short nosed fruit bat	<i>Cynopterus sphinx</i>	12
Rhinolophidae	Rufus horseshoe bat	<i>Rhinolophus rouxii</i>	24
	Horseshoe bat	<i>Rhinolophus sp.</i>	1
Hipposideridae	Schneider's leaf-nosed bat	<i>Hipposideros speoris</i>	1
Megadermatidae	Lesser false vampire bat	<i>Megaderma spasma</i>	70
Emballonuridae	Sheath-tailed bat	<i>Taphozous sp.</i>	11

Vespertilionidae	Myotis bat	<i>Myotis sp.</i>	1
	Painted bat	<i>Kerivoula picta</i>	9
	Pipistrelle bat	<i>Pipistrellus sp.</i>	4

Table 2: Number of species recorded from four locations of the Wayanad Wildlife Sanctuary and adjoining areas during the study period

Location	Scientific name	No of individuals sighted	Total no of individuals
Muthanga	<i>Cynopterus sphinx</i>	12	30
	<i>Kerivoula picta</i>	4	
	<i>Megaderma spasma</i>	3	
	<i>Taphozous sp.</i>	11	
Sulthan Bathery	<i>Pteropus giganteus</i>	538	602
	<i>Megaderma spasma</i>	64	
Kuruchiat	<i>Megaderma spasma</i>	6	6
Tholppetty	<i>Pipistrelle sp.</i>	4	36
	<i>Rhinolophus rouxii</i>	24	
	<i>Kerivoula picta</i>	5	
	<i>Hipposideros speoris</i>	1	
	<i>Rhinolophus sp.</i>	1	
	<i>Myotis sp.</i>	1	

4. 2. ROOSTING HABITAT

Bats were found to occupy different types of roosting sites (Table 3). The two frugivorous bats *Pteropus giganteus* and *Cynopterus sphinx* were found to roost in *Acacia auriculiformis* (Acacia) and *Caryota urens* (Fishtail Palm) trees respectively. In most of the cases, *Megaderma spasma* chose *Terminalia sp.* as their roosting site. On the other hand, *Rhinolophus rouxii* mainly roosted in caves and bridges.

Table 3: Details of the different types of roosting sites occupied by the bat species surveyed during the study period

Locations	Species	Type of roost	Tree Species
Muthanga	<i>Cynopterus sphinx</i>	Tree	<i>Caryota urens</i>
Muthanga	<i>Taphozous sp.</i>	Tree	Dead tree
Muthanga	<i>Taphozous sp.</i>	Tree	<i>Mangifera indica</i>
Muthanga	<i>Kerivoula picta</i>	Plant	<i>Chromolaena odorata</i>
Muthanga	<i>Megaderma spasma</i>	Tree	Dead tree
Sulthan Bathery	<i>Pteropus giganteus</i>	Tree	<i>Acacia auriculiformis</i>
Sulthan Bathery	<i>Megaderma spasma</i>	Tree	<i>Terminalia sp.</i>
Sulthan Bathery	<i>Megaderma spasma</i>	Tree	<i>Terminalia sp.</i>
Sulthan Bathery	<i>Megaderma spasma</i>	Tree	<i>Terminalia sp.</i>
Sulthan Bathery	<i>Megaderma spasma</i>	Tree	<i>Terminalia sp.</i>
Sulthan Bathery	<i>Megaderma spasma</i>	Tree	Dead tree
Sulthan Bathery	<i>Megaderma spasma</i>	Tree	<i>Terminalia sp.</i>
Kuruchyad	<i>Megaderma spasma</i>	Tree	Dead tree
Tholppetty	<i>Rhinolophus rouxii</i>	Bridge	
Tholppetty	<i>Rhinolophus rouxii</i>	Cave	

Tholppetty	<i>Rhinolophus rouxii</i>	Bridge	
Tholppetty	<i>Rhinolophus sp.</i>	Bridge	
Tholppetty	<i>Rhinolophus rouxii</i>	Bridge	
Tholppetty	<i>Hipposideros speoris</i>	Cave	
Tholppetty	<i>Pipistrellus sp.</i>	Tree	

4.3. DIET COMPOSITION

A total of 80 guano samples of *Pteropus giganteus* and 120 guano pellets of *Rhinolophus rouxii* and *Megaderma spasma* were collected and analyzed during the study period.

4.3.1. Diet Composition of *Pteropus giganteus*

The percentage composition of different prey items in the diet of *Pteropus giganteus* is shown in Fig.2. Results indicate (n=80) that *Psidium guajava* (Guava) (37%) was the most preferred fruit by these frugivorous bats. Other fruits such as *Terminalia catappa* (Indian almond) (9%), *Artocarpus heterophyllus* (Jack fruit) (16%), *Coffea arabica* (Coffee) (24%), *Mangifera indica* (Mango) (6%), *Manikara zapota* (Sapota) (3%), *Caryota urens* (Fishtail palmtree) (4%), *Carica papaya* (Papaya) (1%) were also found in the sampled guanos.

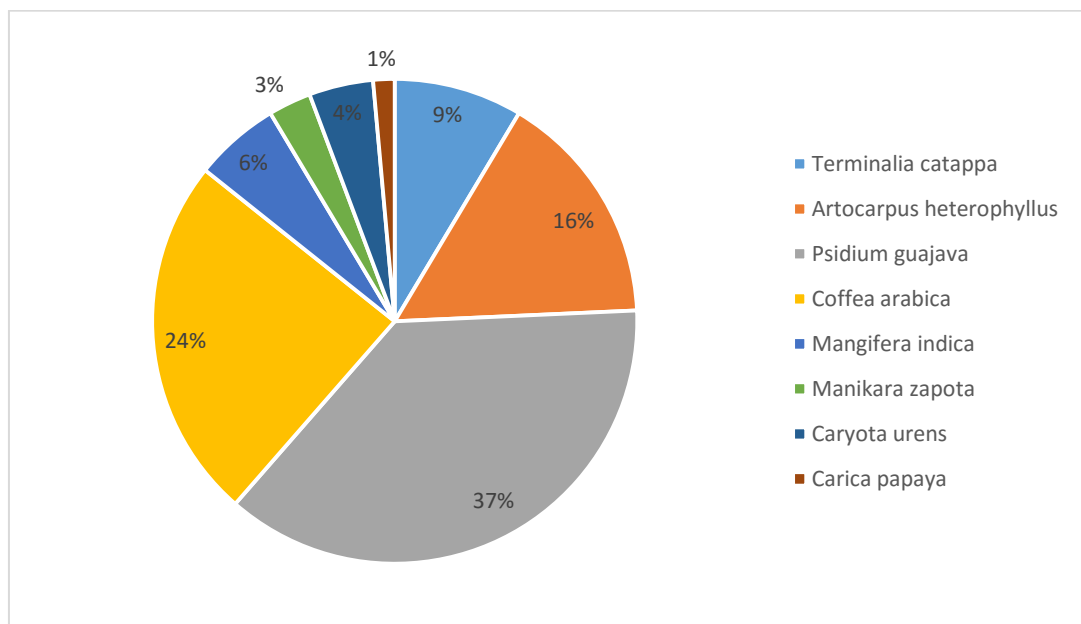


Fig.2: Percentage composition of fruit remains in the guano samples of *Pteropus giganteus* in Sulthan Bathery roost (n=80)

4.3.2. Diet Composition of *Rhinolophus rouxii*

A total of 120 guano pellets were collected and analyzed during the study period. The analyzed samples revealed that *Rhinolophus rouxii* is a generalized insectivorous bat. The percentage composition of different prey items in the diet of *Rhinolophus rouxii* is shown in Fig.3. A total of nine Orders of insects were recorded from the samples. Among the nine orders, Lepidoptera constituted 32% of the samples. The samples also includes *Coleoptera* (18%), *Diptera* (11%), *Hymenoptera* (9%), *Isoptera* (5%), *Odonata* (2%), *Hemiptera* (7%), *Orthoptera* (5%) and *Araneae* (4%).

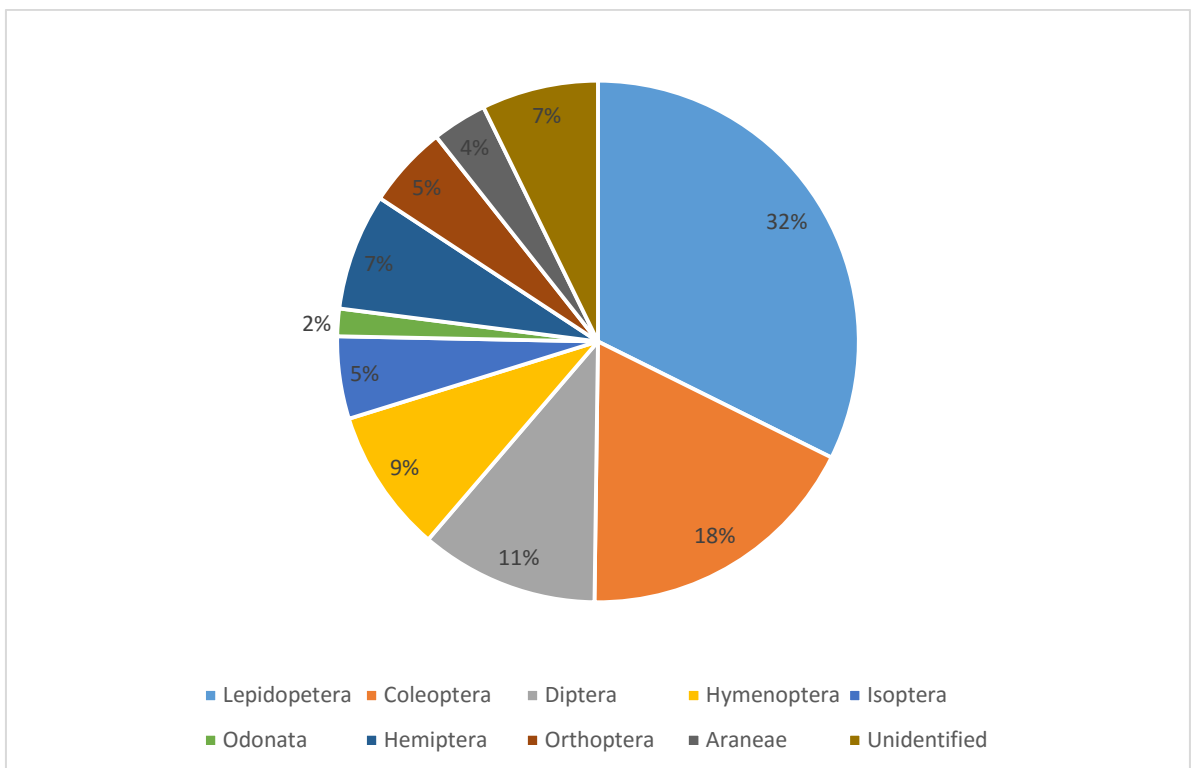


Fig.3: Percentage composition of prey remains in the guano samples of *Rhinolophus rouxii* in Tholppetty roost (n=120)

4.3.3. Diet Composition of *Megaderma spasma*

The guano samples of *Megaderma spasma* (n=120) contained seven orders of insects and one frog species (Fig.4). Among the different orders, *Coleoptera* constituted 33% of the overall diet. Other orders such as *Lepidoptera* (24%), *Diptera* (11%), *Hemiptera* (7%), *Araneae* (4%) and *Anura* (2%) constituted the diet. *Orthoptera* and *Dictyoptera* constituted least percentage in the overall diet.

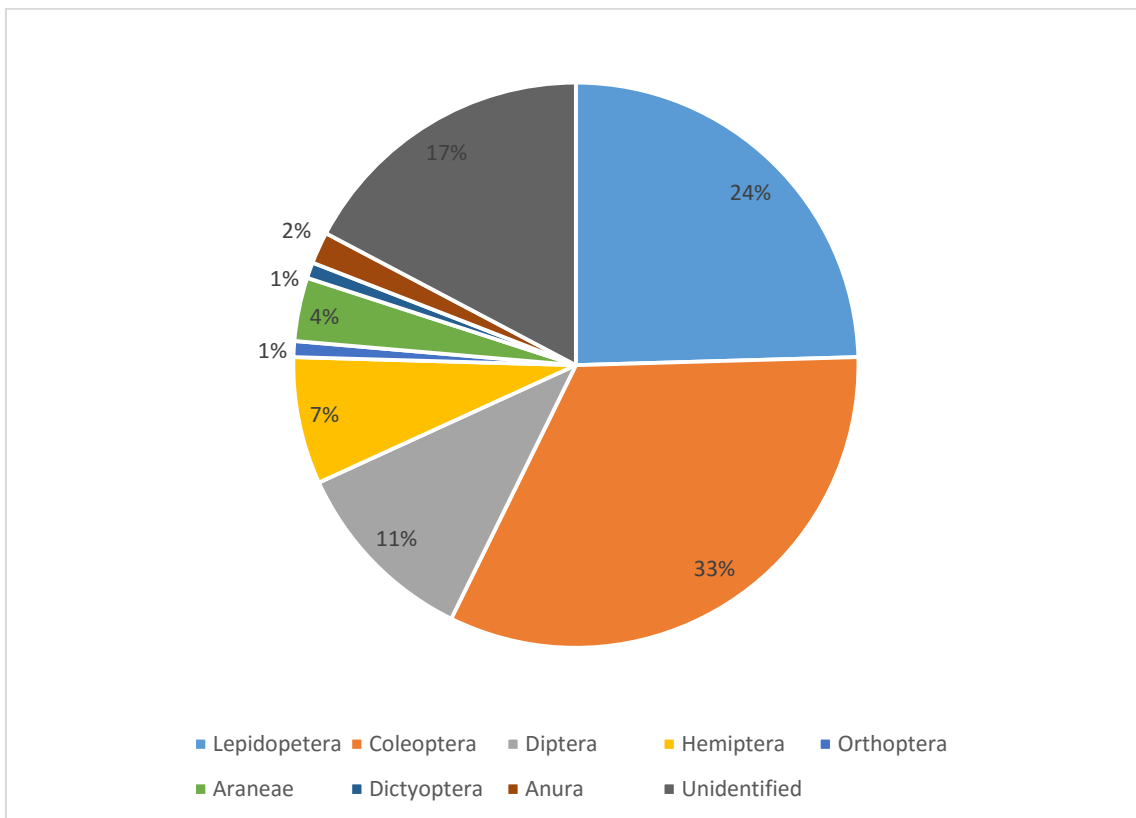


Fig.4: Percentage composition of different prey species in the guano samples of *Megaderma spasma* in Sulthan Bathery roost (n=120)

5. DISCUSSION

The Wayanad Wildlife Sanctuary is known for its good number of tigers and Elephants. Monitoring of these large mammals is done on a yearly basis. Such monitoring programs helped to improve the conservation value of these animals. Together with the conservation of such large mammals other species also got benefitted. Although strict monitoring of large mammals is routinely done in Wayanad Wildlife Sanctuary, monitoring of small mammals is not done on regular basis. Because of the limited or no monitoring of small mammals there is no detailed record of population status or ecosystem services provided by these animals. This work was done in order to assess the population diversity of volant mammals and to stress its importance in the conservation world.

5.1. SPECIES RICHNESS AND ABUNDANCE

This was only a preliminary study on the diversity of bats conducted in Wayanad Wildlife Sanctuary regarding the diversity of Order Chiroptera. During the study period, ten species of bats were observed belonging to six families and eight genera. Among the nine species obtained, two were frugivorous and seven were insectivorous. When moving from one forest type to another, change in the species was also observed.

In Muthanga area, the forest type is dry deciduous. The area was also covered by Acacia plantations. In this area, the coverage of exotic plants like *Lantana camara*, *Senna spectabilis* and *Chromolaena odorata* were high. Five roost sites were recorded from this area and it comprised of five different species of bats. The recorded species from Muthanga were *Cynopterus sphinx*, *Kerivoula picta*, *Megaderma spasma* and *Taphozous sp.* Twelve individuals of *Cynopterus sphinx* were observed in a single roost. The roost was seen around six meters from the ground on a *Terminalia sp.* This is the only place where *Cynopterus sphinx* was

recorded in the study area during the observed time. Eleven individuals of *Taphozous sp.* were observed in two different roosts. One roost was a three meter above the ground on a dead tree which had three individuals and the other eleven individuals were roosting a three meters above the ground on a *Mangifera indica*. Four individuals of *Kerivoula picta* were found roosting in *Chromolaena odorata*. *Kerivoula picta* is mainly seen in agricultural area (Sripathi *et al.*, 2006) and it was surprising to note this species here. Roosting of this species on *Chromolaena odorata* just 1.5 meter above the ground was another interesting observation. Three individuals of *Megaderma spasma* were observed on a dead tree roosting four meters above the ground.

In Sulthan Bathery, the forest is mainly of dry deciduous type. The forest was comparatively denser than the Muthanga area. There were teak plantations in some areas. The exotic plant coverage was comparatively less in this locality. Seven roost sites were observed during this study belonging to two species of bats. The two species observed were *Megaderma spasma* and *Pteropus giganteus*. Among the seven roosts six were of *Megaderma spasma*, 64 individuals of these species were noted from six different roosts. All of these six roosts were on *Terminalia* species. But, the roosts were at different heights from the ground. 538 individuals of *Pteropus giganteus* were observed from a single roost and that is roosted on a 12 meter tall *Acacia auriculiformis* tree. Only two species of bats were observed in this area distributed in seven roosts, but the number of individuals per roost was larger when compared to the other roosts observed in other study areas.

In Kurichiat area, the forest type was semi evergreen and the vegetation type was entirely different from other study areas. Sampling was difficult in this area because of the lack of specialized instruments. Six individuals of *Megaderma spasma* were observed roosting five meters above the ground on a dead tree.

In Tholppetty area, the forest type was moist deciduous forest. Unlike other areas of study, there were roads along the study area which were used for safaris. There were bridges along the roads which acted as suitable places for the bats to roost. Here, seven roosts were observed constituted by bats belonging to five species. The five species were *Rhinolophus rouxii*, *Kerivoula picta*, *Hipposideros speoris*, *Pipistrellus sp.* and another *Rhinolophus* species. All the roost in this area were seen on man-made structures like bridges, caves, buildings *etc.* *Rhinolophus rouxii* was the most common species in this area. There were 24 individuals reported from this area in the study period. One more species belonging to *Rhinolophus* were also observed. Five individuals of *Kerivoula picta* were observed roosting on *Chromolaena odorata*. The same species was observed in Muthanga on the same roost. One individual of *Hipposideros speoris* was observed from a cave. This roosting area was found to be a multispecies roosting area (Klimpel and Mehlhorn, 2014). This species was sharing its roost with eight individuals of *Rinolophous rouxii*. One species of *Myotis* was seen as a road kill along the Tholpetty - Kutta road.

5.2. ROOSTING HABITAT

Bats were found to occupy different type of roosting sites. The collected data (Table2) shows that there was a habitat-wise preference for the roost site selection. This reflects their flexibility to occupy diverse habitat conditions and that it changes with the distribution and availability of tree species and man-made structures found in that area.

The present study shows that, bats in Muthanga area were found to roost in tree holes rather than man-made structures like bridges and buildings. This dry deciduous forest was home for many tree species like *Terminalia sp.*, *Mangifera indica*, *Zyzygium*, *Cassia fistula*, *Caryota urens*, *Acacia auriculiformis etc.* Among the five roosts observed from this area, *Cynopterus sphinx* occupied a Fishtail Palm

Tree (*Caryota urens*) with a population of 12 individuals. During the study period, it was observed that, they mainly fed on the trees nearer to the roost site. Communal grooming, fights and courtship displays were observed during the study. A population of *Megaderma spasma* with three individuals was found to roost in a dead *Terminalia* Tree. Sheath-tailed Bats with a population of three individuals' preferred *Mangifera indica* as their roost site. Their roost was observed around three meter above the ground level and was nearer to a stream side. An interesting thing noted from the study area was that exotic weed plants like *Chromolaena odorata* were also home for bat species like *Kerivoula picta*. A five individual population of *Kerivoula picta* was observed using *Chromolaena odorata* as their living quarters.

Sulthan Bathery area also had the same forest type of that of Muthanga. But, this dry deciduous forest was much denser than that of Muthanga. A total of seven roosts and two species were found from this area. One roost was constituted by *Pteropus giganteus* having a population of 538 individuals. The observed roost sites were found near the road side and the camp was on an *Acacia auriculiformis* (Acacia). A study from Wayanad (Reshma, 2013) showed that *Pteropus giganteus* used 12 tree species for their day roosting. Bates and Harrison (1997) stated that colonies were usually located in close association with human settlements. Seasonal population changes also occurred in the studied colony. Earlier reports indicated that *P.giganteus* also roosted on ficus tree, *Mangifera indica* and *Tamarindus indica* (Vendan, 2003). But, the roosts varied from dense foliage which provided shades and protection from open exposed areas (Kunz, 1982). Height of roosting tree was in between 12 to 15 meters.

The second species was *Megaderma spasma*. It was remarkable that out of the six roosts of *Megaderma spasma* got from the Sulthan Bathery area, five were on *Terminalia* trees and the remaining one was on a dead hollow tree. The greater girth of the *Terminalia* trees may have been the reason for this roosting habit. The Kelakkolli roost and Koottu Road roost were found on the both sides of Kelakkolli

Vayal. During the study period a good number of *Lepidopterans* were observed here. Availability of food and nearby water source may be the reason for this roost selection by *Megaderma spasma*. Some studies showed that bats mainly preferred riparian areas as their roosting site (Betts, 1998). These two roosts were found within a diameter of one kilometer. There may have been an overlapping niche between the individuals of these two colonies. A total of 64 *Megaderma spasma* individuals were reported from Sulthan Bathery range.

In Kurichiat range, the forest type was different from other ranges and had semi evergreen vegetation. The main trees in this area were *Terminalia tomentosa*, *Syzygium cumini*, *Melia dubia*, *Dalbergia latifolia*, *Terminalia bellirica* and *Terminalia chebula*. Only one roost was observed in this area. It was a roost of *Megaderma spasma* with a population of six individuals. They roosted at a height of five meters on a dead tree which had some morphological characters resembling *Terminalia* tree. During the study period, five bridges across a stream in this area were checked. But, no signs of roosts were found there, even though bridges are good roosting sites for insectivorous bats. Availability of more hiding places in the forest may be the reason for this avoidance of man-made structures.

Tholppetty range is had a moist deciduous forest. When comparing with other ranges, this forest area contained more man-made structures like safari roads, bridges, caves *etc.* The main tree species found in this area were *Gmelina arborea* and *Lagerstroemia lanceolata*. Among the eight roosts seen here, four constituted of *Rhinolophus rouxii* with a total population of 24 individuals. Three colonies were found from the bridges and one from a small cave. One unidentified *Rhinolophus* species also was reported from this area which was found to roost in an old building. Another noticeable thing was the observing of a multi species colony of bats here. One individual of *Hipposiderous speoris* was roosting along with *Rhinolophus rouxii*.

There were 12 bridges in the Tholppetty - Kutta road and they were good hiding places for bats. As a part of the study, all the bridges were checked. Under bed of ten bridges were filled with good quantity of guanos. But, no individuals were found in the region. Observations were made for many times during the study period. However, the result was same. Kunz (1994) noted that roost site occupation may be seasonal and migrations also took place in bat colonies.

Disturbance made by the vehicles was also high in this area and it negatively affected the wildlife in this area. A road kill of *Myotis* bat was found from this route during the study period. A total of 2426 road kills were reported from this area during April to November, 2013 (Dhaneesh and Easa, 2013).



Fig 5. A roosting colony of *Megaderma spasma*

5.2. DIET COMPOSITION

5.2.1. Diet Composition of *Pteropus giganteus*

A total of 80 guano samples were collected and analyzed during the study period. Nine different species of fruits were identified from the diet of *Pteropus giganteus* during the study. The sampled fruits included *Psidium guajava* (Guava) (37%), *Terminalia catappa* (Indian almond) (9%), *Artocarpus heterophyllus* (Jack fruit) (16%), *Coffea arabica* (Coffee) (24%), *Mangifera indica* (Mango) (6%), *Manikara zapota* (Sapota) (3%), *Caryota urens* (Fishtail palmnut) (4%) and *Carica papaya* (Papaya) (1%). Foraging studies of some Pteropodidae bats revealed that sometimes they prefer 37 species of fruiting plants (Sudhakaran *et al.*, 2012). *Pteropus giganteus* was preferred fruit which may have become more fleshy and sweet, but may not particularly have been based on the smell or colorful (Wilson and Don, 1997). In this study, most of the fruit species got from the roosting site were fully ripe with odour. The diet preference in bats was mainly based on the morphological characters of fruits (Corrlet, 1996). Around 300 plant species mainly depends on the old world fruit bats for their seed dispersal and these plants produce approximately 500 economically valuable products (Fujitha and Tuttle, 1991).

5.2.2. Diet Composition of *Rhinolophus rouxii*

Rhinolophus rouxii is a generalist insectivore bat species. The diet analysis (n=120) of *Rhinolophus rouxii* revealed that, they fed on nine different insect orders. The insect orders included *Coleoptera* (18%), *Diptera* (11%), *Hymenoptera* (9%), *Isoptera* (5%), *Odonata* (2%), *Hemiptera* (7%), *Orthoptera* (5%), *Araneae* (4%) and Order *Lepidoptera* (*Heterocera*) constituted major percentage (32%) in the diet. The slow flight and small size of this micro lepidopteron moths might result in them being easy prey for *Rhinolophus rouxii*. Similarly, diverse prey selection including *Coleoptera*, *Diptera*, *Hymenoptera*, *Hemiptera*, *Isoptera*, *Orthoptera*, *Odonata*,

Mantodea, *Neuroptera*, *Ephemeroptera* and spiders (*Araneae*) by *Rhinolophus rouxii* was reported by Sachin (2014). Insectivorous bats are the main predators on nocturnal insects and they consume numerous agricultural pest insects (Lee *et al*, 2005). There by they play a major ecosystem role. In this study, the observed diet of *Rhinolophus rouxii* supports the statement. Jones *et al.* (2009) mentioned that bats have great potential as suitable bio indicators.

5.2.3. Diet Composition of *Megaderma spasma*

The analyzed guano pellets (n=120) of *Megaderma spasma* showed that the major diet of this species constituted of insects that came under the Order *Coleoptera*. 33% of their overall diet constituted of this order only. A total of seven orders of insects and one species of amphibian (*Duttaphrynus melanostictus*) were found in the diet. The diet included *Lepidoptera* (24%), *Diptera* (11%), *Hemiptera* (7%), *Araneae* (4%) and *Anura* (2%). There were other studies which showed the frog catching behaviour of *Megaderma* species using echolocation (Marimuthu and Neuweiler, 1986). Remains of *Duttaphrynus melanostictus* and wings of cockroaches were some direct observations from the roosting site only. This insectivorous bat also provided a good ecosystem service. During the study period, a good amount of guano pellets were observed under every roost. Keleher and Sara (1996) studied the importance of bat guano and concluded that it was a good fertilizer rich in nitrogen and bioremediation microbes.

6. SUMMARY

Species richness, abundance, roosting habitat and diet composition of bats in Wayanad Wildlife Sanctuary were studied from December 2014 to September 2015. A total of ten bat species belonging to six families and eight genera were reported during the study period. *Pteropus giganteus* was the highest in abundance (538) followed by *Megaderma spasma* (70), *Rhinolophus rouxii* (24), *Cynopterus sphinx* (12), *Kerivoula picta* (9), *Hipposiderous speoris* (1), *Rhinolophus sp.* (1), *Myotis sp.* (1), *Pipistrelle sp.* (4) and unidentified *Taphozous sp.* belonging to the family *Emballonuridae* (11).

Bats were found to occupy all type of habitat. There was a habitat wise preference for the roost site selection. In Muthanga (dry deciduous forest), a total of five roosts belonging to five species were reported. They were *Cynopterus sphinx*, *Kerivoula picta*, *Megaderma spasma* and *Taphozous sp.* In Sulthan Bathery (dry deciduous forest), two species were found from eight roosts. They were *Pteropus giganteus* and *Megaderma spasma*. In Kuruchyad (semi evergreen forest), only *Megaderma spasma* was found from one roost. In Tholppetty, among nine roosts five were *Rhinolophus rouxii* and other two species were *Kerivoula picta*, *Pipistrellus sp.* and *Hipposiderous speoris*. One road kill of *Myotis* species specimen was also found from this area. Mixed species roosting and seasonal migration has also been reported from Tholppetty.

Examination of guano samples (n=80) revealed that *Pteropus giganteus* mainly fed on *Psidium guajava* (37%). Other fruits such as *Terminalia catappa* (Indian almond) (9%), *Artocarpus heterophyllus* (Jack fruit) (16%), *Coffea arabica* (Coffee) (24%), *Mangifera indica* (Mango) (6%), *Manikara zapota* (Sapota) (3%), *Caryota urens* (Fishtail Palm Nut) (4%) and *Carica papaya* (Papaya) (1%) were also there in the diet. Analyzed guano pellets (n=120) of *Rhinolophus rouxii* showed that the diet consisted of nine insect orders. The major constituent was *Lepidoptera*

(32%) followed by *Coleoptera* (18%), *Diptera* (11%), *Hymenoptera* (9%), *Isoptera* (5%), *Odonata* (2%), *Hemiptera* (7%), *Orthoptera* (5%) and *Araneae* (4%). The results revealed that *Rhinolophus rouxii* was a generalist insectivorous bat. A total of 120 guano pellets of *Megaderma spasma* have analyzed and observed. They fed upon seven insect order with *Coleoptera* (33%) as the major diet. Other insect orders in diet were *Lepidoptera* (24%), *Diptera* (11%), *Hemiptera* (7%), *Araneae* (4%) , *Anura* (2%), *Orthoptera* (1%) and *Dictyoptera* (1%).

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ABSTRACT

Species richness, abundance, roosting habitat and diet composition of bats in different forest types of Wayanad Wildlife Sanctuary were studied from December 2014 to September 2015. Sampling method included direct observations and mist-netting. A total of ten bat species were reported from six families and eight genera during the study period. *Pteropus giganteus* was the highest in abundance (538) followed by *Megaderma spasma* (70), *Rhinolophus rouxii* (24), *Cynopterus sphinx*(12) and *Kerivoula picta* (9). In Muthanga (dry deciduous forest), *Cynopterus sphinx*, *Kerivoula picta*, *Megaderma spasma* and *Taphozous species* were recorded. In Sulthan Bathery (dry deciduous forest), *Pteropus giganteus* and *Megaderma spasma* were found. In Kuruchyad (semi-evergreen forest), only *Megaderma spasma* was found from just one roost. In Tholpetty (moist-deciduous forest), A total of seven roosts were observed and the roosts were occupied by *Rhinolophus rouxii*, *Kerivoula picta*, *Pippistrellus sp.* and *Hipposideros speoris*. One road killed *Myotis* species specimen was also found from this area. Mixed species roosting and seasonal migration was also reported from Tholpetty. Bat species abundance was highest in moist-deciduous forest. Diet composition analysis revealed that guava was the most preferred fruit (37%) of *Pteropus giganteus*. The analyzed samples also indicated *Rhinolophus rouxii* to be a generalized insectivorous bat with *Lepidoptera* forming a major (32%) part of its diet. Diet analysis also revealed that *Megaderma spasma* fed upon seven insect orders with *Coleoptera* forming 33% of its prey. This study, although preliminary, provides baseline information of bats found in WWS.

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