FOOD AND FEEDING HABITS OF GRIZZLED GIANT SQUIRREL *(Ratufa macroura)* AT CHINNAR WILDLIFE SANCTUARY, WESTERN GHATS, KERALA

by

KIRAN THOMAS
(2012-17-101)

THESIS

Submitted in partial fulfilment of the requirement for the degree

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COLLEGE OF FORESTRY
KERALA AGRICULTURAL UNIVERSITY
VELLANIKKARA, THRISSUR -680 656
KERALA, INDIA

2014

DECLARATION

I, hereby declare that this thesis entitled "**FOOD AND FEEDING HABITS OF GRIZZLED GIANT SQUIRREL *(Ratufa macroura)* AT CHINNAR WILDLIFE SANCTUARY, WESTERN GHATS, KERALA**" is a bonafide record of research 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.

Vellanikkara
Date: 23/10/2014

KIRAN THOMAS
(2012-17-101)

CERTIFICATE

Certified that this thesis, entitled **"FOOD AND FEEDING HABITS OF GRIZZLED GIANT SQUIRREL (*Ratufa macroura*) AT CHINNAR WILDLIFE SANCTUARY, WESTERN GHATS, KERALA"** is a record of research work done independently by **Mr. Kiran Thomas (2012-17-101)** under my guidance and supervision and it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

Vellanikkara
Date: 23/10/2014

Dr. P. O. Nameer
(Major Advisor, Advisory Committee)
Associate professor and Head
Dept. Wildlife Sciences,
College of Forestry,
Kerala Agricultural University,
Vellanikkara, Thrissur-680 656

CERTIFICATE

We, the undersigned members of advisory Committee of **Mr. Kiran Thomas (2012-17-101)** a candidate for the degree of **Master of Science in Forestry** with major in Wildlife Sciences, agree that this thesis entitled **"FOOD AND FEEDING HABITS OF GRIZZLED GIANT SQUIRREL *(Ratufa macroura)* AT CHINNAR WILDLIFE SANCTUARY, WESTERN GHATS, KERALA"** may be submitted by Mr. Kiran Thomas (2012-17-101), in partial fulfilment of the requirement for the degree.

Dr. P.O. NAMEER
Associate Professor and Head
Dep. Wildlife Sciences
College of Forestry,
Kerala Agricultural University
Vellanikkara, Thrissur, Kerala
(Chairman)

Dr. E. V. Anoop
Associate Professor and Head,
Dep. Wood Science,
College of Forestry,
Kerala Agricultural University
Vellanikkara, Thrissur, Kerala
(Member)

Dr. T. K. Kunhamu
Associate Professor and Head,
Dep. Silviculture and Agroforestry
College of forestry,
Kerala Agricultural University,
Vellanikkara, Trissur-680656
(Member)

Dr. S. Gopakumar
Associate Professor,
Dept. Forest Management and Utilization.
College of Forestry,
Kerala Agricultural University
Vellanikkara, Thrissur, Kerala
(Member)

EXTERNAL EXAMINER

DIRECTOR
KERALA FOREST RESEARCH INSTITUE
(An Institution of Kerala State Council for Science, Technology and Environment)
Peechi - 680 653, Thrissur, Kerala, India.

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INTRODUCTION

Squirrels of the Order Rodentia are one of the species rich group of mammals. Out of 273 species of squirrels in the world (Thorington and Hoffman, 2005), the Indian sub-continent harbour 28 species of squirrels in 12 genera (Nameer, 2000). Of the four giant arboreal squirrels belonging to the genus *Ratufa*, three are found in Indian limits; in which Malabar Giant Squirrel (*Ratufa indica*) is endemic to the Indian sub-continent, Malayan Giant Squirrel (*Ratufa bicolor*) seen in the North East India and the Grizzled Giant Squirrel (*Ratufa macroura*) is endemic to Western Ghats and Sri Lanka (Menon, 2003).

Grizzled Giant Squirrel (*Ratufa macroura*) shows one of the most important examples of isolated populations. This Near Threatened animal, like all squirrels, are primarily diurnal but their activity has been observed during early and late hours of the day also (Paulraj *et al.*, 1992). The habitat of the animal is extremely unique and is confined primarily to a narrow stretch of riparian vegetation along the Pambar and Chinnar rivers and their major tributaries in the Chinnar Wildlife Sanctuary. So protection of these fragmented habitats of Grizzled Giant Squirrel is of prime importance for the conservation of the species.

Animals need a diet consisting of both macro and micro nutrients in appropriate quantities. Nutrient and energy contents play a major role in the selection of foods that the squirrels eat (Gurnell, 1987) and feeding of Grizzled Giant Squirrel is confined to the middle canopy and very rarely the animal came to the ground to feed on the scattered seeds and other activities. Feeding techniques on a tree is related with the morphology and the mode of locomotion of the species (Clutton-Brock, 1977). An arboreal life like that of Grizzled Giant Squirrel always counteracting with many difficulties and challenges. Linearly distributed branches in the three-dimensional space is the only stratum for an animal on a tree, and maintaining body balance is arduous and indispensable. This may arise as a serious problem when the animal is in an attempt to reap from the terminal branches. Acquisition of nutrients and its concentration constrained by the presence of toxins and digestion inhibitors within plant material forms the most part of studies on the food choice of free ranging arboreal herbivores. Inter-specific difference in the feeding strategy study on arboreal species are still few.

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Studies done in Srivalliputhur Grizzled Squirrel Sanctuary in Tamil Nadu showed that seeds and young fruits form the bulk of the Grizzled Giant squirrel diet. Paulraj *et al.* (1992) reported that tamarind (*Tamarindus indica*) forms a key food tree species of Grizzled Giant Squirrels in Alagarkoil area and he also noticed that Grizzled Giant Squirrels also survive in localities where there are no tamarind trees. Studies on feeding ecology of grey squirrel and fox squirrels have confirmed that food preferences by these squirrels are based on a combination of two factors the speed with which they can ingest the food and the digestibility of the food eaten (Smith and Follmer, 1972). Individuals without access to figs during fruit shortages consumed either other available fruit or resorted to a diet composed largely of fibrous non-fruit resources such as leaves, flowers, bark and pith (Borges, 1993). Malabar Giant Squirrel switches to a diet of leaves (young and mature), flowers and bark during periods of fruit scarcity (Borges, 1989).

Research based on food and feeding habits is very important in two aspects, it would help in making specific management prescriptions for protecting the near threatened Grizzled Giant Squirrel, and not many scientific studies on food and feeding aspects have yet been done. The location specific analysis will help to frame work management plans best suitable for each habitat fragment.

The present study was done to understand the food and feeding habits including the food preferences and time activity budgeting of Grizzled Giant Squirrel. Efforts were also made to find out the population size, population density and distribution of the Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary. Assessment also made to find out the threats, if any, being faced by the Grizzled Giant Squirrel in Chinnar Wildlife Sanctuary.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

2.1 ORDER RODENTIA

2.1.1 Status and distribution in the world

Rodentia, the largest mammalian group, has a worldwide distribution. The most species rich group consisting of 2277 species (out of the total 5416 species of mammals) within 33 different families and they are distributed throughout every continent, except Antarctica (Wilson and Reeder, 2005). Even though, rodents constitute 43.7% of the known living mammals of the world (Wilson and Reeder, 2005), 44% of all the threatened mammal species in world belong to this mammalian group or insectivores and 60% of all recent mammalian extinctions are that of rodents and insectivores (IUCN, 1996). About 330 species of rodents are considered as threatened by IUCN (Jordon, 1999). Sixteen species out of these belongs to one genus *Gerbillus*. But still they are described as one of the most successful groups of animals on the earth today due to their vast breeding potential and easy adaptability to a wide range of habitats.

2.1.2 Status and distribution in India

India, one of the mega biodiversity countries, has 102 species of rodents in four families such as Sciuridae (squirrels), Muridae (rats and mice), Dipodidae (birch mice) and Hystricidae (porcupines) (Nameer, 2000) (Table 1). Even though 42.5% of the total endemic mammals of India are rodents the descriptions about them so far constitute only 5.06% of the total species of rodents in the world.

Table 1. Families and number of species of rodents in India (Nameer, 2000)

Sl. No.	Family	Number of Species
1.	Muridae	70
2.	Sciuridae	28
3.	Hystricidae	3
4.	Dipodidae	1
Total		**102**

2.2 FAMILY SCIURIDAE

This family of order Rodentia includes the squirrels. The earliest attempt on classification of Sciuridae was done by Ellerman (1940), based on skeletal and dental morphology. The squirrel family has two subfamilies, 'Sciurinae' comprises 'tree and ground squirrels' members of which are diurnal and 'Petauristinae' comprises 'flying or gliding squirrels' members of which are nocturnal (Ramachandran, 1992). Squirrels naturally occur throughout the world except in Madagascar, Australia, southern parts of South America and northern parts of Africa (Gurnell, 1987).

There are 273 species of squirrels found in the world *50 genera, 62 species of* squirrels in Indo-Malayan region in 28 genera and 28 species *quirrels in 12 genera found* in the Indian sub-continent. There are seven species of Sciu*en in Kerala (Table 2).*

Table 2. List of sciurids seen in Kerala (Nameer, 2000; *al, 2000)*

Family	Scientific name	Con ne
Sciuridae	*Funambulus tristriatus*	Jungle Stripe
	Funambulus sublineatus	Dusky Striped
	Funambulus palmarum	Indian Palm S
	Ratufa indica	Indian Giant S
	Ratufa macroura	Grizzled Giant
	Petaurista philippensis	Large Brown Fl
	Petinomys fuscocapillus	Small Travancor

2.2.1 Subfamily Sciurinae

Sciurinae includes both the tree and ground squirrels. Tree sc from the genus *Protosciurus* which existed during the Oligocene epo and migrated into Europe through Asia. Even though there is fossil evi Central Europe, its present range is restricted to the Oriental zoogeogra

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Table 2. List of sciurids seen in Kerala (Nameer, 2000; Agrawal, 2000)

Family	Scientific name	Common name
Sciuridae	*Funambulus tristriatus*	Jungle Striped Squirrel
	Funambulus sublineatus	Dusky Striped Squirrel
	Funambulus palmarum	Indian Palm Squirrel
	Ratufa indica	Indian Giant Squirrel
	Ratufa macroura	Grizzled Giant Squirrel
	Petaurista philippensis	Large Brown Flying Squirrel
	Petinomys fuscocapillus	Small Travancore Flying Squirrel

2.2.1 Subfamily Sciurinae

Sciurinae includes both the tree and ground squirrels. Tree squirrels have evolved from the genus *Protosciurus* which existed during the Oligocene epoch in North America and migrated into Europe through Asia. Even though there is fossil evidence of *Ratufa* from Central Europe, its present range is restricted to the Oriental zoogeographical region (Hight

et al., 1974). The divergence of the tree squirrels might have been possible from the sciurus squirrels of the North America during the mid-Miocene period, before the land connection between the south and North America was established (Thorington, 1982).

Though similar in appearance, tree squirrels have varied body size from pygmy and dwarf squirrels to the large Giant Squirrels. The Giant Squirrels of the Oriental zoogeographical region are essentially forest species remaining in the tree canopy only few incidence of coming to the ground. There is a mutual sharing of habitat among the Giant Squirrels with other arboreal mammals such as primates, arboreal civets, and birds like hornbills, pigeons and owls. Even though there are some reports of pest nature by the squirrel, the density of Giant Squirrels are low hence normally they do not tend to reach a pest status.

Ground dwelling squirrels are the most studied among squirrels with respect to their kinship and social behaviour and are mostly found in the Nearctic zoogeographical region. Tree squirrels are comparatively well studied in North America, Russia and in Europe especially in Scandinavian countries as they are important game animals in those regions (Gurnell, 1987). Among the Oriental squirrels, the palm squirrel, *Funambulus pennanti*, is the most widely studied (Prakash *et al.*, 1968). In Malayan forests, Payne (1979) has studied the synecology of Malayan squirrels with special reference to the genus *Ratufa*.

Status and distribution

There are 121 species of tree squirrels including both the giant and pygmy squirrels (Moore, 1959; Corbet and Hill, 1980). The Oriental zoogeographical region has the highest diversity of tree squirrels with 51 species (Gurnell, 1987) followed by the African zoogeographical region with 45 and the Neotropical zoogeographical region with 36 species (Corbet and Hill, 1980).

India has three species of Giant squirrels of which Malabar Giant Squirrel is endemic to the peninsular India (Menon, 2003; Menon, 2014).

2.3 GENUS *Ratufa* (GIANT SQUIRRELS)

The Giant squirrels are the largest squirrels in the world and they belong to the genus *Ratufa*. This genus is the most primitive among recent tree squirrels in some of the anatomical features and in some others they are highly specialized (Emry and Thorington, 1982). Giant Squirrels are found in diverse habitats ranging from deciduous to evergreen forests such as moist deciduous, dry deciduous, riparian forests, old mature teak forests and teak-mixed forests (Ramachandran, 1988; Datta and Goyal, 1996; Kumara and Singh, 2006; Kanoje, 2008; Jathana *et al.*, 2008; Srinivas *et al.*, 2008; Bhaskaran *et al.*, 2011; Gurjar *et al.*, 2013). They are biologically interesting and significant animals. The Giant Squirrels are unique ecologically, morphologically and zoo geographically and serve as biological indicators of the quality of habitat (Thorington and Cifelli, 1989). On zoogeographic basis, they prompt for historic interpretation of distribution which is important for planning conservation strategies.

There are only four species of Giant Squirrels in the world and they occur in Indo-Malayan regions (Oriental region). They are *Ratufa affinis, Ratufa bicolor, Ratufa indica* and *Ratufa macroura*. *Ratufa affinis* is the cream coloured Malayan Giant Squirrel. Its distribution is restricted to the Malaysian forests. *Ratufa bicolor* is the Malayan Black Giant Squirrel found in the Malayan region and north eastern regions of India and Burma. The Indian Giant Squirrel *Ratufa indica* found in peninsular India and the Grizzled Giant Squirrel, *Ratufa macroura*, found only in Southern India and Sri Lanka (Prater, 1971; Nowak, 1999; IUCN, 2014). All the four species are diurnal in nature.

Habitat fragmentation, being the prime cause of the arboreal giant squirrel population, has become the hot subject among investigators and therefore studies on the population status of giant squirrels are enormous (Gurjar *et al.*, 2013). In India, researchers contributed more on the population, distribution and ecology of Indian Giant Squirrel, *R. indica* (Ramachandran, 1988; Borges, 1989; Borges 1993; Borges *et al.*, 1999; Datta, 1993; Datta and Goyal, 1996; Datta, 1998; Datta, 1999; Ganesh and Davidar, 1999; Umapathy and Kumar, 2000; Madhusudan and Karanth, 2002; Kumara and Singh, 2006; Rout and Swain, 2006; Kanoje, 2008; Jathana *et al.*, 2008; Ramesh *et al.*, 2009; Baskaran *et al.*, 2011; Kumbhar *et al.*, 2012; Pradhan *et al.*, 2012; Gurjar *et al.*, 2013).

2.3.1 *Ratufa bicolor*

It is also called Malayan Black Giant Squirrel. *Ratufa bicolor* has an extensive mainland distribution, from northeast India, southern China, Malaysia, Hainan, Sumatra, Bali, Java and many small islands occurring in a variety of tropical and subtropical habitats. Of the three *Ratufa* species found in south Asia, the Malayan Giant Squirrel is the largest, weighing on an average more than 1.5 kg (Prater, 1948; Corbet and Hill, 1992). The head and body length is 350 to 400 mm, while the tail length is 600 mm. The ecology of this species has been studied only in Malaysia and Vietnam (Tien, 1972; Payne, 1980) while in India, some information is available on the habitat use, diet, abundance and responses of this species to logging in Arunachal Pradesh (Datta and Goyal, 1997) as well as shifting cultivation in Mizoram (Raman, 1996). A short study on this species has been carried out in north Bengal (Chakraborty and Chakraborty, 1991)

2.3.2 *Ratufa indica*

Six subspecies of *Ratufa indica* were recognized by Abdulali and Daniel (1952) and later four by Moore and Tate (1965). The reduction in the number because the latter felt that some of the earlier recognized subspecies were intergradations between the more distinct pelage colour combinations. The classification of Moore and Tate (1965) is as follows:

1. *Ratufa indica maxima*: Distributed in the extreme southern Western Ghats, pelage colour is all-black tail, black shoulders, nape, rump and thighs.

2. *R. i. indica*: Distributed in the mid-western Ghats, pelage colour has a red-maroon back and a white-yellow tail tip with the pale portion of varying extent.

3. *R. i. centralis*: Distributed in the central India and the Eastern Ghats has pelage colour having distinct black shoulder patches.

4. *R. i. dealbata*: Distributed in Surat Dangs was albinistic and now believed to be extinct (Borges *et al.* 1999).

The colour change with latitude may be an adaptation to rainfall and temperature regimes or for camouflage especially in the dry forests (Borges, 1999). A similar colour

cline exists in *R. macroura* with the dark form *R. m. melanochra* inhabiting the wettest forests of Sri Lanka and the pale, grizzled form *R. m. dandolena* inhabiting the dry forests of the eastern slopes of the southern Western Ghats (Moore and Tate, 1965). *Ratufa indica maxima* is one of the four sub species of Indian giant squirrels which is found in the south of the Palakkad Gap in the Western Ghats. This animal is distributed in evergreen and moist deciduous forests. There is very little information available on the ecology and behavior of this species (Ramachandran, 1993). An endemic race of the Indian Giant Squirrel, *Ratufa indica dealbata,* originally restricted to the Surat Dangs, is reported to be extinct as a result of the depletion of their natural habitats (Borges *et al.*, 1999).

2.3.3 *Ratufa macroura*

The Grizzled Giant Squirrel, *R. macroura*, is one among the four Giant Squirrels of the world. Grizzled Giant Squirrel is native to India and Sri Lanka (Herlekar, 2010). There are three distinct subspecies of Grizzled Giant Squirrel, with one present in India and all three present in Sri Lanka (Ellerman, 1961; Moore and Tate, 1965; Phillips, 1981; Phillips, 1984; Corbet and Hill, 1992; Menon, 2014). *Ratufa macroura dandolena* is the smallest among the three races of Grizzled Giant Squirrel in the world and is seen in Western Ghats and Sri Lanka, while the other two races, such as *Ratufa macroura macroura* and *Ratufa macroura melanochra*, are endemic to Sri Lanka. The Western Ghats subspecies, apart from being smaller in size, are lighter in colour too, than the other two sub species; the tail is variable in length but usually longer than the head and body. The fur is shorter and rather less dense than in the other two subspecies. The common name of this squirrel came from the grey to brown colouration highlighted with white at the top of the tail, giving it a grizzled appearance (Prater, 1971). Its underside is dirty white.The under part of tail have a distinctive white strip running from base to tip. The ears, crown and dorsal midline are dark brown or black. This greyish brown squirrel weighs around 2kg and has the size of a small cat. It measures about 735mm from nose to tail with the tail being 360 to 400mm long (Nowak, 1991). They construct dreys at forked branches where the crowns of neighbouring trees meet. The home range of an individual is between 0.197ha and 0.611ha (Joshua, 1992). The sexes are very similar in size and color. In the female, the tail appears to be generally longer than her head and body while in the males it appears to be generally shorter.

Population and distribution of Grizzled Giant Squirrel

The Grizzled Giant Squirrel is endemic to southern India and Sri Lanka (Herlekar, 2010). In India the distribution of this species is restricted mostly to patchy riverine habitats in the rain shadow areas of southern India. The distribution pattern of Grizzled Giant Squirrel is isolated, small and patchy in India (Ellerman, 1961) whereas in Sri Lanka the pattern is contiguous. There are less than 500 mature individuals of Grizzled Giant Squirrel in India (Joshua, 1992, Jathana *et al.*, 2008; IUCN, 2014). In India, the Grizzled Giant Squirrel is patchily distributed in the Western and Eastern Ghats (Joshua, 1992; Paulraj *et al.*, 1992; Paulraj and Kasinathan, 1993) including the Srivilliputhur Grizzled Giant Squirrel Sanctuary, the Anamalai (totals about 300 individuals, Joshua *et al.*, 2008), Chinnar Wildlife Sanctuary, Kerala, (numbering about 150 to 200), (Ramachandran, 1993; Senthilkumar *et al.*, 2007), Anamalai Tiger Reserve, Tamil Nadu with no estimated figure (Senthilkumar *et al.*, 2007). Besides, a few individuals have been reported from Palani Hills in the Western Ghats (Davidar, 1989; Sharma, 1992). In the Eastern Ghats, a small population is reported from Kanakapura Forest Division, in southern Karnataka (Karthikeyan *et al.*, 1992; Kumara and Singh, 2006; Baskaran *et al.*, 2011), which is considered as the northern-most population (Kumara and Singh, 2006). Jathana *et al.* (2008) recorded the presence of this species (at least 14 individuals) across eight locations in Hosur forest division along the Cauvery riverine forest, north of earlier reported locations in the Eastern Ghats.

The Chinnar Wildlife Sanctuary supports the second best population of Grizzled Squirrel Sanctuary in India. Perhaps the best population of the Grizzled Squirrel Sanctuary in India would be the Srivilliputtur Grizzled Squirrel Sanctuary. The population of Grizzled Squirrel Sanctuary at Chinnar was first reported by Ramachandran (1989), who reported approximately 75 individuals. Ramachandran (1993), during a study on the animal distribution of Chinnar wildlife sanctuary, 11 Grizzled Giant Squirrels were sighted and 12 new nests of the species were also noted. Subsequently Ramachandran (1993) estimated 150 Grizzled Giant Squirrels from Chinnar Wildlife Sanctuary. Grizzled Giant Squirrel show one of the most important examples of isolated populations. The most recent population estimates of the Grizzled Giant Squirrel held between November 2002 and March 2003 (Senthilkumar *et al.*, 2007), gave the population size of this squirrels in the Chinnar Wildlife Sanctuary as 107.

According to Joshua (1992) the Grizzled Giant Squirrel, *R. macroura*, in southern India is sympatric with the Indian Giant Squirrel, *Ratufa indica*, in the Palani Hills and Azhagarkoil and Ayyanarkoil area of Srivilliputhur Grizzled Giant Squirrel Sanctuary. But the distribution of *R. macroura* is entirely different from that of *R. indica*. The former has a confined distribution in southern India (Joshua, 1992) and the latter has a wider distribution and larger population across central and southern India (Ellerman, 1961; Borges, 1989; Ramachandran, 1992).

Molur *et al.* (2005) reported that in the last 25 years the population size of the Grizzled Giant Squirrel has declined by about 30%. Therefore, any new information in the distribution or occurrence of Grizzled Giant Squirrel is crucial for its conservation.

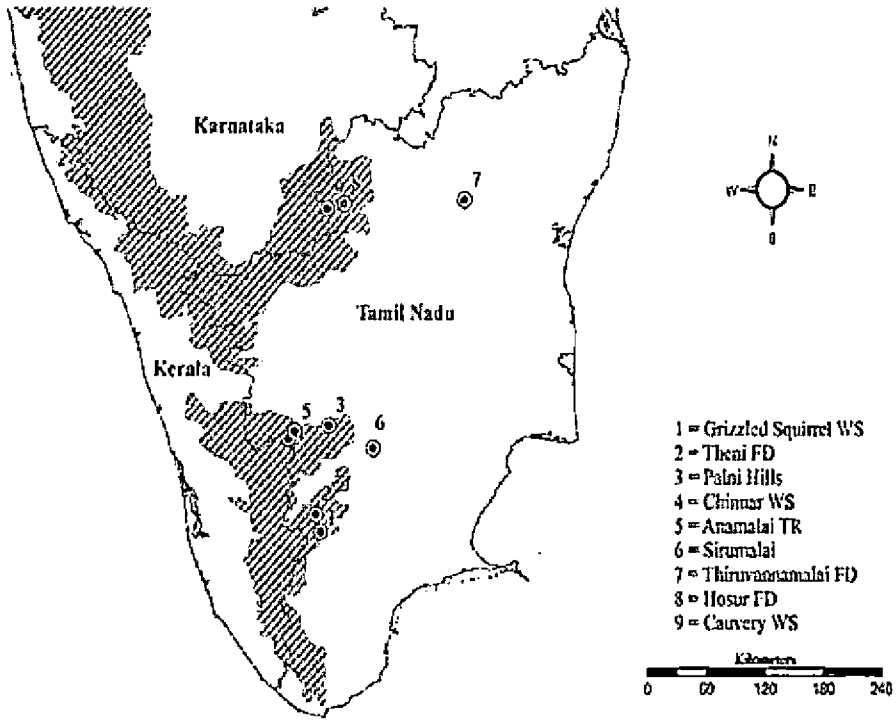

Figure 1. Distribution map of Grizzzled Giant Squirrel in south India (Source: Babu and Kalaimani, 2014).

Status of Grizzled Giant Squirrel

The animal is listed as the Near Threatened in the IUCN Red List (IUCN, 2014). It was listed as Vulnerable (VU) in the 2007 Red List of Threatened Fauna and Flora of Sri

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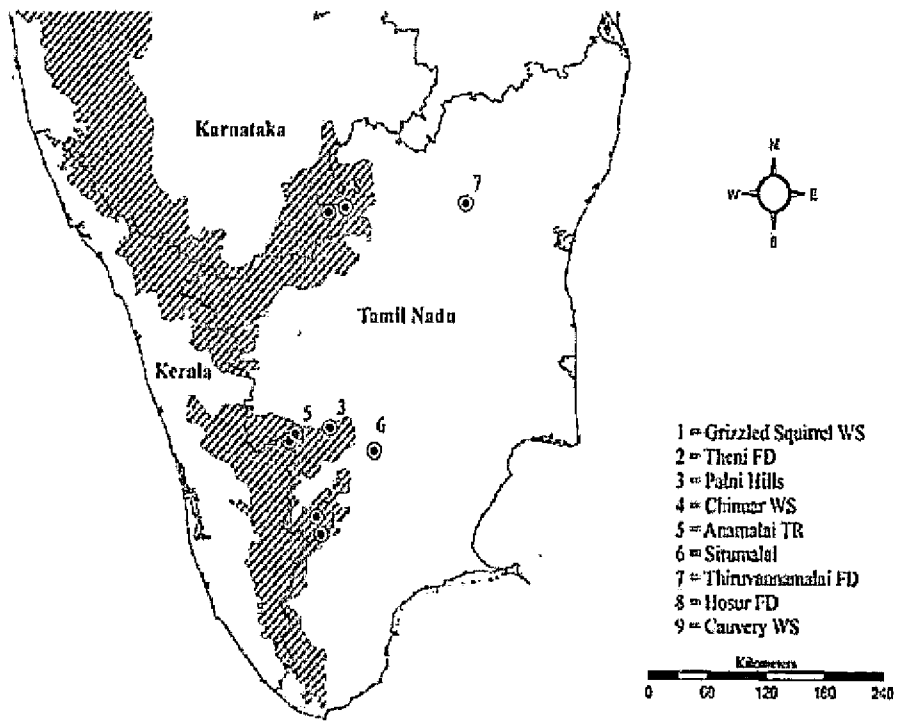

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Lanka. This species is listed under the Schedule II (Part II) of the Indian Wildlife (Protection) Act (1972), and is listed on CITES Appendix II regulating international trade in this species. It is known from the following protected areas in India: Srivilliputhur Grizzled Squirrel Sanctuary and Anamalai Tiger Reserve in Tamil Nadu, Chinnar Wildlife Sanctuary in Kerala and Cauvery Wildlife Sanctuary in Karnataka. In Sri Lanka it is reported from the protected areas like Horton Plains National Park, Central Province and Sinharaja Reserve Forest, Sabargamuwa Province (Molur *et al.*, 2005; Babu and Kalaimani, 2014).

Habitat

Grizzled Giant Squirrel, *Ratufa macroura,* is exclusively a forest animal and are the inhabitants of patchy riverine habitats (Jathanna *et al.,* 2008). The habitat of the animal is narrow and along the major rivers, their tributaries, among the mixed deciduous forest and sholas in distinct patches (Ramachandran, 1993). Subsequent study on this species in Chinnar Wildlife Sanctuary revealed that the distribution of the animals' habitat is limited by treeless areas. In Sri Lanka, it inhabits forests and woodlands (Phillips, 1984), including protected areas and wooded anthropogenic habitats.

Drey building

Grizzled Giant Squirrels build nests using twigs and leaves in the higher canopy. They construct nest at forked branches where the crowns of neighboring trees meet (Vanitharani and Bharathi, 2011). These squirrels are known to prefer areas with good food availability and canopy connectivity to live and build the drey (Vanitharani and Bharathi, 2011). Squirrel usually prefers trees significantly larger in all characteristics with large girth at breast height (gbh) and taller height with number of branches for nest building. According to Ramachandran (1992) such biased selection towards matured trees with greater canopy continuity could facilitate easy movement to and fro the nest in all the directions, a major advantage to escape from predators and to move to other parts of the home range for foraging and other activities. It is perceive that the composition of tree species and structural attributes of the forests play a major role in the usage of habitat by the Giant Squirrel (Ramachandran, 1992). Vanitharani and Bharati (2011) reported the following tree species for building nest: *Lannea coromandelica, Mangifera indica,*

Sterospermum chelonoides, *Cullenia exarillata*, *Eriodendron pentandrum*, *Tamarindus indica*, *Terminalia arjuna*, *Terminalia bellirica*, *Terminalia chebula*, *Terminalia tomentosa*, *Azadirachta indica*, *Melia azadirachta*, *Albizia amara*, *Albizia lebbeck*, *Ficus benghalensis*, *Ficus racemosa*, *Ficus religiosa*, *Syzygium cumini*, *Dalbergia latifolia*, *Pterocarpus marsupium*, *Sapindus emarginatus*, *Schleichera oleosa*, *Grewia tiliifolia*, *Gmelina arborea*, *Tectona grandis*. Because of their canopy dwelling habit the discontinuous forest always restricts their movement and dispersal (Jathanna *et al.*, 2008). Bhaskaran *et al.* (2011) and Vanitharani and Bharathi (2011) suggested that many arboreal dwellers like *R. macroura* prefer those type of habitats which provide dense canopy cover and higher canopy height.

Foraging ecology of Grizzled Giant Squirrel

Inter tree variation in feeding

Seeds and young fruits form the bulk of the squirrel diet. But they primarily feed on seeds of immature and mature fruits from trees and climbers. Eventhough tamarind (*Tamarindus indicus*) forms a key food tree species of Grizzled Giant Squirrel (Ellerman, 1961; Paulraj *et al.*, 1992; Joshua, 1992), it was reported that they also survive in localities where there are no tamarind trees (Paulraj *et al.*, 1992). Vanitharani and Bharathi (2011) reported that *Artocarpus heterophyllus, Artocarpus hirsutus, Ficus benghalensis, Ficus religiosa, Ficus, racemosa, Tamarindus indica, Mangifera indica, Lannea coromandelica, Morinda tinctoria, Syzygium cuminii, Eriodendrum pentadrum, Polyalthia suberosa, Aglaia elaeagnoidea, Chassalia curviflora* and *Sapindus emarginatus* are the main dependant tree species in the dry deciduous and reverine forests of Srivilliputhur Wildlife Sanctuary by Grizzled Giant Squirrels. The squirrels were observed to eat tender leaves of *Tamarindus indica* and *Bauhinia purpuria* (Ellerman, 1961; Joshua, 1992; Vanitharani and Bharathi, 2011). During the non-fruiting season or during the scarcity of the fruits, Grizzled Giant Squirrel feed on the bark and leaves of some of the above listed key tree species (Vanitharani and Bharathi, 2011). Ripe fruit pulp of *Mangifera indica, Artocarpus spp., Ficus spp.* fruits and *Tectona grandis* flowers are also the most significant contributor to the diet of Grizzled Giant Squirrel (Vanitharani and Bharathi, 2011).

Study in Chinnar Wildlife Sanctuary reveals that Grizzled Giant Squirrels in riverine forest were observed to feed on plant parts from 21 tree species (Senthilkumar *et al.*, 2007). According to them out of the 138 feeding observations, 61.6% feeding records related to *Terminalia arjuna* and *Pongamia pinnata*, irrespective of the density. They calculated the preference index as the percentage of food trees divided by the relative abundance of the trees in the habitat, after the analysis, the food trees most preferred by the Grizzled Giant Squirrels were *Tamarindus indica*, *Pleostylia opposite*, *Strychnos potatorum and Terminalia arjuna*. Only seven plant species had a preference index of more than 1 in terms of food choices made by Grizzled Giant Squirrels (Senthilkumar *et al.*, 2007).

Water consumption

There were no specific studies on water intake by Grizzled Giant Squirrel while Malabar Giant Squirrel probably meets its water requirement by feeding on the flowers and leaves. Only two observations were recorded in which two squirrels drank rain water from a hole in a tree trunk (Ramachandran, 1988).

Foraging movements

A study was conducted towards understanding foraging movements in the Malabar Giant Squirrel, *R. indica.* Samples were collected, by means of continuous focal animal sampling, high resolution movement data of *R. indica,* along with behavioural observations of resource utilization. This is complemented by spatio-temporal data on availability of resources of differing quality. Empirically quantitating the spatial movement constraints that the animal has to contend with while foraging is being done. These constraints arise as a consequence of the animal being obligatory arboreal, which means that almost all the movements of the animal are within the canopy of the forest, using the network of interconnected branches (Borges, 1989).

Tree interaction and variation between individuals

Senthilkumar *et al.* (2013) conducted a study in Chinnar Wildlife Sanctuary in which they documented time spent in various activities on different tree species by adult male,

adult female and sub adult. Three full days were spent on feeding behaviour documentation during the study period, according to them in total 13 tree species used by adult female followed by 12 tree species by adult male and 10 tree species by sub adult. Most time spend by all the three categories were on *Terminalia arjuna*, due to the higher availability of *Terminalia arjuna* among the total vegetation cover. On the other hand, adult male and sub adult spent more time on *Tamarindus indica* and *Terminalia arjuna* which is representing lowest relative density among the vegetation cover while adult female spent more time on *Miliusa heyneana* the lowest relative density species among the vegetation cover.

Time Activity budgeting

Animals are designated nocturnal or diurnal based on their peak activity phase. Activity and energetics are mutually related (Gurnell, 1987). Activity pattern of mammals have been a subject of research in various animals around the world. A variety of data can be obtained by investigations on activity pattern, by trained eyes with simple equipment as binoculars (Ashby, 1972). Most animals exhibit an activity pattern which functions as a species-specific schedule (Kavanau, 1967). There could be discrepancy between activity patterns in the laboratory condition and in the field condition. The activities are more or less constant in the field (Kavanau, 1969). The Grizzled Giant Squirrel, *R. macroura dandolena*, was not undergone for detailed studies on their activity patterns. Hence the present investigation covers the activity pattern of this species as observed under field condition.

Reproductive biology

This species has a low rate of reproduction (100 female: 31 young) with female giving birth to one young a year (Joshua, 1992).

Interbreeding between Grizzled Giant Squirrel and Malabar Giant Squirrel

Grizzled Giant Squirrel is found sympatric with Malabar Giant Squirrel in the Ayyanarkoil valley in Rajapalayam hills in the Srivilliputtur Grizzled Giant Squirrel Sanctuary in Tamil Nadu (Joshua, 1992). Joshua reported that during a survey for these squirrels in Ayyanarkoil valley in January 1989, he saw a Grizzled Giant Squirrel female

and a Malabar Giant Squirrel male lying close one behind the other on a branch of an *Albizzia lebbeck* tree at 18m from the ground. The time was 08.15 hrs and is usually the peak feeding time (Joshua, 1992). At 09.12 hrs the Malabar Giant Squirrel male approached the Grizzled Giant Squirrel female where upon she turned and chased the male. At 09.28 hrs the Malabar Giant Squirrel male successfully mounted the Grizzled Giant Squirrel female for a few seconds. After resting for about 20 minutes the Malabar Giant Squirrel male again started to go behind the Grizzled Giant Squirrel female. In the meanwhile a Grizzled Giant Squirrel male interfered and the Malabar Giant Squirrel male started chasing the Grizzled Giant Squirrel male away from the female. For the rest of the day Malabar Giant Squirrel male was involved in keeping the Grizzled Giant Squirrel male away during which he attempted to mount the female only twice, both unsuccessfully. Joshua (1996) also reported Malabar Giant Squirrel with grey colour instead of the usual maroon around the belly and the flanks, which he thought as a hybrid between Malabar Giant Squirrel and Grizzled Giant Squirrel. All the hybrids had coat colours of both Malabar Giant Squirrel and Grizzled Giant Squirrel. It is evident that mating of Malabar Giant Squirrel and Grizzled Giant Squirrel is a common feature at Ayyanarkoil valley as Grizzled Giant Squirrel are pushed into the Malabar Giant Squirrel habitat due to habitat degradation. It would be rather interesting to see and significantly important whether these hybrids are fertile (Joshua, 1996).

Hand rearing of Grizzled Giant Squirrel

The successful hand-rearing of 2-4 weeks old Grizzled Giant Squirrels (*R. macroura dandolena*) that has fallen from their nests was reported from Southern Western Ghats. The Paliyans, an indigenous forest dwellers in the South Western Ghats especially in Tamil Nadu and Kerala, got assistance and guidance from the Wildlife Association of Rajapalyam (WAR) for this and the Young squirrels were taken home for rearing. They were fed with diluted milk formula and a 'Paladai' – a traditional oil lamp and once get older the young ones were given fruits gathered from the forests. A process of soft release was followed from home allowing the squirrel to play outside the house and return at its will until completely independent (Arora, 2013).

Anti-predatory response of the Grizzled Giant Squirrel

Since most mammalian carnivores are nocturnal, birds of prey are likely to be the most important predators of diurnally active squirrels (Emmons, 1980; Hall, 1981). Most studies on temperate and tropical squirrel species have documented the importance of diurnally active raptors as predators on these mammalian ones (Emmons, 1980; Hall, 1981; Joshua, 1992; Borges, 1993). Ramachandran (1991), Joshua (1992), Joshua and Johnsingh (1994) and Borges (1993) observed predation attempts by the black eagle (*Ictinaetus malayensis perniger*) and crested serpent eagle (*Spilornis cheela*) on the Indian Giant Squirrel and Grizzled Giant Squirrel.

Datta (1998) observed three unsuccessful predation attempts by the Crested Hawk Eagle (*Spizaetus cirrhatus limnaetus*) on the Indian Giant Squirrel (*R. indica)* at Bori wildlife sanctuary. Altmann (1974) observed two predation attempts on the Malabar Giant Squirrel by Crested Hawk Eagle (*Spizaetus cirrhatus limnaetus*). Hall (1981) reported the incidents of unsuccessful predation attempts by immature red tailed hawks where the squirrels did not seem to be frightened even when the predator was perched just 3m above them but gave repeated alarm calls.

Ecological importance of Grizzled Giant Squirrel

R. macroura acts as a seed disperser to their foraging trees through dropping seeds when they cruise over the canopy. The key tree species like *Artocarpus heterophyllus, Artocarpus hirsutas, Ficus benghalensis, Ficus religiosa, Ficus racemosa, Tamarindus indica, Mangifera indica, Lannea coromandelica, Morinda tinctoria, Syzygium cumini, Eriodendrum pentadrum, Polyalthia suberosa, Aglaia elaeagnoidea, Chassalia curviflora* and *Sapindus emarginatus* are found to be the feeding trees of Grizzled Giant Squirrel eventually the squirrel may be helping in seed dispersion of these species. (Vanitharani and Bharathi, 2011).

Pest nature

A study by Bandra *et al.* (2012) shows that Grizzled Giant Squirrel (*R. macroura*) has become a serious constraint on various crops in traditional home gardens in Sri Lanka.

Grizzled Giant Squirrels' tendency to chew on various edible and inedible objects caused damage to fruit crops, food crops and spices intensively. The Squirrels were found damaging more than 30 crop species in Sri Lanka. They seem to destroy more than they consume and damage fruits, seeds, leaves and branches of trees. According to this study taxa found in dry zone, intermediate zone and mid hills causes more damage than the taxon found in the low land wet zone. People in rural areas of Sri Lanka consider Giant Squirrels as a pest. As their conclusion, Bandra and his co-workers states that rapid population increase within the last two decades, conversion of forest areas into mono-crop fields and anthropogenic activities can be stated as the reason for this obsession.

Threats and conservation measures

In fact Grizzled Giant Squirrel is more endangered than the Lion-tailed Macaque the latter of which is represented in at least 20 protected areas in three southern states. The two major factors which explain the species disappearance in several places are the forest management system (Paulraj and Kasinathan, 1993) and uncontrolled hunting (Joshua and Johnsingh, 1992; Paulraj and Kasinathan, 1993; Joshua and Johnsingh, 1994; Molur *et al.*, 2005). But as per Kumara and Singh (2006) hunting was not a major threat to Grizzled Giant Squirrel in Karnataka. Habitat loss continues to reduce its numbers significantly throughout most of its distribution areas (Joshua and Johnsingh, 1992; Joshua and Johnsingh, 1994; Molur *et al.*, 2005). The major reason for the habitat loss is fragmentation through felling of forest trees to meet human needs (Joshua, 1992; Joshua and Jonsingh, 1994). So protection of the habitats of Grizzled Giant Squirrel is of prime importance for the conservation of the species. Measures like restoration of habitat, canopy continuity maintenance, control on translocation of squirrels from larger populations and anthropogenic pressures, stopping auctions of *Tamarindus indica* fruits on large scale for commercial purpose by Forest Department may enhance the long term survival of this particular habitat specialist animal (Jathana *et al.*, 2008).

Despite the fact that Grizzled Giant Squirrel is the oldest recorded species of the genus *Ratufa*, dating back to 1769 (Ellerman, 1961), very little is known about its distribution, population status, density, sex ratio, nest-site selection and various ecological aspects. Only few published information is available on this species in India (Joshua, 1991; Joshua and Johnsingh, 1992; Paulraj *et al.*, 1992; Paulraj and Kasinathan, 1993;

Ramachandran, 1993; Kumara and Singh, 2006; Bhaskaran *et al.*, 2011; Senthilkumar *et al.*, 2007; Senthilkumar *et al.*, 2013). Similarly, the foraging ecology aspects of Grizzled Giant Squirrel have been neglected by the scientific community. Mammalian populations dynamics are greatly depend on and influenced by food availability and diet. Therefore, the activity and foraging behavior of squirrels may also get influenced by the differences in food availability and quality among habitats (Koli *et al.*, 2013). Understanding the food resource requirements is essential for the long-term conservation plans of Grizzled Giant Squirrel, hence the present study.

MATERIALS AND METHODS

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3.1 STUDY AREA

The study area, Chinnar Wildlife Sanctuary, was notified as a reserve forest in May 1942 and later, in August 1984, the same was elevated to the status of wildlife sanctuary. This particular area stretches in the Marayoor and Kanthalloor Panchayat under Devikulam Taluk of Idukki district, Kerala State. It comes under the jurisdiction of Munnar Wildlife Division.

3.1.1 Location

The Western Ghats, identified as one of the biodiversity hot spots of the world, is a 1,600 km long chain of mountain ranges running parallel to the western coast of the Indian peninsula. Chinnar Wildlife Sanctuary is located 18 km north of Marayoor in the Marayoor and Kanthalloor Panchayats of Devikulam Taluk in the Idukki district of Kerala state (Fig. 2). It is located between 10°15'- 10°21'N latitude and 77°5'-77°16'E longitudes and has a total area of 90.44 km².

3.1.2 Boundaries

The Sanctuary shares its boundary with Amaravathi reserve forests of Indira Gandhi Wildlife Sanctuary of Tamil Nadu on the north and the east. It is bordered with Eravikulam National Park on the west and Marayoor Reserve Forest on the south, respectively. The sanctuary has a total area of 90.44 km² and the terrain is undulating with altitudes varying from 440 m to 2372 m above mean sea level.

3.1.3 Significance of the study area

The area represents a large number of plants and animals unique to the thorny vegetation. Apart from the dry thorn forests, due to the significant variation in altitude and rainfall, it has a wide array of habitat types like deciduous forests, dry thorny forest, riparian forest, shola forests and grasslands that are interspersed with plains, hillocks, rocks and

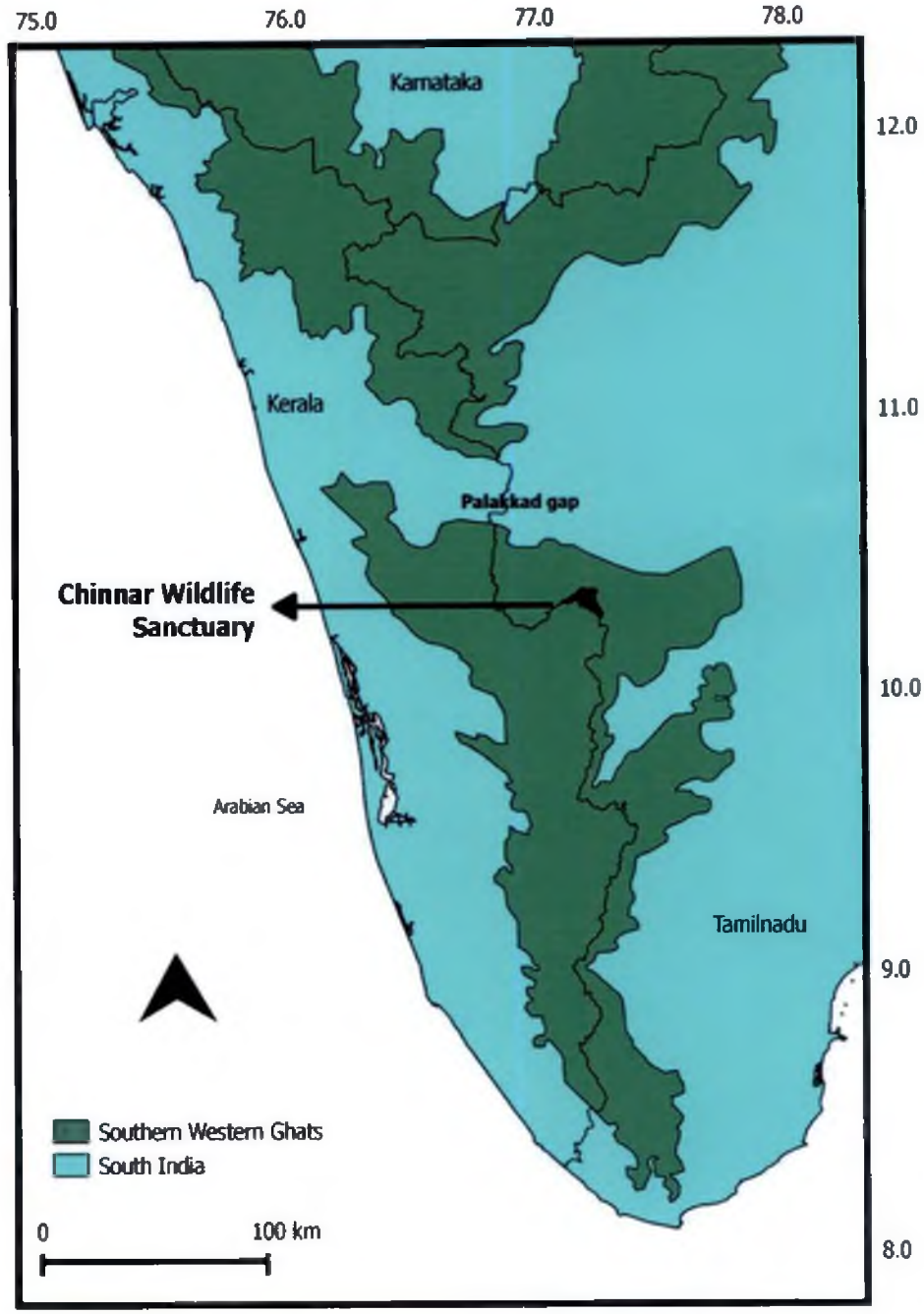


Figure 2. Location map of Chinnar Wildlife Sanctuary

cliffs which provide microhabitats for varied forms of life. The sanctuary falls under the Anamudi Elephant Reserve. *Albizia lathamii,* an endangered species has been reported from the dry forests of Chinnar. It is a well known repository of medicinal plants. The famous 'white bison of Manjampatti' has been reported from Chinnar. With 225 species of birds, Chinnar is rich in avian diversity.

In association with the neighbouring protected areas, Chinnar forms part of a viable conservation unit. The sanctuary provides livelihood options and helps in maintaining the cultural heritage of tribes such as Hill Pulayas and Muthuvans. Archaeologically significant megalithic burial sites consisting of dolmens and cysts are found within the sanctuary. Chinnar Wildlife Sanctuary offers great opportunities for developing a dynamic model of biodiversity conservation in a human dominated landscape. It is the only habitat in the State where the Grizzled Giant Squirrel (*R. macroura*) and Indian Star Tortoise (*Geochelone elegans*) are seen.

3.1.4 Geology, rock and soil

Geologically the sanctuary is comprised of gneissic metamorphic rocks from the Archean shield. The predominant rock type in the area is biotite gneiss and it is also associated with hornblende biotite gneiss in certain areas. The rocks are highly sheared and fractured at places. Joint systems are well developed. The soil is sandy to sandy loam in texture. Sandy nature is prevalent in the riparian zone. The soil reaction varies from slightly alkaline to strongly acidic depending on the vegetation type. The soil in scrub and dry deciduous forests are slightly alkaline in reaction. This is effected by low rainfall and weak leaching of bases. On the other hand the shola soils are strongly acidic in reaction due to higher rainfall regimes and also greater input of organic material into the soil from vegetation. The gravel content in the soils in scrub forest is higher than in other vegetation types indicating high degree of erosion. In the shola soil the content of gravel is negligible and this is due to the closed canopy present there.

3.1.5 Terrain

The terrain is undulating with hills and hillocks of varying heights. The altitude ranges from 400 m at Chinnar to 2372 m at Nandalamala. The other major peaks in the Sanctuary are Varayattumalai (1845m), Thengamalai (1422m), Vellakkalmalai (1883m), Jambumalai (1395m), Aralipana (1494m), Karumalai, Anakkunnu and Gellimalai. The area is drained by two perennial rivers passing through the sanctuary, namely Chinnar and Pambar. During north east monsoon which is the dominant rainy season, a few ephemeral water sources take origin from higher mountains and drain the area and dry up for the rest of the season.

3.1.6 Climate

The sanctuary is situated in the rain shadow region and hence the area experiences prolonged hot/dry season and much less rainy days. The Chinnar plains are generally hot, but the higher altitudes are cool. Chinnar Wildlife Sanctuary shows wide variations from the rule of altitudinal gradient determining microclimate. The major rainfall season is during the north-east monsoons occurring during October-December. The rainy days in a year range between 30 to 40 days which account for about 300-500 mm rainfall in Chinnar and adjacent areas. But the higher altitudes areas like Olikkudy and Mangappara receive rain during both north-east and south-west monsoons with comparatively much higher rainfall. The recorded lowest temperature is 12°C and the highest is 38°C with mean annual temperature of 36°C. The wind velocity recorded at Chinnar shows a more or less uniform magnitude except for the slightly higher speeds recorded during some monsoon months.

3.1.7 Drainage

Chinnar and the east flowing Pambar are the major sources of water. Both originate in the sholas of the upper reaches. Pambar traverses the Turner's Valley in Eravikulam National Park and flows down into Chinnar Wildlife Sanctuary through the Talliar Valley. Chinnar follows the interstate boundary. These two rivers merge at Koottar and drain into the Amaravathy reservoir in Tamil Nadu. Most of the rivulets and streams inside the Sanctuary come alive immediately after the north-east monsoons and dry up soon. The water in the check dams remains for a longer period but they also dry up during summer months. But a few streams originating from the upper reaches are perennial.

3.1.8 Vegetation

The vegetation of the sanctuary is highly disturbed mainly due to anthropogenic factors and cattle grazing. Therefore in many cases secondary forest types replace primary types and an obvious classification of forest types is really a hurdle. Notwithstanding these, the vegetation of the Sanctuary can be broadly classified according to (Champion and Seth, 1968) in to the following types:

1. Southern tropical thorn forest (scrub jungle)

2. Southern dry mixed deciduous forest (dry deciduous forest)

3. Southern moist mixed deciduous forest (moist deciduous forest)

4. Tropical riparian fringing forest (riparian forest)

5. Southern montane wet temperate forest (hill shola forest)

6. Southern montane wet grassland (grassland).

Dry deciduous forest and scrub jungle are the two main forest types which together constitute about 50% of the total forest area. They are located at low land areas.

The likelihood to establish exotic weeds is higher wherever the natural vegetation is disturbed and in turn it is a measure to estimate the degree of disturbance of the vegetation. However, once exotics are spread, they gradually suppress the natural regeneration and take dominance over the other species due to their increased and wide adaptability resulting in the loss of biodiversity and endemism. The same is true in the study area as the practice of shifting cultivation in the past by tribes gave way to the greater chance for the exotics to be established in those areas. The exotics established areas are spread at various regions of the Sanctuary; the major exotics in the Sanctuary are *Lantana* spp., *Parthenium hysterophorus, Argemone mexicana, Vicoa indica. Euphorbia* spp., *Chromolaena odorata* etc.

3.1.9 Fauna

The sanctuary offers a wide range of habitat types to the flora and fauna. There are 28 species of mammals, 225 species of birds, 14 species of fish, 15 species of amphibians, 156 species of butterflies and 52 species of reptiles recorded from the sanctuary. Elevan tribal settlements spread across the sanctuary also have significant impact on the range of wildlife and habitat.

Mammals

Chinnar Wildlife Sanctuary has the only population of Grizzled Giant Squirrel in Kerala. Among the primates the sanctuary is home to Bonnet Macaque (*Macaca radiata*), Tufted Grey Langur *(Semnopithecus priam*) and Slender Loris (*Loris lydekkerianus*). Apart from these the other mammals found in the sanctuary are Elephant (*Elaphas maximus*), Tiger (*Panthera tigris*), Leopard (*Panthera pardus*), Gaur (*Bos gaurus*), Wild Boar (*Sus scrofa*), Sambar Deer (*Rusa unicolor*), Spotted Deer (*Axis axis*), Barking Deer (*Muntiacus muntjak*), Porcupine (*Hystrix indica*), Wild Dog (*Cuon alpinus*), Jackal (*Canis aureus*), Sloth Bear (*Melursus ursinus*), Jungle Cat (*Felis chaus*) etc. The legendry 'white bison' has been sighted from the Manjampetti region in the Chinnar plains, whihc may be an albino individual.

3.2 METHODS

The study was done from April 2013 to May 2014. Monthly observations were made during these periods. The data thus collected were pooled into three seasons, such as South-West monsoon (June-September), North-East Monsoon (October-November) and summer season (December-May). The Grizzled Giant Squirrels were surveyed using the direct observational method using line transects. A detailed reconnaissance survey was done in the Grizzled Giant Squirrel habitat to finalize transects. Five transects were laid in different locations in Chinnar Wildlife Sanctuary, all within the tributary of Chinnar river, Pambar river and their tributaries. The details of transects are given below (plate 1).

1) Chinnar to Kootar: This stretch of the river is perennial in nature and runs close to the Udumalpettu-Munnar highway. The trees are primarily evergreen in nature. One tree top hut for the tourists is located in the riverine belt at Kootar in this transect. This transect is also near to the watch tower which is visited by large number of tourists.

2) Chinnar to Churulipetty: Along Chinnar River from the Chinnar towards Thayannamkudy Muthuva settlement. The trees are primarily evergreen in nature. A power line pass across the riverine patch in this stretch and create a canopy discontinuity of about 15 to 20m. In this stretch also there is a log house called Churulipetty log house, located on the edge of the riverine forests and it offers night stay for the tourists. There is a temple situated in the interstate boundary with Tamil Nadu on the Tamil Nadu side, close to this transect. During the festival season this temple is visited by thousands of people.

3) Kootar to Chambakkadu: This transect is along the Pambar river, which is a perennial river. The trees in this stretch are also primarily evergreen in nature. On the bank of this river there is tribal settlement of Hill Pulayas at Chambakkadu. On this transect also there is a log house, called the Pambar log house. However, when compared to the earlier two transects this transect is less disturbed.

4) Chambakkadu to Athiyoda: This is on the Athiyoda rivulet, which is a tributary of Pambar river. This rivulet also is one of the inter-state boundary landmark. This rivulet is seasonal or ephemeral in nature and is active only during rainy season. This river is intercepted by a road that goes to a settlement located at a place called Manjapetty in Tamil Nadu. The grazing by the domestic cattle is more severe at this location.

Plate 1a. Transect-1Chinnar to Kootar

Plate 1b. Transect-2 Chinnar to Churulipetty

Plate 1c. Transect-3 Kootar to Chambakkad

Plate 1d. Transect-4 Chambakkad to Athiyoda

Plate 1e.Transect-5 Alampetty to Alampetty out post

Plate 1f. Kootar- the place of joining of Chinnar and Pambar river

5) Alampetty to Vazhathura outpost: This transect is along Alampettythodu, it is also ephemeral in nature, towards the upward area to Vazhathura outpost and is a tributary of the Pambar river. There is a tribal settlement at the Alampetty of Hill Pulayas. This area has very huge human pressure because of the tourist attractions like rock arts, Thoovanam waterfalls, dolemen sites etc.

3.2.1 Food and feeding habits and time activity budgeting

Information on composition and seasonal variation in Grizzled Giant Squirrel diet was collected through foraging observations. The method used for this purpose was "Focal Animal Sampling" (Altman, 1974). The activity of the animal while sighting them was also noticed and recorded. In this case one individual was followed and observation on the time spent on feeding, food plant species eaten, plant part eaten etc. were recorded. This was done for the three different seasons such as south-west monsoon, north-east monsoon and summer seasons to understand the seasonal variation. The focal animal sampling of Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary was done for ten months. The various parameters such as number of individuals, mode of detection, time of sighting, height at which the animal when first sighted, activity, tree species identity, animal's distance from the river, were the data collected for the time activity budgeting.

Monthly visual observations for about one week were made in the field during April 2013 to May 2014. Squirrels were observed with the help of 8x40 Olympus binocular. Regular observations were made for knowing the food preference on a seasonal basis. Pick up rates of plant parts such as fruit, leaves and flowers were recorded, from dawn to dusk especially the peak active time early and late hours of the day.

Feeding habits

Feeding activities of the Drizzled Giant Squirrel were divided into the following six elements (Ramachandran, 1992):

a) Seed feeding: This consisted of activities related to the consumption of seeds by gnawing the pod cover, also included feeding on seeds after scraping the pulpy portion and the seed coat.

b) Leaf feeding: This included feeding of parts of leaves and leaf petioles.

c) Flower feeding: Consist of feeding of any part of flowers or bud.

d) Bark feeding: Feeding bark of certain trees after debarking small pieces. It also included feeding twigs of the trees.

e) Sap feeding: Feeding on the sap which was seen oozing out of the bark of trees.

f) Searching behaviour: This included all activities in connection with the appetitive phase of searching for any suitable food.

Data were also collected to identify different feeding postures used by the Grizzled Giant Squirrel in Chinnar Wildlife Sanctuary

Activity pattern

The activities of the squirrel were mainly classified as feeding, moving, resting and calling and these activities across different hours in the day was observed. The percentage duration, percentage frequency and mean duration, of different activities were calculated to see how the animal allocated its activities on day hours and different seasons. Data on each element of behaviour of Grizzled Giant Squirrels were pooled to calculate the total time activity budget.

3.2.2 Tree species composition and diversity in Grizzled Giant Squirrel habitat at Chinnar Wildlife Sanctuary

At every 100m on transect, where the survey was done, one 10m x10m quadrat was taken. Thus a total of 20, 10m x 10m quadrats were taken on every 2km transect, Thus for the total five transects 100 plots of 10m x 10m plots were taken. These quadrats were monitored on a monthly basis to study the phenology of all the tress (>10cm GBH) within them. The observations like species of tree, height of the tree in meters, girth at breast height in centimetres, whether in flowers or in fruits were recorded.

3.2.3 Population and density estimation of Grizzled Giant Squirrel

The population estimation was done using the line transect method. Line transect is one of the important methods for estimating wildlife populations. Much of the material on line transect sampling has been brought together in Buckland *et al.* (2001) and Thomas *et al.* (2010) which provide a detailed reference for these methods.

The transect layout is depicted pictorially in Fig. 3. Only one transect is shown for illustration. The census zone is the whole area of the rectangle. The observer moves along the transect line and the distances indicated by the arrows from transect are measured to the animals seen. It may be noted that the observer could be missing several animals, which may be present in the habitat. This detection probability decreases when the animals are far away from ten transect.

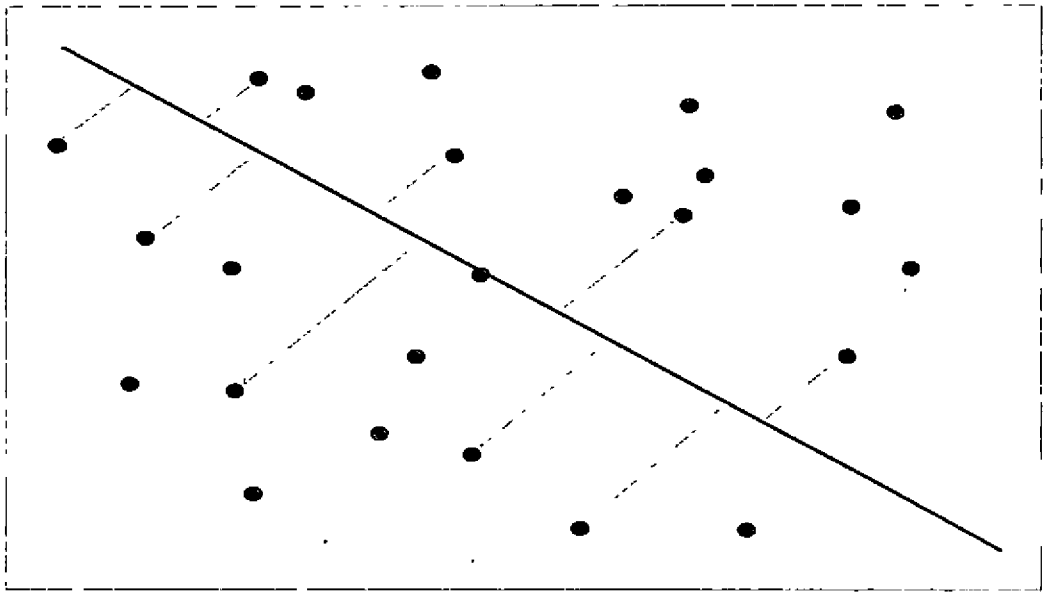


Figure 3. The schematic view of the method of line transects

The line transect census estimation proceed is further detailed in the Fig. 4. A transect line is searched and each animal seen provide one measurement of the perpendicular distance to the transect line.

a. Sighting distance (r)

b. Sighting angle (θ)

c. Perpendicular distance (x)

The perpendicular distance can be calculated from the other two by $x = r \sin \theta$

Transect lines was traversed on foot

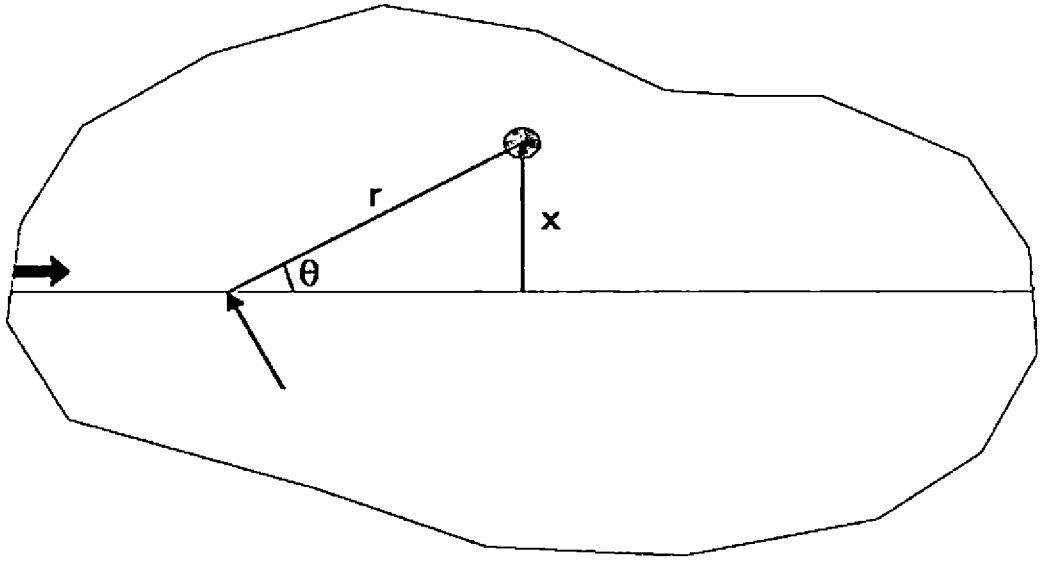


Figure 4. Illustration of the line transect method

The basic measurements that should be taken during the line transect method are sighting angle (θ) and the radial distance (r) to the animals sighted. Using which the perpendicular distance x can be calculated using the formula, $x = r \sin (\theta)$.

Information on relative abundance, density and distribution of the Grizzled Giant Squirrels were collected through direct observations. A detailed reconnaissance survey was done in the Grizzled Giant Squirrel habitat to finalise transects. Five transects were laid in

different locations in Chinnar Wildlife Sanctuary, all within the tributary of Chinnar river, Pambar river and their tributaries. These transects were covered on foot from 6.30hrs to 11.00hrs and 14.00hrs to 18.00hrs and at every sighting of squirrel, recorded the perpendicular distance and group size of the squirrel (Buckland *et al.*, 2004; Thomas *et al.*, 2005). Each transect had an average length of 2km and the field survey has been done for ten months from April 2013 to May 2014. Thus the total length of transects, covered on foot, were 2km (transect) x 2 (up and down) x 2 (twice a day) x 5 (locations) x10 (months) 400km.

The population was also estimated using total count and drey count. All the above three estimates were compared to calculate the population size of Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary

Drey anlysis to check quality of Grizzled Giant Squirrel habitat

The number of dreys, the nest of the squirrels, was enumerated by field perambulation across the habitat of the animal. Dreys provide the indirect evidence on the presence of the animal. The presence of the drey in an area reflects the quality of the habitat around it and also indicates the degree of usage of the area by the species (Datta and Goyal, 2008).

3.2.4 Data analysis

Food and feeding habits

a) Time variation in Grizzled Giant Squirrel diet

Mann Whitney U test was done to check where there is any significant difference between the feeding bout and duration of feeding in the forenoon and afternoon hours of the day when the animal is found to be highly active.

b) Seasonal variations in Grizzled Giant Squirrel diet

The total study period was divided into 3 seasons as Summer (December to May), South-West Monsoon (June to September) and North-East Monsoon (October to November).Analysis of variance was performed to check the seasonal variations in

different parameters of feeding such as height at which the squirrel fed (m), duration of feeding (minutes) and feeding bout (number).

c) Food preference

To check if the animal prefers particular food items with respect to different seasons, χ^2 test to check association between food items feeding and different season was done.

Activity pattern

The activity budget was prepared based on percentage duration of different activities by Grizzled Giant Squirrel. The percentage duration, percentage frequency (Frequency-number of times of occurance of purticular activity) and mean duration for different seasons were compared to check the seasonal variation.

The mean duration of the activity was calculated using the formula:

$$\text{Mean duration} = \frac{\text{Total duration of one activity}}{\text{Frequency of occurrence of that activity (Ramachandran, 1992)}}$$

To find out the seasonal variation and diurnal variation in the activity parameters of the Grizzled Giant Squirrel, ANOVA was performed to check the effect of time of the day and season on the activity parameters such as height at which the squirrel when first sighted (m), squirrel's distance from the river (m) and duration of observation (minutes).

Phenology

The flowering and fruiting periods of each species that forms the part of Grizzled Giant Squirrel diet were observed.

Vegetation analysis

The vegetation was quantitatively analysed for their abundance, frequency, density and their relative values and important value index (Curtis and McIntosh, 1950). All individuals with GBH equal to or above 10cm and height greater than 1m were classified as "tree" and were enumerated by measuring their height and GBH using Ravi altimeter and a tape respectively. In order to determine the quantitative relationship between the species, the following parameters were determined.

1. Density (D) = No: of individuals/hectare

2. Relative Density (R.D) = $\frac{\text{No: of individuals of the species}}{\text{No: of individuals of all species}} \times 100$

3. Abundance (A) = $\frac{\text{Total No: of individuals of the species}}{\text{No. of quadrats of occurrence}}$

4. Percentage Frequency (PF) = $\frac{\text{No. of quadrats of occurrence}}{\text{Total No. of quadrats studied}} \times 100$

5. Relative Frequency (RF) = $\frac{\text{Percentage Frequency of individuals species}}{\text{Sum Percentage Frequency of all species}} \times 100$

6. Basal Area (BA) = $\frac{GBH^2}{4\Pi}$

7. Relative Basal Area (RBA) = $\frac{\text{Basal area of the species}}{\text{Basal area of all species}} \times 100$

8. Important Value Index (IVI) = RD + RF + RBA

To understand if there is any relationship between the number of times the squirrel was sighted on a purticular tree species, duration for which the squirrel was seen on a particular tree species and above explained seven variables for plant density and characters,

multivariate analysis was done followed by Redundancy Analysis (RDA)in freeware BiPlot for depiction of the result.

Population estimation

Population density of the Grizzled Giant Squirrel was estimated using the software DISTANCE version 6.0 (Buckland *et al.*, 2004; Thomas *et al.*, 2005) and etxrapolating this to whole of Chinnar Wildlife Sanctuary. The average monthly encounter rate was calculated. The 'population estimate' based on drey count was also made (Phillips, 1984).

Drey analysis to check the quality of Grizzled Giant Squirrel habitat

Chi-square test for association between location and plant species used for nest building was done and followed by Correspondence analysis to indicate particular tree at particular area was used by the animal for drey construction (Magurann, 1988).

RESULTS

RESULTS

4.1 FEEDING ECOLOGY

Regular monthly observations were made for understanding the food preference of Grizzled Giant Squirrel. Pick up rates and duration of feeding of plant parts such as fruit, leaves, flowers and sap were noted. This yielded data on food intake.

4.1.1 Feeding Behaviour

Feeding technique

The feeding techniques include how the Grizzled Giant Squirrel select, harvest and feed on the food articles. The Grizzled Giant Squirrels in Chinnar Wildlife Sanctuary were found to be highly selective in picking the food articles. The selection of food article was done by Grizzled Giant Squirrel based on the smell of the articles (Plate 2a). The Grizzled Giant Squirrel was found to be handling its food with both mouth and fore-limbs. The squirrel goes to the tip of the branch or other areas of the crown of the tree according to the availability of food source and cuts the pod, fruit, leaves or flower with its mouth (Plate 2c). Sometimes the food article was brought to mouth with the help of forelimbs (Plate 2b). Holding the fruit in mouth, the squirrel then moves to the thick horizontal branch to sit firmly, sometimes the feeding started at the place of harvest itself. The squirrel holds the branch with the help of claws of the hind-limbs and the tail hanging down, which gives further balancing (plate 2d). It then gnaws the epicarp of the fruit to extract the seed to be fed. During the course of feeding, the fore limbs were used effectively to manipulate food articles whether it is long pods of *Bauhinia racemosa* or small fruit of *Grewia tiliifolia.*

Feeding postures

The postures are the positioning of the body while feeding. Mainly three postures were observed during the present study. The most commonest feeding posture is the squirrel perched itself on a horizontal branch of the tree and then feeding, second posture is that the squirrel on the bole of the tree and feeding upside down, the third posture is that animal

Plate 2a. Selection by smell

Plate 2b. Making the food reach to mouth with the help of fore-limbs

Plate 2c. Cutting the fruit with the mouth

Plate 2d. Feeding on the seeds by sitting on a firm branch

hangs upside down from small branches, supporting with the hind limbs and the tail, and reaching down to the food in the hanging posture.

During majority of the instances of observations on feeding posture, the squirrels were found feeding by sitting on the branch, holding the branch with hind limbs and the tail hanging down. The hanging tail helps the animal in balancing the body. This kind of posture was observed during the feeding incidence on *Bauhinia racemosa* and *Grewia tiliifolia* (Plate 3a). The second body posture consists of Grizzled Giant Squirrel hanging upside down on the tree branch with the help of claws of hind limbs, while tail was kept curled over the branch and fed in that posture. This posture was observed mainly in instances of feeding clustered fruits and flowers on small branches which cannot support the body weight of the squirrel. Sometimes this posture was used only for harvest. This was observed while Grizzled Giant Squirrel feeding on *Strychnos potatorum* and *Nothopegia beddomei* (Plate 3b). The third feeding posture observed was Grizzled Giant Squirrel found lying on the vertical bole of the tree, anchoring on to the tree trunk with the claws of the hind limbs and manipulating the food with mouth and fore-limbs. The observed instances were while feeding on the climbers found on the trees (Plate 3c).

4.1.2 Food article composition

The Grizzled Giant Squirrel in Chinnar Wildlife Sanctuary was found to be feeding on different plant parts including the leaves, seeds, flowers and sap of different trees and other vegetation (Table 3; Plate 4). The data collected through direct feeding observation were analysed to understand the food composition. The various parameters collected during the observation were time of feeding, duration of feeding, feeding bout, plant part fed and height at which the animal found feeding.

Food composition

A total of 1324 minutes of feeding observation was taken during the study. The Grizzled Giant Squirrel was found feeding on 30 different species of plants at Chinnar Wildlife Sanctuary. This include 22 tree species, four climbers, one liana, one paraphyte, one shrub and one cactus species. The maximum duration of feeding was observed on *Bauhinia racemosa* (19.79%), followed by *Tamarindus indica* (14.08%), *Nothopegia*

Plate 3a. Feeding posture one- sitting posture

Plate 3b. Feeding posture two-hanging posture

Plate 3c. Feeding posture three-clinging posture

Plate 4a. Grizzled Giant Squirrel in Chinnar Wildlife Sanctuary

Plate 4b.Two individuals of Grizzled Giant Squirrel adult female and a young one

Plate 4c. Drey of Grizzled Giant Squirrel on *Terminalia arjuna* tree

beddomei (9.89%), *Strychnos potatorum* (7.23%) and *Terminalia arjuna* (6.47%) and *Cassia fistula* (0.33%) (Table 3).

The animal was found to be feeding on different species according to the food availability in various months. The Grizzled Giant Squirrel found to be feeding on *Terminalia arjuna* and *Tamarindus indica* in three different months followed by *Bauhinia racemosa* and *Ficus microcarpa* in two different months. However, the other plant species were found fed only once during the study period. The climbers that were used by the squirrel for feeding were *Derris brevipes, Diplocyclos palmatus* and *Cayratia trifolia*. They also used shrubs like *Hibiscus rosa-chinensis*, cactus like *Euphorbia trigona,* and liana like *Entada rheedii* for feeding. Out of this 30 plant species used by the Grizzled Giant Squirrel for feeding, ten of them were also used for the drey construction.

The Grizzled Giant Squirrel in Chinnar Wildlife Sanctuary was found to be feeding on plant species under 18 different families. Among them the most preferred family was Fabaceae, eight plant species under this family was found fed by Grizzled Giant Squirrel. This was followed by Moraceae having four species and Anacardiaceae having two species which were preferred by Grizzled Giant Squirrel for feeding at Chinnar wildlife Sanctuary. The rest of the families having only single species under them which were found fed by Grizzled Giant Squirrel.

Table 3. List of the tree species on which the animal feeds, their family, month in which the incidence occurred, plant part fed and duration of feeding.

Sl. No	Species used for feeding	Family	Month	Part eaten	Total duration (minutes)	Percentage duration of feeding
1.	*Mangifera indica*	Anacardiaceae	October	Leaves and flowers	15	1.14
2.	*Nothopegia beddomei*	Anacardiaceae	May	Immature seeds	130	9.89
3.	*Commiphora caudata*	Burseraceae	March	Bark and tender leaves	10	0.76
4.	*Terminalia arjuna*	Combretaceae	April, September, January	Leaves and fruits	85	6.47
5.	*Diplocyclos palmatus*	Cucurbitaceae	November	Immature leaves and seeds	45	3.42
6.	*Hopea parviflora*	Dipterocarpaceae	February	Leaves	8	0.61
7.	*Euphorbia trigona*	Euphorbaceae	August	Leaves	27	2.05
8.	*Acacia spp.*	Fabaceae	March	Seeds of immature fruit	35	2.66
9.	*Albizzia lebbeck*	Fabaceae	March	Tender leaves and flowers	36	2.74
10.	*Bauhinia racemosa*	Fabaceae	February, March	Immature seeds	260	19.79
11.	*Derris brevipes*	Fabaceae	March	Tender leaves and flowers	17	1.29
12.	*Entada rheedii*	Fabaceae	March	Tender leaves and flowers	15	1.14
13.	*Pongamia pinnata*	Fabaceae	April	Immature leaves	23	1.75
14.	*Tamarindus indica*	Fabaceae	November, December, May	seeds of immature fruit and flowers	185	14.08

15.	*Cassia fistula*	Fabaceae	May	Bark	3	0.23
16.	*Strychnos potatorum*	Loganiaceae	January	Immature seed	95	7.23
17.	*Macrosolon capitellatus*	Loranthaceae	May	Immature seeds	55	4.19
18.	*Hibiscus rosa – chinensis*	Malvaceae	March	Tender leaves and flowers	15	1.14
19.	*Melia dubia*	Meliaceae	September	Leaves	37	2.82
20.	*Ficus albiphyla*	Moraceae	February	Tender leaves and bark	40	3.04
21.	*Ficus microcarpa*	Moraceae	November, February	Leaves and immature seed	29	2.21
22.	*Ficus spp.*1	Moraceae	November	Leaves and immature seed	16	1.22
23.	*Ficus spp.*2	Moraceae	September	Leaves	16	1.22
24.	*Syzygium cumini*	Myrtaceae	August, May	seeds of immature and mature fruits and leaves	52	3.96
25.	*Psychotria subintegra*	Rubiaceae	September	Leaves, flowers and sap	13	0.99
26.	*Aegle marmelos*	Rutaceae	October	Leaves	3	0.23
27.	*Santalum album*	Santalaceae	November	Immature leaves and flowers	9	0.68
28.	*Grewia tiliifolia*	Tiliaceae	October	Leaves, flowers and fruits	25	1.90
29.	*Cayratia trifolia*	Vitaceae	March	Tender leaves and flowers	10	0.76
30.	Unidentified		May	Leaves	5	0.38

Percentage contribution of different food article to squirrel diet

The percentage contribution of different food article to squirrel diet was analysed based on duration of feeding on a particular article and number of times of feeding incidence on particular article observed during the whole study period. The total feeding incidence across whole study period was summed up and it found to be a total of 62 feeding incidences. Within one feeding incident, the feeding of more than one food articles were observed; that means within one incident the squirrel was found to be feeding on both leaf and flower or leaf and seed and they were counted separately for each article by giving one incidence both for leaf and flower or other combination. Out of 62 feeding incidences, 30 incidences were on leaf feeding (48.39%) followed by seed feeding (27.32%), flower feeding (16.13 %) and further followed by sap feeding (8.06 %) (Fig. 5).

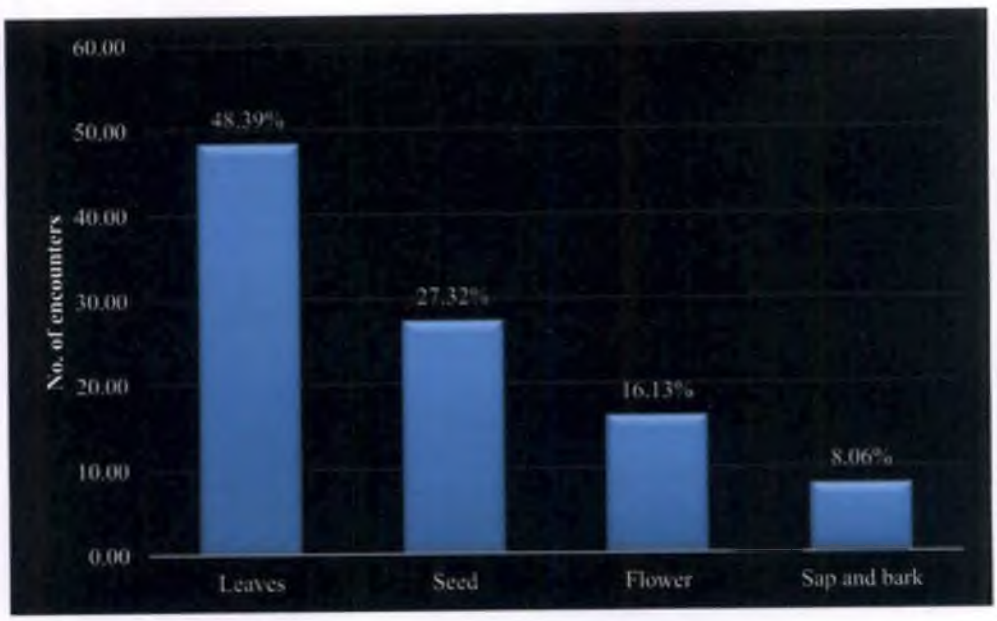


Figure 5. The percentage contribution of each food items to total feeding incidence based on number of times feeding on a particular item occured.

The duration of feeding on different articles of food were also computed. The squirrels were spending maximum duration on feeding upon seeds (52.12 %), followed by leaves (32.55 %), flowers (10.58 %) and sap (4.76 %) (Fig. 6).

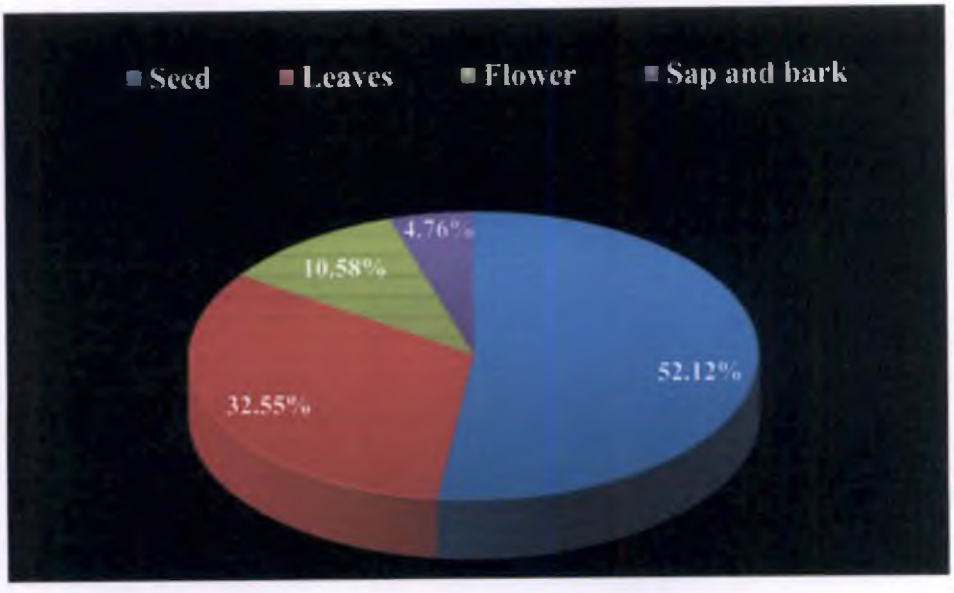


Figure 6. Contribution of different food article to total diet of Grizzled Giant Squirrel

4.1.3 Diurnal variation in Grizzled Giant Squirrel feeding habit

The time variation in the feeding habit means the difference in the feeding behaviour of Grizzled Giant Squirrel in different hours of the day. Mainly the day hours are classified under two categories, forenoon and afternoon, and the difference in duration of feeding and feeding bouts were compared.

Comparison of feeding bout and duration of feeding by Grizzled Giant Squirrel in the forenoon and afternoon hours

The duration of feeding recorded for whole study period was 1314 minutes including 915 feeding bouts. Within this 1314 minutes of feeding observation, 42% of total feeding duration was contributed by forenoon observation and the rest 58% by afternoon observation, when the feeding bout into consideration forenoon hours had 321 bouts while the afternoon had around twice the value as 594 bouts. The activities occur in bouts that are

periods of, for example feeding activity within a food source or movement between two sources. During the period spent in the food source some of the time was allotted to searching food item, selection by smelling, remain inactive or other grooming activities. The length of the bout was judged as period between entry into and exit from the source. However, Grizzled Giant Squirrel in Chinnar Wildlife Sanctuary found to be inactive in a food source for some time before commencing the feeding or after feeding, before going elsewhere in search of new source or for other activities. In some cases the Grizzled Giant Squirrel found to be inactive at a food source between periods of intensive feeding.

Difference in feeding activities of Grizzled Giant Squirrel in the forenoon and afternoon hours

Assuming the data is not normally distributed a non-parametric test "Mann Whitney U" test was done to know whether there was any significant difference between the feeding bout and duration of feeding in the forenoon and afternoon hours of the day when the animal was found to be highly active.

Even though the box plots shows that the mean duration of feeding and feeding bout were higher for the afternoon hours than for the forenoon hours, the result was not found significant. For duration of feeding ($U = 189.5$ $p = 0.319$) and feeding bout ($U = 205.50$ $p = 0.542$) (Fig. 7 and Fig. 8).

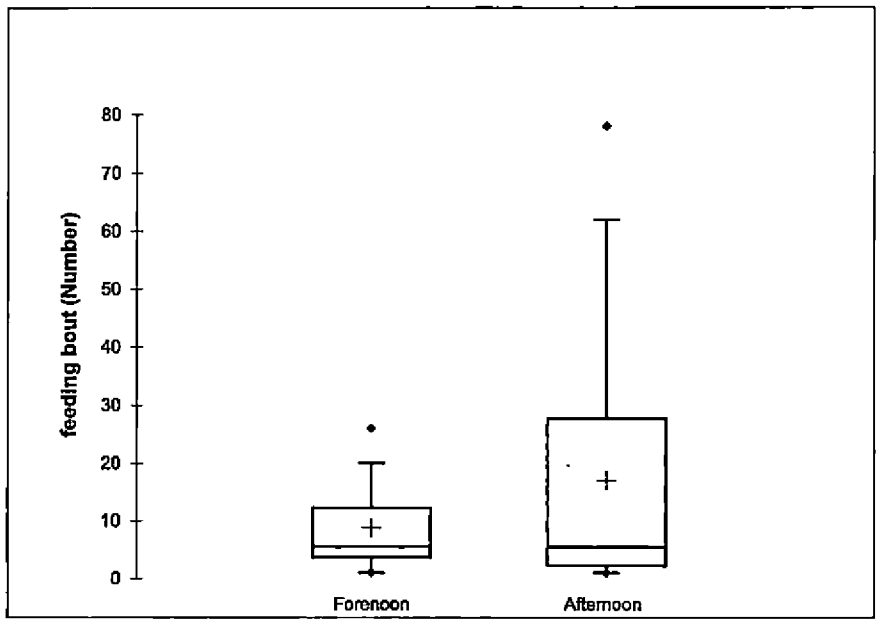


Figure 7. The feeding bouts both in the forenoon and afternoon.

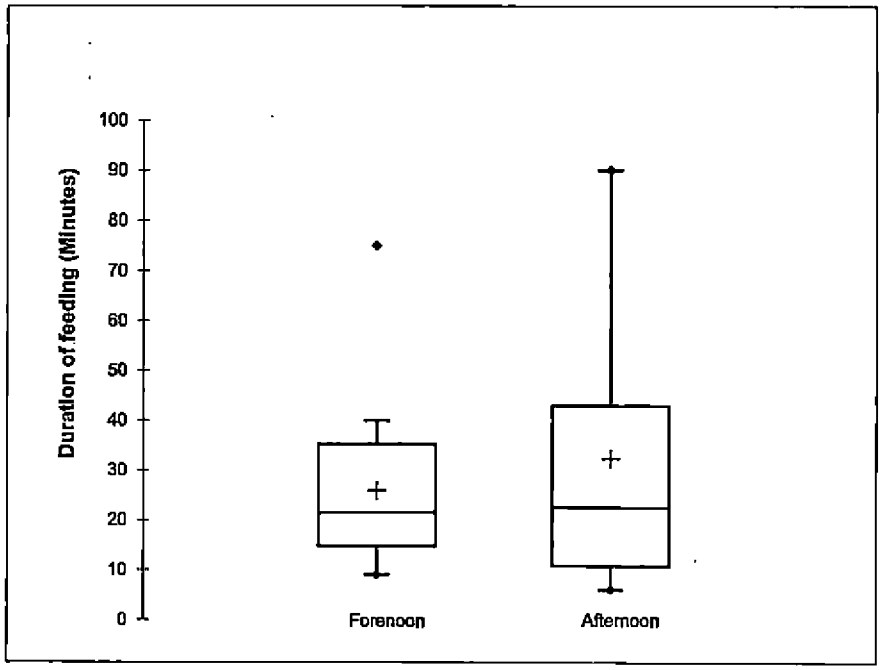


Figure 8. The duration of feeding both in the forenoon and afternoon

The comparison between the feeding bout and duration of feeding was done by plotting them on the graph separately for forenoon and afternoon hours. The slope of the graph shows that in the forenoon hours the animal tend to be feeding by sitting at one place while in the afternoon hours the Grizzled Giant Squirrel found to be moving more frequently while feeding. There was a significant relationship between duration of feeding and feeding bouts in total data, forenoon hours and afternoon hours (Fig.9 and Fig. 10). However there is a slight difference in the slope of the relationship in the forenoon hours and afternoon hours indicating that in the afternoon the feeding bouts increase more rapidly with the duration of feeding than in the forenoon.

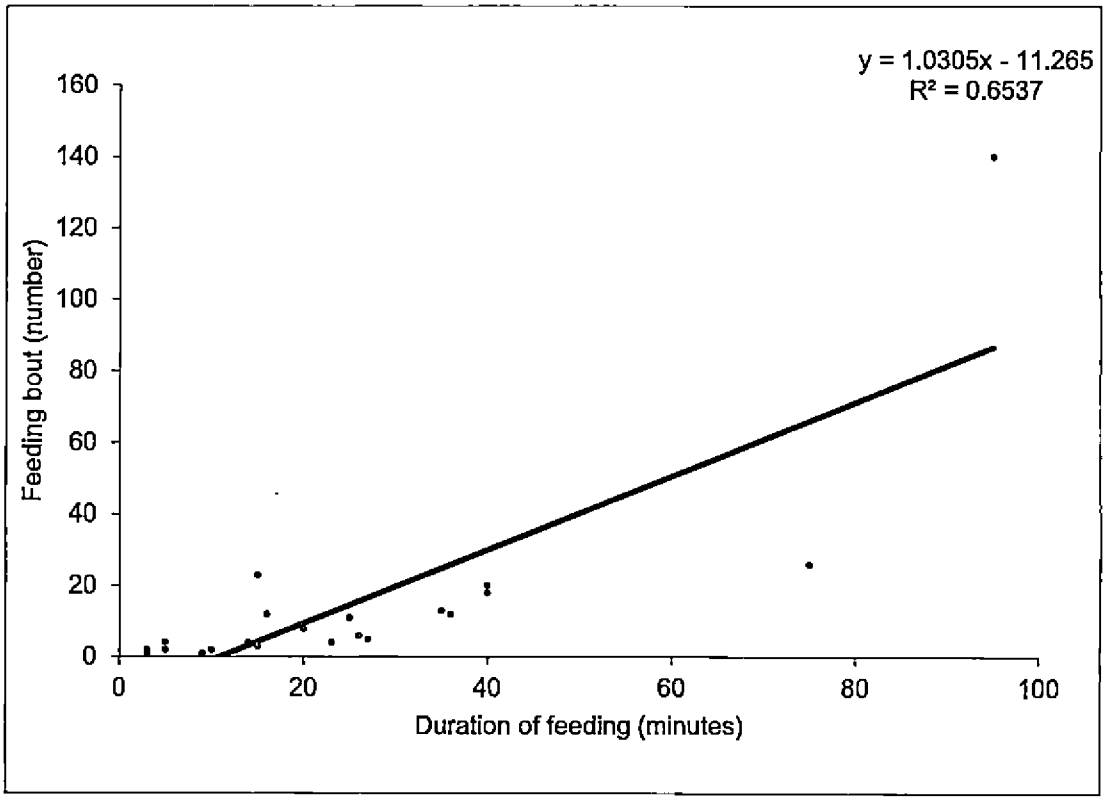


Figure 9. Linear regression model for the feeding bout and duration of feeding in the forenoon hours.

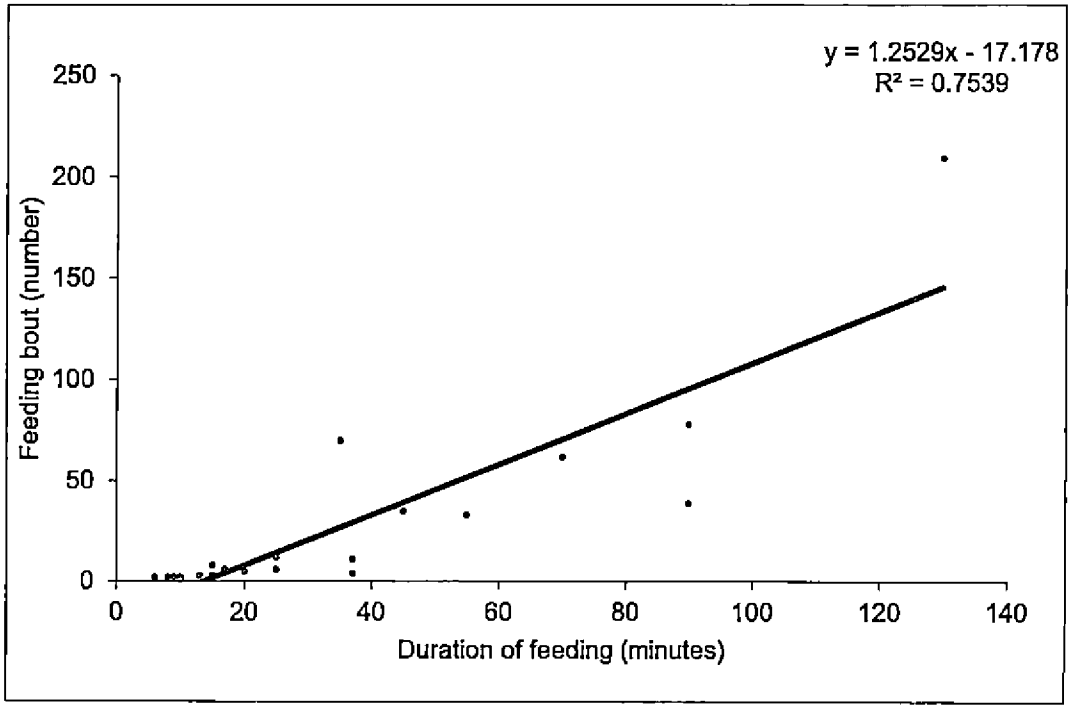


Figure 10. Linear regression model for the feeding bout and duration of feeding in the afternoon hours.

4.1.4 Seasonal variation in Grizzled Giant Squirrel diet at Chinnar Wildlife Sanctuary

The total study period was divided into 3 seasons as summer (December to May), south-west monsoon (June to September) and north-east monsoon (October to November). The feeding observation were categorized into these three seasons and the analysis was done. Three type of analysis was done to check the seasonal variation as, based on number of incidences of feeding on different articles across different seasons, based on species preferred in different seasons for feeding and the variables under observation like, duration of feeding, feeding bout and height at which the animal feeds in different seasons chosen for the study.

Number of feeding incidences of Grizzled Giant Squirrel on different articles across different seasons at Chinnar Wildlife Sanctuary

The incidence of feeding on different food articles across different seasons were categorised. The feeding incidence on all the different food articles were maximum in the

summer season followed by North-East monsoon and then by South-West monsoon (Fig. 11).

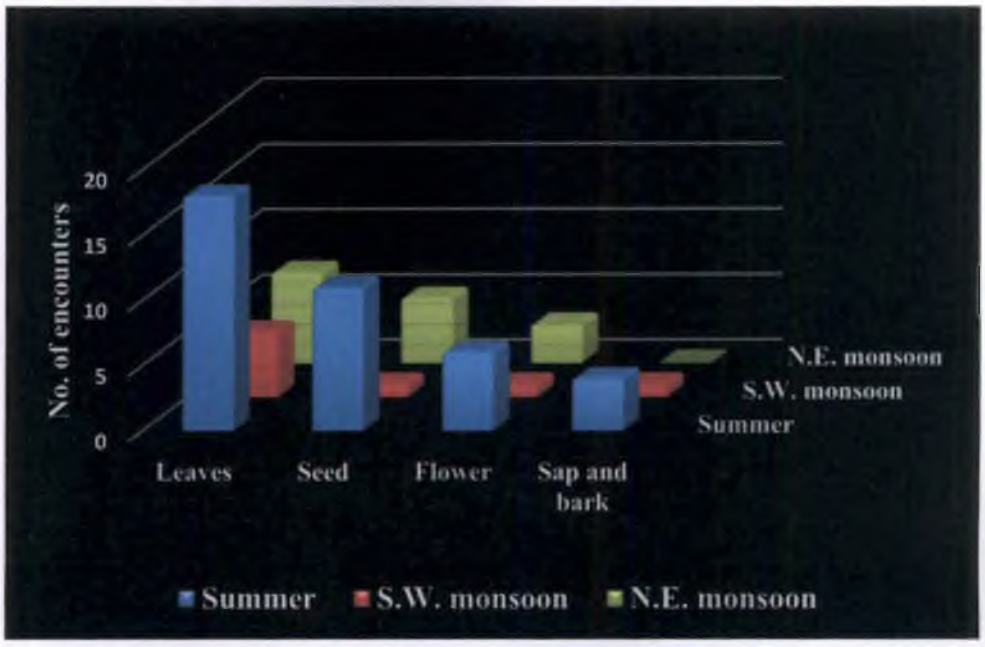


Figure 11. The number of incidence of feeding on different food articles across different seasons.

Seasonal variation in duration of feeding, feeding bout and height at which the animal feeds across different seasons

In the season wise analysis of data, the various parameters like duration of feeding, feeding bout and height at which the animal fed were taken in to consideration. In the absence of correlation between different variables under consideration, uni-variate analysis was done; there was no effect of season and time of the day on height at which the animal fed, the duration of feeding and the feeding bouts. Through this it can be clearly explained that there is no significant effect of season on the various feeding habit parameters of the Grizzled Giant Squirrel such as the height at which it feeds, duration of feeding and feeding bouts (Appendix 1; Fig. 12; Fig. 13 and Fig. 14).

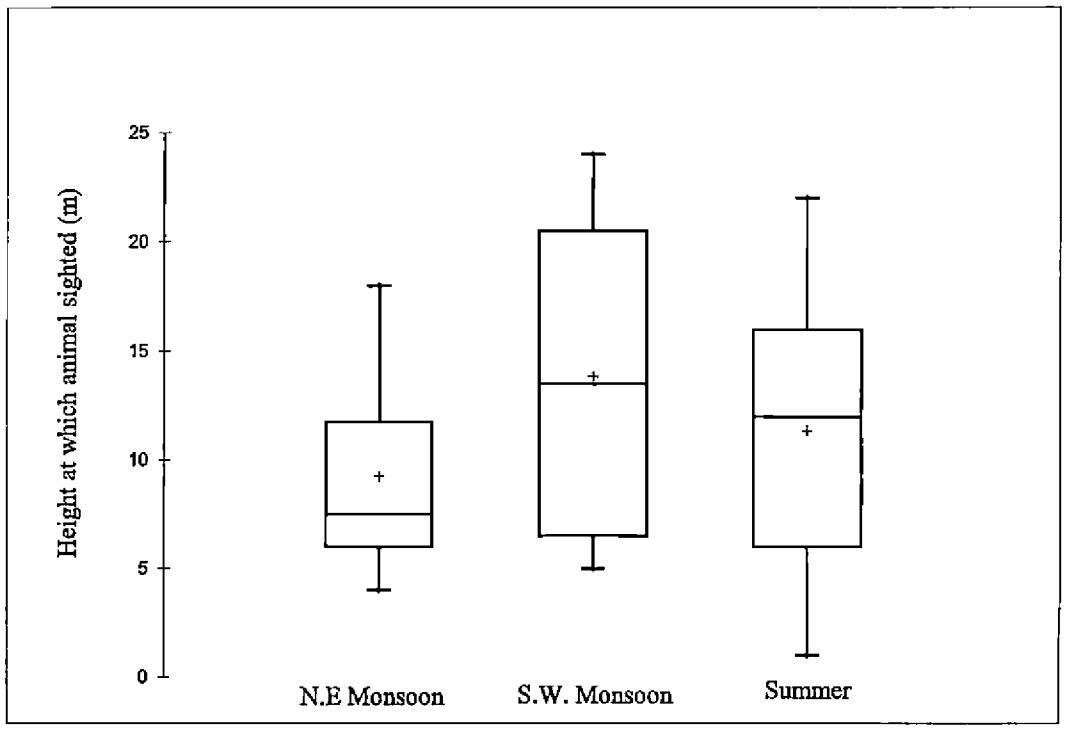


Figure 12. The height at which Grizzled Giant Squirrel feeding across different seasons.

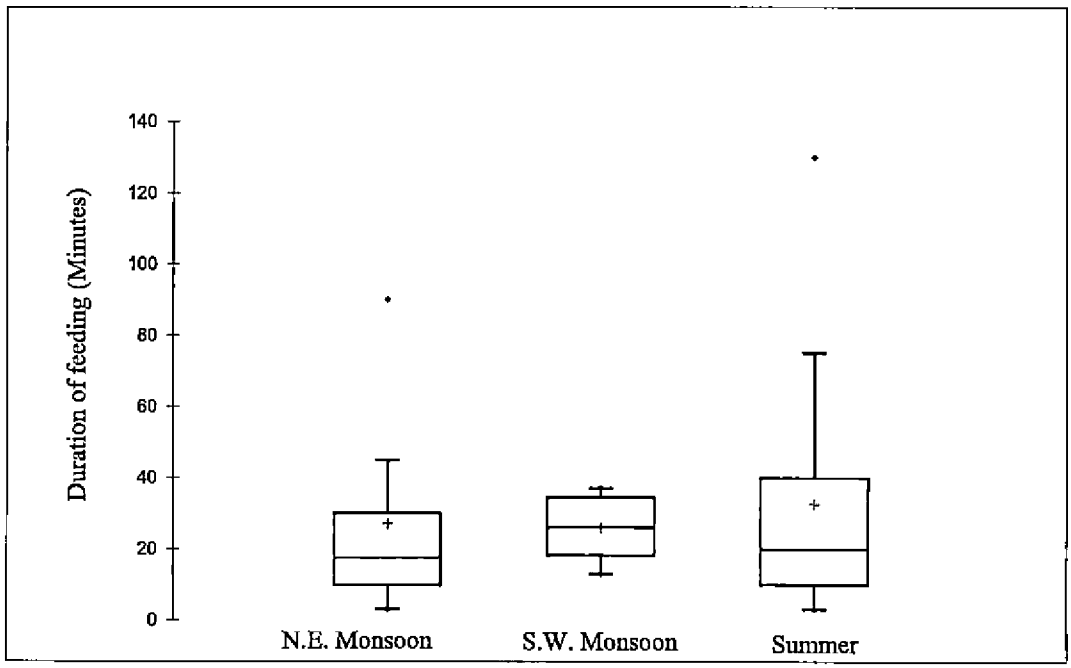


Figure 13. The duration of feeding (in minutes), across different seasons

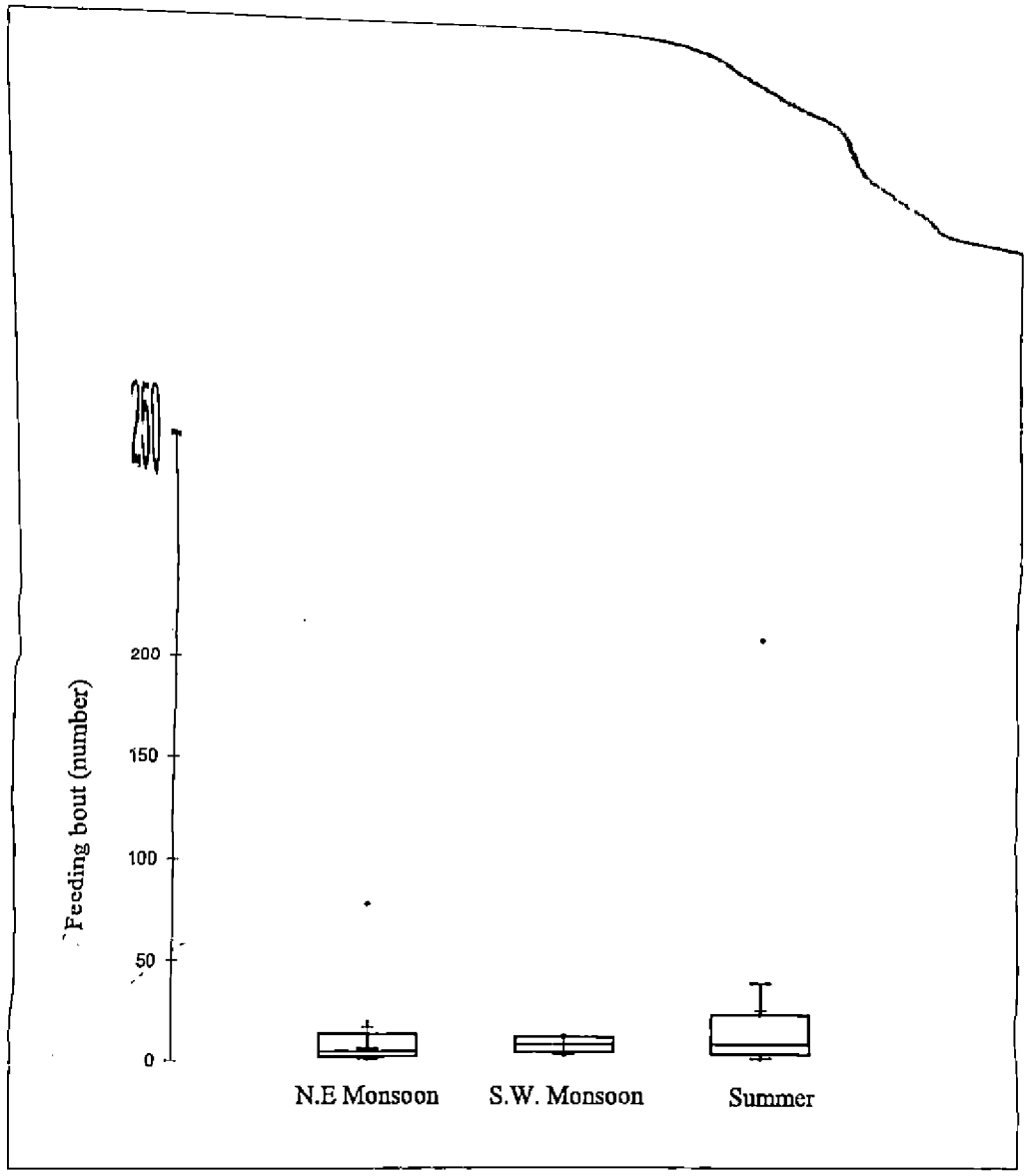


Figure 14. The feeding bout (number) across different seasons by Grizzled Giant Squirrel

Species preference by Grizzled Giant Squirrel for feeding in different seasons

The seasonal variation in the feeding preference of the Grizzled Giant Squirrel was studied for the three seasons such as summer, South-West monsoon and North-East monsoon. In summer, 23 species contributes to the squirrel diet. Based on percentage duration of feeding the most preferred food plant species in summer were *Bauhinia racemosa* (27.60%), *Nothopegia beddomei* (13.80%) *Strychnos potatorum* (10.08%), *Tamarindus indica* (7.43%), *Terminalia arjuna* (6.37%), and *Macrosolen capitellatus* (5.84%) etc (Fig.15).

During the south-west monsoon the Grizzled Giant Squirrel was found feeding on six species of plants such as *Syzygium cumini* (23.87%), *Melia dubia* (23.87%) with equal weightage, followed by one cactus species *Euphorbia trigona* (17.42%), then by *Terminalia arjuna* (16.13%), *Ficus spp.*2 (10.32%), and one shrub *Psychotria subintegra* (8.39%) (Fig. 16).

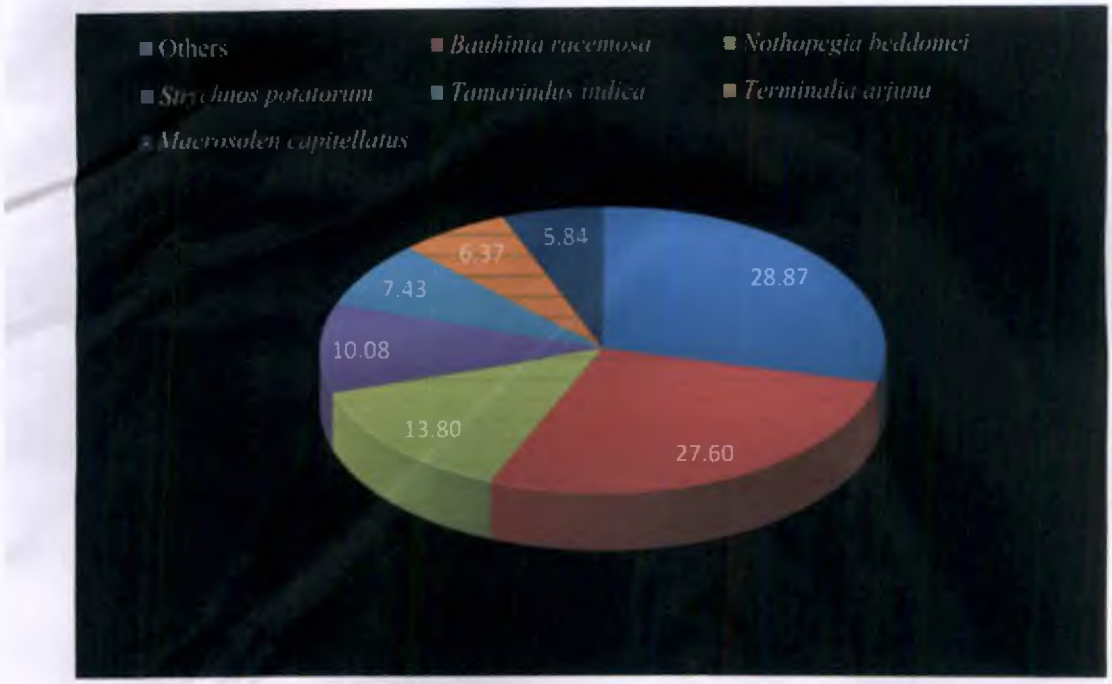


Figure 15. The food species preference of the Grizzled Giant Squirrel in summer season at Chinnar Wildlife Sanctuary

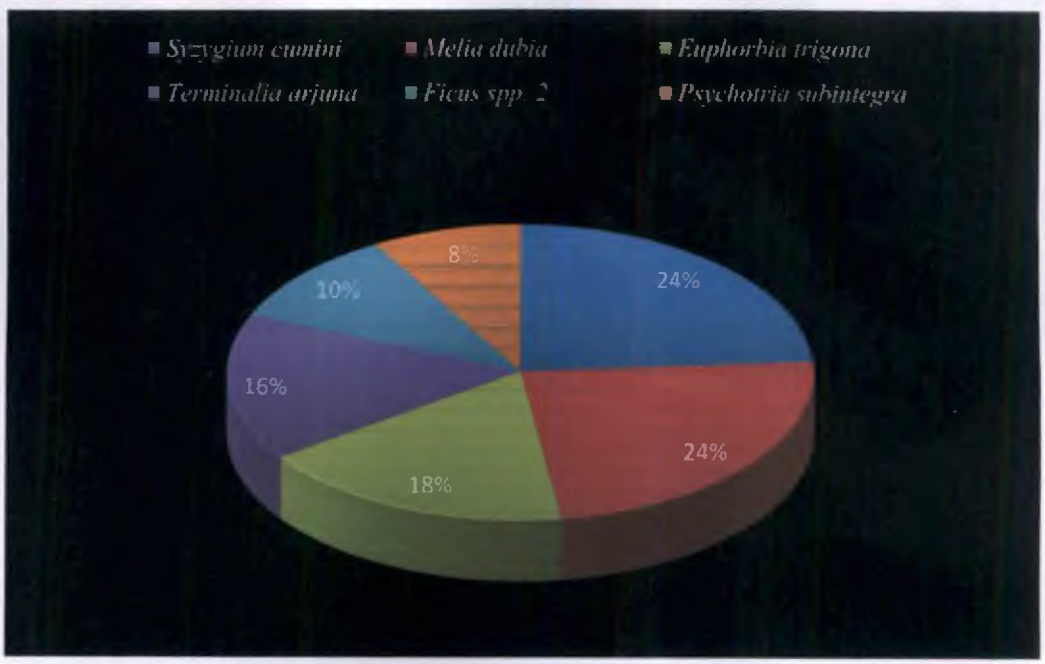


Figure 16. The food species preference of the Grizzled Giant Squirrel in South -West monsoon season at Chinnar Wildlife Sanctuary

While during the north-east monsoon period they fed on eight species namely *Tamarindus indica* (39.65%), *Diplocyclos palmatus* (19.82%), *Grewia tiliifolia* (11.01%),

Ficus microcarpa (8.81%), *Ficus spp.*1 (4.41%), *Mangifera indica* (6.61%), *Aegle marmelos* (5.73%) and *Santalum album* (3.96%) (Fig. 17).

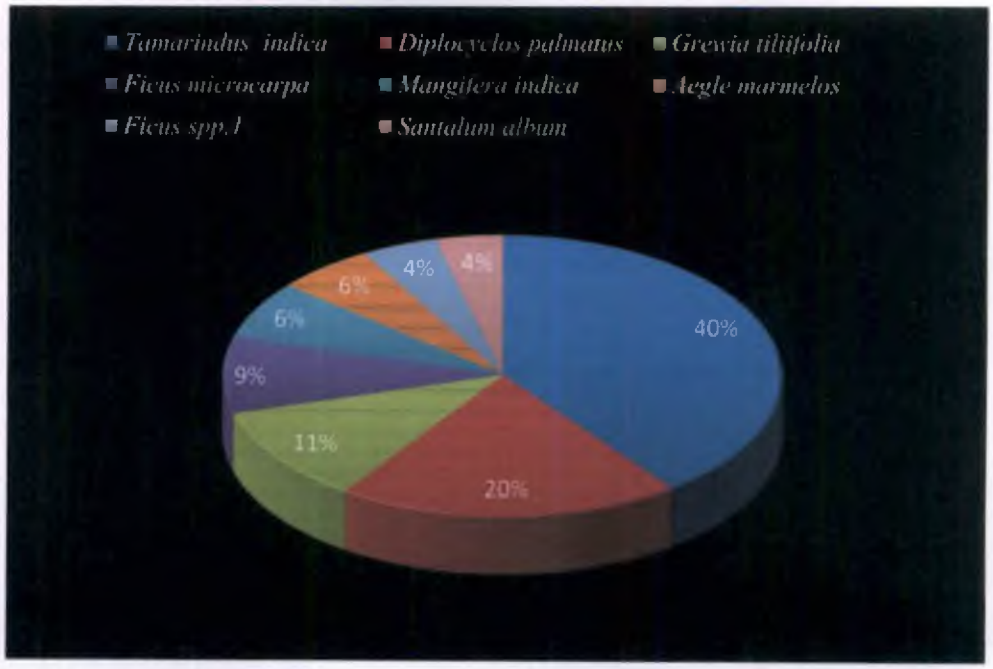


Figure 17. The food species preference of the Grizzled Giant Squirrel in North-East monsoon at Chinnar Wildlife Sanctuary

Association between food items fed in different seasons by Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary

To check if the animal prefers particular food items with respect to different seasons, χ^2 test for association between food items fed and different season was done. However, no significant association between these two (χ^2= 6.32, p= 0.70), could be observed. Thus the food species preference by the Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary was found not affected by the seasons. But the Squirrel was found to be feeding based on the availability of various food sources across different seasons in the Chinnar Wildlife Sanctuary.

There was no instance of Grizzled Giant Squirrel hoarding the food items observed. Moreover there was not even a single instance Grizzled Giant Squirrel consuming water from any of the water source observed during the study period. However in the month of

March (summer) more instances of Grizzled Giant Squirrel feeding on tender leaves and flowers were observed.

4.2 TIME ACTIVITY BUDGETING

Focal animal sampling was done to find out the time activity budgeting of the Grizzled Giant Squirrel. One individual was followed as much time possible and the different activities such as feeding, moving, resting and calling were recorded. Data collected during the whole study period were pooled to get distribution of activities during the different seasons. Frequency, percentage frequency, total duration, percentage duration and mean duration for each activity during the different seasons were calculated. Frequency of a specific act refers to the number of occurrence of that particular activity counted during the observation period. Total duration of one activity refers to the total time spent in that activity during the whole observation period.

4.2.1 The time activity budget, mean duration and percentage duration of Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary

Total of 2052.5 minutes of observation on various activities of squirrel was taken. They spent most of the time for feeding 1304 minutes, followed by resting 572 minutes, moving 149.5 minutes and calling 17 minutes.

Activity time budget of Grizzled Giant Squirrel at Chinnar Wildlife sanctuary

Based on the duration of different activities percentage contribution of different activity to total duration was found out. The primary activity that the Grizzled Giant Squirrel performed during the study period was feeding, which accounted for 64 percent, which was followed by resting (28%), moving (7%) and calling (1%) (Fig. 18).

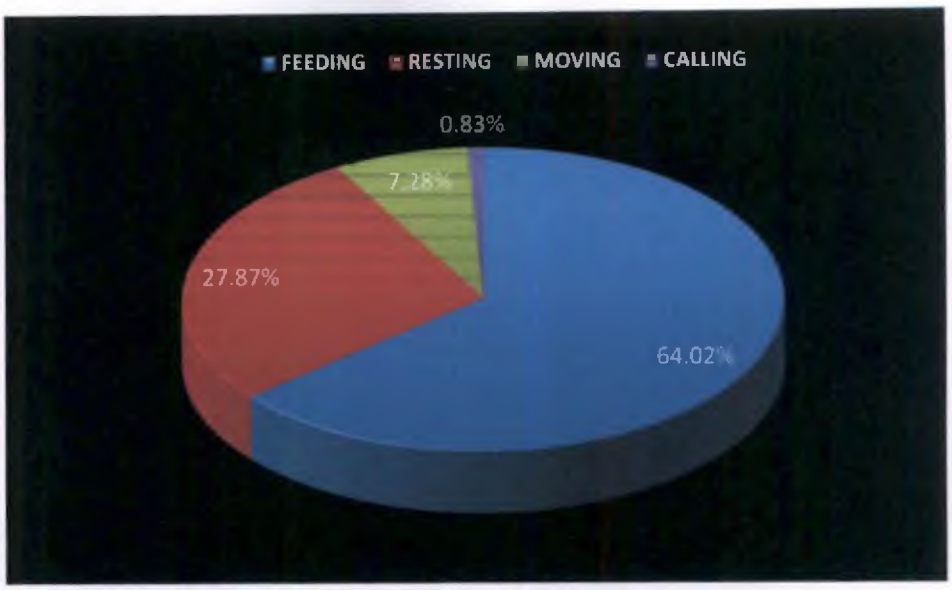


Figure 18. Activity time budget of Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary

Mean duration of activities of Grizzled Giant Squirrel at Chinnar Wildlife sanctuary

The mean duration was calculated by dividing the duration of a particular activity by number of occurrence of that activity (frequency) (Ramachandran, 1992). In this case also feeding accounted for the maximum duration of 30.56 minutes. However, unlike the time activity budgeting, the calling duration was more than the duration that the Grizzled Giant Squirrel took for moving (Fig. 19).

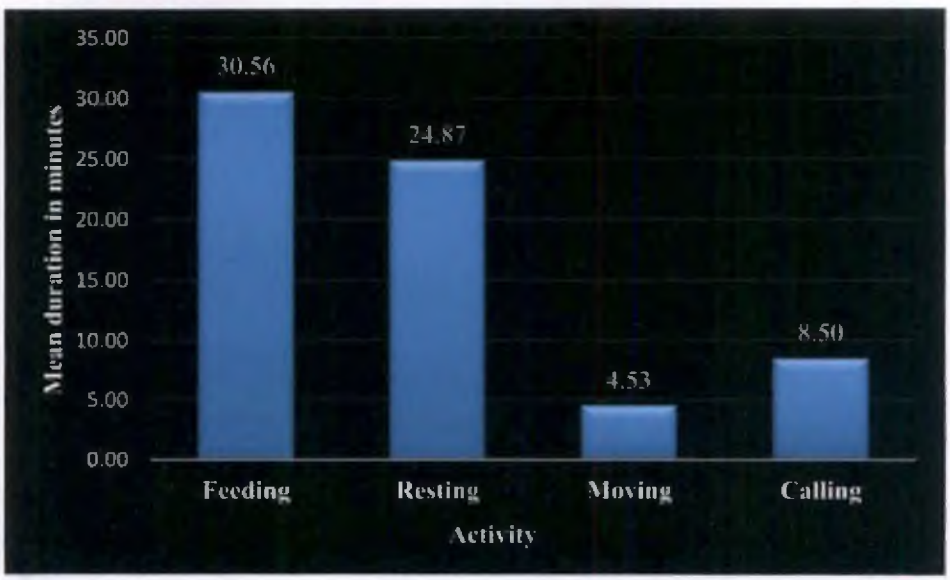


Figure 19. Mean duration of activities of Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary.

Percentage frequency of various activities of Grizzled Giant Squirrel at Chinnar Wildlife sanctuary

Frequency of a specific act refers to the number of occurrence of that particular activity counted during the observation period.The percentage frequency of various activities by Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary was thus calculated. The activities had shown a trend as maximum percentage frequency was for feeding (42.57%) followed by moving (32.67%), resting (22.77%) and the least by calling (1.98%) (Fig. 20). Compared to that of percentage duration the 'moving' activity had the higher value than 'resting' in percentage frequency. The shift in this hierarchy was because, the moving activity observed many times during the study period but for a small duration. The squirrel moves very quickly so while moving the squirrel will reach out of sight in a very short time which made the duration of observation very small for each sighting of moving. Thus the above three analysis concludes that animal spends its most of the day time for feeding followed by resting, moving and calling.

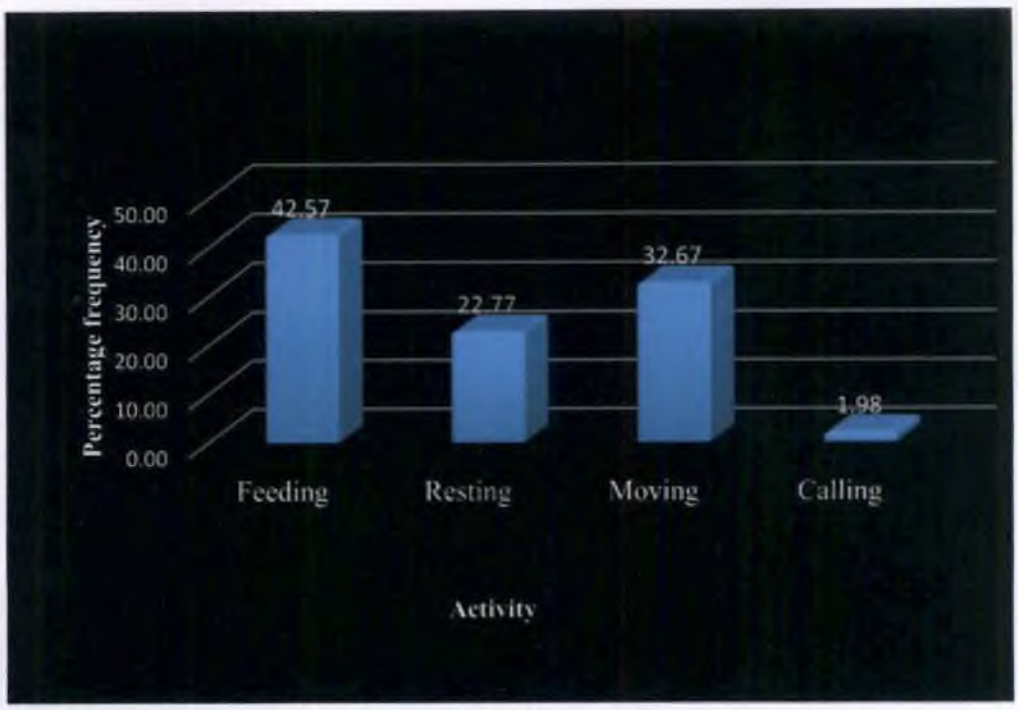


Figure 20. Percentage frequency of activities by Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary.

4.2.2 Seasonal variation in time activity budgeting of Grizzled Giant Squirrel

The seasonal variation in the time activity budgeting was calculated for the different seasons such as summer, South-West monsoon and North-East monsoon. The percentage duration, mean duration and percentage frequency of activities for all the three seasons were enumerated and they were used for the seasonal comparison.

Percentage duration of various activities of Grizzled Giant Squirrel at Chinnar Wildlife sanctuary across different seasons

The percentage duration of activities by Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary was calculated separately for the three seasons and are detailed below.

Summer

The activity budgeting for the summer season had observation for duration of 1432 minutes. The main activity performed during the summer season was feeding (65.78%) followed by resting (29.05%), moving (4.68%) and calling (0.49%) (Fig. 21).

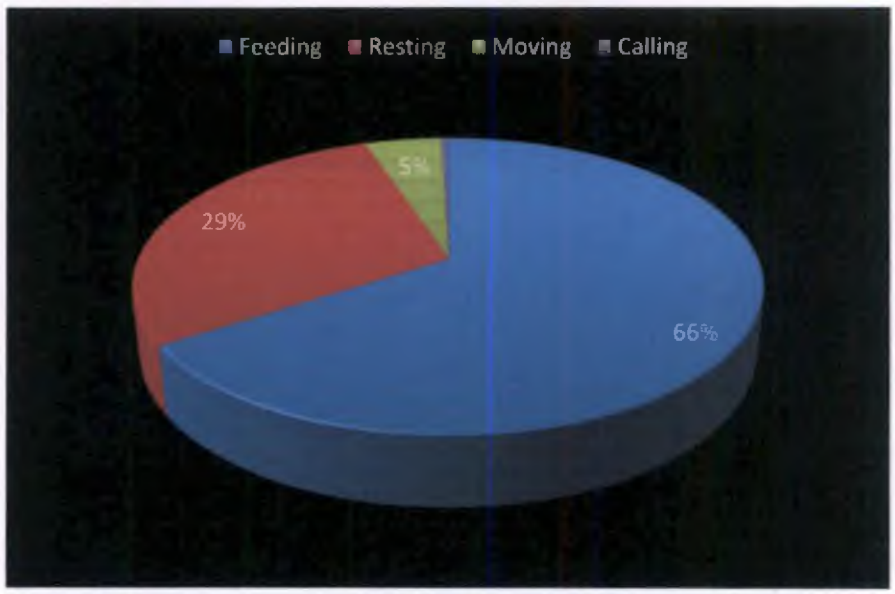


Figure 21. Activity time budget of Grizzled Giant Squirrel in Chinnar Wildlife Sanctuary during summer season.

South-west monsoon

Similarly in the south-west monsoon period out of the total duration of observation on various activities for a total of 308.5 minutes, the predominant activity performed by the GSS was feeding (50.24%) followed by resting (23.34%), moving (23.18 %) and calling (3.24%) (Fig. 22).

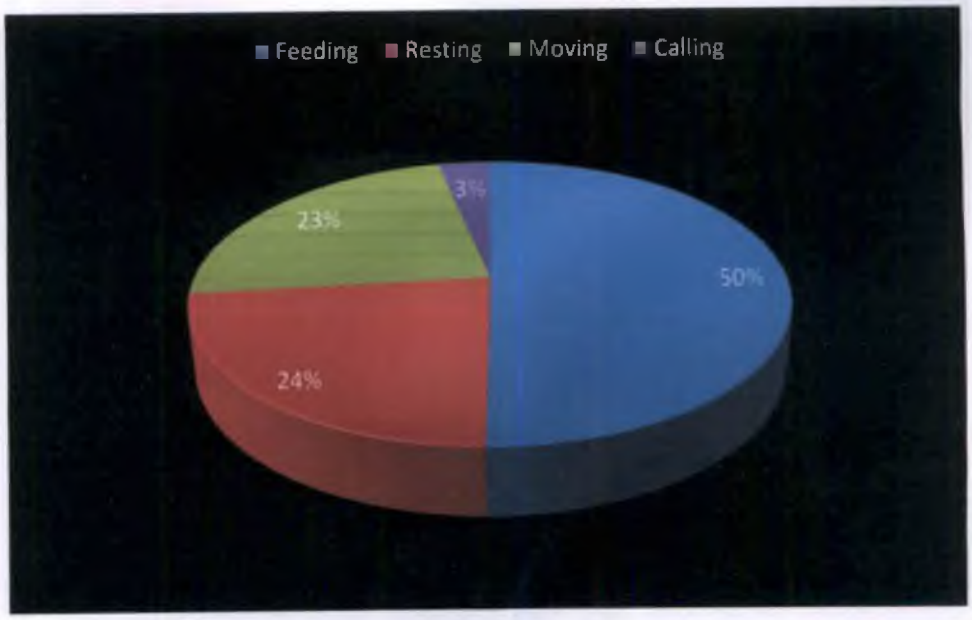


Figure 22. Activity time budget of Grizzled Giant Squirrel in Chinnar Wildlife Sanctuary during South west monsoon.

North-East monsoon

During north-east monsoon, a total of 312 minutes of observation was taken and in this case also feeding was the most predominant activity accounting for 69.55% followed by resting (26.92%) and moving (3.53%) (Fig. 23).

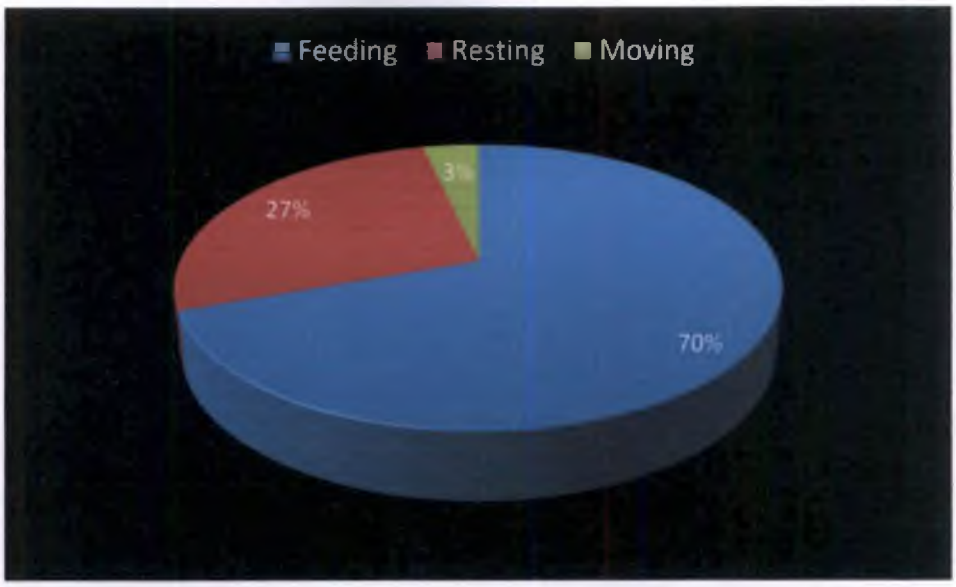


Figure 23. Activity time budget of Grizzled Giant Squirrel in Chinnar Wildlife Sanctuary during North East monsoon.

Mean duration of various activities of Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary across different seasons

The mean duration of activities for all the three seasons were estimated and it was found that the general trend of 'feeding' as the predominant activity. The 'calling' activity overcomes the 'moving' activity in terms of percentage duration both in summer and South west monsoon season (Fig. 24; Table 4). The frequency of 'calling' activity was one each for both these seasons so while calculating the mean duration their values remain unchanged but the moving duration become small because of higher number of frequency with short duration of observation. In the north east monsoon the resting activity found slightly overcomes the feeding activity because the frequency of moving found lower which in turn made the value higher for mean duration.

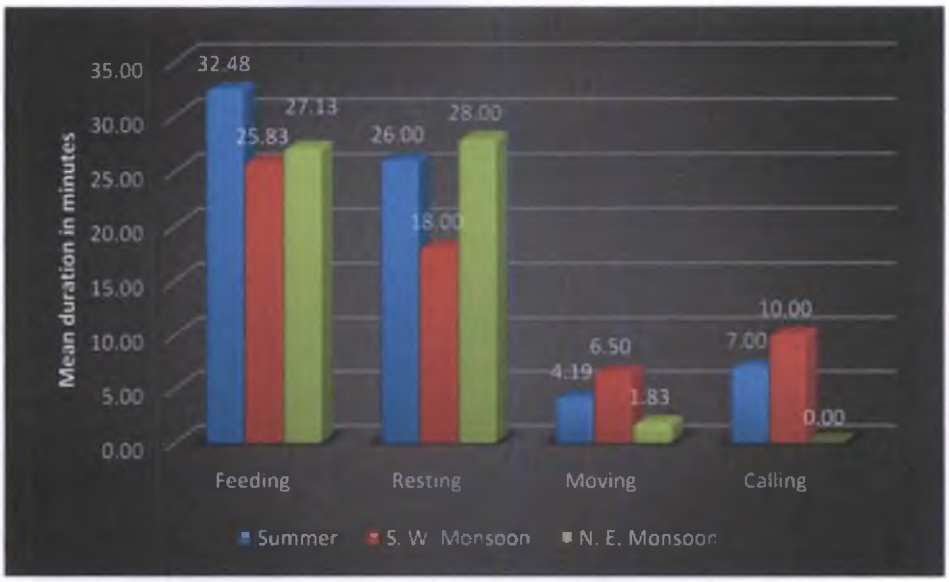


Figure 24. Mean duration of activities by Grizzled Giant Squirrel across different seasons

Table 4. Mean duration of activities by Grizzled Giant Squirrel across different seasons at Chinnar Wildlife Sanctuary

Sl. No.	Season	Activity (minutes)			
		Feeding	Resting	Moving	Calling
1.	Summer	32.48	26.00	4.19	7.00
2.	South-west monsoon	25.83	18.00	6.50	10.00
3.	North-east monsoon	27.13	28.00	1.83	0.00

Percentage frequency of various activities of Grizzled Giant Squirrel at Chinnar Wildlife sanctuary across different seasons

The percentage frequency of occurrence of different activities were analysed and it was observed that the activities followed the normal hierarchy as maximum for feeding followed by resting, moving and calling. While the moving activity found overcomes the resting or even the feeding with respect to percentage frequency. This is because more number of moving incidences were recorded but all are of short duration (Table 5) (Fig. 25).

Figure 25. The percentage frequency of different activities of Grizzled Giant Squirrel across different seasons.

Table 5. The percentage frequency of different activities of Grizzled Giant Squirrel across different seasons.

Sl. No.	Season	Activity in percentage frequency (number)			
		Feeding	Resting	Moving	Calling
1	Summer	46.77	25.81	25.81	1.61
2	South west monsoon	27.27	18.18	50	4.55
3	North east monsoon	47.06	17.65	35.29	0

4.3 THE SEASONAL VARIATION AND DIURNAL (FORENOON AND AFTERNOON) VARIATION IN THE ACTIVITIES OF THE GRIZZLED GIANT SQUIRREL AT CHINNAR WILDLIFE SANCTUARY

To find out the seasonal variation and time variation in the activities of the squirrel Uni-variate analysis was done because of the lack of correlation between different variables under consideration. To see the different variables under consideration as (dependent variables) height at which the animal when first sighted (m), animal's distance from the river (m) and duration of observation (minutes) were got influenced or not by the place which means the five locations of study namely Kootar, Churulipetty, Chambakkadu, Athiyoda and Alampetty, time of the day, activity by the animal, habitat at the site and season. The habitat at the site also taken into consideration because there were twelve incidences of sightings of Squirrel at dry deciduous forest had recorded, accounting for a duration of 336 minutes (16.37%) of total recorded duration.

The first variable height at which the animal when first sighted (m) was found influenced by the place, means at different study locations within the Chinnar Wildlife Sanctuary the animal found using different height for their activities and time of the day also found influencing the height of activity (Appendix 2 , Fig. 26). The effect of place could be attributed to the difference in the vegetation due to different species composition. The Grizzled Giant Squirrel was sighted at higher heights in the afternoon hours than the forenoon hours (Fig. 27).

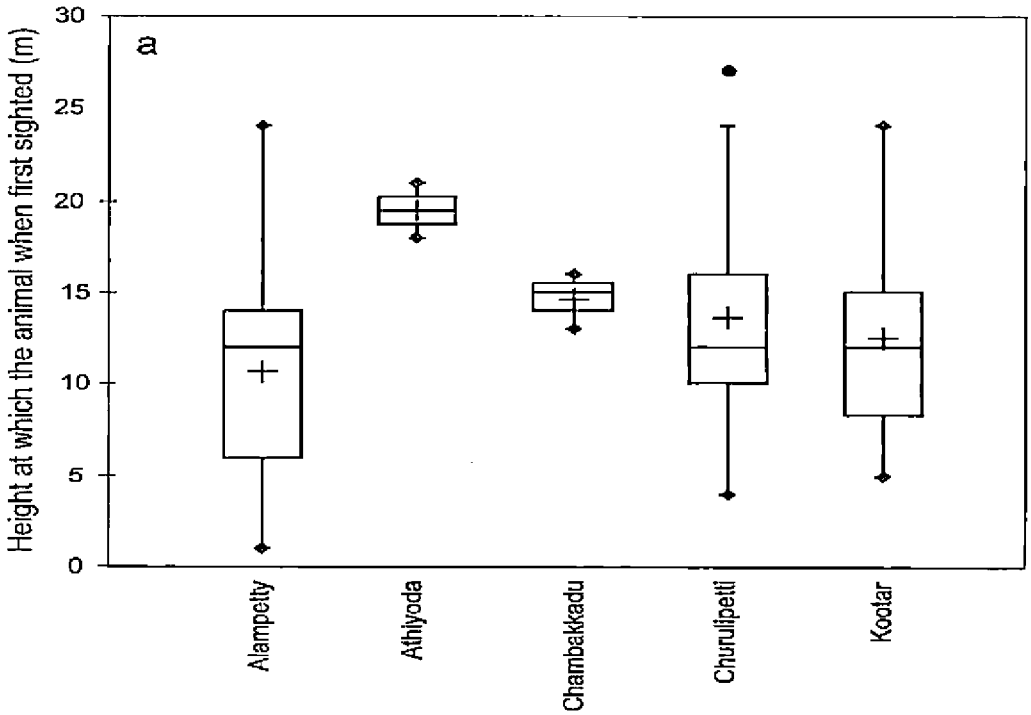


Figure 26. The height at which the Grizzled Giant Squirrels sighted at different locations.

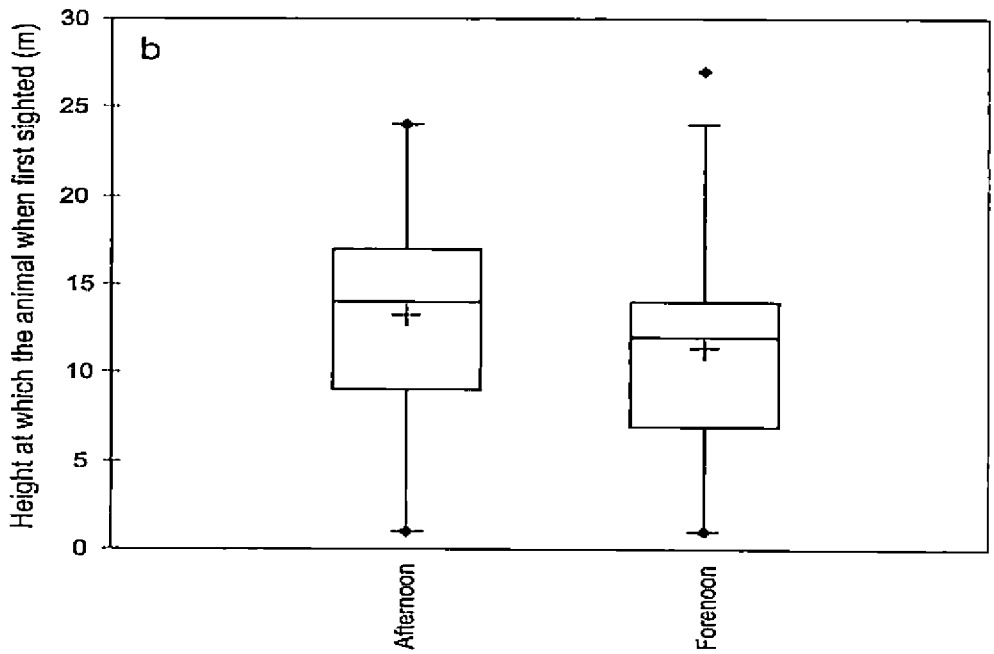


Figure 27. The height at which the Grizzled Giant Squirrels sighted in different time of the day (forenoon and afternoon).

The second dependent variable animal's distance from the river (m) was found to be influenced by habitat at the site and season (Appendix 2; Fig. 28 and 29). Even though the sampling area was riparian forest a few incidences of sighting of the squirrel had occurred from dry deciduous forest where this habitat are closer to riparian forest. As likely the squirrel was found closer to river in riparian forest than dry deciduous forest (Fig. 28). The analysis also revealed that the squirrels were found closer to river in summer season than in the monsoon season (Fig. 29).

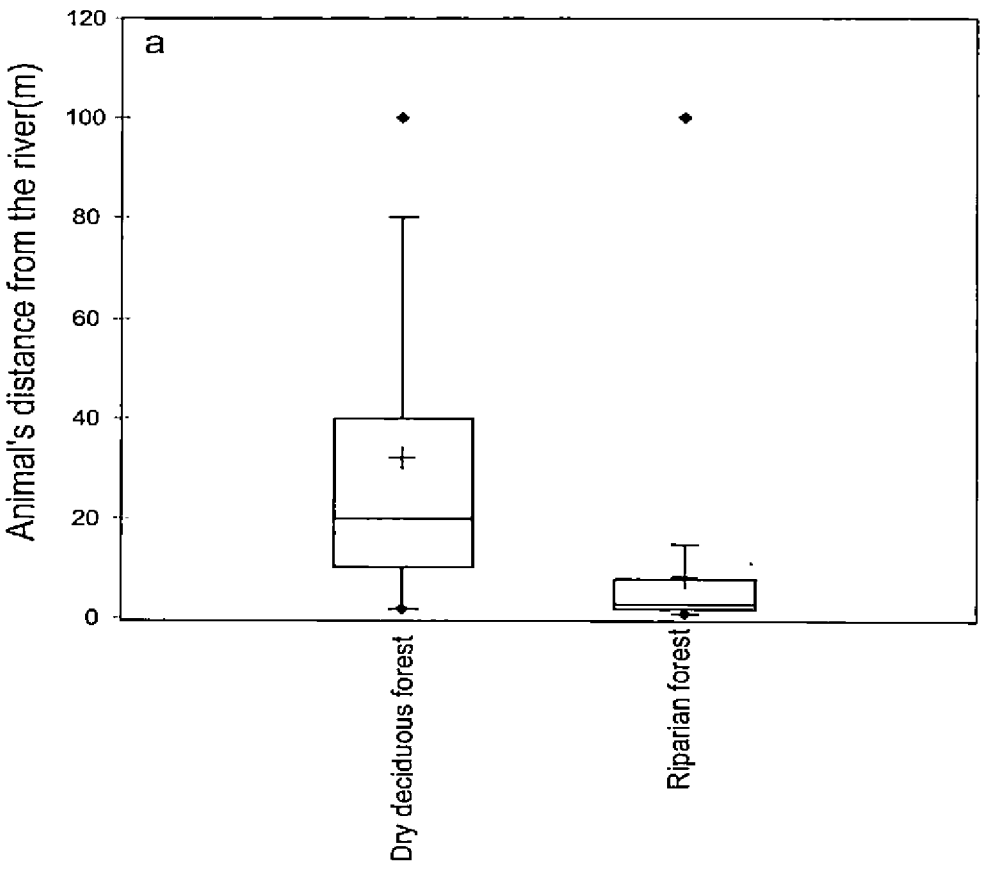


Figure 28. The Grizzled Giant Squirrels distance from the river in different habitat.

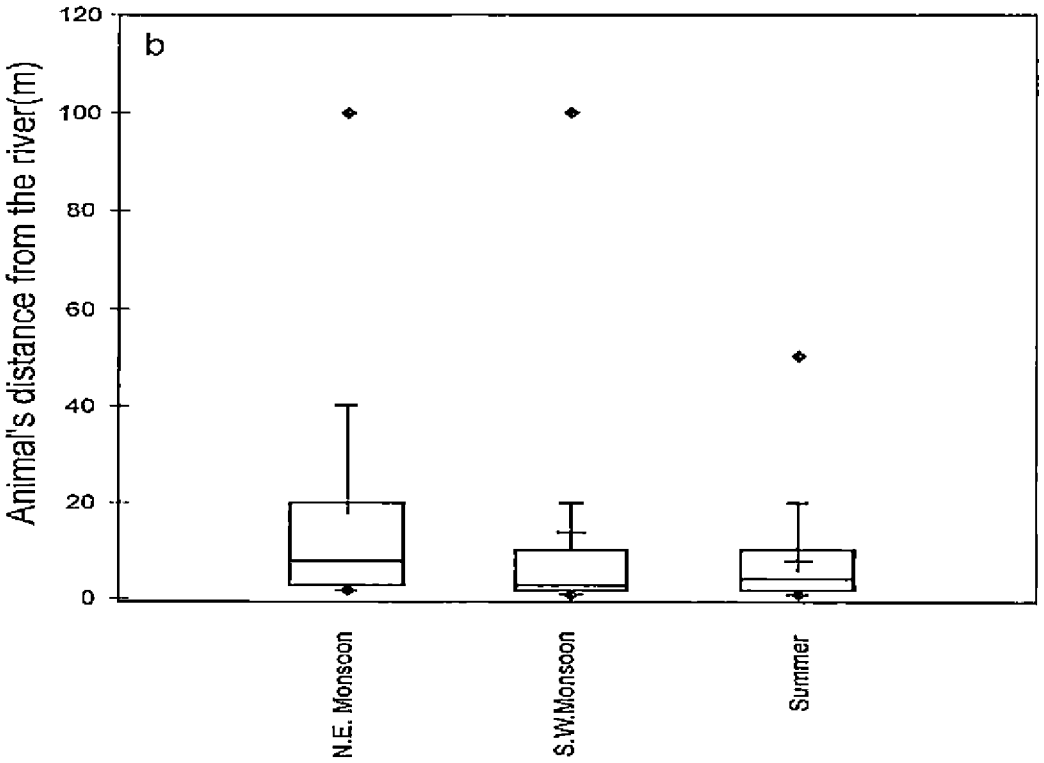


Figure 29. The Grizzled Giant Squirrels distance from the river in different seasons.

The third activity parameter, duration of activity (minutes) found to be significantly different among the types of the activity and the habitat (Appendix 2). It can be explained as squirrel spent most time in feeding followed by resting, while moving time was very less, that means squirrel allocated considerably different amount of time for doing particular activity (Fig. 30). The squirrel found spending more time in activities in dry deciduous forests than in riparian forests, this was because only a few incidence of occurrence of squirrel at dry deciduous forest had recorded and that all of higher duration. Thus the proportionate duration for each occurrence became higher in this habitat. While in riparian forest there were many incidence of moving activity having short duration, eventually which made the proportionate duration of each incidence lower (Fig. 31).

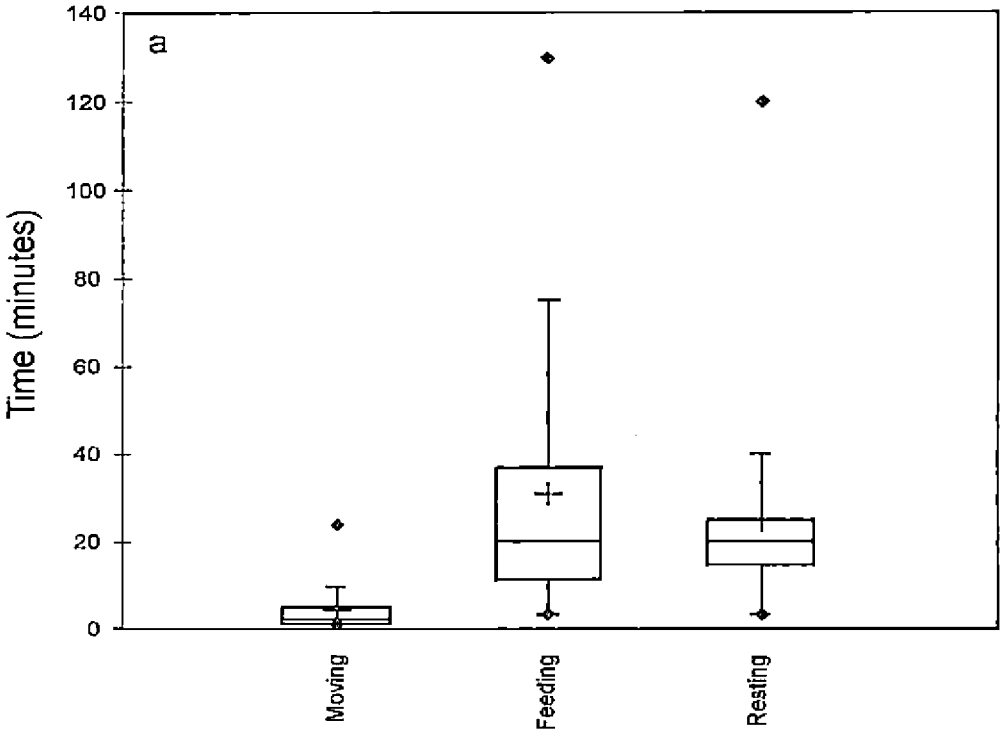


Figure 30. The duration of different activities by Grizzled Giant Squirrel in minutes

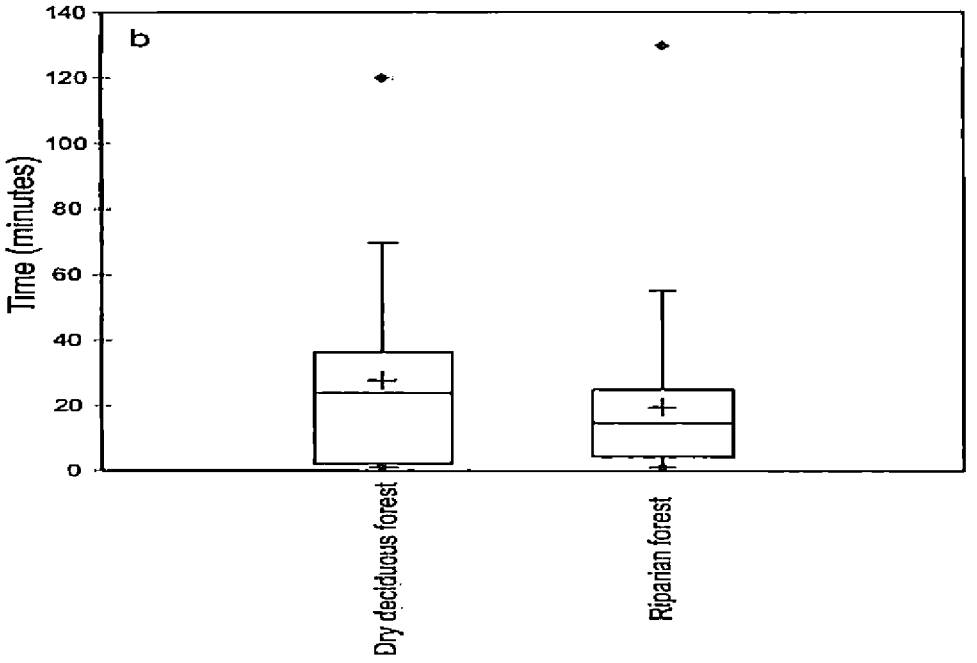


Figure 31. The duration of different activities by Grizzled Giant Squirrels in two habitat.

4.4 ACTIVITY AND TREE INTERACTION OF GRIZZLED GIANT SQUIRREL AT CHINNAR WILDLIFE SANCTUARY

4.4.1 Tree interaction by Grizzled Giant Squirrel for various types of activities

The total activities of Grizzled Giant Squirrel were separately considered and analysed based on the squirrel-tree interaction for each type of activity.

Resting

The resting duration of the squirrel in Chinnar Wildlife Sanctuary was found to be 572 minutes. The tree preference for the resting followed a trend based on maximum percentage duration on *Acacia nilotica* (28.32%), *Terminalia arjuna* (15.03%), *Tamarindus indica* (13.46%), *Ficus spp.*2 (13.29%), *Diospyros ebenum* (6.99%) and *Mangifera indica* (2.27%) (Table 6).

Table 6. Duration of resting by Grizzled Giant Squirrel on different tree species

Sl. No.	Tree species	Duration (minutes)	Percentage duration
1.	*Acacia nilotica*	162	28.32
2.	*Terminalia arjuna*	86	15.03
3.	*Tamarindus indica*	77	13.46
4.	*Ficus spp.* 2	76	13.29
5.	*Diospyros ebenum*	40	6.99
6.	*Dalbergia latifolia*	30	5.24
7.	*Ficus spp.* 1	30	5.24
8.	*Ficus albiphyla*	23	4.02
9.	*Ficus racemosa*	21	3.67
10.	*Ficus relegiosa*	14	2.45
11.	*Mangifera indica*	13	2.27

Moving

The total duration of the moving activity recorded was 149.5 minutes. Major part of this moving activity based on percentage duration found associated with *Terminalia arjuna* (48.83%), followed by *Ficus albiphyla* (10.03%), *Ficus spp.*2 (9.36%) and *Mangifera indica* (6.69%).

Table 7. Duration of moving by Grizzled Giant Squirrel on different tree species

Sl. No.	Tree species	Duration (minutes)	Percentage duration
1.	*Terminalia arjuna*	73	48.83
2.	*Ficus albiphyla*	15	10.03
3.	*Ficus spp.2*	14	9.36
4.	*Mangifera indica*	10	6.69
5.	*Syzygium cumini*	9	6.02
6.	*Ficus relegiosa*	7	4.68
7.	*Ficus spp. 1*	5	3.34
8.	*Pongamia pinnatta*	5	3.34
9.	*Acacia nilotica*	4	2.68
10.	*Miliusa tomentosa*	3	2.01
11.	*Ficus racemosa*	1.5	1.00
12.	*Dalbergia latifolia*	1	0.67
13.	*Pterocarpus marsupium*	1	0.67
14.	*Santalum album*	1	0.67

Calling

During the course of the entire study period there were only two instances when I heard the Grizzled Giant Squirrel calling. Once in September, while the squirrel was on a *Diospyros ebenum*, the squirrel called for about 10 minutes and on another occasion in the month of February, the animal was calling for about seven minutes. On this occasion the squirrel was on a *Bauhinia racemosa.* The call during the month of September could be that it was the breeding season of the GSS and they may be making the calls to get the attention of the other sex, while in February the squirrels were chased by the domestic dogs in the nearby tribal settlement and the calls that the squirrel made could be the alarm call.

Otherwise, it can be concluded that the Grizzled Giant Squirrel is a more silent squirrel, when compared to the Malabar Giant Squirrel.

4.4.2 Tree interaction by Grizzled Giant Squirrel for various activities at Chinnar Wildlife Sanctuary

The percentage duration spent by Grizzled Giant Squirrel on each interacting tree species for various activities were calculated and the species which had the percentage duration more than ten were analyzed and it found that *Bauhinia racemosa* (13.01%) was at the top because this species was intensively used for feeding by the Grizzled Giant Squirrel for two different months. The second and third species *Tamarindus indica* (12.76%) and *Terminalia arjuna* (12.03%) were used up by Grizzled Giant Squirrel for both feeding (found in three different months) and moving. Beside these this two species were also found used by the Grizzled Giant Squirrel for drey construction which had given them high weightage (Table 8).

Table 8. Grizzled Giant Squirrel interacting plant species based on duration of observation on that particular species

Sl. No.	Species	Observation time (minutes)	Percentage duration
1.	*Bauhinia racemosa*	267	13.01
2.	*Tamarindus indica*	262	12.76
3.	*Terminalia arjuna*	247	12.03
4.	*Prosopis juliflora*	164	7.99
5.	*Ficus spp.* 1	52	2.53
6.	*Nothopegia beddomei*	130	6.33
7.	*Strychnos potatorum*	95	4.63
8.	*Ficus albiphyla*	81	3.95
9.	*Diospyros ebenum*	70	3.41
10.	*Syzigium cumini*	61	2.97
11.	*Macrosolon capittellatus*	55	2.68
12.	*Diplocyclos palmatus*	45	2.19
13.	*Mangifera indica*	38	1.85
14.	*Melia dubia*	37	1.80
15.	*Albizzia lebbeck*	36	1.75
16.	*Ficus spp.* 2	29	1.41
17.	*Acacia incia*	35	1.71

18.	*Dalbergia latifolia*	31	1.51
19.	*Euphorbia trigona*	27	1.32
20.	*Grewia tiliifolia*	25	1.22
21.	*Ficus racemosa*	22.5	1.10
22.	*Ficus religiosa*	46	2.24
23.	*Derris brevipes*	17	0.83
24.	*Hibiscus rosa-chinensis*	15	0.73
25.	*Cayratia trifolia*	15	0.73
26.	*Psychotria subintegra*	13	0.63
27.	*Commiphora caudata*	10	0.49
28.	*Entada rheedi*	10	0.49
29.	*Santalum album*	10	0.49
30.	*Ficus microcarpa*	63	3.07
31.	*Hopea parviflora*	8	0.39
32.	unidentified	5	0.24
33.	*Pongamia pinnatta*	5	0.24
34.	*Aegle marmelos*	3	0.15
35.	*Cassia fistula*	3	0.15
36.	*Miliusa tomentosa*	3	0.15
37.	*Acacia nilotica*	2	0.10
38.	*Pterocarpus marsupium*	1	0.05
39.	*Ficus benghalensis*	14	0.68

4.5 TREE SPECIES COMPOSITION AND DIVERSITY IN GRIZZLED GIANT SQUIRREL HABITAT AT CHINNAR WILDLIFE SANCTUARY

A total of 100 quadrats of 10m x 10m, in five locations such as Kootar, Churulipetty, Chambakkadu, Athiyoda and Alampetty were taken for the vegetation studies on the GSS habitat along the riverine forest. In order to determine the quantitative relationship between the species eight parameters such as density (D), relative density (RD), abundance (A), percentage frequency (PF), relative frequency (RF), basal area (BA), relative basal area (RBA) and important value index (IVI), were determined. Only trees with >10 cm were enumerated within each plot. Data on species, gbh (cm), height (m), either in flowers or in fruits were recorded from each plot.

Analysis were separately done for each of this five locations and they were pooled to get the attributes for whole of Chinnar. Total of 95 tree species were identified from the study area out of which the Grizzled Giant Squirrel found to be interacting with 48 species,

36 species for drey construction and 22 tree species for feeding. Ten species of trees were used to serve both the purpose of feeding and drey construction. The analysis at each location is separately discussed below with interacting tree species by Grizzled Giant Squirrel.

4.5.1 Kootar

The riverine vegetation at Kootar was dominated by *Terminalia arjuna, Mangifera indica, Pongamia pinnata, Ficus microcarpa, Garcinia gummigutta, Canarium strictum, Tamarindus indica, Hopea parviflora* and *Artocarpus hirsutus* etc which has a IVI more than 10 (Table 9). In Kootar the Grizzled Giant Squirrel used only three tree species for the construction of drey. The details of which are given in Table 10. These three tree species were among the dominant tree species in the Kootar region. Among them about 85% of the drey was built on *Terminalia arjuna* and *Mangifera indica.* Out of the 17 tree species at Kootar the details on the trees upon which the Grizzled Giant Squirrel fed are given in Table 11. At Kootar, the Grizzled Giant Squirrel was found feeding primarily on the *Strychnos potatorum* and *Terminalia arjuna.*

Table 9. Quantitative relationship between the species at Kootar

Sl. No.	Species	Density (trees/ha)	Relative density	Abundance	Percentage frequency	Relative frequency	Basal area (m^2)	Relative basal area	Important value index	RIVI
1	*Terminalia arjuna*	150	30.3	1.9	0.8	22.9	0.08	8.1	61.2	20.4
2	*Mangifera indica*	95	19.2	1.5	0.7	18.6	0.09	8.2	46.0	15.3
3	*Pongamia pinnata*	85	17.2	1.7	0.5	14.3	0.04	3.9	35.4	11.8
4	*Ficus microcarpa*	20	4.0	1.3	0.2	4.3	0.15	15.4	23.7	7.9
5	*Garcinia gummi-gutta*	30	6.1	1.2	0.3	7.1	0.04	4.1	17.3	5.8
6	*Canarium strictum*	25	5.1	1.0	0.3	7.1	0.05	4.4	16.6	5.5
7	*Tamarindus indica*	20	4.0	1.0	0.2	5.7	0.11	6.3	16.1	5.4
8	*Hopea parviflora*	10	2.0	1.0	0.1	2.9	0.06	11.0	15.8	5.3
9	*Artocarpus hirsutus*	5	1.0	1.0	0.1	1.4	0.09	8.2	10.7	3.6
10	*Strychnos potatorum*	10	2.0	1.0	0.1	2.9	0.04	4.5	9.4	3.1
11	*Crotalaria pellida*	10	2.0	1.0	0.1	2.9	0.03	3.3	8.2	2.7
12	*Alphonsea sclerocarpa*	10	2.0	1.0	0.1	2.9	0.03	3.1	8.0	2.7
13	*Sapindus tetraphylla*	5	1.0	1.0	0.1	1.4	0.05	4.9	7.3	2.4
14	*Syzygium cumini*	5	1.0	1.0	0.1	1.4	0.05	4.5	7.0	2.3
15	*Excoecaria oppositifolia*	5	1.0	1.0	0.1	1.4	0.04	4.2	6.6	2.2
16	*Gyrocarpus asiaticus*	5	1.0	1.0	0.1	1.4	0.03	3.1	5.6	1.9
17	*Schleichera oleosa*	5	1.0	1.0	0.1	1.4	0.03	2.7	5.2	1.7

Table 10. Tree species preferred by Grizzled Giant Squirrel for drey construction at Kootar.

Sl. No	Species	Number of Dreys	Percentage use
1	*Terminalia arjuna*	3	42.86
2	*Mangifera indica*	3	42.86
3	*Hopea parviflora*	1	14.29

Table 11. Feeding activity by Grizzled Giant Squirrel at Kootar

Sl. No	Species	Duration	Percentage use
1	*Strychnos potatorum*	95	42.60
2	*Terminalia arjuna*	46	20.63
3	*Ficus spp.*1	30	13.45
4	*Euphorbia trigona*	27	12.11
5	*Derris brevipes*	17	7.62
6	*Hopea parviflora*	8	3.59

4.5.2 Churulipetty

The riverine vegetation at Kootar was dominated by the species such as *Pongamia pinnata, Terminalia arjuna, Mangifera indica, Ficus microcarpa, Artocarpus hirsutus, Syzygium cumini, Tamarindus indica, Hopea parviflora*, and *Mitragyna parviflora* etc which has IVI more than ten (Table 12). Six species are found to be used by Grizzled Giant Squirrel for drey construction at Churulipetty. These tree species were among the dominant tree species in the Churulipetty region. (Table 13) and nine species forms the part of diet (Table 14). Based on these two preferences the trees of importance at this area for Grizzled Giant Squirrel are *Terminalia arjuna, Mangifera indica, Pongamia pinnata,* and *Syzygium cumini.*

Table 12. Quantitative relationship between the species at Churulipetty

Sl. No.	Species	Density (trees/ha)	Relative Density	Abundance	Percentage Frequency	Relative Frequency	Basal Area (m^2)	Relative Basal Area	Important Value Index	RIVI
1	*Pongamia pinnata*	155	31	1.94	0.80	22.22	0.03	3.02	56.24	18.75
2	*Terminalia arjuna*	95	19	1.36	0.70	19.44	0.06	5.94	44.38	14.79
3	*Mangifera indica*	75	15	1.5	0.50	13.89	0.08	7.69	36.58	12.19
4	*Ficus microcarpa*	10	2	1	0.10	2.78	0.17	16.72	21.50	7.17
5	*Artocarpus hirsutus*	35	7	1.17	0.30	8.33	0.05	5.40	20.74	6.91
6	*Syzygium cumini*	20	4	1.33	0.15	4.17	0.09	8.98	17.15	5.72
7	*Tamarindus indica*	20	4	1.33	0.15	4.17	0.06	5.54	13.70	4.57
8	*Hopea parvifolia*	15	3	1	0.15	4.17	0.05	5.40	12.57	4.19
9	*Mitragyna parviflora*	15	3	1	0.15	4.17	0.04	3.84	11.01	3.67
10	*Sapindus tetraphylla*	10	2	1	0.10	2.78	0.04	4.41	9.19	3.06
11	*Cassine paniculata*	10	2	1	0.10	2.78	0.04	3.95	8.73	2.91
12	*Acacia nilotica*	5	1	1	0.05	1.39	0.06	5.94	8.33	2.78
13	*Melia dubia*	5	1	1	0.05	1.39	0.06	5.94	8.33	2.78
14	*Excoecaria oppositifolia*	5	1	1	0.05	1.39	0.06	5.54	7.92	2.64
15	*Grewia tiliifolia*	5	1	1	0.05	1.39	0.04	4.41	6.80	2.27
16	*Azadirachta indica*	5	1	1	0.05	1.39	0.04	3.95	6.34	2.11
17	Unidentified 1	5	1	1	0.05	1.39	0.03	3.31	5.70	1.90

Table 13. Tree species preferred by Grizzled Giant Squirrel for drey construction at Churulipetty

Sl. No	Species	Number of Dreys	Percentage
1	*Mangifera indica*	9	45
2	*Terminalia arjuna*	4	20
3	*Tamarindus indica*	3	15
4	*Acacia ferruginea*	2	10
5	*Garcinia gummi-gutta*	1	5
6	*Pongamia pinnata*	1	5

Table 14. Feeding activity by Grizzled Giant Squirrel at Churulippetty

Sl. No.	Species	Duration	Percentage
1	*Terminalia arjuna*	62	25.20
2	*Syzygium cumini*	37	15.04
3	*Melia dubia*	37	15.04
4	*Acacia incia*	35	14.23
5	*Macrosolen capitellatus*	35	14.23
6	*Ficus spp.*1	16	6.50
7	*Mangifera indica*	15	6.10
8	*Ficus spp.* 2	6	2.44
9	*Aegle marmelos*	3	1.22

4.5.3 Chambakkad

The riverine vegetation at Chambakkad was dominated by the species such as *Pongamia pinnata, Mangifera indica, Terminalia arjuna, Pterocarpus marsupium, Sapindus tetraphylla, Syzygium cumini*, and *Schleichera oleosa* as they have IVI more than ten (Table 16). Seven species are found to be used by Grizzled Giant Squirrel for drey construction at Chambakkad. *Ficus racemosa, Terminalia arjuna* and *Alphonsea sclerocarpa* have 75 percent of the dreys of Grizzled Giant Squirrel (Table 15). Only one species forms the part of Grizzled Giant Squirrel diet, at Chambakkad which was a paraphyte, *Macrosolon capitellatus*. The paraphyte *Macrosolon capitellatus* which was preferred by Grizzled Giant Squirrel for feeding found to be growing on *Terminalia arjuna* which increases the importance of this species.

Table 15. Tree species preferred by Grizzled Giant Squirrel for Drey construction at Chambakkad

Sl. No.	Species	Number of Dreys	Percentage
1	*Ficus racemosa*	3	21.43
2	*Terminalia arjuna*	3	21.43
3	*Alphonsea sclerocarpa*	3	21.43
4	*Pongamia pinnata*	2	14.29
5	*Mitragyna parvifolia*	1	7.14
6	*Pongamia pinnata*	1	7.14
7	*Vateria indica*	1	7.14

Table 16. Quantitative relationship between the species of Chambakkad

Sl. No.	Species	Density (trees/ha)	Relative Density	Abundance	Percentage Frequency	Relative Frequency	Basal Area (m^2)	Relative Basal Area	Important Value Index	RIVI
1	*Pongamia pinnata*	315	29.72	3.94	0.80	13.01	0.03	0.63	43.35	14.45
2	*Mangifera indica*	10	0.94	1.00	0.10	1.63	1.27	27.85	30.42	10.14
3	*Terminalia arjuna*	75	7.08	1.25	0.60	9.76	0.24	5.27	22.10	7.37
4	*Pterocarpus marsupium*	5	0.47	1.00	0.05	0.81	0.87	18.95	20.24	6.75
5	*Sapindus tetraphylla*	70	6.60	1.75	0.40	6.50	0.01	0.24	13.35	4.45
6	*Syzygium cumini*	55	5.19	1.83	0.30	4.88	0.15	3.27	13.33	4.44
7	*Schleichera oleosa*	40	3.77	1.14	0.35	5.69	0.03	0.57	10.03	3.34
8	*Lepisanthes senegalensis*	55	5.19	2.20	0.25	4.07	0.03	0.67	9.92	3.31
9	*Melia dubia*	10	0.94	2.00	0.05	0.81	0.34	7.53	9.29	3.10
10	*Calophyllum inophyllum*	25	2.36	1.67	0.15	2.44	0.19	4.18	8.98	2.99
11	*Ficus benghalensis*	15	1.42	1.00	0.15	2.44	0.19	4.24	8.09	2.70
12	*Ficus microcarpa*	15	1.42	1.00	0.15	2.44	0.17	3.76	7.62	2.54
13	*Randia dumetorum*	25	2.36	1.00	0.25	4.07	0.005	0.11	6.53	2.18
14	Unidentified 2	20	1.89	1.00	0.20	3.25	0.06	1.35	6.49	2.16

15	*Acacia leucophloea*	15	1.42	1.50	0.10	1.63	0.10	2.22	5.26	1.75
16	*Cassine paniculata*	20	1.89	2.00	0.10	1.63	0.05	1.14	4.65	1.55
17	*Tamarindus indica*	5	0.47	1.00	0.05	0.81	0.15	3.22	4.50	1.50
18	*Ziziphus oenoplia*	20	1.89	1.33	0.15	2.44	0.01	0.13	4.45	1.48
19	*Azadirachta indica*	15	1.42	1.00	0.15	2.44	0.02	0.37	4.22	1.41
20	*Anthocephalus cadamba*	5	0.47	1.00	0.05	0.81	0.13	2.76	4.05	1.35
21	*Bauhinia racemosa*	20	1.89	2.00	0.10	1.63	0.02	0.49	4.00	1.33
22	*Dalbergia latifolia*	15	1.42	1.50	0.10	1.63	0.03	0.57	3.61	1.20
23	*Olea dioica*	15	1.42	1.50	0.10	1.63	0.02	0.47	3.51	1.17
24	*Hopea parviflora*	10	0.94	1.00	0.10	1.63	0.04	0.93	3.50	1.17
25	*Strychnos potatorum*	15	1.42	1.50	0.10	1.63	0.02	0.45	3.49	1.16
26	*Manilkara roxburghiana*	10	0.94	1.00	0.10	1.63	0.02	0.55	3.12	1.04
27	*Ziziphus mauritiana*	10	0.94	1.00	0.10	1.63	0.01	0.24	2.81	0.94
28	*Albizia odoratissima*	5	0.47	1.00	0.05	0.81	0.06	1.41	2.69	0.90
29	*Garcinia gummi-gutta*	5	0.47	1.00	0.05	0.81	0.06	1.32	2.60	0.87
30	Unidentified 3	15	1.42	3.00	0.05	0.81	0.01	0.26	2.49	0.83
31	Unidentified 4	15	1.42	3.00	0.05	0.81	0.01	0.23	2.45	0.82
32	*Euphorbia spp.*	15	1.42	3.00	0.05	0.81	0.003	0.06	2.29	0.76
33	*Alphonsea sclerocarpa*	5	0.47	1.00	0.05	0.81	0.05	1.01	2.29	0.76
34	*Cassia fistula*	10	0.94	2.00	0.05	0.81	0.02	0.53	2.28	0.76
35	*Phyllanthus emblica*	10	0.94	2.00	0.05	0.81	0.02	0.37	2.12	0.71

36	unidentified 5	5	0.47	1.00	0.05	0.81	0.03	0.59	1.87	0.62
37	unidentified 6	10	0.94	2.00	0.05	0.81	0.004	0.08	1.83	0.61
38	*Acacia nilotica*	5	0.47	1.00	0.05	0.81	0.02	0.42	1.70	0.57
39	*Ailanthus triphysa*	5	0.47	1.00	0.05	0.81	0.02	0.35	1.64	0.55
40	*Sapindus trifolia*	5	0.47	1.00	0.05	0.81	0.01	0.26	1.55	0.52
41	*Acacia insia*	5	0.47	1.00	0.05	0.81	0.01	0.24	1.52	0.51
42	*Santalum album*	5	0.47	1.00	0.05	0.81	0.01	0.23	1.51	0.50
43	*Acacia catechu*	5	0.47	1.00	0.05	0.81	0.01	0.14	1.42	0.47
44	*Canthium dicoccum*	5	0.47	1.00	0.05	0.81	0.01	0.13	1.41	0.47
45	unidentified 7	5	0.47	1.00	0.05	0.81	0.005	0.10	1.38	0.46
46	*Streblus asper*	5	0.47	1.00	0.05	0.81	0.004	0.08	1.37	0.46
47	*Helicteres isora*	5	0.47	1.00	0.05	0.81	0.002	0.05	1.34	0.45
48	unidentified 8	5	0.47	1.00	0.05	0.81	0.001	0.03	1.31	0.44

4.5.4 Athiyoda

The riverine vegetation at Athiyoda was dominated by the species such as *Ficus benghalensis*, *Terminalia arjuna*, *Alphonsea sclerocarpa*, *Pongamia pinnata*, *Jatropha spp.*, *Mallotus philippensis*, *Gyrocarpus asiaticus*, *Albizia odoratissima*, *Ficus racemosa*, *Lepisanthes senegalensis*, and *Commiphora caudata* had IVI more than ten (Table 18). Ten species were found to be used by Grizzled Giant Squirrel for drey construction at Athiyoda among them *Pongamia pinnata* and *Mitragyna parvifolia* are having 50 percent of the dreys (Table 17). Only one species found to be preferred by Grizzled Giant Squirrel for feeding, *Albizzia lebbeck* having IVI value six. Eventhough *Albizia lebbeck* having low IVI value (six) is of higher importance as this species is used by the Grizzled Giant Squirrel for both drey construction and feeding.

Table 17. Tree species preferred by Grizzled Giant Squirrel for drey construction at Athiyoda

Sl. No.	Species	Number of Dreys	Percentage
1	*Pongamia pinnata*	6	30
2	*Mitragyna parvifolia*	4	20
3	*Albizia procera*	2	10
4	*Gyrocarpus asiaticus*	2	10
5	*Alphonsea sclerocarpa*	1	5
6	*Terminalia arjuna*	1	5
7	*Diospyros ebenum*	1	5
8	*Vateria indica*	1	5
9	*Ficus microcarpa*	1	5
10	*Albizia lebbeck*	1	5

Table 18. Quantitative relationship between the species of Athiyoda

Sl. No.	Species	Density (trees/ha)	Relative Density	Abundance	Percentage Frequency	Relative Frequency	Basal Area (m^2)	Relative Basal Area	Important Value Index	RIVI
1	*Ficus benghalensis*	5	0.56	1.00	0.05	0.98	2.86	39.78	41.32	13.77
2	*Terminalia arjuna*	50	5.56	1.11	0.45	8.82	1.61	22.38	36.76	12.25
3	*Alphonsea sclerocarpa*	210	23.33	5.25	0.40	7.84	0.03	0.44	31.62	10.54
4	*Pongamia pinnata*	150	16.67	2.50	0.60	11.76	0.03	0.40	28.83	9.61
5	*Jatropha spp.*	65	7.22	1.63	0.40	7.84	0.005	0.06	15.13	5.04
6	*Mallotus philippensis*	55	6.11	1.38	0.40	7.84	0.05	0.67	14.63	4.88
7	*Gyrocarpus asiaticus*	50	5.56	1.43	0.35	6.86	0.05	0.76	13.18	4.39
8	*Albizia odoratissima*	5	0.56	1.00	0.05	0.98	0.72	9.95	11.48	3.83
9	*Ficus racemosa*	5	0.56	1.00	0.05	0.98	0.72	9.95	11.48	3.83
10	*Lepisanthes senegalensis*	30	3.33	1.00	0.30	5.88	0.14	1.95	11.17	3.72
11	*Commiphora caudata*	45	5.00	1.80	0.25	4.90	0.03	0.36	10.26	3.42
12	*Sapindus tetraphylla*	25	2.78	1.00	0.25	4.90	0.05	0.71	8.39	2.80
13	*Drypetes sepiaria*	25	2.78	1.25	0.20	3.92	0.04	0.50	7.20	2.40

14	*Euphorbia spp.*	35	3.89	2.33	0.15	2.94	0.005	0.06	6.89	2.30
15	*Albizia lebbeck*	15	1.67	1.50	0.10	1.96	0.20	2.79	6.42	2.14
16	*Syzygium cumini*	10	1.11	1.00	0.10	1.96	0.19	2.69	5.76	1.92
17	Unidentified 8	20	2.22	1.33	0.15	2.94	0.002	0.03	5.19	1.73
18	*Tamarindus indica*	10	1.11	1.00	0.10	1.96	0.11	1.49	4.56	1.52
19	*Diospyros ebenum*	20	2.22	2.00	0.10	1.96	0.02	0.33	4.52	1.51
20	*Streblus asper*	15	1.67	1.50	0.10	1.96	0.02	0.22	3.85	1.28
21	*Ficus microcarpa*	5	0.56	1.00	0.05	0.98	0.06	0.88	2.41	0.80
22	*Ziziphus xylopyrus*	5	0.56	1.00	0.05	0.98	0.05	0.69	2.23	0.74
23	*Miliusa tomentosa*	5	0.56	1.00	0.05	0.98	0.04	0.57	2.11	0.70
24	*Memicylon umballatum*	5	0.56	1.00	0.05	0.98	0.04	0.54	2.08	0.69
25	*Canthium dicoccum*	5	0.56	1.00	0.05	0.98	0.04	0.51	2.05	0.68
26	Unidentified 6	5	0.56	1.00	0.05	0.98	0.03	0.42	1.96	0.65
27	Unidentified 4	5	0.56	1.00	0.05	0.98	0.03	0.38	1.92	0.64
28	*Terminalia paniculata*	5	0.56	1.00	0.05	0.98	0.03	0.37	1.91	0.64
29	*Randia dumatorum*	5	0.56	1.00	0.05	0.98	0.005	0.06	1.60	0.53
30	*Manilkara hexandra*	5	0.56	1.00	0.05	0.98	0.002	0.03	1.57	0.52
31	*Garuga floribunda*	5	0.56	1.00	0.05	0.98	0.001	0.01	1.55	0.52

4.5.5 Alampetty

The riverine vegetation at Alampetty was dominated by the species such as *Mangifera indica*, *Pongamia pinnata*, *Spondias pinnata*, *Psychoteris subintegra*, *Diospyros ebenum*, *Syzygium cumini*, and *Ficus microcarpa* as they had IVI more than ten (Table 20). 26 species were used by Grizzled Giant Squirrel for drey construction at Alampetty, among them *Ficus microcarpa* (17.24%), *Diospyros ebenum* (15.52%) and *Mangifera indica* (10.34%) are the highly preferred species (Table 21). Sixteen species were preferred by Grizzled Giant Squirrel for feeding at Alampetty. *Bauhinia racemosa* and *Tamarindus indica* are highly preferred by the Grizzled Giant Squirrel as these species together constitute more than 50 percent of total feeding duration at Alampetty (Table 19).

Table 19. Feeding activity by Grizzled Giant Squirrel at Alampetty on different plant species

Sl. No	Species	Duration	Percentage
1	*Bauhinia racemosa*	260	32.95
2	*Tamarindus indica*	185	23.45
3	*Nothopegia beddomei*	130	16.48
4	*Diplocyclos palmatus*	45	5.70
5	*Ficus albiphyla*	40	5.07
6	*Grewia tiliifolia*	25	3.17
7	*Cayratia trifolia*	15	1.90
8	*Hibiscus rosa-chinensis*	15	1.90
9	*Syzygium cumini*	15	1.90
10	*Psychotria subintegra*	13	1.65
11	*Entada rheedi*	10	1.27
12	*Commiphora caudata*	10	1.27
13	*Santalum album*	9	1.14
14	*Ficus microcarpa*	9	1.14
15	unidentified	5	0.63
16	*Cassia fistula*	3	0.38

Table 20. Quantitative relationship between the species of Alampetty.

Sl. No.	Species	Density (trees/ha)	Relative Density	Abundance	Percentage Frequency	Relative Frequency	Basal Area (m^2)	Relative Basal Area	Important Value Index	RIVI
1	*Mangifera indica*	60	4.14	1.50	0.40	4.37	0.70	15.35	23.86	7.95
2	*Pongamia pinnata*	205	14.14	2.56	0.80	8.74	0.04	0.85	23.73	7.91
3	*Spondias pinnata*	100	6.90	1.67	0.60	6.56	0.38	8.27	21.72	7.24
4	*Psychoteris subintegra*	115	7.93	1.77	0.65	7.10	0.01	0.13	15.16	5.05
5	*Diospyros ebenum*	95	6.55	1.90	0.50	5.46	0.05	1.06	13.07	4.36
6	*Syzygium cumini*	40	2.76	1.60	0.25	2.73	0.32	7.10	12.59	4.20
7	*Ficus microcarpa*	75	5.17	1.50	0.50	5.46	0.07	1.44	12.08	4.03
8	*Melia dubia*	20	1.38	1.33	0.15	1.64	0.30	6.62	9.64	3.21
9	*Alphonsea sclerocarpa*	40	2.76	1.33	0.30	3.28	0.08	1.74	7.78	2.59
10	*Gmelina arborea*	50	3.45	2.00	0.25	2.73	0.04	0.88	7.06	2.35
11	*Emblica officinalis*	5	0.34	1.00	0.05	0.55	0.28	6.02	6.91	2.30
12	*Garuga floribunda*	20	1.38	1.00	0.20	2.19	0.14	3.17	6.74	2.25
13	*Cassia fistula*	35	2.41	1.40	0.25	2.73	0.05	1.20	6.34	2.11
14	*Bauhinia racemosa*	10	0.69	1.00	0.10	1.09	0.19	4.24	6.02	2.01

15	*Albizia procera*	30	2.07	1.20	0.25	2.73	0.04	0.90	5.70	1.90
16	*Dalbergia latifolia*	35	2.41	2.33	0.15	1.64	0.07	1.51	5.56	1.85
17	*Stereospermum chelonoides*	25	1.72	1.25	0.20	2.19	0.07	1.51	5.42	1.81
18	*Garuga pinnata*	40	2.76	2.00	0.20	2.19	0.02	0.40	5.35	1.78
19	*Santalum album*	30	2.07	1.20	0.25	2.73	0.01	0.24	5.04	1.68
20	*Chloroxylon swietenia*	10	0.69	1.00	0.10	1.09	0.15	3.22	5.00	1.67
21	*Albizia odoratissima*	20	1.38	2.00	0.10	1.09	0.11	2.46	4.94	1.65
22	*Strychnus nux-vomica*	25	1.72	1.25	0.20	2.19	0.04	0.83	4.74	1.58
23	*Lepisanthes senegalensis*	10	0.69	1.00	0.10	1.09	0.13	2.85	4.63	1.54
24	*Ceiba pentandra*	10	0.69	2.00	0.05	0.55	0.15	3.22	4.45	1.48
25	*Anogeissus latifolia*	30	2.07	2.00	0.15	1.64	0.03	0.59	4.29	1.43
26	*Phyllanthus emblica*	15	1.03	1.00	0.15	1.64	0.07	1.47	4.15	1.38
27	*Vitex altissima*	15	1.03	3.00	0.05	0.55	0.11	2.51	4.09	1.36
28	*Olea dioica*	10	0.69	1.00	0.10	1.09	0.11	2.30	4.08	1.36
29	*Ixora brachiata*	20	1.38	1.00	0.20	2.19	0.02	0.38	3.95	1.32
30	*Euphorbia spp.*	20	1.38	1.00	0.20	2.19	0.01	0.24	3.80	1.27
31	*Jatropha spp.*	25	1.72	1.67	0.15	1.64	0.00	0.07	3.43	1.14
32	*Mallottus alba*	25	1.72	2.50	0.10	1.09	0.02	0.53	3.34	1.11
33	*Ficus albiphyla*	5	0.34	1.00	0.05	0.55	0.10	2.26	3.15	1.05
34	*canthium umbellatum*	25	1.72	2.50	0.10	1.09	0.01	0.23	3.04	1.01
35	*Ficus spp.*	10	0.69	1.00	0.10	1.09	0.05	1.14	2.92	0.97

36	*Mallotus philippensis*	15	1.03	1.00	0.15	1.64	0.01	0.20	2.88	0.96
37	*Gyrocarpus asiaticus*	10	0.69	2.00	0.05	0.55	0.07	1.60	2.84	0.95
38	*Schleichera oleosa*	5	0.34	1.00	0.05	0.55	0.08	1.74	2.63	0.88
39	*Memecylon umbellatum*	5	0.34	1.00	0.05	0.55	0.07	1.60	2.50	0.83
40	*Alseodaphne semecarpifolia*	10	0.69	1.00	0.10	1.09	0.02	0.49	2.27	0.76
41	*Ficus racemosa*	5	0.34	1.00	0.05	0.55	0.06	1.35	2.24	0.75
42	*Aporosa cardiosperma*	5	0.34	1.00	0.05	0.55	0.06	1.32	2.21	0.74
43	*Commiphora caudate*	5	0.34	1.00	0.05	0.55	0.05	1.17	2.06	0.69
44	*Holigarna arnottiana*	5	0.34	1.00	0.05	0.55	0.05	1.17	2.06	0.69
45	*Acacia leucophloea*	15	1.03	3.00	0.05	0.55	0.02	0.44	2.02	0.67
46	*Lepisanthes tetraphylla*	10	0.69	1.00	0.10	1.09	0.01	0.21	2.00	0.67
47	*Bamboo spp.*	10	0.69	1.00	0.10	1.09	0.01	0.19	1.97	0.66
48	*Euphorbia trigona*	10	0.69	1.00	0.10	1.09	0.01	0.19	1.97	0.66
49	*Plumaria alba*	5	0.34	1.00	0.05	0.55	0.03	0.74	1.63	0.54
50	*Artocarpus hirsutus*	10	0.69	2.00	0.05	0.55	0.02	0.38	1.62	0.54
51	*Helicteres isora*	10	0.69	2.00	0.05	0.55	0.00	0.06	1.29	0.43
52	*Ficus hispida*	5	0.34	1.00	0.05	0.55	0.01	0.21	1.10	0.37
53	*Chukrasia tabularis*	5	0.34	1.00	0.05	0.55	0.001	0.03	0.92	0.31

Table 21. Tree species preferred by Grizzled Giant Squirrel for Drey construction at Alampetty

Sl. No.	Species	Number of Dreys	Percentage
1	*Ficus microcarpa*	10	17.24
2	*Diospyros ebenum*	9	15.52
3	*Mangifera indica*	6	10.34
4	*Syzygium cumini*	6	10.34
5	*Terminalia arjuna*	5	8.62
6	*Melia dubia*	3	5.17
7	*Acacia nilotica*	2	3.45
8	*Premna wightiana*	2	3.45
9	*Callophyllum inophyllum*	1	1.72
10	*Schleichera oleosa*	1	1.72
11	*Alphonsea sclerocarpa*	1	1.72
12	*Psychotria subintegra*	1	1.72
13	*Holoptelia integrifolia*	1	1.72
14	*Schifflera wallichiana*	1	1.72
15	*Albizia procera*	1	1.72
16	*Acacia leucophloea*	1	1.72
17	*Albizia lebbeck*	1	1.72
18	*Walsura trifolia*	1	1.72
19	*Holoptelia integrifolia*	1	1.72
20	*Pterocarpus marsupium*	1	1.72
21	*Tectona grandis*	1	1.72
22	*Alphonsea sclerocarpa*	1	1.72
23	*Tetrameles nudiflora*	1	1.72

4.5.6 Chinnar Wildlife Sanctuary

Total of 95 species were identified from the riparian habitat along the Chinnar and Pambar rivers at Chinnar Wildlife Sanctuary. The vegetation found dominated by the species such as *Pongamia pinnata, Terminalia arjuna, Mangifera indica, Pterocarpus marsupium, Alphonsea sclerocarpa, Ficus benghalensis, Syzygium cumini, Ficus microcarpa, Sapindus tetraphylla, Spondias pinnata, Lepisanthes senegalensis, Diospyros ebenum, Melia dubia,* and *Psychoteris subintegra* as they had IVI value more than five (Table 22).

The Grizzled Giant Squirrel found to be interacting with 56 species out of which 48 were tree species. Comparing the percentage interaction with Grizzled Giant Squirrel the important trees at the Chinnar Wildlife Sanctuary for the existence of Grizzled Giant Squirrel are *Terminalia arjuna, Hopea parviflora, Mangifera indica, Pongamia pinnata, Syzygium cumini, Gyrocarpus asiaticus, Albizia odoratissima, Alphonsea sclerocarpa, Albizia lebbeck, Ficus microcarpa, Psychoteris subintegra* and *Diospyros ebenum.*

Table 22. The total tree species observed along the riparian forest habitat at Chinnar Wildlife Sanctuary and their quantitative relationship.

Sl. No.	Species	Density (trees/ha)	Relative Density	Abundance	Percentage Frequency	Relative Frequency	Basal Area (m^2)	Relative Basal Area	Important Value Index	RIVI
1	*Pongamia pinnata*	182	21.11	2.60	3.50	12.99	0.03	0.45	34.55	11.52
2	*Terminalia arjuna*	74	8.58	1.45	2.55	9.46	0.23	3.28	21.33	7.11
3	*Mangifera indica*	48	5.57	1.45	1.65	6.12	0.21	2.91	14.60	4.87
4	*Pterocarpus marsupium*	1	0.12	1.00	0.05	0.19	0.87	12.22	12.52	4.17
5	*Alphonsea sclerocarpa*	53	6.15	3.12	0.85	3.15	0.04	0.52	9.82	3.27
6	*Ficus benghalensis*	4	0.46	1.00	0.20	0.74	0.56	7.88	9.09	3.03
7	*Syzygium cumini*	26	3.02	1.53	0.85	3.15	0.17	2.46	8.63	2.88
8	*Ficus microcarpa*	25	2.90	1.32	0.95	3.53	0.09	1.31	7.73	2.58
9	*Sapindus tetraphylla*	22	2.55	1.38	0.80	2.97	0.02	0.32	5.84	1.95
10	*Spondias pinnata*	1	0.12	1.00	0.05	0.19	0.38	5.33	5.63	1.88
11	*Lepisanthes senegalensis*	19	2.20	1.46	0.65	2.41	0.07	0.95	5.57	1.86
12	*Diospyros ebenum*	23	2.67	1.92	0.60	2.23	0.04	0.61	5.51	1.84
13	*Melia dubia*	7	0.81	1.40	0.25	0.93	0.27	3.76	5.50	1.83
14	*Psychoteris subintegra*	23	2.67	1.77	0.65	2.41	0.01	0.08	5.16	1.72
15	*Ficus racemosa*	2	0.23	1.00	0.10	0.37	0.30	4.22	4.83	1.61
16	*Mallotus philippensis*	14	1.62	1.27	0.55	2.04	0.04	0.53	4.20	1.40
17	*Jatropha spp.*	18	2.09	1.64	0.55	2.04	0.00	0.06	4.19	1.40
18	*Emblica officinalis*	1	0.12	1.00	0.05	0.19	0.28	3.88	4.18	1.39
19	*Gyrocarpus asiaticus*	13	1.51	1.44	0.45	1.67	0.05	0.77	3.95	1.32

20	*Calophyllum inophyllum*	5	0.58	1.67	0.15	0.56	0.19	2.70	3.83	1.28
21	*Albizia odoratissima*	6	0.70	1.50	0.20	0.74	0.17	2.36	3.80	1.27
22	*Schleichera oleosa*	11	1.28	1.10	0.50	1.86	0.04	0.60	3.73	1.24
23	*Albizia lebbeck*	3	0.35	1.50	0.10	0.37	0.20	2.84	3.56	1.19
24	*Manilkara hexandra*	1	0.12	1.00	0.05	0.19	0.22	3.06	3.36	1.12
25	*Artocarpus hirsutus*	10	1.16	1.25	0.40	1.48	0.04	0.57	3.21	1.07
26	*Euphorbia spp.*	14	1.62	1.75	0.40	1.48	0.01	0.08	3.19	1.06
27	*Tamarindus indica*	11	1.28	1.10	0.50	1.86	0.01	0.00	3.13	1.04
28	*Hopea parviflora*	7	0.81	1.00	0.35	1.30	0.07	0.97	3.08	1.03
29	*Dalbergia latifolia*	10	1.16	2.00	0.25	0.93	0.05	0.75	2.84	0.95
30	*Garuga floribunda*	5	0.58	1.00	0.25	0.93	0.09	1.33	2.84	0.95
31	*Cassia fistula*	9	1.04	1.50	0.30	1.11	0.05	0.67	2.82	0.94
32	*Chloroxylon swietenia*	2	0.23	1.00	0.10	0.37	0.15	2.08	2.68	0.89
33	*Commiphora caudata*	10	1.16	1.67	0.30	1.11	0.03	0.39	2.66	0.89
34	*Gmelina arborea*	10	1.16	2.00	0.25	0.93	0.04	0.57	2.65	0.88
35	*Garcinia gummi-gutta*	7	0.81	1.17	0.30	1.11	0.05	0.65	2.57	0.86
36	*Ceiba pentandra*	2	0.23	2.00	0.05	0.19	0.15	2.08	2.49	0.83
37	*Bauhinia racemosa*	6	0.70	1.50	0.20	0.74	0.06	0.87	2.31	0.77
38	*Stereospermum chelonoides*	5	0.58	1.25	0.20	0.74	0.07	0.97	2.29	0.76
39	*Albizia procera*	6	0.70	1.20	0.25	0.93	0.04	0.58	2.21	0.74
40	*Canarium strictum*	5	0.58	1.00	0.25	0.93	0.05	0.67	2.17	0.72
41	*Vitex altissima*	3	0.35	3.00	0.05	0.19	0.11	1.59	2.12	0.71
42	*Cassine paniculata*	6	0.70	1.50	0.20	0.74	0.05	0.68	2.12	0.71
43	*Anthocephalus cadamba*	1	0.12	1.00	0.05	0.19	0.13	1.78	2.08	0.69
44	unidentified 2	4	0.46	1.00	0.20	0.74	0.06	0.87	2.08	0.69
45	*Santalum album*	7	0.81	1.17	0.30	1.11	0.01	0.15	2.07	0.69
46	*Olea dioica*	5	0.58	1.25	0.20	0.74	0.05	0.67	1.99	0.66
47	*Phyllanthus emblica*	5	0.58	1.25	0.20	0.74	0.04	0.61	1.94	0.65

48	*Garuga pinnata*	8	0.93	2.00	0.20	0.74	0.02	0.26	1.93	0.64
49	*Randia dumetorum*	6	0.70	1.00	0.30	1.11	0.01	0.08	1.89	0.63
50	*Acacia leucophloea*	6	0.70	2.00	0.15	0.56	0.04	0.63	1.88	0.63
51	*Strychnus nux-vomica*	5	0.58	1.25	0.20	0.74	0.04	0.53	1.86	0.62
52	*Drypetes sepiaria*	5	0.58	1.25	0.20	0.74	0.04	0.50	1.83	0.61
53	*Strychnos potatorum*	5	0.58	1.25	0.20	0.74	0.03	0.45	1.77	0.59
54	*Ficus albiphyla*	1	0.12	1.00	0.05	0.19	0.10	1.46	1.76	0.59
55	*Anogeissus latifolia*	6	0.70	2.00	0.15	0.56	0.03	0.38	1.63	0.54
56	*Azadirachta indica*	4	0.46	1.00	0.20	0.74	0.02	0.30	1.51	0.50
57	*Ixora brachiata*	4	0.46	1.00	0.20	0.74	0.02	0.25	1.45	0.48
58	*Mitragyna parvifolia*	3	0.35	1.00	0.15	0.56	0.03	0.47	1.38	0.46
59	*Memecylon umbellatum*	2	0.23	1.00	0.10	0.37	0.05	0.77	1.38	0.46
60	*Ficus spp.*	2	0.23	1.00	0.10	0.37	0.05	0.74	1.34	0.45
61	unidentified 8	5	0.58	1.25	0.20	0.74	0.03	0.01	1.33	0.44
62	*Excoecaria oppositifolia*	2	0.23	1.00	0.10	0.37	0.05	0.70	1.30	0.43
63	*Mallottus alba*	5	0.58	2.50	0.10	0.37	0.02	0.34	1.29	0.43
64	*Streblus asper*	4	0.46	1.33	0.15	0.56	0.01	0.18	1.20	0.40
65	*Aporosa cardiosperma*	1	0.12	1.00	0.05	0.19	0.06	0.85	1.15	0.38
66	*Acacia nilotica*	2	0.23	1.00	0.10	0.37	0.04	0.52	1.12	0.37
67	*Ziziphus oenoplia*	4	0.46	1.33	0.15	0.56	0.01	0.09	1.11	0.37
68	*Canthium umbellatum*	5	0.58	2.50	0.10	0.37	0.01	0.15	1.10	0.37
69	*Crotalaria pellida*	2	0.23	1.00	0.10	0.37	0.03	0.47	1.08	0.36
70	*Holigarna arnotiana*	1	0.12	1.00	0.05	0.19	0.05	0.75	1.06	0.35
71	unidentified 4	4	0.46	2.00	0.10	0.37	0.01	0.20	1.03	0.34
72	*Ziziphus xylopyrus*	1	0.12	1.00	0.05	0.19	0.05	0.70	1.00	0.33
73	*Manilkara roxburghiana*	2	0.23	1.00	0.10	0.37	0.02	0.35	0.95	0.32
74	*Grewia tiliifolia*	1	0.12	1.00	0.05	0.19	0.04	0.63	0.93	0.31
75	*Alseodaphnae semecarpifolia*	2	0.23	1.00	0.10	0.37	0.02	0.32	0.92	0.31

76	*Miliusa tomentosa*	1	0.12	1.00	0.05	0.19	0.04	0.58	0.88	0.29
77	unidentified 6	3	0.35	1.50	0.10	0.37	0.01	0.14	0.86	0.29
78	*Canthium dicoccum*	2	0.23	1.00	0.10	0.37	0.02	0.25	0.85	0.28
79	unidentified 1	1	0.12	1.00	0.05	0.19	0.03	0.47	0.78	0.26
80	*Plumeria alba*	1	0.12	1.00	0.05	0.19	0.03	0.47	0.78	0.26
81	*Sapindus trifoliatus*	2	0.23	1.00	0.10	0.37	0.01	0.17	0.77	0.26
82	*Ziziphus mauritiana*	2	0.23	1.00	0.10	0.37	0.01	0.15	0.76	0.25
83	*Helicteres isora*	3	0.35	1.50	0.10	0.37	0.002	0.03	0.75	0.25
84	*Lepisanthes tetraphylla*	2	0.23	1.00	0.10	0.37	0.01	0.14	0.74	0.25
85	*Bamboo spp.*	2	0.23	1.00	0.10	0.37	0.01	0.12	0.73	0.24
86	*Euphorbia trigona*	2	0.23	1.00	0.10	0.37	0.01	0.12	0.73	0.24
87	unidentified 3	3	0.35	3.00	0.05	0.19	0.01	0.17	0.70	0.23
88	*Terminalia paniculata*	1	0.12	1.00	0.05	0.19	0.03	0.38	0.68	0.23
89	unidentified 5	1	0.12	1.00	0.05	0.19	0.03	0.38	0.68	0.23
90	*Ailanthus triphysa*	1	0.12	1.00	0.05	0.19	0.02	0.23	0.53	0.18
91	*Acacia intsia*	1	0.12	1.00	0.05	0.19	0.01	0.15	0.46	0.15
92	*Ficus hispida*	1	0.12	1.00	0.05	0.19	0.01	0.14	0.44	0.15
93	*Acacia catechu*	1	0.12	1.00	0.05	0.19	0.01	0.09	0.39	0.13
94	unidentified 7	1	0.12	1.00	0.05	0.19	0.006	0.06	0.37	0.12
95	*Chukrasia tabularis*	1	0.12	1.00	0.05	0.19	0.001	0.02	0.32	0.11

4.6 REDUNDANCY ANALYSIS

To understand if there is any relationship between the Grizzled Giant Squirrel interaction, here number of times the animal was sighted and duration for which the animal was seen on a particular tree species and seven quantitative variables for plant density and characters, Redundancy Analysis (RDA) was performed in freeware BiPlot. Number of times the animal sighted on a particular tree species was positively correlated with the second canonical axis while the duration was correlated with the first canonical axis (Fig. 32, Appendix 3). All the seven quantitative variables for plant density and characters were strongly positively correlated with the second axis (Figure 32, Appendix 3). Therefore it can be said that the number of times the animal was sighted is positively correlated with all the quantitative variables for plant density and characters while these variables had no effect on the duration for which the animal was sighted.

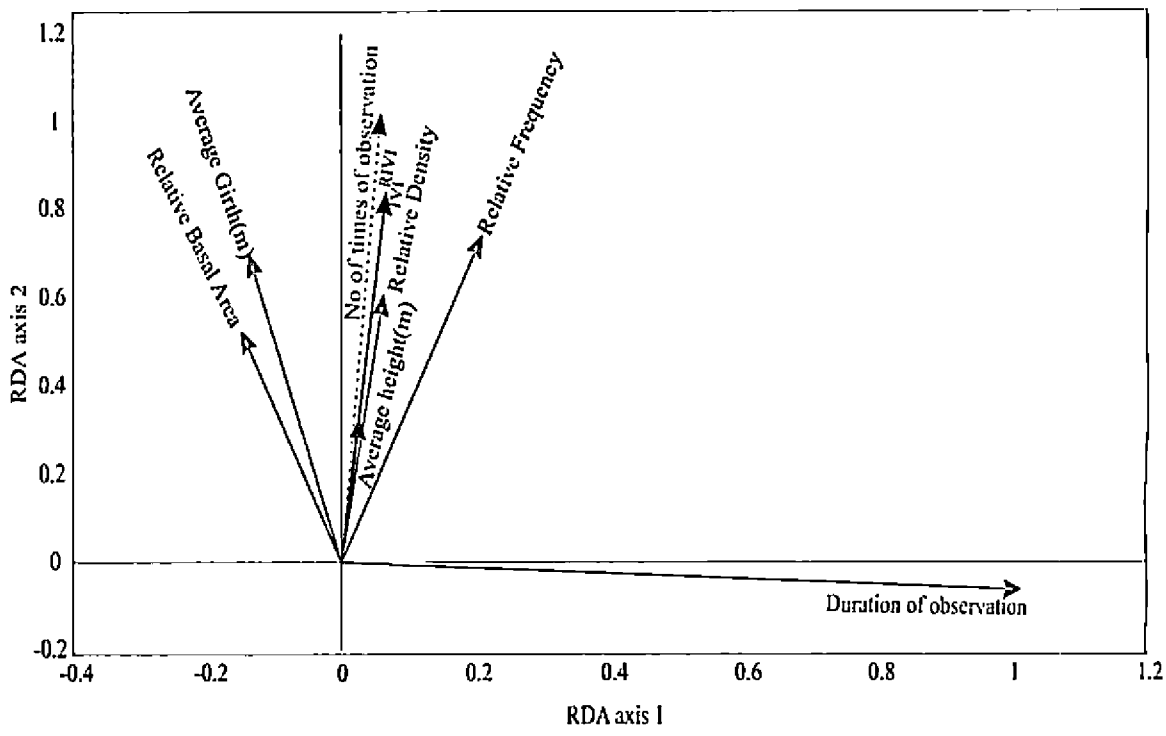


Figure 32. The correlation between the Grizzled Giant Squirrel interaction with tree species and their quantitative measurements.

4.7 DISTRIBUTION AND POPULATION DENSITY

4.7.1 Distribution pattern and total count of the Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary

Mapped the distribution of Grizzled Giant Squirrel based on the presence and/or absence of squirrel's direct sightings (Plate 6a) and their nests, by walking along five transects laid across the sanctuary. The major habitat was the riverine forests along the Chinnar and Pambar river and their tributaries. The riverine or the riparian or the gallery forests are quite distinct and conspicuous among the surrounding scrub jungle and dry deciduous forests of Chinnar Wildlife Sanctuary. Five transects selected for the present study were Kootar, Churulipetty, Athiyoda, Chambakkadu and Alampetty.

The population of the Grizzled Giant Squirrel estimated using the total count method is presented in Table 23. The study revealed that maximum number of individuals is at Alampetty, followed by Churulipetty, Kootar, Chambakkadu and Athiyoda. From Chambakkadu only four individuals were sighted and all these four individuals were observed in a single instance in the month of May 2014. The average number of Grizzled Giant Squirrel varied between six to 17 animals across the various months during the study period (Table 23). The maximum number of Grizzled Giant Squirrel was sighted in the month of February and May 2014, when 17 Grizzled Giant Squirrel were sighted from the whole of Chinnar, which was followed by 16 Grizzled Giant Squirrel in September 2013. The average number of Grizzled Giant Squirrel sighted from Chinnar between the various months during the study period varied between1.2 to 3.4, between February, May and September months reporting maximum number of Grizzled Giant Squirrel (Table 23).

Between the various transects, maximum number of Grizzled Giant Squirrel were sighted at Alampetty reporting a maximum of 8 animals in September 2013 and the average Grizzled Giant Squirrel across the months from Alampetty to be 4.1. This was followed by Kootar (7, 2.7) and Churulipetty (6, 3). The average number of Grizzled Giant Squirrel that could be found is 10.5 squirrels at a single visit (Table 23).

Table 23. The population estimate by total count of Grizzled Giant Squirrel at different locations at Chinnar Wildlife Sanctuary

Place	Number of individual sighted in each month										
	April, 2013	August, 2013	September, 2013	October, 2013	November, 2013	December, 2013	January, 2014	February, 2014	March, 2014	May, 2014	Average/place
Alampetty	1	2	8	2	5	3	4	7	2	7	4.1
Churulipetty	3	3	6	3	0	2	1	6	2	4	3
Kootar	4	1	1	1	4	1	3	4	7	1	2.7
Chambakkad	0	0	0	0	0	0	0	0	0	4	0.4
Athiyoda	0	0	1	0	0	0	0	0	1	1	0.3
Monthly average	1.6	1.2	3.2	1.2	1.8	1.2	1.6	3.4	2.4	3.4	**10.5**

4.7.2 Population density of Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary

A total of 85 group sightings (Plate 6b) of Grizzled Giant Squirrel were made, account for 105 individuals with a mean group size of 0.21 squirrels sighting across 400 km, amounting to density of individuals 15.26 ± 2.96 squirrels/km^2 (Lower Confidence Limit 10.45 squirrels/km^2 and Upper Confidence Limit 22.30 squirrels/km^2) (Table 24). But the effective strip width according to the present study comes to only 40m. And the effective habitat for the Grizzled Giant Squirrel has been estimated to be 1.6km^2 [40m (average width of the riverine vegetation) x 40000m (total length of the river, estimated using QGIs)]. Accordingly the population estimate of the Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary during the present study comes to 1.6 x 15.26 = 24.416 animals. The lower density limit would be 10.45 x = 16.72 and the upper density limit would be 35.68. The probability detection function is shown in (Fig. 33).

Table 24. Density of Grizzled Giant Squirrel estimated in Chinnar Wildlife Sanctuary using DISTANCE software.

Parameters	Values
Effort (distance in km)	400 km
Number of cluster (group) detections (n)	85
Encounter rate (squirrel clusters/km)	0.21
Model selected	Hazard Rate
Minimum Akaike Information Criteria	457.07
Squirrel density / km^2 ± Standard Error	15.26 ± 2.96
Squirrel density 95% Confidence Interval, lower limit-upper limit	10.45 ± 22.30

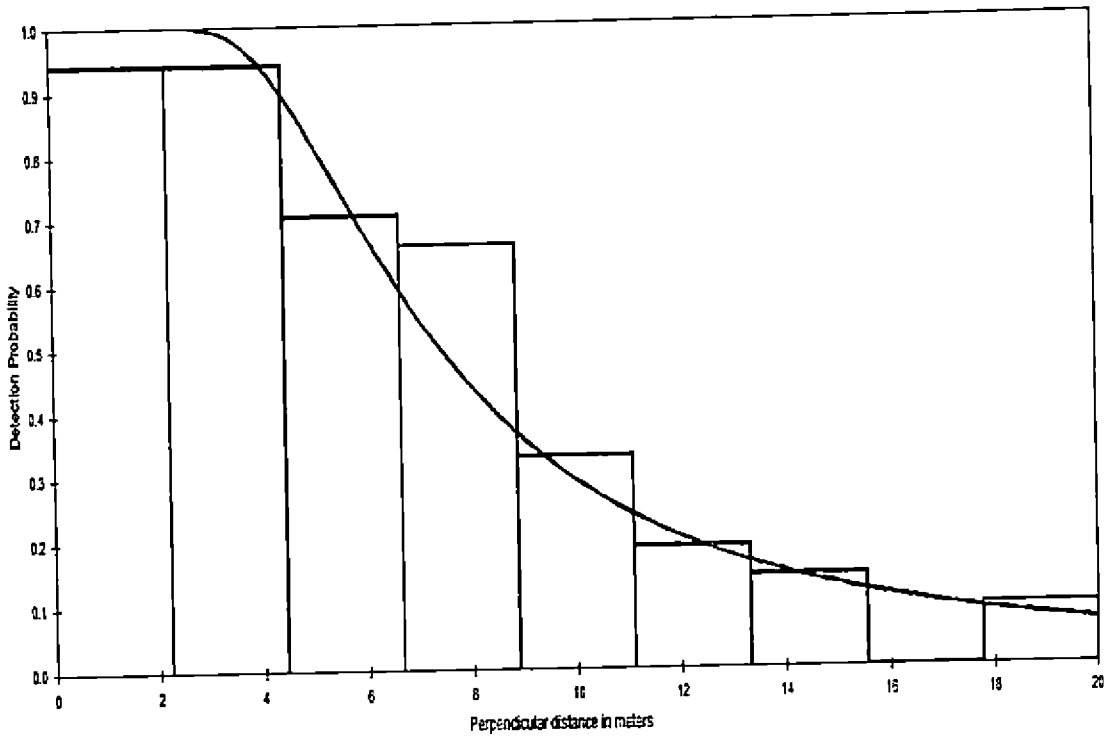


Figure 33. Detection probability curve and effective strip width of Grizzled Giant Squirrel habitat in Chinnar Wildlife Sanctuary

4.7.3 Estimation of the Grizzled Giant Squirrel population by counting the drey

The drey, the nest of the squirrel, details are regarded as a measure for the presence of the squirrels in a particular area (Plate 6c). Most of the dreys were located at Alampetty followed by Churulipetty, Athiyoda, Chambakkadu and Kootar (Table 25). It is interesting to note that the maximum number of drey as well as the maximum number of squirrels was seen from Alampetty. Phillips (1981) and Borges (2014) have reported that one squirrel on an average makes about four to five dreys. Going by that logic, the Alampetty would have about 11 squirrels (Table 24) and accordingly there could be a total of 23.4 Grizzled Giant squirrels at Chinnar Wildlife Sanctuary.

Table 25. Total number of dreys observed during the study period from different study locations.

Sl. No.	Place	Number of dreys	Estimated number of Grizzled Giant Squirrel(number of dreys/5)
1.	Alampetty	56	11.2
2.	Churulipetty	20	4.0
3.	Athiyoda	20	4.0
4.	Chambakkadu	14	2.8
5.	Kootar	7	1.4
Total		**117**	**23.4**

Table 26. Comparison of population estmates by different methods

Sl. No.	Method	Population size
1	Total count	10.5 squirrels
2	Density method	24.42 squirrels
3	Drey count	23.4 squirrels

The total count found to be not an effective method for estimating the population of Grizzled Giant Squirrel and based on the other two methods the population of Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary was found to be between 30 to 35 squirrels.

4.7.4 Tree preference for the dreys of the Grizzled Giant Squirrels at Chinnar Wildlife Sanctuary

The Grizzled Giant Squirrels were found using about 36 trees in Chinnar Wildlife Sanctuary. The details of those trees are given in Table 27. A total of 144 drey were found during the study period from entire Chinnar Wildlife Sanctuary. Most of the dreys were located on the trees such as *Mangifera indica* (19) followed by *Terminalia arjuna* (18), *Ficus microcarpa* (16), *Diospyros ebenum* (14), and *Pongamia pinnata* (12). This accounted for 54.86 % of the total dreys of Grizzled Giant Squirrel. One common character of all these highly preferred tree species is that all of them are evergreen trees. The tree species preference by Grizzled Giant Squirrel for drey construction was found higher for the evergreen trees (73.61%) than that of the deciduous trees (26.39%).Among the 36 tree species preferred for drey construction by the Grizzled Giant Squirrel, 20 species were evergreen species and 16 were deciduous species.

Table 27. Tree preference by Grizzled Giant Squirrel for drey construction at Chinnar Wildlife Sanctuary

Sl. No	Species	Number of drey	Habit	Family
1.	*Mangifera indica*	19	Evergreen	Anacardiaceae
2.	*Terminalia arjuna*	18	Evergreen	Combretaceae
3.	*Ficus microcarpa*	16	Evergreen	Moraceae
4.	*Diospyros ebenum*	14	Evergreen	Ebenaceae
5.	*Pongamia pinnata*	12	Evergreen	Fabaceae/leguminosae
6.	*Syzygium cumini*	8	Evergreen	Myrtaceae
7.	*Alphonsea sclerocarpa*	5	Deciduous	Annonaceae
8.	*Albizia lebbeck*	5	Deciduous	Fabaceae
9.	*Mitragyna parviflora*	5	Deciduous	Rubiaceae
10.	*Albizia procera*	4	Deciduous	Fabaceae
11.	*Tamarindus indica*	3	Evergreen	Fabaceae
12.	*Melia dubia*	3	Deciduous	Meliaceae
13.	*Ficus racemosa*	3	Evergreen	Moraceae
14.	*Vateria indica*	2	Evergreen	Dipterocarpaceae
15.	*Acacia ferruginea*	2	Deciduous	Fabaceae
16.	*Acacia nilotica*	2	Deciduous	Fabaceae
17.	*Gyrocarpus asiaticus*	2	Deciduous	Hernandiaceae

18.	*Holoptelea integrifolia*	2	Deciduous	Ulmaceae
19.	*Premna wightiana*	2	Deciduous	Verbenaceae
20.	*Schifflera wallichiana*	1	Evergreen	Araliaceae
21.	*Tetrameles nudiflora*	1	Deciduous	Datiscaceae
22.	*Hopea parviflora*	1	Evergreen	Dipterocarpaceae
23.	*Acacia leucophloea*	1	Deciduous	Fabaceae
24.	*Dalbergia latifolia*	1	Deciduous	Fabaceae
25.	*Pterocarpus marsupium*	1	Deciduous	Fabaceae
26.	*Scolopia crenata*	1	Evergreen	Flacourtiaceae
27.	*Calophyllum inophyllum*	1	Evergreen	Guttiferae
28.	*Garcinia gummi-gutta*	1	Evergreen	Guttiferae
29.	*Tectona grandis*	1	Deciduous	Lamiaceae
30.	*Memecylon grande*	1	Evergreen	Melastomataceae
31.	*Walsura trifolia*	1	Evergreen	Meliaceae
32.	*Ficus benghalensis*	1	Evergreen	Moraceae
33.	*Psychotria subintegra*	1	Evergreen	Rubiaceae
34.	*Sapindus trifoliatus*	1	Evergreen	Sapindaceae
35.	*Schleichera oleosa*	1	Deciduous	Sapindaceae
36.	*Sterculia guttata*	1	Evergreen	Sterculiaceae

Association between the tree species used for the drey construction at different study locations

χ^2 test was conducted to find out the association between tree species used for drey building and different locations in Chinnar Wildlife Sanctuary. It was observed that there was a significant association between plant species used for drey building at different locations in Chinnar Wildlife Sanctuary ($\chi^2 = 431.6$, df = 242, $p < 0.001$). As the χ^2 test found significant for the association between tree species preference and different locations, correspondence analysis was done. The results of the correspondence analysis indicated that at Palapetty the tree species used for the drey construction were quite distinct from the tree species used for drey construction at other locations (Fig. 34). The species trees used for drey construction at Palapetty such as *Memecylon grande*, *Ficus benghalensis*, *Dalbergia latifolia* and *Sterculia guttata*, were unique to this location could not be found in other places. Another feature of the habitat at the Palapetty in this place the Grizzled Giant Squirrel was sighted in the riverine patches of tributaries of Pambar river. Moreover, at Palapetty the habitat surrounding

patch was dry deciduous forests, while at all other sites the habitat surrounding the riverine patches were scrub jungle.

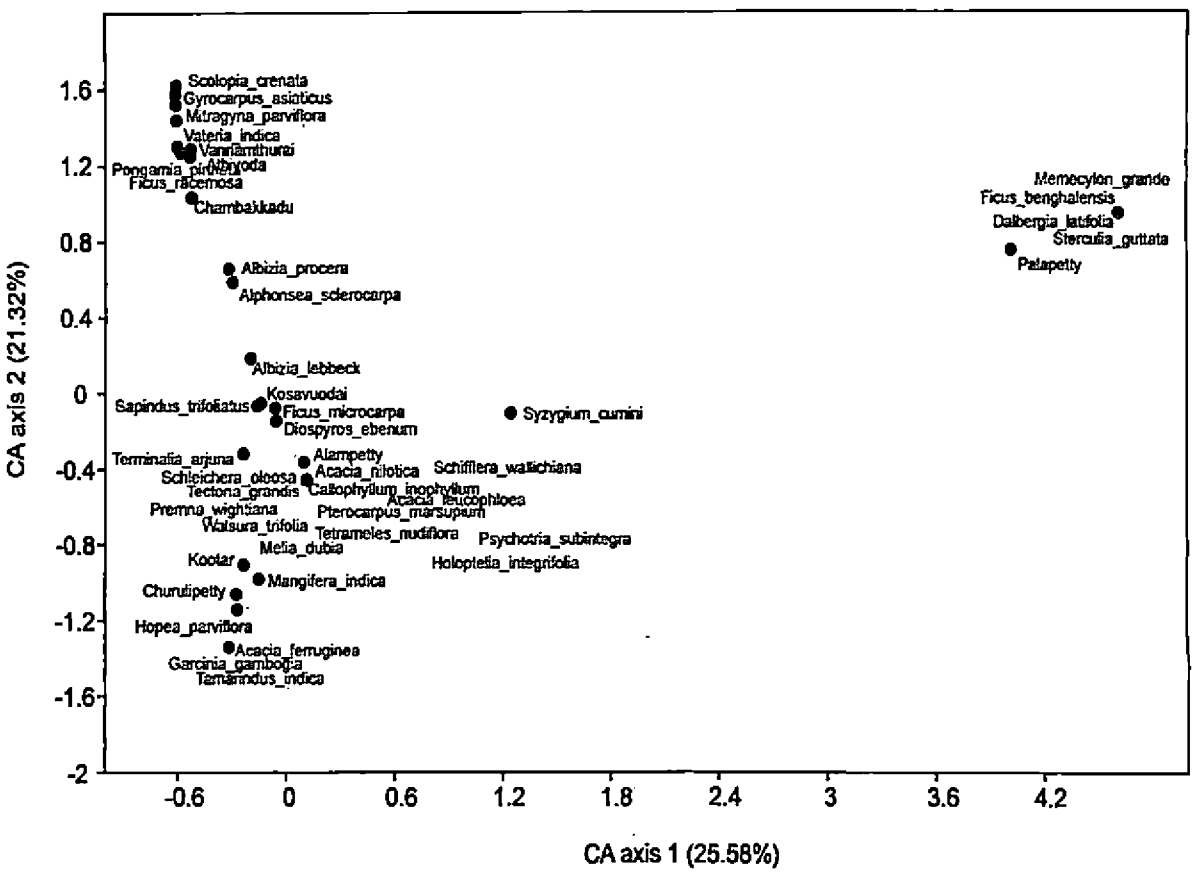


Figure 34. Preference of different tree species by Grizzled Giant Squirrel at different study locations for drey construction.

Relationship between the height of the tree species and the height of the drey in Chinnar Wildlife Sanctuary

To find out the relationship between the height of the tree species and the height at which the drey was located in Chinnar Wildlife Sanctuary, a linear regression model was drawn (Fig. 35). This analysis clearly showed a strong correlation between the height of the tree and the height at which the drey was constructed ($R = 0.9483$, $P < 0.0001$). The slope of the graph (0.8771) showed that the dreys are not made at the top of the tree, but the squirrel preferred to build the drey at a height which is about 88% of actual height of the tree. It can also be deduced from this graph that the Grizzled Giant Squirrels showed a high range of variation in the height of the trees used for the construction of the dreys,

which varied from 5m to 30m (Fig. 35), with most of the drey height being between 15 to 20m. However, it is interesting to note that the drey height selection is influenced by the tree height in the respective habitat (Table 28, Fig. 36a and 36b).

Table 28. The height of the tree and height of the drey at different study locations

Number of drey	Tree species	Location	Height (m)	Height of Drey(m)
1	*Acacia ferruginea*	Churulipetti	16	14
1	*Acacia ferruginea*	Churulipetti	21	19
1	*Acacia leucophloea*	Alampetty	8	7
2	*Acacia nilotica*	Alampetty	5	4
1	*Albizia lebbeck*	Athiyoda	15	14
1	*Albizia lebbeck*	Alampetty	13	11
2	*Albizia procera*	Athiyoda	8	7
1	*Albizia procera*	Alampetty	8	7
3	*Alphonsea sclerocarpa*	Chambakkadu	17	16
1	*Alphonsea sclerocarpa*	Athiyoda	7	6
1	*Alphonsea sclerocarpa*	Alampetty	11	10
1	*Alphonsea sclerocarpa*	Alampetty	12	11
1	*Callophyllum inophyllum*	Alampetty	18	14
1	*Diospyros ebenum*	Athiyoda	12	10
1	*Diospyros ebenum*	Alampetty	14	13
2	*Diospyros ebenum*	Alampetty	12	11
3	*Diospyros ebenum*	Alampetty	14	13
1	*Diospyros ebenum*	Alampetty	14	11
1	*Ficus microcarpa*	Athiyoda	26	23
1	*Ficus microcarpa*	Alampetty	16	14
1	*Ficus microcarpa*	Alampetty	18	16
1	*Ficus microcarpa*	Alampetty	16	13
2	*Ficus microcarpa*	Alampetty	12	10
3	*Ficus microcarpa*	Alampetty	12	9
1	*Ficus microcarpa*	Alampetty	12	10
3	*Ficus racemosa*	Chambakkadu	18	17
1	*Garcinia gambogia*	Churulipetti	16	15
2	*Gyrocarpus asiaticus*	Athiyoda	14	12
1	*Holoptelia integrifolia*	Alampetty	16	14

1	*Holoptelia integrifolia*	Alampetty	14	13
1	*Hopea parviflora*	Kootar	18	9
1	*Mangifera indica*	Kootar	22	13
1	*Mangifera indica*	Kootar	14	11
1	*Mangifera indica*	Kootar	16	8
1	*Mangifera indica*	Churulipetti	27	22
1	*Mangifera indica*	Churulipetti	27	24
1	*Mangifera indica*	Churulipetti	35	31
3	*Mangifera indica*	Churulipetti	18	16
1	*Mangifera indica*	Churulipetti	38	34
1	*Mangifera indica*	Churulipetti	22	20
1	*Mangifera indica*	Churulipetti	22	17
1	*Mangifera indica*	Alampetty	22	21
2	*Mangifera indica*	Alampetty	16	13
1	*Mangifera indica*	Alampetty	19	17
2	*Mangifera indica*	Alampetty	23	22
1	*Mangifera indica*	Alampetty	23	21
2	*Melia dubia*	Alampetty	14	13
1	*Melia dubia*	Alampetty	16	13
1	*Mitragyna parviflora*	Chambakkadu	14	12
1	*Mitragyna parviflora*	Athiyoda	8	6
3	*Mitragyna parviflora*	Athiyoda	11	9
1	*Pongamia pinnata*	Churulipetti	15	14
2	*Pongamia pinnata*	Chambakkadu	16	15
1	*Pongamia pinnata*	Chambakkadu	16	13
1	*Pongamia pinnata*	Athiyoda	9	7
4	*Pongamia pinnata*	Athiyoda	12	10
1	*Pongamia pinnata*	Athiyoda	13	11
1	*Prèmna wightiana*	Alampetty	17	16
1	*Premna wightiana*	Alampetty	7	6
1	*Psychotria subintegra*	Alampetty	8	6
1	*Pterocarpus marsupium*	Alampetty	20	19
1	*Schifflera wallichiana*	Alampetty	17	16
1	*Schleichera oleosa*	Alampetty	16	13
2	*Syzygium cumini*	Alampetty	14	12
1	*Syzygium cumini*	Alampetty	10	9
1	*Syzygium cumini*	Alampetty	11	9
1	*Syzygium cumini*	Alampetty	12	11
1	*Syzygium cumini*	Alampetty	16	14
3	*Tamarindus indica*	Churulipetti	18	16
1	*Tectona grandis*	Alampetty	14	12
1	*Terminalia arjuna*	Kootar	30	22

1	*Terminalia arjuna*	Kootar	16	8
1	*Terminalia arjuna*	Kootar	20	14
1	*Terminalia arjuna*	Churulipetti	13	12
1	*Terminalia arjuna*	Churulipetti	26	23
1	*Terminalia arjuna*	Churulipetti	27	25
1	*Terminalia arjuna*	Churulipetti	23	21
3	*Terminalia arjuna*	Chambakkadu	24	21
1	*Terminalia arjuna*	Athiyoda	21	19
2	*Terminalia arjuna*	Alampetty	12	11
3	*Terminalia arjuna*	Alampetty	18	12
1	*Tetrameles nudiflora*	Alampetty	6	5
1	*Vateria indica*	Chambakkadu	16	13
1	*Vateria indica*	Athiyoda	14	12
1	*Walsura trifolia*	Alampetty	14	12

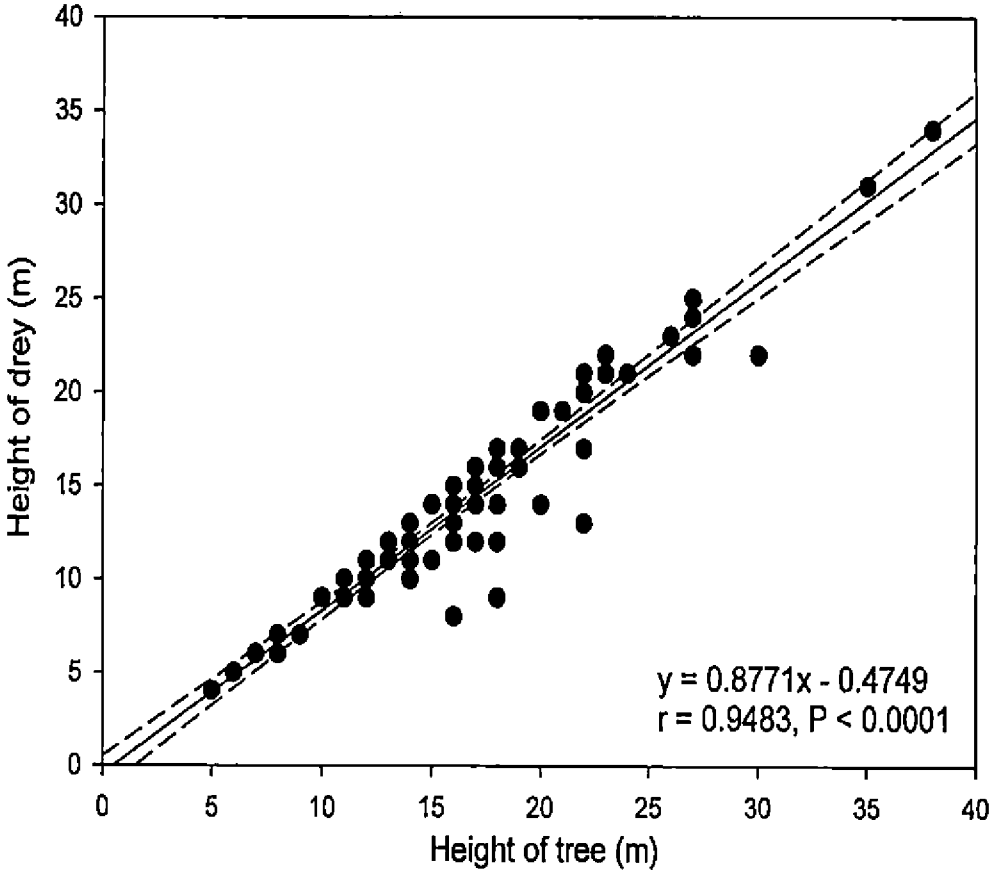


Figure 35. Linear regresion model for comparison between height of the drey and height of the tree

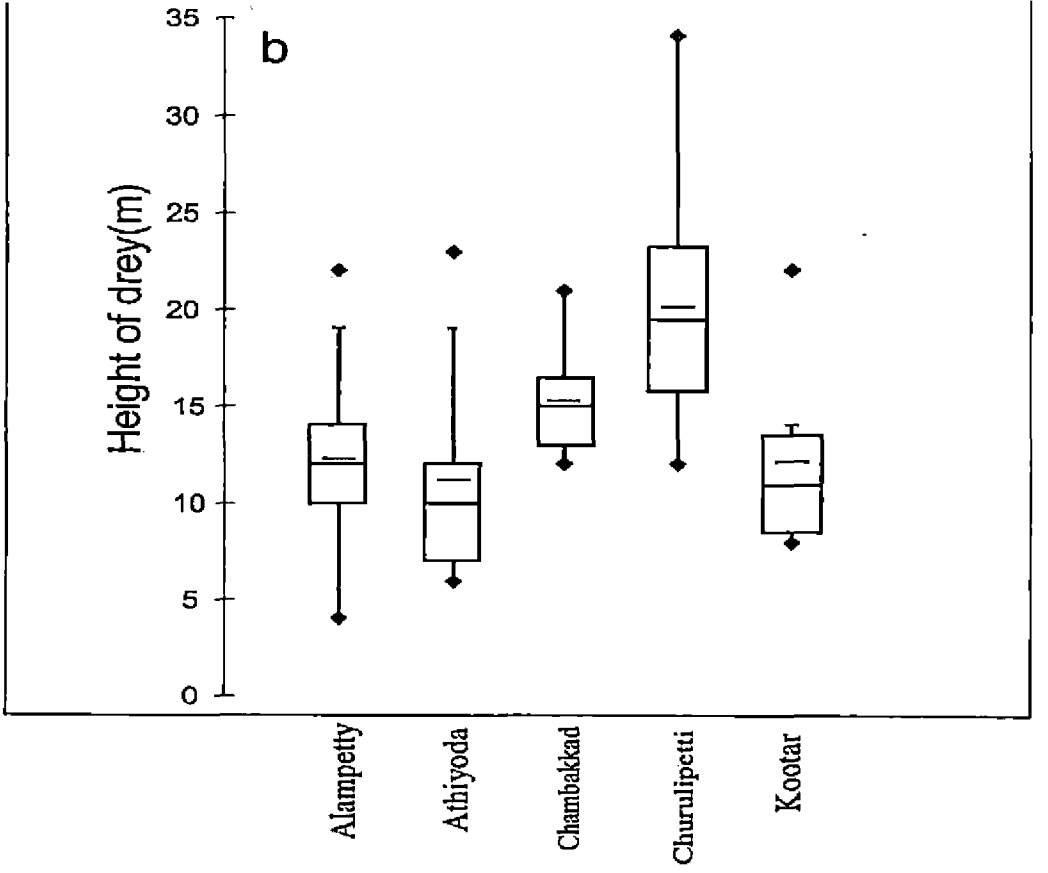
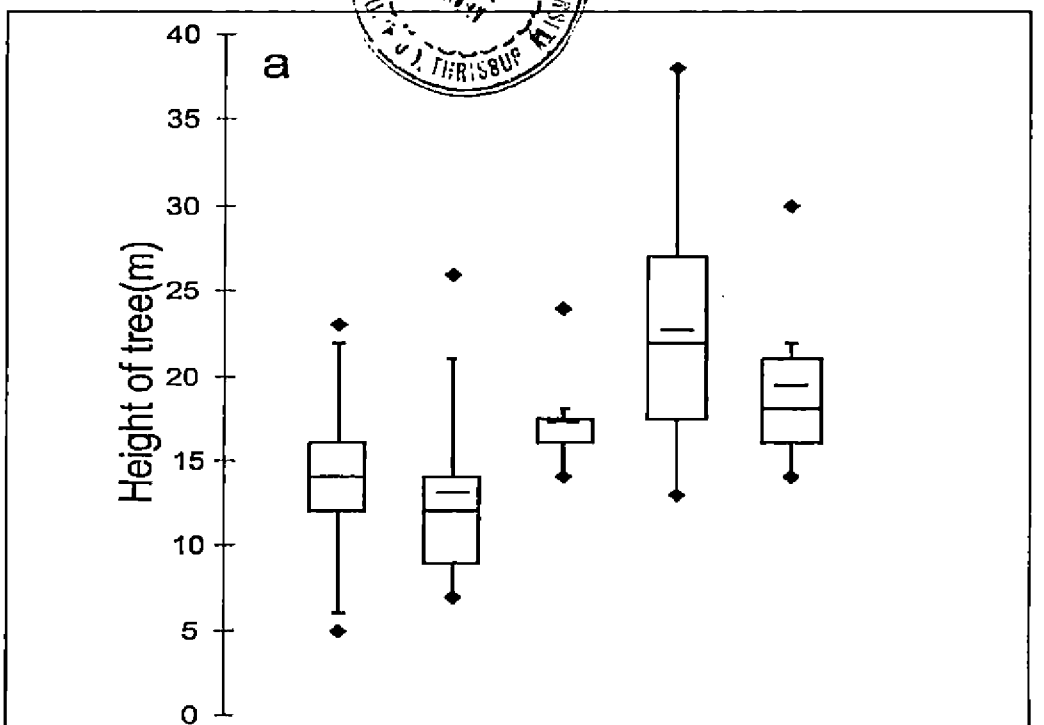


Figure (36a) Place vs height of tree (36b) Place vs height of drey



4.8 THREATS TO GRIZZLED GIANT SQUIRREL

The anthropogenic disturbance, habitat loss, increased predation and interbreeding between the Grizzled Giant Squirrel and Malabar Giant Squirrel are found to be the major threats for the Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary.

During the study period the predation on Grizzled Giant Squirrel by Changeable Hawk eagle (*Nisaetus cirrhatus*) was observed. The incidence was on Chinnar to Churulipetty transect on a *Schleichera oleosa* tree at a height of 14 meter. The time was around 9.17 am at an altitude of 445 meters. The eagle was found feeding on the carcass on a branch. The carcass was collected and extends possible the measures were taken. The individual was a female having 45 cm of tail length, 29 m of head to tail length, hind foot of 7.5 cm and pinnae of 3 cm. The carcass assumes to be one day old. The occurrence of new predators may be due to the opening up in the canopy.

DISCUSSION

DISCUSSION

5.1 FEEDING ECOLOGY

5.1.1 Feeding technique

The mouth and fore limbs are the organs helps in manipulating the food article while hind limbs and tail plays roles as supporting organs for body balancing during the course of feeding (Plate 5). All the three feeding postures such as sitting, hanging and clinging postures, were found to be effectively used by the animal for feeding. This was found according to the availability and nature of food article foraged. Similar feeding postures were reported by Ramachandran (1992) on Malabar Giant Squirrels.

5.1.2 Food composition

During the present study it was observed that Grizzled Giant Squirrel fed on food article from 30 different species of plants including 22 tree species and eight species of climbers, lianas, paraphytes, shrubs and cacti in Chinnar Wildlife Sanctuary. Senthilkumar *et al.* (2007), however reported only 21 tree species fed by the Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary. According to them the most preferred species by the Grizzled Giant Squirrels were *Tamarindus indica*, *Pleostylia opposita*, *Strychnos potatorum* and *Terminalia arjuna*. While in the present study the preferred tree species used by Grizzled Giant Squirrel were *Bauhinia racemosa, Strychnos potatorum, Tamarindus indica, Terminalia arjuna, Diplocyclos palmatus, Ficus albiphyla, Melia dubia, Syzygium cumini* and *Albizia lebbeck*. They were primarily feeding on the tender leaves, flowers, bark and seed of these plants. While in the earlier studies there have not been any mention on the plant or plant parts being fed by the Grizzled Giant Squirrel, in the present study I have reported the Grizzled Giant Squirrel using eight species of lianas, climbers, shrub and even one cactus (Plate 6). The squirrels were observed to feed on tender leaves and flowers of the plant species such as *Derris brevipes* and *Diplocyclos palmatus*, (climbers), *Entada rheedii* (liana), *Hibiscus rosa-chinensis* (shrub) and *Euphorbia trigona* (cactus). Joshua

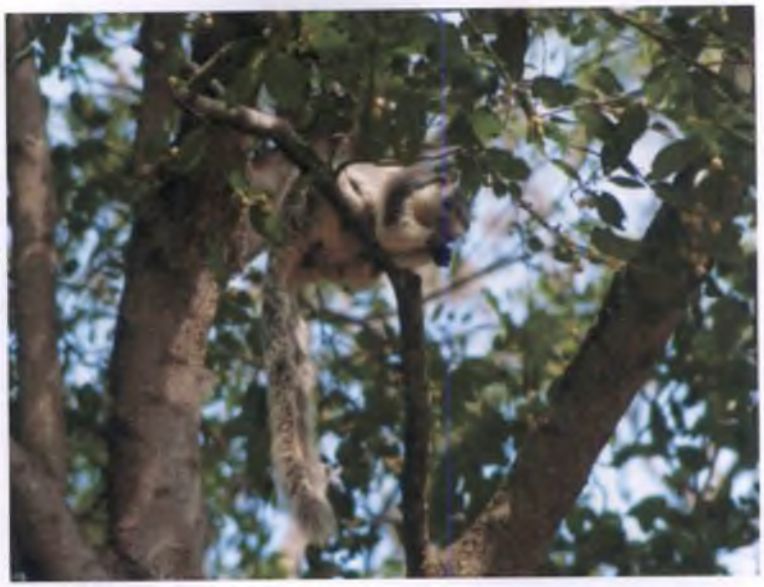


Plate 5a. Grizzled Giant Squirrel feeding on *Strychnos potatorum*

Plate 5b. A young one snatching food from its mother while feeding on *Bauhinia racemosa*

Plate 5c.Two individuals found feeding together on *Terminalia arjuna*.

Plate 5d. Grizzled Giant Squirrel feeding on *Cassia fistula* bark

Plate 6a. *Bauhinia racemosa* pod and remnants after feeding by Grizzled Giant Squirrel

Plate 6b. Remnants of *Euphorbia trigona* after feeding by Grizzled Giant Squirrel

Plate 6c. Remnants of *Terminalia arjuna* fruits after feeding by Grizzled Giant Squirrel

Plate 6d. Remnants of *Syzigium cumini* fruits after feeding by Grizzled Giant Squirrel

Plate 6e. Remnants of *Macrosolon capitellatus* seeds after feeding by Grizzled Giant Squirrel

Plate 6f. Remnants of *Nothopegia beddomei* fruits after feeding by Grizzled Giant Squirrel

Plate 6g. Fed Leaves of *Melia dubia* by Grizzled Giant Squirrel

Plate 6h. Bark and sap of *Commiphora caudata* fed by Grizzled Giant Squirrel

Plate 6i. *Diplocyclos palmatus* whose leaves are fed by Grizzled Giant Squirrel

(1992), as well as Vanitharani and Bharathi (2011) reported that the Grizzled Giant Squirrel fed on the tender leaves and flowers of *Tamarindus indica* and *Bauhinia purpurea.*

Optimal foraging theory proposed by Pyke (1984) suggests that a forager should eat only the most preferred or highest ranked item if there is enough amount of that item to fulfill its daily diet requirements. As the highly preferred food item is depleted, the forager should include the next ranked item in its diet. The percentage contribution of each article based on the duration of feeding shown a trend as maximum by the seeds (59%), followed by leaves (32%), flower (6%) and sap (3%). This indicates that the animal is basically a seed feeder, switching over to leafy food items, flower and sap when seeds are not available.

Ripe fruit pulp of *Mangifera indica, Artocarpus spp.,* and *Ficus spp.* are most significant contributors to the diet of *R. macroura* at Srivalliputhur Grizzled Giant Squirrel Sanctuary (Vanitharani and Bharathi, 2011). Unlike the above observations the present study did not make any observation on the feeding of fruit pulp by the Grizzled Giant Squirrel from Chinnar Wildlife Sanctuary. However, the present observation corroborates the findings of Thorington and Cifelli (1989) on *R. indica* at Mudumalai Wildlife Sanctuary and Ramachandran (1992) at Periyar, Parambikulam and Silent Valley that the *R. indica* did not feed on fruit pulp. According to Vanitharani and Bharathi (2011) the Grizzled Giant Squirrel (*Ratufa macroura*) played an important role as a seed disperser to their foraging trees *via* dropping seeds as they cruise over the canopy. In the present study also the Grizzled Giant Squirrel at Chinnar acts as an important seed dispersing agent for many of this riverine tree/plant species.

There was no instance of hoarding in Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary during the study period. This may be either clear indication of the optimal availability of food in the habitat (Ando *et al.*, 1984) or the Grizzled Giant Squirrel does not have this habit. More studies are required on the energetics of Grizzled Giant Squirrel as this animal is a generalist plant feeder feeding on seeds, sap, leaves and flowers.

5.1.3 Diurnal variation in Grizzled Giant Squirrel diet

The feeding observation across different hours of the day shows that the animal was highly active in morning and evening hours of the day, the resting occurred in the mid-day

time. Thus the animal's feeding activity affected by the weather factors in the area, in the hours of high sunlight and rainfall the animal activity was found to be very low.

5.2 TIME ACTIVITY BUDGETTING

Animals are designated nocturnal or diurnal based on their peak activity phase. Activity and energetics are mutually related (Gurnell, 1987). Activity pattern of mammals have been a subject of research in various animals around the world. A variety of data can be obtained by investigations on activity pattern, by trained eyes with simple equipment as binoculars (Ashby, 1972). Most animals exhibit an activity pattern which functions as a species-specific schedule (Kavanau, 1967). There could be discrepancy between activity patterns in the laboratory condition and in the field condition. The activities are more or less constant in the field (Kavanau, 1969).

The primary activity that the Grizzled Giant Squirrel performed during the present study period was feeding, which accounted for 64 percent, which was followed by resting, moving and calling. No seasonal variation in the activity pattern was observed in Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary. The seasonal variation in the various activity parameters were analysed against the distance of the animal from the river, across the different seasons. The analysis revealed that the squirrels were found closer to mid-part of the river in summer season than the river edges, than in the monsoon season. This may be to escape from the scorching heat that the scrub jungle and dry deciduous forests of Chinnar experiences.

5.3 POPULATION AND DISTRIBUTION OF GRIZZLED GIANT SQUIRREL AT CHINNAR WILDLIFE SANCTUARY

5.3.1 Population density of Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary

The population density of the Grizzled Giant Squirrel during the present study was estimated to be 15.26 squirrels/km^2, which is lower than the population density of Grizzled Giant Squirrel estimated by Ramachandran (1993), 18-23 squirrels/ km^2. However, while extrapolating the density data to the animal numbers, Ramachandran (1993) used the effective strip width as 70m and he had estimated the population size of Grizzled Giant

Squirrel as 150 animals. But the effective strip width according to the present study comes to only 40m. And the effective habitat for the Grizzled Giant Squirrel has been estimated to be 1.6km^2 [40m (average width of the riverine vegetation) x 40000m (total length of the river, estimated using QGIs)]. Accordingly the population estimate of the Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary during the present study comes to 1.6 x 15.26 = 24.416 animals.

In another recent population estimation study done by Senthilkumar (2007), gave a density figure of 0.64 squirrels/ha. This would account for a density estimate of 64 squirrels/km^2. This is an exorbitantly higher density estimate for the Grizzled Giant Squirrel. And the validity of this data is questionable. This is particularly so, as the author argues that he had done the transects in three habitats, out of which at least in one of the habitats, the dry deciduous forests, the Grizzled Giant squirrel is completely absent.

Thus there is a gross decline in the population of Grizzled Giant Squirrel, than the earlier population estimation done by Ramachandran (1993). This could be due to couple of reasons, either the Grizzled Giant Squirrel population was over estimated by Ramachandran (1993), or there has been a drastic decline in the population of the Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary.

5.3.2 Population estimate of Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary using drey count method

During the study period a total of 117 drey's were counted from Chinnar Wildlife Sanctuary. Philips (1981) and Borges (2014) have reported that one squirrel on an average makes about 4 to 5 drey's. Going by that logic there could be a total of 23.4 Grizzled Giant Squirrels at Chinnar Wildlife Sanctuary.

5.3.3 Population estimate of Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary using total count method

The first ever population count on the Grizzled Giant squirrel at Chinnar Wildlife Sanctuary, by Ramachandran (1993) estimated the population to be 51 squirrels from Chinnar Wildlife Sanctuary. This was done as total count from 10 March to 14 March 1991.

While, Joshua (1992) estimated the population of Grizzled Giant Squirrel to be 75. Later Senthilkumar *et al.* (2007), who did a study on the Grizzled Giant Squirrel between 2002 and 2003, had reported the sighting of 107 Grizzled Giant Squirrels from the sanctuary. However, how he has get this furfure is unclear, as in his methods, he explains that he used the density estimation only. In the present study, however, I have recorded an average of 10.5 animals in any given month, with the minimum number sighted was 6 squirrels and the maximum was 17. Thus based on the present study, the most realistic estimate of the population of Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary would be between 30 to 35 animals.

5.4. TREE PREFERENCE FOR THE DREY'S BY THE GRIZZLED GIANT SQUIRRELS AT CHINNAR WILDLIFE SANCTUARY

The Giant Squirrels are known to prefer areas with good food availability and canopy connectivity to live and build their nests (Vanitharani and Bharathi, 2011). The observations in this study corroborate this statement. Grizzled Giant Squirrel found to prefer trees significantly larger in all characteristics with large girth at breast height (GBH) and taller height with adequate number of horizontal branches for nest building and movement. According to Ramachandran (1993) such biased selection towards matured trees with greater canopy continuity could facilitate easy movement to and from the nest in all the directions, a major advantage to escape from predators and to move to other parts of the home range for foraging and other activities.

The Grizzled Giant Squirrel in Chinnar Wildlife Sanctuary found to be constructs globular nests or dreys using leaves and twigs, multiple in numbers within their home range, as similar to that of Giant Squirrels explained by Srinivas *et al.* (2008). Giant Squirrels are known to build nests in several trees, sometimes even within a small area (Prater, 1980). Of the 59 squirrel interacting key tree species within the sanctuary, the Grizzled Giant squirrels preferred only 36 of them for nest building. The high preference for *Mangifera indica* and *Terminalia arjuna*, found mostly along the rivers and streams, could be due to the dense canopy cover, higher canopy height and contiguity which inturn might be offered better protection and a way to escape from the predators. Nagarajan *et al.* (2011) suggested that many arboreal dwellers prefer this type of habitat.

According to Kanoje (2008) in the Sitanadi Wildlife Sanctuary, the Giant Squirrel's 77.68 per cent of the nests were found on deciduous trees while 22.32 per cent were located on the evergreen trees. In the present study 73.61 per cent of nesting trees were evergreen in nature while 26.39 per cent were deciduous based on the number of drey. Among the 36 tree species preferred for drey construction by Grizzled Giant Squirrel 55.55 percent of species were evergreen and rest 44.45 percent were deciduous trees. The high preference might due to the canopy cover that the evergreen species could provide throughout the year which shelters the squirrel from birds of prey and adverse climate.

The χ^2 test for association between location and plant species used for drey building showed significant association between the location and plant species used for nesting. So the difference in the preference of trees might be due to the variation in tree community composition found across different study locations and other attributes like dependency on mature forests that provide tree articles like leaves, flowers, fruit, sap and seeds as food, ability to provide strong stems and canopies as launch sites, canopies with enough cover which can provide protection from predators and unfavorable weather conditions. The tendency of the Grizzled Giant Squirrel to use different type of trees at different sites leads to the concept of site specific conservation of trees. The conservation plan should not be tree species specific in Chinnar Wildlife Sanctuary but should be site specific.

The height of the tree and the height of the drey at tree showed that animal using wide range of height for the drey construction, but in general with increase in tree height the drey height also increased. This could lead to the conclusion that the animal prefers to build the drey at higher points but the height of the tree becomes the determining factor. Thus for better survival of the animal, taller trees are necessary which implies the importance of mature forest for survival of Grizzled Giant Squirrel. The average height point used by the animal for drey building is 87 per cent of the height of the tree. This might be to get protection from birds of prey because if the drey's are exposed at the top of the trees, then the chance of the drey's being spotted by the birds of prey will be higher. Moreover, the unfavourable weather condition like the direct sunlight and rainfall also would be disadvantageous to the Grizzled Giant Squirrels, if they had constructed the nests on the top of the canopy. According to Vanithrani and Bharathi (2011), in the Srivalliputhur Grizzled Giant Squirrel Sanctuary the animal construct drey's at forked branches where the crowns of neighbouring trees meet, but during the present study it was observed that

eventhough the dreys are constructed at forked branches it is not necessary that the crowns of neighbours meet. This might be because of higher extent of fragmentation in the Chinnar Wildlife Sanctuary.

The height of the drey across different study locations draws the effect of anthropogenic disturbance on height of the drey construction. Along Churulipetty, a highly disturbed location, the drey's found at much higher points even though the trees are taller. But in the Kootar and Alampetty area the drey height found to be much lower than that of tree height because of the availability of certain preferred species having low height and less extent of disturbance at the animal micro habitat.

5.5 THREATS TO GRIZZLED GIANT SQUIRREL

The anthropogenic disturbance, habitat loss, increased predation and interbreeding between the Grizzled Giant Squirrel and Malabar Giant Squirrel are found to be the major threats for the Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary. The anthropogenic disturbances are in the forms of pilgrimage, tourism, road transport and tribal settlements, within the Chinnar Wildlife Sanctuary.

5.5.1 Pilgrimage

A temple located on the banks of Chinnar river near Churulipetty area. This temple attracts huge number of pilgrims who visit there at least three times a week. This is causing high level of disturbance to the Grizzled Giant Squirrel's habitat by way of these pilgrims taking bath and wash in the river. Moreover, they also perform cooking on the banks of the river, for which the firewood is taken from the riverine forests, the Grizzled Giant Squirrel habitat. Added to this temporary shops would be functioning during the pilgrimage season. All these activities are causing extreme stress for the Grizzled Giant Squirrel.

5.5.2 Ecotourism

Another major threat to the Grizzled Giant Squirrels is the ecotourism activities that are being practiced at Chinnar Wildlife Sanctuary. As part of the ecotourism activities tree top huts have been construed at Koottar, and log houses at Churulipetty, Chambakkad and

Thoovanam. All these are located in the prime Grizzled Giant Squirrel habitat and thus is causing disturbance to the squirrels. All these places provide facilities for the night stay and trekking for the tourists. These activities leads to pollution and deterioration of Grizzled Giant Squirrel's habitat.

5.5.3 Roads and the electric lines

Another challenge for the survival of the Grizzled Giant Squirrel at Chinnar is the road connecting Munnar to Udumalpetta. This road actually divides the sanctuary into two halves. Moreover, this road disrupts the canopy continuum of the riverine habitat at at least two locations, the Chinnar check posts area and the Alampetty area. This has led to the habitat fragmentation of the Grizzled Giant Squirrels, forcing them to come on to the ground to pass on to the adjacent patch of forests. In that process they could be jeopardizing their life, as is evidenced by the road kill carcass of the Grizzled Giant Squirrel. Similarly there is one forest road that breaks the canopy contiguity at Champakad and Athiyoda regions too.

Another reason for the habitat discontinuity at Chinnar or the Grizzled Giant Squirrel is the 220 KV electrical lines that criss cross the sanctuary, in places like Churulipetty for e.g.

5.5.4 Qualitative deterioration of the habitat

Predation on Grizzled Giant Squirrel by Changeable Hawk-Eagle (*Nisaetus cirrhatus*) was observed in Chinnar Wildlife Sanctuary during the course of present study. Predation attempts by the Black Eagle (*Ictinaetus malayensis*) and Crested Serpent Eagle (*Spilornis cheela*) on the Indian Giant Squirrel and Grizzled Giant Squirrel was reported earlier by Ramachandran (1991), Joshua (1992), Joshua and Johnsingh (1994) and Borges (1993). This might be the first report of this new predator (Plate 7) on the Grizzled Giant Squirrel. In any case the excessive predation on the Grizzled Giant Squirrel by the birds of prey could be due to the more canopy void created by the qualitative deterioration of the habitat, need to be examined.

Plate 7a. Grizzled Giant Squirrel's carcass

Plate 7b. Electric line which breaks the canopy continuum at Churulipetty

Plate 7c. The diety worshipping at Churulipetty

Plate 8. Hybrids of Grizzled Giant Squirrel and Malabar Giant Squirrel at Chinnar Wildlife Sanctuary

5.5.5 Hybridization between Grizzled Giant Squirrel and Malabar Giant Squirrel

Another, threat to the Grizzled Giant Squirrels at Chinnar could be the hybridization that could be happening between the Grizzled Giant Squirrels and the Malabar Giant Squirrels. This is evidenced by the presence of few individuals, (Plate 8). These squirrels coexists in Marayur and one instance of the copulation between Grizzled Giant Squirrel and Grizzled Giant Squirrel, photographed and videographed (Jomals and Vinod, pers. comm.). Joshua (1996) has reported the interbreeding between Grizzled Giant Squirrel and Malabar Giant Squirrel at Sri Villiputhur Grizzled Giant Squirrel sanctuary, where he had seen seven hybrid individuals. In Chinnar, I saw at least three individual's with suspected hybrid coat color. This interbreeding could be a challenge to the long-term conservation of the Grizzled Giant Squirrels at Chinnar.

5.6 CONSERVATION RECOMMENDATIONS ON THE GRIZZLED GIANT SQUIRREL AT CHINNAR WILDLIFE SANCTUARY

The pilgrimage pressure in the Churulapetti region should be regulated. The use of river for bathing, washing and cooking etc. should be stopped with immediate effect. The ill effect of the ecotourism activities through the log houses and the tree top huts constructed on the bank of the riverine habitat should be regulated, if not stopped, as it is detrimental to the Grizzled Giant Squirrel habitat. Moreover a habitat restoration programme should be launched by planting appropriate species at different locations in the Grizzled Giant Squirrel habitat at Chinnar. This is particularly important taking into account the fact that the regeneration of the trees at the riparian habitat was extremely low at Chinnar and this situation is really alarming. It is also important to undertake regular, systematic and scientific monitoring of Grizzled Giant Squirrel population estimation at least once in a year to understand the population fluctuation of the Grizzled Giant Squirrels at Chinnar Willife Sanctuary.

SUMMARY

SUMMARY

A study on the food and feeding habits of Grizzled Giant Squirrel was carried out at Chinnar Wildlife sanctuary from April 2013 to May 2014. The summary of the findings are given below.

- The Grizzled Giant Squirrel observed to feed on food article from 30 plant species in Chinnar Wildlife Sanctuary including 22 tree species.

- The Grizzled Giant Squirrel in Chinnar Wildlife Sanctuary was found to be feeding on plant species under 18 different families. Among them the most preferred family was Fabaceae, followed by Moraceae and Anacardiaceae.

- The most preferred tree species used for feeding by Grizzled Giant Squirrel were *Bauhinia racemosa, Strychnos potatorum, Tamarindus indica, Terminalia arjuna, Diplocyclos palmatus, Ficus albiphyla, Melia dubia, Syzygium cumini* and *Albizia lebbeck.*

- The Grizzled Giant Squirrel fed on the leaves and fruits of lianas, climbers, shrub and even the cactus. The climbers were *Derris brevipes, Diplocyclos palmatus* and *Cayratia trifolia*. They also used shrubs like *Hibiscus rosa-chinensis,* cactus like *Euphorbia trigona* and liana like *Entada rheedii* for feeding.

- The most preferred food item by the Grizzled Giant Squirrel was seeds (59%), followed by leaves (32%), flower (6%) and sap (3%).

- No seasonal variation in the feeding pattern of Grizzled Giant Squirrel could be observed in the Chinnar Wildlife Sanctuary.

- The time activity budgeting study revealed that the primary activity that the Grizzled Giant Squirrel performed during the study period was feeding (64 percent) followed by resting (28%), moving (7%) and calling (1%).

- Total of 95 species were identified from the riparian habitat along the Chinnar and Pambar rivers at Chinnar Wildlife Sanctuary. The vegetation found dominated by the species such as *Pongamia pinnata, Terminalia arjuna, Mangifera indica, Pterocarpus marsupium, Alphonsea sclerocarpa, Ficus benghalensis, Syzygium cumini, Ficus microcarpa, Sapindus tetraphylla, Spondias pinnata, Lepisanthes senegalensis, Diospyros ebenum, Melia dubia,* and *Psychoteris subintegra* as they had IVI value more than five.

- The Grizzled Giant Squirrel found to be interacting with 56 plant species. And the most preferred ones are *Terminalia arjuna, Hopea parviflora, Mangifera indica, Pongamia pinnata, Syzygium cumini, Gyrocarpus asiaticus, Albizia odoratissima, Alphonsea sclerocarpa, Albizia lebbeck, Ficus microcarpa, Psychoteris subintegra* and *Diospyros ebenum*.

- The number of times the Grizzled Giant Squirrel sighted on a particular species was positively correlated with vegetation parameters such as average girth (cm), average height (m), relative density, relative frequency, relative basal area, important value index (IVI) and relative important value index (RIVI).

- The present study in Chinnar Wildlife Sanctuary reveals that maximum number of individuals is at Alampetty, followed by Churulipetty, Kootar, Athiyoda and Chambakkadu.

- The population density of Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary was estimated as 15.26 squirrels/km^2.

- The population estimate based on the total count as well as the drey count is estimated to be between 30 to 35 Grizzled Giant Squirrels. This population estimate is considerably lower than the earlier population estimates on the Grizzled Giant Squirrels and is a matter of concern.

- The Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary found to be constructing the dreys at a height about 87 percent of height of the tree, means dreys are not made at the top of the tree.

- The anthropogenic disturbance, habitat loss, increased predation and interbreeding between the Grizzled Giant Squirrel and Malabar Giant Squirrel are found to be the major threats for the Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary.

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**Original not seen*

APPENDIX

Appendix 1. ANOVA table for feeding habit parameters of Grizzled Giant Squirrel across different seasons at Chinnar WLS

Parameters	Source of variation	DF	Sum of squares	Mean squares	F value	P value
Height (m)	Season	2	73.03	36.51	0.97	0.39
Duration of feeding (minutes)	Season	2	722.58	361.29	0.44	0.65
Feeding bout (number)	Season	2	2726.06	1363.03	0.87	0.43

APPENDICES

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Appendix 1. ANOVA table for feeding habit parameters of Grizzled Giant Squirrel across different seasons at Chinnar WLS

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Height (m)	Season	2	73.03	36.51	0.97	0.39
Duration of feeding (minutes)	Season	2	722.58	361.29	0.44	0.65
Feeding bout (number)	Season	2	2726.06	1363.03	0.87	0.43

Appendix 2: ANOVA table for the factors influencing the Grizzled Giant Squirrel activity parameters. P values in bold are significant after sequential Bon-ferroni correction.

	Source	DF	Sum of Squares	Mean squares	F value	P value
Height at which the animal when first sighted(m)	Place	4	347.77	86.94	3.18	**0.017**
	Time of the day	1	147.94	147.94	5.41	**0.022**
	Activity	2	98.77	49.38	1.80	0.170
	Habitat	1	75.83	75.83	2.77	0.099
	Season	2	160.59	80.29	2.93	0.058
Animal's distance from the river(m)	Place	4	702.11	175.52	0.59	0.667
	Time of the day	1	337.03	337.03	1.14	0.288
	Activity	2	11.88	5.94	0.02	0.980
	Habitat	1	5500.78	5500.78	18.63	**< 0.0001**
	Season	2	2228.43	1114.21	3.77	**0.027**
Duration of Activity (minutes)	Place	4	1262.15	315.54	0.67	0.608
	Time of the day	1	1302.66	1302.66	2.80	0.098
	Activity	2	11400.50	5700.25	12.26	**< 0.0001**
	Habitat	1	2407.19	2407.19	5.18	**0.025**
	Season	2	1271.06	635.53	1.36	0.260

Appendix 3. The variables and their correlation with the two canonical axis in redundancy analysis.

	RDA axis 1	**RDA axis 2**
Eigen values	123999.73	58.79
Cumulative % of Eigenvalues	1.00	1.00
Species scores = Y		
No of times of observation	0.06	1.00
Duration of observation	1.00	-0.06
X variables scores = corrélation (X, V)		
Average gbh (m)	-0.14	0.70
Average height (m)	0.03	0.33
Relative Density	0.06	0.61
Relative Frequency	0.21	0.74
Relative Basal Area	-0.15	0.53
Important Value Index (IVI)	0.07	0.84
Relative IVI	0.07	0.84

FOOD AND FEEDING HABITS OF GRIZZLED GIANT SQUIRREL *(Ratufa macroura)* AT CHINNAR WILDLIFE SANCTUARY, WESTERN GHATS, KERALA.

by

KIRAN THOMAS

(2012-17-101)

ABSTRACT

Submitted in partial fulfilment of the requirement for the degree

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Faculty of Forestry

Kerala Agricultural University

DEPARTMENT OF WILDLIFE SCIENCES

COLLEGE OF FORESTRY

KERALA AGRICULTURAL UNIVERSITY

VELLANIKKARA, THRISSUR -680 656

KERALA, INDIA

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ABSTRACT

The research work entitled "Food and feeding habits of Grizzled Giant Squirrel (*Ratufa macroura*) in Chinnar Wildlife Sanctuary, Western Ghats, Kerala" was carried out in five locations namely Chinnar, Kootar, Chambakkadu, Athiyoda and Alampetty in the Chinnar Wildlife Sanctuary. The main objective of the study was to find out the food and feeding habits including the food preferences and time activity budgeting of Grizzled Giant Squirrel. Apart from that an attempt has been made on the population estimation of the Grizzled Giant Squirrel and also the habitat quality analysis. Focal animal sampling method across different season was deployed to gather information on food species and article preference, feeding habits, seasonal variation in feeding and the time activity budgeting. Besides these, the population density of the squirrel was estimated by direct observation through line transect method. The indirect population estimation and quality of available habitat was estimated through drey (nest of the squirrels) analysis. The vegetation within the Grizzled Giant Squirrel habitat was studied using quadrate method and Important Value Index.

The Grizzled Giant Squirrel in Chinnar Wildlife Sanctuary found to be feeding on 30 plant species. The squirrel's preference for diet was found primarily affected by availability of food tree species and food article rather than the season. The climbers, lianas, shrubs and cactus also formed the part of squirrel's diet. It is for the first time that non-tree elements have been reported from the diet of Grizzled Giant Squirrel. The Grizzled Giant Squirrel has been primarily a frugivorous animal, but at the time of the non-availability of fruits and seeds they fed on leaves, flowers and bark. The Grizzled Giant Squirrel in Chinnar Wildlife Sanctuary was found to be spending most of its time on feeding followed by resting, moving and calling.

The animal was found to be using 48 tree species at Chinnar Wildlife Sanctuary, of which 22 tree species were used for feeding, 36 tree species were used for drey construction, while ten tree species were used for both feeding as well as drey construction. The population size of the Grizzled Giant Squirrel was estimated to be 30-35 individuals. This is considerably fewer than the earlier population estimates of Grizzled Giant Squirrel at Chinnar and is a matter of concern. The major threats of Grizzled Giant Squirrel at Chinnar Wildlife Sanctuary were anthropogenic disturbance, habitat loss, predation and hybridization. The Grizzled Giant Squirrels' preference for bigger and taller trees for drey construction indicates the significance of presence of mature forest trees with canopy continuum for long-term survival of squirrel at Chinnar Wildlife Sanctuary.