

## CHAPTER 1

### GENERAL INTRODUCTION

#### 1.1 Tree 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 tree squirrels might have been possible from the *Sciurus* squirrels of North America during the mid-miocene period, before the land connection between North and South America was established (Emry and 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 canopy of trees. Giant squirrels share their habitats with arboreal mammals such as primates, arboreal civets, and birds like hornbills and pigeons. The

density of giant squirrels is low and hence they do not tend to reach a pest status.

## 1.2 Distribution

Squirrels (family Sciuridae, order Rodentia) include two subfamilies, viz. subfamily 'Sciurinae' comprising tree and ground squirrels; members of which are diurnal and the subfamily 'Petauristinae' comprising flying or gliding squirrels; members of which are nocturnal. Squirrels naturally occur throughout the world except in Madagascar, Australia, southern parts of South America and northern parts of Africa (Gurnell, 1987). There are 121 species of tree squirrels including 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). Next is the African zoogeographical region with 45 species (Table 1) and the Neotropical zoogeographical region with 36 species (Corbet and Hill, 1980). Thus, the highest diversity of tree squirrels is in the Oriental zoogeographical region and tropical Africa. Ground dwelling squirrels are mostly found in the Nearctic zoogeographical region and are the most studied among

Table 1. Distribution of squirrels in different zoogeographical regions

Region	Number of species occur		
	Tree squirrel	Flying squirrel	Ground dwelling squirrel
Nearctic	8	2	63
Palaearctic	14	20	15
Neotropical	36	-	3
African	45	-	2
Oriental	51	32	-
Australian	*	-	-

\*Only introduced squirrels occur

(Source: Corbet and Hill, 1980; Gurnell, 1987)

squirrels with respect to their social behaviour and kinship. Their absence is conspicuous in the Oriental zoogeographical region. The earliest classification of Sciuridae was based on skeletal and dental morphology (Ellerman, 1940; Moore, 1959). Based on immunological studies, Hight *et al.* (1974) showed that *Ratufa* is different from groups such as *Callosciurus*, *Sundasciurus*, *Tamiops*, *Funambulus* and *Mentes*, which are closely related.

### 1.3 Literature survey

Squirrels have been the subject of detailed investigations for a long time. Detailed ecological investigations have been made on *Sciurus carolinensis* (Barkalow *et al.*, 1970); *Tamiasciurus hudsonicus* (Hamilton, 1939; Smith, 1968); *Funambulus pennanti* (Prakash *et al.*, 1968); *Marmota monax* (Hamilton, 1934); *Marmota olympus* (Barash, 1973); *Cynomys ludovicianus* (Koford, 1958); *Sciurus columbianus* (Manville, 1959); *Spermophilus lateralis* (McKeever, 1964); *Spermophilus tridecemlineatus* (McCarley, 1966); *Tamias striatus* (Elliot, 1978) and *Eutamias amoenus* (Broadbrooks, 1958).

Detailed investigations on various aspects of behaviour of some species of squirrels have also been made. These include behaviour of *Sciurus carolinensis* (Horwich, 1972); *Sciurus aberti* (Farentinos, 1974); *Tamiasciurus hudsonicus* (Kilham, 1954; Smith, 1968); *Xerus erythropus* (Ewer, 1965); *Marmota monax* (Bronson, 1963; Lloyd, 1972); *Marmota flaviventris* (Waring, 1966; Armitage, 1962); *Marmota olympus* (Barash, 1973); *Cynomys ludovicianis* (King, 1955); *Cynomys leucurus* (Waring, 1970); *Spermophilus undulatus* (Watton and Keeneyside, 1974); *Spermophilus richardsoni* (Yeaton, 1972); *Spermophilus beecheyi* (Lindsdale, 1946); *Spermophilus columbianus* (Steiner, 1973); *Spermophilus armatus* (Balph and Stokes, 1963; Balph and Balph, 1966); *Spermophilus lateralis* (Gordon, 1943; Wirtz, 1967) and *Tamias striatus* (Dunford, 1970).

Studies on reproduction and ontogeny of *Sciurus carolinensis* (Horwich, 1972); *Tamiasciurus hudsonicus* (Layne, 1954); *Funambulus pennanti* (Prakash et al., 1968); *Cynomys leucurus* (Bakko and Brown, 1967); *Tamias striatus* (Elliot, 1978); *Glaucomys volans* (Sollberger, 1943) and *Glaucomys sabrinus* (Muul, 1969) are note-worthy.

As the grey squirrels were introduced into Britain which subsequently became a pest of young forest plantations (Kenward, 1982; Kenward and Parish, 1986), it was subjected to various types of control measures (Rowe, 1980; 1983). Due to the spread of grey squirrels, the range of native red squirrel has declined and the latter has attained the status of protected species in Great Britain. 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 (1979b) has studied the synecology of Malayan squirrels with special reference to the genus *Ratufa*.

Recently, there has been considerable interest in the ecological studies of giant squirrels in India. A preliminary study on the ecology and behaviour of giant squirrels in Parambikulam Wildlife Sanctuary was made (Ramachandran, 1988). Foraging ecology of the Indian

giant squirrels in Magod, Karnataka and Bhimashankar, Maharashtra, was studied (Borges, 1989). The ecology of grizzled giant squirrel and its endangered habitat in Srivilliputtur forests in Tamil Nadu, has been studied (Joshua and Johnsingh, 1992).

#### 1.4 Distribution of giant squirrels

The genus *Ratufa* occurs in Indo-Malayan regions. Giant squirrels are found in diverse habitats ranging from deciduous to evergreen forests.

All the four species of giant squirrels of the Oriental region belong to the genus *Ratufa*. 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. *Ratufa macroura*, the grizzled giant squirrel, is found in Sri Lanka and in the dry deciduous forests of Srivilliputtur in the eastern side of the Western Ghats in Tamil Nadu and in Chinnar Wildlife Sanctuary in Kerala. *Ratufa macroura* is found to

be quite abundant along the river sides in the Wilpattu National Park in Sri Lanka (Eisenberg and Lockhart, 1972). Based on pelage colour, Abdulali and Daniel (1952) reported eight races of *Ratufa indica*. Studying the materials of the collection of Zoological Survey of India, Agrawal and Chakraborty (1979) described seven subspecies of *Ratufa* (Table 2). 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 (Worah *et al.*, 1989).

#### 1.5 Characteristics of the seven races of Indian giant squirrel

##### *Ratufa indica indica* (Erxleben)

Type locality: Bombay Presidency

Racial characteristics: Body colour is brown throughout, with under parts yellowish and forehead clay coloured.

Tail has the same colour as body with pale tip.

Habitat: Bhimashankar and Khandala

##### *Ratufa indica superans* (Ryley)

Type locality: Wotekalli, South Coorg (West of Brahmagiris).

Table 2. Distribution of different races of *Ratufa indica* in India

Subspecies	Distribution
<i>Ratufa indica indica</i> (Erxleben)	Surat Dangs in Gujarat, Maharashtra, Goa, and Dharwad and Kanara in Karnataka
<i>Ratufa indica superans</i> (Ryley)	Coorg, Makut, Wotekolli of Karnataka
<i>Ratufa indica bengalensis</i> (Blanford)	Coorg, Kutta, Barampady forests in Karnataka and the Nilgiris in Tamil Nadu
<i>Ratufa indica centralis</i> (Ryley)	Madhya Pradesh, Andhra Pradesh, South Karnataka, Bihar and Orissa.
<i>Ratufa indica elphinstonei</i> (Sykes)	Bhimashankar, Maharashtra.
<i>Ratufa indica maxima</i> (Schreber)	Western Ghats of Kerala and Tamil Nadu
<i>Ratufa indica dealbata</i> (Blanford)	No authentic record of existence for the past 41 years

Racial characteristics: This race is larger in size. Colour is identical with that of the bay colour of *R. indica indica* of Kanara.

*Ratufa indica bengalensis* (Blanford)

Type locality: Supposed to be eastern side of the Brahmagiris in Coorg.

Racial characteristics: In size, this race is equal to *superans* and identical with it in colour except that the tail is black with a pale rufous tip.

Habitat: East of Brahmagiris

*Ratufa indica centralis* (Ryley)

Type locality: Bori, Hoshangabad district, Madhya Pradesh.

Racial characteristics: Separated from the *bengalensis* race in its smaller size and distinction of having black patches on the shoulders and occasionally on the rump.

Habitat: Moist and dry deciduous forests.

*Ratufa indica elphinstonei* (Sykes)

Type locality: Bhimashankar, Maharashtra, India.

Racial characteristics: Half the tail reddish chestnut and other half white.

Habitat: Evergreen forests

*Ratufa indica maxima* (Schreber)

Type locality: Travancore, Kerala, India

Racial characteristics: This race is bay coloured with the upper arm, shoulder, rump and tail black and with a median black dorsal line in most cases. Tail is completely black with no pale tip, but with a thin line of rufous running along the under surface. *Ratufa indica maxima* is the race found in the southern part of the Western Ghats.

Habitat: Evergreen, semi-evergreen and moist deciduous forests of Kerala State.

*Ratufa indica dealbata* (Blanford)

Type locality: Surat Dangs

Racial characteristics: The body colour is cream buff with the tail colour paler. Ear tufts are brown. This race is extinct.

Habitat: Evergreen forest.

### 1.6 Importance of the genus *Ratufa*

*Ratufa* is the most primitive among recent tree squirrels (Emry and Thorington, 1982). In some of the anatomical features, the giant squirrels are the most primitive among the recent tree squirrels and in some others they are highly specialized. According to Thorington and Cifelli (1989), Indian giant squirrels are excellent animals for the study of mosaic evolution. The

giant squirrels are biologically interesting and significant animals. They are unique ecologically, morphologically and zoogeographically and serve as a biological indicator of the quality of habitat (Thorington and Cifelli, 1989). Morphologically, they exhibit primitive as well as derived characters. Zoogeographically, they give a clue for historic interpretation of distribution which in turn is important for developing conservation strategies. Malabar giant squirrel, *Ratufa indica maxima*, is exclusively a forest animal and is the most brightly coloured among the different races of the Indian giant squirrels. This race is distributed from evergreen to moist deciduous forests of the Western Ghats in Peninsular India. There is very little information available on the ecology and behaviour of this species.

## 1.7 Malabar giant squirrel

### 1.7.1 Morphology

The most striking feature of the Malabar giant squirrel, *Ratufa indica maxima*, is its large size. This race is predominantly of bay coloured, but shoulder, rump and tail are black (Plate 1). There is a continuity of black colour in the median dorsal side. The fore-feet and ventral side are dull cream coloured and the tail is

Plate 1    A Malabar giant squirrel, *Ratufa indica maxima*, in its feeding posture.



completely black. Head and body length of Malabar giant squirrel is about 30 to 40 cm and the tail is about 60 cm (Prater, 1980). The average head and body length in eight specimens studied in the collections of Zoological Survey of India is 39.5 cm and their tail length is about 48 cm (Agrawal and Chakraborty, 1979). Ear pinnae are tufted. Tail is bushy throughout. Fore-feet have four digits. Limbs have pads in the fore-arms. The distal ends of the digits have claws. Hind-limbs have five digits with claws. There is no sexual dimorphism in the pelage colour. Adult males have pendent sagging testicles which can be clearly seen. Three pairs of mammae can be seen on careful observations in lactating females. Juvenile males and females look alike. It is reported that giant squirrels may live up to 16 years in captivity (Flower, 1931). Owing to its impressive colour and large size, the Malabar giant squirrels were exported to other countries as pet (Crandall, 1964).

#### 1.7.2 Habitat distribution

According to Nair *et al.* (1978), giant squirrels occur throughout the moist deciduous and semi-evergreen forests in Bandipur and Nagarhole National Parks

(Karnataka), Mudumalai Wildlife Sanctuary (Tamil Nadu) and Wynad Wildlife Sanctuary (Kerala). Good population of *Ratufa indica* was reported by Nair et al. (1978) in Mudumalai Wildlife Sanctuary excepting Moyar Reserve. They are not much threatened by poaching pressure in the undisturbed forests of Wynad and Nagarhole Wildlife Sanctuaries. Giant squirrels were 'abundant' in the evergreen, sholas and the climax and degraded forests in Karnataka but were 'absent' both in the climax and degraded scrubs (Prasad et al., 1980). In Periyar Tiger Reserve, giant squirrels were widely distributed from evergreen to moist deciduous forests (Vijayan et al., 1979; Ramachandran et al., 1986). This species was seen in the forest on either side of the pilgrims trekking path to Sabarimala Temple in Periyar Tiger Reserve. Reconnaissance surveys carried out in Periyar indicate sightings of 76 giant squirrels and 75 calls from 62 locations (Vijayan et al., 1979). Maximum number of aggregation during feeding on a particular tree was less than five individuals. They do not occur in groups. The forest working plans refer to the presence of Malabar giant squirrels which were looked upon as vermin, eat away all the seeds of some desired forestry species. But it was not

known on what else they feed in other seasons of the year when seeds were not available in plenty. During a reconnaissance survey in Silent Valley, Vijayan and Balakrishnan (1977) sighted 25 giant squirrels in addition to the 11 calls. They have also sighted 22 giant squirrels in the adjacent Attappady Reserve Forest. Balakrishnan (1984) had estimated the population of Malabar giant squirrel in Silent Valley and adjoining forests in Kerala State to be about 150 heads. A total of 28 giant squirrels were reported from the natural forests in Parambikulam Wildlife Sanctuary (Balakrishnan and Easa, 1986). In Varagaliar evergreen forest area in Indira Gandhi Wildlife Sanctuary in Tamil Nadu, Kumar (1987) has reported a population density of 31 giant squirrels/km<sup>2</sup>. Ramachandran (1989) had conducted a census of grizzled giant squirrel (*Ratufa macroura*) in Chinnar Wildlife Sanctuary. This is an endangered giant squirrel which has only two viable populations, restricted to the dry deciduous habitat of Srivilliputtur grizzled giant squirrel sanctuary in Tamil Nadu and Chinnar Wildlife Sanctuary in Kerala. The population of this species in Chinnar Wildlife Sanctuary is only about 150 animals.

During 1978 to 1989, giant squirrels were studied in Periyar Tiger Reserve, Parambikulam Wildlife Sanctuary and Silent Valley National Park in Kerala, South India. During this period giant squirrels were sighted in Marayoor (700 m), Thekkady (900 m), Silent Valley (1,000 m), Goodrickal range in Pachakanam area, Kulathupuzha (900 m) and Pooyamkutty area (400 m). A questionnaire survey on mammals occurring in various forest ranges of Kerala by the Wildlife Biology Division, Kerala Forest Research Institute, revealed a rough indication on the presence or absence of Malabar giant squirrel in different ranges. Giant squirrels were reported in Mannarappara, Kodanad, Kollathirumedu, Chungathara, Arienkavu, Thenmala, Nedumangad, Vadasserikara, Ayyappankoil, Nagarampara, Neriamangalam, Kothamangalam, Sholayar, Vazhachal, Sulthan Bathery, Begur, Mananthavady and Kasaragod forest ranges. They were absent in the silvicultural research range of Nilambur and Devikolam range in Munnar Forest Division. Kodanad range, Kollathirumedu range, Vadasserikara range, Sholayar range, Vazhachal range and Mananthavady special range are the forest ranges where giant squirrels are seen outside the wildlife sanctuaries.

The Kerala Forest Department had done a statewide census of wild animals from 16th to 19th May 1990 using the 'total count technique'. This was a general census of all medium and large sized species. During this census, Malabar giant squirrel was sighted from 27 out of the 28 forest divisions in Kerala (Table 3) (Kerala Forest Department, 1990). Achenkovil Kallar Valley Teak Plantation was the only Division where Malabar giant squirrel was not sighted. No census was conducted during the period in Eravikulam National Park.

An analysis of the Malabar giant squirrel population in various ranges in the 27 forest divisions of Kerala revealed the presence of the species in 79 out of the 91 ranges. Among the forest ranges, 12 (13%) did not have the Malabar giant squirrel sightings. These ranges are either with degraded or isolated forests which do not have contiguity with the remaining forests of the Western Ghats, or are converted to forest plantations. There were 1,237 giant squirrels sighted in all during the census. Total for all the areas north of Palakkad gap was 410 and for all the areas south of Palakkad gap was 827 giant squirrels. In Eravikulam National Park, Malabar giant

Table 3. Census data of Malabar giant squirrel in Kerala\*

Sl. No.	Forest Division	Number of animals
i) North of Palakkad Gap		
1	Kannur	22
2	North Wyanad	52
3	South Wyanad	5
4	Wyanad (Wildlife)	123
5	Kozhikode	11
6	Nilambur North	41
7	Nilambur South	61
8	Mannarkkad	49
9	Silent Valley	30
10	Palakkad	16
ii) South of Palakkad gap		
11	Nenmara	37
12	Parambikulam (Wildlife)	87
13	Thrissur	19
14	Vazhachal	95
15	Chalakkudy	19
16	Idukki (Wildlife)	48
17	Kothamangalam	1
18	Malayattur	93
19	Kottayam	11
20	Munnar	41
21	Thekkady (Wildlife)	91
22	Ranni	54
23	Konni	20
24	Thenmala	52
25	Punalur	19
26	Achenkovil Kallar Valley Teak Plantation	-
27	Thiruvananthapuram (Wildlife)	94
28	Thiruvananthapuram	46
	Total for the State of Kerala	1,237

(\*Source: Kerala Forest Department, 1990).

squirrels were sighted in the shola forests in the Turner's Valley, during another census in which the author participated in 1989.

### 1.7.3 Current population status

Population status of the Malabar giant squirrels has never been systematically surveyed. In earlier days, there were only attempts to record different species occurring in various parts of India. Such estimates of population have been done in protected areas only. In all the sighting records of giant squirrels, the specific race involved is also not clear. More studies are required to establish the identity of each race and its distribution pattern in any geographical range.

During the surveys of other animals, the presence of giant squirrels was recorded but their number seems to be underestimated depending on the time of the survey and less consistency in the methodology adopted by different individuals. As Malabar giant squirrels occur in the forests of evergreen, semi-evergreen and moist deciduous forests, they are not confronted with the serious problem of extinction. Large scale conversion of natural forests into plantations of monoculture like teak and eucalyptus

has reduced the extent of their suitable habitats as the giant squirrels are denizens of natural forests. This is also applicable to other arboreal species such as the Nilgiri langur, *Presbytis johni*, and lion-tailed macaque, *Macaca silenus*, which are also confined to the natural forests of Western Ghats.

Declaration of the Indian Wildlife Protection Act 1972 has given the Malabar giant squirrel and the grizzled giant squirrel the status of protected species. The latter is extremely endangered (Ramachandran, 1989). There seems to be a lot of speciation taking place in the giant squirrels (Rodgers and Panwar, 1988).

#### 1.8 Objectives of the present study

The present study was conducted to enhance our knowledge of one of the less studied protected animals of our forest, the Malabar giant squirrel, *Ratufa indica maxima*. This animal is a biological indicator of habitat quality which is restricted in its distribution to the natural forests with tree cover. The study in Periyar Tiger Reserve gave a clear picture of the general behaviour of Malabar giant squirrel. A long-term study was

necessary to understand the ecological implications of use of various dreys. The present study was undertaken with the following objectives.

- To analyse the basic ecological requirements of the Malabar giant squirrel.
- To understand the optimum habitat for giant squirrels in a moist deciduous forest where there is regular leaf shedding.
- To study the activity pattern of the giant squirrel.
- To study the breeding and parental behaviour of this solitary species.
- To know the significance of having a number of dreys made by the same individual.
- To study the inter and intraspecific behavioural interactions of giant squirrels.
- To study the predators of the species in the natural forest ecosystem.
- To study the behaviour among conspecifics and during interspecific interactions.

### 1.9 Aspects covered in the present investigation

During the present study field observations were made in Periyar Tiger Reserve, Parambikulam Wildlife

Sanctuary and Silent Valley National Park. Prolonged observations were made on known individuals. Continuous observations on marked young ones facilitated acquiring data on the development of behaviour.

Chapter 1 of this thesis deals with general introduction. Chapter 2 deals with the description of study areas. Chapter 3 describes the food and feeding habits of the species giving more stress to Thellikkal study area of the Parambikulam Wildlife Sanctuary. Major activities and general behaviour of the species are discussed in Chapter 4. Chapter 5 gives an account of the drey and home range of giant squirrels. Chapter 6 deals with the breeding and parental care of the species. Chapter 7 gives association of the species with other arboreal animals including predators. Chapter 8 gives the summary of the present investigation. References forms the last section of the thesis.