Status and Distribution of Malabar Giant Squirrel Ratufa indica in Western Ghats of Maharashtra, India

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The Indian giant squirrel Ratufa indica is a widely distributed species, perceived to be of high occurrence and is included under the Least Concern category of IUCN. However, throughout its range, it is facing threats to its survival from habitat loss and persecution by local people. It is this concern that led us in to initiating an investigation of its status from the Western Ghats of Maharashtra. Being declared as a Least Concern species, it did not fit in the investment priorities of many agencies making the task of finding support for the project difficult.

We are therefore extremely grateful to WWF New Delhi and Ruffords Small Grant Program, UK for believing in the need to carry out this survey and providing generous financial support for the study. We express our gratitude to Dr. Sejal Vorah CEO, WWF and Dr. Parikshit Gautam, Director, Small Grants Program from WWF and to Dr. Josh Cole and Ms. Jane Raymond of Ruffords Program for facilitating the grant for this survey. We thank Dr. Anjana Pant from WWF for coordinating the grant process.

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Dr. Renee Borges's name is synonymous with giant squirrel in Maharashtra. We thank Dr. Borges for reviewing the draft report, providing technical inputs and also for several insightful discussions we had with her at Bangalore and Pune on the subject.

We are grateful to Tushar Pawar, Ranjit Sahoo and Evangeline Arulmalar for their sincere participation in the field survey and helping in preparation of the data for the analysis. The occupancy analysis was carried out by Girish Punjabi and we thank him for his intensive inputs in the analysis.

We hope that information provided in this report will be used by the concerned agencies to plan appropriate land-use practices for securing the future of Malabar Giant Squirrel in its home state.

Prachi Mehta & Jayant Kulkarni

Contents

Chapter 1

Introduction

1.1 Tropical Forests and Fragmentation

Landscape level alteration caused by deforestation is an issue of major concern globally. Deforestation has serious consequences on tropical forest ecosystem. Although tropical forests cover less than 7 % of the terrestrial surface, it supports more than 50 % of known plant and animal species. Today, it is the most species rich terrestrial ecosystem and is also facing deforestation faster than any other biome in the world (Myers 1988, Myers 1990). Uncontrolled use of tropical forests for agricultural expansion, mining, development projects, forestry operations, industrialization, urbanization and exotic plantations is a major cause of forest degradation in many regions. In last two decades, an annual loss of 1 % tropical forest cover has been reported globally (Mayaux *et al.* 2005, FAO 2007)

Fragmentation of tropical forests is a complex phenomenon as it leads to major physical and biological changes in the forest ecosystem. Apart from causing destruction of habitat, it isolates formerly contiguous habitat, increases edge effects (McGarigal and Cushman 2002; Broadbent *et.al* 2008).and alters species population dynamics (Watson 2005, Broadbent *et al*. 2008). Opening up of canopy in dense forests disrupts the continuity of forests, changes the micro-climate and can lead to invasion of exotics. This would have direct implications on the carrying capacity of forest patches and types of species it can support. Also, because of fragmentation, populations are isolated leading to risks of in-breeding and spread of disease. The size and extent of isolation of forest fragment often determines species re-colonization potential, mortality and dispersal (Joshi *et al* 2005, Boyle 2007, Broadbent *et al*. 2008).The net effect of this is increased vulnerability of species to extinction (Myers *et al*. 2000) causing serious threat to biodiversity of tropics (Gascon *et al* 2000; Giriraj *et al.* 2009). Response of a species to forest fragmentation varies with the life history traits of individual species and the matrix of forest surrounding the fragment (Laurance 1990, Boyle 2008).

It is therefore necessary to determine the factors influencing the distribution of species inhabiting fragile ecosystems in order to plan management interventions for its long-term conservation.

1.2 Tropical Forests of Western Ghats

The Western Ghats of India represents some of the best non-equatorial, tropical evergreen forests in the world. Located along the west coast of India, the Western Ghats are extremely rich in biodiversity and has the distinction of being declared as one of the 34 global biodiversity hotspots (Myers et al 2000). The Western Ghats barely covers 6 % of the country's land but is home to more than 30 per cent of the country's fauna. Like any other biodiversity hotspots, the Western Ghats supports many endemic species and are also facing threats of rapid deforestation (Myers 1988, 2003, Western Ghats Ecosystem Profile 2007).

The Western Ghats are divisible in two district regions based on the geology, topography, rainfall pattern and vegetation composition. The hills north of Krishna basin running along in to the states of Gujarat and Maharashtra are volcanic in origin with isolated, conical, flat-topped hills, with terraced terrain and steep slopes having a gradient of low rainfall from north to south. South of Krishna basin is the hills of Southern Western Ghats of Goa, Karnataka, Tamil Nadu and Kerala which are of Precambrian origin with high altitude plateaus and high rainfall.

Historically, the Western Ghats were well-forested and its inaccessibility prevented the people from cultivating and constructing in the region. However with the advent of British Rule followed by the spell of industrialization in post-independence era, the once inhospitable region witnessed large scale clearing of forests for giving way to development projects, commercial plantations and expanded agricultural activities. Substantial areas of lowland evergreen and semi-evergreen evergreen forests on the coastal plains to the west of the Ghats were deforested because of this (Daniels *et al* 1990, Stattersfield *et al* 1998, Western Ghats Ecosystem Profile 2007).

1.3 Status of Maharashtra Western Ghats

With a high density of 250 people/ km^2, approximately 20 % of the original forest covers remains in pristine state, with very few regions having intact forest blocks. Contiguous blocks of forests larger than 200 km^2 are remaining in the Agasthyamala Hills, Cardamom Hills, Silent Valley-New Amarambalam Forests, and southern parts of Karnataka State (Western Ghats Ecosystem Profile 2007).

The forest loss is relatively more in Northern Western Ghats than in southern Western Ghats (Panigrahy *et al.* 2010, Northern Western Ghats State Report 2010). The region has witnessed rapid urban expansion and an increase in development projects since last three decades. Large scale projects for luxury townships, resorts and development

project for railways, highways, power plants and mines have swept away the forest cover in the region (Mehta and Kulkarni 2010, Northern Western Ghats State Report 2010). Panigrahy *et al*. (2010) examined the changes in forest cover of Maharashtra Western Ghats from 1985 to 2005 based on satellite imageries. The study reported an annual decline of 0.72 % in dense forest cover and 0.42 % in the open forest cover owing to development projects, urbanization and an increase in water-bodies in the area in last two decades.

The Western Ghats of Maharashtra are in the forefront of the entire Western Ghats and therefore play a vital role in the zoogeography of India. Unlike its southern counterpart, the Maharashtra Western Ghats has not attracted much attention from the researcher community perhaps owing to its drier and fragmented landscape. The Indian or Malabar giant squirrel *Ratufa indica* is endemic to Western Ghats and is totally dependent on the canopy connectedness for its survival. Given the rapid rate of forest loss in this region, it was important to understand the status of giant squirrel in Maharashtra, where it is also declared as a State Animal. The Wildlife Research and Conservation Society (WRCS) of Pune in Maharashtra initiated a status survey of Malabar giant squirrel along the length of Maharashtra Western Ghats. The survey was supported by Worldwide Fund for Nature (WWF), New Delhi and Rufford Small Grants Program, United Kingdom.

1.4 Introduction to Arboreal Squirrels

The squirrels are included under family Sciuridae and order Rodentia whose descendants are known to be living since last 30 to 40 million years ago. Members of Sciuridae family comprises of a variety of diverse species such as the terrestrial chipmunks, marmots, semi-fossorial Praire dogs and arboreal tree and flying squirrels. The Sciurids are capable of occupying different niches from temperate to tropical regions of the world. They are diurnal and chiefly herbivorous feeding on plants, seeds, fruits, leaves and occasionally on small vertebrates and insects (Thorington et al 2012).
Earlier, squirrels were classified in two subfamilies: *Sciurinae* and *Pteromyinae* that included tree, arboreal and flying squirrels respectively. However with recent findings based on molecular evidences, squirrels are classified in 5 sub-families: *Ratufinae*, *Sciurillinae*, *Sciurinae*, *Xerinae*, and *Callosciurinae* (Stephan and Shawn 2006).

Large-bodied squirrels belong to the *Ratufinae* family. Among the terrestrial squirrels, the largest ones are marmots of North America and Asia while the largest arboreal squirrels are the giant squirrels from South and South-East Asian countries.

Although arboreal squirrels are known to damage fruits in orchards, feed on crops (Thorington *et al* 2012), and cause injuries to trees by debarking, they also provide certain valuable ecosystem services and therefore have an important role in biodiversity conservation. Ecological studies on Indian giant squirrel *Ratufa indica* have pointed out the importance of canopy connectivity, tall trees, contiguous forest patches and presence of lianas for supporting viable population of the species (Ramachandran 1988, Borges 1989, Ramakrishnan 1990, Datta and Goyal 1996, Srinivas 2008, Kankoje 2006). Apart from being an indicator species for structurally diverse forests, arboreal squirrels play an important role in seed-dispersal. Seeds form a majority portion of their food item (Ramachandran 1989, Borges 1992), bark, pith, flowers, fruit pulp and figs were consumed as per the availability (Borges 1993).

Although scatter-hoarding and larder–hoarding is best known most among temperate squirrels, it has been observed recently in arboreal Malabar giant squirrel (Somanathan *et al* 2007). Squirrels are known to assist in germination of a few hardwood species by terrestrial seed hoarding and also provide food resources to avian furgivores in the vicinity. Fungi also forms a part of the squirrels diet and thus assists in dispersal of fungi in the forests.

Members of Genus Ratufa

Giant squirrels belong to Genus Ratufa that consists of 4 species of canopy-dwelling squirrels generally restricted to sub- canopy with diet comprising mainly of fruits, seeds, bark and leaves of tropical trees (Borges 2007, Thorington et al 2012). All the four species of Ratufa are on Appendix II of CITES and Schedule I of Indian Wildlife (Protection) Act 1972.

Ratufa affinis is a brown giant squirrel inhabiting rainforests of south-east Asia. Nine sub-species have been identified. The species is included under near-threatened category of IUCN.

Ratufa bicolor is a black and white giant squirrel of North–east India and South-East Asia with eleven sub-species. It occupies broad-leaf evergreen forests and is listed as near-threatened by IUCN.

Ratufa indica is a maroon and buff colored giant squirrel endemic to India with four sub-species. Widely distributed from semi-evergreen, moist deciduous to riparian forests in drier areas, this species is now under the least concern category of IUCN.

Ratufa macroura has a black brown and buff coat, prefers evergreen forests. It has three sub-species, of which one is confined to southern India and other two are in Sri Lanka. The species is near-threatened as per the IUCN status.

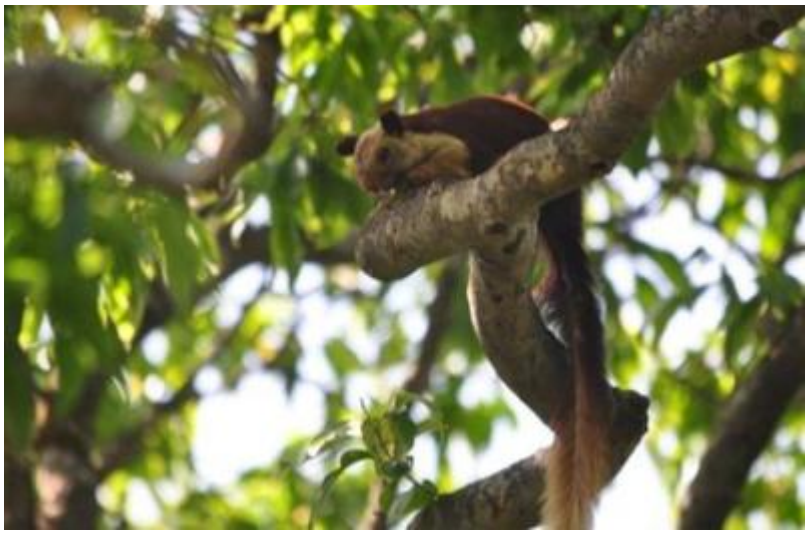
1.5 The Indian Giant Squirrel *R. indica*

Of the four species described above, *R. indica* has been studied extensively in the country. The species is widely distributed in Indian peninsula (Abdual Ali and Daniel 1952) and is almost totally arboreal and very rarely come down on the ground (Ramachandran 1988, Borges 1989). Their feeding activity is mainly in top to mid-canopy (Ramakrishnan 1990, Borges 1989, Kumara and Singh 2006); they prefer higher GBH (> 150 cm) and taller trees (> 15 m) for feeding and nesting (Datta and Goal 1996, Baskaran et al 2011). Leafy trees with canopy continuity and liana growth are preferred for nesting (Ramachandran 1988, Datta and Goyal 1996, Umapathy and Kumar 2000, Kankoje 2008, Baskaran et al 2011) and many times large nesting trees also served as feeding trees (Kankoje 2008, Baskaran et al 2011).

Giant squirrels are found across a range of natural forests from moist deciduous to dry deciduous forests types, riparian forests (Borges 1989, 1992, Datta and Goyal 1996, Srinivas *et al*. 2008, Kankoje 2008, Jathana *et al* 2008, Baskaran et al 2011), old mature teak forests (Ramachandran 1988) and teak-mixed forests (Kumara and Singh 2006) *R.indica* has five recognized sub-species based on their pelage color (Moore and Tate 1965).

- The palest and albinistic form *R. i. dealbata* (Blanford, 1897) from Gujarat Western Ghats
- *R. i. bengalensis* (Blanford, 1897) from wet crestline forests in Brahmagiri in Karnataka Western Ghats and to its eastern sides
- R*. i. centralis* (Ryley 1913) from drier teak associated forests of Central India
- *R. i. maxima* (Schreber 1784) from Malabar region in Kerala and
- *R .i. indica* from the Sahyadri-Konkan region of Maharashtra, Goa and northern parts of Karnataka Western Ghats (Prater 1980).

Studies on *R. indica* have been carried out in the Protected Areas in Western Ghats and Central India. Even within the Western Ghats, the southern Western Ghats have been extensively studied for its ecology and distribution status.



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Ecological Studies on R. indica

- An ecological study on *R .i .maxima* in Parambikulum Wildlife Sanctuary (WLS) in Kerala Western Ghats in south India was carried out from 1983 to 1985 by Ramachandran (1988). The study focused on the home-range, diet and breeding behavior of giant squirrels in the area. The study reported that giant squirrels require tall trees with interlinking crowns for nesting and feeding. Primarily, they feed on seeds but during the non-availability of seeds they also feed on leaves barks and twigs. The study reported a density of 31 individuals for 100 km^2in the area
- Renee Borges studied the resource use and foraging ecology of *R. indica* in Bhimashankar WLS in Maharashtra Western Ghats during 1983 to1988 (Borges 1989a, b). The study revealed that 95% of the daily giant squirrel diet was contributed by lianas and stressed the importance of liana conservation. The home range of squirrel was reported to be around 0.8 to 1.0 ha in the study area. The density of squirrel in Bhimashankar Rai (riparian area within Bhimashankar) was reported to be 100 individuals / km^2 (Borges 1989 Unpublished Report to USFWS)
- Borges (1990, 1992) studied the nutritional analysis and foraging strategies of giant squirrels. The study revealed that squirrels have adapted to a generalist feeding strategy owing to its large body size and constraints in availability of highly nutritious food items throughout the year (Borges 1992). Figs as fruits are taken by those individuals who have them in their territory as squirrels are sedentary and have small home ranges (Borges 1993).
- During 1992, Datta and Goyal (1996) carried out a short-term study on *R .i .centralis* comparing habitat use in a riparian forests and dry deciduous forests in

Bori Wildlife Sanctuary in Central India. The study reported preference of squirrels on tall (> 15 m) and higher GBH (> 150 cm) trees for feeding and nesting.

- Baskaran et al (2011) carried out ecological study of *R. indica* in Mudumalai Wildlife Sanctuary in Tamil Nadu. The squirrel diet showed high percentage of teak seed, bark, leaf and flowers in their diet. Tall trees with interlinking canopy were preferred for nesting.
- Kankoje (2006) studied nest site selection by *R. i. centralis* in Sitanadi WLS in Central India. The study revealed squirrel's dependence on tall trees with interlinking crowns as nest trees.
- Somanathan *et al*. (2007) reported an interesting record of seed storage in the nests of *R. indica* in Bhimashankar. While arboreal larders are useful in supplementing diet to individuals facing food storage in lean fruiting season and is common in temperate regions, it has not been observed in tropical forest so far. Also, terrestrial seed hoarding assists in plant germination, while arboreal hoarding of seeds had no clear role for plant germination therefore making this observation more intriguing.

Studies on Distribution Status of *R. indica*

- A status survey of *R. indica* by Mali *et al.* (1998) was carried out from 1992 to 1993 in Western Ghats and Central India in Protected Areas and intervening Reserved Forests. The survey confirmed local extinction of *R. i. dealbata* from Gujarat and vulnerable status of *R. indica* from Maharashtra Western Ghats. The study also compared the home range and density of *R .indica* in Bhimashankar WLS that was studied earlier by Borges (1989). After a gap of 10 years, the home range had doubled and a decline of 30 % in the population was recorded from the intensive study area. The cause of this decline was mainly habitat degradation in Bhimashankar WLS.
- From 1994 to 1996, Umapathy and Kumar (2000) examined the occurrence of arboreal mammals including giant squirrels in rain forest fragments in Indira Gandhi WLS in southern Western Ghats. The authors reported an increase in density of giant squirrels from disturbed and smaller fragments of forests. The explanation for this was that since giant squirrel has smaller home range it could occupy in smaller fragments and in absence of other arboreal mammals from smaller fragments, the squirrels had less resource competition and could survive in moderately disturbed areas.
- Madhusudan and Karanth (2000) compared densities of nine mammals including *R. indica* from Alkeri and Nalkeri sites of Nagarhole National Park in South India. Although both the sites were within the PA and had similar size and forest types, Alkeri had significantly lower density of *R. indica* (5.5. km^2) than Nalkeri

(8.5 /km^2). Intensive hunting at Alkeri was the main reason for the difference in the R. indica density between the sites.

- Between 1998 to 2000, Baskaran et al (2011) estimated the population of giant squirrels from Mudumalai WLS in Tamil Nadu. A density of 2.9 individuals /km2 was reported from the study area with an estimated mean home range to be 1.3ha.
- From 2001 to 2004, Kumara and Singh (2006) assessed the status of *R.indica* in 3 Protected Areas of Western Ghats of Karnataka namely**.** Pushpagiri, Brahmhagiri, Nagarhole, and forests of Sirsi–Honavar. The squirrel encounter rate was higher in Nagarhole National Park and in moist forests of Srinegri Forests. Giant squirrels were detected only from the narrow crest-line forests of Western Ghats but were found to be absent from plains of costal Karnataka and eastern Karnataka.
- Between 2002 to 2003, Jathana *et al*. (2008) used line transect sampling method to estimate population density of *R. indica* in 3 Protected Areas of Bhadra Tiger Reserve, Nagarhole Tiger Reserve and Bandipur Tiger Reserve in Karnataka. The encounter rates and densities were highest in moist forests. The encounter rates ranged from 0.18 to 0.79 in dry to wet evergreen forests respectively.
- From 2004 to 2008, Molur and Singh (2009) carried out a survey of non-volant mammals in Kodagu District in Karnataka and recorded the presence of giant squirrels in large undistributed fragments of Western Ghats.
- Molur *et a*l (2005) carried out a detailed assessment of non-volant mammals in India. The giant squirrel was placed in the category on Vulnerable in 2003 because of habitat degradation due to increase in agro-industry, large scale monoculture plantations, timber harvesting and hunting for meat.
- In 2005, Srinivas *et al*. (2008) carried out an occupancy assessment of giant squirrels in Kalakad Mundantharai Tiger Reserve (KMTR) in Tamil Nadu in South India. The occupancy rates of squirrels were higher in contiguous patches of evergreen and moist forests and lowest in drier, degraded and disturbed forests.

1.6 Relevance of this Project

The status of *R. i. dealbata*, the palest cline of giant squirrel has been surveyed in Gujarat Western Ghats by Dr. Sejal Vorah and Dr. Muni (unpublished) and Mali *et al.* (1998). The local people reported seeing the species last during 1970s and Borges et al (1998) could not locate any individuals of the species. Extensive hunting for meat by tribal's, extreme habitat fragmentation, conversion of natural forests in to teak and bamboo plantations, and lopping of trees were identified as factors responsible for extinction of *R. i. dealbata* from Gujarat (Borges et al 1998). Kumara and Singh (2006) reported

complete absence of *R. indica* coastal plains and eastern plains of Karnataka. The reasons were attributed to increased deforestation, increase in monoculture plantation, and hunting of squirrels for domestic consumption.

Recent extinction of *R. i. dealbata* from Northern Western Ghats indicates that the Malabar Giant Squirrel is an extremely vulnerable species and needs to be monitored regularly to assess its status. Information on status and distribution of the Malabar Giant Squirrel from Southern Western Ghats has been contributed by many studies mentioned above while the same information from Western Ghats of northern Maharashtra is available only from an earlier survey carried out twenty years ago between 1992 to 1993 by Borges et al (1998).

After the disappearance of *R. i. dealbata* from Gujarat Western Ghats, the northern-most distribution range of *R.indica* starts from Maharashtra Western Ghats. The moist and evergreen forests Western Ghats of Maharashtra have the required floristic composition and structure required for conservation of Malabar Giant Squirrel. However, of late this area has been witnessing expansion of agro-industry based plantations and developmental projects which are rapidly modifying the forests in this region.

Hunting for giant squirrels was reported to be prevalent throughout its range, with intensity of hunting being more outside the Protected Areas than inside the Protected Area (Borges et al 1998, Kumara and Singh 2006, Srinivas *et a*l 2008). Hunting was for mainly for meat but trade of the squirrel as pet and for body parts is also reported (Borges et al 1998). Most commonly used hunting methods were using guns, catapults, slicing the nest, catching the pups with the help of domestic dogs and capturing from the nests.

A 30 % decline in the population of *R. indica* in Bhimashankar Sanctuary owing to habitat degradation and fragmentation was an alarming report considering that Bhimashankar is a Protected Area and biotic pressures are expected to much less here. Another perturbing finding of their survey was hunting of squirrels for meat and also for making pinnae necklaces by the local tribal's in northern region of Maharashtra Western Ghats.

In spite of strong recommendation by Borges and Borges et al (1998) to afford immediate protection to the Malabar Giant Squirrel in Northern Western Ghats, no active measure to protect the species or even re-assess its status has been attempted in Northern Western Ghats.

In light of the threats that are endangering its existence and the fact that the squirrel is an excellent indicator of undisturbed closed canopy high diversity forests (Borges 1989, Borges et al 1998), WRCS initiated a survey to assess the status and distribution of the Malabar Giant Squirrel in Western Ghats of Maharashtra.

1.7 Project Objectives

The following objectives were established for the project

1. To carry out a distribution survey of the Malabar Giant Squirrel in the Study Area
2. To estimate the population of the Malabar Giant Squirrel in the Study Area
3. To identify threats to Malabar Giant Squirrel in the Study Area
4. To identify vulnerable populations of Malabar Giant Squirrel in the study area in immediate need of conservation action

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Chapter 2

Study Area

2.1 Description of Western Ghats of Maharashtra

The Western Ghats of Maharashtra, also known as Northern Western Ghats lie roughly between 15° 60' and 20° 75' N and between 72° 60' and 74° 40' E, covering about 52,000 km²area. The Northern Western Ghats are characterized by 3 distinct geographical regions: Konkan is the western low-lying region which is about 40 to 60 km wide and rarely rises above 400 masl. The Ghats are mountain tops in the east with average elevation up to 900 masl and have highest peaks rising up to 1400 masl. Mawal is the easternmost portion of the Ghats at an altitude of 600 to 800 masl. The average elevation varies between 2000 ft and 3500 ft above mean sea level, with occasional peaks over 4000 ft. There are only three peaks namely Kalsubai, Salher and Ghannachakkar over 4000 ft. The region is dominated by high altitude plateau such as Koleshwar, Raireshwar, Panchgani and Mahabaleshwar (about 5400 ft) (Ghate *et al* 1993, Ghate 1994). The deeply dissected terrain has created localized variations in rainfall and habitat types which is responsible for differences in species distribution between the northern and southern region. From north to south there is a slight increase in rainfall. (Mani 1972).

Basaltic and barren hill tops and evergreen forests in the Western Ghats of Maharashtra

Prachi Mehta

Although the entire Northern Western Ghats support tropical moist forests, the Ghats have primarily evergreen forests while region south of 19^0 has semi-evergreen forests.

North of 19 ^{0} are mainly deciduous forests. Because of severe biotic pressure, the semi-evergreen and evergreen components are confined in some areas with relatively better protection while large areas of forests are fragmented to a considerable extent. Moist deciduous forests with teak are present at lower altitude of about 600 m. Evergreen forests are present in Ghats section while in the foothills it is mostly semi-evergreen (Ghate *et al* 1993).

There are totally twelve Districts in the Western Ghats of Maharashtra. The giant squirrel survey was carried out in seven districts namely Ahmednagar, Pune, Thane, Raigad, Satara, Sangli and Kolhapur. The coastal districts of Sindhudurg and Ratnagiri could not be surveyed due to shortage of time. The survey was carried out in six Protected Areas and intervening Reserved Forests. Keeping with the objectives of the study, our survey was carried out only in tall and dense forests in the area.

2.2 Details of Survey Locations

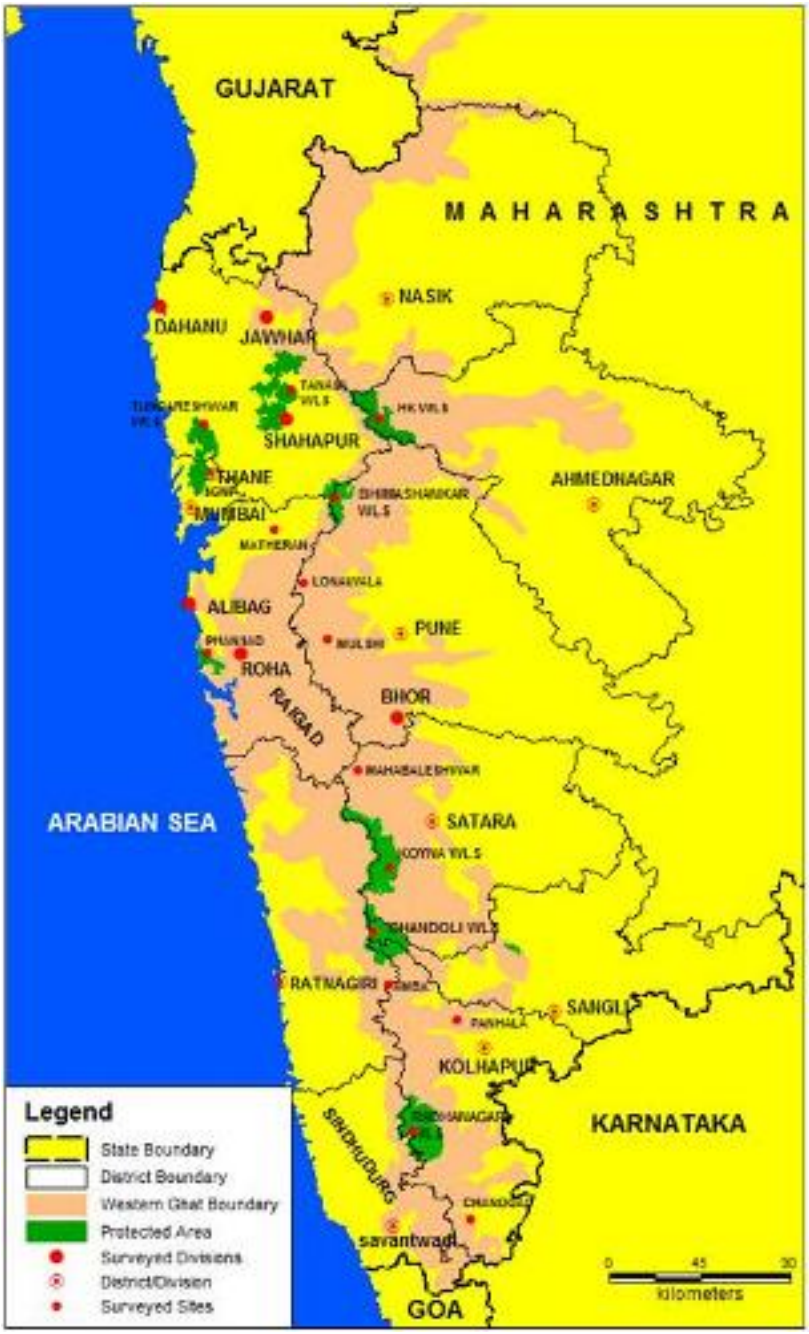
Table 2.1: Details on Surveyed Locations

District	Area Surveyed	Ranges Surveyed	Protected Area Status
Nashik	West Nashik Division	Igatpuri, Peth, Nashik*	Reserved Forest
Ahmednagar	Harishchadragad-Kalusbai Sanctuary (HKS)	Rajur and Bhandardhara	Protected Area
Thane	Thane Division	North and South Tokawade	Reserved Forest
Thane-Mumbai	Sanjay Gandhi National Park and Tungareswar Wildlife Sanctuary *		Protected Area
Pune	Pune Division, Junnar Division and Bhor sub-Division Bhimashankar WLS	Wadavgaon, Shirota, Paud (Pune) , Khanapur, Otur, Junnar , Khed (Junnar), Nasrapur and	Reserved Forest Bhimashankar is a PA

		Bhor	
Raigad	Alibaug and Roha Divisions	Matheran, Panvel, Karjat, Sudhagad Pali (Alibaug) Phansad WLS, Murud, Mahasale, Srivardhan, Roha (Roha)	Phansad is a PA and rest all are Reserved Forest
Satara	Satara and Koyna Division	Mahableswar, Jawadi, Patan, Dhebewadi (Satara) Koyna Wildlife	Koyan is a PA and rest all Reserved Forests
Sangli	Chandoli	Chandoli Wildlife	Protected Area
Kolhapur	Kolhapur	Radhanagri WLS Ganganbawda, Malkapur, Panhala, Pendhakhade, Gargoti, Kadgoan, Azra, Chandgad, Patne	Radhanagri is a PA rest all are RF

* Based on prior information and discussions with forest officers, these areas were not surveyed as they do not have giant squirrels.

Figure 2.1: Location of Surveyed Areas in Northern Western Ghats



Chapter 3

Survey Methods

3.1 Importance of Species Abundance Measures

Accurate assessments of distribution and conservation status of species are vital parameters to plan effective management strategies. Assessments should also include reliable quantification of target species as it helps in understanding its global and regional conservation significance. Evaluation of species status over a period of time allows revision of status criteria for species of interest. Based on the assessments provided by the evaluators, the species is upgraded, downgraded or maintained in the current status in the Red Data List of the IUCN.

Surveys are carried out to confirm presence/absence of a species and also to ascertain the status of a species in terms of its distribution and abundance. Surveys are typically carried out by searching for a species at a number of sites using appropriate field methods for detection of the species. When a species is detected, it is considered to be present but when a species is not detected, care should be taken before declaring it as being absent from the site. The surveys for species presence must take into account the problems of imperfect detections. Detection probability is always < 1.

Differences in detections can occur mainly due to vastness of the area to be surveyed and also due to the intrinsic detectability quotient of a species. Some species are very conspicuous and are easily seen while others are difficult to detect even if present on the site. Also, if areas to be sampled are enormous in scale, it will not be possible to cover all different types of habitats within the given resources and time leading to incomplete sampling of the area (MacKenzie *et al*. 2002, 2003).

Traditionally, studies have used abundance measure of a species to obtain near-reliable estimates or count statistics in a small area or over a long study period but this method is time consuming and effort intensive if it is to be implemented over a wide-geographical area. Investigators have used mainly two types of survey methods for detecting presence of *R .indica.* A survey for estimating encounters of squirrel presence such as direct sightings and indirect evidences such as nests and calls in different forest and vegetation types (Borges et al 1998, Umapathy and Kumar 2000, Kumara and Singh 2006, Molur and Singh 2009). The abundance index was calculated based on the count statistics.

Jathana *et al.* (2008) used line-transect based distance sampling method to estimate densities of giant squirrel. Srinivas *et al.* (2008) used grid-based occupancy survey to assess the status of giant squirrel. Both the investigators used the function of detection probabilities to model densities and occupancy of giant squirrels from a small and compact Protected Area in southern India.

3.2 Occupancy Model for Estimating Species Distribution

The problem of imperfect detection is addressed by carrying out the survey and the data analysis in an occupancy framework described by MacKenzie *et al* (2002). The authors suggested a new method based on "detection-non-detection" of a species. The occupancy method allows the use of proportion of area occupied (POD) as a low-cost surrogate for species abundance. The occupancy model is based on the premise that changes in the proportion of area occupied by a species may be corresponding with changes in its population size. Presence/absence surveys can be conducted at a number of sites across a broad landscape, with the history of its presence/absence being maintained. The model allows building detection probability built over capture history of the species and also incorporates habitat covariates such as habitat types, forest type, vegetation composition and biotic influences to account for variation in detectability and occupancy. This also takes in to account variations in occupancy based on habitat characteristics. For a large-scale species survey, proportion of area occupied is a reasonable state variable to be used as suggested by Mackenzie et al. (2002, 2003, 2004) and Linkie *et al* (2007).

The first objective of our survey was to evaluate the distribution status of Malabar giant squirrel in the Western Ghats of Maharashtra. This was achieved by using the occupancy modeling framework (Mackenzie *et al.* 2002).

The area of the survey was from Northern boundary of Harishchandragad-Kalsubai WLS of Ahemadnagar District in the north to Chandgad Taluka of Kolhapur District in the south. The survey was carried out in a grid-wise manner. The study area was divided into grids of 2.5 minutes (latitude) x 2.5 minutes (longitude). This is equivalent to a rectangle of 4.332 km (latitude) x 4.613 km (longitude) at the northernmost extreme and 4.465 km (latitude) x 4.610 km (longitude) at the southernmost extreme of the surveyed area. Degrees were used as a unit for demarcating the grids instead of kilometers because it is a more intuitive unit to use in the field with help of a GPS and does not make a substantial difference to the grid size. The average grid size was 20.28 km^2

A total of 184 grids were sampled in the study area. Each grid was divided into four sub-grids of 1.25 minutes (latitude) x 1.25 minutes (longitude) that is 5.07 km^2. Each sub-grid represented one spatial replicate. So each grid had a minimum of one and a maximum of four spatial replicates. If a giant squirrel was detected in a spatial-replicate it was given a '1' and if it was undetected it was given a '0'. In this way, we created capture histories for each of the 184 grids.

3.3 Methods for Assessing Species Abundance

The second objective was estimating the density of the giant squirrel in the study area. Distance sampling along line transects is a popular technique for population estimation of animals. Jathana *et al* (2008) used distance sampling along pre-marked straight line transects to estimate giant squirrel populations. Marking line transects for measuring abundance is not a feasible option given the extensive study area and limited study period of 9 months. The survey was therefore carried out along natural trails and paths in the forests as an alternate options suggested by Krishna and Hiby (2001).There is a possibility of bias in this approach because trails may influence the distribution of species by either attracting a species or repelling it for various reasons such as change in habitat and resource availability. A second cause of bias can be change of detectability along trails due to openings in the canopy due to trails. In the present survey a vast majority of the sampling trails passed through closed canopy forests with the forest canopy covering the trails so that there was no break in the canopy. Since the canopy above the trails was generally continuous squirrel distribution is unlikely to be affected by the presence of the trails. Because of closed canopy detectability was also unlikely to be affected by the presence of the trails. Hence we contend that distance sampling carried out during our survey was substantially unbiased.

We used number of squirrels per total effort (encounter rates =n/l) to compare its relative abundance across the habitat types within the study area.

3.4 Threat Assessment

The Third Objective was to assess the threats to the giant squirrel population in the study area. Some types of threats such as firewood collection, lopping, tree cutting and cattle grazing are localized and can be assessed by direct observations on the trail. A few other types of threats are understood better by evaluating the larger area as they may not be localized but may have long-term, permanent and even continued impact. Examples of such types of threats are poaching, hunting, habitat loss due to fragmentation and deforestation, impact due to old and new development projects, and disturbance due to human presence.

Based on the general information on prevailing biotic pressures, potential threats were categorized as below:

- Livestock presence: Under this category, presence of livestock, and signs of cattle dung were included.
- Firewood Collection: Observations of people carrying head-loads or signs of cut firewood were recorded.
- Tree cutting and lopping: Signs of old and new stumps of trees, cut branches, illegal felling of trees, stacked logs, and timber harvesting were recorded.
- Poaching and hunting: Direct information on squirrel hunting could not be collected because it is usually done on the spot by slicing of nests, catching the pups of with guns. On the other hand, use of snares, traps and hides were easy to detect as they are installed in the forests. Presence of snare etc does not directly indicate hunting of squirrel but it does indicate overall hunting pressure in the area.
- Human Presence: Presence of people, tourists, and villagers were recorded.
- Presence of Domestic Dogs: Domestic dogs are used often for hunting of squirrels and it also indicates human presence in the area.
- Development Projects: Upcoming projects for highways, canals, dams, mining projects, windmills, railways were recorded by discussing with local officers and people.
- Plantations: Plantations of teak, eucalyptus or any other species observed on the trails were recorded.
- Information was collated from findings based on occupancy analysis, density estimates and threat assessment for individual sites for identifying vulnerable populations of giant squirrels.

3.5 Details of Field Survey

The field survey was carried out from October 2011 to mid-June 2012 by trained researchers. Since extensive area was to be surveyed in the given time, three researchers were appointed to carry out the survey.

Prior to starting the survey, the study area was gridded as per the given grid size. Within each grid, potential sites to be surveyed were identified based on visible forest cover using Goggle Earth. The Forest Divisions within each grid were identified and after discussing with the local officers, the research team visited each site and verified the presence of tall forests within the division. The survey was carried out at the range level within each forest division.

After identifying potential sites to be surveyed in each range, three survey routes were selected per day. Each route was surveyed by one field researcher accompanied by a local guide. The survey for giant squirrel was carried out along existing trails in the sub-grids. The sub-grids were accessed by driving to the nearest point by a four-wheel vehicle and then walking to the start of the trail. The surveys were carried out through the day between 08.00 hrs to 17.00 hrs as per the availability of forest cover in the sub-grid. An attempt was made to start the survey early in the morning since this is the period when squirrels are most active. However this was not always possible since the sub-grids were often located far from the campsite. The length of trail in each sub-grid was about 2 to 3 km where there was substantial forest area. Correspondingly lower effort was employed in sub-grids where the forest area was lower.

We recorded giant squirrel presence based on direct evidences (sightings and calls), and indirect evidences (nests). Since calls are heard from a maximum distance of 100 m the squirrels were assumed to be in the same sub-grid as the observer even if recorded at the boundary of the sub-grid. Distance sampling was used for population estimation. Squirrels are generally found singly but are occasionally seen in pairs. On sighting the squirrel, number of individuals seen, perpendicular distance of the squirrels from the trail, and sighting angle were recorded.

The nests were categorized as new and old based on their appearance. New nests were lined by green foliage and appeared compact while old nests generally had a disheveled appearance. The nest trees and nest heights were also recorded.

Observations on types of threats encountered were recorded on the trail. All observations, including the direct sighting of squirrels, locations of nests and threat types were marked on the GPS.

In-use or new nest and un-used or old nest

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Research team

List of Researchers who participated in the Survey

Field Researcher	Area Surveyed
Mr. Tushar Pawar	Ahemadnagar and Junnar Division, Bhimashankar WLS
Mr. Ranjit Sahoo	Ahemadnagar, Junnar, Thane, Pune, Raigad, Satara, Sangli, Kolhapur
Ms. Evangeline Arulmalar	Satara, Sangli, Raigad, Pune, Kolhapur Divisions
Mr. Adwaite Deshpande	Satara and Pune Divisions
Ms. Ipsita Herlekar	Ahemadnagar and Junnar Division, Bhimashankar WLS
Mr. Gaurav Nalkur	Ahemadnagar and Junnar Division, Bhimashankar WLS

Chapter 4

Distribution of Malabar Giant Squirrel in the Western Ghats of Maharashtra

4.1 Determinants of Giant Squirrel Distribution in the Study Area

Our objective was to examine potential covariates that influenced grid-level giant squirrel occupancy in the landscape; however we expected that some of these covariates would also influence squirrel detection due to variation in squirrel behavior, abundance or observer visibility. Therefore, we first prepared a set of candidate models to determine the covariate structure for detection probability ***p*** (replicate-level) and then further used this structure along with potential covariates to model squirrel occupancy ***Psi*** (based on Karanth *et al*. 2011).

Habitat Factors Considered as Covariates

A total of 8 covariates were considered for the analysis and specific hypotheses based on their expected direction of influence were established. For each grid, we used a few remotely sensed variables and few field based covariates. The table below describes a list of potential variables, and expected direction of influence in explaining giant squirrel occupancy and detection probability in the study area.

We performed pair-wise Pearson's correlations for the variables to examine if any variables were highly correlated with each other ($r > \pm 0.6$). Edge density per grid was highly correlated with Percentage forest cover and Edge density for patch, therefore it was removed from further analysis (Table 4.1) All covariates, except for the categorical variable for Presence of Protected area, were converted to z-scores and used in the occupancy modeling analysis further.

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Table 4.1: Habitat Covariates used in Estimating Site-occupancy by *R. indica*

Sl. No.	Variable	Code	Description	Expected influence-on occupancy *Psi*	Expected influence on detection probability *p*
1	% Forest cover	FC	Area of forest cover for both classes of forest, semi-evergreen and moist deciduous, were calculated from the LULC MAP. This area was divided by the total area of the grid and converted to percentage.	Positive	Positive
2	Average slope	Slope	Slope was calculated in degrees using 30m ASTER DEM raster for the study area. This was then averaged for each grid, using the 'Zonal statistics' plug-in in QGIS (Version 1.7.0 Wroclaw).	Negative	Negative
3	Presence of Protected area	PA	Presence of Protected area was a categorical variable represented by a '1' or '0'.	Positive	Positive
4	Mean Patch size	MPS	Patch size was calculated for patches of Forest (both semi-evergreen and moist deciduous) in FRAGSTATS at the level of every grid. Mean Patch size was calculated by dividing the sum of all Patch sizes by the number of patches within a grid.	Positive	Positive
5	Disturbance Index	DI	Disturbance index was calculated as an encounter rate, which included the number of disturbance signs detected in each grid divided by the walk effort.	Negative	Positive
6	Edge density per grid	EDG	Edge density per grid was calculated by dividing total perimeter of Forest patches with total area of Forest patches for every grid. Here the Forest patch was restricted to within each grid cell, i.e. to say that area or perimeter of	Negative	

			Forest patches extending beyond the grid cell were not calculated. Only patch characteristics within the grid cell were used for analysis.		
7	Edge density for Patch	ED	Edge density for patch was calculated by dividing total perimeter of Forest patches with total area of Forest patches for every grid. Here the Forest patch was NOT restricted to within each grid cell, i.e. area and perimeter of Forest patches extending beyond the grid cell were also calculated. Patch characteristics beyond the grid cell were used for analysis.	Negative	
8	Walk Effort	Effort	Walk effort was calculated in kilometers using the sum line lengths tool in the 'fTools' plug-in in QGIS (Version 1.7.0 Wroclaw)	Positive	Positive

Table 4.2: Pair-wise Pearson's correlation explaining occupancy and detection probability for *R. indica*

Variables	Walk Effort	%Forest cover	Average Slope	Disturbance index	PA	Mean Patch size	Edge Density per grid	Edge Density for patch
Walk Effort	1.00	0.15	0.16	-0.04	0.20	-0.09	0.02	0.05
%Forest cover	0.15	1.00	0.32	-0.03	0.24	0.30	**-0.81**	-0.56
Average Slope	0.16	0.32	1.00	-0.14	0.02	-0.10	0.03	0.17
Disturbance index	-0.04	-0.03	-0.14	1.00	0.14	-0.10	-0.03	-0.06
PA	0.20	0.24	-0.02	-0.14	1.00	0.16	-0.27	-0.25
Mean Patch size	-0.09	0.30	-0.10	-0.10	0.16	1.00	-0.35	-0.25
Edge Density per grid	0.02	**-0.81**	0.03	-0.03	0.27	-0.35	1.00	**0.83**
Edge Density for patch	0.05	-0.56	0.17	-0.06	0.25	-0.25	**0.83**	1.00

% Forest cover = Percentage forest cover; Average Slope = Average Slope per grid; PA = presence of Protected Area; Mean Patch Size = Mean patch size per grid

We then ran another 10 alternative models, keeping the covariate structure for ***Psi*** fixed, to select the model structure for ***p***. The lowest scored AIC model (highest ranked) was selected to fix the model structure for ***p***. We then kept this model structure for ***p*** unchanged and further ran a total of 11 occupancy models. The covariate 'Presence of Protected area (PA)' was removed from the all the occupancy models since the parameter was facing convergence issues and causing lack of model fit during initial model runs. We re-ran all 11 occupancy models without the PA covariate and used an information-theoretic model selection approach (Burnham & Anderson, 2002).

Model fit was examined by bootstrapping and observing c-hat values. Model averaging was performed and weighted parameter estimates and unconditional standard errors were calculated for model parameter estimates from the best ranked models (AIC<2) (Burnham & Anderson, 2002).

All analysis was performed in software PRESENCE (version 3.0 beta, Hines 2006). Model selection was performed using Akaike's Information criterion (AIC) and model weights. We first defined a global model for occupancy, which included all covariates except walk effort, which was only used to model its effect on detection probability.
The top ranked model (Akaike weight (w_i) = 0.445) for the covariate structure for replicate level detection probability (***p***) has been shown in Table 4.3. Percentage Forest cover, Walk effort, Slope and Disturbance index were ranked as important variables in explaining replicate level detection probability. This model structure was chosen for detection probability (***p***) in further occupancy analysis.

As per this model, for squirrel occupancy ***Psi*** (% Forest Cover + Slope+ Protected Area + Mean Patch Size +Edge Density for Patch+ Disturbance index) variables were considered and for detection probability ***p*** (Walk effort + % Forest Cover + Slope + Protected Area + Mean Patch Size +Edge Density for Patch) variables were considered.

Table 4.3: Candidate models considered and top model (highlighted) to define the covariate structure for detection probability (*p*)

Model	AIC	ΔAIC	AIC wgt	Model likelihood	No. of Para-meters
psi(FC+Slope+PA+MPS+ED+DI),p(Effort+FC+Slope+DI)	431.45	0	0.4458	1	12
psi(FC+Slope+PA+MPS+ED+DI),p(Efffort+FC+DI)	431.97	0.52	0.3438	0.7711	11

psi(FC+Slope+PA+MPS+ED+DI),p(Effort+FC+PA+DI)	433.81	2.36	0.137	0.3073	12
psi(FC+Slope+PA+MPS+ED+DI),p(Effort,FC)	436.31	4.86	0.0392	0.088	10
psi(FC+Slope+PA+MPS+ED+DI),p(Effort+FC+Slope+PA+MPS+ED+DI)	437.13	5.68	0.026	0.0584	15
psi(FC+Slope+PA+MPS+ED+DI),p(Effort+DI)	439.77	8.32	0.007	0.0156	10
psi(FC+Slope+PA+MPS+ED+DI),p(Effort)	443.37	11.92	0.0012	0.0026	9
psi(FC+Slope+PA+MPS+ED+DI),p(FC+DI)	450.38	18.93	0	0.0001	10
psi(FC+Slope+PA+MPS+ED+DI),p(FC)	460.59	29.14	0	0	9
psi(FC+Slope+PA+MPS+ED+DI),p(DI)	474.09	42.64	0	0	9
psi(FC+Slope+PA+MPS+ED+DI),p(Effort+FC+Slope+DI)	431.45	0	0.4458	1	12
psi(FC+Slope+PA+MPS+ED+DI),p(Efffort+FC+DI)	431.97	0.52	0.3438	0.7711	11
psi(FC+Slope+PA+MPS+ED+DI),p(Effort+FC+PA+DI)	433.81	2.36	0.137	0.3073	12

Where, FC = Percentage forest cover; Slope = Slope; PA = presence of Protected area; MPS = Mean patch size; ED = Edge density for patch; DI = Disturbance index; Effort = Walk effort; psi = site-level Occupancy parameter; p = replicate level detection probability parameter; (.) = null model; AIC = Akaike's information criterion score; ΔAIC = delta AIC or difference in AIC score; AIC wgt = Akaike weights

After keeping this covariate structure fixed for ***p***, we used 11 plausible models for examining their effect on site-level occupancy of giant squirrels. No single model received most support and three models were ranked as the top models (with delta AIC <2) (Table 4.4). Since no single model received adequate support, model averaged parameter estimates had to be calculated for these three top models. Model averaged parameter estimates and their unconditional standard errors (SE) have been shown in Table 4.5. All models had c-hat values close to 1, indicating good fit for models overall.

Table 4.4: Candidate models considered and model selection results (highlighted models) for explaining R.indica occupancy (*Psi*)

Model	AIC	ΔAIC	AIC wgt	Model Likelihood	No. of Para-meters
psi(Slope+ED+ DI),p(Effort+FC+Slope+DI)	432.51	0	0.3306	1	9
psi(Slope+ED+MPS+DI),p(Effort+FC+Slope+DI)	432.81	0.3	0.2846	0.8607	10
psi(Slope+FC+ED+DI),p(Effort+FC+Slope+DI)	434.47	1.96	0.1241	0.3753	10
psi(FC+Slope+MPS+ED+DI),p(Effort+FC+Slope+DI)	434.81	2.3	0.1047	0.3166	11
psi(ED+DI),p(Effort+FC+Slope+DI)	435.25	2.74	0.084	0.2541	8
psi(DI),p(Effort+FC+Slope+DI)	436.97	4.46	0.0356	0.1075	7
psi(Slope+DI),p(Effort+FC+Slope+DI)	438.45	5.94	0.017	0.0513	8

psi(ED),p(Effort+FC+Slope+DI)	439.15	6.64	0.012	0.0362	7
psi(Slope+ED),p(Effort+FC+Slope+DI)	440.7	8.19	0.0055	0.0167	8
psi(Slope),p(Effort+FC+Slope+DI)	442.74	10.23	0.002	0.006	7
psi(.),p(.)	471.03	38.52	0	0	2

Where, FC = Percentage forest cover; Slope = Slope; MPS = Mean patch size; ED = Edge density for patch; DI = Disturbance index; Effort = Walk effort; psi = site-level Occupancy parameter; p = replicate level detection probability parameter; (.) = null model; AIC = Akaike's information criterion score; ΔAIC = delta AIC or difference in AIC score; AIC wgt = Akaike weights

Model averaged parameter estimates, along with 95% Confidence Intervals (CIs) indicated that Slope and Disturbance index both had a negative influence on occupancy of Giant squirrels as expected (Table 4.5). Other covariates in the top models, including Forest cover, Edge Density for Patch and Mean Patch size did not show up as important in explaining occupancy due to large unconditional standard errors for the parameter estimates. Walk Effort, % Forest cover, and Disturbance index were important covariates in explaining detection probability of giant squirrels.

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Table 4.5: model averaged weighted parameter estimates and unconditional standard errors in explaining *R. indica* occupancy and detection probability

	Variables	Wt. Parameter estimates	Wt. unconditional SE	Lower 95%CI	Upper 95% CI
	Slope	**-1.302**	**0.647**	**-2.57**	**-0.03**
	ED	3.808	2.056	-0.22	7.84
Psi	**DI**	**-1.177**	**0.469**	**-2.10**	**-0.26**
	MPS	2.004	2.416	-2.73	6.74
	FC	0.163	0.786	-1.38	1.70
	Effort	**0.588**	**0.194**	**0.21**	**0.97**
p	**FC**	**0.379**	**0.139**	**0.11**	**0.65**

	Slope	0.206	0.140	-0.07	0.48
	DI	**0.609**	**0.175**	**0.27**	**0.95**

FC = Percentage forest cover; Slope = Slope; DI = Disturbance index; MPS = Mean patch size; ED = Edge density for patch; Effort = Walk effort; psi = site-level Occupancy parameter; p = replicate level detection probability parameter; Wt. Parameter estimates = weighted parameter estimate; Wt. unconditional SE = weighted unconditional Standard Error; Lower 95% CI = Lower 95% Confidence Interval; Upper 95% CI = Upper 95% Confidence Interval

4.2 Site-Occupancy of Giant Squirrel in the Study Area

The naïve occupancy (***Psi***) that is generated without using the capture-recapture framework, was found to be 0.75, i.e. to say that 75% of the sampled landscape was detected to have squirrels. Final parameter of occupancy (**Psi**) was estimated to be **0.95 (SE = 0.03)**. The probability of detecting (***p***) squirrel presence, if present at a replicate was estimated to be **0.61 (±0.05)**.

Table 4.6: Model parameter estimates and standard errors from the best models in explaining Giant squirrel occupancy and detection probability

Model	Slope (SE)	ED (SE)	DI (SE)	MPS (SE)	FC (SE)	Effort (SE)	FC (SE)	Slope (SE)	DI (SE)
psi(Slope+ED+DI),p(Effort+FC+Slope+DI)	-1.25 (0.64)	3.33 (1.72)	-1.22 (0.47)			0.59 (0.19)	0.38 (0.14)	0.20 (0.14)	0.61 (0.17)
psi(Slope+ED+MPS+DI),p(Effort+FC+Slope+DI)	-1.37 (0.64)	4.51 (2.32)	-1.12 (0.45)	2.00 (2.42)	0.59 (0.19)	0.38 (0.14)	0.21 (0.14)	0.61 (0.18)	
psi(Slope+FC+ED+DI),p(Effort+FC+Slope+DI)	-1.28 (0.67)	3.48 (1.90)	-1.19 (0.49)		0.16 (0.79)	0.59 (0.19)	0.38 (0.14)	0.20 (0.14)	0.61 (0.17)

Where, FC = Percentage forest cover; Slope = Slope; DI = Disturbance index; PA = presence of Protected area; MPS = Mean patch size; ED = Edge density per grid; Effort = Walk effort

Figure 4.1: Giant Squirrel Distribution based on Predicted Occupancy *Psi*

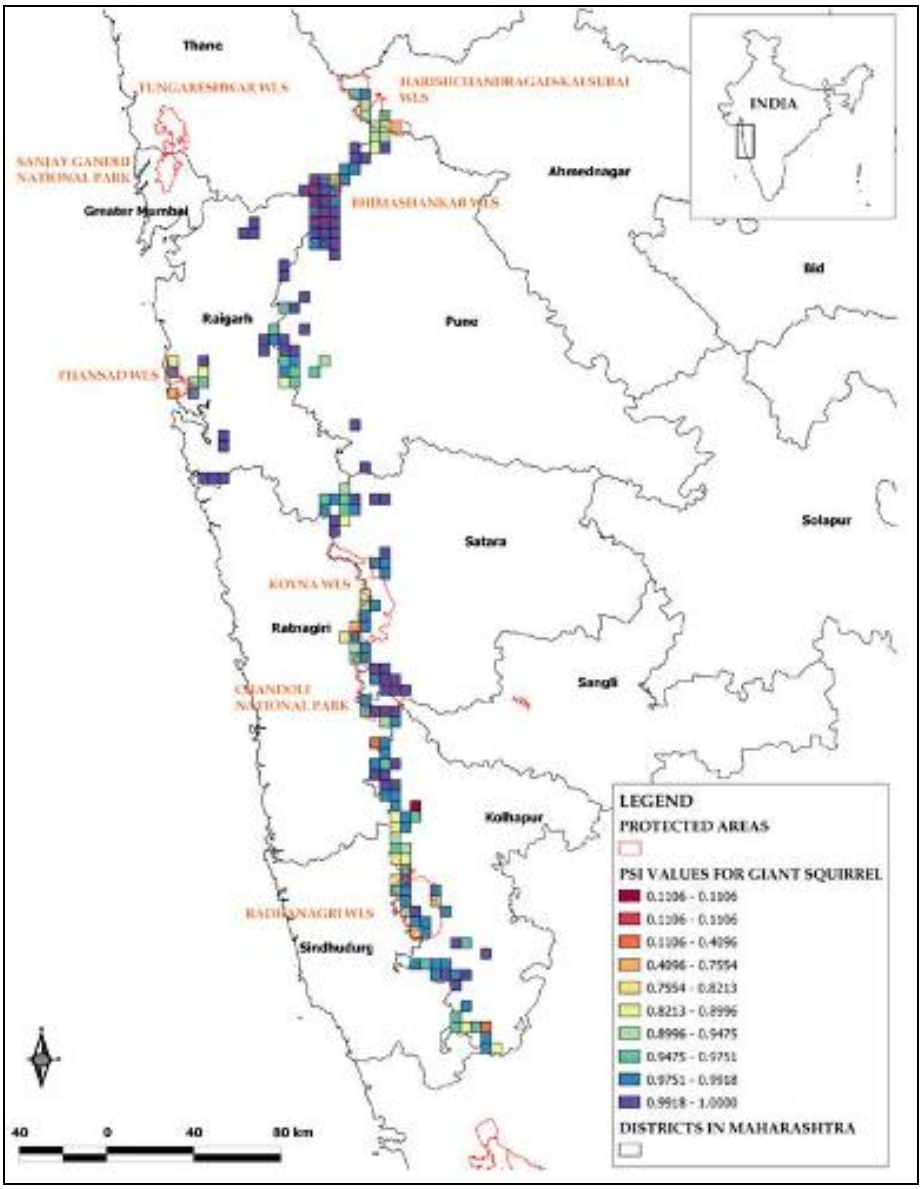

Figure 4.2: Conditional Occupancy of Giant Squirrel in the Study Area

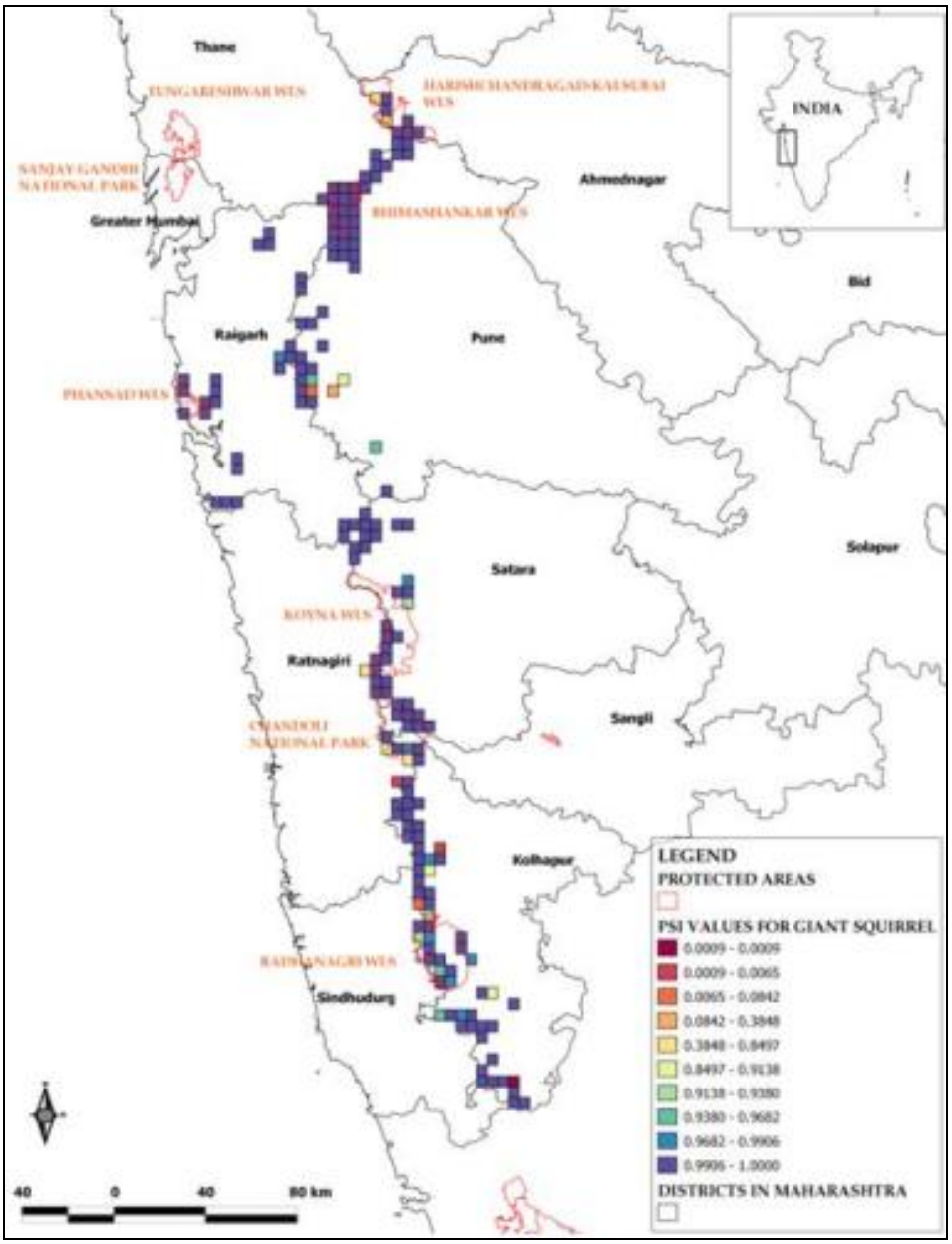

Figure 4.3: Grids showing Detected /Undetected History

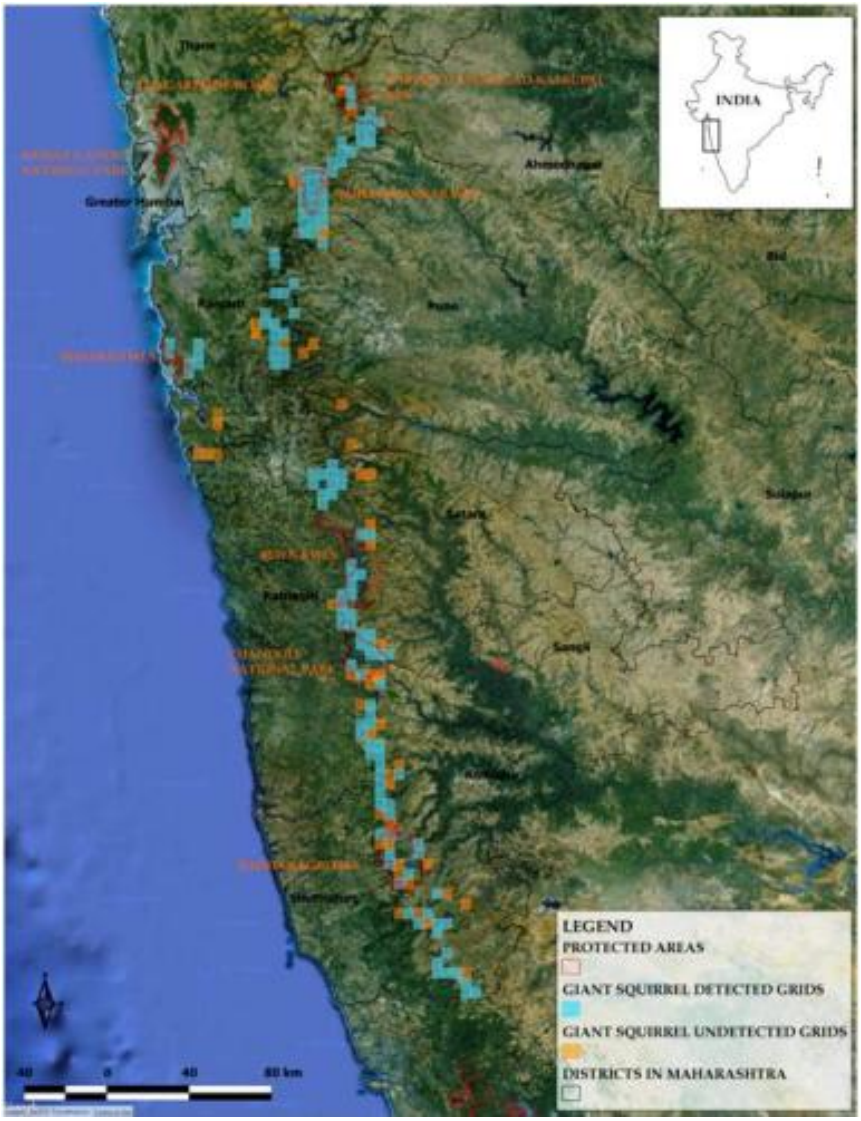

Figure 4.1 shows predicted occupancy model of giant squirrel presence in Maharashtra Western Ghats. Here the occupancy is predicted based on the attributes of covariates for each sampled grid. Based on the covariate values of each grid and capture histories, the model predicts occupancy estimates as shown. This map predicts giant squirrel distribution in the area.

The conditional occupancy model of giant squirrel presence in the study area is as shown in Figure 4.2 In this map, the grid where the giant squirrel was detected was assigned a score of 1 (deep purple color). In grids where the giant squirrel was not detected the occupancy is considered as the *Psi* value estimated by the occupancy model. The map uses predictive values for un-detected grids. The map helps

understanding the status (and therefore the cause) of associated covariates in the undetected grids.

Figure 4.3 is prepared plainly with detected and undetected (1 or 0) records based on the field data. This map displays distribution pattern of giant squirrel at the landscape level.

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Chapter 5

Density Estimates of Malabar Giant Squirrel in the Study Area

5.1 Determination of Multiplier

Density estimation was carried out based on distance data of giant sightings collected during the survey. Of the total 160 giant squirrel sightings, 90 were recorded from Bhimashankar Range 1 alone. Apart from higher abundance in Bhimashankar, the sampling intensity was also much higher in this range compared to the survey in the remaining areas. It was therefore decided to carry out the density analysis separately in Bhima1 Range and the rest of the study area.

Giant squirrels are much more active during the morning hours and evening hours (peak hours) with a lull in the middle of the day (off-peak hours). Therefore sampling should ideally be carried out in the peak hours when the giant squirrels are most active. However, in the present survey, it was not possible to restrict sampling only to peak hours and survey was carried out at peak as well as off-peak hours depending on the trail location and the logistics of reaching the trail.

A basic assumption of line transect surveys is that all squirrels are "available" for sampling. This is the case during the peak hours. However, during the off-peak hours some giant squirrels retire to their nests and are "not available" for sampling. This is the case only for a percentage of squirrels. This is contrary to the basic assumption that all squirrels are available for survey. Conventional distance sampling assumes that g(0)=1 on the sampling line. However, in the present situation g(0) is less than 1 in off-peak hours because of some squirrels not being available for sampling. A correction factor needs to be applied to the density estimate known as a multiplier. The multiplier is usually determined by a separate experiment.

Since the sightings made at Bhimashankar Range 1 were made in the same location and we had substantial number of sightings these were used to determine the multiplier.

We divided the sightings made at Bhimashankar into sightings made during peak hours and those made during off-peak hours. Peak hours were considered as the time before 11 am and after 4 pm during winter. In summer peak hours were considered as the time before 10 am and after 5 pm. The interval in between was considered as off-peak hours (Renee Borges, pers. comm.). The length of each trail was also divided into length sampled during peak hours and length during off-peak hours. In this manner the entire data for Bhimashankar Range 1 was segregated into two sets consisting of data

collected during peak hours and data collected during off-peak hours. The encounter rates were determined for both these data sets as follows:

Re_{peal} = Number of sightings during peak hours
Effort during peak hours

$Ru_{ff\text{-}peak}$ = Number of sightings made during off-peak hours
Effort during off-peak hours

Table 5.1: Encounter Rates (n/l) during peak and off-peak hours in Bhimashankar Sanctuary

Description	Total	Peak Hours	Off-peak hours
No. of trails	54	37	37
No. of Encounters	100	52	38
Effort	186.78	78.31	108.47
Encounter Rate		0.8812	0.5059
Standard Error		0.216	0.165

The encounter rates at peak and off-peak hours would have been the same if the giant squirrels were active throughout the day. However since they are less active during the off-peak the encounter rates during these hours is lower than the peak hours. The ratio of the two encounter rates reflects the ratio of giant squirrels that is available during off-peak hours to those available during peak hours. Therefore the multiplier is calculated as:

$$M = \frac{Ru_{ff\text{-}peak}}{Re_{peal}} = \frac{0.5059}{0.8812} = 0.5741$$

5.2 Density of Giant Squirrels in the Study Area

The analysis was carried out in Distance 6.0 Release 2. As stated earlier we defined two sets of data, each with their own sets of trails as shown in Table __. The off-peak trails need to be assigned the above multiplier so that the density estimate based on these trails is increased to reflect the number of giant squirrels that is not available for sampling. However the present version of Distance allows assignment of multipliers only at the Global layer and not at the transect layer. To circumvent this limitation the effort for off-peak lengths of all transects was multiplied by the above multiplier. This

has the effect of reducing the transect length of the trails during off-peak hours thereby increasing the density to account for the unavailable giant squirrels.

The density estimation parameters for Bhima 1 are given in Table 5.1 and the density estimation parameters for the rest of the study area is given in Table 5.2.

Table 5.2: Density of Giant Squirrel in Bhimashankar Range 1

		Value	
	Total	**Peak**	**Off-peak**
Number of Trails	63	55	53
Encounters	86	52	38
Number of Giant Squirrels	97	61	40
Effort	186.8	78.3	108.5
Effort (corrected)	140.6	78.3	62.3
Max strip half width (m)	42 m		
Truncated strip half width (m)	30 m		
Average cluster size	1.126		
Selected Model	Uniform with polynomial correction		
Density	15.89/sq.km. (11.00-22.74)		
%CV	18.29 %		

Table 5.3: Density of Giant Squirrel in Rest of Study Area (Other than Bhimashankar)

Item		Value	
	Total	**Peak**	**Off-peak**
Number of Trails	191	123	146
Encounters	43	29	24
Number of Giant Squirrels	55	31	24
Effort	538.6	206.3	332.3
Effort (corrected)	397.1	206.3	190.8
Max strip half width (m)	55 m		
Truncated strip half width (m)	40 m		
Mean cluster size	1.037		
Model	Uniform with cosine correction		
Density	2.92/sq.km. (1.95-4.43)		
%CV	15.82%		

The density estimate for Bhimashankar is quite high at 15.89 /km^{2}while the average density of giant squirrel in the rest of the study area is 2.92/km^2.

Estimation of number of giant squirrel requires estimation of giant squirrel habitat in the sampled area. This is a complex exercise and involves interpretation of satellite imagery. It was not possible within the time and resources available to us. Hence estimation of giant squirrel numbers was not carried out. However this is a feasible exercise and may be attempted in the future.

Chapter 6

Measure of Giant Squirrel Abundance in Surveyed Areas

6.1 Index of Abundance

This section describes the profile of all the surveyed area and number of giant squirrel signs encountered in the study area. For understanding the trend in squirrel population, we have compared numbers of squirrel signs recorded during 1992-93 by Borges et al (1998) with the signs obtained during this survey. Comparisons were possible only from similar areas and because of some administrative re-arrangements, some areas had to be clubbed for comparisons. Since there was no mention of effort from the previous survey, encounter rates could not be compared.

Table 6.1: Total Effort for the Survey

Total Effort	723.16 km
Number of Trails walked	254
Number of Sightings	160
Number of Calls Heard	336
Number of New Nests	3416
Number of Old Nests	1879

6.2 Nashik District

Location	**$19^0 40'$N-20^0N; $73^0 20'$E- $73^0 30'$E**
Average Elevation	950 m -1287 masl
Forest Type	Moist deciduous with teak and evergreen species
Protected Status	Reserved Forests

Topography and Vegetation: Nashik District has two divisions namely east and west Nashik. The east Nashik Division is a drier region and has mainly scrub forests and grasslands so this division was not surveyed. West Nashik Division has 5 Ranges. None of the ranges had records of giant squirrel in the area. In 1992, West Nashik Division was surveyed by Mali *et al.* (1998) and they reported no sightings of squirrel from the

area. The survey reported considerable fragmentation of forests from most of the areas in West Nashik Division.

Status of *R. indica* in Nashik Division: We interviewed Forest officers and staff in West Nashik about history of Giant Squirrel. The Sawarda and Vaitarna valley in Tansa WLS may have had squirrels in the past but since last 3 decades there are no records of the species from the area. Forests around Mauhli Gad and Khor Village one supported tall forests but due to recent deforestation and encroachment the forests are very scanty in appearance and do not support giant squirrels.

6.3 Ahmednagar District

Location	**19⁰25′N-19⁰ 35′ N;73⁰ 40′E- 73⁰ 50′E**
Area	Harishchandragad-Kalsubai WLS (HKS)
Average Elevation	600 - 1400 masl
Forest Type	Moist deciduous with teak and evergreen species near the crest-line
Protected Status	Wildlife Sanctuary

Topography and Vegetation: HKS is located at the northernmost region of Maharashtra Western Ghats. Although the total area of the **s**anctuary is 362 km^2, only 171 km^2 is under Reserved Forest and 29 km^2 is under Protected Forests while the remaining 162 km^2 belongs to villagers as Private Forests.

The Harishchandragad Fort, Tarabai temple and Kalsubai peak are the major attraction for the tourists here. The base of the Sanctuary is at 600 masl and the highest peak is at Kalsubai at 1646 masl. Kalsubai is the highest peak in Northern Western Ghats. There are many other smaller peaks in the region that people visit for trekking.

Interestingly, the southernmost part of Harishchandragad marks the northern-most limits of evergreen forests in Sahyadri. The northern half and eastern fringe of the Sanctuary has semi-evergreen and deciduous forests. Commonly found tree species in Typical vegetation in the region includes *Terminalia chebula, Memecylon umbellatum, Olea diocia, Syzygium cumini, Actinodaphne angustifolia, Bridelia retusa, Ficus glomerata, Terminalia tomentosa, Macaranga pultala, Cassia fistula, Actinodaphne hookeri , Diospyros montana , Albizzia procera , Trema orientalis , Memecylon umbellatum, Phyllanthus emblica.* There are many villages located inside the Sanctuary and they all depend on the forests for their biotic needs (Mehta and Kulkarni 2010).

HKS Wildlife Sanctuary now represents the northern-most range of *R. indica*

Prachi Mehta

Status of *R. indica in* Harishchandragad-Kalsubai Sanctuary (HKS): Very few evidences of squirrel presence were obtained from northern areas of Alang, Kulang, Ratanwadi, Ghatghar located in Bhandardhara Range. Rajur Range located in southern portion of HKS has tall forests in valleys. Areas like Tolar Khind, Jamran, Tale Vihir, Mahvasa, Virachi Rai, Kothale, Harishchandragad, and Tarabaigad have a good population of giant squirrels. The slopes have dense thickets of *M. umbellatum* and squirrels feed on fruits and leaves of the tree. Although these trees are not very tall, squirrel nests were seen on these trees.

Considerable extent of forest area is fragmented due to presence of villages inside the sanctuary. The local tribes known as Kolis, Thakurs and Katkaris from Ratanwadi, Thakurwadi and Ghatghar villages are famous for their hunting skills with catapults (Mehta and Kulkarni 2010) and hunting of squirrels was a regular practice since earlier times here (Borges et al 1998). People from Thakurwadi and Ratanwadi admitted to hunting the squirrels but changed their statements once they realized that the survey was for assessing the status of squirrels. During the survey in Ratanwadi, several teams of young boys were seen in the forests with traps, snares and dogs actively hunting for wild boar, birds and small mammals. It is quite common to see gangs of boys with catapult in the area so hunting of squirrel from the area cannot be ruled out. HKS represents the northern-most population of *R .indica* for the Western Ghats, it requires regular monitoring to control deforestation and hunting of giant squirrels in the area.

In Ratanwadi, the semi-evergreen forests were patchy interspersed with tall shrubs of *Carvia callosa*, grassy blanks and degraded forests. Most forest patches were secondary in nature with signs of grazing, lopping and hunting. A few older villages informed that the squirrel presence has declined in the area due to hunting.

Table 6.2: Count of *R. indica* in HKS WLS in 1992 and 2012

	Total Effort (km)	Sightings	Calls	Nest (Old + New)
Borges et al (1998)	NA	11	-	97
This survey	24.24	2	6	43

Table 6.3: Encounter Rate of *R. indica* Harishchandragad Kalsubai WLS

Sighting	Calls	New Nest	Old Nests
0.08(0.04)	0.20(0.12)	1.41(0.38)	0.20(0.12)

Figure in parentheses represent standard error.

Wild Boar Trap at Ratanwadi and Signs of cut tree stumps in Tale Vihir, HKS

Gaurav Nalkur

6.4 Thane District

Location	**19^{0}10'N-20' N;72^0 50'E- 73^0 15'E**
Areas	Thane Wildlife, Malshej Ghats, Tansa WLS, Tokwade Forests
Average Elevation	200 to 700 masl
Forest Type	Moist mixed deciduous with teak plantations
Protected Status	SGNP and Tansa are PA and rest all RF

Within Thane District, there are 4 divisions' viz., Dhanu, Jawahar, Shahapur, and Thane Wildlife. Giant squirrels are not reported from Dhanu, Jawahar and Shahapur divisions mainly because they support drier forests with teak plantations (Borges et al 1998). Within Thane Division, exploratory visits were made around forests of Badlapur, Mandvi, Murbad and Kalyan Ranges. The forests were dry, scrubby and degraded and not found to for giant squirrels.

There is no record of giant squirrels from SGNP, Tungareshwar and nearby forests. This was confirmed with Forest officers of SGNP and naturalists from Mumbai also. There are no giant squirrels now in Tansa Wildlife sanctuary but some old villagers mentioned seeing it around mid-1970s around the forests of Vaitarna lake.

Forests on the hills of Tokwade, Nagjhurim Dareghat, Ramdeoli and Madrai areas have presence of giant squirrels. Nane Ghat, Ambe Rai, Malshej Ghats are in relatively undisturbed conditions and support giant squirrels.

Table 6.4: Count of *R. indica* in Malshej Ghat in 1992 and 2012

	Total Effort (km)	Sightings	Calls	Nest (Old + New)
Borges et al (1998)	NA	6	NA	46
This survey	30	2	-	67

Table 6.5: Encounter Rate of *R.indica* in Malshej Ghats in Thane Division

Sighting	Calls	New Nest	Old Nests
0.05(0.04)	0	0.98(0.29)	1.28(0.18)

Figure in parentheses represent standard error.

6.5 Pune District

Location	**18^{0}10'N-19^0 25' N;73^0 20'E- 73^0 50'E**
Areas	Bhimashankar Sanctuary, Pune, Junnar and Bhor Divisions
Average Elevation	650 to 902 masl
Forest Type	Moist mixed deciduous with teak in the valleys, semi-

	evergreen, subtropical broad-leaved
Protected Status	Except Bhimashankar all are Reserved Forests

Topography and Vegetation: The region is located towards eastern slopes of Western Ghats Range and includes river valleys of Ghod, Bhima, Mulshi, Mutha, Amba and Andhara and also catchments of Panshet, Khadakwasla, Shirota, Varasgaon, Bhira lakes. The area has semi -evergreen to moist deciduous forests with patches of dry deciduous patches including many tropical thorn forest and grasslands. Due to many disturbances in the near past many patches are secondary in nature and dominated by scrub forests. The major tree species include *Mangifera, Terminalia, Syzigium, Ficus* etc.

Status of R. indica in Pune Division: Within Pune Forest Division, survey was carried out in Wadgaon Range (Pimpri, Dangergaon, Tungi, Lohagarh), Shirota Range (Kunewadi vill, Pimpri, Kashakule windmill, Rajmachi), Paud range (Tamhini, Dhaukhind, Plus valley, Deepdhara, Temgharh vill), Malgaon Range (Lavasa, Khandala, Lonavala).

In last 10 years, there has been a spurt in developmental activities in this region in the form of luxury townships, resorts, private farmhouses, and hotels. Lavasa and Amby valley are mega-township projects developed by acquiring forest lands. The dynamiting of roads, increased vehicular traffic, sound pollution and air pollution has disturbed the once serene ecosystem in the area. Besides, there are large to small scale projects for highways, railways, mining leases, windmills, irrigation canals, hydro-electricity and commercial tourism which has led to substantial fragmentation of habitat. Rajmachi area is also witnessing increased tourist inflow because of the new motor able road.

Another serious concern in Pune Division is constructions on the hill tops. Presence of JCB earth-movers, and rock crushing machines on hill tops for removal of rocks and debris indicates initiation of concrete constructions on hills. Labour camps are established for working in the sites has led to an increase in lopping, firewood collection in the area. Gradually the intact and inaccessible forests of the slopes are coming under the axe of construction pressures.

Upcoming Resort and tree cutting on Forest Land at Kalika Matha Pune Division


Evangeline Arulmalar

The villages in the region are dominated by Katkari communities though other communities like Maratha, Dhangar, and Thakurs are also present. The locals are well-known for hunting small games. The local people are hired by tourists to supply fresh meat from the forest. There is substantial trade for meat to major cities of Lonavala, Mumbai and Pune from this region. Hunting of birds, mammals and giant squirrels is reported from Lonavala, Tamhini and Mulshi region. There is information on squirrel trade from this area. The squirrels are captured for keeping as pets in luxury resorts in Mumbai and Lonavala (TRAFFIC Office, pers.comm).

Forest Fire on the the boundary of Ajjiwali Sacred Grove, Paud


Evangeline Arulmalar

Forest areas around Tamhini Ghat are relatively better preserved but the area has problems of increased tourism, lopping and hunting. Forests in Wadgaon are largely undistributed except for signs of livestock grazing. However there are reports of hunting of squirrels in this area by stoning of nests and killing with catapults (Mali *et al.*1998).

Table 6.5: Count of R. indica in Pune Division in 1992 and 2012

	Total Effort (km)	Sightings	Calls	Nest (Old + New)
Borges et al (1998)	NA	-	NA	5
This survey	115	14	4	464

Data from very few areas in Pune Division was available in Borges et al

Table 6.6: Encounter Rate of R. indica Squirrel in Pune Division

Ranges	Sighting	Calls	New Nest	Old Nests
Khanapur	0.30 (0.25)	0.03 (0.03)	1.01(0.66)	0.06(0.06)
Paud	0.13(0.12)	0	4.09(1.55)	1.31(0.62)
Shirota	0.06(0.05)	0.06(0.04)	4.57(1.17)	1.99(0.53)
Wadagaon	0.69(0.56)	0	2.57(1.01)	0.63(0.33)

Figure in parentheses represent standard error.

Junnar Division

Topography and Vegetation: The division lies along the eastern boundary of the Western Ghats crest-line. The area supports sub-tropical montane broard-leaved type forests comprising of Memecylon-Syzygium-Actinodaphne, Bridelia-Syzygium-Terminalia-Ficus and Tectona-Lagerstroemia-Terminalia species. There are eight ranges within the division namely Junnar, Otur, Narayangaon, Manchar, Ghodegaon, Rajgurunagar, Chakan and Shirur. Tall forests are present mainly in Junnar, Khed and Otur ranges while the remaining areas support scrub open forests.

Status of *R. indica* in Junnar Division: Junnar and Khed Ranges had more signs of squirrel presence than Otur Range. In Phlagun-Gavan and Bikerode, tall forests are present in a 2 km narrow stretch on higher slopes of the hill. Many new nests were seen

in these forests and unfortunately many people were seen cutting trees in this area. Khutadwara and Hatveez area in Junnar Range had patchy forests with grasslands and trees. Human presence was seen all over the area. Relatively lower squirrel presence was observed from this area. Amboli in Junnar Range had many privately owned forests. The area had high intensity of human use as signs of NTFP collection, firewood collection and livestock grazing was recorded from everywhere. No sign of squirrel presence was recorded from the area. The forests in Khed Range are dense and thick. There are many windmills on the plateau but overall human activity and disturbance was much less in the forests. 53 new nests and 2 individuals were seen in this region. Vandre in Khed Range is located near southern boundary of Bhimashankar where windmills are installed. Nests of squirrels were observed below the windmill location. There is a proposal for building a highway around this region. In Kohlewadi and Kaudmali of Otur Range, no signs of squirrels were observed. Tree felling was observed in this area. Two nests and two individuals were recorded from a small sacred grove on the Otur hill.

Table 6.7: Count of *R.indica* in Junnar Division in 1992 and 2012

	Total Effort (km)	Sightings	Calls	Nest (Old + New)
Borges et al (1998)	NA	10	NA	124
This survey	59.15	14	27	371

Table 6.8: Encounter Rates of *R.indica* in Junnar Division

Ranges	Sighting	Calls	New Nest	Old Nests
Junnar	0.25 (0.09)	0.20 (0.11)	4.87(2.11)	2.55(0.05)
Khed	0.21(0.01)	0.64	6.50 (1.55)	4.93(0.52)
Otur	0.07(0.06)	0.75(0.54)	4.14(1.34)	1.35(0.15)

Figures in parentheses represent standard error.

Bhor Division

Topography and Vegetation: Undulating terrain with steep slopes and plateaus of Raireshwar mark Bhor sub-division. The forests are in advance stage of degradation. In small patches one can still see tall trees of *Randia, Syzygium, Mangifera, Terminalia, Actinodaphne hookeri* and luxurious growth of *Carissa* species. Most areas have heavy canopy breaks and habitat fragmentation. Around Raireshwar plateau, ferns and epiphytes were recorded. This area receives high rainfall and is very windy. Plantations of *Grewelia robusta* (Silver Oak) and *Actinodaphne* were seen in most areas.

Status of R. indica in Bhor

Giant squirrels were not encountered in Bhor sub-division. However, villagers in the Raireshwar temple area reported having sighted giant squirrels 10 years ago when the forests were tall and contiguous. There is a serious problem of forest fire in the area. In Mhalay forest of Velvand round in Rajgarh, forest guards informed that during 1960-70, the forests in this region were clear-felled and burnt for shifting cultivation for millet crop by local people. The forests are largely secondary forests. There is a proposal for dam construction around Bhor region and many private resorts are coming up in the area. Bhor sub-division has moist forests as seen by presence of ferns in the understory but the quality of habitat is totally degraded due to biotic pressures and does not support giant squirrels.

Patchy and degraded forests of Bhor sub-division, Pune

Evangeline Arulmalar

Remnants of Closed Canopy forests

Bhimashankar Wildlife Sanctuary

Topography and vegetation: Bhimashankar WLS lies in the northern part of Maharashtra Western Ghats. Situated in the crest of main Sahyadri range and includes steep terraced western slopes running in to Konkan region and spurs running gradually into the eastern plains**.** The sanctuary displays a range of different habitat such as steep slopes, plateaus, uplands, gorges, valleys and cliffs. In the heart of the sanctuary is an old temple of Shiva at the origin of Bhima River.

Typical vegetation shows semi-evergreen, moist deciduous and grassy forest. A few uncommon specie of Western Ghats such as *Memecylon umbellatum, Atlantia racemosa, Xantolis tomentosa* are seen here. *Carvia callosa* is wide spread here (Ghate *et al*. 1994).Bhimashankar has two Ranges, namely Bhima 1(Slope and Plains in Konkan side) and Bhima 2 (Crestline forests of Bhimashankar, Ahupe, Bhorgiri and Kondwal).There are 8 villages inside Bhimashankar WLS. People cultivate rice, wheat and corn. The main community is *Mahadev Koli* and there are a few settlements of *Thakkar* and *Agri.*

Giant Squirrel habitat in Bhimashankar

Jayant Kulkarni

Status of *R. indica* in Bhimashankar

Giant squirrels are present throughout the Sanctuary. Best locations to locate them are around the temple, Bhatti che Raan, Bhakadevi, Forests around Kondwal village, Forest of Bhorgiri, Malewadi,Yelwale, and Nigdale village. Other areas such as Patan, Malewadi, Rajpur to Pimpri, Padarwadi, Mhasobacha Padar and Bhomale are also good. Being a Protected Area, giant squirrels are better secured here but some people mentioned hunting of herbivores and squirrels still go on in some areas. Thakers and Agri communities used to regularly hunt giant squirrels for meat but since many years that practice has stopped. Towards Kokan side (Bhima 2), groups of people come from Mumbai with guns for shooting herbivores like sambar and barking deer and also hunt squirrels if they come across any. Several traps and snares were found for killing birds, wild boar, mouse deer and barking deer. In Kondhwal and Nigdale village, traps for wild pigs were set up under the mango trees as pigs feed on mango seed. Net traps called (*wagur*) are used to catch small game, deer, and pigs. Local people from Khandas village make local guns made spare parts of vehicles called as *Thasanichi Banduk* and use it with gun powder to shoot animals. The villagers also use trained dogs for hunting small mammals. The dogs are also used for hunting giant squirrels. .Signs of lopping and firewood collections is visible everywhere. Local people are allowed to take dead trees and bamboos for their house maintenance after taking the permission from forest staff. However, on many instances it was observed that people cut big live trees, allow it die and then carry it home. At some places, people saw the tree and make in to planks for ease in carrying them home. We found several signs of forest fires in Kondwal, Bhorgiri and Nigdale villages. During April-May the people start preparing their fields by burning the wood in their fields to enrich the soil. This practice called *Raab* burning is risky as sometimes the fire spreads to the forests and damage the understory and trees. This can affect the habitat of giant squirrel.

Grey Jungel Fowl caught in the trap

Wire snares for catching hare and small mammals

Tushar Pawar

Bhimashankar being a famous religious shrine is visited by thousands of tourists during festivals. This causes severe disturbance and pollution in the sanctuary. Firewood extraction is at peak at this time because hotels provide food for thousands of tourists and some tourists cook in the forests by themselves. There is considerable extraction of medicinal plants from the sanctuary almost throughout the year. Garbage deposition is another issue of major concern in the sanctuary. The fruit of Terminalia chebula are eaten by giant squirrels (Borges 1989) and is also collected in large numbers by the local villagers as an NTFP. Uncontrolled and large scale extraction of Hirda fruits can create a negative impact on foraging resources of giant squirrel. Construction of roads for windmills has caused concerns for biodiversity of Bhimashankar. The windmills are installed on flat plateau 3 km from the southern boundary of Bhimashankar. A 13 m wide road has been made through the forests to carry heavy machinery and cranes. These forests are continuous with the sanctuary forests and giant squirrel nests were observed near the windmill sites in Kharpude and Wandre village. About 28,000 trees

have been cut to make the approach road however a few villagers said the figure was around 80,000.

Windmills on the boundary of Bhimashankar

Hide made for poaching

Tushar Pawar

Table 6.9: Count of R. indica in Bhimashankar WLS in 1992 and 2012

	Total Effort (km)	Sightings	Calls	Nest (Old + New)
Borges et al (1998)	NA	NA	NA	NA
This survey	209	105	250	3202

Table 6.10: Encounter Rates of R. indica in Bhimashankar Sanctuary

Ranges	Sighting	Calls	New Nest	Old Nests
Bhima 1	0.29 (0.05)	1.10 (0.27)	6.35 (0.49)	3.26(0.45)
Bhima 2	0.24 (0.12)	0.17 (0.15)	3.01(1.63)	1.26(0.66)

Figure in parentheses represent standard error.

Nets and traps set for catching small mammals

Tushar Pawar

6.6 Raigad District

Location	**18⁰ 05′N-19⁰ 10′ N;72⁰ 55′E- 73⁰ 40′E**
Areas	Alibaug and Roha Divisions
Average Elevation	100 -755 m
Forest Type	Coastal semi-evergreen, subtropical broadleaved, evergreen in foothills, Moist Deciduous everywhere
Protected Status	Except Phansad Sanctuary all Reserved Forests

Alibaug Division

Topography and vegetation: Alibaug region is marked with plains interspersed with hills. Towards Alibaug the forests are coastal semi-evergreen, subtropical- broadleaved in Matheran side. Vegetation comprises mainly of moist deciduous forests in the hills

with species such *Syzygium, Olea indica, M.umbellatum, T.belerica, T.tomentosa*. There are seven ranges within Alibaug Division, namely Alibaug, Wadkhal, Panvel, Karjat, Matheran-Khalapur, Sudhagad-Pali and Pen.

Status of *R. indica* in Alibaug Division: Giant squirrels are absent from Sudhagadh-Pali, Alibaug, Wadkhal, Pen and Karjat Ranges. Within Sudhagad-Pali, Nagshet beat, Sudhagad, South Sudhagarh beat, Medist beat, Pimpololi, Khandsande beat, Pachapur, Siddheswar beat, Thanale were surveyed. Moist deciduous to semi-evergreen patches are found in Pachapur Round. Dominant tree species include teak, *Mangifera* and *Terminalia* species. There are extensive plantations of *Acacia, Eucalyptus* and Cashew in this region. Most of the areas are dominated by secondary scrub and forest patches. Signs of cattle grazing and presence of domestic dogs were frequent in the surveyed patches. Tree lopping or felling is pronounced in Nagshet and Sudhagarh patches.

Many areas in the region support dense and tall forests, especially around Sudhagarh-Pali, Karjat and Pen areas but giant squirrels were missing from the forests. Earlier survey by Mali et al. (1998) have reported hunting of giant squirrels from these areas by slicing the nests and hunting by use of catapult, sickle, gun and stoning animals, especially round Matheran, Alibaug, Murud and Mahad. Local communities including Katkari, Dhangari, Thakur, Agri and Maratha inhabit these forests. A few villages practice cultivation but also indulge in hunting of mammals and birds. Though agriculture is their primary source of income, frequent selling of lands to other companies or private people has increased in recent years. In Pachpur road, practice of shifting cultivation is still being continued by the Thakur community. Hunting by local Thakur communities for wild boar, barking deer and hare is prevalent in these areas. Disturbance due to shifting cultivation has added to the loss of habitat in the area. After 20 years, the forests appear to be devoid of squirrels and hunting could be one of the possible causes.

Open canopy forests in Sudhagad-Pali and Malshej Ghats

Matheran is part of the Tawli hill Range of Western Ghats located westwards from the main Western Ghats ridge. It is a small plateau and because of its pleasant climate, is a popular hill-station mainly among trekkers and youngsters. It has semi-evergreen forests with stunted trees and closed canopy. The area is declared as eco-sensitive zone but tourism activity is high here. Squirrel presence was recorded in areas with tall trees. Matheran is frequented by people and there is presence of forest staff here because of which hunting is under control. Because of this, squirrels could be seen near public places also.

Prabalgarh is also a plateau located further west of Matheran plateau. The area has tall semi-evergreen to moist deciduous patches with the average of 20 m tree height. As per the local information, the youngster had not seen squirrels on the plateau but the older generation reported seeing them. The nests were seen in the lower areas of Prabal Machi. Locals informed that the abundance of squirrels has declined in the area due to forest degradation and presence of people in the area

Patchy forests in Matheran and Prabalgad

Ranjit Sahoo

Table 6.11: Count of R. indica in Matheran and Alibaug Division in 1992 and 2012

	Total Effort (km)	Sightings	Calls	Nest (Old + New)
Matheran (1998)	NA	7	NA	16
Matheran (2012)	24	2	10	14

Karjat (1998)		5		49
Karjat (2012)		0	0	0

Table 6.12: Encounter Rates of Squirrel Presence in Alibaug Division

Ranges	Sighting	Calls	New Nest	Old Nests
Panvel	0	0	0.62	0.93
Matheran-Khalapur	0.05(0.04)	0.57(0.21)	0.48(0.15)	0.23(0.08)

Figures in parentheses represent standard error.

Roha Division

Topography and vegetation: Low-lying coastal forests near the Arabian Sea forming creeks near Mhasala region Major tree species include teak, *Terminalia* species, *Ficus* species, *Lagerstromia microcarpa* and associated species. There are four ranges in Roha Division, namely Roha, Murud, Mhasala and Mahad. Giant squirrels are not present in Mahad Range so the survey was carried out in Mhasala (Devgarh, Talwa), Srivardhan (Nivale, Borli R), Murud (Sudkoli, Temgarh RF, Chanera R, Garambi RF), Roha (Gopan R, Kathenjali), Mangaon (Shirwadi beat). The forest type varies from range to range. The forests in Srivardhan and Murud range represent coastal semi-evergreen,. Roha range is dominated by very dry deciduous forests including scrub forests. Mhasala and Mangaon range is dominated by secondary patches with not-so-tall trees.

Status of *R. indica* in Roha Division: Giant squirrels were recorded only from Roha (Gopan Round and Kathenjali village) and Murud ranges (Sudkoli, Temgarh, Channera, Garambhi). Kanthejalli is a small settlement of Katkari tribes. They are presently living inside the forests in Gopan round. They regularly hunt squirrels for meat with catapults. Signs of biotic pressures such as livestock grazing, presence of domestic dogs in the forest, firewood collection and lopping was observed everywhere. In Srivardhan, there are patches of primary forests but they are isolated and not connected to each other. Deforestation and firewood collection is prominent in Murud range. A dam is under progress in Sudkoli of Murud range which is likely to submerge the adjacent forest patch where few new nests of giant squirrel were found. In Roha Range, there is extensive lopping and cattle grazing in the forest areas. Involvement of locals in alcohol brewing in the forest areas was a major problem. The locals indulge in hunting of giant squirrels for food in this region.

Evergreen forests of Kathenjali and patchy forests of Murud, Roha

Evangeline Arulmalar

Phansad Wildlife Sanctuary

Phansad Sanctuary is located in Tehsil Murud and Roha of Raigad district. Phansad is located slightly to the western side of Western Ghats. Of the total area of 54.08 km^2, 45.04 km^2 are un-classed forests in Murud range and 8.46 km^2 are reserved forests from Roha range. The sanctuary used to be the hunting ground of local Nawabs but has been converted in to a Protected Area now. There are a few temples and Sacred Groves within the sanctuary that is visited by the tourists. A few villages around the Sanctuary depend on the forests for meeting their local needs. Phansad Sanctuary is located away from the main crest line of Western Ghats, yet it has some unique floral elements that are found mainly in the higher altitude. Different types of forest encountered here are (a) Southern moist teak bearing forests where teak grows to a height of above 25 m in most suitable areas. Teak is the dominant species here along with associate species such as *Terminalia tomentosa, T. paniculata, Garuga pinnata, Dalbergia latifolia,* and *Pterocarpus masupium*. These forests have thick undergrowth as well as grass cover, b) Southern mixed Moist deciduous forests where teak is present occasionally and species such as *Terminalia belerica, Mangifera indica* etc are common. Average tree height in this forest type is around 20 m. c) Tropical Riparian fringe forests are confined to stream banks and water holes, This type has typical riparian tree composition. The typical mesic tree species such *Mangifera indica, Tetrameters nudiflora, Holigarna grahamii,* are abundant in riparian forests. Phansad has unique forests as such forests types are rare to be found above 16^o N in the Northern Western Ghats now as most of them are disturbed and exists in small patches (Ghate et al 1994, Mehta and Kulkarni 2010). Supegaon beat,

Ghunyechamal, Chikalghan (Kashiol Beat), Belastha (Dakshin Phansad), Savrat Road were surveyed in Phansad.

Nest of giant squirrel in evergreen forest in Phansad

Prachi Mehta

Status of *R. indica* in Phansad WLS: Phansad sanctuary is well known for its giant squirrel population as it is easily visible in these forests. About 10 new nests of giant squirrels were observed on a small patch of Eucalyptus plantations. On the southern side of the sanctuary, a new is being built that is likely to submerge the forest patch adjacent to it. We recorded 17 old and nests from this area.

Phansad is a Protected Area but there were many signs of human pressures. Signs of cattle grazing were s found in most places. Signs of tree lopping was observed around Ghunyachamal, Kashiol beat and Dakshin Phansad and in low intense in Supegaon beat. Local people with domestic dogs were observed near Ghunyechamal. These people had possibly come for hunting wild boar and barking deer around the sacred groove in Supegaon beat. Signs of firewood collection, littering by tourists were observed near many waterholes.

Table 6.13: Count of R. indica in Raigad Division in 1992 and 2012

	Total Effort (km)	Sightings	Calls	Nest (Old + New)
Borges et al (1998)	NA	-	NA	61
This survey	57.76	2		237

Table 6.14: Encounter Rates of R. indica in Roha Division

Ranges	Sighting	Calls	New Nest	Old Nests
Phansad	0.03(0.02)	0.03(0.02)	14.67(4.38)	2.10(0.31)
Mahasala	0.13(0.10)	0	4.77(1.33)	1.59(0.48)
Roha	0	0	1.58(0.26)	0.34(0.24)

Figures in parentheses represent standard error.

6.7 Satara District

Location	**18^0 05′N-19^0 10′ N;72^0 55′E- 73^0 40′E**
Areas	Koyna WLS, Mahabaleshwar and Satara Division
Average Elevation	700 -1400 m
Forest Type	Crestline semi-evergreen, subtropical broadleaved, evergreen in foothills, Moist Deciduous everywhere
Protected Status	Except Koyna all are Reserved Forests

Topography and Vegetation: Satara Division has Mahabaleshwar, Wai, Jawdi-Medha, Patan and Dhebewadi ranges. Areas surveyed include Dhebewadi (Satara, Umbaranay, Huduki, Humberne), Patan (Ghatmatha, Nechal, Goare, Roatghi, Bhathodi malzhi, Gawar), Medha (Kas, Kakarwadi, Kargoan), and Mahabaleshwar (Parpar, Wilson point road, Pratapghad, Chatturbeat, Makarandhghad, Dubedabigarh, Panchagini road, Hirda Rest house, Pratapsingh garden, Lingamala road, Kate's point, Van-bhuvan, Rosmond road, Robber's cave, Gaolani point, Arthur's seat point, Coolie path, Lodwick point, Tiger path). Giant squirrels are absent from Wai Range.

Mahabaleshwar plateau lies on the Sahyadri Crestline with its ridges running in 5 different directions on the crest-line. There are deep valleys located below these ridges. The valleys are created by erosion of five main rivers originating from Mahabaleshwar namely Krishna, Koyna, Venna, Solshi, and Savithri. The typical vegetation is of secondary origin with few evergreen species. *Domicarpus longan*, *Elaecarpus tectorius*,

Neolitsea zeylonica are seen seldom while most common species are of Actinodaphne angustifolia, Memecylon umbellatum, Olea dioica and Syzygium cumini. (Ghate *et al* 1994). Mahabaleshwar plateau is inhabited by local people as well as tribal who are now working for the tourism industry in various ways. From 1984 to 1994, 10 % of the area was deforested in Mahabaleshwar to meet the firewood demand of tourists (Ghate *et al* 1994). This deforestation rate must have increased in last 10 years with increased flow of tourists in the area.

In Patan and Dhewewadi, semi-evergreen to moist and dry deciduous forests are present with a matrix of dense forest cover surrounded by secondary forests. In many areas, the forests patches were isolated without any connectivity. The area also has extensive private forests interspersed between forest lands that are cleared on short rotation cycles. Few regions had mixed forests. No Plantations were recorded in Patan whereas Eucalyptus plantations dominated in Dhebewadi Range. Medha is dominated by secondary patches dry deciduous and 58scrubby in nature. Kakarewadi areas overlooking Chandoli had semi-evergreen to moist deciduous forests in good condition.

Status of *R.indica*: In Dhebewadi, signs of forest fires, felling and lopping were observed in many locations in Umbarny, Satara and Humberni. In Humberne an electric gridding line is proposed. This will certainly result in fragmentation of good primary forests in that area. Renovation of Valmiki temple Umbarney has caused considerable disturbance in the area and now primary forest exists only in the sacred groove around the temple. In Patan, forests around Gawar and Nechal are highly fragmented. The proposed clearing of electric grid lines is likely to cause further fragmentation of the forests. Some parts of Roatghi forest of Patan had good primary forest with trees as tall as 45ft on an average but these forests did not have any signs of squirrels. In Nechal, lopping and tree felling by locals were observed in many places.

Opportunistically 3 New nests, 1 old nest and 2 sightings were observed in Ghatmatha of Patan.

Medha Range has similar problems of forest degradation due to excessive lopping and livestock grazing. Mahableshwar being a hill station, the tall forests are preserved in public gardens, government rest houses, and near estates of the original residents. In all other areas, forests are facing a lot of pressure from lopping, fire-wood collection and human presence. The current trend is to cultivate strawberries and flower nurseries in place of privately owned land. This is leading to fragmentation by clearing vegetation around the forests. Lopping of trees for acquiring wooden supports for strawberry orchards and use of fertilizers to increase the output is another issue of concern. Construction of roads for tourists has also led to dividing the forests patches and

opening up of canopy. Impact of uncontrolled tourism is visible everywhere in the form of large number of vehicles, littering of plastic and sound pollution.

Closed canopy forests of western and stunted forests of eastern Mahableshwar

Prachi Mehta

In Makarandgad, the Forest Department initiated a biogas project in Biramani village but it is in dysfunctional state. The forests near Kate's point are totally degraded and has extensive grasslands now. Local communities such as Maratha, Dhangar, Mahadev and Koli live in Mahabaleshwar. Recently Katkaris from Chiplun have put up temporary tents to collect honey near Goare village in Patan. The Katkaris and local people from Kathrewadi indulge in hunting of wild boar, deer, peacock and hare in the forests. They used to hunt giant squirrels for meat also they say they have stopped it now. In Patan and Medha, the squirrel abundance has declined compared to previous years as reported by the forest staff.

Koyna Wildlife Sanctuary

Koyna Wildlife Sanctuary is located in Satara District under Kolhapur Wildlife Division. The sanctuary forms the northern portion of the Sahyadri Tiger Reserve. The Sanctuary is located in the Tehsil of Jawali and Patan in Satara district and extends westward till Ratnagiri district. Koyna WLS includes the eastern and western catchments of Koyna Dam, which is a major hydro-electric project in Western Maharashtra. The Shivasagar Reservoir generates about 2200 MW electricity and offers very important protection to the sanctuary in the eastern side while the steep slopes makes the area inaccessible from the western boundary. The ruins of famous Vasota fort constructed during 1178-1193, is located in the center of the sanctuary. Vasota is a popular destination for the trekkers.
The Sanctuary has Southern Tropical Evergreen Forests and Southern Moist Mixed Deciduous Forests (Champion and Seth 1968). The threatened tree Narkya *Mappia*

foetida is seen here. The vegetation is evergreen throughout, except in eastern fringes where the composition becomes semi-evergreen. At higher elevation, species such as *Garcina latbotii, Litsea stocksii*, and *Drypetes venusta* were present. The re-colonized forests at many sites had evergreen species such as *Memecylon umbellatum*, *Olea dioica* and *Syzygium cumini*. Western Ghats endemic tree such as *Turpunia malabarica* and *Harpulia arborea* are also seen here (Ghate 1993, Islam and Rahmani 2004). Koyna and Chandoli WLS together now constitute the Sahyadri Tiger Reserve. Surveyed areas include Karanjode, Shirshinga and Navaja. Survey could not be completed in other areas of the sanctuary due to onset of rains.

Status of *R. indica* in Koyna WLS: Giant squirrel are present in good numbers in Koyna WLS. In recent years, many windmill projects, tourist resorts, and plantations have come up near the fringes of the sanctuary and near the Koyna Dam. The entire area is fragmented due to presence of private forests interspersed with reserved forests. Many villages have been relocated from the Sanctuary and proposal is on to relocate the remaining ones. The natural barriers in the form of Shivasagar reservoir and steep slopes of the Western Ghats on both the sides provide offers great protection to the biodiversity of Koyna Sanctuary.

Table 6.15: Count of *R. indica* in Satara Division

	Total Effort (km)	Sightings	Calls	Nest (Old + New)
Borges et al (1998)	NA	NA	NA	NA
Satara Division	53.75	7		154
Mahabaleshwar	58.6	10	2	240
Koyna WLS	39.2	0	1	42

Table 6.16: Encounter Rates of *R. indica* in Satara Division

Ranges	Sighting	Calls	New Nest	Old Nests
Mahableshwar	0.15(0.05)	0.03(0.02)	2.96(0.99)	1.17(0.33)
Dhebewadi	0	0.11(0.07)	1.61(0.91)	0.30(0.15)
Medha	0	0	1.29(1.12)	1.66(0.63)
Patan	0.28(0.11)	0.3(0.15)	4.46(1.14)	1.17(0.05)
Koyna WLS	0	0.15(0.050	5.5 (1.7)	0.5 (0.14)

Figures in parentheses represent standard error.

6.8 Sangli District

Location	**18^0 05′N-19^0 10′ N;72^0 55′E- 73^0 40′E**
Areas	Chandoli WLS
Average Elevation	500 -1400 m
Forest Type	Crestline semi-evergreen, subtropical broadleaved, evergreen in foothills, Moist Deciduous everywhere
Protected Status	Chandoli is a Protected Area

Chandoli National Park

Topography and vegetation: Chandoli Sanctuary is located at the crest of North Sahyadri Range of Western Ghats forming a catchment of Warana Dam Reservoir. The reservoir offers good protection to the Sanctuary. The terrain of the entire Protected Area is undulating, with steep escarpments, often with exposed basalt. A most distinct feature of the Sanctuary is the presence of numerous barren rocky and lateritic plateaus, locally called "Saddas" with less perennial vegetation and have over hanging cliffs on the edges and numerous fallen boulders with dense thorny vegetation and small caves.

Chandoli is classified in biogeographic province 5 b of Western Ghats along the crest of Sahyadri Range. Most common floral species found here are *Memecylon umbellatum*, *Syzigium cumini* and *Actinodaphaone angustifolia*. The revenue west land and Malki lands included in the Protected Area have scattered bushy tree growth in between and along nalla banks. Only on the flat lands on the east of Zolambi and Tanali the deciduous species like *Bombax ceiba, Butea monosperma, Careya arborea, Cassia fistula, Terminalia tomentosa, Cordia dichotoma,* and *Lagerstromia microcarpa* are seen. Giant climbers such as *Garambi*, *Bauhinia vahilii* etc. are the characteristic of Rundhiv forest. Bamboo species like *Kalak* and *chiva* are mainly grown along the banks of stream, cane is mainly found in the Shidheshwar and Rundhiv areas near Prachitgad (Ghate *et al*. 1994). There were 32 villages inside the Sanctuary. Of these 29 have been relocated outside and the process for the remaining 3 village is ongoing.

Surveyed area include the following beats namely Nivale, Chandel, Talkaley, Nandoli, Zolumbe, Tambave, Gothane and Dhakale in Kolapur-Sangli districts and the entire

portion that falls in Satara district till the Bhairavnath temple that overlooks Ratnagiri district.

Undisturbed Habitat in Chandoli National Park

Prachi Mehta and Tushar Pawar

Status of *R. indica* in Chandoli National Park: Giant squirrels are present in good population in Chandoli. Being a Protected Area, minimum biotic pressures were observed here. Because of village relocation, biotic pressures have reduced considerably. There are some feral cattle in the area and in some relocated village sites the forests are still in secondary stage with open or little canopy cover.

Table 6.17: Count of *R. indica* in Chandoli National Park

	Total Effort (km)	Sightings	Calls	Nest (Old + New)
Borges et al (1998)	NA	NA	NA	NA
Chandoli NP	39.2	0	4	32

Table 6.18: Encounter Rates of R. indica in Chandoli National Park

	Sighting	Calls	New Nest	Old Nests
Chandoli NP	0	0.06 (0.03)	1.12(0.4)	0.12(0.06)

Figures in parentheses represent standard error.

6.9 Kolhapur District

Location	**16° 22′ N to 74°′ E**
Areas	Kolhapur Division and Radhanagri WLS
Average Elevation	500 to 972 masl
Forest Type	Moist mixed deciduous with teak in the valleys, semi-evergreen, subtropical broad-leaved
Protected Status	Except Radhanagri WLS all Reserved Forests

Topography and Vegetation: Kolhapur Division consists largely of valleys, slopes and plain areas at higher altitudes. Main types of forests in Kolhapur district are sub-tropical evergreen, moist & dry deciduous & the semi-evergreen.

The typical species found include *Canthium dicocum, Lagerstroemia microcarpa, Diospyros montana, Bridelia, S. cumini, S. hemisphericum, F. arnottiana, M. umbellatum, Cinnamomum, Diospyros candolleana, Lagerstroemia microcarpa, Syzigium cumini, Holigarna graham, Ficus tsjakela, Beilschmeidia dalzellii, Gnetum ula.*

Kolhapur Division has eight ranges namely Ajara, Patne, Chandgad, Ganganbavda, Gargoti, Kadgaon, Malkapur and Panhala. After discussing with local staff, following areas were selected for the survey.

- Gargoti Range: Kalgoan and Megoli.
- Ajara Range: Aundi, Korwade, Ketwade, Dhangarmala and Parpoli
- Patne Range: Jalugade, Mhalunge, Parle, Bandrai, Tilari, Kolik
- Chandgad Range: Isapur, Wagothri, Bhogoli, Jambre
- Radhanagri Range: Parale, Bhaivai Devarai, Sarade beat
- Gaganbavda Range: Ramalinga forest, Wesruf village, Kodhey Bhudruk, Thaliyae, lakmapur, Narveli
- Panhala Range: Kalzavade forest in Bazaar Bhogaav round, Thorala Ooda jungle and Pisadhri village in Manwad round, Pombre, Kaladunk, Goatney, Padasaley, Wasi, Pendhasala
- Pendhakheda Range: Berki, Anuskura, Warki, Hiruda, Tapira, Matherpet, Gajapur and Manzare jungle in Gaydawaday
- Malkapur Range: Satekamal, Iyamavedi, etc. of Manoli, Amba and Udgiri in Malkapur.

Vegetation composition in each range as given:

- Pendhakheda Range has predominantly secondary forest with a mix of semi-evergreen, moist and dry deciduous patches observed in Kalgoan, Pombre of Panhala, Berki and Anuskara
- A mix of primary and secondary forests were found in Parpoli of Ajara, Pattan, Isapur, Wagothri of Chandgad, Matherpet, Gajapur of Pendakale, Udgiri in Malkapur Range.
- Forests were mostly primary in Tilari of Patane , Jambre and Bhogoli of Chandgad, Amba of Malkapur and Kaladunk, Goatney, Padasaley of Panhala.
- Forests were predominantly secondary in Gaganbhavda, Megoli in Gargoti, Warki, Manzare jungle in Pendakale, Manoli of Malkapur, Aundi, Ketwade, of Ajara, Yeni jungle in Radhanagari RF. Secondary forests but tall trees in Parle beat of Pattane.
- Dhangarmola round of Ajara has tall trees only on the riverine side.
- In Parale & Bhaivai Devarai in Radhanagari, there were tall trees only around the temple in the sacred groove.
- Understory was thorny in Gargoti, Ajara, Amba, Panhala and Gaganbhavda.
- Understory as well as scrubby patches were chiefly Karvi dominated. Karvandh also was highly prevalent. Rameta and Lantana were observed in some regions as in Gaganbhavda and Radhanagari respectively.
- High numbers of *Memecylon* recruits were observed in Gaganbhavda, kalgoan and in certain regions of Ajara and Pendakale.
- Garambi and other lianas were common in most areas. Dhangarmola round of Ajara, Kodhey Bhudruk of Gaganbhavda, Wasi and Pendhasala in Panhala are areas where lianas were high.
- Acacia plantations were found in all ranges especially at RF boundaries.
- One entire round in Ajara is plantations with 32 tree species mainly of fast growing and exotic ones. Manwad round of Panhala were almost completely Acacia plantations
- Casurina and Nilgiri plantations also were quite common in this division. Cashew and Bamboo plantations were rare and observed in Kalzavade forest in Bazaar Bhogaav round of Panhala Range and at Amba of Malkapur.
- *Canarium strictum* which were heavily felled earlier for making incense sticks were artificially planted in the Manoli forests of Malkapur.

Status of *R. indica* in Kolhapur Division: Though there are primary forests in Kolhapur Division, giant squirrel presence was not as expected. The entire landscape is a matrix of Private Forests interspersed with Primary Forests , cultivation and plantations. Kolhapur Division has several development projects. Some of which are mentioned below:

- Mining at boundary in Kalgoan.
- Dam near Jalugade forests of Patan, Wesruf village of Gaganbhavda, Pombre of Panhala.
- Dam constructed 20 to 25 years back at Kodhey Bhudruk of Gaganbhavda range. Forest areas destroyed and trees cut to build dam and create the reservoir area.
- Proposed dam at Mhalunge forests of Patan, in Kolik and Tilari of Patane in good forest areas.
- In Jambre of Chandgad region, 49 ha out of 64 ha forest area has been cleared for dam construction
- Road construction in Manoli forest in Malkapur.
- Established temple and Bauxite mining in encroached lands in Udgiri in Malkapur

Apart from these, large areas exist as Private Forests and the owners use the forests as per their discretion by harvesting firewood and timber for selling them for commercial purpose or for cultivating exotic plantations. There was large scale felling of trees by locals from the reserved forests during the month of May. They store this firewood for using during the monsoon season.

Signs of lopping were very high in Kolik of Patane, Warki in Pendhakale and Wagothri of Chandgad. In other ranges like Ajara, Pattan, Radhanagari, Gaganbhavda, Kaladunk, Goatney, Malkapur and Panhala lopping sings were of moderate level. Lopping has caused frequent breaks in forest structure and there are open patches in the forests. In open areas, weeds like Karvi have invaded the forests and can be seen as thick undergrowth in Matherpet, Gajapur and Manzare in Pendakale, Manoli in Malkapur, open grasslands and thorn patches as in Borbet of Gaganbhavda. Owing to heavy human activity in this division forests have degraded from semi evergreen to fragmented forests. Degradation is high towards forest boundaries.

Tree cutting in Malkapur

Encroachemnt in forests in Mahalunge

Evangeline Arulmalar

There are many irrigations tanks and canals in the area because of sugarcane and plantation crops. Signs of forest fires were observed from Patne, Tilari Area, Berki and Anuskara in Pendakheda, Manoli and Udgiri in Malkapur, Kalgoan, Parpoli, Aundi, Dhangarmola round of Ajara and Kolik of Patane . These forests are now in secondary stage. In Manzare Forests in Gaydawaday beat in Pendakhale Range, the forest staff had set fire to clear the area for plantations.

There is an active bauxite mine in Udgiri in Malkapur Range. Loaded trucks ply through the day on the road creating severe air and noise pollution. There are 20 ft tall primary forests for nearly 100 to 150 m on either side of the Udgiri road but they are covered with thick layer of dust forests and completely brown in appearance. Sacred groove in Udgiri were devoid of squirrels as the whole area is degraded and disturbed due to large number of pilgrims visiting the area.

Signs of livestock grazing, especially that of goats were observed from all areas including Kaladunk, Goatney, Padasaley of Panhala Range.

Negative impact of tourism could be seen at Tilari of Patne, Wagzarai in Amba of Malkapur, Parale & Bhaivai Devarai, Ajara, Mhalunge forests of Patan, Wagothri of Chandgad, Borbet of Gaganbhavda, Udgiri in Malkapur, Matherpet, and Gajapur of Pendakale

Presence of domestic dogs was observed inside the forests in Dhangarmola round of Ajara, Mhalunge forests of Pattan, in Kolik of Patane, Wagothri of Chandgad and Warki in Pendakheda.

An instance of squirrel racing across the road was recorded near Waghotri though there was canopy continuity in the forests for squirrels to jump across. Near Jalgude, a giant squirrel was observed to come near the ground with a troop of Hanuman langurs. This could be an interaction of play between langurs and squirrels.

Hunting of wildlife was earlier reported in Ketwade and Parpoli of Ajara, Borbet of Gaganbhavda, Pombre of Panhala, Berki and Anuskara of Pendakale and Manoli in Malkapur Range. Since last 10 to 15 years, hunting is completely banned in these areas. Hunting by the Dhangar for food was previously pronounced but now is less intense in Kolik of Pattane and in some parts of Ajara and Gargoti areas. These tribes are now dependent on forest and agricultural products for food. Some hunting of Barking deer and Porcupine are reported in Warki of Pendakale. Hunting of wild boar, Hare, Sambar, Barking deer and MGSq for consumption are still prevalent in Parale and Mhalunge in Patan range.

In Ajra and Gargoti, no change in population trend of squirrel was perceived but in Patne and Panhala, local staff reported a decline in squirrel population. Another old villager named Shamrav Bhosle, from Iyamavedi village, reported an increase in squirrel population due to an increase in protection and ban on hunting in Malkapur range.

Radhanagri Sanctuary

Topography and Vegetation: Radhanagari Wildlife Sanctuary is located in the Radhanagari Taluka of Kolhapur district and on the border of Kolhapur and Sindhudurg Districts. The Sanctuary lies between the Shahu Sagar and Laxmi Sagar reservoirs which supplies water to entire city of Kolhapur. Radhanagri and Kalamwadi are two dams within the Sanctuary. This area was earlier the hunting grounds of Royal family of Kolhapur but since 1968 it has been converted in to a Protected Area. The terrain is undulating with steep escarpments and dense forests. The uniqueness of this place is that the topography of entire protected area is undulating and steep with a high percentage of bauxite ore.

The forests in this area are typically semi-evergreen, evergreen and moist deciduous type. Major tree species seen here are *Memecylon umbellatum, Terminalia chebula, Careya arborea* and *Lagerstroemia microcarpa (*Ghate *et al* 1994*).* There is an active bauxite mine on the eastern boundary of Radhanagri WLS.

Forest areas visited include the Dajaipur range and Konoli beat in the Radhanagari range. It requires more areas to be surveyed to completely represent the sanctuary

Status of *R.indica* in Radhanagri WLS: The occurrence of giant squirrels is common in the Dajipur range. During 1984-85, patches near Konkauli beat were clear-felled and burnt for shifting cultivation and now these forests are regenerating as secondary forests. There are a few fragmented patches with open canopy in this area but they are connected to the Primary forests so overall canopy contiguity is maintained here.

Table 6.20 Count of *R. indica* in Kolhapur Division

	Total Effort (km)	Sightings	Calls	Nest (Old + New)
Borges et al (1998)	NA	NA	NA	NA
Kolhapur Division	152.4	2	12	291
Radhanagri WLS	27.92	2	3	43

Table 6.21 Encounter Rates of *R indica* in Kolhapur Division

Ranges	Sighting	Calls	New Nest	Old Nests
Radhanagri WLS	0.04 (0.04)	0.07 (0.07)	0.85(0.37)	0.49 (0.28)
Ajra	0	0.05 (0.05)	0.67(0.28)	0.47(0.15)
Chandgad	0	0.16 (0.13)	4.26 (1.17)	0.35(0.2)
Ganganbavda	0.03(0.03)	0.08 (0.06)	1.02 (0.34)	0.55(0.25)
Gargoti	0	0	0.63 (0.44)	0.94 (0.66)
Kadgoan	0	0	0.06(0.05)	0
Malkapur	0.02(0.02)	0.07(0.07)	2.07(0.8)	1.04(0.4)
Panhala	0	0.03(0.2)	0.45(0.17)	0.42(0.17)
Patne	0	0	2.18(0.99)	1.57(0.18)
Pendhakheda	0	0	1.36(0.60)	1.04(0.44)
Radhanagri	0	0	3.44	0

Figures in parentheses represent standard error.

Signs of Anthropogenic Influences in the Forests

Evangeline Arulmalar and Tushar Pawar

6.10 Human -Squirrels Conflict

The current survey was carried out in an extensive geographic area of Maharashtra Western Ghats. Due to the vastness of the area and onset of monsoons in the month of June, Ratnagiri and Sindhudurg districts could not surveyed. Both are coastal districts and Sindhudurg has highest forest cover in the State but it is rapidly being lost due to commercial plantations, mining and agricultural expansion. We were informed that since last 5 years, giant squirrel have started entering plantation orchards in towns nears Sawantwadi Range. The research team made a quick visit to a few villages and confirmed that the giant squirrels have been feeding on coconut, banana and cashew plantations. The farmers claim to suffer high financial losses as these are commercial crops. The farmers shoot the squirrel with guns to prevent them from feeding on the crops. This is a serious issue as a lot of the area is being converted in commercial plantations in Sindhudurg.

Signs of Giant Squirrel feeding on coconut and cashew fruits in Sawantwadi

Evangeline Arulmalar

Chapter 7

Status of Malabar Giant Squirrel in the Study Area

7. 1 Distribution of Giant Squirrel in the Study Area

The pattern of occupancy by giant squirrel in Maharashtra Western Ghats is demonstrated in three maps based on predictive model, conditional model and records of detection and non-detection history respectively.

The predicted estimated occupancy rate of 0.95 (SE 0.03) indicates that in Western Ghats of Maharashtra, the probability of occupancy by giant squirrel is 95 percent or Proportion of Area (POA) occupied by giant squirrel is about 95 % with a detection probability of 0.61 (±0.05). For most grids the probability of occupancy was predicted to be high (0.84 - 1.0), which means that the probability that squirrels occur there or chances of squirrels occurring are high. In other grids, which have lower occupancy (0.0009 - 0.3848), the probability or chances that squirrels occur are much lower.

One of the reasons for having high predictive occupancy estimates is that the survey was carried out only in grids having semi-evergreen and moist deciduous forest with tall trees and dense canopy which is considered to be optimal habitat for the squirrels. Most of these forest patches did have some signs of squirrel presence. Sub-optimal habitats such as dry deciduous and scrub forests were not sampled in the grids therefore all grids having squirrel presence scored high on its occupancy estimates. Secondly, although the sampling was carried out in smaller grids of 4 km2, occupancy estimates were considered for the main grid of 20 km^2. This was done to obtain a broader pattern of distribution. If the analysis had been done at the sub-grid level, it would have yielded occupancy estimates at finer scale which is not desirable at the landscape level.

Giant squirrel occupancy was influenced majorly by the disturbance index and average slope in the surveyed area. Disturbance index included signs of tree cutting and lopping since it has a direct impact on the forests by creating gaps in the canopy. Grids that had higher signs of tree cutting had lower occupancy rates. Similarly, areas with higher slopes affected the presence of giant squirrels negatively. This could be an artefact of geology and topography of the area. The volcanic ranges of Maharashtra Western Ghats have steep escarpments with lateritic and basaltic soils. Because of its rocky substrate, the crestline and plateaus have short but often dense forests and the slopes are barren or support thickets of dwarf stunted trees such as *Syzygium, Actionadaphnae with* an under storey of *Memecylon* and *Carvia callosa.* Such vegetation does not provide suitable habitat

for giant squirrels. This topographical feature is exclusive to Maharashtra Western Ghats and is not seen elsewhere. In southern Western Ghats, Srinivas et al (2008) found giant squirrel distribution higher in areas with undulating terrain because in their study area, moist and evergreen forests were found on the higher slopes.

Forests are scanty on steep slopes and deep in the valleys in surveyed areas

Evangeline Arulmalar

In some grids in the coastal region, such as Srivardhan Range in Roha Division, high occupancy is predicted in spite of no detections (Refer to Figures 5.1, 5.2 and 5.3). The occupancy model predicts high occupancy but field survey showed total absence of giant squirrel. There are two possible reasons for this: one is that being a coastal area, the slope is very low which is one of the covariate used in predicting high squirrel occupancy. This is unlikely to be correct based on the experience of the survey team. The robustness of the model for the plains region needs to be improved by providing more data points (surveying more grids) in this region

Edge density per patch was expected to be negatively co-related to the occupancy of squirrel since more edge would result in more fragmentation and hence lower occupancy by squirrels. However, edge density showed a weak positive correlation to occupancy estimates and did not contribute significantly in explaining the occupancy by giant squirrel.

In KMTR, the estimated occupancy rate of giant squirrel was reported to be 0.82 (SE 0.08) with a detection probability of 0.71(±0.05). Although KMTR is a Protected Area, the overall occupancy rate was lower than the estimated rate in this study. As mentioned earlier, degraded habitats were not surveyed in our study while in KMTR, grids with degraded scrub thorny forests, and Mundantharai plateau were also sampled that would have contributed to lowering the overall occupancy estimates of giant squirrel in the area (Srinivas *et al* 2008).

7.2 Relative Abundance of Giant Squirrel

The density of Malabar giant squirrel in Bhimashankar was highest in the study area but it is lower than earlier estimates from Bhimashankar by Borges *et a*l (1998). The density in Bhimashankar is comparable to density estimates from moister forests of Bhadra Tiger Reserve. Overall high density of squirrels from moister forests indicates that moister forests can support higher population of giant squirrels.

Table 7.1: Density Estimates of R. indica from Northern and Southern Western Ghats

	Moist Forests of Bhimashankar	Moist Forests of Maharashtra Western Ghats	Moist Forests of Southern Western Ghats	Drier Forests of Southern Western Ghats
Borges *et al*	100/km²	NA	-	-
This Survey	15.89/km² (11-22)	2.9/km²	-	-
Other Surveys	-	-	31 /km² Parambikulum WLS (Ramachandran 1988), 11 to 64 /km²Indira Gandhi WLS (Umapathy and Kumar 2000), 5.5 and 8.5 /km2 in Alkeri and Nalkeri in Nagarhole (Madhusudan and Karanth 2000), 10.4 to 12.3 /km²Bhadra TR (Jathana et al 2008)	2.3 to 4.8 /km²Bandipur and Nagarhole (Jathana et al 2008), 2.8 /km²Mudumalai (Baskaran et al 2011)

Excluding Bhimashankar, other surveyed areas in Maharashtra Western Ghats had a much lower density of squirrels. The forests in these areas are similar to Bhimashankar with semi-evergreen and moist elements but density estimates are much lower than in Bhimashankar and is closer to the estimates of density from drier forests of southern Western Ghats.

Closed Canopy Forest of Bhima 1 and Fragmented Forests of HKS

Tushar Pawar and Prachi Mehta

Another indication of lower abundance of giant squirrel in surveyed sites is obtained by comparing commonly used index of encounter rates. Encounter Rates were compared between sites and between Maharashtra and Southern Western Ghats.

Table 7.2: Relative Encounter Rates of R. *indica* in the Study Area

Protected Area	Sighting	New Nests
HKS	0.08 (0.04)	2.3 (0.38)
Bhimashankar	0.7 (0.16)	12.3(1.43)
SGNP, Tungareshwar	0	0
Tansa	0	0
Phansad	0.03	7.57 (2.99)
Koyna	0	5.5 (1.7)
Chandoli	0	2.1(0.8)
Radhanagri	0.3(0.3)	5.4(2.3)
Reserved Forests	**Sighting**	**New Nests**
Nashik	0	0
Malshej Ghat	0.09(0.08)	4.4(1.7)
Thane Division	0.02 (0.02)	0.8(0.4)
Junnar Division	0.3(0.15)	4.8 (2.0)
Pune Division	0.3(0.16)	7.0 (1.3)
Roha Division	0.1(0.11)	5.6(2.4)
Raigad Division	0.04 (0.04)	0.4(0.2)
Satara Division	0.2(0.09)	6.3(1.3)
Kolhapur Division	0.05(0.03)	2.7 (0.5)

Figures in parentheses represent standard error

Average encounter rate of giant squirrel from Maharashtra was 0.33 while within Bhimashankar it was highest at 0.7 (0.16). Excluding Bhimashankar, the overall encounter rate dropped to 0.18 from the remaining surveyed areas. Kumara and Singh (2006) reported an encounter rate of 0.27 from wet forests of Western Ghats of Karnataka. Between individual sites, encounter rates were highest in moist forests of Srinegri (0.8) followed by drier forests of Nagarhole (0.34), Sirsi (0.24), Brahmagiri (0.21) and Pushpagiri (0.1). Jathana et al (2008) reported lower encounter rates from drier forests of Bandipur (0.17) and Nalkeri (0.29) and moderately high from moister forests of Sunkadakatte (0.36) and higher encounter rates form wetter forests of Lakkavalliee (0.54) and Muthodi (0.6) areas of Karnataka. In the study area, somewhat similar estimates were observed from divisions of Junnar (0.3), Pune (0.3), Satara (0.2) and Roha (0.1). Lowest encounter rates were in Malshej, Thane, Raigad and Kolhapur Divisions.

Lower abundance of giant squirrel in Maharashtra Western Ghats indicates that because of degradation, fragmentation and canopy breaks, the moist forests in the region are not able to support giant squirrels in higher abundance. These abundance measures are similar to those reported for dry deciduous forests in southern Western Ghats. Hunting of squirrels is a likely cause for suppressing the densities but except it a few cases, active hunting was difficult to establish in the study area.

Chapter 8

Conservation of Malabar Giant Squirrel in Western Ghats of Maharashtra

8.1 Current Land-use in the Study Area

The forest in Western Ghats of Maharashtra have not received much conservation focus and research planning as in southern Western Ghats but has attracted much attention from developmental and commercial projects. Area-wise details on projects undertaken in forest area are included in Chapter 6. The section below describes major commercial and developmental activities undertaken in the forest area in Maharashtra.

Rapid Industrial Development: Maharashtra is known as a 'progressive' state in terms of large number of industries it has. The Maharashtra Industrial Development Corporation (MIDC) has initiated several industrial projects in rural areas of Thane, Sahapur, Lonavala, Nashik, Pune, Raigad, Roha, Mulshi, Karjat and Satara. Availability of land, water and cheap labour has attracted investments in these areas. Reserved Forests in these areas are patchy and isolated because of sanctioning of land for small and large scale industries. Mining industry is posing a serious threat to the region. The Maharashtra Western Ghats are well known for its bauxite mining companies. Mining has fragmented the forests in the area and in absence of appropriate restoration policies, is adding to degradation of the remaining forests on the mined plateaus.

Extensive Road Networks: New roads and expansion of existing roads have fragmented the forests all along the landscape. Demands for new road, link roads, highways, bye passes and railways have been increasing and many of the projects are being implemented without proper EIAs resulting in further isolation of forests.

Windmills on Plateaus: Windmills are seen throughout the rocky plateaus of Maharashtra Western Ghats from Pune onwards to Kolhapur. The rocky plateaus in Maharashtra are specialized habitats (*Sadas*) as they support seasonal ephemeral flora and related biodiversity. The project authorities and even the Forest Department are often ignorant about the values of these apparently barren sites. Windmill farms are a source of renewable energy but their presence on all available hill tops and crestline has marred the beauty and naturalness of the area. Also, the approach road to the windmill sites passes through the forests leading to substantial loss of trees causing fragmentation. The construction companies are handed over the windmill sites but there is no monitoring of forests in the area for the entire period.

Damming of Rivers: Several hydroelectric projects are implemented in Maharashtra Western Ghats. The catchment areas and their reservoirs have created isolation of forest patches in most of the areas. The reservoirs which are usually in the Ghats region have submerged acres of primary forests which are difficult to regenerate in the present conditions. There are hardly any large valleys in Maharashtra that have remained intact.

Exploitation of Private Forests: There are large areas of private forests in Maharashtra Western Ghats, also known as malki forests. Wherever these forests are often found in good condition they provide habitat for giant squirrel. However private forests are often badly managed and found in a degraded condition. In many areas these forests are felled and the wood sold for timber and firewood. They are also used for various other reasons such as domestic firewood, *Raab* (wood-ash) burning, shifting cultivation and pasture. Businessmen are buying private forests on a large scale for future investment. In some regions of Satara private forests have been sold to windmill companies. In hill stations such as Amba and Amboli they have been sold for creation of resorts. In Tokavde Range of Thane Division we found that private forests were being converted to resorts and farmhouses. Protection of private forests is important for conservation of giant squirrel.

Exotic and Commercial Plantations: Forest Department's policy to plant fast growing exotics like *Eucalyptus , Gliricidia sepium, Acacia auriculiformis, Casurina equisitifolia and Leucaena leucocephala* has led to creating on scanty forests that do not offer required habitat to any species in the area. Many farmers in Sindhudurg have sold their private land to farmers from south India. These farmers have good know-how of cultivating oil palm, rubber, coconut and bananas and slowly the landscape is acquiring completely different vegetation. The original semi-evergreen forests can be seen in smaller patches surrounded by commercial plantations in this area.

Spread of Urbanization: Maharashtra Western Ghats has picturesque locations in the form of hill tops, plateaus and valleys. Developers have begun to acquire these areas for making fancy townships and luxury farmhouses. Mega projects such as Amby valley and Lavasa in Pune and Mulshi Talukas have been created at the cost of major violation of environmental norms. The trend of neo-rich residents of Maharashtra is to acquire land from original inhabitants at a cheap rate, covert it in to satellite townships or resorts and disturb the ecology and economy of the area by flouting the rules. This trend is responsible for increasing rural landless people and encroachment of forest land in the area.

8.2 Important Areas for Giant Squirrel in the Study Area

The forests in Maharashtra Western Ghats are largely and inadequately protected leading to isolation of PAs from each other unlike in the Southern Western Ghats**.** Except Koyna and Chandoli and Radhanagri, other PAs are relatively small is size, isolated with porous boundaries and have settlements inside. However, being declared as a PA gives it certain immunity against the ills of non-protected forests.

SGNP and Tungareshwar WLS are partly located in the mega-metropolis city of Mumbai and have several issues of encroachment, forest degradation and quarrying. Historically, these areas have never been inhabited by giant squirrel possibly because of isolation from the main forests and its urban surroundings.

Since the extinction of *R .i. dealbata* from Gujarat, now the northern-most range of giant squirrel is represented by Harishchandragad Kalsubai WLS. Within the HKS, Rajur Range located in south-east region of the sanctuary supports giant squirrel habitat and has giant squirrel population. The northern and western region of the sanctuary has very low signs of squirrel presence. The forests in the region are patchy and degraded due to fragmentation. Since it is Protected Area, people do not easily divulge information of hunting but a few locals from Ratanwadi admitted to indulge in opportunistic hunting of squirrels. Villagers from Thakurwadi use catapult for hunting birds and small mammals (Mehta and Kulkarni 2010) but did not reveal information on hunting of squirrels. Borges et al (1998) had reported endangered status of squirrel from this area but since then no action has been taken by the Forest Department. In HKS, areas such as Tolar Khind, Kothale, Lawle, Ratanwadi, Thakurwadi requires intensive monitoring on hunting and land-use practices by local people. The Forest Department should initiate a long-term conservation program in the area to address the needs of locals and improving the status of forests in the area.

Bhimashankar WLS remains the stronghold of Malabar giant squirrel in Maharashtra. During 1992-93, Borges et al reported a decline in 30 % of the population and an increase in the home range of the individual squirrels as a consequence of fragmentation and tree cutting pressure. During the current survey, many signs of tree-cutting and herbivore poaching was recorded from Bhimashankar. In spite of this, giant squirrels are seen in good numbers in Bhimashankar and from their behavior it appears that they are not afraid of human presence indicating that people do not hunt squirrels in Bhimashankar. Tree cutting was also observed from HKS also but in absence of hunting, giant squirrels are present in higher numbers in Bhimashankar. Hunting is a serious threat to giant squirrels and needs to be controlled.

Phansad WLS is small in area but supports good population of giant squirrels. With its evergreen vegetation and lower anthropogenic influences, Phansad has the potential to support giant squirrels in good numbers. The forests of Koyna, Chandoli and Radhanagri WLS offer good habitat to giant squirrel because it is well protected due to natural barriers, has very few villages inside and supports continuous patches of evergreen forests. Hunting of giant squirrel has not been reported from these PAs.

There are major State Highways passing through Phansad (Murud-Alibaug-Roha), Koyna and Chandoli (Karad-Chiplun) Radhanagri (Kankwali-Kolhapur-Vaibhavwadi) which has already disrupted the forest continuity and often contribute to road kills. Most PAs have large dams. Koyna Dam in Koyna WLS, Shausagar Dam in Chandoli, Radhanagri Dam in Radhanagri, Wadeshwar and Dimbhe Dam in Bhimashankar and Vihur and Phansad Dam in Phansad WLS exist since last 3 to 4 decades. Although now the dams offer good protection as natural barrier, it has submerged extensive forest area in the past. Overall, giant squirrel population in PAs is safe and is likely to remain so if protection levels are maintained and demands for development projects are not met with.

The Reserved Forests of Junnar and Wadgaon Range of Pune Division has good population of giant squirrel. These areas support large continuous tracts of forests and pressures are relatively low. Better protection will ensure long-term presence of giant squirrels in these areas.

Forests of Thane, Roha, Mulshi, Lonavala, Matheran, Kolhapur and Raigad are rapidly being converted for commercial projects. Rapid action program is required to monitor the scale of forest loss and implementation of conservation planning. All these areas above are vital for maintaining viable population of giant squirrel in the study area.

8.3 Suggestions for Conservation of Giant Squirrel in the Study Area

Two factors govern the present distribution of giant squirrels in the Western Ghats of Maharashtra. First, the integrity of the moist and semi-evergreen forests and second is the intensity of squirrel hunting. We discuss the suggested conservation strategy under the given points

<u>Maintaining the Integrity of Giant squirrel Habitat in Western Ghats</u>

In past 10 years, several committees have been constituted to recommend measures to protect the integrity of forests in Maharashtra Western Ghats. The measures include recommendations for identifying Multiple Use Area (MUA) and Ecologically Sensitive Areas (ESA) that can be utilized judiciously with long-term conservation benefits

(Kapoor et al 2009). The ESAs in Maharashtra includes all PAs, a 10 kilometer buffer around each Protected Area and the three hill stations of Matheran, Mahabaleshwar and Panchgani.

The EZA rule has banned any developmental activities in the 10 km radius around the PA but it has not been successful in stalling developmental projects in the area. Recently, the Centrally Empowered Committee (CEC) has relaxed these guidelines to reduce the zone of activity from 100 m to 2 km radius around the PAs depending on the type of forests it supports. This is a very general guideline and is likely to be misused contributing further in hastening the process of forest degradation in the area.

Utilization of forested habitat for non-forest purpose should be made on site-specific basis and must be commensurate with ecological value of the forest area. Permissions for using forest land for non-forest activities must not be issued unless there is a commitment for retaining natural vegetation and connectivity to larger forests in the area.

Review of the Least Concern Category of Giant Squirrel

Presence of giant squirrel in the Reserved Forests is not considered to be significant by authorities seeking clearance for roads, mining, and dams as the species is considered to be of "Least Concern". It is argued that giant squirrels are commonly encountered across the landscape and the population is present in high densities therefore they will not be adversely affected by loss of habitat.

The least concern category is suitable for species that are generalist and able to occupy a wide range of habitats. The results of our occupancy analysis indicate that giant squirrels though widely distributed, occupy only the moist and semi-evergreen forests with canopy connectivity. In that sense they are habitat specialists and cannot survive in dry, degraded forests or monocultures. Inclusion of Malabar giant squirrel under the Least Concern category outweighs its importance as an indicator of undisturbed forests. Secondly, the density estimates prove that squirrels are present in high densities only in Protected Areas and outside they exist in much lower densities. The densities in semi-evergreen forests are as low as those in drier forests in southern Western Ghats. Considering the trend of lower and probably declining squirrel population from Maharashtra Western Ghats, it is important to review the Least Concern status of Malabar giant squirrel at the international and national level.

Setting Aside Important Areas for Giant Squirrel

In Maharashtra, the status of Reserved Forest is changing rapidly. In the vast landscape of Maharashtra with its demanding economy, it may not be possible to protect all

populations of giant squirrel though it is highly desirable to do so. Nonetheless, it is possible to set aside important areas that can support viable population of giant squirrel. Reserved Forests that are diverse, largely intact, and connected to PAs can serve as potential areas for long-term conservation of giant squirrels. Areas outside Koyna, Chandoli, Bhimashankar and Radhanagri are vital for giant squirrel conservation. The forests in this region should not be compromised for any developmental activities. A systematic EIA must be carried out in areas assigned for non-forest use to assess the implications of upcoming projects. The EIA should be conducted by genuine and reputed NGOs who can give unbiased and scientific assessment report. Sanction of the project should be based on the recommendations in the report

Restoration of Degraded Forests

Maintaining connectivity of forests outside PAs is very essential for preserving corridors. Afforestation or restoration projects should be made mandatory for mining and irrigation projects. Plantation of species similar to that found in the adjacent forests will help in recovering from the effects of fragmentation and degradation over a period of time. Similarly, scientific and well managed restorations can help recreating native vegetation and help in re-colonizing of biodiversity in the area.

Incentive based protection of forests

Although conceptually sound, the project of Joint Forest Management (JFM) did not yield desired results in India. Incentive-based management of reserved forests and private forests can help in maintaining integrity of the intervening forests and corridors. Offering income-generating but conservation oriented incentives will help in reducing degradation of forests in the area. This is most applicable in Private Forests Private forest owners should be encourage to develop sustainable management plan for their forests so they get continuous income from their forest without jeopardizing the ecology of the forests (Kulkarni et al 2012).

Control on Hunting of Giant Squirrel

Hunting of giant squirrels for meat and trade is reported from Maharashtra Western Ghats. Tribal's livings close to the forests are more likely to hunt squirrels since it is part of their traditional life style. Urban people also indulge in hunting for meat and for keeping them as a pet. However it is a well-documented fact that persistent hunting suppresses animal densities and can lead to local, regional and finally total extinction of a species Areas facing the pressures of habitat degradation and fragmentation have a hope to regenerate in future if corrective measures are taken to restore the vegetation but in presence of intense hunting the species has no hope for survival. Lower abundance of important seed-dispersals such as the giant squirrel can impact

regeneration and thereby modify the vegetation composition in the forests (Madhusudan and Karanth 2000, Karanth *et al.* 2009). It is difficult to control hunting but a serious attempt should be made by intensive enforcement and stepping up protection in RFs coupled with awareness programs among local people.

Generating Awareness on the status of giant squirrel in Maharashtra

Awareness about the issues concerning giant squirrel conservation is important among the senior Forest Officers and local communities. The findings of the project will be shared with Forest Department and conservation organizations.

A few newspaper articles on the project have been published by the reporters in English and Marathi daily. In February 2012, a poster on the project was presented at a national biodiversity conservation conference in Pune. The PI has written a popular article highlighting the conservation issues for WWF magazine. A twenty minute film on line transect sampling method has been prepared by Mr. Jayant Kulkarni from WRCS with the support of Mr. Kondal Rao, CCF Pune. The film can be used for generating awareness and training the staff in population monitoring methods.

8.4 Further Work

Except in Harishchandragad-Kalsubai WLS, the Malabar Giant Squirrel population is considerably safe in all other PAs of Maharashtra Western Ghats. Owing to faulty policies, neglected concerns and unplanned forest management, the populations from Reserved Forests is certainly declining. The concerns and actions for protection of giant squirrel need to be invested on priority basis in the Reserved Forests. The Forest Department can start a regular monitoring program on giant squirrels in the RF areas. Training of Forest Staff in scientific methods of monitoring giant squirrel in their areas is very essential. Large areas can be monitored for population monitoring with the help of local volunteers and students from education institutes

Existing policies and law have not been effective in protection of the giant squirrels in Maharashtra Western Ghats. New and innovative strategies need to be implemented for the conservation of this beautiful and charismatic species in Maharashtra.

Prachi Mehta

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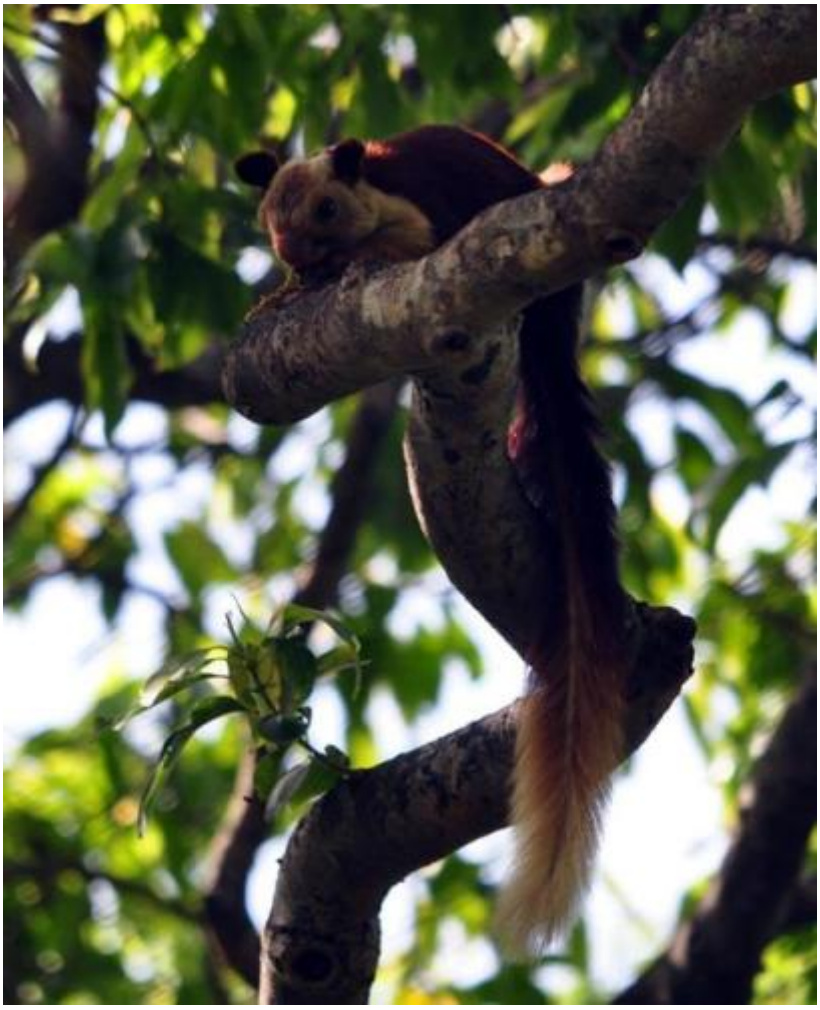

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