Effect of Village Relocation on Ground Birds and Small Mammals in Sariska Tiger Reserve, Rajasthan, India

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By

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CERTIFICATE

This is to certify that **Mr. Rakesh Mondal** of Wildlife Institute of India has carried out an original research titled **"Effect of village relocation on ground birds and small mammals in Sariska Tiger Reserve, Rajasthan, India"** in partial fulfilment of his **"Master in Wildlife Science"** from **Saurashtra University**, Rajkot. This study was carried out under our supervision at **Wildlife Institute of India** from December 2016 to June 2017. We also certify that this work has not been submitted for any other degree to any other university.

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Abstract:

1) Conservation related resettlement has been practised in India from 1960's. However, studies related to the effect of village relocation on wildlife are limited.

2) Exploitation of natural resources by resident communities causes direct negative impact on native fauna and flora. These activities may include extraction of natural resources (fodder and fuel) or competition for the available resources by existing livestock with native fauna. Alterations in the vegetation structure can result in alteration of the bird community in these areas.

3) Galliformes is one such taxon that has been documented to be affected by human disturbance and grazing. These species are good indicators of habitat quality as they are solely dependent on the ground layer for food and cover.

4) There are 29 villages inside the Sariska Tiger Reserve and a relocation effort initiated as early as 1966 provides an excellent opportunity to study its effect on wild fauna and flora.

5) The study was carried out in four sites, with two sites where villages had been relocated 50 years (Slopka) and 10 years back (Bhagani); one site where village had been partially relocated (Sukola) and one where the village still existed (Lilunda). The primary objective was to understand the influence of village relocation on galliformes, small mammals and small carnivores. Additionally, vegetation structure at each village was also studied to understand influence of village relocation on natural vegetation.

6) The study revealed variation in densities of the galliform communities across the study sites with the highest density estimated from Bhagani (331.4/km^2), followed by Slopka (240.4/km^2), Lilunda (181.3/km^2) and Sukola (180.7/ km^2). Species composition varied across the study sites with peafowl being dominant in the sites with existing villages, as compared to other sites, where different species of galliformes contributed to the diversity.

7) Similar results were obtained for small mammals where Slopka had the highest density of rodents (13.08/ha), followed by Bhagani (9.72/ha), Sukola (9.12/ha) and Lilunda (3.21/ha). Composition of species was different across the four village sites. The study revealed considerable difference in vegetation structure in sites where relocation was carried out as compared to the existing village sites.

CHAPTER I
INTRODUCTION

1.1. Introduction

Human induced conversion of natural habitat is the largest primary cause of loss of biological diversity. In order to protect the biodiversity and conserve the existing native fauna and flora, the habitats were provided legal status and established as Protected Areas (PA's). These areas, though considered as protected, have human settlements that greatly influence these habitats. The human communities considerably depend on the natural resources to meet their day-to-day requirements. The unsustainable demand for these resources by the local communities and various developmental activities, have subjected these systems to great stress. The balance between natural habitat and human-dominated landscapes however, determines the future of biological diversity and its conservation over large areas of the planet. The fundamental challenge in terms of maintaining biological diversity in large parts of Asia is the increasing rate of habitat loss or modification due to contemporary human activities, such as timber extraction and forest clearance for agriculture and other purposes (Sodhi *et al.* 2004). The expansion of the land use that accompanies human population growth also results in the fragmentation of natural habitat. Fragmentation causes the reduction, isolation, and removal of native vegetation from the natural landscape that is detrimental for the biodiversity (Fahrig 1997).

In 2009, 12.9% of the total land area of the world, was under legal protection that rose up from <4% in 1985 (Jenkins 2009). Of the world's 821 terrestrial ecoregions, half had <10% of their area protected (Joppa *et al.* 2009). In the future, how effectively these areas harbour species within their boundaries is an essential input to predict future extinction rates. Protected areas provide the considerable effect for preventing extinctions. Globally, sites of particular importance with >50% protection are sliding toward extinction only half as rapidly as those with <50% of their important sites protected. Today only 1.4% of the Earth's surface considered as protected area which is home to almost half of all plant species and more than one-third of all vertebrates (Heltberg 2001). However, the expansion of parks and nature reserves has not stopped the destruction of living species. In the world, more than half of the protected areas are inhabited by local populations, like in India where 65% of protected areas are inhabited by human populations (Kothari 1995). In developing countries, rural communities have always been largely dependent on natural resources for their livelihood and millions of forest dwellers continue this dependence. A rough estimation of 200 million people, which constitute 20% of the Indian population depend for their livelihood on natural resources (McNeely and Scherr 2003). The conservation of natural resources is thus, closely linked to the sustainable development of native populations in developing countries and to the conservation of their way of life. To achieve biodiversity conservation, resettling forest-dwelling communities is critical and has been a contentious issue worldwide (Agrawal and Redford 2006). This issue is particularly relevant in developing countries, which often have a high degree of biodiversity, large human populations, an acute dependence on natural resources, and high rates of poverty (Grimble and Chan 1995). The ability of protected areas to conserve species is reduced by intensifying human land use surrounding the protected areas (DeFries and Hansen 2007).

How intensively humans use the land (e.g., agriculture or housing) and whether the uses lead to, for example, the introduction of pathogens or invasive species determines the extinction of species (Benton *et al.* 2003; Jackson and Sax 2010). Species richness to land-use intensity have been identified to cause nonlinear response for mammals (Panzacchi *et al.* 2010), fishes (Alberti 2003), birds (Lepczyk *et al.* 2008), and insects (Gagne and Fahrig 2010). It differs among various taxonomic groups and decreases monotonically as land-use intensity increases (Tews *et al.* 2004). Concentrations of threatened species more closely match concentrations of small-ranged species than the total species numbers. A vital point is that habitat destruction is greatest where the highest concentrations of small-ranged species live (Myers *et al.* 2000). Long-term loss of forest bird species due to deforestation has been reported from highly deforested areas in Singapore, Southeast Asia, where more than 90% forest cover loss and 67% bird species loss was documented between1923 to 2000 (Castelletta *et al.* 2000). Based on estimates of forest loss and the species-area relationship, it has been estimated that 16–32% of Southeast Asian forest bird species and 21-48% of mammals species are predicted to go extinct by 2100 (Brook *et al.* .2003). Land use changes act as a primary driver for biodiversity loss, employing species-area relationship. For example, Pimm and Raven (2000) pointed out that 18% extinction by 2100 due to deforestation to date in tropical forest hotspots and 40% extinction if these regions retained natural habitat only in currently protected areas.

Long-term studies are needed to understand biotic sustainability in regenerating and degraded forests. These studies should include habitat use, dispersal, and population viability. The amount of forests (i.e. thresholds) required to retain forest species richness in human-dominated areas is needed for better knowledge. Information is required for understanding the mechanisms of species losses in isolated forests. Specifically, the evidence is necessitated on the synergistic or additive effects of biodiversity loss drivers such as forest degradation, invasive species, drought, wildfires and climate change on forest biodiversity in human-dominated landscapes (Brook *et al.* 2008).

1.2. Rationale of the Study

Today, humans impact Earth's ecosystems at extraordinary rates through conversion of land and resource consumption (Turner *et al.* 1991), alteration of habitats and species composition (McKinney 2002), disruption of hydrological processes (Arnold and Gibbons 1996). At least half of the world's forests have disappeared as a result of human activity, and three-quarters of that total have disappeared since 1700 (Harrison and Pearce 2001).

Most of the protected area (PA) in the Indian subcontinent lies within high human density landscape and are highly sensitive to surrounding pressures. The majority of India's PA's have human communities dependent on their resources for sustenance and livelihood. A national survey done in the late 1980s revealed that 69 percent of surveyed PA's had a human population living inside, and 64 percent had community rights, leases or concessions inside them (Kothari *et al.* 1989). The most common activity inside was grazing that was present in 69 percent of the surveyed PA's while 57 percent of the surveyed PA's had collection of non-timber forest produce. A rough extrapolation of available data from the same survey revealed that there were at least three million people living inside PAs.

The effects of fragmentation of a large expanse of habitat into a number of smaller remnants is often accompanied by other forms of disturbance such as fire, tree windfalls; increased grazing pressure and human-induced disturbance (Ledig 1992). Disturbance affects the resource base of a community by destroying old resources, creating new resources and modifying existing resources. This change in the resource base can result in an additional niche or local extinction. Invasion of natural communities by exotic species have been found to be disturbance-dependent. Different taxa have been shown to respond differently in both the magnitude and temporal extent of the response (Kitchener *et al.* 1982). This is a reflection of different species perceived habitat requirements. Fragmentation effects are thus expected to vary not only among species, but also among different landscape structures. Studies on the effects of tropical forest fragmentation (Laurance and Bierregaard 1997) show that fragmented landscapes are complex and variable mainly because of the altered habitats that surround fragments (Crome 1997; Laurance *et al.* 1997). Unfortunately, many studies on disturbance in the fragmented landscape do not include comparisons of animal species composition among forest types, or stands. Habitat fragmentation studies that aim at improving tropical forest conservation strategies should focus on the investigation of the relative importance of different underlying processes such as population size, species dispersal, structure and quantity of available habitat and the probability of invasion (Bierregaard *et al.* 1997; Crome 1997). In view of the rapid and massive modification and conversion of natural forests in India, and the fact that this trend is likely to continue in the foreseeable future, it is imperative to elucidate how these changes affect the forests and, in turn, the different biological communities living within.

In India, voluntary relocation of villages has been one of the principles in the management of protected areas. The aim of voluntary relocation from wildlife sanctuaries and national parks is to create inviolate space for biodiversity conservation where minimal human use is allowed (Shahabuddin 2005). Such inviolate spaces are essential for sustaining natural biodiversity in large continuous forest habitats. However, most village relocations in the country have historically taken place in the absence of information related socio-economic status or forest dependency or identification of key needs that are required in new sites. For example, previous study in the same landscape on relocation programmes has been ineffective in successfully rehabilitating people, leading to severe impoverishment and social dislocation of marginalised groups (Shahabuddin *et al.* 2014). For those reasons, village relocation has always been a controversial issue in conservation circles. Yet little is known about the socio-economic impacts of such displacements or their effectiveness in restoring biodiversity.

Sariska Tiger Reserve is one such Indian protected area where village relocation has been prioritised as one of the key programmes to be undertaken for saving biodiversity. Sariska was one of the important conservation areas for the Tiger (*Panthera tigris*) in its north-western limit in India until it got locally extinctions in 2004-2005. It represents the last few remnants of native tropical dry forest and scrub still to be found in the Aravalli Range.

Sariska already has a long history of village relocations. Relocation of villages located within the Sanctuary area was undertaken in 1960's. One village, Karnakawas was moved from the Core area between 1975-77, and unsuccessful attempts have been made to move two other villages, Kiraska and Kanakwari. Since then six villages have successfully been relocated from the reserve till date. Some villages are still remaining inside the park and need to be relocated. The relocation of villages was successfully carried out in the year 1966-67, 1976-77, 2008-09 and 2011-12. Some of the villages were partially relocated and still the relocation programme is ongoing. These different phases of relocation produced heterogeneous mosaic of different successional stages of secondary forest, interspersed with cleared areas dominated by shrubs and bushes, and pockets of primary forest.

Table 1: Details of village relocation efforts in Sariska Tiger Reserve (STR)

Name of Villages	Year of Relocation
Kalighati and Slopka	1966-67
Karnakawas	1976-77
Deori and Rotkyla	2008-09
Bhagini and Umri	2007-10
Kankawadi-Karat- Pilapani	2011 (Partially relocated)
Haripura, Dabli, Kiraska & Sukola	2013 (Relocation ongoing)
Lilunda, Kundalka & Rekamala	Not reloctaed

1.3. Research Objectives

- To estimate the abundance of small mammals and ground birds at different village sites with respect to the year of relocation.
- To estimate the changes in vegetation structure over time at different village site with respect to year of relocation.

1.4. Literature review:

1.4.1. Literature on ground birds:

Forest fragmentation results in smaller patches and greater edges (Ranney *et al.* 1981) that negatively affects abundance and distribution of birds by predation on avian nests (Kerlinger and Doremus 198, Chasko and Gates 1982). This contention is based on the observations that forest edge increases with the fragmentation (Ranney *et al.* 1981) and the mammalian predators frequently use these edges (Gates and Gysel 1978). Moreover, the nesting success is less in forest fragments than in larger forests (Ambuel and Temple 1983). Increased habitat alteration may also favour the persistence of disturbance-associated species. Primary forest avifauna is known to sustain in certain degraded habitats but tropical birds are assumed to be more affected by habitat disturbance as compared to its counterpart in the temperate region (Mitra and Sheldon 1993). The ability to maintain reproductively viable populations in degraded habitats depend upon the resilience of the species. However, variation in vegetation structure is known to affect bird species (MacArthur and MacArthur 1961; Cody 1981); the disturbance related vegetation changes are not associated with the abundance and richness of resident bird species. It has been documented that some bird species are resilient to habitat disturbance and urban encroachment (e.g., Friesen *et al.* 1995 for resident birds near urbanization and Hutto 1989 for migratory land birds in tropical deciduous forests), although it is species specific, the patterns are highly complex. Certainly, human disturbance has a negative effect on bird species (Friesen *et al.* 1995; Jullien and Thiollay 1996). As deforestation becomes increasingly prevalent in most tropical regions, it is critical to understand the ecological impacts it has on the native forest biota, as well as the responses of these species to the loss of their natural habitats.

1.4.2. Literature on Small mammals:

Four major aspects of fragmentation have been postulated as important to the small mammal community: fragment size, isolation, edge effects and increasing vulnerability to external disturbance (Kitchener *et al.*, 1980b, 1982; Simberloff& Abele 1982; Opdam *et al.* 1984; Quinn & Harrison 1988). Fragmented landscapes are complex and heterogeneous systems which are influenced by factors other than the size or degree of isolation of forest remnants. Studies on fragmentation of tropical forest indicate that qualities of the matrix are influenced by edge-induced habitat changes. One of the cornerstones of ecology is "habitat heterogeneity hypothesis" (MacArthur and Wilson 1967; Lack 1969). It presumes that more niches are provided by structurally complex habitats and diversify the ways of exploiting the environmental resources and thus species diversity increase (Bazzaz 1975). Plant communities determine the physical structure of the environment in most of the habitat, and therefore, have a considerable influence on interactions of animal species and their distributions (Lawton 1983; McCoy and Bell, 1991). For example, the abundance of small mammals is strongly associated with the density of vegetation with fewest numbers of mammals residing in highly disturbed sites (Dickman and Doncaster 1987).) Similar are the result in the tropical forest for small mammals, where species richness was correlated with increased alteration of habitat and human presence.

In general, small mammals exhibit species-specific responses depending upon their habitat requirements and strongly respond to habitat alteration. No studies have been carried out long enough to show if small mammal fauna in small forest fragments will eventually return to its original state as the surrounding matrix of logged forest regenerates approaching its original structure. However, Lynam (1997) who studied the effects of habitat fragmentation because of dam construction in Southern Thailand remarked that unless forest fragments are connected to a larger, relatively undisturbed tract of forest that may act as a "source" habitat; it is unlikely that the natural small mammal community will recover in fragments. In this respect, it is indispensable to maintain the continuity between the large primary forest tracts of the core area with the rest of the logged-over areas, including small primary forest patches. Increased habitat alteration may favour the persistence of disturbance-associated species. For all species combined, however, small mammal abundance was less in disturbed sites, suggesting that increased habitat alteration across the study area will result in an overall decline in small mammal abundance. However, Gardner *et al.* 2007 showed that species richness in small mammals, amphibians, birds, butterflies, and trees did not change, but the composition of species did change across a gradient of land use from strictly protected parks to areas of high human activity.

Thus, heterogeneity in local land uses may protect or promote biological diversity at the regional scale, by creating areas with complimentary sets of species. Degraded habitats and landscapes can, in some cases serve as surrogate habitats for some of the forest biota (Mitra and Sheldon 1993; Sodhi *et al.* 2010). If forests are allowed to regenerate in heavily disturbed areas, they might act as good refuges for the forest biota (Castellatta *et al.* 2005). In terms of conservation management, it is imperative to incorporate the size and overall surrounding environment of a forest into forest management concepts, and although not equivalent to areas of primary forest, the old regenerating secondary forest needs to be considered as an important component for the preservation of small mammal species diversity.

CHAPTER II

STUDY AREA

2. Study area

Sariska tiger reserve (STR) is located in the Alwar district of Rajasthan and spreads over the ancient ranges of the Aravallis. The total area of the Tiger reserve is 1200 km^2, with 274 km^2 as a notified National Park. Rugged terrain, undulating plateaus and the wide valleys of the Aravallis with tropical dry deciduous thorn forest (Champion and Seth 1968) characterize a major portion of the area. The pre-Cambrian rocks of the Delhi system and Aravalli system which comprise of quartzite, conglomerates, grits, limestone, phyllite, granites and schist (Pascoe 1950; Sankar 1994) occupy most of the area. The altitude of Sariska varies from 340 m to777 m. The two main plateaus are Kankawadi (524 m) and Kiraska (592 m). The homogeneity in the heights, level summits, and uniform appearance is the most remarkable characteristic of these hills, which stretch out from northeast to southwest, in more or less parallel lines. The soil is sandy to sandy-loam, shallow, and covered with boulders. The depth of soil layer is more than 1 m in valleys, whereas it is only a few centimetres deep on the hill slopes.

2.1. Location and extent: The highly dissected topography of Sariska tiger Reserve lies between Longitude: 79° 17' to 76°34'N and Latitude: 27° 5' to 27° 33'E in the Aravalli ranges of Rajasthan. The reserve is administratively divided into six ranges; these are Sariska, Tehla, Akbarpur, Alwar buffer, Ajabgargh and Talvriksh; which together encompasses 102 beats, generally recognized for wildlife monitoring. The area of the tiger reserve is also divided into 'buffer' and '**Critical Tiger Habitat**' (CTH). The CTH lies on Delhi-Jaipur State Highway via Alwar, at a distance of 200 km from Delhi, 36 km from Alwar and 110 km from Jaipur.

The Core Area of STR lies between Latitude 27° 05' 45.6" to 27° 38' 54.9" North Longitude 76° 14' 30.1" to 76° 32' 44.5" East. The buffer area is 1054.8km^2 and mostly surrounded by Revenue land and villages. The adjoining forest of Alwar and Jamuna Ramgarh Wildlife Sanctuary forms an important corridor for movement of wild animals. The major river passing through the area is Ruparail. Few live springs or nullahs are perennial water sources which provide life-saving water to wild animals during the summers.

2.2. Climate: Sariska has a sub-tropical climate characterized by a distinct summer and winter, a small period of monsoon and very short spring. Summer commences from mid-March and continues until end of June. The summers are extremely hot with temperatures soaring up to 50°C. Winter commences from November. In winter, the temperature has been observed to drop to 3° C. Summer is followed by monsoon from the south-west in July and August. The mean annual rainfall is 650 mm (Sankar 1994) and mainly occurs during monsoon period from July to September.

2.3. History and Archaeological Richness: In the pre-independence period, the Park used to be maintained as a hunting reserve of the erstwhile royal family of Alwar. After independence, the forests came under the control of the Government of Rajasthan. On 7th November of 1955, Sariska was declared as a Wild Life Reserve, under the Rajasthan Wild Animals and Birds Protection Act, 1951. The Reserve status was upgraded to that of a Sanctuary in 1958. The government of India included Sariska as a tiger reserve in 1978 as the 11th Tiger Reserve. An area of 274 km2 was declared as Sariska National Park in the year 1984 vide preliminary Notification NO. *F11 (22) Raj-8/78 Jaipur Dated 27 August 1982 under Wild Life Protection Act 1972 (Central Act No. 53) section 35 (1).*

The disappearance of the tiger from Sariska was confirmed in 2004 and a poaching epidemic had afflicted the region unnoticed for the previous few years (Wheeler 2009). An earnest effort was made by the Government of India and Government of Rajasthan to undertake a unique conservation project. It was launched in July 2008 to re-introduce the tiger in Sariska tiger reserve. As per a new guideline of the National Tiger Conservation Authority (NTCA), the Government of Rajasthan through – Order No F 3(34) Forest/2007, dated 28th December, 2007 – has notified 881.11km^2 of area as Critical Tiger Habitat for protecting prime areas for biodiversity conservation in the north-western distributional limit of tigers in India.

2.4. Major Vegetation Types: The topography of Sariska supports semi-deciduous riparian forest, scrub-thorn arid forests, dry deciduous forests, rocks and grasses. The vegetation types of Sariska falls within group V and group VI according to Champion and Seth classification -Northern tropical dry deciduous forests (subgroups 5B; 5/E1 and 5/E2) and Northern Tropical Thorn Forest (subgroup 6B) (Champion and Seth, 1968). The dominant tree species is *Anogeissus pendula* (Dhok), covering over 40 per cent of the area in the forest (Sankar, 1994). *Boswellia serrata* (Indian frankincense or salar) and *Lannea coromandelica* (goonja or gurjan) grow on steep rocky hills. *Dendrocalamus strictus* (Bamboo) and *Phoenix sylvestris* (Indian date or khajur) mostly grow along the streams or riverine patches. *Acacia catechu* (khair), *Butea monosperma* (palash) and *Zizyphus mauritiana* (ber) are common in the valleys. *Albizia lebbeck, Diospyros melanoxylon, Holoptelia integrifolia* and *Ficus* spp. are found in moist localities. Grasslands are interspersed with *Zizyphus mauritiana* and *Acacia leucophloea.* On the side of nallahs or riparian vegetation cons*Mangifera indica* (mango), *Syzgium cumini* (Indian blackberry and jamun), *Tamarindus indicus* (Imli) and *Cordia dichotoma* (Lasoda) etc.

Sariska has four major vegetation types according to Parmar (1985) and Rodgers (1991). These are as follows:

1. *Anogeissus pendula* forest
2. *Boswellia serrata* forest
3. *Acacia catechu* forest and
4. Miscellaneous forest, which can be further sub-divided into three categories viz.
   a) *Butea monosperma* forest
   b) Forest along nallahs and
   c) Scrub land

In Sariska TR, nine different vegetation types and land cover categories have been delineated (Sankar *et. al.* 2007). They are *Anogeissus* dominated forest, *Boswellia* dominated forest, *Butea* dominated forest, Acacia mixed forest, *Zizyphus* mixed forest, scrubland, agricultural land, water body and barren land.

2.5. Fauna: Sariska Tiger Reserve harbours a rich diversity of fauna including large and small mammals, notably: chital (Axis axis), sambar (*Rusa unicolor*), and nilgai (*Boselaphus tragocamelus*), four-horned Antelope or Chowsingha. (*Tetracerus quadricornis*). Omnivores found are the wild pig (*Sus scorfa*) and jackal (*Canis aureus*). Large carnivores found are reintroduced tigers (*Panthera tigris*), leopard

(*Panthera pardus*), striped hyaena (*Hyaena hyaena*). Small carnivores are caracal (*Caracal caracal*), jungle cat (*Felis chaus*), common mongoose (*Herpestes edwardsi*), small Indian mongoose (*H. auropunctatus*), ruddy mongoose (*H. smithi*), palm civet (*Paradoxurus hermaphroditus*), Small Indian civet (*Viverricula indica*) and Ratel (*Mellivora capensis*). Rhesus macaque (*Macaca mulatta*) and common langur (*Seminopithecus entellus*) are the two primates found here. Porcupine (*Hystrix indica*) and rufous tailed hare (*Lepus nigricollis ruficaudatus*) are also found in Sariska TR. Eleven species of small rodents were captured during the present study viz. Indian gerbil (*Tatera indica*), Indian bush rat (*Golunda ellioti*), spiny tailed mouse (*Mus platythrix*), house mice (*Mus musculus*), little Indian field mice (*Mus booduga*) long tailed tree mouse (*Vandeleuria oleracea*), sand coloured Rat (*Millardia gleadowi*), soft fur field rat (*Millardia meltada*), brown rat (*Rattus norwegicus*), house rat (*Rattus rattus*) and pygmy gerbil (*Gerbillus nanus*).

The predominant domestic livestock found inside the reserve are buffaloes, Brahminy cattle (*Bos taurus*) and goats (*Capra hircus*) (Sankar 1994). Sariska has the highest prey base density for large carnivores with the highest density of Sambar and Wild boar.

Sariska also holds a variety of bird species which includes 211 species of birds out of which 120 residents, 73 species as migrant and 18 species recorded as vagrants (Sankar *et al.* 1993). Kidwai *et.al.* 2011 recorded very high density of peafowl as well as grey francolin in Sariska TR.

2.6. Human settlements:

Of the 29 villages situated inside Critical Tiger Habitat of Sariska Tiger Reserve, three villages have been relocated completely only recently (Umri, Baghani, Routkela) and another six villages (Kankwari, Kiraska, Sukola, Daabli, Deori and Haripura) are being considered for relocation on a priority basis and have been partially relocated. The process of relocation was however initiated in 1966 with initial relocation of Karnakawas and Slopka and further Bhagani and Routkela in 2007-08 and Village Umri in 2012. The villages are located deep inside the reserve and are a source of considerable disturbance to the natural ecosystem and more evidently to the wild animals. Most of the habitations, situated inside the core area, are not connected by road and lack basic amenities like electricity, school, hospital or market thereby limiting social and economic development. Besides this, they are resource users resulting in high forest degradation in the core area. On the one hand, people remain deprived of the fruits of development and are aggravated by hardships, while on the other hand, the protected area suffers because of fragmentation and degradation of habitat by these people and their cattle. To improve the condition of the people and to provide a better undisturbed habitat for the wild animals; relocation of these villages has become quite relevant.

Some of the villages like Kankwadi, Dabli and Devri are among the oldest villages in the reserve. These villages were inhabited by Bhagvata, Mina and Rajput communities in the past and currently by Gujjars and Minas largely with a few Brahmins. The communities are dependent on the resources provided by these forests for their livelihood requirements (Srivastava 2013).

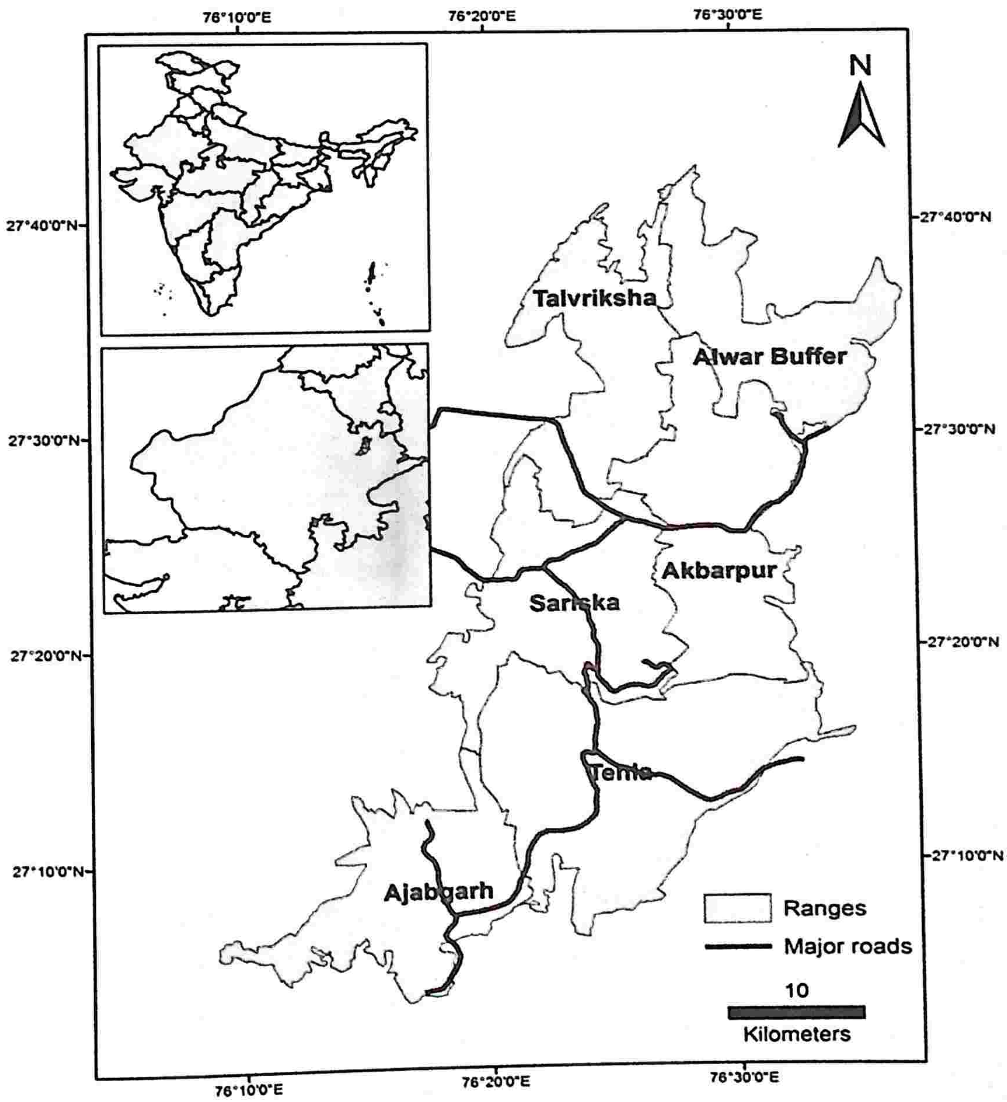

Figure 1: Map of Sariska Tiger Reserve (STR), Rajasthan, India

2.7. Intensive study area: Four villages were selected on the basis of the year of relocation, major vegetation type and elevation. These villages are listed below:

1. **Slopka:** Village Slopka was relocated 50 years ago in the year 1966-67. It is situated in the middle of the core area of the tiger reserve. It comes under the range 'Sariska'.

   Latitude: 27°18'5.40"N, **Longitude:** 76°25'55.50"E

2. **Bhagini:** Bhagini was relocated 10 years ago in the year 2007-08. It is also situated in the core area of the tiger reserve. It comes under the range 'Tehla'.

   Latitude: 27°17'49.82"N, **Longitude:** 76°23'2.39"E

3 **Sukola:** The relocation of this village was started in the year 2013 and since then 10 households have been relocated successfully and efforts are on way to relocate another eight households. Sukola village site was considered as partially relocated for the study. It is also situated in the core area of the tiger reserve and comes under the range 'Akbarpur'.

   Latitude: 27°23'56.71"N, **Longitude:** 76°27'33.62"E

4 **Lilunda:** Lilunda is situated inside the core area of the tiger reserve. Relocation process is yet to start. Lilunda also comes under the range 'Sariska'.

   Latitude: 27°23'50.22"N, **Longitude:** 76°25'36.52"E

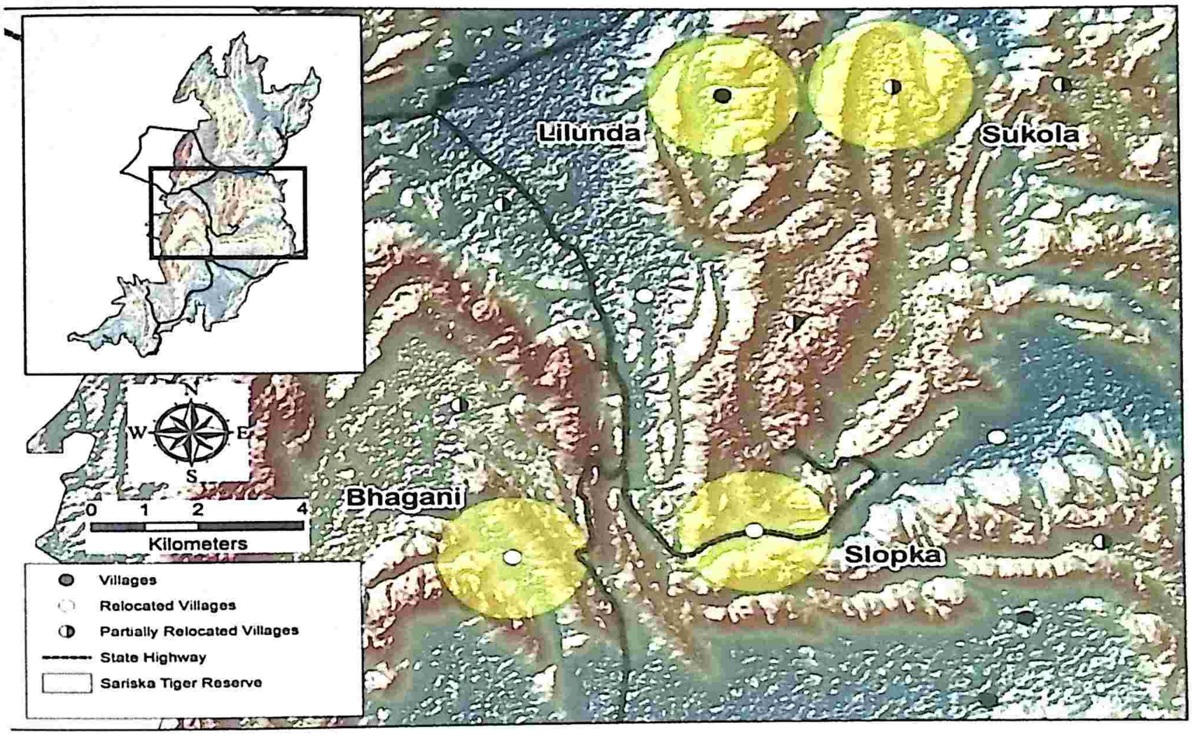

Figure 2: Intensive study area map in STR showing location of villages

CHAPTER III

METHODS

3. Methods

3.1. Population estimation of ground birds: For most species, estimation of abundance is a fundamental tool for conservation. Line transect method was used to estimate the population of selected species of galliformes in the study area. For estimating biological population, line transect sampling is practical, efficient and relatively inexpensive (Anderson *et. al.* 1979). Line transects method was selected as compared to point counts for estimating birds as it is more accurate (Raman 2003).

From the centre of the each village, a 1.5 km radius circular area was chosen for intensive sampling. The size of the area was 7.07 sq. Km and was divided into 500x500 m grid and 15 transect were laid in chequerboard design to cover all types of habitat. Length of transects varied from 500 m to 680 m. A total of 60 transects were laid in all four village sites and the total effort was 36.17 Km. All transects were walked once in the morning between 07:00 AM to 09:30 AM during the month of December to April. In total 60 transect in all four village sites (study site) were walked.

Data was analysed using the program DISTANCE 6.2 (Thomas *et. al.* 2009). Four key functions (uniform, half-normal hazard rate and negative exponential all with cosine series adjustment) were considered for analysis. Minimum Akaike Information Criterion (AIC) and Chi-square was used for the selection of the best-fit models. The encounter rates were obtained using the formula by Rodgers (1991). Encounter rate (ER) = n / l (Whereas 'n' is the number of individual and 'l' is the total length of the transect).The value derived from the above calculation was used for obtaining the index of abundance.

3.2. Population estimation of rodents: Rodent density was estimated using trapping web design at four different village sites of the intensive study area. Two trap points were selected for rodent trapping from the 500x500 m grid of each village site. One trap point was selected within 200 m from the centre of the village site and other one at1 km. The standard Sherman live traps (5 x 6.5 x 16.5 cm) were used for rodent trapping at eight different sites in all four-study area (village site). Each trap was run for 15 consecutive trap nights with total sampling period amounted to 120 trap nights in all four study site. The trapping was carried out in 0.28 hector area (60 m x 60 m) concentric rings of 30 m radius. The traps were kept near bushes, trees, rocks, fallen logs or any other possible run way of rodents in sampling area. All the traps were baited with peanut butter between evening 05:30 PM to morning 07:00 AM and checked between 07:00 AM to 08:30 AM in the morning. Trapped rodents were identified, weighed and measured for the tail length and body to head length (HBL). Rodents were identified up to species level using field guides (Prater 1980; Menon 2014). Animal sex was identified based on their genitalia. Each of the rodent was marked by paint colour at the base of the tail or either on the hind limb. Four colours were used for marking rodent viz red, blue, green and pink. The capture animal was marked and released at the spot where they were trapped. Program Mark was used for data analysis. Huggins **p** and **c** models were selected for closed capture data type. Minimum Akaike Information Criterion (AIC) was used to select the best-fitted models.

3.3. Quantification of vegetation: Since majority of the studies showed that changes in bird communities happen due to habitat alteration resulting from changes in forest vegetation structure such as in the density of trees, density of bamboo understorey, tree size class variation, densities of old trees and snags, amount of woody litter and tree species composition (Raman *et al.* 1998; Lohr, Gauthreaux and Kilgo 2002), the quantification of vegetation was carried out on each transect at 200 m interval. The vegetation structure studied included assessment of canopy cover, shrub cover, ground layer cover and invasive species. Three plots were selected in each transect. The first plot was laid at the beginning of the transect and remainder of the two plots laid at 200 m and 400 m. Three types of circular area were laid for sampling vegetation in each plot. For trees, a 15m radius circular plot, 5 m radius plot for shrub and two 0.5m radius plot for ground layer cover were laid for sampling vegetation. A total of 180 plots were laid for vegetation sampling in all four-village sites. Percentage of canopy cover, shrub cover and abundance of invasive species were calculated and compared between four village sites. The lopping score for each tree was additionally measured on a scale of 0–4 as follows: 0, no lopping; 1, rudimentary signs of lopping; 2, up to half of the main branches lopped; 3, more than half of the main branches lopped; 4, the tree reduced to a stump. The scale of lopping was calculated as the total lopping score divided by the total number of trees present. To obtain the Human disturbance factors such as wood cutting, lopping, grazing, human trails, and livestock dung was quantified in each plot. These were quantified at each plot in a scale of 0 to 4 (0–none, 1–low, 2–medium, 3–high and 4–very high).1 = Low (Less than 25%), 2 = Medium (25%–50%), 3 = High (50%–75%), 4 = Very high (Above 75%).

3.4. Camera trapping for small carnivores: A reconnaissance survey was carried out in each village sites before placing camera traps. Indirect signs such as spoor, scats and track signs of carnivores were identified and marked using a handheld Global Positioning System (Garmine etrex vista). The camera trapping was carried out within 1.5 Km radius circular area. A single camera was deployed in a 500x500 m grid on the basis of any evidence (spoor, scats and track sign). A total of 24 to 30 locations were selected for deploying cuddeback (Model-Attack, Ambush and C1) camera traps in each 7.07 sq. Km. intensive study area. Each camera traps ran for a minimum of 7 days to maximum of 25 days. CamtrapR software was used for analysing the data

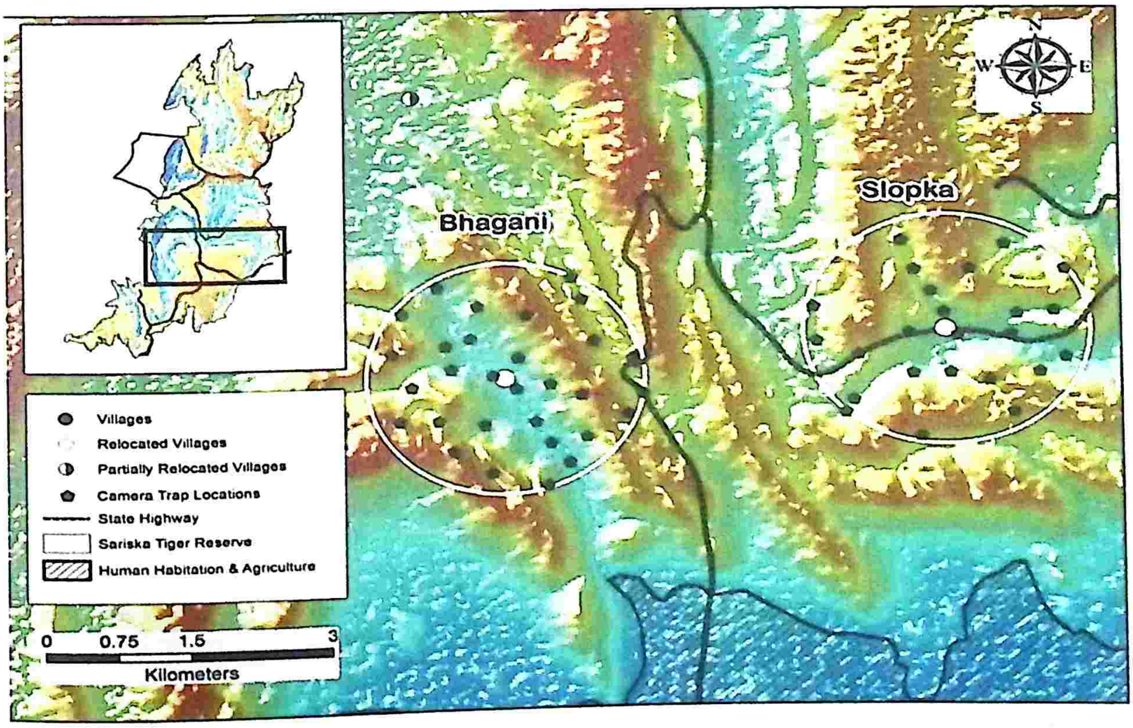

Figure 3: Camera trap locations of the village sites Slopka and Bhagani.

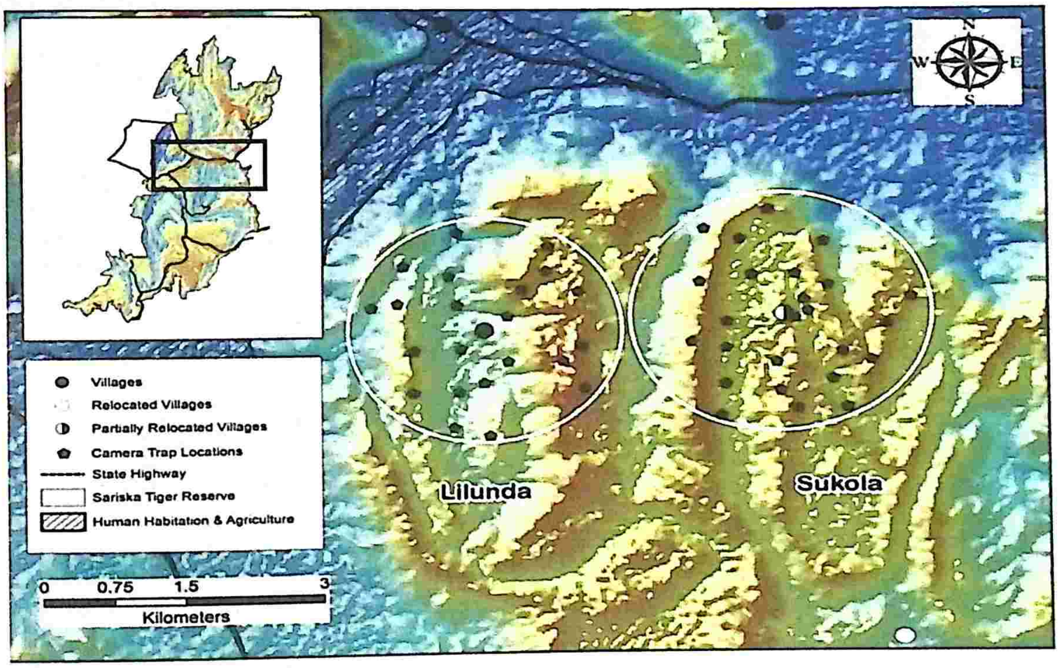

Figure 4: Camera trap locations of the village sites Sukola and Lilunda.

CHAPTER IV

RESULTS

4. Results

4.1. Density estimates of ground birds: In total, five species of galliformes (ground birds) were detected on line transect. These included the Peafowl (*Pavo cristatus*), Jungle bush quail (*Perdicula asiatica*), Grey francolin (*Francolinus pondicerianus*), Painted spur fowl (*Galloperdix lunulata*) and Red spur fowl (*Galloperdix spadicea).*

Density estimates of selected galliformes species at each village site were computed. There were only few sightings of grey francolin (n=23, 20, 12 & 6), painted Spurfowl (n=6, 4, &2), Red Spurfowl (n=3, 1) and jungle bush quail (n=3, 1) so we could not estimate their density separately. Estimated density of galliformes was highest for Bhagani (331/Km^2) followed by Slopka (240/Km^2), Lilunda (181/Km^2) and Sukola (180/Km^2) respectively. (**Table 2** & **Figure** 5)

Table 2: Density of Galliformes in four different village sites of STR.

Name of villages	Species	Model	AIC	Chi square P value	Effective strip width (SE)	Mean Group size	Detection probability	Encounter rate (SE) per km	Group density (SE) per sq.km.	Individual density (SE) per sq.km.
Slopka	**Galliformes**	Half-normal-cosine	119.17	0.90	38.08 (±6.77)	2.75 (±0.26)	0.82	0.006 (±0.0009)	87.13 (±18.7)	**240.42 (±56.5)**
Bhagani	**Galliformes**	Half-normal-cosine	102.08	0.87	24.66 (±3.30)	3.07 (±0.32)	0.58	0.005 (±0.0007)	107.87 (±21.7)	**331.40 (±75.53)**
Sukola	**Galliformes**	Half-normal-cosine	71.20	0.96	27.46 (±4.41)	2.91 (±0.35)	0.54	0.003 (±0.0005)	61.97 (±14.8)	**180.79 (±48.79)**
Lilunda	**Galliformes**	Half-normal-cosine	67.78	0.99	21.78 (±3.46)	2.09 (±0.21)	0.64	0.003 (±0.0004)	86.43 (±18.9)	**181.32 (±43.9)**

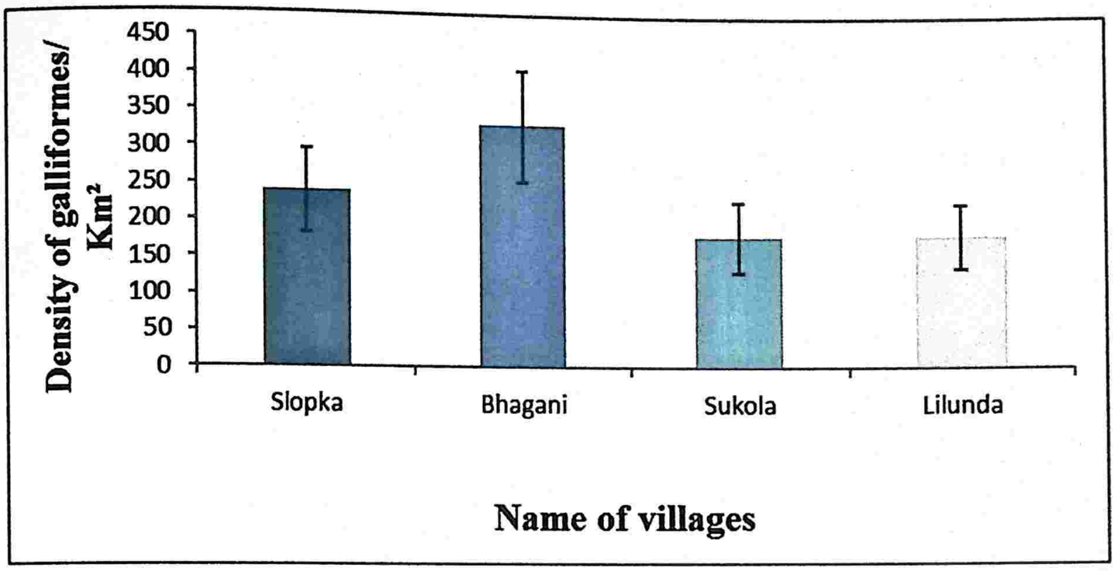

Figure 5: Density of galliformes in the all four village sites of STR.

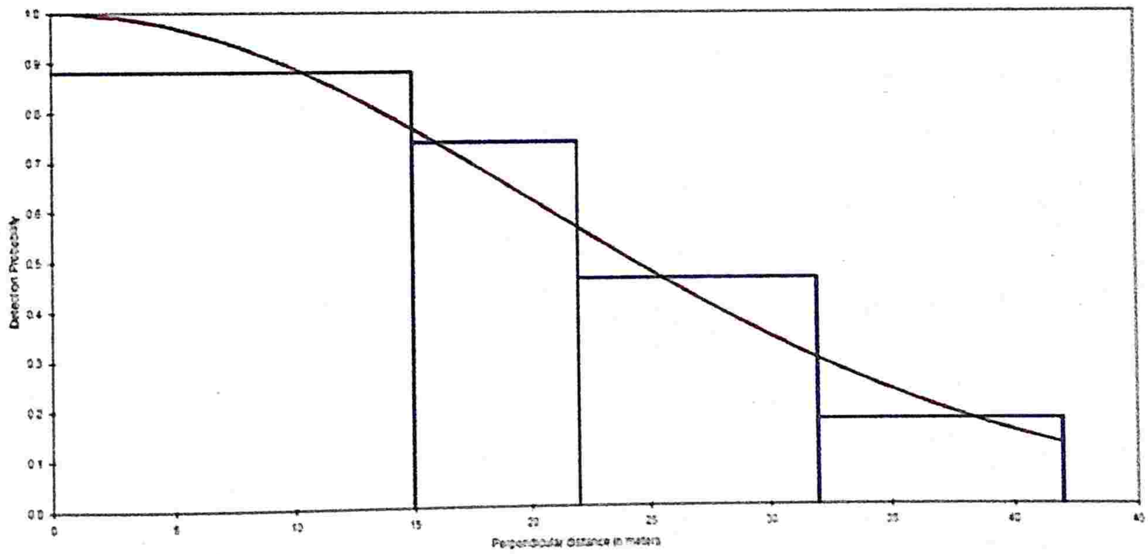

Figure 6: Detection function of best selected model for galliformes in Bhagani

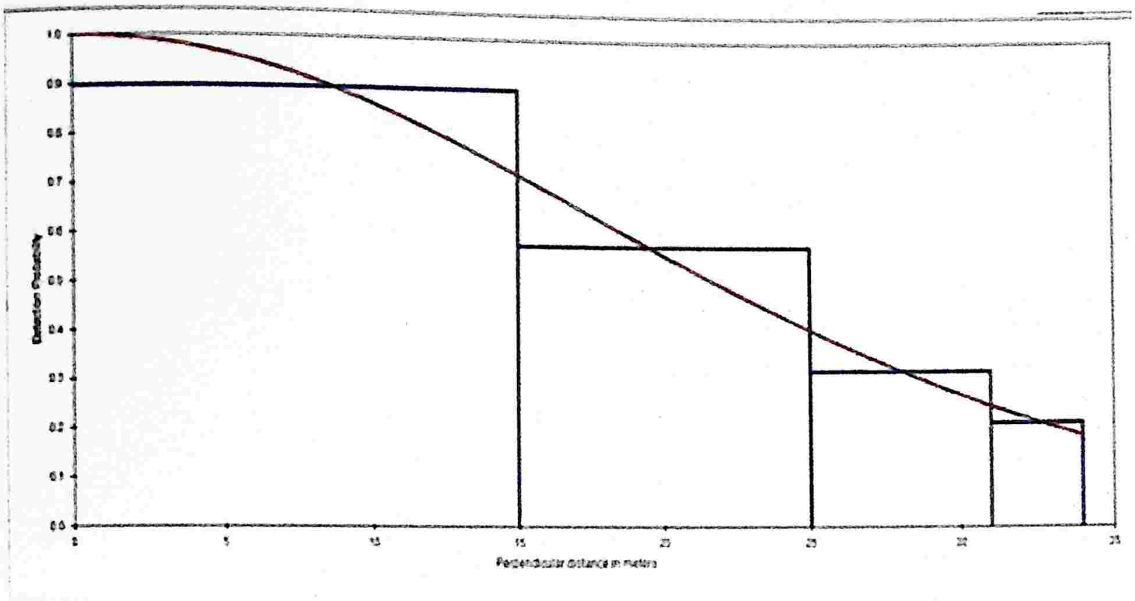

Figure 7: Detection function of best selected model for galliformes in Lilunda.

4.2. Density of Peafowl: Among all galliformes species, peafowl was found most abundant in all study sites. Detection of peafowl was best explained by half normal detection function with cosine adjustment. Estimated density of peafowl was highest in Bhagani (158/ Km^2) followed by Lilunda (124/Km^2), Sukola (115/Km^2) and Slopka (108/Km^2) respectively. (**Table** 3 & **Figure** 8)

Table 3: Density of Peafowl in four different village sites of STR.

Name of village	**Species**	**Model**	**AIC**	**Chi square P value**	**Effective strip width (SE)**	**Mean Group size**	**Detection probability**	**Encounter rate (SE) per km**	**Group density (SE) per sq.km.**	**Individual density (SE) per sq.km.**
Slopka	**Peafowl**	Half-normal-cosine	56.65	0.99	33.08 (±6.77)	2.24 (±0.34)	0.73	0.003 (±0.0004)	48.61 (±12.2)	**108.89 (±32.17)**
Bhagani	**Peafowl**	Half-normal-cosine	42.30	0.98	18.49 (±3.59)	2.16 (±0.36)	0.54	0.002 (±0.0002)	73.16 (±17)	**158.72 (±45.69)**
Sukola	**Peafowl**	Half-normal-cosine	32.31	0.91	17.19 (±2.60)	1.70 (±0.2)	0.66	0.0023 (±	67.4 (±13.8)	**115.05 (±27.4)**
Lilunda	**Peafowl**	Half-normal-cosine	36.09	0.97	17.69c (±4.10)	1.79 (±0.21)	0.65	0.002 (±0.0003)	69.63 (±19.7)	**124.7 (±38.28)**

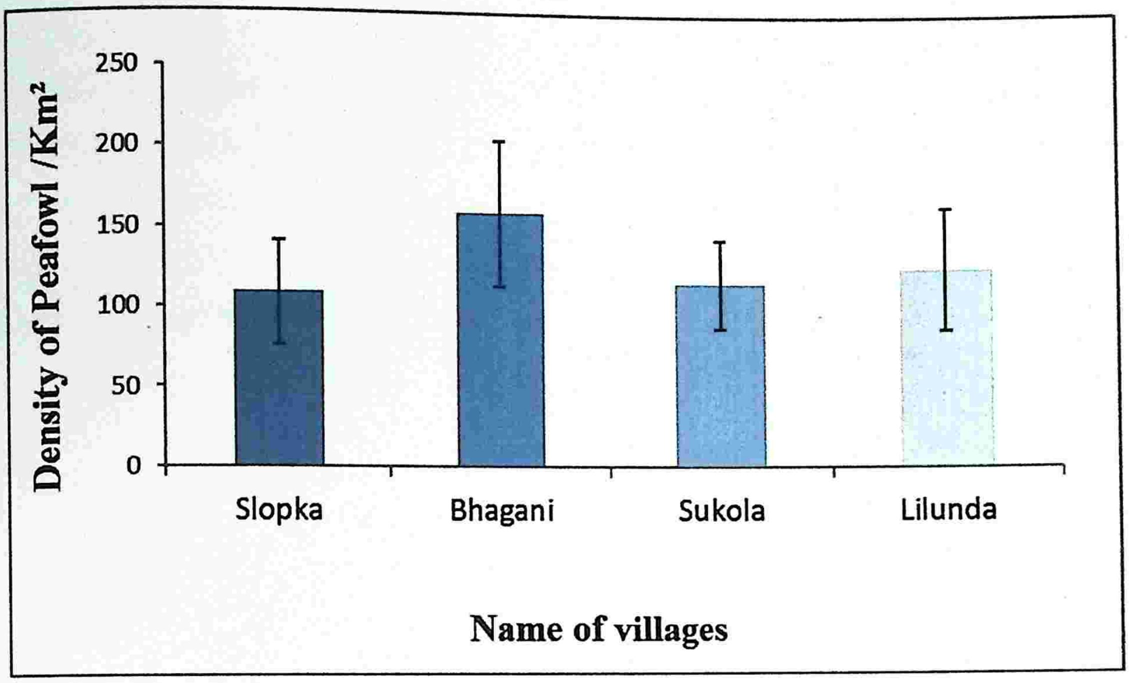

Figure 8*:* Density of Peafowl in the all four village sites of STR

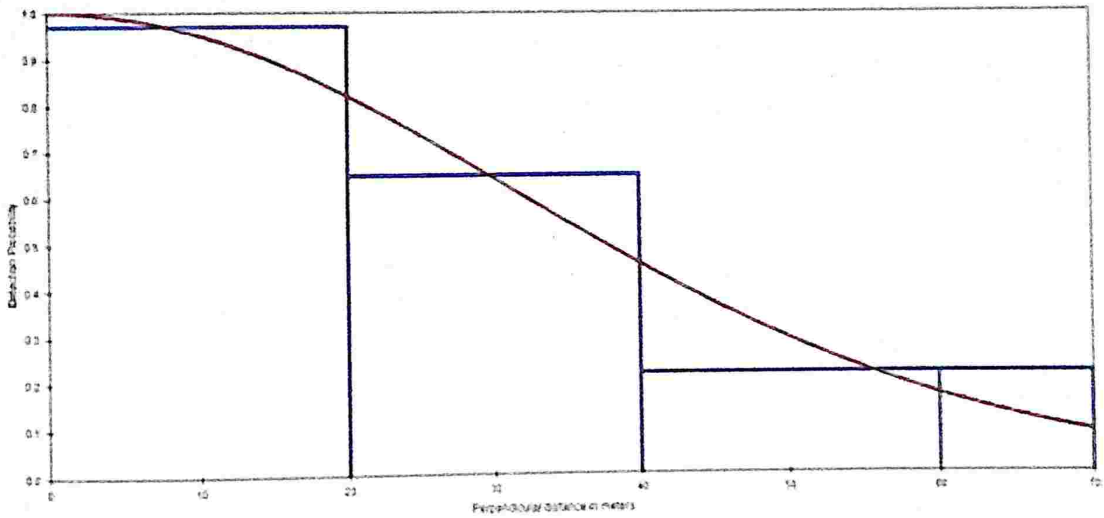

Figure 9: Detection function of best selected model for peafowl in Sukola

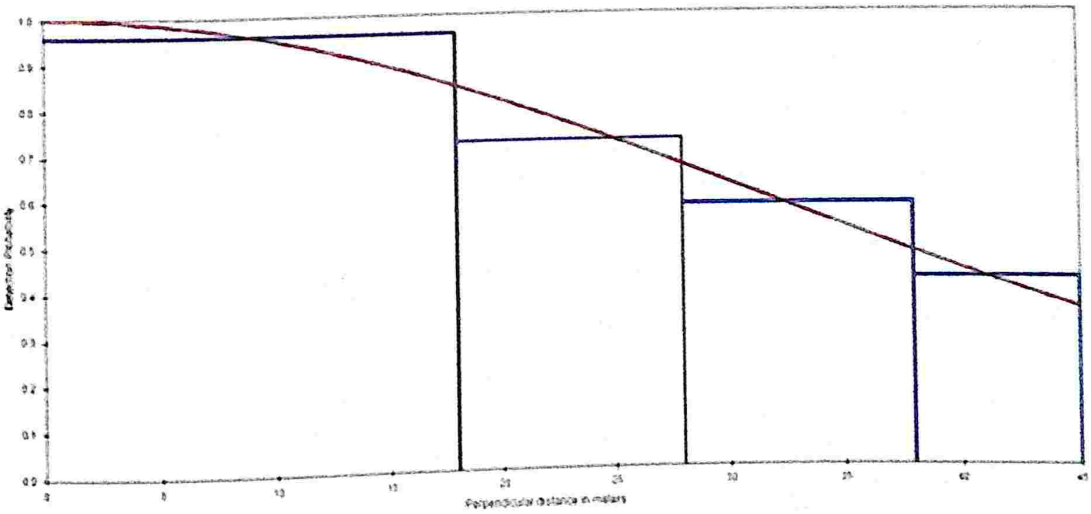

Figure 10: Detection function of best selected model for peafowl in Slopka

4.3. Encounter rate of galliformes: In total, 117 individuals of five species were detected on the line transect during the study period. The encounter rate was highest for peafowl (2.13±0.11 per Km.) followed by grey francolin (1.26 ±0.11 per km), painted Spurfowl (0.33 ±0.112 per km), red Spurfowl (0.03 ±0.11 per km) and jungle bush quail (0.11 ±0.11) (**Figure** 11). The encounter rate of all galliformes species were calculated in different habitat types, as most of the galliformes species are very specific in terms of habitat use.

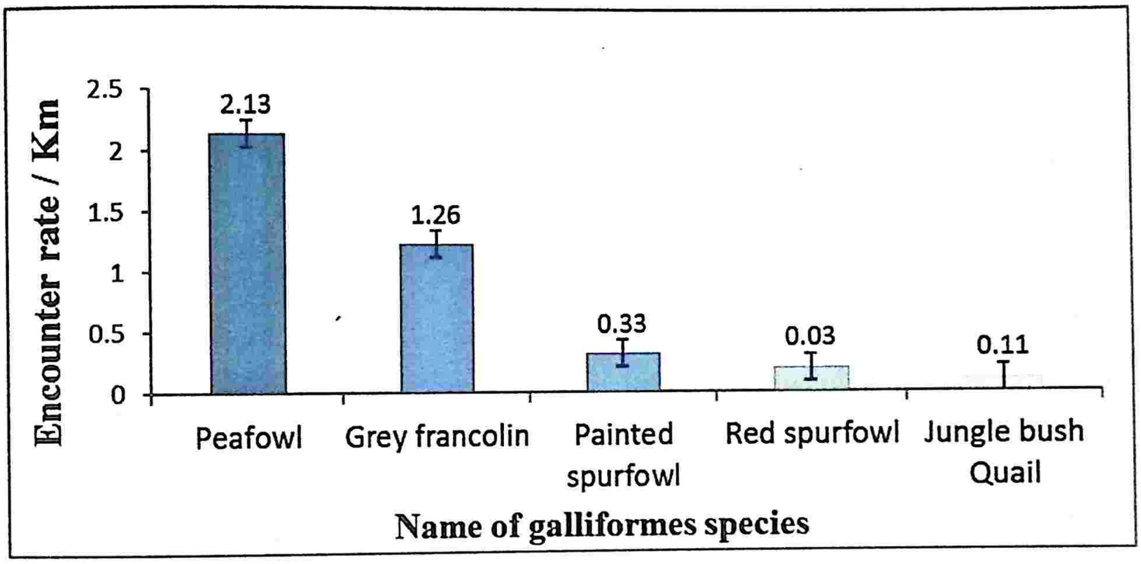

Figure 11: Encounter rate of all galliformes species in STR

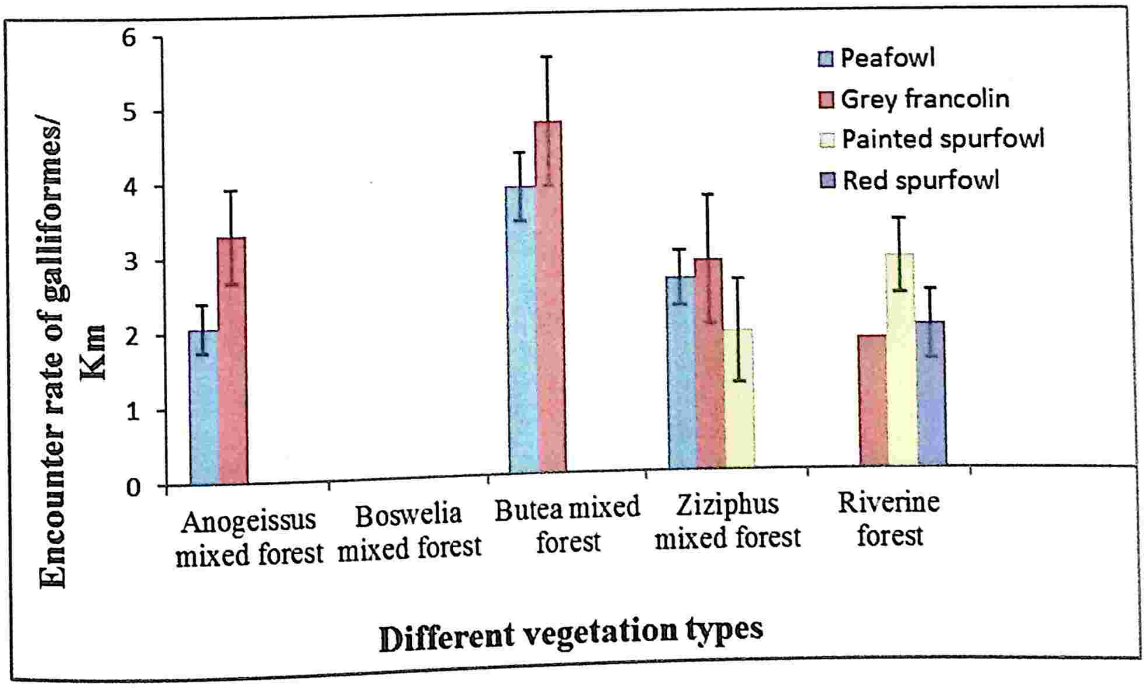

Figure 12: Encounter rate of galliformes /Km in different habitat types of village site Slopka.

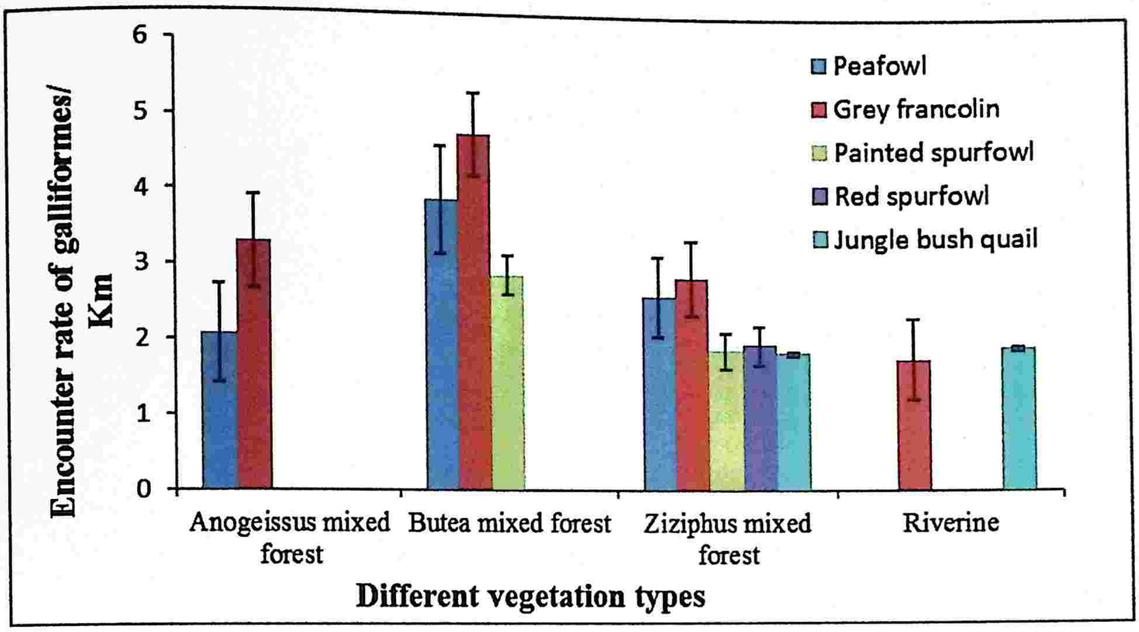

Figure 13: Encounter rate of galliformes / Km in different habitat types of village site Bhagani.

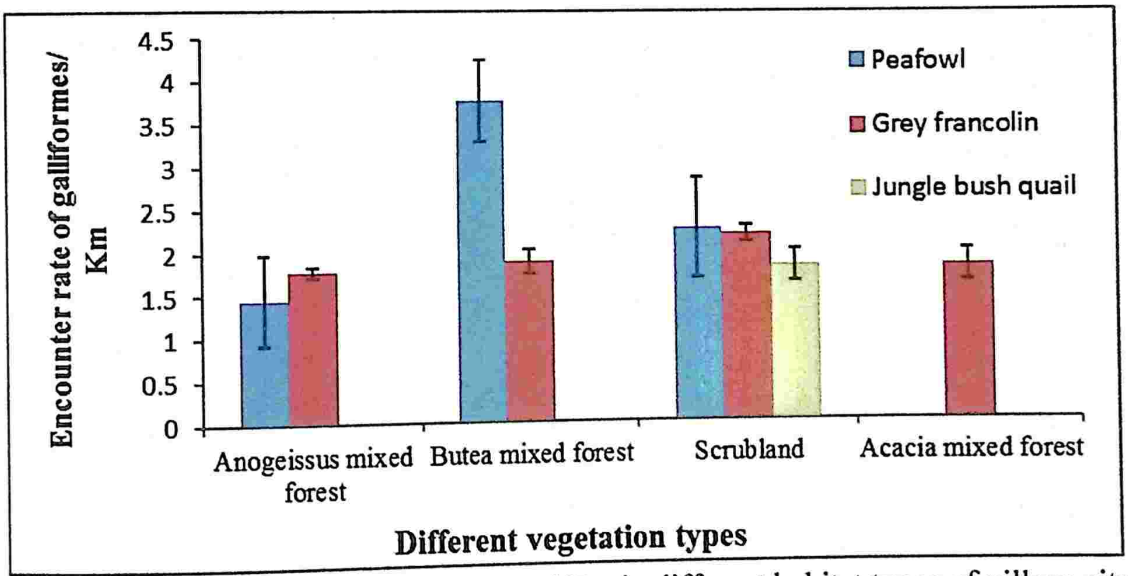

Figure 14: Encounter rate of galliformes / Km in different habitat types of village site Sukola.

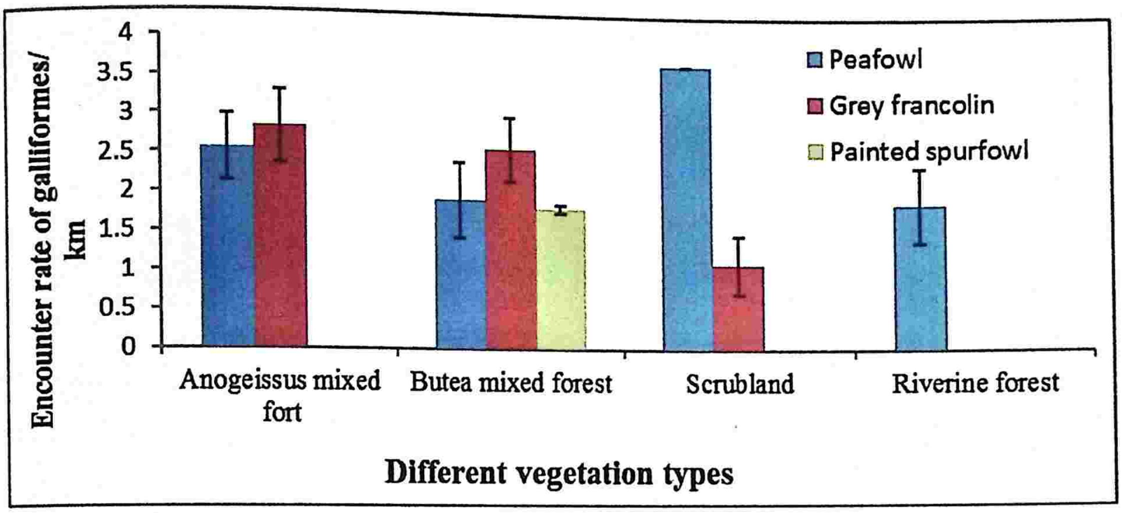

Figure 15: Encounter rate of galliformes / Km in different habitat types of village site Lilunda.

Encounter rates of galliformes species showed marked difference in the different habitat types of different village sites of Sariska tiger reserve. The encounter rate of peafowl was highest in Butea mixed forest ((3.86/km, 3.86/km,3.70/km and 1.92/km) followed by Ziziphus mixed forest (2.61/km, 2.29/km) and Scrubland (2.22/km, 3.68/km). Grey francolin was also observed in Butea mixed forest (4.62/Km, 4.72/Km) as well as Ziziphus mixed forest (2.57/Km, 2.87/Km). Encounter rate of Painted spurfowl and red spurfowl shows mark preference in riverine (1.78 and1.82/Km) areas as well as Ziziphus mixed forest (2.57/km, 1.83/km and 1.82/km) (**Figure** 12,13, 14 & 15)

4.4. Density estimates of rodents: In total 34 individuals of six species were captured in four study sites of Sariska. Among all species, Indian bush rat (*Gollunda ellioti*) was abundant (n=14) across all study sites followed by Little Indian field mouse *(Mus booduga*) (n=10) and Indian gerbil (*Tatera indica*) (n=3). The other species were Soft furred rat (*Millardia meltada*) (n=1), House mouse (*Mus musculus*) (n=3), and Brown rat (*Rattus norvegicus*) (n=3). Sampling of rodent was carried out in all four-village sites. Program Mark was used to estimate rodent density for each site. Huggins' p and c model was selected in program Mark for density estimation and minimum AIC value was taken for model selection. Highest density of rodents was estimated from Slopka (13.08 ± 0.31/ha) followed by Bhagani (9.72 ±1.38/ha), Sukola (9.12 ± 0.42/ha) and Lilunda (3.21± 0.71/ha) (**Table** 4).

Table 4. Density of rodents at four different village sites of STR.

	Model selection	AIC	Density /ha	Standard error
Slopka	Huggins' p and c	226.09	**13.08**	0.31
Bhagani	Huggins' p and c	130.92	**9.72**	1.38
Sukola	Huggins' p and c	155.38	**9.12**	0.42
Lilunda	Huggins' p and c	71.23	**3.21**	0.71

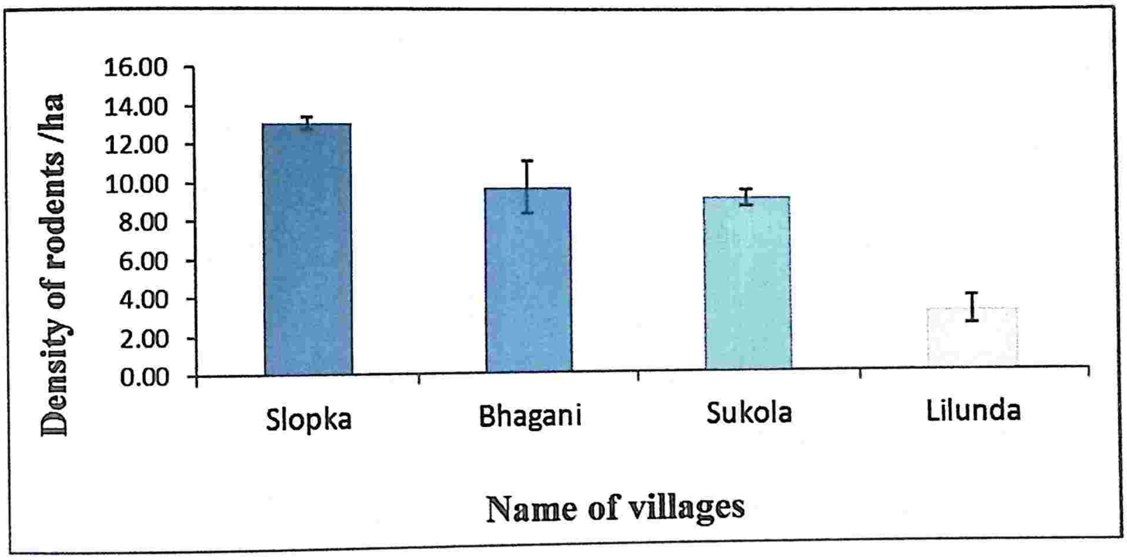

Figure 16: Density of rodents at four different village sites of STR.

Table 5: Average body length ,tail length and weight of all rodent species captured during the study period

Sl no.	Species	*HBL (mm)	Tail length	Weight (gm)
1	Indian bush rat	73.06	78.12	63.15
2	Little Indian field mouse	76.83	79.72	65.28
3	Indian gerbil	77.83	113.00	54.67
4	House mouse	51.25	60.00	49.38
5	Soft furred fat	42.00	50.00	46.00
6	House mouse	150.00	135.33	164.33

*HBL= Head body length

4.5. Vegetation quantification: A total of 45 circular plots of 15m radius circular area were laid in each village. Plots were designed to include tree, shrubs, herbs and grasses. The plots were laid to represent all the vegetation communities. Different Parameters of human disturbance were also recorded in each plot. Sign of cutting, lopping and grazing was recorded from each plot. Densities of trees along with canopy cover, shrub cover and presence of invasive species were compared with disturbed and undisturbed site. Abundance of different tree species was computed for all study sites. *Anogeissus pendula* was found to be most abundant tree species (1266 ± 1.43) followed by *Ziziphus mauritiana* (495 ± 0.94), *Butea monosperma* (408 ± 0.73), *Boswelia serrata* (452 ± 0.55) and *Acacia catechu* (369 ±0.59) (**Figure** 17).

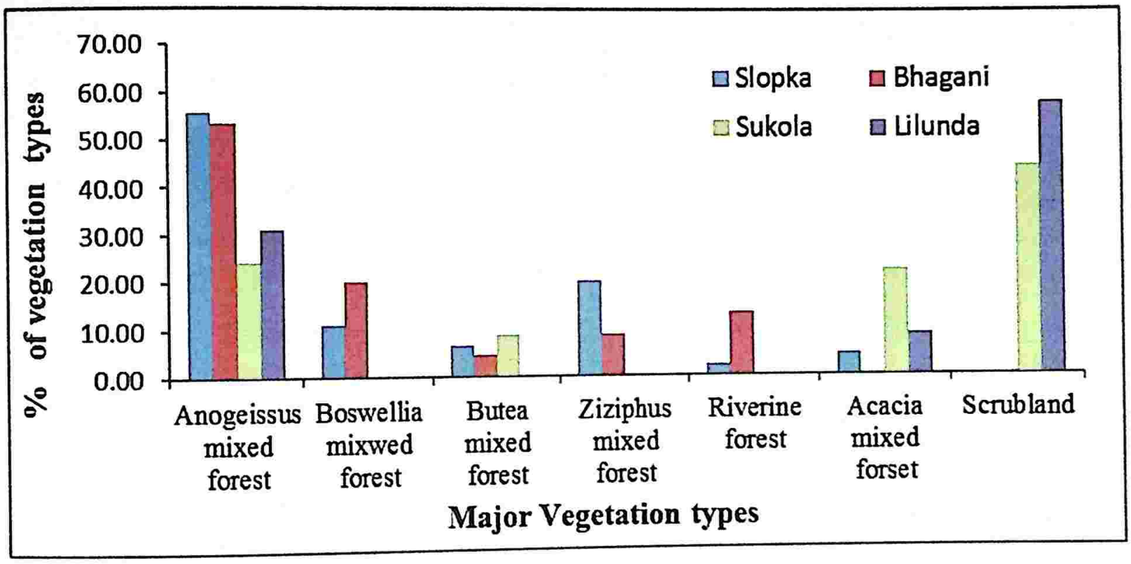

Figure 17 : Vegetation types at four village sites in STR.

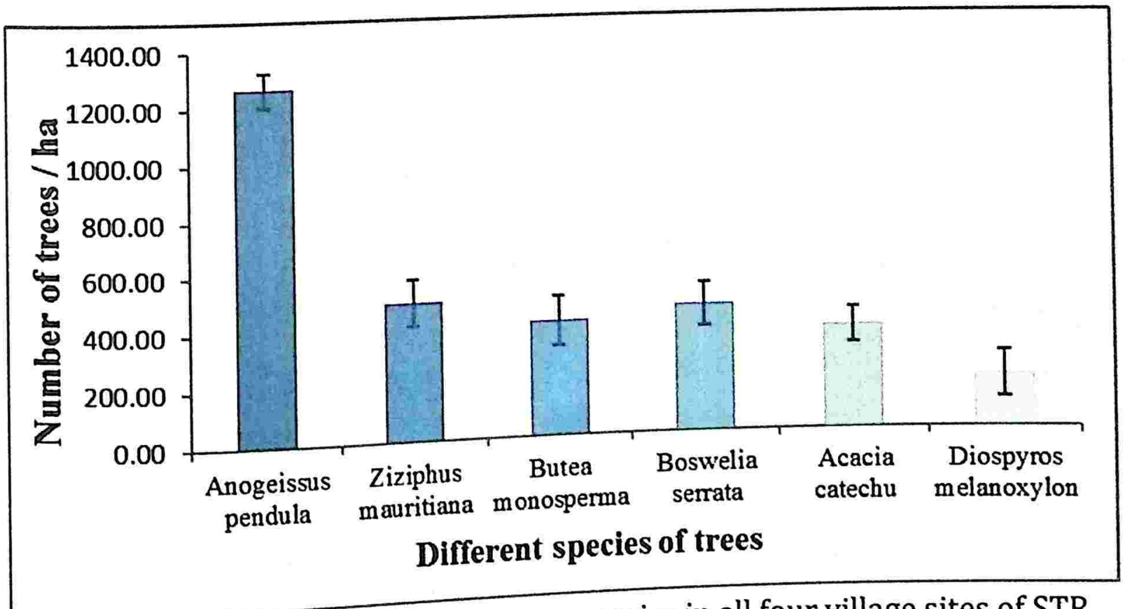

Figure 18: Abundance of different tree species in all four village sites of STR.

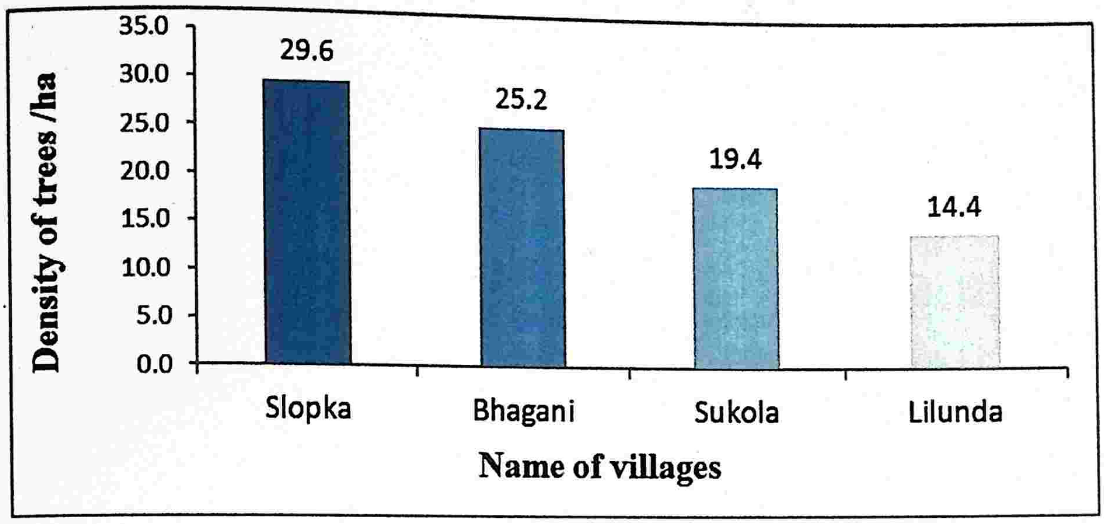

Figure 19: Density of trees in different village sites of STR.

Densities of trees were assessed for each village site. Estimated density of tree was highest in Slopka (29.6±/ha), followed by Bhagani (25.2±/ha), Sukola (19.4±/ha) and Lilunda (14.4±/ha) (**Figure** 19).

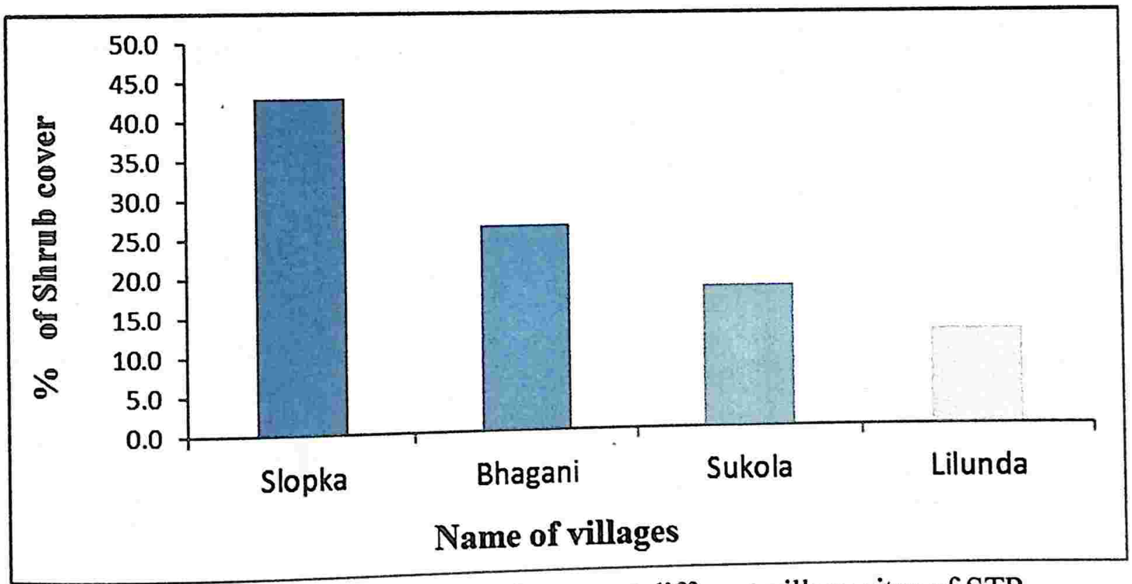

Figure 20: Percentages of shrub cover at different village sites of STR.

Shrub cover was assessed for each village site. Highest shrub cover was recorded from village Slopka (43%), followed by Bhagani (26%), Sukola (18.3%) and Lilunda (12.3%). (**Figure** 20)

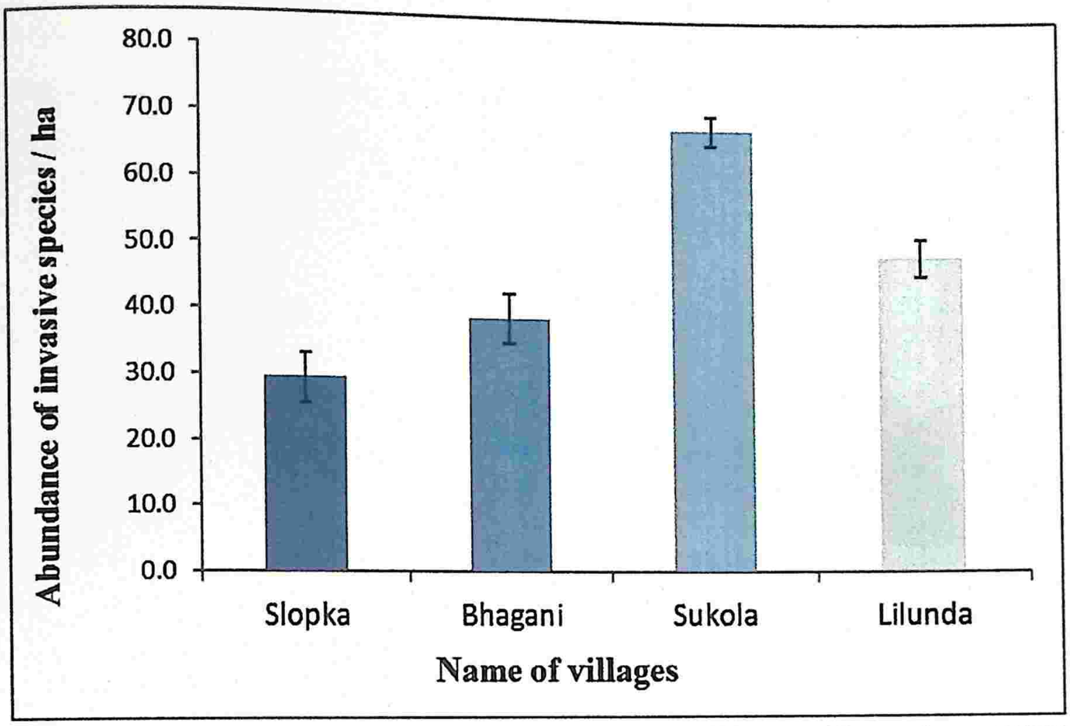

Figure 21: Abundance of invasive species at four different village sites of STR

Abundance of invasive species was quantified for each village site. Highest abundance of invasive species was found in Sukola (68.1±3.75/ha), followed by Lilunda (48.6±3.80/ha) and Bhagani (38.8±2.20/ha). Among all villages, Slopka has the low abundance of invasive species (29.5±2.80/ha). (**Figure** 21)

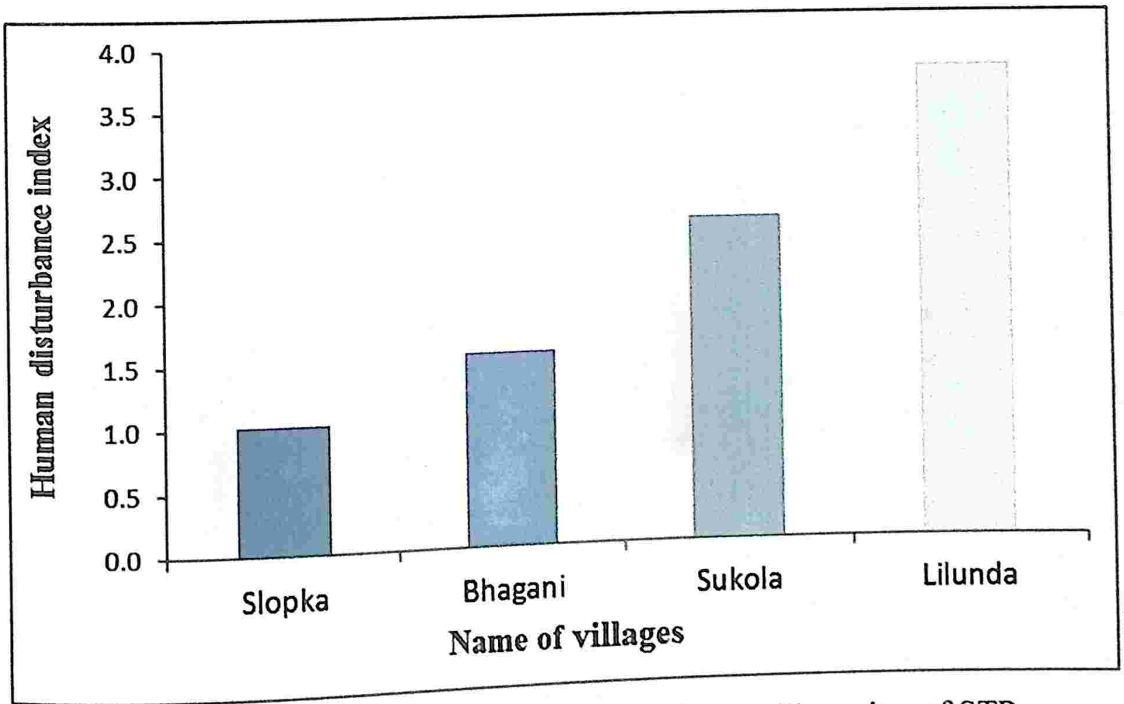

Figure 22: Human disturbance in four different village sites of STR.

Human disturbance for each village site was quantified by scaling 0 to 4 in each plot. Average value was calculated for each village site. Lilunda highest score (3.8) followed by Sukola (2.6), Bhagani (1.6) and Slopka (1.0) (**Figure** 22).

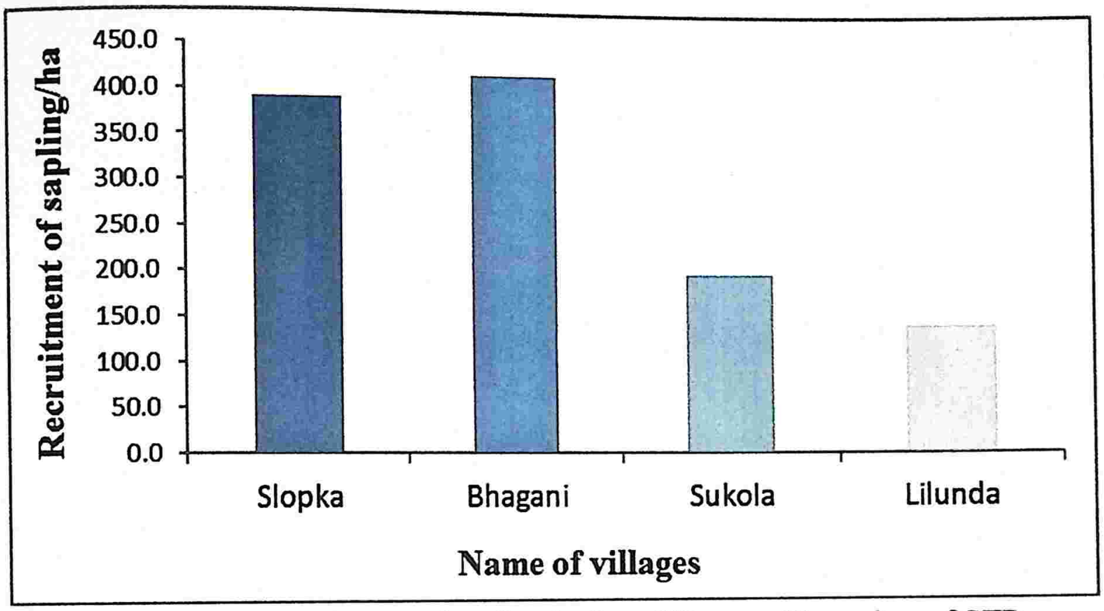

Figure 23: Recruitment of sapling in four different village sites of STR.

Number of sapling was counted in each plot for all village sites. Highest recruitment rate was estimated in Bhagani (416.2±9.8/ha), followed by Slopka (390.7±13.2/ha), Sukola (198.2±18.1/ha) and Lilunda (141.6±15.3/ha). (**Figure** 23)

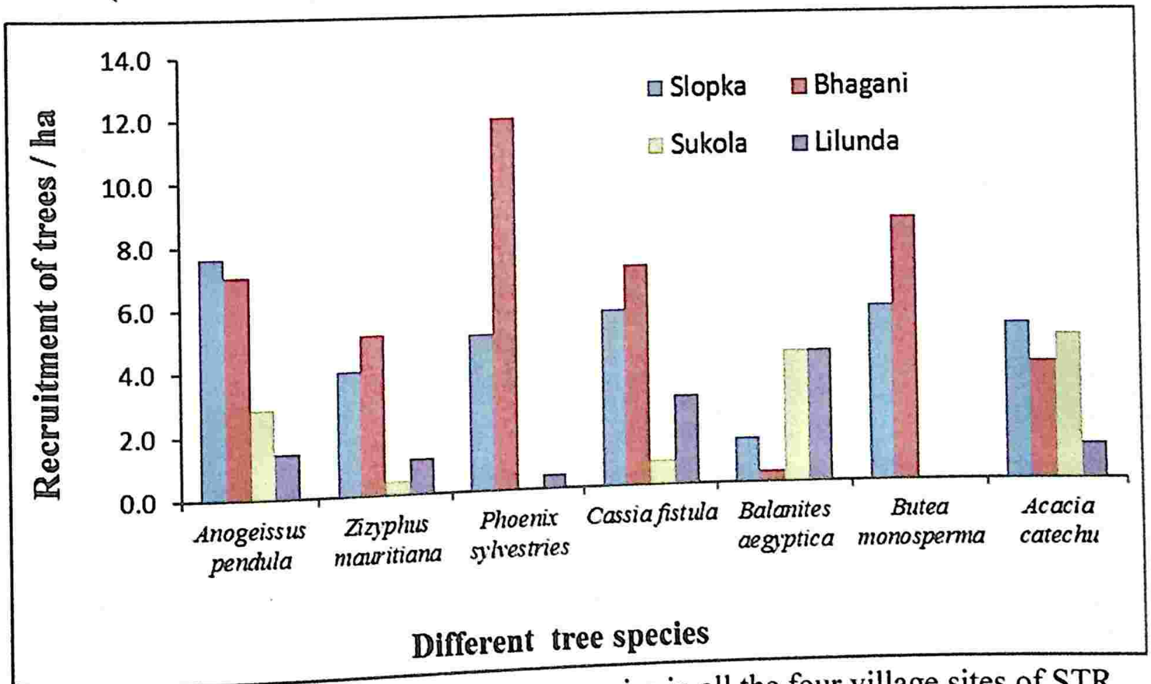

Figure 24: Recruitment of different tree species in all the four village sites of STR.

Recruitment rate of each tree species was observed in each plot. Highest recruitment rate was observed in *Anogeissus pendula* tree in village Slopka (7.6/ ha) followed by

Cassia fistula (5.7/ha), *Phoenix sylvestries* (5.0/ha) and *Butea monosperma* (5.7/ha). Bhagani has highest recruitment rate for *P. sylvestries* tree (11.9/ha), followed by *A. pendula* (7.0/ha), *B. monosperma* (8.5/ha) and *Z. mauritiana* (5.1/ha). Village Sukola has highest recruitment rate of *Balanites aegyptica* tree (4.3/ha), followed by *Acacia catechu* (3.8/ha), *A. pendula* (2.8/ha). (**Figure** 24) *B. aegyptica* (4.3/ha) has the highest recruitment rate followed by *Cassia fistula* (2.8/ha) and *A. pendula* (1.4/ha).

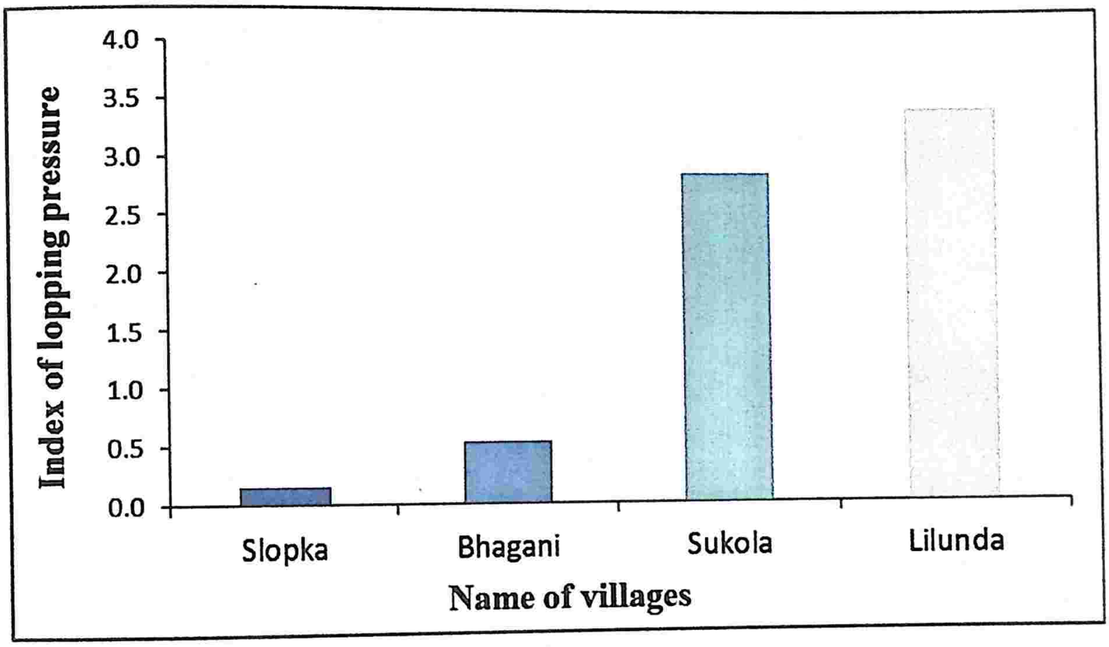

Figure 25: Index of lopping pressure at four different village sites of STR.

The proportion of the total number of trees showing signs of lopping was recorded. The lopping score for each tree was additionally measured on a scale of 0–4 as follows: 0, no lopping; 1, rudimentary signs of lopping; 2, up to half of the main branches lopped; 3, more than half of the main branches lopped; 4, the tree reduced to a stump. Average value of lopping sign was calculated for each village sites and an index was created. Highest signs of lopping were found in the village Lilunda (3.4), followed by Sukola (2.9) and Bhagani (0.5), Slopka has the lowest signs of lopping (0.2). (**Figure** 25)

4.6. Results of camera trapping:

In total, 102 camera traps were deployed in all four sites for 1530 camera trap nights during the whole study period. In each village site, approximately 25 camera trap locations were selected for deploying the camera trap. Photographic capture rate of each species was calculated and used for the evaluation of habitat use by wild animals. Activity pattern of wild animals and their overlap with human activity, show marked difference in each village sites respective to the amount of disturbance. A total nineteen species and human was photograph during the entire study period. Highest capture rate was found for livestock (294.5/100 trap nights), followed by human (252.4/100 trap nights), chital (157.6/100 trap nights) Peafowl (144.9/ 100 trap nights) and Sambar (107.05/trap nights). (**Figure** 26)

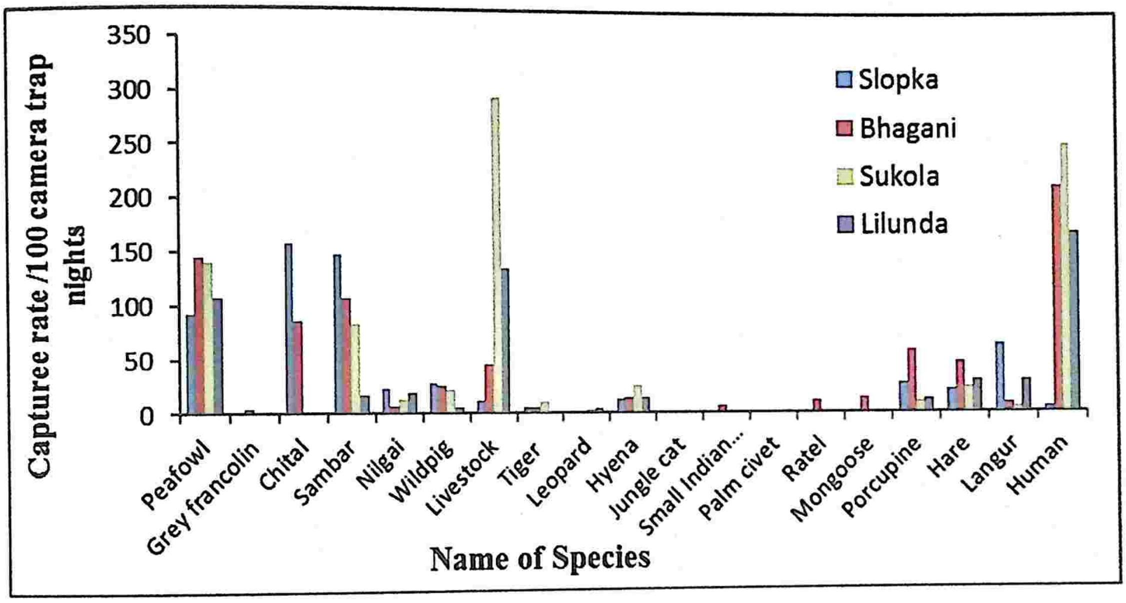

Figure 26: Photographic capture rate of all species in the four village sites of STR.

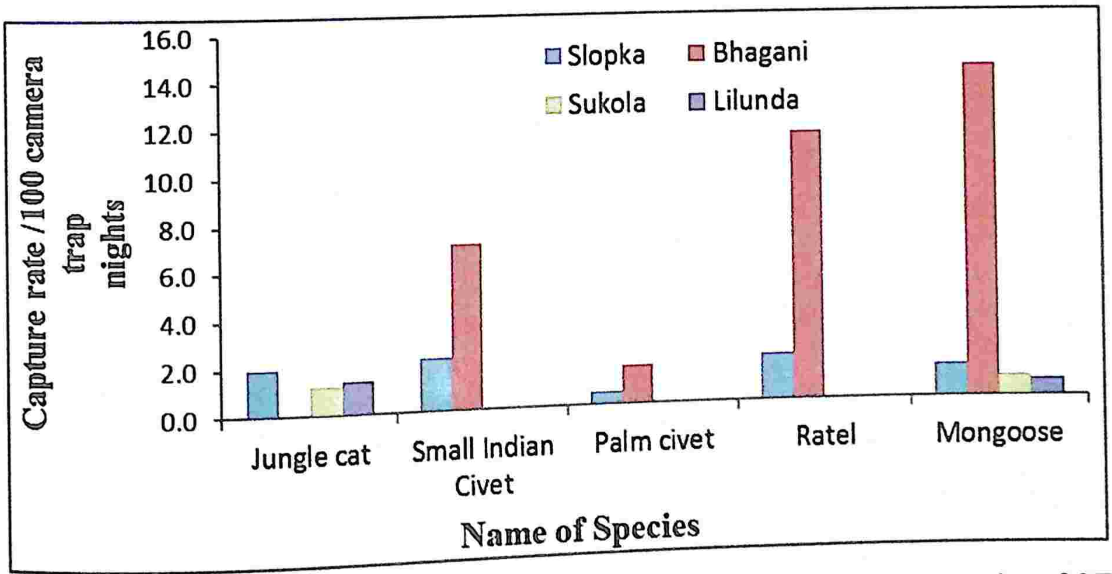

Figure 27: Photographic capture rate of small carnivores in four village site of STR.

Highest capture rate for small carnivore was recorded from Bhagani followed by Slopka, Sukola and Lilunda. Slopka had the highest capture rate of Small Indian civet (2.3/100 trap nights) followed by Ratel (2.0/100 trap nights), Jungle cat (2.0/100 trap nights), Mongoose (1.4/100 trap nights) and Palm civet (0.6/100 trap nights). In Bhagani highest capture rate was recorded for Mongoose (14.4/100 trap nights), followed by Ratel (11.5/100 trap nights), Small Indian civet (7.1/100 trap nights) and Palm civet (1.6/ 100 trap nights). Sukola had the capture rate of jungle cat (1.2/100 trap nights) and Mongoose (0.9/100 trap nights). (**Figure** 27) Highest capture rate was found for Jungle cat (1.4/100 trap nights) followed by Mongoose (0.7/100 trap nights).

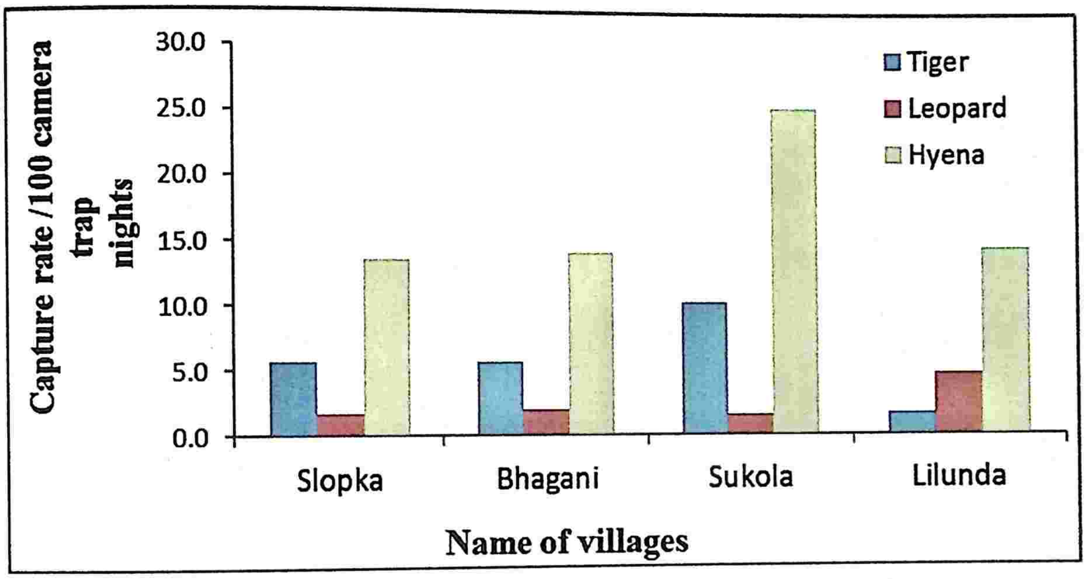

Figure 28: Photographic capture rate of large carnivore in all four village sites of STR

Highest capture rate of Tiger (25.30/100 trap nights) was recorded from the Sukola followed by Lilunda (14.46/100 trap nights), Bhagani (14.10/100 trap nights) and Lilunda (13.53/100 trap nights). Lilunda has the highest capture rate of leopard (4.07/100 trap nights), followed by the Bhagani (2.05/100 trap nights), Slopka (1.64/ 100 trap nights) and Sukola (1.55/100 trap nights). Highest capture rate of Hyena was found in the village Sukola (10.24/100 trap nights), followed by Bhagani (5.64/100 trap nights), Slopka (5.61/100 trap nights) and Lilunda (1.71/100 trap nights). (**Figure** 28)

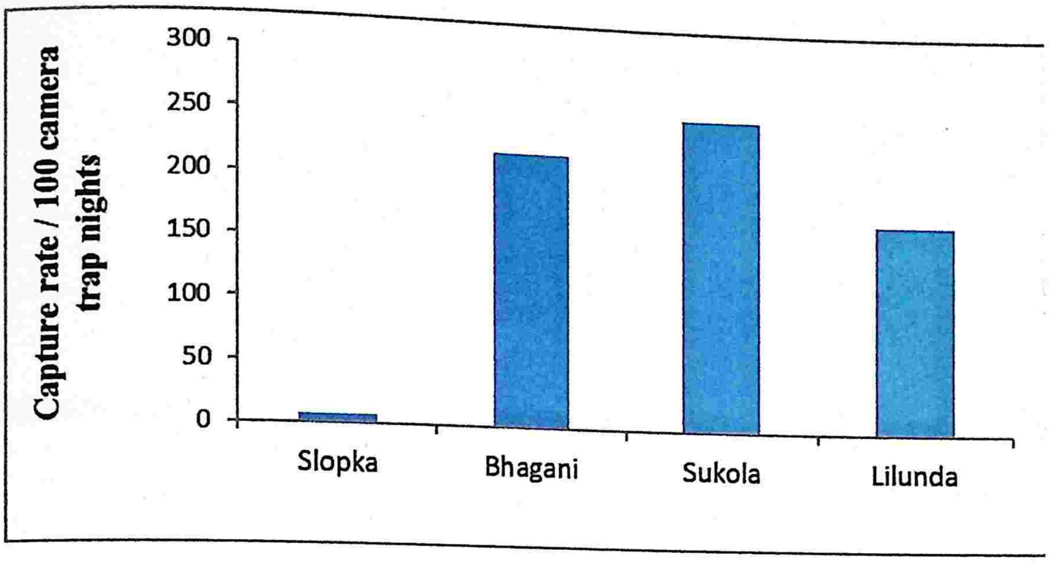

Figure 29: Photographic capture rate of human in all four village sites of STR.

Highest capture rate was found in the village Sukola (252.4/100 trap nights), Bhagani (220/100 trap nights), Lilunda (170/100 trap nights) and Slopka (6.26/100 trap nights) (Figure 30). Human capture rate was higher in Bhagani because it has a motor able public road at the periphery of its boundary. (**Figure** 29 & 31)

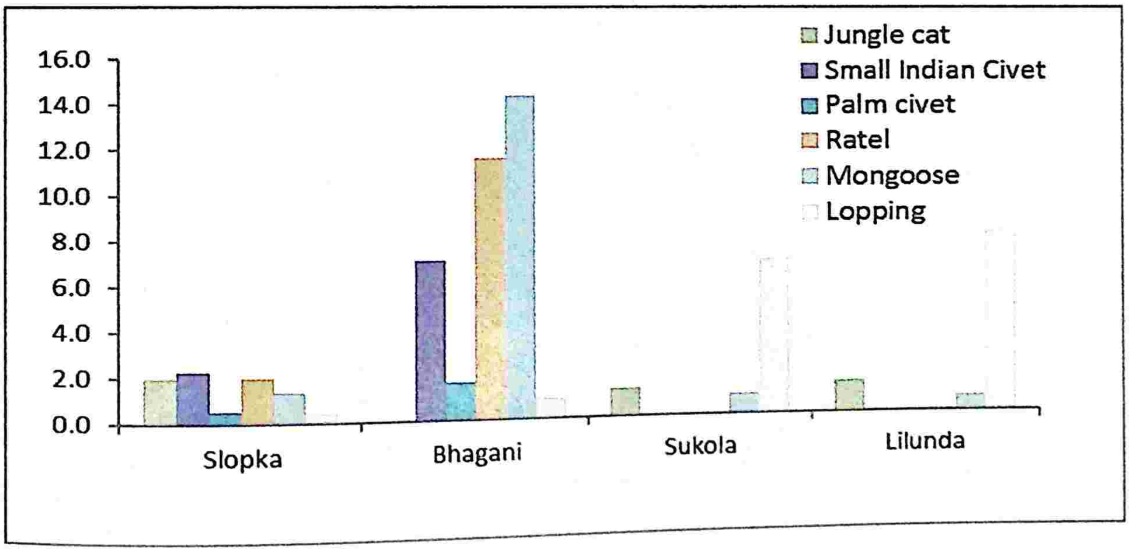

Figure 30: Capture rate of small carnivores with respond to lopping pressure.

This result showed that presence of small carnivores negatively affected by the amount of lopping pressure. More number of small carnivore species were captured where amount of lopping pressure was low, while opposite results were found in highly lopped areas. Different species of small carnivores showed that their respond to lopping pressure differ among species. Small Indian civet, palm civet and ratel were highly affected by lopping pressure and totally absent from the highly lopped village sites but mongoose and jungle cats were present all across the study sites. (**Figure** 30)

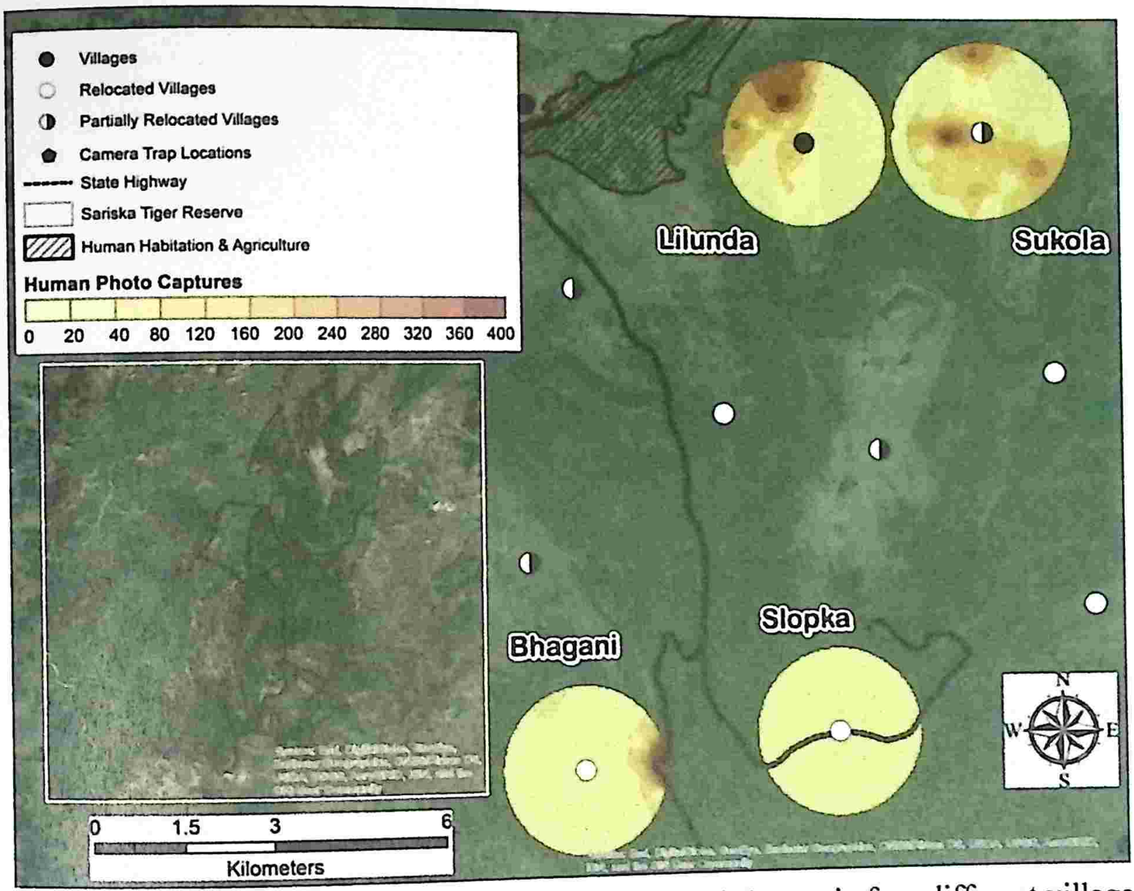

Figure 31: Map showing photographic capture rate of Human in four different village sites of STR.

Activity patterns of Galliformes and Small carnivores at relocated village site of Slopka.

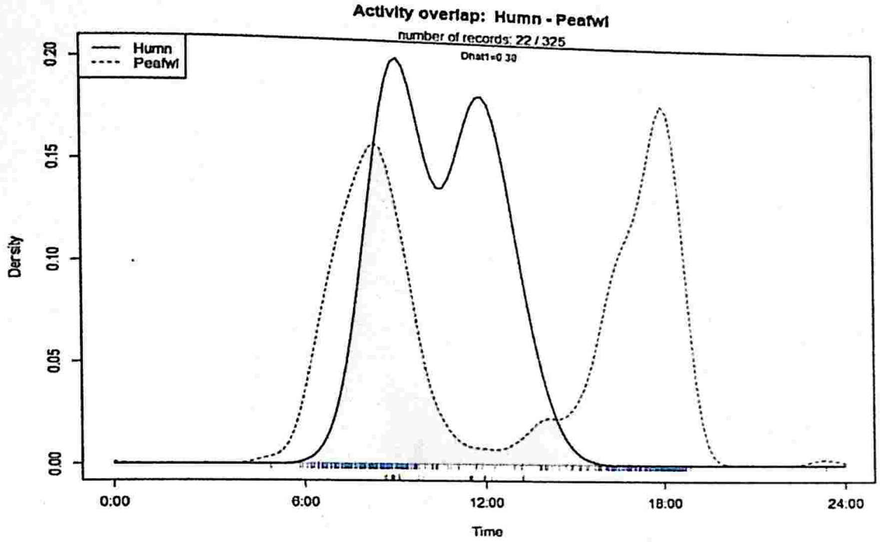

Figure 32: Activity overlaps of peafowl with human at Slopka

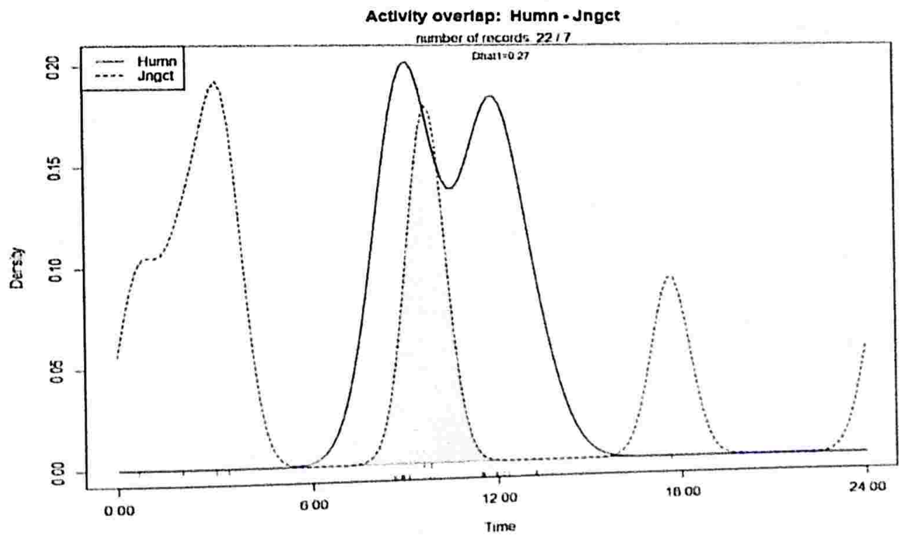

Figure 33: Activity overlaps of jungle cat with human at Slopka

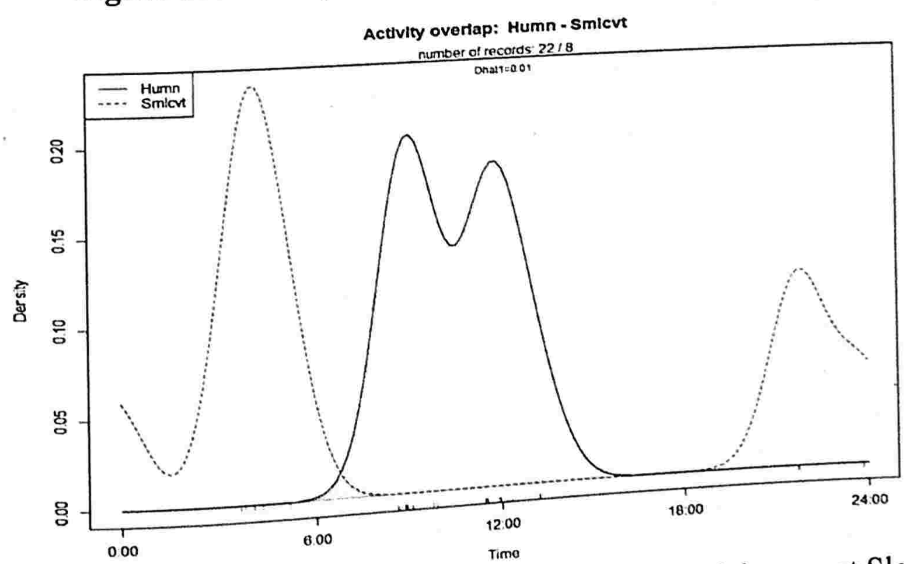

Figure 34: Activity overlap of small Indian civet with human at Slopka

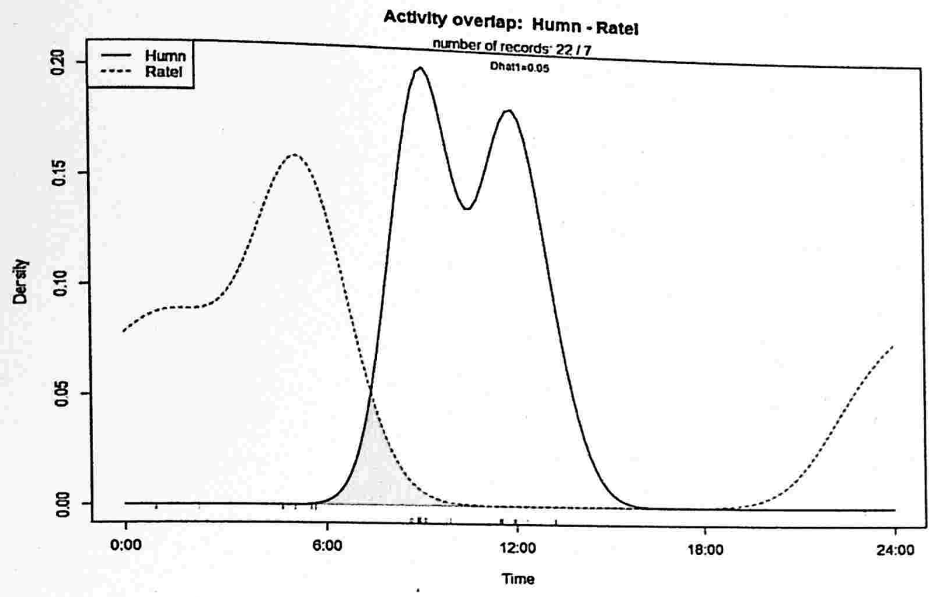

Figure 35: Activity overlaps of ratel with human at Slopka

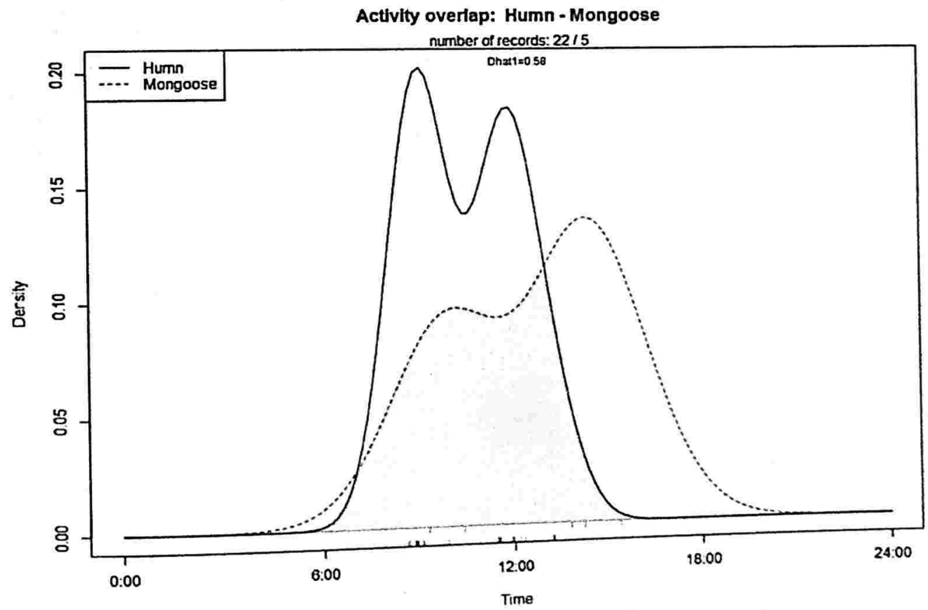

Figure 36: Activity overlaps of mongoose with human at Slopka

Activity pattern of Galliformes and Small carnivores with humans in relocated village site of Bhagani

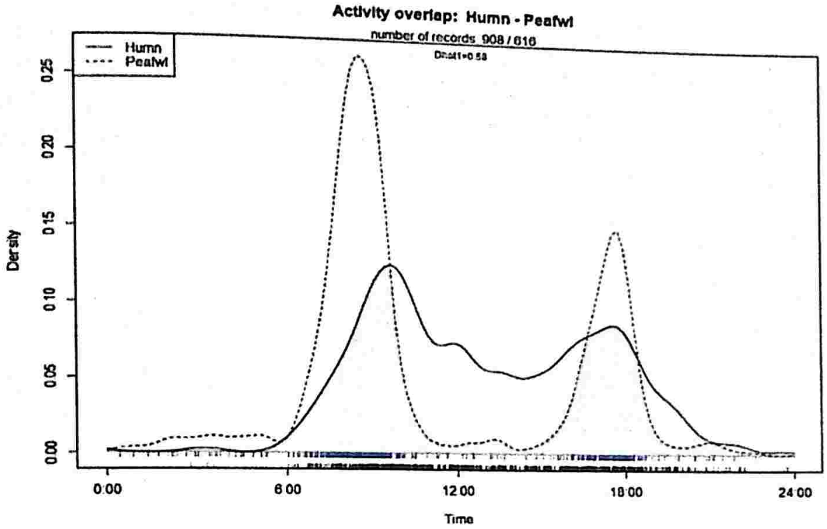

Figure 37: Activity overlaps of peafowl with humans at Bhagani

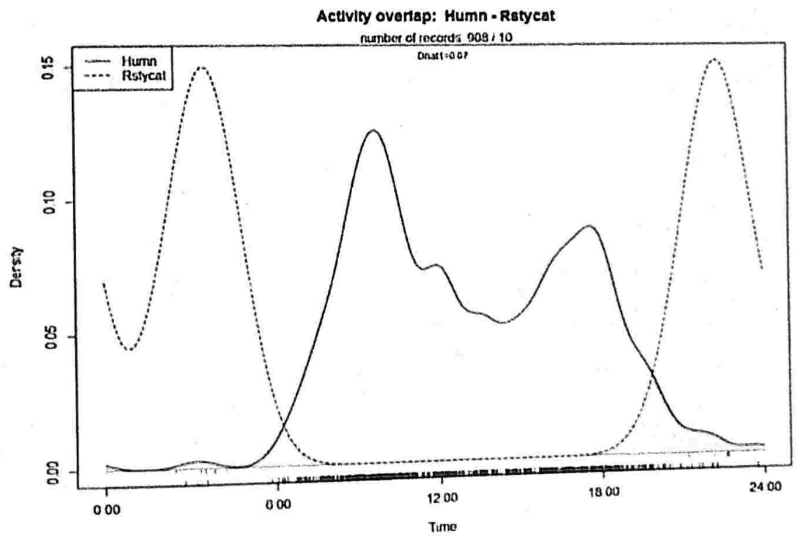

Figure 38: Activity overlaps of rusty spotted cat with human at Bhagani

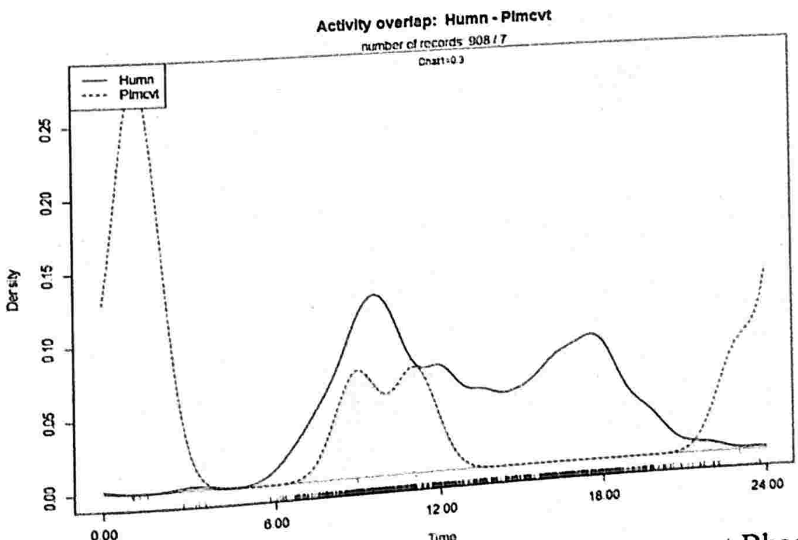

Figure 39: Activity overlap of palm civet with human at Bhagani

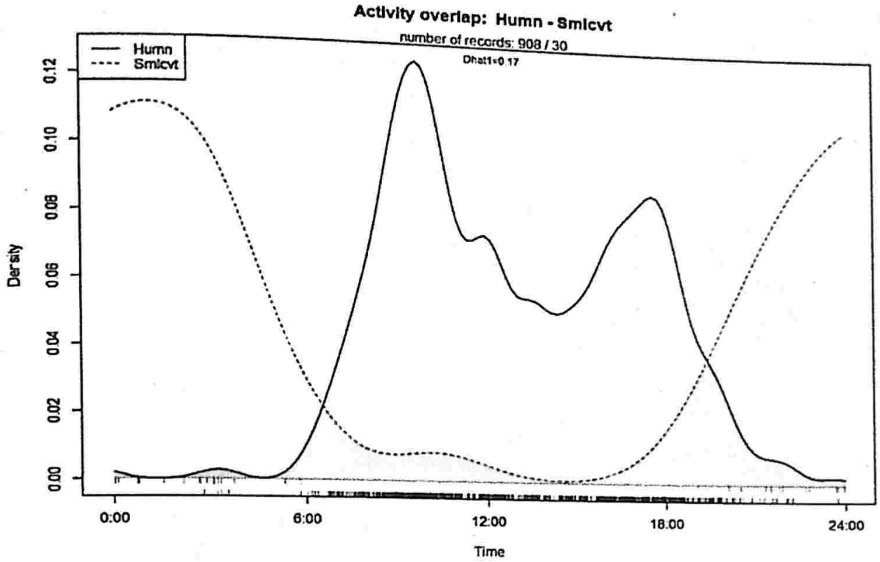

Figure 40: Activity overlaps of small Indian civet with human at Bhagani

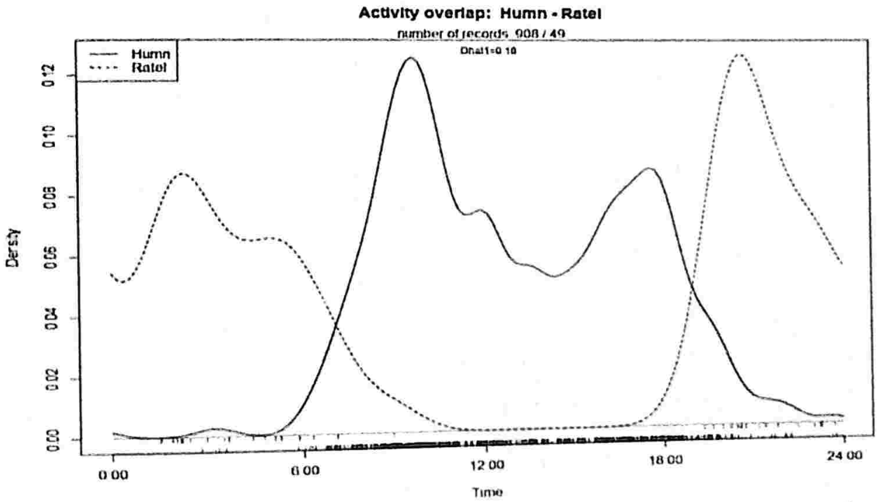

Figure 41: Activity Overlaps of ratel with human at Bhagani

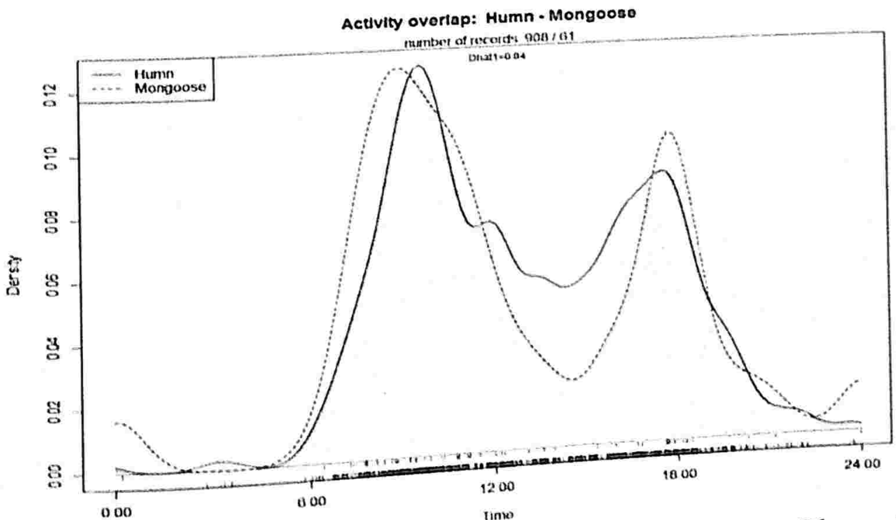

Figure 42: Activity overlaps of mongoose with human at Bhagani

Activity Pattern of Galliformes and Small carnivores in existing village site of Sukola

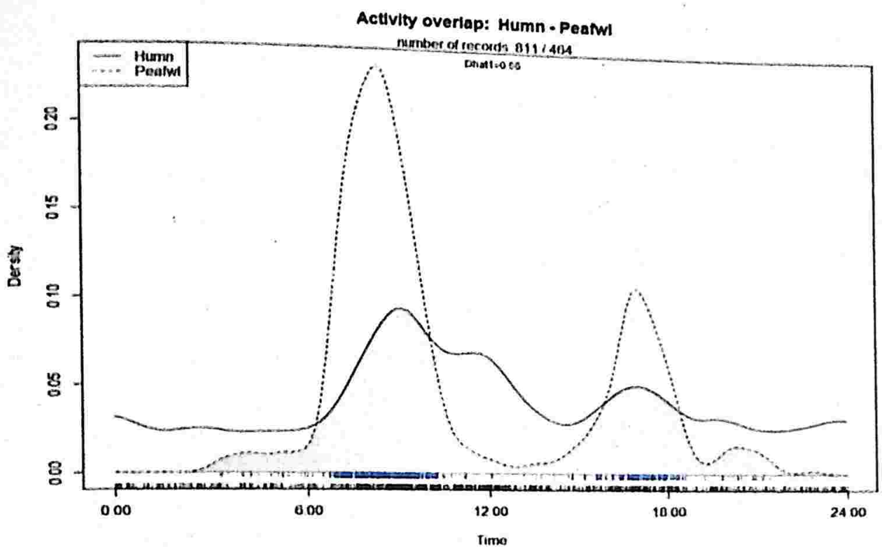

Figure 43: Activity overlaps of peafowl with human at Sukola

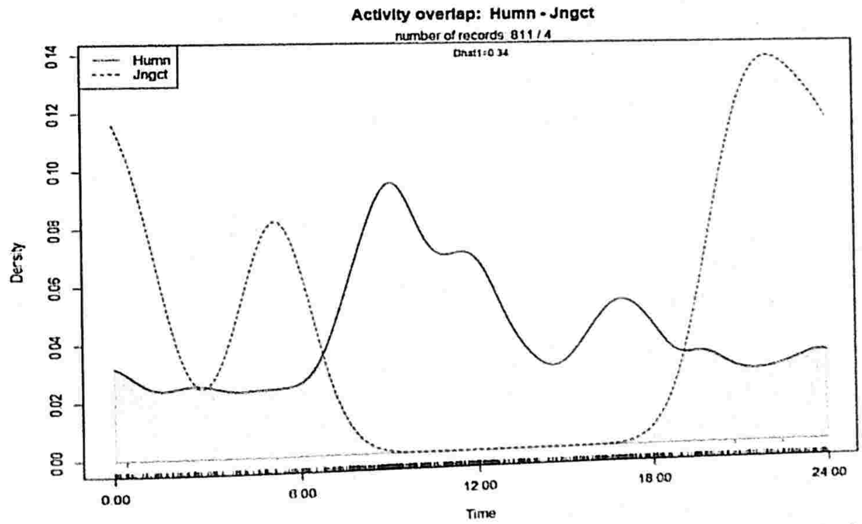

Figure 44: Activity overlaps of Jungle cat with Human at Sukola

Activity Patterns of Galliformes and Small carnivores in existing village site of Lilunda

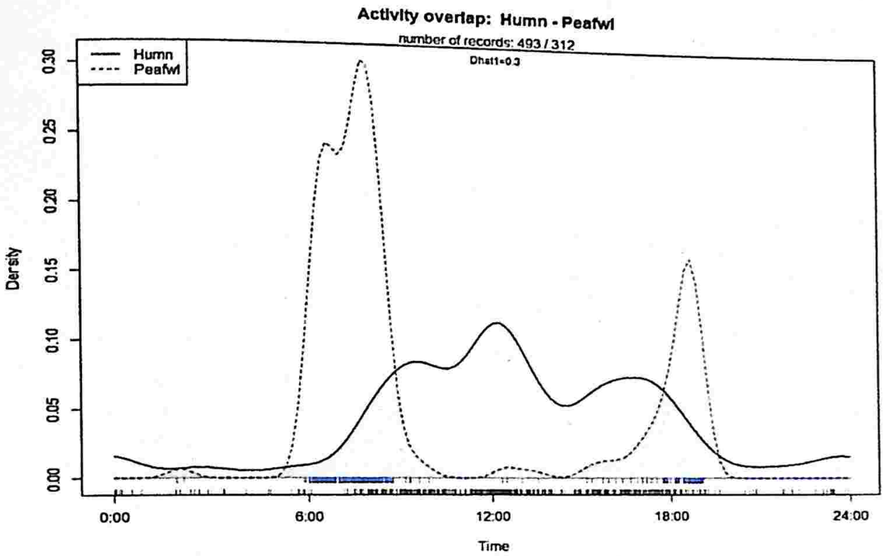

Figure 45: Activity overlaps of Peafowl with Human at Lilunda

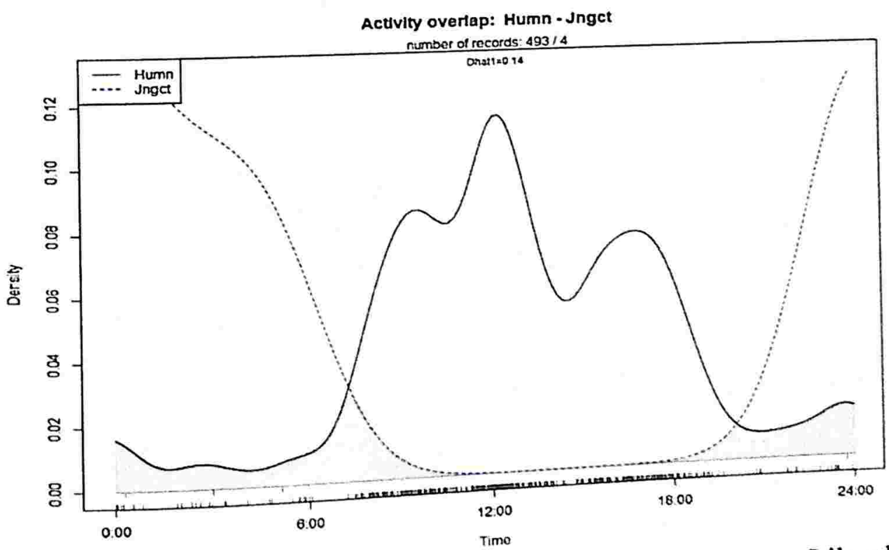

Figure 46: Activity overlaps of Jungle cat with Human at Lilunda

CHAPTER V

DISCUSSION

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5. Discussion

5.1. Effect of relocation on galliformes: As for most wildlife, the single most serious threat to the survival of galliformes is habitat loss, degradation and fragmentation. In fact, they are important indicator species and their presence or absence in an area is a good indication of the health of the ecosystem. In this present study, assessment of their population was carried out in the Sariska tiger reserve of Rajasthan. Previous studies showed that Sariska had the highest density of peafowl as well as grey francolin (Kidwai *et al.* 2011). However, 29 villages in Sariska pose a great threat to existing natural flora and fauna due to human presence, biological extraction and grazing pressure. Bhattacharya *et al.* 2007 reported that Presence of human and livestock cause negative impact on galliformes. The present study was carried out in the sites from where villages were relocated, partially relocated or due for relocation, to study the abundance and habitat use of galliformes with respect to disturbance.

The density of ground bird was estimated highest in village site Bhagani which had been relocated 10 years back followed by Slopka that was relocated more than 40 years ago. It shows that there is a significant difference in density of ground birds (galliformes) between relocated village sites to existing village sites with least difference between existing village sites. Two relocated village sites have obvious difference in ground bird density. We also computed the peafowl density for each village sites. The density of peafowl was found to be highest in Bhagani (158.72 ± 45.6) followed by Lilunda (124.7 ± 38.2), Sukola (115.05 ± 27.4) and Slopka (108.89 ± 32.17). In case of peafowl, two existing village sites had the highest density than the relocated villages of Slopka and may be attributed to species biology and their specific habitat uses. Since, peafowl is a large bodied species; it occupies wide forest areas i.e. open forest, bushland, thorn forest (Madge and Mc Gowan 2002). Peafowl have come into increasing contact with human because of human encroachment into their natural habitats. (Madge and Mc Gowan 2002). Peafowl is a disturbance tolerant species; mostly prefer open scrubland, degraded areas than the dense forest.

Previous studies show that Sariska has the highest galliformes density, peafowl ($174/km^2$) followed by grey francolin ($40.8 /Km^2$) and jungle bush quail ($20 /Km^2$) (Gupta *et al.* 2011).

In case of galliformes, the highest density was observed in two relocated village sites with Grey francolin (n=23, 20), painted spurfowl (n=6, 4) and red spurfowl (n=3, 1) constituting majority of sighting other than peafowl that were more in existing village site. This difference can be observed in encounter rate of each species at different habitats in different village site. The encounter rate of grey francolin was $4.62/ km^2$ and $4.72/ km^2$ in Butea mixed forest and 2.57/Km & $2.87/Km^2$ in Ziziphus mixed forest in Slopka and Bhagani respectively. Butea mixed forest and Ziziphus mixed forest are least in existing village site as compared to relocated village sites. The abundance of grey francolin is affected by shrub cover and ground cover layer whereas painted spurfowl and red spurfowl both of them are mostly restricted to riverine forest and bamboo forest. Earlier studies on galliformes showed that they occupy non- overlapping habitats due to their preference to different habitat types. Their abundance also depends on a variety of habitat factors like tree cover, shrub cover, anthropogenic pressures etc. (Kidwai *et al.* 2011). The galliformes densities in existing village sites are mostly high due to high peafowl density wherein relocated village sites, overall galliformes density was high but peafowl density was low. This indicates that in relocated villages, majority of the galliformes density comprised of galliforms species other than peafowl. The abundance of other galliformes species is very less in existing villages as it fails to provide different habitat types. Species like painted spurfowl and red spurfowl are habitat specific and restricted in riverine and bamboo forest are least in existing village as it fails to provide such areas. In existing village sites most of the areas comprises of scrubland that are mostly occupied by peafowl. Presence or absence of galliformes can affect the abundance of small carnivores as they form a significant prey base.

5.2. Effect of relocation on rodents: Various studies have shown important roles of rodent in the diet of many small and medium sized carnivores. They are found to play an important role by contributing 4.4% in the diet of golden jackal and 34.3% in jungle cat (Gupta *et al.* 2011). Some of them are the indicator of habitat quality as they mostly depend upon ground layer cover for food and shelter. Sampling of rodent was carried out at four different village sites to investigate their diversity and abundance. Different types of habitat were selected for rodent trapping. The highest density was recorded from relocated village site Slopka (13.08 ±0.31) followed by Bhagani (9.72 ±1.38), Sukola (9.12 ± 0.42) and Lilunda (3.21 ± 0.71). Previous study on rodent shows an overall rodent density in winter to be 22.92 ±4.65 animals/ha to 7.81 ±2.25 (SE) animals/ha in summer. Most number of individual were captured in the village Slopka (n=12) followed by Sukola (n=10), Bhagani (n=9) and Lilunda (n=3). Majority of species were captured from the relocated village Bhagani (n=4) followed by Slopka (n=3). Earlier studies suggest that different species of rodents are restricted to specific habitat types for example *Vandeleuria oleracea* was captured only in *Anogessius* dominant forest; *Millardia meltada* in *Butea* mixed forest; *Millardia gleadowi* in *Butea- Ziziphus* mixed forest; and *Golunda ellioti* largely in open scrubland (Gupta *et al.* 2011). In the present study, highest number of rodents were captured in scrubland (n=10) followed by Ziziphus mixed forest (n=9) and Butea mixed forest (n=8). Relocated village sites had the highest density of rodents as it provides different types of habitat that are essential for species diversity. Density of rodents was same in Sukola (partially relocated) with Bhagani (relocated) but the species composition is different. In Sukola majority of capture species were House mouse (*Mus musculus)* which is known to live near human habitation. While in Bhagani soft furred rat (*Milardia meltada*) as well as Indian gerbil (*Tatera indica*) and little Indian field mouse (*Mus booduga*) was captured from the forested areas. Only Brown rats (*Rattus norvegicus*) were captured from the non-relocated village site Lilunda indicating that the existing villages might have high density of rodents though their composition was very different. Both brown rats and house mouse are known to reside near human habitation and indicator of disturbed habitats. While in the case of other species like Indian bush rat, Little Indian field mouse and Soft furred rat that were captured from the relocated village sites has negative relation with disturbance. The study indicates that presence of villages has considerable effect on species composition of small mammals and their abundance. As they are the major prey species, they can affect the abundance of small carnivore locally.

5.3. Effect of relocation on vegetation structure: The forest in Sariska represents some of the very few remaining tracts of tropical dry deciduous forests still remaining in the Aravallis; an eco-region otherwise subject to intensive grazing and biomass collection pressures. Long-term use of forest for grazing, fodder collection and firewood removal by local residents has been seen as the primary cause for degradation and biodiversity loss (Sankar *et al.* 2007).

Vegetation sampling was carried out for evaluation of vegetation structure in different village sites of Sariska. The results showed that overall there have been qualitative changes in vegetation structure at four different village sites in Sariska. Among all four study sites, Lilunda had most disturbed habitat followed by Sukola whereas Slopka had least disturbance. Major vegetation types showed drastic difference in four different village sites. Anogeissus mixed forest followed by Ziziphus mixed forest mostly dominated in relocated villages (Slopka & Bhagani). The existing village (Sukola & Lilunda) were mostly dominated by scrublands and Acacia mixed forest. Density of trees and percentages of shrub cover was also highest in relocated village as compared to existing village site since the existing village site has high intensity of cutting trees and biomass collection. Lopping pressure was found to be high in existing villages compared to relocated villages. Result of human disturbance index showed existing village sites also have high human activity as compared to relocated villages. The villages are completely dependent on forest for fuel wood and fodder (Sankar *et al.* 2007, Shahabuddin and Kumar 2005). The most dominant vegetation type in Sariska is the Anogeissus forest (35.43%) that is found in undulating areas and on hills (Sankar *et al.* 2009). Relocated village sites also have Anogeissus mixed forest as compared to the existing village sites where scrubland dominates majority of the areas. The results show that human activity has shifted the natural vegetation from the existing villages. The result of recruitment of sapling shows that Bhagani has the highest recruitment of trees followed by Slopka where other two village sites have very low recruitment. In relocated village site highest recruitment rate was observed in *Anogeissus pendula* trees followed by *Phoenix sylvestries*, *Ziziphus mauritiana*, *Butea monosperma* and *Cassia fistula*. In case of existing village sites, most recruited trees are *Balanites aegyptica* and *Acacia catechu* which are mostly associated with scrubland. The main fuel wood used by villagers is *Anogeissus*, *Ziziphus*, *Boswellia* and *Acacia* (Sankar *et al.* 2007) which is another reason of changing natural vegetation structure in existing village site. *Anogeissus, Ziziphus* and *Butea* are major fodder species of wild herbivores in Sariska but less number of these species in existing villages makes the habitat less suitable for wild animals. Changes in vegetation structure can cause other detrimental effect like presence of invasive species which can cause deleterious effect on native species. Abundance of invasive species was found to be highest in Sukola and Lilunda (existing village sites) than relocated village sites. Much of the change is attributed to the fact that increased human disturbances in existing village sites had led to the decline in forest cover. Biomass extraction activities in STR are one of the prime reasons for continued pressures on natural resources (Shahabuddin and Kumar 2005). Trends in this study indicate that vegetation is changing towards drier forms i.e. scrub vegetation in existing villages as compared to relocated villages. If grazing pressure, woodcutting and biomass collection continues, much of this vegetation would be replaced by dry scrub and thorny forest that would fail to offer suitable habitat for many wild animals and thus led to change in species composition.

5.4. Effect of relocation on small carnivores: Camera traps were used for activity pattern of small carnivores in each village site. Photographic capture rate of each species was computed all across the study site. The camera trap pictures of each site were analysed in CamtrapR to see the activity overlaps of galliforms and small carnivores with human. Results of camera trap shows that livestock has highest capture rate followed by human, chital and peafowl all across the study site.

Results of Capture rate shows that relocated villages have the highest capture rate of small carnivore than existing village compare to relocated villages. Species composition also varied across different village sites. Species like jungle cat and mongoose that are known to have tolerance towards human disturbance were present all across the village sites. Animals that avoid human disturbance like palm civet, small Indian civet and ratel were captured only from relocated village sites. These species were not present in existing village sites not only because they avoid human disturbance but also because they are affected by the vegetation structure. Capture rate of large carnivore shows totally opposite result as compared to small carnivores. Tiger, leopards and hyena were mostly captured from the existing village sites since livestock in the villages are major attractant for them. The other reason could be that villagers dump their dead cattle just outside of the village which is major attraction for scavenger like hyena as well as other large carnivores.

5.4.1. Slopka (relocated 50 years ago): In Slopka activity overlap between peafowl and human was found to be 0.38%. The most active time of peafowl was at the 8:00 AM in the morning and 2:00PM in the afternoon (**Figure** 32). The activity overlap of grey francolin was not computed because of low number of capture (n=2).

The activity pattern of Jungle cat shows 0.21% overlap with human because they are active in the morning (10:00 AM) which is the same time as that of tourist activity in the area. (**Figure** 33) This indicates that Slopka has least disturbance as compared to other village site. Though palm civet was captured from this village site, the activity pattern was not comparable due to few captures (n=2). Small Indian civet was mostly active during late evenings (08:00 PM) and showed least overlap (0.05%) with human. (**Figure** 34) Being nocturnal creature, ratel showed minimal overlap (0.05%) and was mostly active after 8:00 PM to throughout the night. (**Figure** 35) Mongoose showed 0.58% activity overlap with human and was mostly active from 10:00 AM to 1:00PM. (**Figure** 36) In this village site, small carnivores were active according to their biological clock and have very small influence of human disturbance.

5.4.2. Bhagani (relocated 10 years ago): In Bhagani peafowl showed 0.58% activity overlap with human and were mostly active in the 8:00 AM in the morning and 5:00 PM in the evening. (**Figure** 37) Activity of grey francolin was not computed because of small number of capture (n=2). Rusty spotted cat was found to be active in the beginning of the night (8:00PM) and showed minimal overlap 0.07% with human.(**Figure** 38) Being a highly nocturnal creature, palm civet showed least activity overlap (0.03%) and was mostly active after 12:00 AM. (**Figure** 39) The overlap between activity patterns with human was 0.17% in case of small Indian civet and the activity was primarily from 6:00PM to throughout the night. (**Figure** 40) The activity overlap of ratel with human was only 0.18% and mostly were active after 6:00 PM in the evening to throughout the night. (**Figure** 41) Mongoose showed high activity overlap of 0.84% with human and most active at the 10:00 AM in the morning and 5:00 PM in the evening.(**Figure** 42) Activity pattern of animals in Bhagani were least affected by human presence or disturbance.

5.4.3. Sukola (Partially relocated): This village is partially relocated with people still living and causing considerable disturbance. The activity overlap of peafowl showed 0.56% overlap with human and were are mostly active at 8:00AM in the morning and 5:00PM in the evening. (**Figure** 43) The activity overlap of jungle cat was found to be 0.34% with human and they are most active after 6:00 PM in the evening to till 12:00 PM in the night. (**Figure** 44) Activity pattern of mongoose was not computed because of low number of capture. In this village site, jungle cat avoided human by being active at night. Peafowl was tolerant to human disturbance and were found mostly near human habitation due to easy availability of food sources. Mongoose, a versatile predator with high adaptability of human disturbances can survive near human habitation. However, other small carnivores like Small Indian civet, Palm civet and ratel are known to affect by disturbances.

5.4.4. Lilunda (Not relocated): Village Lilunda is located inside the national park. The activity pattern of peafowl has least overlap (0.3%) with human and avoided human presence. (**Figure** 45) Their activity time shows two peaks, one at the 7:00AM in the morning and another in the 6:00 PM in the evening. The activity time of jungle cat showed that they were active at 12:00 AM in the night and show minimal overlap (0.15%) with human. (**Figure** 46) The activity pattern of mongoose was not computed because of minimal number of captures. The village Lilunda seems to have high amount of disturbance since most of the species that are known to be disturbance tolerant (e.g. - Peafowl, Jungle cat) also avoided human and shifted their temporal activity.

5.5. Conclusion:

The study highlighted the changes in species composition of galliformes and small carnivores across different sites where village relocation had been carried out at different phases of time. The sites which were completely relocated had higher diversity of galliformes and small carnivores as compared to sites where village relocation had not been carried out. The study revealed that activity pattern of small carnivores varied among sites with different levels of disturbance. The study also showed considerable difference in vegetation structure in relocated village sites as compared to the existing village sites.

Presence of villages inside the protected areas negatively affects the species diversity and composition thereby making the area less suitable for many species. It therefore becomes relevant to initiate relocation of villages on priority to maintain healthy ecosystems that support native flora and fauna.

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Plate 1: *Anogeissus -Ziziphus* mixed forest at village site Slopka

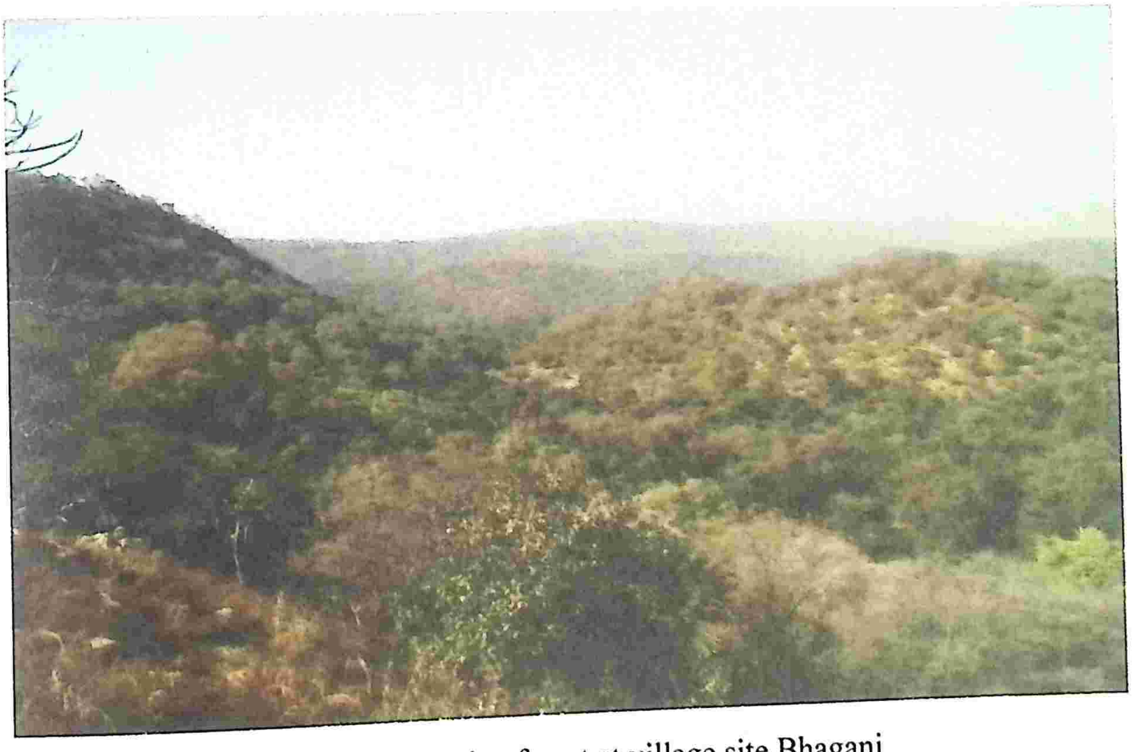

Plate 2: Riverine forest at village site Bhagani

Plate 3: Scrubland at existing village site Sukola.

Plate 4: Scrubland at village site Lilunda.

(A)

(B)

(C)

(D)

(E)

Plate 5: Rodents captured during study period (A- Indian bush rat, B- Little Indian field mouse, C- Soft furred rat, D- Indian gerbil and E- Brown rat)

A)

B)

C)

D)

E)

F)

Plate 6: Camera trap images of small carnivores captured during the study period. (A- Jungle cat, B- Rusty spotted cat, C- Asian palm civet, D- Small India civet, E- Ratel or Honey badger and F - Grey Indian mongoose)