ECOLOGY AND FEEDING BEHAVIOUR OF SLOTH BEAR (*Melursus ursinus*) IN PARAMBIKULAM TIGER RESERVE, KERALA

By

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(2011-17-102)

THESIS

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DECLARATION

I hereby declare that the thesis entitled **"Ecology and feeding behaviour of Sloth Bear (*Melursus ursinus*) in Parambikulam Tiger Reserve, Kerala"** is a bonafide record of research done by me during the course of research and that this thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other University or Society.

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Dedicated to my loving

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Introduction

INTRODUCTION

Mammals evolved from reptiles nearly 180-220 million years ago and they have got rampant growth on earth after the extinction of dinosaurs (Wilson and Reeder, 2005). Some mammals like the whales, dolphins and dugongs are adapted to live in water. Similarly, the bats are adapted for an aerial mode of life. They also vary in their dietary habits. There are herbivores, carnivores including flesh-eaters and scavengers, frugivores, insectivores and omnivores among the mammals. All these make the mammals the most successful group of animals on earth.

There are about 5,416 species of mammals distributed in about 1,229 genera, 153 families, and 29 orders (Wilson and Reeder, 2005). Four hundred and twenty species of mammals (7.75% of the world's mammals) are known from India (Nameer, 2008). Around 145 species of mammals have been reported within the political boundaries of Kerala state.

Among the mammals carnivores are the most widely distributed terrestrial animals on earth (Prater, 1948) and is represented by nine families in India (Wilson and Reeder, 2005; Schipper et al., 2008). Bears are the members of the order carnivore and family Ursidae. There are seven known species of bears in the world (Table 1). Out of these, six of which are threatened (IUCN, 2012). All the members of the family Ursidae have large heads and heavily built bodies with short, strong limbs and short tails. Eyes and ears are small, ears being erect and rounded. All have five digits on each limb and each digit is armed with a long, recurved and non–retractile claw. The lips are free from the gums and protrusible. Bears rely principally on their sense of smell however the eye sight and hearing are comparatively poor (Prater, 1971). Most bears are opportunistic omnivores. Their activities are mainly governed by the availability of food items and dietary components within their habitat (Joshi *et al.*, 1995).

Out of the seven known species of Bears, four are seen in India which include Himalayan Brown Bear (*Ursus arctos*), Asiatic Black Bear (*Ursus thibetanus*), Sun Bear (*Helarctos malayanus*) and Sloth Bear (*Melursus ursinus*).

Table 1. Seven species of Bears in the world

Common Name	Scientific Name	IUCN Status
American Black Bear	*Ursus americanus*	Least Concern
Asiatic Black Bear	*Ursus thibetanus*	Vulnerable
Sun Bear	*Helarctos malayanus*	Vulnerable
Polar Bear	*Ursus maritimus*	Vulnerable
Sloth Bear	*Melursus ursinus*	Vulnerable
Himalayan Brown Bear	*Ursus arctos*	Endangered
Spectacled Bear	*Tremarctos ornatus*	Vulnerable

Source: IUCN 2012

Sloth Bear (*Melursus ursinus*) is one of the four bear species found in India and is entirely tropical in distribution and possesses several morphological, physiological and behavioural adaptations to the tropical habitat (Yoganand *et al.*, 2006). In India, Sloth Bears are found from the foothills of Himalayas to the southern end of Western Ghats the southern end of Western Ghats (Yoganand *et al.*, 2006). They are also found in the Brahmaputra valley of Assam (Cowan, 1972; Krishnan, 1972; Brander, 1982). The bear lives in a variety of habitat such as teak forest and sal forest, lowland evergreen forest and the hill country up to elevation of 1700m and riparian forests and tall grass areas on the floodplains of Nepal (Joshi *et al.*, 1995). Among the four species of Bears present in Indian subcontinent, Sloth Bear (*Melursus ursinus*) is one of the least studied animals especially in the Western Ghats region.

Sloth Bears are one of the largest termite-eaters among mammals. A significant portion of their diet consists of ants and termites (Schaller, 1969; Eisenberg and Lockhart, 1972; Laurie and Seidensticker, 1977; Joshi *et al.*, 1999). And hence the Sloth Bear is considered as the only myrmecophagous among Ursidae.

Mammals often consume fleshy fruits and disperse significant quantities of the enclosed seeds. Primates as well as birds and bats, recently, some carnivores including bears and civets act as seed dispersers (Herrera, 1989; Koike *et al.*, 2008). Since some Ursids disperse seeds they are considered to be important seed dispersers for many tropical plant species where fruits form major part of their diet (Willson, 1993; Bhaskaran *et al.*, 1997; Kitamura *et al.*, 2002 Sreekumaran and Balakrishnan, 2002; Koike *et al.*, 2008).

Seed dispersal is generally advantageous because conspecific recruitment is often poor under parent trees (Howe, 1984). Further, seed passage through the gut of mammalian frugivores may enhance the probability of seed germination (Willson, 1993). The frugivores generally inhabit the thick, undisturbed tropical forest where fruiting trees are abundant. Therefore, their presence or absence is directly related to the health of the forest, which signifies that the forest is intact and in good condition without any disturbances. Although seed passage through bear digestive tracts and the composition of scats known to affect germination rates to some degree, the most important role of bears in seed dispersal is probably transport (Sreekumar and Balakrishnan, 2002; Willson and Gende , 2004) and thereby reduces the mortality due to competition for resources with their parent and higher levels of density dependent seed predation.

Although Sloth Bears (*Melursus ursinus*) are widely distributed (Yoganand *et al.*, 2006) its range has shrunk in recent times and the populations have become fragmented, threatening its overall survival. Many populations are declining due to habitat loss and deterioration (Johnsingh, 2003), diminished food resources (Murthy and Sanakar, 1995), timber and firewood harvesting, and use of their body parts in

medicines (Cowan 1972, Servheen, 1990). They were reported to be abundant during the mid-1800s, but declined severely between the late 1800's and mid 1950s due to habitat loss and hunting (Prater, 1971; Krishnan, 1972). Sloth Bear is included in Schedule I of Indian Wildlife Protection Act 1972 and Appendix I of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES).

To insure the natural seed dispersal process in the forest, an evaluation of all frugivore groups in the forest is urgently needed .The vegetation density and diversity is an important factor determining the habitat condition for particular wild animals. Different animals prefer different type of habitats for food and shelter. Scientific management of the remaining populations and their degrading habitat is necessary for the long-term conservation of the species. The current study is conducted at Parambikulam Tiger Reserve and is one of the strongholds of the Sloth Bears in Kerala. Since Sloth Bear is a threatened species immediate action need to be taken to prevent any further decline in population. For this a thorough knowledge of the behaviour and habitat of the Sloth Bear is essential.

In this back drop, a study was taken up with the primary objectives,

a. to study distribution and relative abundance of Sloth Bear (*Melursus ursinus*) in relation to habitat characteristics
b. to study the food habits and seasonal changes in the dietary intake of Sloth Bear (*Melursus ursinus*)
c. to study the efficiency and effectiveness of seed dispersal

Review Of Literature

REVIEW OF LITERATURE

The Order Carnivora, to which the Bears belong, is widely distributed around the world (Wilson and Reeder, 2005). Ursidae's home is largely distributed in the northern hemisphere. There are seven species of bears in the world where every region has its characteristic species (Waits *et al.*, 1999). The Arctic is the home of the polar bear (*Ursus maritimus*). The temperate zone, south of the Arctic, is the typical habitat for brown bear (*Ursus arctos*) and the black bear (*Ursus americanus* and *Ursus thibetanus*). South of the temperate zone, forests of India and south-eastern Asia are the home of two tropical bear species, the Sloth Bear (*Melursus ursinus*) and the sun bear (*Helarctos malayanus*). The one species of bear found only in the southern hemisphere is the spectacled bear (*Tremarctos ornatus*), a native of the Andes (Novak and Paradiso, 1983).

2.1 SLOTH BEAR (*Melursus ursinus*)

2.1.1 Physical Characteristics

Sloth Bear is a medium-sized mammal weighing between 127 and 145 kg. It is typically black and can be distinguished by a narrow snout; protractible mobile lips, black shaggy coat, long tongue, and a whitish 'V' or 'U' shaped breast patch. The long, pale muzzle is covered with thin, short, greyish white hair. The fore head region from just below the eyes up to the ears and sides of the head is covered with short tidy black hair. The neck region, from behind their thick ears, up to the shoulder possesses dense, long hair and lacks under fur (Brander, 1982; Pocock, 1933; Prater 1971).

Sloth Bears stand 65-85 cm at shoulder and are 140-170 cm from nose to tail. Adult males weigh between 80 and 150 kg, are larger than adult females, which weigh between 60 and 100 kg (Prater, 1971; Garshelis *et al.* 1999a; Yoganand *et al*, 1999). The rhinarium has a mobile projection, with which it can close the nostrils. The lips and tongue are exceptionally protrusible, this is perhaps an adaptation to its mode of feeding on ants and termites (Pocock, 1933). The posterior part of the palate is broad

and long, a feature common in other ant-eating mammals. A typical characteristic of this species is the structure of the anterior palate, which has a shallow, concave, saucer like area bordered by the incisors and a transverse ridge formed between the upper canines (Erdbrink, 1953). Sloth Bear possess the same number of teeth as other bears. Both incisors are present, in a reduced state, in the milk dentition (Pocock, 1933). However, they lose the first two upper incisors at an early stage, which is a characteristic feature of this species (Erdbrink, 1953). The molars are relatively small compared to those of other bears, in keeping with the softer and more easily digestible diet.

The front claws of Sloth Bears are long (up to 7 cm) and curved an adaptation for digging (Laurie and Seidensticker, 1977). They vary to some extent in color, from greyish to ivory-white. The claws on the hind leg are shorter and are about 3 cm in length. The short hind legs of the Sloth Bear are suggestive of an adaptation for digging, as the hind legs might help in stabilizing the body when the forelimbs dig. The soles on the feet are naked. The five digital pads are arranged in a line and are fused together up to their distal ends (Harris and Steudel, 1997).

2.1.2 Nomenclature and Taxonomy

The description about Sloth Bear was first given by Shaw and Nodder in 1791. They were named it *Bradypus ursinus* or a bear-like sloth. This species was initially considered to be a sloth because of the common characteristics with sloths such as long claws and the absence of upper middle incisors (Erdbrink, 1953). Meyer (1793) was the first to recognize this animal as a bear and not a sloth, and gave it an appropriate name *Melursus lybius*. De Blainville (1817) identified the animal as belonging to the genus Ursus and named it *Ursus labiatus*. Lydekker (1884) suggested that this species should be placed in the genus Ursus, because the dentitional differences from other bears are not so great as to warrant a separate genus. On account of other significant differences, Erdbrink (1953) suggested recognition at a sub generical level and named it *Ursus (Melursus) ursinus* Shaw.

Although the subfamily Ursinae is agreed to be of monophyletic origin, there is disagreement as to the relationship within the subfamily. Goldman *et al.* (1989) suggested that all ursids should be classified in the single genus Ursus. Talbot and Shields (1996) supposed that the greater morphological divergence of Sloth Bear was likely to be due to recent adaptive change and not accompanied by molecular evolution. Waits *et al.* (1999) examined the phylogenetic relationships of the bears using mitochondrial DNA analyses and attempted to resolve outstanding ambiguities. They concurred with earlier studies (Talbot and Shields, 1996) that the Sloth Bear is the basal ursine bear and a sister taxon to the later five species of bears (excluding the giant panda and the spectacled bear that diverged much earlier). The genetic and morphological differentiation of the Sloth Bear therefore supports the separate placement in the genus *Melursus* (Wozencraft, 1989; Corbett and Hill, 1991; Waits *et al.*, 1999). Two races of Sloth Bears such as *Melursus ursinus ursinus* and *Melursus ursinus inornatus* distinguished by Pocock (1933), in which the former is occurring in continental India and the second, found only in Sri Lanka. The Sri Lankan race is smaller in general dimensions including the dimensions of teeth and has much shorter hair on the body, making it looks less shaggy (Erdbrink, 1953).

2.1.3 Status and Distribution

The Sloth Bears (*Melursus ursinus*) are the most wide spread species of Indian subcontinent and distributed from the lowlands of Nepal , Bhutan, India and Sri Lanka (Yoganand *et al.*, 2006; Ratnayeke *et al.*, 2007) (Figure 1). In India Sloth Bears are found from the foothills of Himalayas to the southern end of Western Ghats. Along the northern part, the Sloth Bear range overlaps slightly with the range of the Asiatic black bear (*Ursus thibetanus*). These two species coexist in some National parks and Wildlife sanctuaries such as Corbett, Jaldapara and Kaziranga. Its eastern distribution is bounded by the wet forests of the Naga hills to the south of Brahmaputra river and overlap with the range of Malayan sun bear (*Ursus malayanus*) makes the only places in the world occupied by three species of Bears (Choudhury,

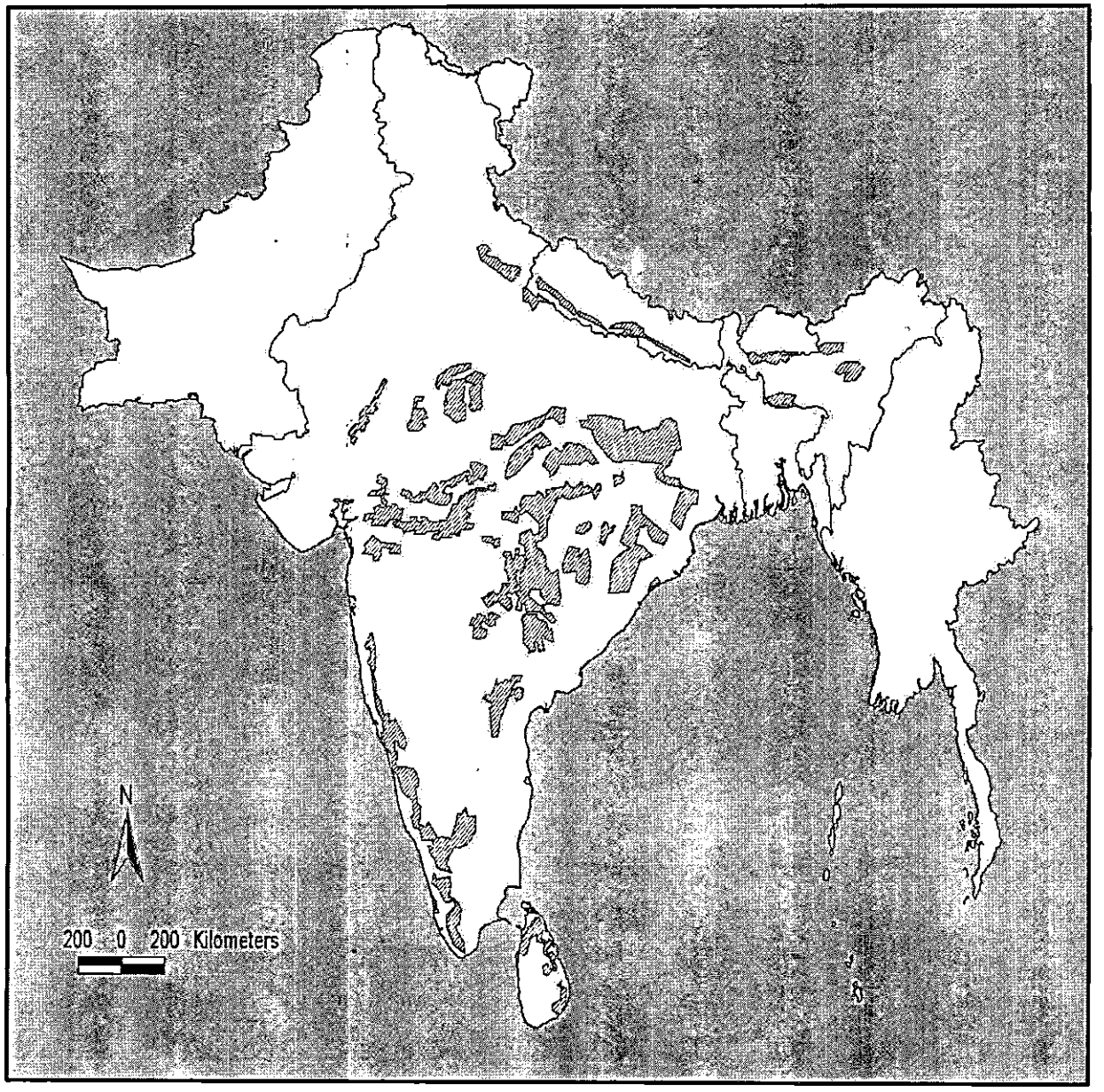

Figure1. Distribution map of Sloth Bear (*Melursus ursinus*) (Yoganand *et al.*, 2006)

2011). Its western distribution is limited by the desert regions of Rajasthan (Yoganand *et al.*, 2006). The forests of the Western Ghats and the central Indian highlands are currently the two strongholds of the Sloth Bear (Yoganand *et al.*, 1999).

In Nepal and Bhutan, Sloth Bears are found in the lowland terai grasslands and the Shivalik hill ranges, but have recently been vanished in parts of Nepal (Garshelis *et al.*, 1999a). Servheen (1990) reported that it may still occur in the wet forest regions of eastern Bangladesh bordering the Mizoram state of India, from where it has been reported by Yoganand *et al.* (1999). However, it has been extirpated from the moist deciduous forests of central Bangladesh (Khan, 1982; Servheen, 1990).

In Sri Lanka, it is presently found only in the northern and eastern lowland forests, and even in these areas it may no longer occur in most of the degraded areas. In the past Santiapillai and Santiapillai (1990) reported Sloth Bears presence in the north central and in the eastern areas of the southern province, including the hill country. The present range has shrunk along its peripheries and has become fragmented overall, concurrent with shrinking forest cover and perhaps to some extent due to over-hunting (Garshelis *et al.*, 1999a).

Yoganand *et al.* (1999) have also been reported the population decline in India from the north-western region in the state of Rajasthan and few isolated forests in the northern Western Ghats and adjoining areas, along the north-western Shivalik hills, the northern forested areas of the state of West Bengal bordering Sikkim and Bhutan. The populations in Terai , Shivaliks and in the north-eastern India have probably become isolated from the rest and face high poaching pressure (Choudhury, 2011).

Sloth Bears were reported to exist in 260 distinct forest patches in India, of which 174 were PAs, including 46 National Parks and 128 Wildlife Sanctuaries (Chauhan *et al.*, 2004; Yoganand *et al.*, 2006). Populations appear to be reasonably well protected inside these PAs, but faced with deteriorating habitat conditions

outside PAs. Akhtar *et al.* (2004) reported that reduced forest cover and available food resources outside PAs have led to increased bear–human conflicts, including frequent maulings (Bargali *et al.*, 2004). It is estimated that half to two-thirds of the Sloth Bears in India live outside PAs. However, an extensive survey conducted in Sri Lanka found that about half the occupied range of Sloth Bear lies within PAs (Ratnayeke *et al.*, 2007). Threats to Sloth Bears outside PAs were largely responsible for their listing as Vulnerable by the IUCN.

2.2. ECOLOGY AND BEHAVIOUR

2.2.1 Studies on habitat preference of Sloth Bear (*Melursus ursinus*)

Sloth Bears are found in a wide range of habitats ranging from wet evergreen forest to dry deciduous and degraded scrub forests. Sloth Bears appear to occur at higher densities in the moist deciduous and dry forests compared to other forest types such as scrub and evergreen forests (Yoganand *et al.*, 1999). However, their abundance varies in the different habitats; probably depending on resource availability. In Royal Chitwan National Park, Nepal, Sloth Bears primarily concentrated in areas with thick forest cover, although they used all habitats (Laurie and Seidensticker, 1977). Joshi *et al.* (1995) observed that Sloth Bears preferred alluvial grasslands during the dry season to facilitate foraging on termites. They apparently moved to different habitats and areas according to the availability of food. The highly productive "terai" grasslands along with the associated moist deciduous forests of the Shivalik hills hold high Sloth Bear densities (Garshelis *et al.*, 1999b).

In India various studies have shown that Sloth Bears prefer variety of habitat in relation to food availability. Schaller (1969) reported the greater reliance towards dry forests than closed forest in Kanha National Park. Baskaran *et al.* (1997) reported that in Mudumalai Wildlife Sanctuary Sloth Bear sign was more frequent in dry deciduous forests and this habitat had greater fruit abundance, more cover and less human disturbance than other habitats in the area. Sloth Bears preferred areas with

dense cover in Panna (Yoganand *et al.*, 1999) and used escarpment areas and *Lantana* shrub patches frequently for day-resting and foraging. In Parambikulam wildlife sanctuary Easa (2001) reported that Sloth Bear sign was more in plantations and moist dry forest as the indication of Sloth Bears prefer mostly open forests than closed forests having food availability.

Habitat use of Sloth Bear is also determined by other factors other than food availability. A study conducted across the lowlands of Nepal indicated that Sloth Bears were either absent or occurred at low densities in areas with high human use, even though the area having high termite densities (Garshelis *et al.*, 1999b). Thus, although the Sloth Bear abundance in an area is related to the abundance of resources, which in turn is related to the type of habitat, the level of human disturbance in that area may influence abundance as well.

2.2.2 Studies on Feeding habits of Sloth Bear (*Melursus ursinus*)

Studies on food habits of Sloth Bears *Melursus ursinus* mostly use scat analysis method (Schaller 1969; Laurie & Seidensticker 1977; Baskaran 1990; Gokula *et al.*, 1995; Baskaran *et al.*, 1995; Desai *et al.*, 1997; Joshi *et al.*, 1999; Easa, 2001). In this method, the diet composition is arrived at from indigested food remains in the scats using different quantitative measures. Some studies have used percent occurrence of various undigested food remains in the scat, but this does not indicate the quantities consumed (Schaller, 1969).

Most of the studies (Laurie & Seidensticker, 1977; Baskaran , 1990; Gopal, 1991; Baskaran *et al.*, 1997; Gokula *et al.*, 1995; Desai *et al.*, 1997; Joshi *et al.*, 1999) however estimate the relative contribution of various food species merely based on indigestible food remains that appear in the scat by assuming the relative contribution of digestible and indigestible parts equally for all the species.

Sloth Bear is the only species of bear adapted specifically for myrmecophagy (Garshelis *et al.*, 1999a). They have morphological adaptations to feed on social insects but, like other bear species, they are opportunistic omnivores and their diets may vary seasonally and geographically. Despite specific myrmecophagous adaptations, Sloth Bears are omnivorous and also feed on a variety of fruits. Recently, Joshi *et al.* (1995) studied habitat-related diets of Sloth Bears in Nepal and found that insects, particularly termites, formed the major part of their diet.

In South India, however, fruit comprises a major part of their diet (Baskaran *et al.*, 1997). Sloth Bears consumed both animal and plant matter depending upon the food availability in different seasons (Laurie and Seidensticker, 1977; Gokula *et al.*, 1995; Baskaran *et al.*, 1997; Joshi *et al.*, 1999). Sloth Bears subsist primarily on termites, ants, and fruits (Sacco and Valkenburgh, 2004). The ratio of insects to fruits in the diet varies seasonally and geographically (Baskaran *et al.*, 1997; Joshi *et al.*, 1999; Bargali *et al.*, 2004). Bargali *et al.* (2004) reported that Sloth Bears consumed about 21 plant species in central India.

2.2.2.1 ***Plant matter in the diet of Sloth Bear*** (*Melursus ursinus*)

Sloth Bears in southern India consume ripe and dried fruits of *Cassia fistula* and reported that it was the widely used plant by Sloth Bear in terms of frequency of occurrence (Baskaran *et al.*, 1997; Easa, 2001; Ramesh *et al.*, 2010). In Panna National Park (Schallar,1969) reported that during dry season 51% of the consumed biomass was fruits, 36% was ants and 10% was termites, which is the main fruiting season, but during the monsoon fruits were 36% and ants 52% of the consumed biomass. Sloth Bear was reported to feed different fruits such as *Ficus* spp., *Cordia myxa*, *Zizyphus jujuba, Mangifera indica, Syzygium cumini* and *Cassia fistula* (Gopal, 1991)

According to Joshi *et al.* (1999) in Chitawan, overall 83% of scats were insect remains, in the non-fruiting season, and even in the fruiting season 58% of scats were made of insect remains; the main insect prey was termites with fruits making up 38% of the diet in the fruiting season.

A study in disturbed, unprotected areas of Madhya Pradesh (Bargali *et al.*, 2004) found that two fruiting shrubs *Zizyphus oenoplia* and *Zizyphus nummulariaand* eight fruits of trees *Ficus racemosa, Ficus virens, Ficus benghalensis, Ficus religiosa, Zizyphus mauritiana, Aegle marmelos, Syzygium cumini* and *Madhuca indica* in the diet of Sloth Bear.

Baskaran *et al.* (1997) in Mudumalai Wildlife Sanctuary, Tamil Nadu, southern India, a study based on scat analysis detected at least 20 plant species. Fruit was a major part of the diet; fruit remains made up 87.9% of the dry weight of scats; the major fruits eaten were those of pulpy *Cassia fistula, Syzygium cumini, Zizyphus mauritiana* and *Cordia domestica.* Easa (2001) reported five species of plants from the scats of Sloth Bear which include two shrub species such as *Glycosmis pentaphylla, Zizyphus rugosa* and three tree species such as *Mangifera indica, Cordia dichotoma, Ficus spp.* in Parambikulam Tiger Reserve.

Sreekumar and Balakrishnan (2002) in Neyyar Wildlife Sanctuary, Kerala found that Sloth Bear fed on different fruits in different seasons which include *Artocarpus intergrifolia, Artocarpus hirsuta, Zizyphus rugosa, Zizyphus oenoplia, Baccauria courtallensis, Aporosa lyndleyana, Eleocarpus tuberculata, Lantana camera, Phoenix humilis, Ixora coccina, Mangifera indica, Cassia fistula and Syzigium cumini.*

2.2.2.2 ***Animal matter in the diet of Sloth Bear*** (*Melursus ursinus*)

In the Royal Chitawan National Park, Nepal, foods eaten included termites such as *Odontotermes obesus*, red ants (e.g. *Solenopsis* sp.), black ants (including *Camponotus* sp.), beetles, dung beetles, crickets (*Gryllotalpa africana*), honey, Overall, insects appeared to make up 52% of the diet and fruits 47%. Insects were available all year, but different fruits were available and eaten seasonally. Termites were a staple part of the diet all year round. In Kanha National Park, India (Gopal, 1991) found that 38% of droppings contain only termites and ants.

According to Schallar (1969) in Panna National Park, India Sloth Bears fed on termites and ants. Remain of ants and termites were found in nearly 70% and 44% of scats respectively and together made up more than 10% of scat dry weight, indicating these were important in the diet, probably as a major protein source; beetles and their grubs were less important (1.4% of scats, 0.04% of dry weight). Wax and bee remains indicated honey consumption (7.9% of scats, 1.5% of dry weight). Similarly, a study on Sloth Bears in central India, (Gopal, 1991) found that termites, ants, and honey were the predominant food of Sloth Bears.

2.2.3 Studies on social behaviour

Sloth Bears are solitary, but territoriality has not been observed (Laurie and Seidensticker 1977, Joshi *et al.*, 1999). Sloth Bears have relatively small home ranges compared to other bears and do not make extensive seasonal movements (Joshi *et al.*, 1995, Yoganand *et al.*, 2006). Individual home ranges overlap considerably, though the extent of overlap varies among localities, perhaps depending on the resource abundance in an area (Joshi *et al.*, 1999, Yoganand *et al.*, 2006). Joshi *et al.* (1999) observed that seasonal home ranges overlapped extensively among adults of the same sex (>50%) and between adults and sub adults of both sexes (>70%) and that

the zones of overlap were used in proportion to their area. However, they observed that sub adults and females with dependant young limited their activity to daylight hours and they proposed that this might be to temporally avoid other bears or predators. Occasional noisy interactions between bears were observed during all times of the year, mostly between males. During the mating period there are increased noisy interactions and fighting between males (Laurie and Seidensticker 1977, Joshi *et al.*, 1999). Cubs are frequently carried on their mothers' backs from the time they leave the den until they are about six months of age (Laurie and Seidensticker 1977, Joshi *et al.*, 1999). Carrying cubs by the mother seems to be a defense against attacks by predators or other bears. Cubs stay with their mothers for 1.5 or 2.5 years, becoming independent just before the breeding season. Thus, females breed at either two-or three-year intervals. The mother-young unit is the only long-lasting social grouping exhibited by the Sloth Bear (Eisenberg and Lockhart 1972, Joshi *et al.*, 1999).

2.4.2 Studies on time activity pattern of Sloth Bear

Camera trapping data gives valuable information about ecology and behaviour of Sloth Bears and has its own advantage that includes capture of more number of individuals at a spatial scale which is a limitation in radio-collared studies (Ramesh 2010). However, use of information from systematic camera trapping surveys to understand activity patterns remains rare (Gopalaswamy, 2006).

Activity patterns are governed largely by the biological requirements of a species (Wrangham & Rubenstein, 1986). Activity patterns in mammals can be influenced by foraging, prey behaviour, predator avoidance, physiological traits, vegetation cover and climate (Seidensticker,1976). The activity patterns of Sloth Bears have been marked out based on radio-collared individuals (Joshi *et al.*, 1995; Yoganand *et al.*, 2006; Ratnayeke *et al.*, 2007), den site observations and indirect evidences (Baskaran 1990; Desai *et al.*, 1997; Akhtar *et al.*, 2004; Chauhan *et al.*,

2004). Sloth Bears are known to be nocturnal and crepuscular in activity (Chauhan *et al.*, 2004; Yoganand *et al.*, 2005).

Sloth Bears have a behavioural adaptation to avoid hot weather conditions in their habitat by reducing daytime activity (Yoganand *et al.*, 1999). Clutton-Brock and Harvey (1983) suggested that the large body size of the Sloth Bear help it to conserve heat; to travel great distances in search food; to enhance the ability to survive on qualitatively poorer food of insects and fruits; to enable it to break hard termite mounds and to dig deep into social insect colonies. Joshi *et al.* (1999) also found that although the bears were active at all times of the day, they were most active at night. However, for females with cubs and sub adult bears, were more active during day and rested at night. Laurie and Seidensticker (1977) observed that the main period of activity of bears was during the evening and night in Chitwan. In Panna, Sloth Bears were mostly nocturnal and crepuscular and they used dens to rest during the day (Yoganand *et al.*, 1999).

2.3 ECOSYSTEM SERVICES

2.3.1 Dispersal of seeds by Bears

Ursids are sometimes important seed dispersers in rain forest where fruits form a major part of their diets (Willson, 1993). Seed dispersal by bears is reported in studies of the Asiatic black bear (*Ursus thibetanus*) (Koike *et al.*, 2003; Sathyakumar and Viswanath, 2003), American black bear (*Ursus americanus*) (Janene *et al.*, 2002), Brown bear (*Ursus arctos*) (Applegate *et al.*, 1979; Willson and Gende, 2004), Sun Bear (*Helarctos malayanus*) (McConkey and Galetti ,1999), and Sloth Bear (*Melursus ursinus*) (Baskaran *et al.*, 1997; Sreekumar and Balakrishnan, 2002; Ramesh, 2010). Takahashi *et al.*(2008) in south eastern Alaska reported Brown Bears (*Ursus arctos*) are among the most important dispersers of seeds for the numerous plant species producing fleshy fruits, because these bears are abundant often eat large quantities of fruit, and commonly excrete several thousand seeds in germinable condition.

Seed dispersal is generally advantageous because conspecific recruitment is often poor under parent trees (Howe, 1984). Being highly mobile, ursids like the Sloth Bear can potentially disperse seeds large distances from a parent plant. Koike *et al.* (2008) reported that five members of the order Carnivora such as Asiatic black bear, Japanese marten, badger, red fox, and raccoon dog in the cool-temperate deciduous forests of Japan consume the fruits of trees, and they are potential dispersers of the seeds of fleshy-fruited plants in cool-temperate deciduous forest. Asiatic black bears seldom digest ingested seeds, thereby contributing to the seed dispersal of their food plants, including species with fruits that are too large to be swallowed by frugivorous birds. In Kerala except few studies in Parambikulam Wildlife Sanctuary (Easa, 2001) and Neyyar Wildlife Sanctuary (Sreekumar and Balakrishnan, 2002) little is known about the role of the Sloth Bears as seed dispersers.

2.3.2 Effects on seed germination

Seed retention in digestive tract is one factor affecting seed germination (Traveset, 1998). Seed passage through the gut of mammalian frugivores may enhance the probability of seed germination (Willson, 1993). The fate of seeds following passage through the digestive tract of animals is one qualitative aspect of disperser effectiveness (Schupp, 1993). Although seed passage through bear digestive tracts and the composition of scats, are known to affect germination rates to some degree, the most important role of bears in seed dispersal is probably transportation of seeds from the parent plant. Sreekumar and Balakrishnan (2002) compared germination rate for seeds collected from scats and seeds not passing through bears. Of the six species of plant seeds three germinated faster and germination percentage was not higher in any of the species. These results suggest that the Sloth Bear may play an important role in the dispersal of fleshy-fruited species of the region.

2.4 CONSERVATION

2.4.1 Habitat Status

The degradation and loss of forests, especially outside protected areas, causes a major threat to Sloth Bear populations and thereby affecting the continued existence of Sloth Bears in India (Garshelis *et al.*, 1999a). Yoganand *et al.* (2006) reported that fragmentation of forests may lead to isolated, non-viable bear populations in the dry forests of India due to habitat degradation in the form of overgrazing, tree-felling, fire, conversion and reclamation for other uses, and over-extraction of forest resources. The degradation and loss of forests, especially outside protected areas, causes a major threat to Sloth Bear populations and thereby affecting the continued existence of Sloth Bears in India (Garshelis *et al.*, 1999a).

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2.4.2 Population Status

Reliable data on the abundance of Sloth Bear and other population parameters that are essential to determine its exact status are not yet available. The Sloth Bear is listed as "Vulnerable" by the IUCN (2012), listed under Appendix I of CITES and protected under Schedule I of the Indian Wildlife (Protection) Act of 1972. There have been several estimates of total Sloth Bear population size. Jefferson (1975) conducted the first survey of the status of the Sloth Bear population in India. Based

on mailed questionnaires it was estimated an average density of six bears per 100 km^2.

A later survey using questionnaire responses information from Wildlife Institute of India's database and other published literature Garshelis *et al.* (1999a) gave an estimate, with reservation, of the world population of the Sloth Bear as between 10,000 and 25,000, occurring in 56,000 km^2 of protected areas and 200,000-300,000 km^2 of forests outside protected areas. Santiapillai and Santiapillai (1990) estimated a population of 300 to 600 Sloth Bears in Sri Lanka assuming a density of 5 to 10 Bears /100 km^2. In Royal Chitwan National Park, Nepal, Garshelis *et al.* (1999b) estimated a population of 200-250 bears. They also conducted a survey in most parts of the Sloth Bear range in Nepal, and estimated that Nepal's Sloth Bear population as less than 1,000 bears.

Yoganand *et al.* (1999) estimated population size for India by carrying out a questionnaire survey and calibrating the abundance ranks received from the respondents, based on their studies in central India and observations elsewhere. They estimated minimum and maximum values for average densities for each abundance rank (abundant = 8 and 12 bears / 100 km^2; frequent = 6 and 8 bears / 100 km^2; occasional = 3 and 4 bears / 100 km^2; rare = 1 and 2 bears / 100 km^2) and then proportionately extrapolated those average densities to 50,000 km^2 area of suitable protected reserves, and 200,000 km^2 of other potential Sloth Bear habitat outside reserves. They arrived at a minimum and maximum estimate of 9,000 and 13,000 Sloth Bears for India.

2.4.3 Conservation implications

Garshelis *et al.* (1999a) suggested that the Sloth Bear distribution should be mapped in relation to forest cover, and discrete population units need to be traced. Due to the low reproductive rate of this species and seasonality of its required resources, moderate to large-sized reserves are required to maintain viable

populations (Yoganand *et al.*, 2006). Regeneration of forests outside reserves and restoration of degraded habitats would significantly expand the habitat for Sloth Bears.

In order to conserve this species that is unique in its ecology, behaviour, and specific conservation plans and an active management of the existing populations should be urgently needed.

Materials And Methods

MATERIALS AND METHODS

3.1. STUDY AREA

3.1.1Name, Location and extent

Parambikulam Tiger Reserve (PKTR), lies within the geographical extremes of latitudes $10^0$20' and $10^0$26'N and longitudes $76^0$35'and $76^0$50' E (Figure 2) in the southern part of Western Ghat, immediately south of Palghat gap. PKTR is the second Tiger Reserve of the state and also the 38th Tiger Reserve of India came into existence in 2010 with an extent of 643.66km^2 with a core area of 390.89Km^2 and buffer area of 252.77km^2. The present study was carried out in Parambikulam Wildlife Sanctuary with a extent of 285km^2 (Kaler, 2011).

It lies between the Anamalai hills and Nelliampathy hills. The Altitude ranges between 300m and 1438m above MSL. There are 7 major valleys and 3 major river systems. Major peaks in the sanctuary are Karimala (1438m), Pandaravarai (1290m), Kuchimudi, Vengoli (1120m) and Puliyarapadam (1010m). Apart from the natural rivers and streams, the sanctuary possesses three man-made reservoirs namely Parambikulam, Thunacadavu and Peruvaripallam (Plate 1).

A unique forest tramway was in existence at Kuriarkutty at PKTR from 1907 exclusively meant for timber transport from Parambikulam to Chalakudy. Extensive extraction of timber took place during this period, but the tramway was abandoned in 1951. The first plantation in this area was raised in 1912. All the plantations after 1932 were raised under taungya system (Vijayan, 1979).

3.1.2 Geology, Rock and Soil

3.1.2.1 *Geology*

Lying south of the Palghat gap in the Anamalai hills of Western Ghats, the reserve manifests interesting geological formations. The Western Ghats in general is formed of charnockites that had its origin in the Pre Cambrian era, formed about 4600

PARAMBIKULAM TIGER RESERVE

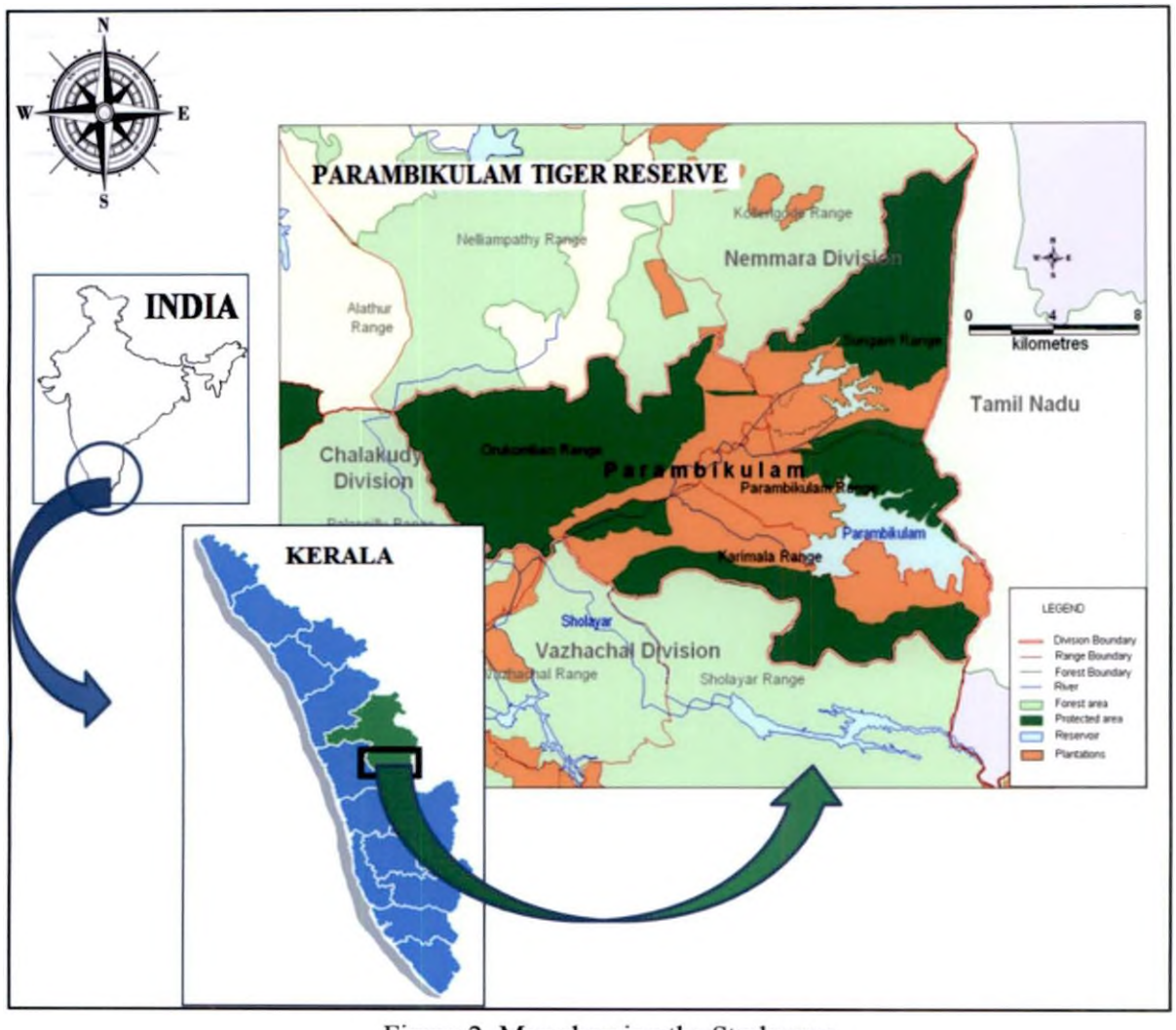


Figure 2. Map showing the Study area

A) Thunacadavu dam

B) Parambikulam dam

C) Peruvaripallam dam

Plate 1. An overview of Parambikulam TR

to 570 million years ago. Major geologic formations are metamorphic where as the intruded ones are igneous in origin (Kaler, 2011).

3.1.2.2 *Rock*

A superfluous observation of the major rock exposures reveals that most of them are banded gneisses, which can be inferred so from its gneissose structure and characteristic foliating nature. Charnockites are seen along the high precipitous slopes. Presence of hypersthane as the major component confirms it as charnockites. Rock specimen, identified as pegmatite, was found from Thunacadavu. Large extent of rocky blanks with outcrops of sheet rock is found in Nelliampathy Hills. Granite fragments were also seen along the foothills, which adhere to the fact that dykes have intruded into the originally metamorphic rocks of the area. Major minerals found in the rocks of the reserve are quartz and feldspars. Biotite Hornblende and Hypersthenes are the other minerals. Mineral deposits of economic importance are not found within the reserve (Kaler, 2011).

3.1.2.3. *Soil*

Different types of soil are met with in the core area of PKTR. It varies from very shallow gravelly soil on the upper slopes to deep filler textured soil on the lower slopes and in the valleys. Alluvial deposits are also met with along the stream and riverbanks. The types of soil found in PKTR include alluvial soil, laterite soil, red soil and the forest and hill soil (Kaler, 2011).

3.1.3 Terrain

The area in general has a slope towards west. The altitude ranges from 430 to 1438m, with the highest peak being Karimalagopuram (1438m) and the lowest, the bank of Chalakkudy river (439m). The Tiger Reserve includes the hilly terrain with undulating plateau. The Nelliampathy hills in the north and west constitute the westerly extension of Anamalais. The hills drop steeply down to Thekkady-Keerapadi in the south-west and raises precipitously up to Pandaravara malai. The hills slope

down gently towards the south to Thunacadavu valley of Sungam Range and the valley is fairly large ascending southwards to Vengolimalai (1224m). The Nelliampathy hills in the north-west gradually descend and open up in Thuthampara, Thellickal and Parambikulam valley forming widest valley areas in the Tiger Reserve. The valley ends up in Poopara and Karimala peaks forming the southern boundary of the Tiger Reserve. The mountain slopes in the area are non-symmetric and non-uniform spreading throughout in different directions (Kaler, 2011).

3.1.4 Climate

3.1.4.1 *Rainfall Pattern and Distribution*

The annual rainfall ranges from 1400-2000mm. The PKTR receives rainfall from both South-West and North-East monsoons. The bulk of the annual rainfall is from the southwest monsoon (Kaler, 2011).

3.1.4.2 *Temperature*

The dry season is from December to May. Absolute extreme range of temperature in the PKTR is 32.8^{0}C. However March is the hottest month with mean monthly temperature of 25.74^{0}C and January is the coolest month with 21.2^{0}C (Kaler, 2011).

3.1.4.3 *Wind*

There are two prevailing winds in the tract blowing in the direction of two monsoon currents. But the northeast winds blowing through the Palghat gap of Western Ghats have desiccating effect and cause heavy leaf fall resulting in accumulation of combustible materials on the ground inducing wild fires.

3.1.5 Water Source

The reserve is blessed with both natural and artificial water sources. There are a number of seasonal watercourses, which carry bulk of water in the rainy season, but invariably dry up during summer. There are a few springs noticed most of which are

perennial, but some linger for a few months and dry up during the hot months. Even if most of the streamlets and some streams dry up during the summer season there are many streams and rivers, which are perennial in nature spreading as a network over the entire area.

These rivers along with their tributaries form a very good water supply and drainage system. The seven water spread areas, viz., reservoirs of Parambikulam, Peruvarippallam, Poringal, Pothundy, Sholayar, Thunakkadavu and Mangalam augment the water supply in this reserve. The PKTR is drained by Thekkady river, Parambikulam river, Kuriarkutti river, Thunacadavu river, Thellickal river, Karappara river, Bagapallam river, Vetti river and Pulikkal river. In addition to this there are other artificial water sources comprising of man-made water holes and check dams are also present.

3.1.6 Vegetation

Natural vegetation of this reserve is a combination of Malabar and Deccan elements. Micro climatic fluctuations coupled with edaphic, topographic and biotic factors have endowed this reserve with rich floral diversity. The PKTR has a variety of habitats, both natural and man-made (Plate 2). Natural habitats include moist deciduous forests to tropical wet evergreen rain forests .Grasslands are seen on the upper reaches of Karimalagopuram and Vengoli hills above 1000m. The man-made habitats are primarily teak plantations, which have an extent of about 90km^2, and were first introduced in the year 1912. In addition to this, a small area of the Tiger Reserve bordering Tamil Nadu is planted with eucalyptus (Menon, 1991).

According to Champion and Seth (1968), the natural vegetation of this reserve can be classified into following forest types. The vegetation map is shown in Figure 3.

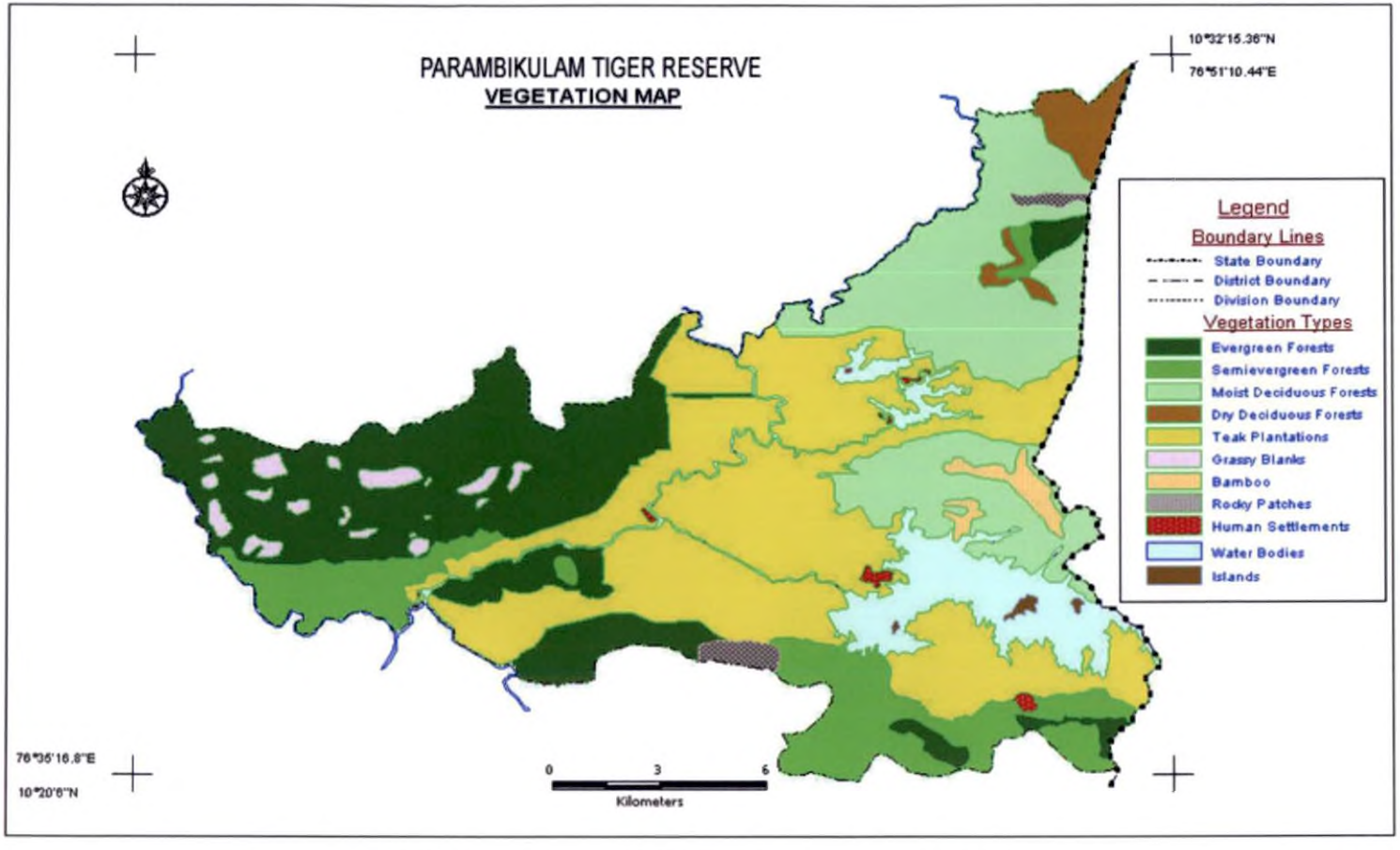


Figure 3. Vegetation map of Parambikulam Tiger Reserve

A) Moist deciduous forest

B) Evergreen forest

C) *Vayals* and Bamboos

D) Teak plantation

Plate 2. Major habitats of Parambikulam Tiger Reserve

3.1.6.1. *West Coast Tropical Evergreen Forests (1A/C4)*

This kind of forests are represented in pockets of Karimala, Pooppara, Medamchal areas of Karimala Range, Muthuvarachal, Orukomban and Padukutty areas of Orukomban Range, Komalappara, Kavala, Myladappan areas of Kavala section in Vellikkulangara Range, Pothumala, Karapara, Pullalamala, Pakuthippalam and Vellattimala areas of Nelliyampathy reserve forests, Malakkippara, Sholayar, Karimalagopuram, Karanthodu, Sheikalmudi of Vazhachal forests. The forest is characterized by the presence of lofty evergreen trees of height up to 45m. The canopy is extremely dense, presence of woody climbers and epiphytes as well as terrestrial orchids, ferns, mosses and other herbaceous flowering plants are also present. Ground vegetation may be generally absent. This type of forest is found in areas wherever humidity and soil moisture conditions are favorable, rainfall is 1500-5000mm or more and altitude is 250 to 1200m.

Tree species like *Palaquium ellipticum, Calophyllum polyanthum, Mesua ferrea, Cullenia exarillata, Dipterocarpus indicus, Artocarpus hirsutus, Hopea parviflora, Vateria indica , Dysoxylum malabaricum, Myristica malabarica, Polyalthia fragrans, Canarium strictum*, etc. form the top storey of these type of forests. While the Middle canopy trees normally attain a height of about 20m or more. The common species are *Aglaia lawii, Diospyros spp. Elaeocarpus glandulous, Garcinia gummi-gutta, Garcinia spicta, Hydnocarpus pentandra*, etc. The lower storey is mainly of *Aporusa lindleyana, Vitex altissima, Elaeocarpus serratus, Cinnamomum verum, Evodia lunu-ankenda, Holigarna arnottiana*, etc. *Calamus spp., Dendrocnide sinuata, Nilgirianthus spp., Elettaria cardamomum* etc. form the ground vegetation.

3.1.6.2. *West Coast Tropical Semi-evergreen Forests (2A/C2)*

These forests appear to be ecological zones in areas where the moist deciduous forests merge with evergreen. The ground floor of semi evergreen forests receives more light than the ground floor of evergreen forests, due to comparatively lighter

canopy. Due to variation in the mixture of species of evergreen forests and deciduous Forests, it becomes difficult to determine the exact status of these forests. Tree species like *Adina cordifolia, Artocarpus hirsutus, Bombax ceiba, Syzygium cumini, Holoptelea integrifolia, Hopea parviflora, Lagerstroemia reginae, Mangifera indica, Miliusa tomentosa, Polyalthia fragrans, Sterculia alata, Tetrameles nudiflora, Vitex altissima,* etc. occupies the top canopy. The Middle Canopy is mainly of *Aporosa lindleyana, Cinnamomum malabaricum, Euodia roxburghiana, Mallotus philipenensis, Xanthophyllum arnottianum* etc. Lower Canopy is very similar to the lower canopy of the evergreen forests. These type of forests are present in Minnampara, Pannimudi Thekkady (Kollengode Range), Kaikatty, Suryanelli and Padagiri of Nelliampathy range, Muthuvarachal, Watchmaram, Mukkumpuzha, Poringal, Manimaruthuthodu etc,.

3.1.6.3. *Southern Moist Mixed Deciduous Forests (3B/C2)*

These forests are found over the ridges and lower slopes having elevation of 100m to 400m where the soil is generally rich. The top canopy remains leafless between March and May. They are found along the ridges and lower slopes covering an area of about 60km^2. Tree species observed in the area include *Haldina cordifolia, Albizia procera, Dalbergia sissoides, D. latifolia, Pterocarpus marsupium, Bauhinia racemosa, Tectona grandis, Dillenia pentagyna, Cassia fistula, Xylia xylocarpa, Pongamia pinnata, Careya arborea, Bombax ceiba, Terminalia paniculata, T. bellirica, T. alata, Phyllanthus emblica, Grewia tiliifolia, Lagerstroemia microcarpa* etc. In the lower reaches of the Vengoli and Karimala these forest types are seen. some areas in Kothala, Pulikkal, Thellikkal, Kottayali also having this forest type.

Naturally growing moist teak was one of the dominant species present in these forests. Kannimara teak tree of girth 6.48m and height 48.75m is one of the largest natural teak trees in Asia. In order to represent the old natural growth of Teak trees a plot has been preserved in Sungam range. It has been observed in Anappady, Elathode and interstate boundary area that the floral elements of dry deciduous forests

consisting of Anogeissus, Bombax, Tamarindus etc., exist within the moist deciduous forests.

Bamboo: *Bambusa arundinacea* is growing profusely in these areas as well as in semi evergreen forests. Gregarious growth is found along streams, reservoir banks and around *vayals* providing sufficient fodder and cover to wildlife. During 1983-84, this bamboo had flowered gregariously. The natural regeneration of bamboo is found satisfactory.

3.1.6.4. *Southern Dry Mixed Deciduous Forests (5A/C3)*

The north east portion of PKTR adjacent to the plains of Tamil Nadu has a small patch of this type of forests covering about an area of 15km^2 around Thekkady and Keerappady. This type of forest is attributed to relatively low rainfall and lower altitude any species growing in this forest type are common to the moist deciduous forests. However their percentage of occurrence is low. These forests are highly prone to fire. Due to repeated forest fires in the past, the forests have degraded and thus a few fire-hardy species are growing in these areas.The dry deciduous forests are dominated by *Anogeissus latifolia* along with other species of the moist deciduous forests. Extensive natural regeneration of *Bambusa arundinacea* are also found in the dry deciduous forests.

3.1.6.5. *Moist Bamboo Brakes (2/E3)*

Bamboo brakes are usually found along streams or on badly drained hollows more or less displacing the trees. More or less continuous cover of one or two species of tall clumped bamboos with occasional stands of Terminalias and other trees are found. The moist bamboo brakes are sufficiently aggressive to be able to hold against tree growth. The latter probably gains ground after good seed years, so that gradually the bamboo ceases to dominate.

Bambusa arundinacea, the only bamboo has come up in highly fertile and well drained soil in Muduvarachal, Pulikkal, Kothala, Pooppara, Vengoli and

Thellikkal areas of this Tiger Reserve. The Natural bamboo brakes also occur along the stream banks, reservoir banks and in sheltered depressions. Vengoli has the largest area of such bamboo brakes in the Tiger Reserve. In Elathode, Thellikkal east and Thekkady areas where habitats are comparatively dry *Dendrocalamus strictus* is growing. *D. strictus* is not growing gregariously like *Bambusa arundinacea*, but it is heavily browsed, so it has acquired the shape of thicket. However, its regeneration is satisfactory.

3.1.6.6. *Ochlandra Reed Brakes (8A/C1/E1)*

The reed grows into impenetrable thickets of 3m to 5m height with scattered over wood of evergreen trees. They are restricted to moist areas. Unlike bamboos, the reed brakes occur in high altitude within evergreen forests. The stream banks and the areas under the shelter of evergreen and semi evergreen forests of Pooppara, Karimala, Pulikkal, Orukomban and Muduvarachal support reed brakes. The reed does not grow gregariously and its height varies between 2-4m. They occur densely along the stream banks. The following species are found in the Tiger Reserve viz., *Ochlandra rheedii*, *Ochlandra travancorica* and *Ochlandra brandisii.*

3.1.6.7. *Southern Montane Wet Grasslands (11A/C1/DS2)*

The grasslands are viewed as a stable degradation stage of vegetation because of recurrent fire, high wind velocity and shallow soil on the top of high altitude undulating terrain. This type of montane wet grasslands are confined to hill-top of Karimalagopuram, Vengoli and Pandaravarai areas of this Tiger Reserve. The vegetation is dominated by grasses along with several herbaceous and sub-shrubby species. The main grass species that are found includes, *Arundinella leptochloa, Chrysopogon asper, Cymbopogon flexuosus, Sacciolepis indica, Themeda triandra, Zenkeria elegans* etc.

3.1.6.8. *Low Altitude Marshy Grasslands -Vayals*

Low altitude marshy grasslands are termed as *Vayals* in Malayalam which is one of the major characteristics of PKTR. They have profuse growth of grasses and sedges providing high-density feeding ground for the wild herbivores during the lean season also. Some of the grass species growing in *vayals* are *Axonopus compressus, Paspalum spp. Eragrostis spp.* and sedges like *Lipocarpa argentea, Fuirena umbellata, Fimbristylis tetragona, Cyprus cuspidatus* and *Rynchospora corymbosa* (coarse and unpalatable species) are also grown in *vayals*.

Moist deciduous tree species of *Butea, Careya, Mitragyna, Adina* and *Terminalia* and Bamboos are seen invading along the fringes of the *vayals*. Similarly the central marshy portions of *vayals* are being invaded by coarse and unpalatable sedges like *Rhyncospora corymbosa*. This reduces the availability of palatable grasses in the *vayals* and hence need special attention.

3.1.6.9. *Teak Plantations*

The valley and the lower hills of the PKTR were planted with teak after clear felling the moist deciduous, evergreen and semi evergreen forests in patches during the period 1921 to 1983. The total area under teak is 8,559.215Ha and its distribution in Karimala, Orukombam, Parambikulam and Sungam ranges. The growth of teak is good in the valley when compared to the elevated locations. Many of these plantations especially, those in the remote corners have not been tended properly. However, many such areas bear a good regeneration of the indigenous species and are preferred by wildlife.

3.1.6.10. *Eucalypts Plantations*

Over a period of time, 81.5Ha of dry deciduous forests in the Elathode section of the PKTR had been converted into eucalypts plantations. Most of these eucalypts plantations have been clear-felled. Only some stock of 1971 and 1973 plantations

were not extracted so far. These plantations however are not of any practical utility for the wildlife since they lack food source even in their under storey.

3.1.7 Fauna

The sanctuary is endowed with very rich and diverse wildlife due to the mosaic pattern of vegetation. The ecotones (edge effects) created at the interspersion of different vegetation types are the vital wildlife habitats. Such junctions are plenty in this sanctuary and are well distributed as well. Same is the case with water resources constituted by the reservoirs, rivers and streams. The abundant herbivore population present in the sanctuary in turn supports a substancial population of predators like tiger and leopard. And also harbour animals such as Sloth Bear, Gaur, sambar deer, elephant, small cats etc

The major herbivores seen in PKTR are Asian Elephants *Elephas maximus*, Gaur *Bos gaurus*, Wild Boar *Sus scrofa*, Sambar Deer *Rusa unicolor*, Spotted Deer *Axis axis*, Barking Deer *Muntiacus muntjac* and Mouse Deer *Moschiola indica* (Easa and Balakrishnan, 1986). The primates seen at PKTR are Lion-tailed Macaque *Macaca silenus*, Bonnet Macaque (*Macaca radiate)*, Nilgiri Langur (*Semnopithecus johnii)*, Common Langur (*Semnopithecus priam)* and Slender Loris (*Loris lydekkarianus)* are seen in the area. Other arboreals include the Malabar Giant Squirrel *Ratufa indica* and Flying squirrel. Carnivores such as Tiger (*Panthera tigris)*, Leopard (*Panthera pardus)*, Sloth Bear (*Melursus ursinus)* and Wild Dog (*Cuon alpines)* could be sighted here. The less charismatic mammals include Porcupine (*Hystrix indica)*, Pangolin (*Manis crassicaudata)*, Black-naped Hare (*Lepsu nigricollis)*, Nilgiri Tahr (*Nilgiritragus hylocrius)* is found in isolated places at Vengoli and Karimalagopuram. The otters seen in the reservoirs of PKTR are Smooth-coated Otter (*Lutrogale perspicillata)* (Easa and Balakrishnan, 1986).

Nameer and Praveen (2006) recorded 230 species of birds from PKTR. The interesting species of birds recorded from PKTR include Lesser Adjutant-Stork, Lesser Fish-Eagle, Mountain Hawk-Eagle, Nilgiri Wood-Pigeon, Orange-breasted

Green-Pigeon, Blue-winged Parakeet, Oriental Bay-Owl, Forest Eagle-Owl, Ceylon Frogmouth, Black-capped Kingfisher, Blue-bearded Bee-eater, Oriental Broad-billed Roller, Malabar Grey Hornbill, Great Pied Hornbill, Great Black Woodpecker, Grey-headed Bulbul, Wynaad Laughingthrush, Nilgiri Flycatcher, White-bellied Blue-Flycatcher and White-bellied Treepie (Nameer and Praveen, 2006).

Sivaperuman *et al.* (2005) recorded 51 species of spiders belonging to 19 families and 34 genera from various habitats of PKTR. Shijo *et al.* (2007) studied the food habits and relative abundance of large carnivores through scat analysis technique in PKTR. Later Jahas and Easa (2008) recorded 19 species of Amphibians and 51 species of reptiles from PKTR.

3.1.8 Tribal Community

There are four tribal communities in PKTR. They are Muduva, Kadar, Malayar and Malai-malasar. They are settled in six colonies such as Kadas colony, Kuriarkutty colony, Earthendam colony, Pooppara colony , Sungam colony and Fifth colony with a total population of 1,110.

3.2 METHODS

3.2.1 Period of Observation

The study was done from Feb 2012 to January 2013. Monthly observations were made during these periods. The study period was divided into two seasons such as monsoon seasons (June to November) and summer season (December to May).

3.2.2 Selection of Site

Stratified random sampling with equal allocation of sampling units was followed to select the study sites. Four strata, the evergreen, moist deciduous, Teak plantation and *Vayals* were selected for studying the ecology of the Sloth Bears in

Parambikulam Tiger Reserve (Table 2). This method is used to get the same level of precision for each stratum. This also gives habitat-specific estimates which may be of greater interest than a single estimate. Though the areas show some semi-evergreen patches, their clear-cut distinction from the evergreen forest was very difficult. Thus the semi-evergreen forests were treated along with the evergreen forests. The places were also selected by observing the presence of termite mound and fruiting trees.

3.3.3 Day transect for indirect evidences

Line transects of two km length were selected randomly in each habitat. The length of each transect were measured using GPS. A total of 72 transects were laid covering a length of 240km. A single transect can run through more than one vegetation type. All transects were walked atleast once and most them repeated every month. During the transect walk, the indirect evidences primarily the scats of the Sloth Bears were recorded (Plate 3). Direct sightings if any were also noted. The data collected through this method were used for estimating the abundance of the species. Apart from the scat evidence the indirect evidences such as termite digging and foot prints were also identified and GPS locations were taken to make distribution map of Sloth Bears.

3.3.4 Camera trap survey

Since Sloth Bears are crepuscular animals camera trapping technique is one of the best tool to study them (Ramesh, 2010). Digital scout cameras having passive infrared sensors for heat and motion detection (Bushnell Trophy Cam model no. 1194436) was used for this survey.Total of 1050 camera trap efforts (15 days X 35 stations= 525 in each season) were made in the Tiger Reserve during the study period (Figure 4). Trap stations were selected randomly with an average inter-station distance of 3 km to cover the study sites. In each location, camera traps were installed singly, near the trails and water sources, tied on trees (Plate 4) or placed with rocks (Plate 5), 60 cms

Plate 3. Line transect survey for indirect evidences

Plate 4. Camera trap fixing in a station

Plate 5.Camera trap set near the den site

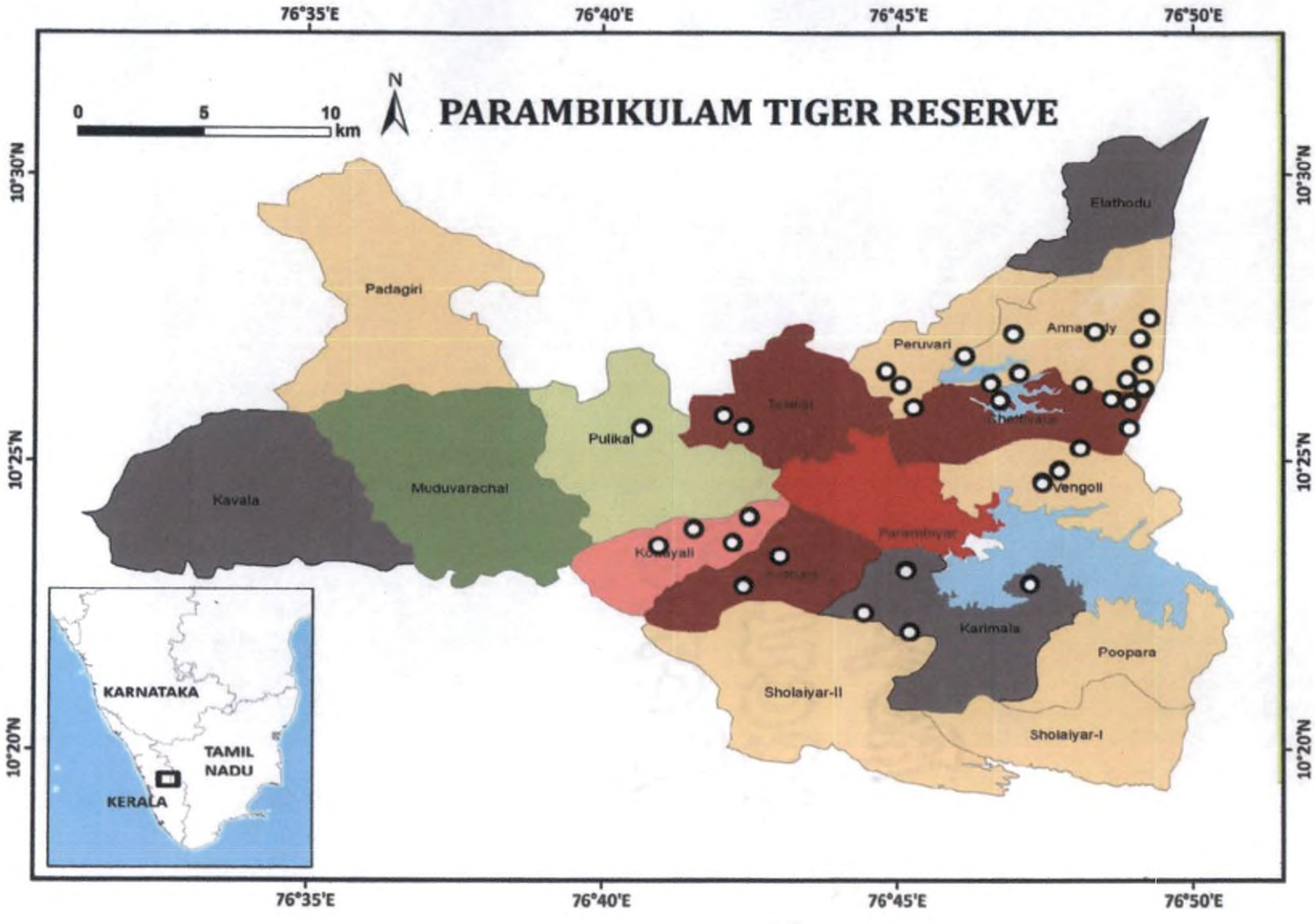


Figure 4. Camera trap stations in Parambikulam Tiger Reserve

above the ground on an average. The camera stations were placed on roads, trails, dens, stream-beds or near water holes to maximize bear photo captures. The camera trap locations were recorded with Garmin GPSMAP 76CSx. At each trapping stations, cameras were checked after 15 days.

Table 2. Study locations and vegetation type of Parambikulam TR

Sl. No.	Transect	Habitat
1	Karimala	Evergreen
2	Orukomban	Evergreen
3	Kariyan schola	Evergreen
4	Vengoli	Moist deciduous
5	Thellikkal	Moist deciduous
6	Anappady	Moist deciduous
7	Kuryarkutty	Plantation
8	Kannimara	Plantation
9	Seechali	*Vayals*
10	Kottala	*Vayals*

3.3.5 Study of the food preference

The food habit of Sloth Bear has been studied with the help of scat analysis technique (Laurie and Seidensticker, 1971; Desai *et al.*, 1997). Because Sloth Bears in this area forage primarily at night, it is very difficult to collect data based on direct observations, and thus depended on scats to provide information on food habits. The

bear scats thus collected were brought to the field station. The scat then segregated into plant matter (seeds, fruits, leaves etc) and invertebrate matter (the remnants of ants, termites, beetles etc). The proportion of each item was estimated using percentage of occurrence, percentage count and percentage dry weight composition in the scats.

3.3.6 Germination studies

Seeds of different species collected from scats were sown in randomised block design in three replications and observations were taken (Koike *et al.*, 2008). The seeds collected from the scat were identified to genus/species level and the seeds were subjected to germination studies to estimate the efficiency of germination of the seeds passed though the digestive tract of the bear. This seeds were compared simultaneously with germination studies on the same seeds collected from the wild.

3.3.7 Phenological studies

At every 200m on the transect, where the scat survey is done, one 10mx10m quadrat was taken. Thus on every 2km transect 10, quadrats was taken. These quadrats were monitored on a monthly basis to study the phenology of all the fruiting trees within these quadrats. The observations were recorded including identification of species, whether in flowers, and whether in fruits.

3.3 DATA ANALYSIS

3.3.1 Estimation of Abundance

Different measures were followed to assess the abundance of a species in the Tiger Reserve (Easa and Balakrishnan, 1986).

3.3.1.1 *Abundance of Sloth Bear*

The abundance of scats (scats / km) was used as an indicator of the abundance of the Sloth Bear since other measures such as camera traps and transect walk for direct sightings give in adequate data (Easa, 2001). Scat abundance was estimated as the number of scats encounter per kilometer surveyed with respect to a habitat or an area. All scats were recorded based on scat morphology and collected for detailed analysis.

$$\text{Abundance} = \frac{\text{Total number of scats obtained}}{\text{Total transect walk in kilometer}} \times 100$$

3.3.2 Habitat use Assessment

3.3.2.1 *Habitat use index (HUI)*

This index was used to understand the habitat preference of a species in an area. This index was developed from the indirect evidences recorded from different habitats of Parambikulam Tiger Reserve. All locations of scats, tracks or other Bear sign were mapped using a Garmin GPS. In this study, the scat evidence was taken to analyse the habitat preference of Sloth Bear. The HUI is calculated by the formula given below

$$\textbf{Habitat Use Index (HUI)} = \frac{N_{HI}}{N_H} \times 100$$

Where, N_{HI} =Total number of indirect evidences (scats) from one habitat

N_H = Total number of indirect evidences (scats) from all the habitats.

3.3.3. Scat analysis

Scats were collected monthly basis from different paths or roads which were selected based on the type of vegetation (Desai *et al.*, 1997). The dietary composition was analysed by using with reference seed collection. Scats were collected from the study area once each month from February 2012 to January 2013. All scats, except

those used for germination studies, were preserved in polythene air tight zip cover. These samples were washed in water and sieved (1 X 1 mm mesh size) to recover seeds (Plate 6). Seed identified in the faeces were verified through comparison with seeds obtained from known plants.

3.3.3.1 ***Frequency of occurrence***

$$\text{Percentage frequency} = \frac{\text{No of scats in which a specific food items occurred}}{\text{Total number of scats}} \times 100$$

Percentage frequency shows the preference of the Sloth Bear to each food type (Baskaran *et al.*, 1997)

3.3.3.2 ***Percentage count of seeds***

$$\text{Percentage count} = \frac{\text{No of seeds of one species}}{\text{Total no of seeds}} \times 100$$

Percentage count is a measure which can be used to indicate the ability of a Sloth Bear to disperse each species of seed.

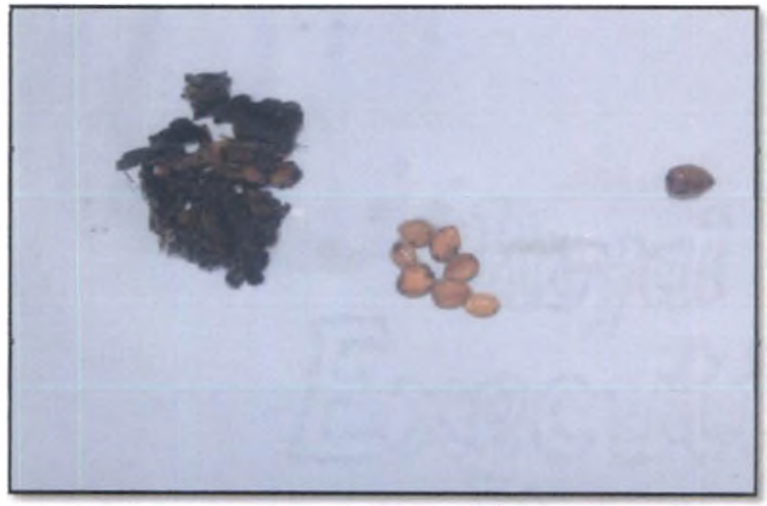
3.3.3.4 ***Percent dry weight***

$$\text{Percent dry weight} = \frac{\text{Dry weight of specific food item in all scats together}}{\text{Total dry weight of all food items for each scat separately}} \times 100$$

3.3.4 Seed germination studies

To assess whether passage of seeds through Sloth Bears affected germination, seeds of *Cassia fistula*, *Zizyphus oenoplina*, *Glycosmis pentaphylla*, *Syzygium cumini* retrieved from Sloth Bear scats were sown in trays . Available seeds of each species were sown 10 cm apart and replicated three times (minimum of 30 seeds for each species). Unpassed seeds collected from intact fruits of each species were germinated in an identical fashion. For each species, germination was observed. Adequate soil moisture was maintained throughout the germination trial. Appearance

A) Washing of Sloth Bear scat



B) Segregated plant components in the bear scat

Plate 6. Scat analysis

of cotyledons was regarded as the sign of germination. The percentage of seeds that germinated was analysed and significant difference was found out using Paired t-test (Sreekumaran and Balakrishnan, 2001).

3.3.5 Time activity pattern of Sloth Bear using Camera trap data

Camera trap data obtained during the study period was used to create activity index of Sloth Bear in Parambikulam Tiger Reserve. The event of capturing an individual Sloth Bear, photographed by the camera traps, was considered to be an independent record of that species based on time and trap location. Duplicate photographs of the same animals were taken during a short period of time (<30 seconds) were discarded and one photo was considered as an independent photo for further analysis. The percentage of activity level was used to indicate whether the study species was nocturnal or diurnal. Time of capture was used to create 24-hr activity patterns of Sloth Bear. Photographs provided information on the date and time of the picture (Ramesh *et al.*, 2012).

To understand the activity pattern of the focal species, based on their time of capture, the day was divided into 8 three-hour periods and the number of photos in each interval was noted (Jenks *et al.*, 2011).

$$\textbf{Daily Activity Index (DAI)} = \frac{\text{Total no. of photos captured of a species}}{\text{No. of photos in a duration}} \times 100$$

The DAI's were plotted against each duration graphically to approximate activity patterns for the species.

3.3.6 Statistical Analysis

The statistical Packages such as SPSS statistics 17, Microsoft Office Excel (Version 2007) were used for statistical analysis of the data collected.

Results

RESULTS

4.1 DISTRIBUTION AND RELATIVE ABUNDANCE OF SLOTH BEAR IN RELATION TO HABITAT AT PARAMBIKULAM TIGER RESERVE

4.1.1 Indirect evidences of Sloth Bear in Parambikulam TR

The distribution of the Sloth Bear was studied by analyzing the indirect evidences such as bear droppings, termite diggings, footprints and camera trappings (Desai *et al.*, 1997; Seidensticker, 1977) (Plate 7). A total of 171 indirect evidences have been obtained on the Sloth Bear from Parambikulam TR during the study period. Of which 112 were in the form of scats, 31 digging locations near termite mounts, 19 images of the Sloth Bear captured in the camera traps and nine footprints (Table 3, Figure 5).

Table 3. Indirect evidences showing the presence of Sloth Bear in Parambikulam TR

Sl. No.	Indirect evidences	No. of evidences
1.	Scats	112 (65.5%)
2.	Diggings near termite mounds	31 (18.13%)
3.	Camera trap evidences	19 (11.11%)
4.	Footprints	9 (5.26 %)
	Total	**171**

(Values in the parenthesis shows the percentage of evidences)

4.1.1.1 *Presence of scats*

A total of 112 scats pertaining to Sloth Bears were identified from 240 km transect walk. Existing trails, forest roads and near den sites which seemed to be used more frequently by Sloth Bears were selected as transects. The proportion of scats seen in various habitats in the Tiger Reserve is shown in the Table 4. Moist deciduous habitat

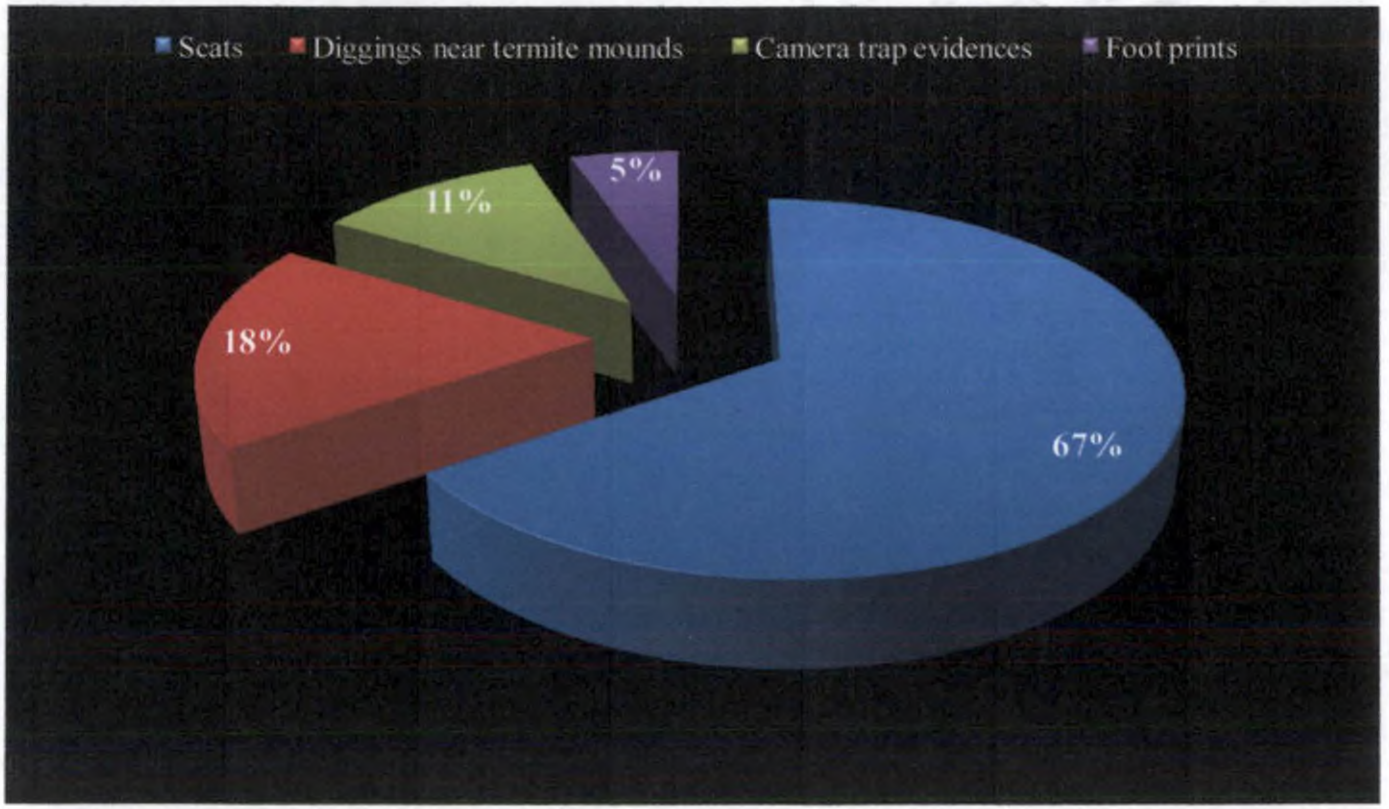


Figure 5. Percentage of indirect evidences showing the presence of Sloth Bear in Parambikulam TR

A) Rear paw of Sloth Bear

B) Front paw of Sloth Bear

C) Scat of Sloth Bear

D) Sloth Bear diggings near termite mound

E) Abandoned cottage evidenced with bear scat

F) Den site of Sloth Bear

Plate 7. Indirect evidences of Sloth Bear observed in the Parambikulam TR

(42.8%) and Teak plantations (38.3%) were seemed to be more scat abundance than any other habitats such as evergreen forest (13.3%) and *Vayals* (5.3%).

Table 4. The proportion of various indirect evidences of Sloth Bear in various habitats in Parambikulam TR

	Habitat (%)			
Indirect evidences	**EG**	**MDF**	**TP**	**V**
Scats	13.3	42.8	38.3	5.3
Diggings near termite mounds	6.4	25.8	67.7	0
Camera trap evidences	10.5	52.6	36.8	0
Footprints	11.1	66.6	22.2	0

EG-Evergreen, **MDF**-Moist deciduous, **TP**-Teak plantation, **V**-Vayals

Scat abundance (scats/kilometer) was calculated as a measure to represent the abundance of Sloth Bear in the Tiger Reserve. Scat abundance in various habitats is given in Table 3. It shows the Sloth Bear was abundant in the moist deciduous (2.1) and teak plantations (1.9) (Table 5 and Figure 6).

Table 5. Abundance (scat encounter/kilometer) of Sloth Bear in various habitats of Parambikulam TR

Sl No	**Habitat**	**Scat encounter/ kilometer**
1.	Moist deciduous forests	2.1
2.	Teak plantation	1.9
3.	Evergreen forests	0.54
4.	*Vayals and* bamboos	0.29

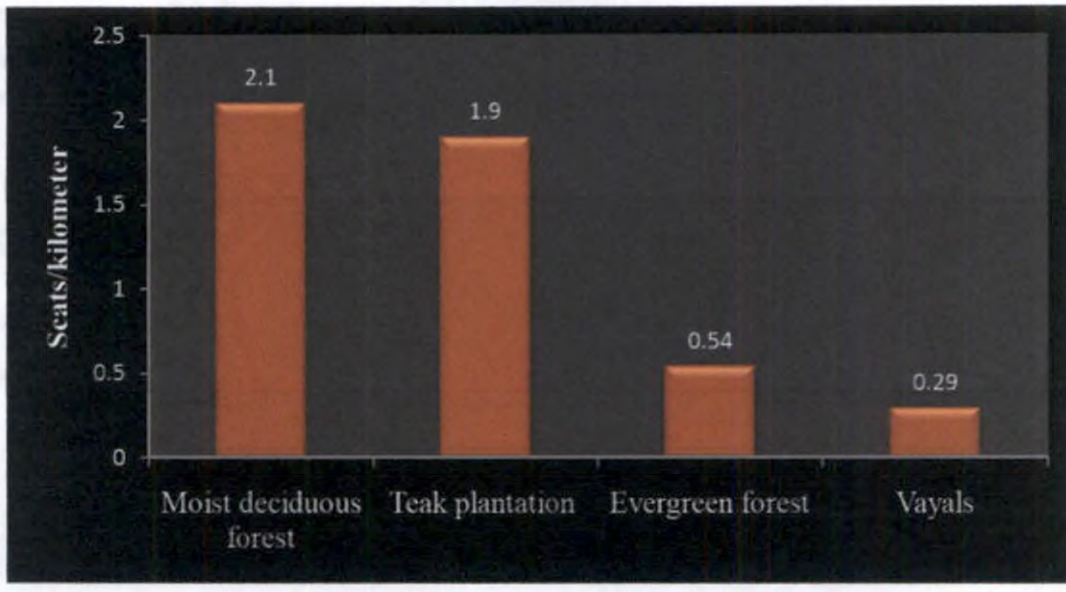


Figure 6. Abundance (scats encounter/ kilometer) of Sloth Bear in various habitats of Parambikulam TR

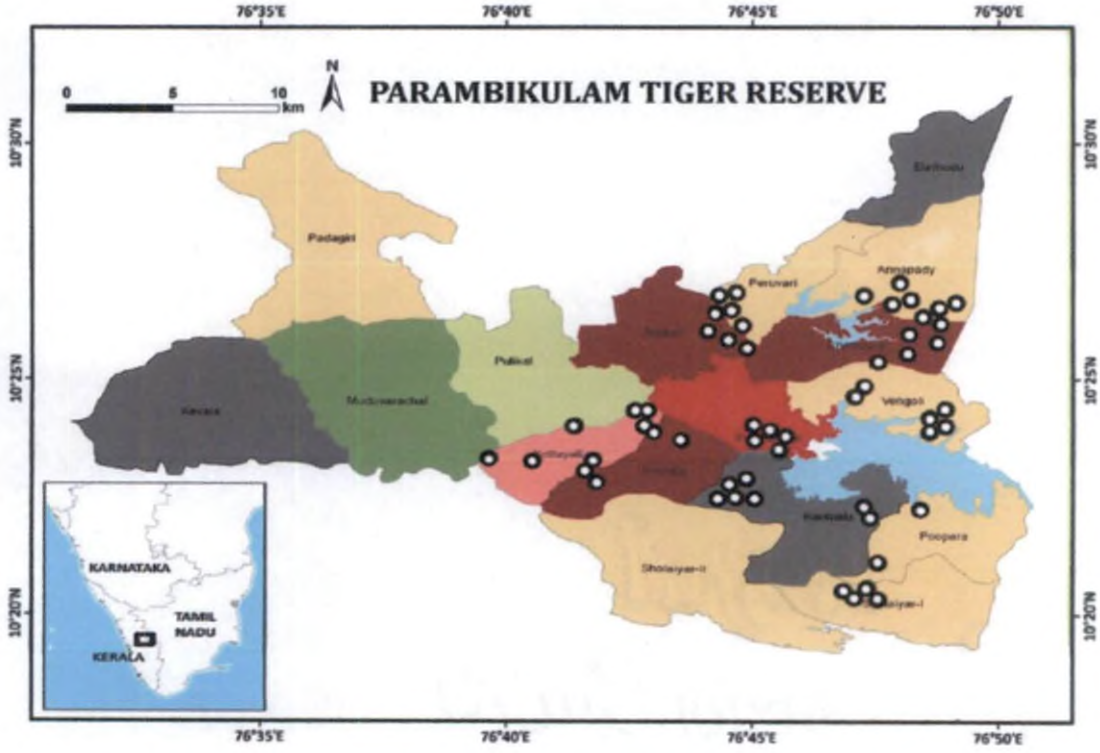


Figure 7. Distribution map showing the presence of scats in Parambikulam TR

4.1.1.2 *Presence of footprints*

The foot prints of Sloth Bear observed in different parts of the Tiger Reserve was taken and identified (Plate 6). A total of nine foot prints were recorded from various habitats. Maximum number of footprints were obtained from the river banks near moist deciduous forest (66.6%) and also from teak plantations near termite mounds (22.2%) (Table 3). It was very difficult to make out the tracks during monsoon season since it washes away. Pugmarks of several other carnivores were also collected from the Tiger Reserve which include Tiger (*Panthera tigris*), common leopard (*Panthera pardus*), wild dog (*Cuon alpinus*) and civets.

4.1.1.3 *Presence of diggings near termite mound*

Several termite mound diggings were observed during the survey. The observation showed that teak plantation had maximum number of termite mound diggings (67.7%) followed by moist deciduous forest (25.8%) (Table 3).

4.1.1.4 *Results from camera- trapping*

Total of 19 camera trap evidences were obtained for Sloth Bears during the study period in which maximum captures obtained from moist deciduous forest and Teak plantations.

Apart from the above indirect evidences other evidences of Sloth Bears presence such as dens and abandoned cottages were also observed (Plate 7), which had a clear evidence of scats at the entrance and also showed the presence of constant use of the den.

4.1.2 Habitat preference of the Sloth Bear in Parambikulam TR

A total of 112 scat samples were collected from Parambikulam TR over a period of one year during the study period (Table 6 and Figure 7). The number of scat samples collected was very low during rainy reasons (Figure 8). However the samples collected were representative of areas and seasons. Out of this 112 scat samples collected the highest number of scat samples obtained during the month of January, April and March. Among the scat samples collected from different places in Parambikulam Tiger Reserve representing different habitat (Table 5, Figure 9) the highest percentage of scats were obtained from Vengoli (25.00%) followed by Kuriyarkutty (17.86%) and Anappady (16.96%).

Table 6. Number of scats collected in different months in Parambikulam TR

Month	No. of scats
February 2012	13
March 2012	18
April 2012	20
May 2012	0
June 2012	2
July 2012	3
August 2012	5
September 2012	9
October 2012	12
November 2012	5
December 2012	4
January 2013	21
Total	**112**

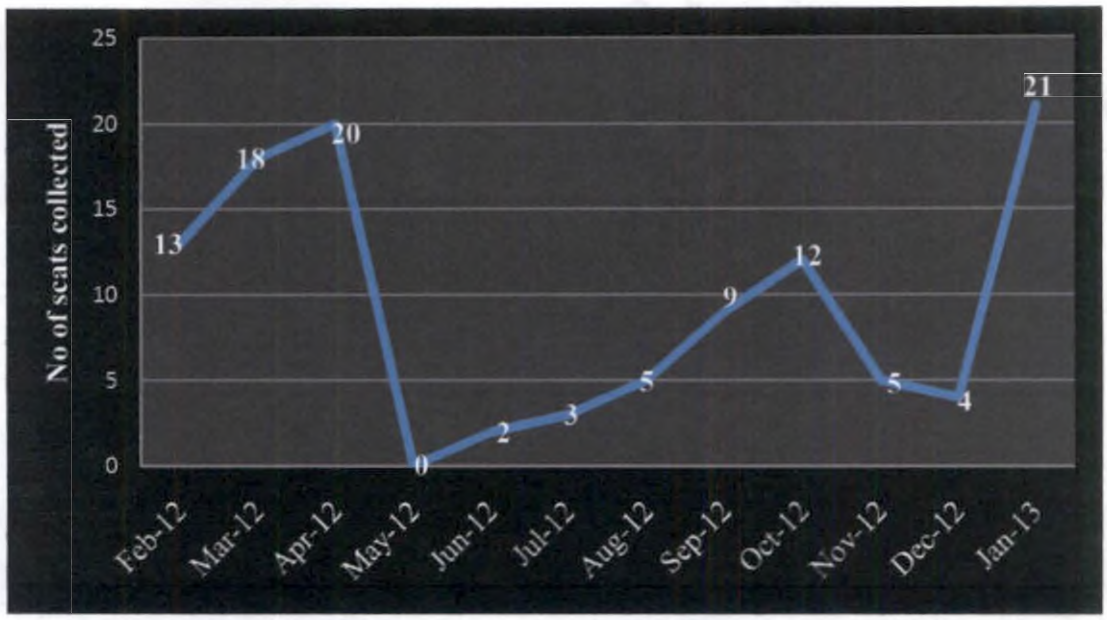


Figure 8. Number of scats collected in different months in Parambikulam TR

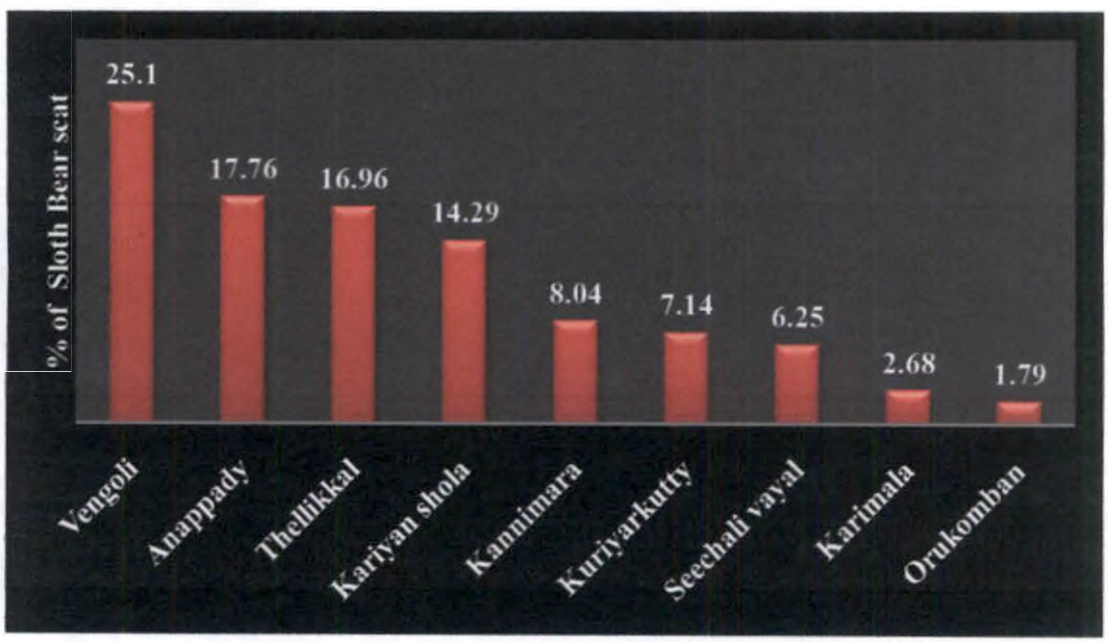


Figure 9. Percentage of scats collected in different places in Parambikulam TR

Table 7. Percentage of scats collected in different places in Parambikulam TR

Place	Altitude(m)	Habitat	% of scats
1. Vengoli (n=8)	930	Moist deciduous	25.0
2. Kuriyarkutty (n=12)	721	Teak plantation	17.86
3. Anappady (n=6)	594	Moist deciduous	16.96
4. Thellikkal (n=4)	499	Moist deciduous	14.29
5. Kannimara (n=12)	515	Teak plantation	8.04
6. Kariyan shola (n=6)	521	Evergreen	7.14
7. Seechali (n=6)	502	Vayal	6.25
8. Karimala (n=5)	792	Evergreen	2.68
9. Orukomban (n=4)	478	Evergreen	1.79

(n= Number of transects taken)

4.1.2.1 *Habitat Use Index (HUI)*

The Habitat Use Index (HUI) of Sloth Bear in Tiger Reserve was developed from the scat evidences observed in all the habitats. The distribution of the scat evidences of Sloth Bear in different habitat types is given in Table 8. Results of distribution of scats in different habitats are given in Figure10. The higher percentage of scats was collected from moist deciduous forest (42.32%) followed by Teak plantation (38.25%). Other habitats such as Evergreen forest and *Vayals* and bamboos have contributed about 13.18% and 6.25% respectively.

The Habitat Use Index by Sloth Bear at Parambikulam TR shows that they mostly prefer moist deciduous forests and teak plantations than other habitats of Parambikulam Tiger Reserve.

Table 8. Habitat use index (**HUI**) of Sloth Bear in Parambikulam TR

Sl.no	**Habitat**	**Habitat use index (HUI)**
1.	Moist deciduous forests	42.32
2.	Teak plantation	38.25
3.	Evergreen forests	13.18
4.	*Vayals and* bamboos	6.25

4.1.4. Seasonal distribution of scats

Seasonal distribution of scats during monsoon and summer season is given in the Table 9 and Figure 11. Teak plantation had high number of scats compared to all other habitats during monsoon season (58.06%). During the summer season maximum scats were collected from moist deciduous forest (44.3%). Evergreen and *Vayals* showed less number of scats in all the seasons.

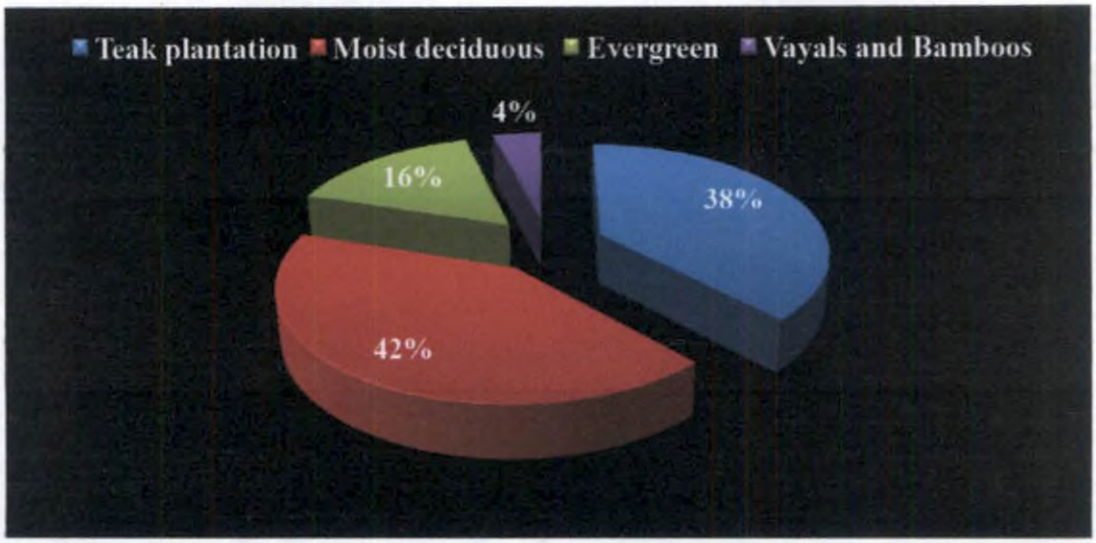


Figure 10. Habitat use index (HUI) of Sloth Bear in Parambikulam TR

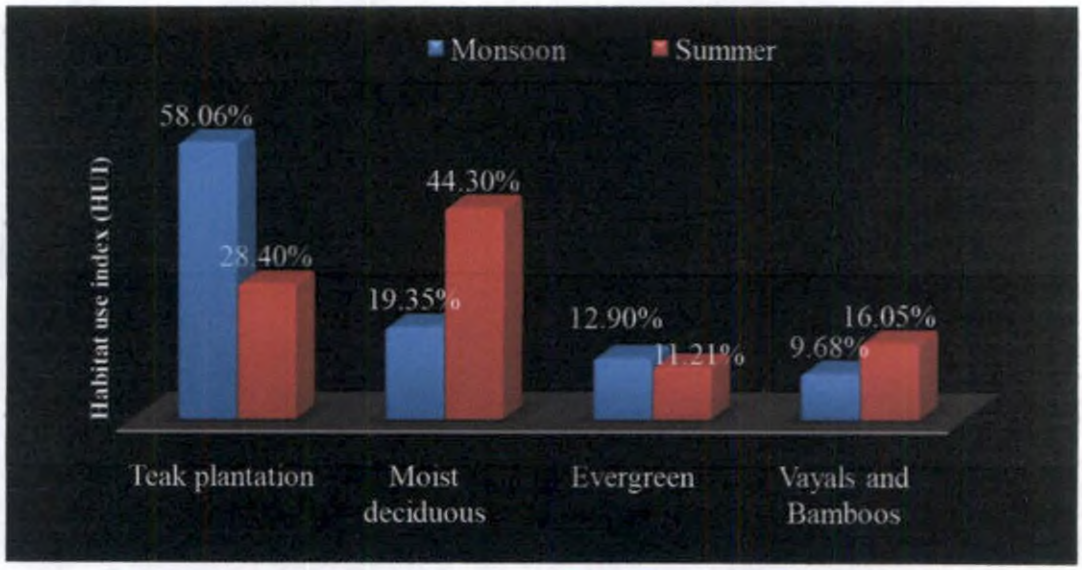


Figure 11. Seasonal Habitat use index (HUI) of Sloth Bear in Parambikulam TR

Table 9. Seasonal habitat use index (HUI) of Sloth Bears in Parambikulam TR

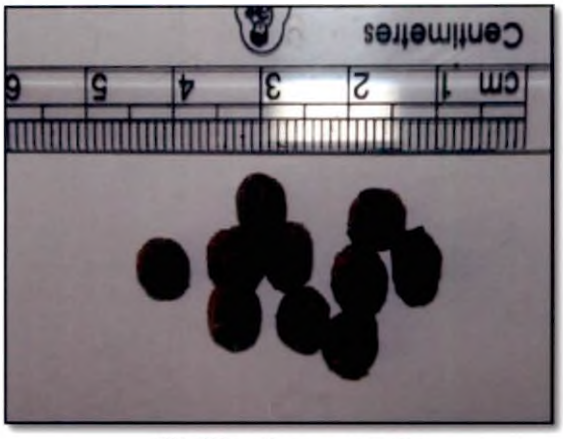
Sl no.	Habitat	Monsoon	Summer
1.	Teak plantation	58.06	28.4
2.	Moist deciduous forest	19.35	44.3
3.	Evergreen forest	12.90	11.21
4.	*Vayals* and Bamboos	9.68	16.05

4.2 FOOD AND FEEDING HABITS OF SLOTH BEAR AT PARAMBIKULAM TIGER RESERVE

4.2.2 The composition of food of Sloth Bear at Parambikulam TR

The food and feeding habits of Sloth Bear at Parambikulam TR was studied by analyzing the scats collected from representative habitats (Desai *et al.*, 1997). Out of 112 scats analyzed, 81 scats (72.32%) were obtained during summer seasons and 31 scats (27.68%) during monsoon seasons. The present study recorded a total of 15 food items in the Sloth Bear scats, which consisted of plant as well as animal matter. The plant matter consisted of ten plant species belonging to nine families and unidentified grass blades (Plates 8a and 8b), while the animal matter included termites, ants, bees, beetles (Plate 9) and other unknown animal matter (hairs), latter of which is quite negligible in quantity as it is obtained from just two (<2%) out of the 112 scats. The plant species consumed included *Cassia fistula, Zizyphus oenoplina, Glycosmis pentaphylla, Holigarna arnottiana, Ficus spp., Syzygium cumini, Grewia tiliifolia, Mangifera indica, Bridelia retusa* and *Cordia dichotoma.* On the basis of frequency of occurance the plant species *Cassia fistula* (32.35%) dominated the diet of Sloth Bear at Parambikulam TR which was followed by *Zizyphus oenoplia* (25%) and *Glycosmis pentaphylla* (14.71%) (Table 10 and Figure 12). While among the animal matter the

A) *Cassia fistula*



B) *Zizyphus oenoplia*

C) *Glycosmis pentaphylla*

D) *Grewia tiliifoila*

E) *Syzygium cumini*

F) *Cordia dichotoma*

Plate 8a. Plant matter observed in the bear scat

G) Ficus seeds along with Bear scat

H) *Holigarna arnottiana*

I) Mango seeds (*Mangifera indica*)

J) *Bridelia retusa*

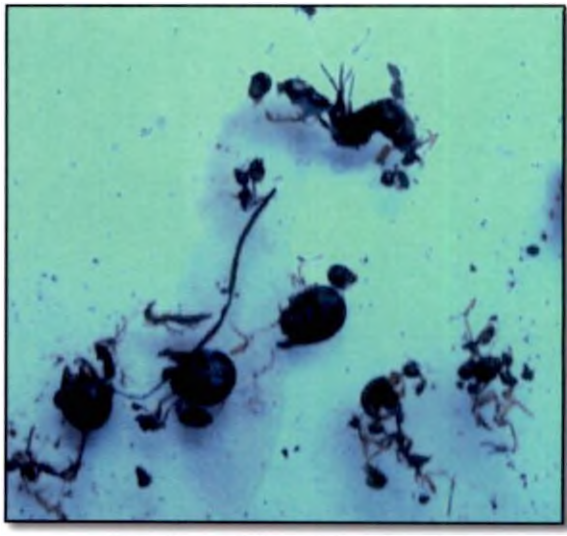
K) Unidentified grass blades in the Bear scat

Plate 8b. Plant matter observed in the bear scat

A) Beetles (Magnification:4x)

B) Termites (Magnification:4x)

C)Termite observed near bear digging



D) Ants (Magnification:4x)

Plate 9. Animal matter in the Bear scat

black ants (60.16%) dominated the diet followed by termites (43.75%) and beetles (12.50%) (Table 11 and Figure 13). The following three plants were fed by the Sloth Bear only during rainy season, which include *Syzygium cumini, Grewia tiliifolia* and *Mangifera indica.*

Table 10. Percentage of occurrence of plant matter in the scats of Sloth Bears by season in Parambikulam TR

Percentage of Occurrence (%)			
Food item	Summer (n=81)	Monsoon (n=31)	Annual (n=112)
Cassia fistula	32.36	0	32.36
Ficus spp.	5.88	0	5.88
Zizyphus oenoplina,	25	0	25
Bridelia retusa	1.4	0	1.4
Syzygium cumini	0	4.41	4.41
Glycosmis pentaphylla	14.7	0	14.7
Grewia tiliifolia	0	2.9	2.9
Holigarna arnottiana	7.35	0	7.35
Cordia dichotoma	1.4	0	1.4
Mangifera indica	0	4.41	4.41

(n= number of scats collected)

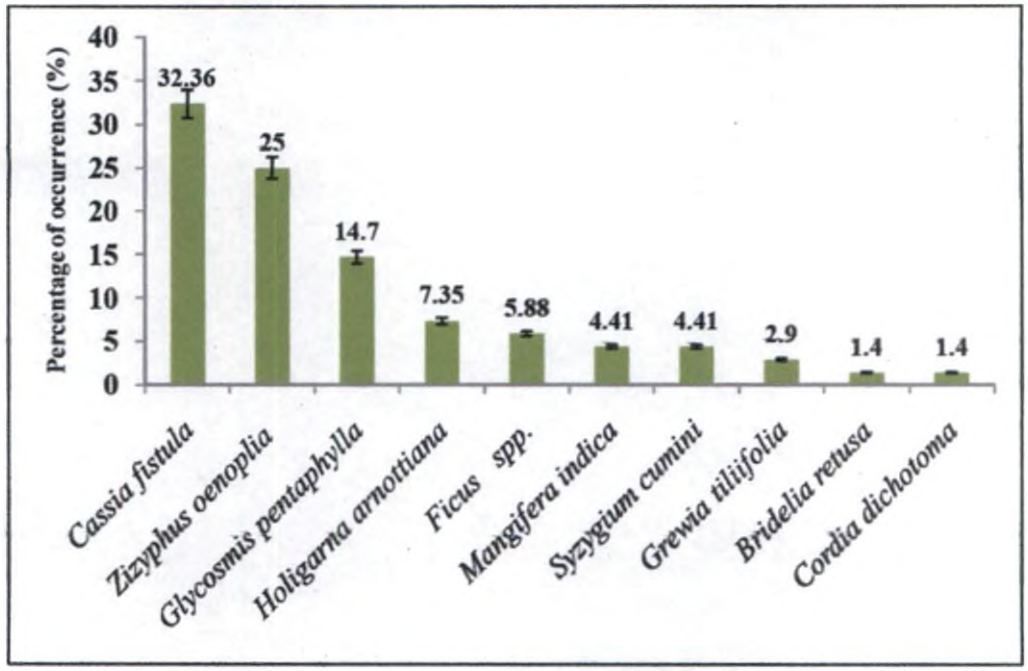


Figure 12.Percentage of occurrence of plant matter in scats of Sloth Bear in Parambikulam TR

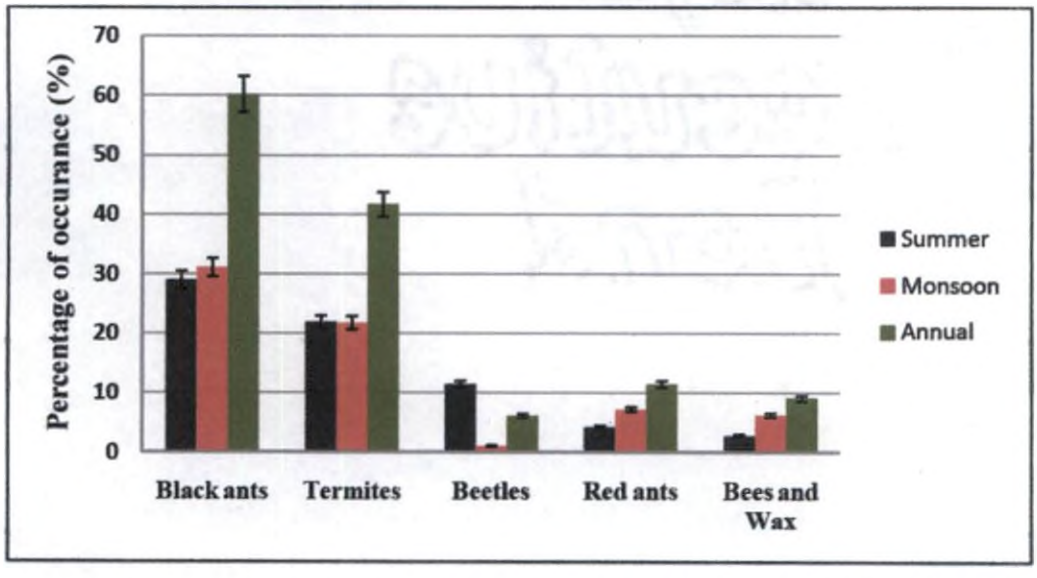


Figure 13. Percentage of occurrence of animal matter in scats of Sloth Bear in different months during summer season and monsoon season in Parambikulam TR

Table 11. Percentage of occurrence of animal matter in the scats of Sloth Bears by season in Parambikulam TR

Percentage of Occurrence of animal matter (%)			
Food item	**Summer (n=81)**	**Monsoon (n=31)**	**Annual (n=112)**
1. Family. Formicidae (Black ant)	29.06	31.10	60.16
2. Fam. Formicidae, (Termites)	21.95	21.80	41.73
3. Order: Coleoptera Beetles	11.46	1.04	6.15
4. Fam. Formicidae (Red ant)	4.25	7.20	11.47
5. Order: Hymenoptera Bees and Wax	2.85	6.25	9.08

(n= number of scats collected)

4.2.1 Seasonal variation in food and feeding of Sloth Bear

The seasonal variation of plant matter in the food of Sloth Bear at Parambikulam TR is given in Figure 14. It can be seen that Sloth Bear fed upon the *Zizyphus oenoplia* between the months of October to March, while *Glycosmis pentaphylla* was fed between October to December and again in March. The plants such as *Syzygium cumini, Grewia tiliifolia* and *Mangifera indica* were fed duirng the monsoon period between the months of June to July 2012. The overall seasonal dietary variation in the food and feeding pattern of Sloth Bear is given in Figure15. Though Sloth Bear feed on plant as well as animal matter, the animal matter dominate food items. However, the animal matter is almost exclusively is that of invertebrates,

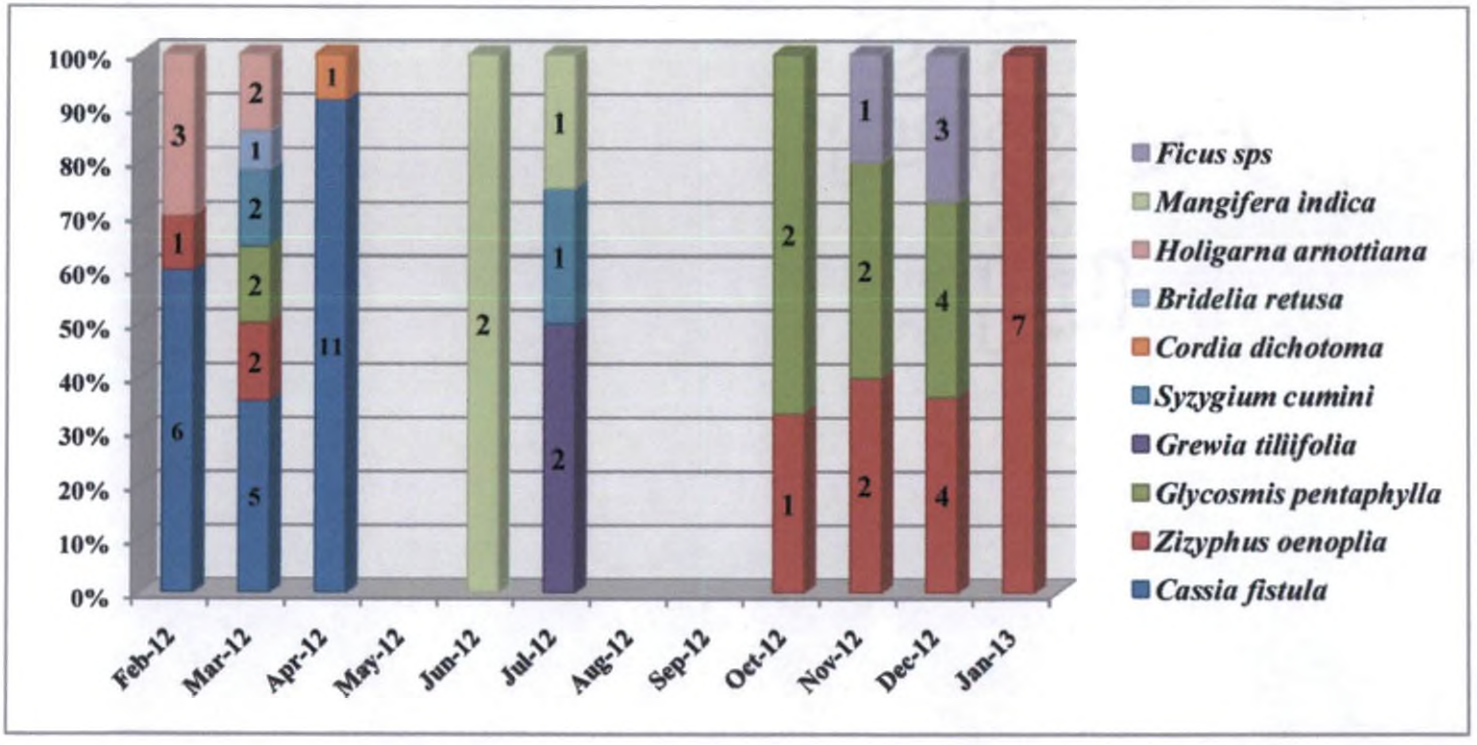


Figure 14. Freequency of occurrence of different plant species in different months in Parambikulam TR

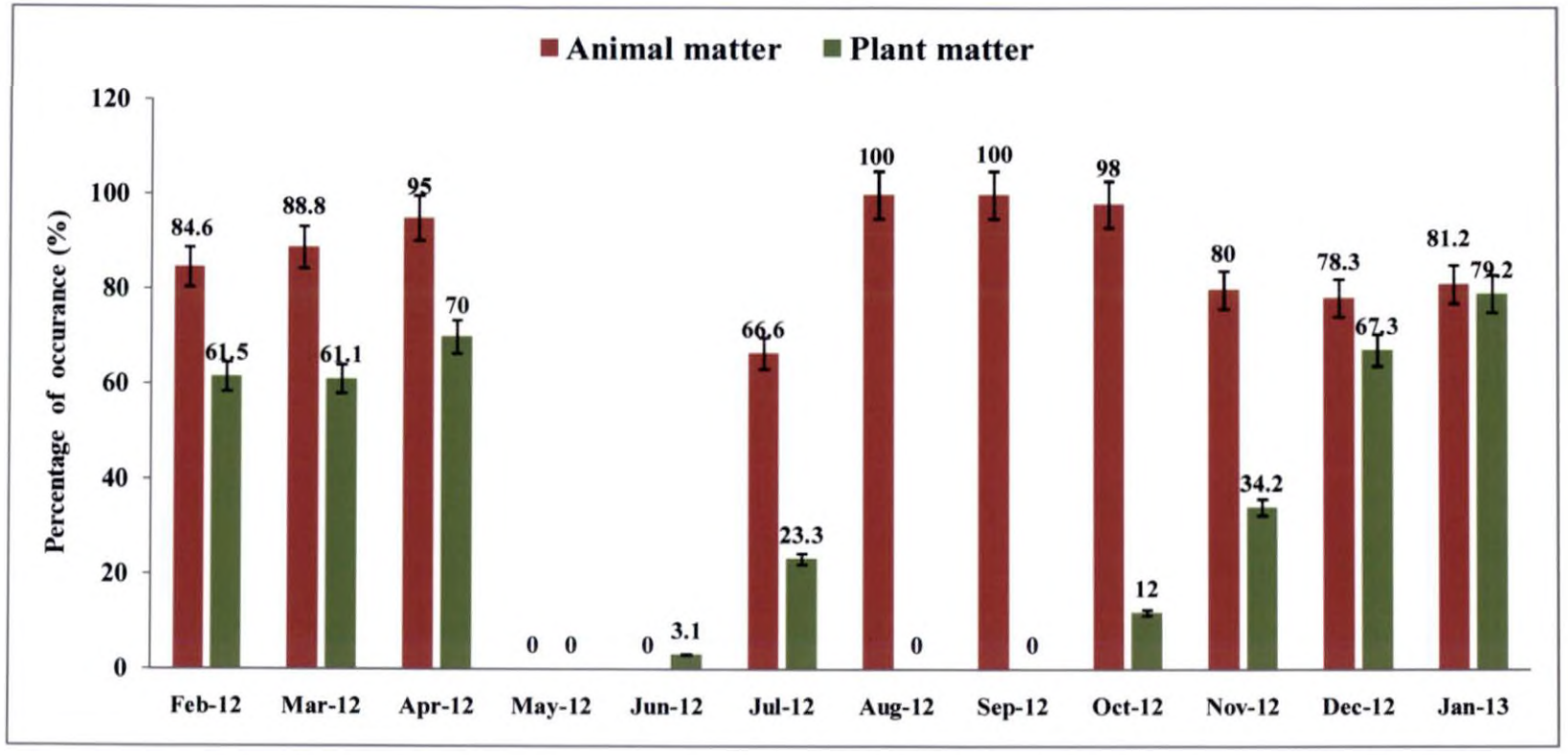


Figure 15. Percentage of occurrence of food items in scats of Sloth Bear in different months during February 2012- January 2013 in Parambikulam TR

barring few hair samples. It can also be seen from the Figure 15 that Sloth Bear fed almost exclusively on the animal matter during the month of August and September, while the plant component in the food item consumed increased in the month of January.

4.2.2 Percent dry weight composition of food items

The dry weight composition of food items consumed by the Sloth Bears at Parambikulam TR is given in Table 12. In the dry weight composition also the three dominant plants consumed by Sloth Bear at Parambikulam TR were *Zizyphus oenoplina, Cassia fistula and Glycosmis pentaphylla.*

Table 12. Percent dry weight composition of food items in the scats of Sloth Bears by season in Parambikulam TR

Dry weight percentage in scats, plant matter			
Plant species	**Summer (n=81)**	**Monsoon (n=31)**	**Annual (n=112)**
1. *Zizyphus oenoplina*	5.91	0	5.91
2. *Cassia fistula*	4.91	0	4.91
3. *Glycosmis pentaphylla*	3.69	0	3.69
4. *Mangifera indica*	0	0.91	0.91
5. *Holigarna arnottiana*	0.76	0	0.76
6. *Syzygium cumini*	0	0.72	0.72
7. *Ficus spp.*	0.58	0	0.58
8. *Grewia tiliifolia*	0	0.54	0.54
9. *Cordia dichotoma*	0.31	0	0.31
10. *Bridelia retusa*	0.04	0	0.04

(n=number of scats collected)

4.3 EFFICIENCY AND EFFECTIVENESS OF SEED DISPERSAL

4.3.1 Seed dispersal by Sloth Bear

The Sloth Bear was found to consume the fruits and seeds of the following plants (Table13). These species belong to the nine families such as Anacardiaceae, Boraginaceae, Euphorbiaceae, Fabaceae, Moraceae, Myrtaceae, Rhamnaceae, Rutaceae and Teliaceae. It was found that more than 80% of the fruits consumed by the Sloth Bear having the fruit type of drupes followed by berries which is an indication of fruit dispersal syndrome for mammalochory. The description of Plant species obtained from the scats is given below (Chacko *et al.*, 2002).

1*) Holigarna arnottiana*

A medium to large sized spreading evergreen tree distributed throughout in Western-ghats and grows up to 50 meters in height. It belongs to the family Anacardiaceae. Flowers small found in axillary panicles. Fruits are drupes, dark green when immature and turn to dark purple when ripe, containing single seed.

2) *Mangifera indica*

Medium to large sized tree belongs to the family Anacardiaceae. Fruit is drupe and edible. in the wild mainly dispersed by mammals especially monkeys and bears. Green when immature and turn to bright coloured, or red when ripe.

3*) Glycosmis pentaphylla*

Small erect shrubs belong to the family Rutaceae. Leaves 3-7-foliolate; leaflets sub opposite, Fruit is Berry ovoid, white turning pink when ripe, 1-2-seeded.

4) *Cassia fistula*

It is a fast-growing, deciduous tree belongs to the family Fabaceae. In its natural habitat, the fruits (legumes) ripen in the months of April and May. Outside its habitat the season for ripening varies. Fruits remain hanging on the tree for two or

three months after ripening the green pods turns to black. Each fruit contains numerous seeds. The seed coat is light brown, smooth, shiny, and cartaceous with fracture lines.

5) *Zizyphus oenoplia*

It is a spreading, sometimes climbing, thorny shrub growing to 1.5 m in height. The leaves are simple, alternate, ovate-lanceolate, acute and oblique. The fruit is a globose drupe, black and shiny when ripe, containing a single seed.

6) *Grewia tiliifolia*

A large tree belongs to the family tiliaceae found in moist deciduous tracts of South East Asia. Leaves simple, alternate. Fruit is drupe, globose to sub globose, reddish-purple when ripe, 2-lobed, and sparsely hairy.

7) *Cordia dichotoma*

Cordia dichotoma is a small to moderate-sized deciduous tree belongs to the family Boraginaceae. Flowers are short-stalked, bisexual, and white in colour which opens only at night. The fruit is a yellow or pinkish-yellow shining globose which turns black on ripening and the pulp gets viscid.

8) *Syzygium cumini*

It is a medium to large sized trees belongs to the family Myrtaceae and start flowering from March to April. The flowers of are fragrant and small, about 5 mm in diameter. The fruits develop by May or June and resemble large berries. The fruit is oblong, ovoid, starts green and turns pink to shining crimson black as it matures.

9) *Bridelia retusa*

Medium sized tree belongs to the family Euphorbiaceae and distributed throughout India. Fruit is globose, fleshy sweetish drupe, about the size of a pea, purple-black.

10) Ficus *spp.*

Ficus are keystone species in many tropical ecosystems. Their fruits are a key resource for most of the frugivores and characterized by its unique fruit type syconium.

Table 13. Fruit and seed characteristics of plant species collected from bear scat in Parambikulam TR

Species	Family	Fruit type
1. *Holigarna arnottiana*	Anacardiaceae	Drupe
2. *Mangifera indica*	Anacardiaceae	Drupe
3. *Cordia dichotoma*	Boraginaceae	Drupe
4. *Bridelia retusa*	Euphorbiaceae	Drupe
5. *Cassia fistula*	Fabaceae	Lomentum
6. *Ficus spp.*	Moraceae	Syconium
7. *Syzygium cumini*	Myrtaceae	Berry
8. *Zizyphus oenoplina,*	Rhamnaceae	Drupe
9. *Glycosmis pentaphylla*	Rutaceae	Berry
10. *Grewia tiliifolia*	Teliaceae	Drupe

The numbers of seeds that are being passed through the droppings of the Sloth Bear at Parambikulam TR between February 2012 to January 2013 are given in Table 14. The maximum seeds were dispersed of the plants such as *Zizyphus oenoplina* (n=369), *Cassia fistula* (n=287) and *Glycosmis pentaphylla* (n=215). This is an indication that the Sloth Bear helps in the seed dispersal at least of these ten plant species which also coincide with the general fruiting and flowering phenology of the fruit trees or shrubs in the tiger reserve (Table 15). The phenology of three dominant plant species consumed by Sloth Bear in Parambikulam TR during the study period

as shown in the Plate10, *Cassia fistula* had unripened pod during August to November which were ripening in February March and April. It was without leaves during March and April when it had mature pods and the tree was full of yellowish flowers. *Glycosmis pentaphylla* started flowering in August extending through October and November. The fruits of *Glycosmis pentaphylla* were mature by December, January and February. From April onwards the plants were completely fruit less. During August *Glycosmis pentaphylla* started flushing new leaves and flowering started. *Zizyphus oenoplia* was with mature fruits in December, January and February. In March the leves started falling profusely. In April *Zizyphus oenoplia* was without leaves. In Augest flushing started followed by flowering. The unripened fruits are conspicuous by September and almost mature fruits of Zizyphus were observed during December and January.

Table 14. Number of seeds in Sloth Bears scat by season in Parambikulam TR

Food item	**Number of seeds**		
	Summer (n=81)	Monsoon (n=31)	Annual (n=112)
Zizyphus oenoplina	369	0	369
Cassia fistula	287	0	287
Glycosmis pentaphylla	215	0	215
Holigarna arnottiana	44	0	44
Grewia tiliifolia	0	31	31
Bridelia retusa	24	0	24
Syzygium cumini	0	42	42
Mangifera indica	0	33	33
Cordia dichotoma	16	0	16

(n = number of scats collected)

Table 15. Phenology of plant species consumed by Sloth Bear in Parambikulam TR

Month	*Cassia fistula*	*Zizyphus oenoplia*	*Glycosmis pentaphylla*	*Grewia tiliifolia*	*Syzygium cumini*	*Cordia dichotoma*	*Bridelia retusa*	*Holigarna arnottiana*	*Mangifera indica*	*Ficus sp.*
Feb 2012	FL	FR	-	-	FL	-	FR	FR	FL	FR
Mar 2012	FR	-	-	-	FR	-	FR	FR	FL	-
Apr 2012	FR	-	-	-	FR	FL	-	FR	FL	-
May 2012	-	-	-	FL	-	FL	-	-	FR	-
Jun 2012	-	-	-	FL	-	FR	-	-	FR	-
July 2012	-	-	-	FR	-	FR	-	-	FR	-
Aug 2012	-	FL	FL	FL	-	FR	-	-	-	FL
Sep 2012	FR	FL	FL	-	-	-	-	-	-	FL
Oct 2012	FR	FR	FR	-	-	-	FL	-	-	FL
Nov 2012	-		FR	-	-	-	FL	-	-	FR
Dec 2012	FL	FR	FR	-		-	FR	-	-	FR
Jan 2013	FR	FR	FR	-	FL	-	FR	-	FL	FR

(**FL**- Flowering , **FR**- Fruiting, **-** = Flowering & Fruiting not observed)

Zizyphus oenoplia
(Aug- Sept)

Zizyphus oenoplia
(Oct- Dec)

Zizyphus oenoplia
(Nov- Feb)

Glycosmis pentaphylla
(Aug- Sep)

Glycosmis pentaphylla
(Aug- Sep)

Glycosmis pentaphylla
(Oct-Jan)

Cassia fistula **(Dec- Apr)**

Cassia fistula **(Aug-Nov)**

Cassia fistula **(Jan-Apr)**

Plate 10. Phenology of dominant food species in the Parambikulam TR

4.3.2 Germination percentage of the Sloth Bear fed seeds

Bears fed only on mature fruits and so obtained high-quality nutrients (Koike *et al.*, 2008). Intact seeds from fleshy-fruited species occurred frequently in the scats of Sloth Bears. Germination tests showed that ingestion of fruits by the bears caused no physical damage to the seeds. Ingested seeds showed (Table16) significant difference in germination percentage from seeds, whose pulp was manually removed. These results indicate that bears are potentially effective dispersers from a qualitative perspective and, to some extent, from a quantitative perspective.

Table 16.Comparison of germination percentage of seeds collected from bear scats in Parambikulam TR

Species	Seeds (Passed)	Seeds (Unpassed)	t- value
Glycosmis pentaphylla (n=20)	77.73	27.73	3.99*
Zizyphus oenoplia (n=22)	56.2	41.6	2.63*
Syzygium cumini (n=12)	86.6	88.3	ns
Cassia fistula (n=24)	50.3	59.7	1.09*

(n= no of seeds sown in each replication, *significant at 0.05, ns- non significant)

The germination experiment showed that in all the cases the germination percentage was more than 50% in the case of the seeds that were ingested by the Sloth Bear and passed through the alimentary canal of the Sloth Bear (Table16). However, when comparing the germination success of the bear-fed seeds with the germination success of the non-bear fed seeds, it can be seen that the bear-fed seeds germinated better in the case of *Glycosmis pentaphylla* and *Zizyphus oenoplia,* while in the case of

Syzygium cumini, the germination percentage was almost the same for both the passed and unpassed seeds. In the case of *Cassia fistula* however, the germination percentage was slightly higher in the unpassed seeds than the passed seeds.

4.4 TIME ACTIVITY PATTERN OF SLOTH BEAR USING CAMERA TRAP DATA

4.4.1 Camera trap success of Sloth Bear at Parambikulam TR

The camera-trap surveys were designed to photo-capture terrestrial carnivores. Our survey yielded 19 photographs of Sloth Bears of which most of them are captured during summer season. The survey produced a total of 1050 trap efforts: 525 for summer season and 525 for monsoon season (Table 17). The Sloth Bear was camera trapped 19 times in a total camera trap effort of 1090, with a capture success of 4.04% for a period of one year. The details on the camera trapped images of Sloth Bear from Parambikulam TR during the study period are given in Table 18. Mostly the bear was seen alone (73.68%), indicating the solitary nature of the Sloth Bear and on two occasions a mother and cubs were seen (Plate11a and Plate11b). One of the camera trap also evidenced with carrying the cub by mother on its back while moving showing the parental care of the animal (Plate 11b, E). The Sloth Bear was camera trapped mostly from Anappadi (4 times) followed by Tellikkal and Vengoli (three times each). The map showing the success camera trap locations are given in the Figure 16.

The camera traps also documented the presence of other mammals such as Tiger (*Panthera tigris*), Leopard (*Panthera pardus*), Leopard cat (*Prionailurus bengalensis*), Wild Dog (*Cuon alpinus*) Asian Elephant (*Elephas maximus*), Sambar Deer (*Rusa unicolor*), Spotted Deer (*Axis axis*), Barking Deer (*Muntiacus muntjak*), Mouse Deer (*Moschiola indica*), Gaur (*Bos gaurus*), Wild Boar (*Sus scrofa*), Indian Hare (*Lepus nigricollis*), Brown palm civet (*Paradoxurus jerdoni)*, small Indian civet (*Viverricula indica)*, Indian Crested Porcupine *(Hystrix indica)*, Bonnet Macaque

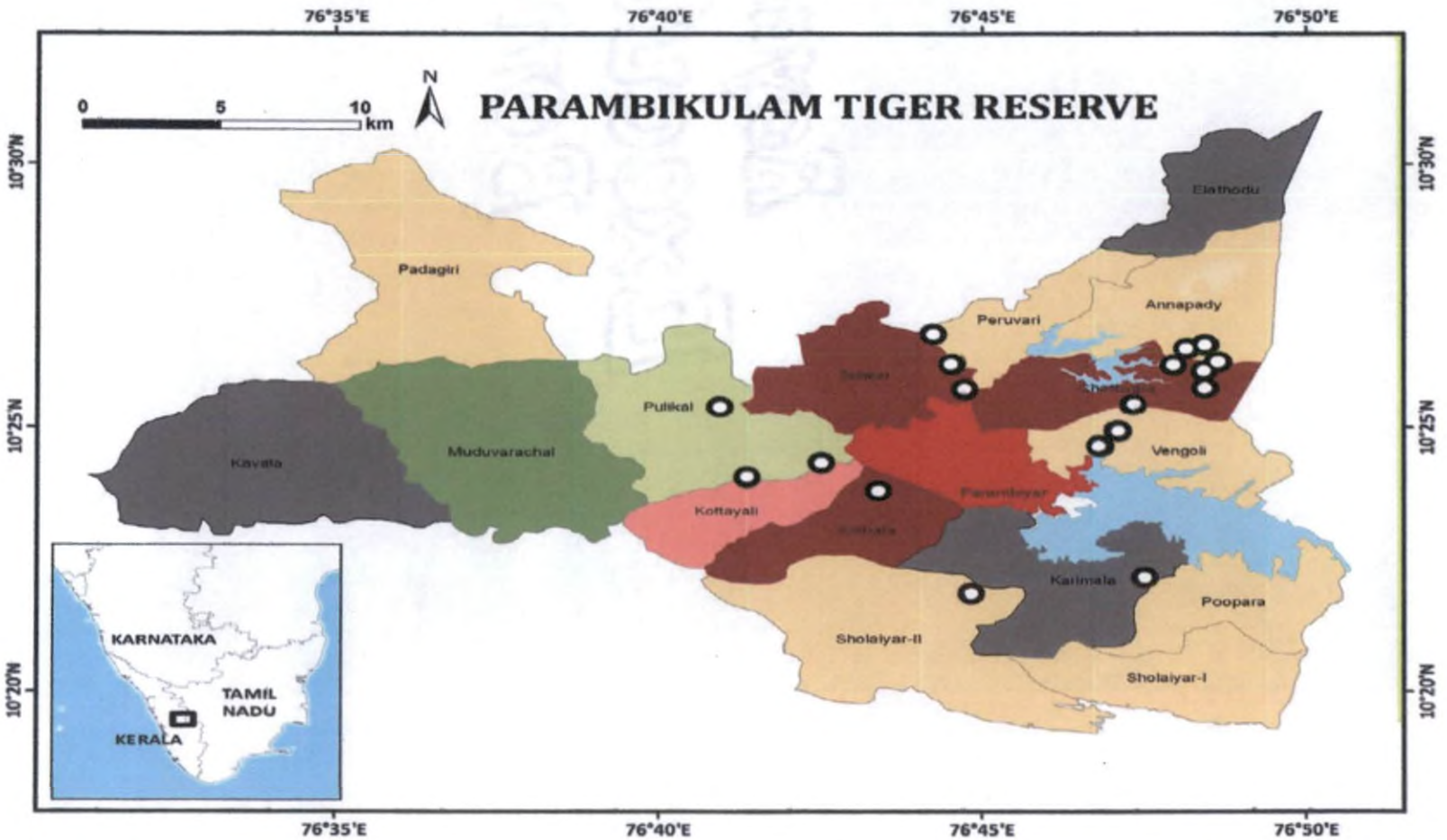
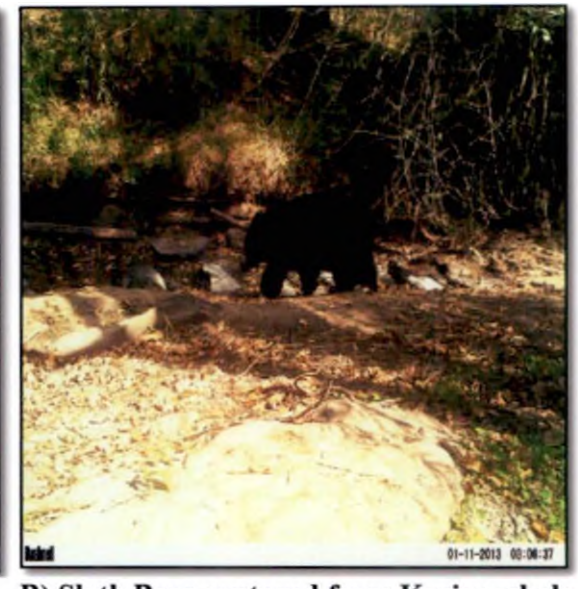
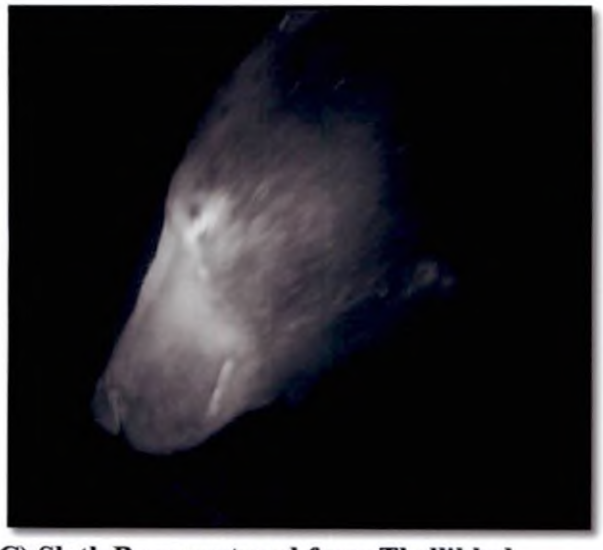


Figure 16. Map showing the success camera trap locations of Sloth Bear in Parambikulam Tiger Reserve

A) Sloth Bear captured from Vengoli



B) Sloth Bear captured from Kariyanshola



C) Sloth Bear captured from Thellikkal

D) Sloth Bear captured from Vengoli

Plate 11a. Camera trap captures of Sloth Bear in Parambikulam TR

E) Sloth Bear captured from Thellikkal

F) Sloth Bear captured from Anappady

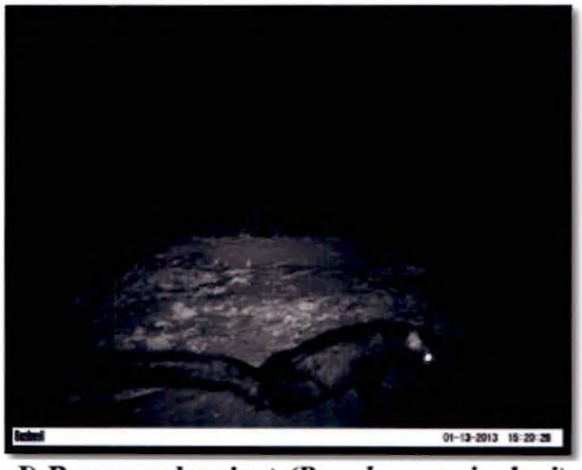
G) Sloth Bear captured from Anappady

H) Sloth Bear captured from Kannimara

Plate 11b Camera trap captures of Sloth Bear in Parambikulam TR

G) Spotted deer *(Axis axis)*

H) Wild gaur *(Bos gaurus)*



I) Brown palm civet *(Paradoxurus jerdoni)*

J) Small Indian civet (*Viverricula indica)*

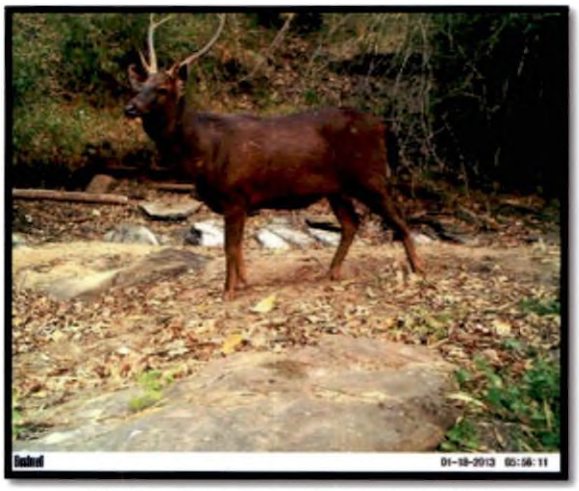
K) Asian elephant (*Elephas maximus*)

L)Wild boar *(Sus scrofa)*

Plate 12a. Camera trap images of other mammals in Parambikulam TR

A) Tiger *(Panthera tigris)*

B) Leopard *(Panthera pardus)*



C) Sambar deer *(Rusa unicolor)*

D) Barking deer *(Muntiacus muntjak)*

E) Indian porcupine *(Hystrix indica)*

F) Leopard cat *(Prionailurus bengalensis)*

Plate 12b. Camera trap images of other mammals in Parambikulam TR

(*Macaca radiate)* and Nilgiri Langur (*Semnopithecus johnii)* from the PKTR. These species have accounted for the 90% of the camera trap pictures at PKTR (Plate 12a and 12b).

Table 17.Camera trap efforts and number of Sloth Bear images captured in different habitats of Parambikulam TR

Habitat	**Trapping efforts**		**No of Images captured**
	Summer	Monsoon	
Evergreen	110	110	2
Moist deciduous	141	141	10
Teak Plantation	196	196	7
Vayals and Bamboos	78	78	0
Total	**1050**		**19**

4.4.2 Time activity pattern (Daily activity index (DAI)) of Sloth Bear

The time-activity pattern of the Sloth Bear at Parambikulam TR is given in Figure 17. Sloth Bears showed bimodal peaks in their activity; the first peak was observed from early morning, from 03:00hrs to 09:00hrs and another small peak in the late evening, 15:00hrs to 21:00hrs. The activity was almost nil during the hot period of the mid-day from 11:00hrs to 14:00hrs. Though Sloth Bears were active throughout the day they exhibited reduced activity during the hottest hours of the day.

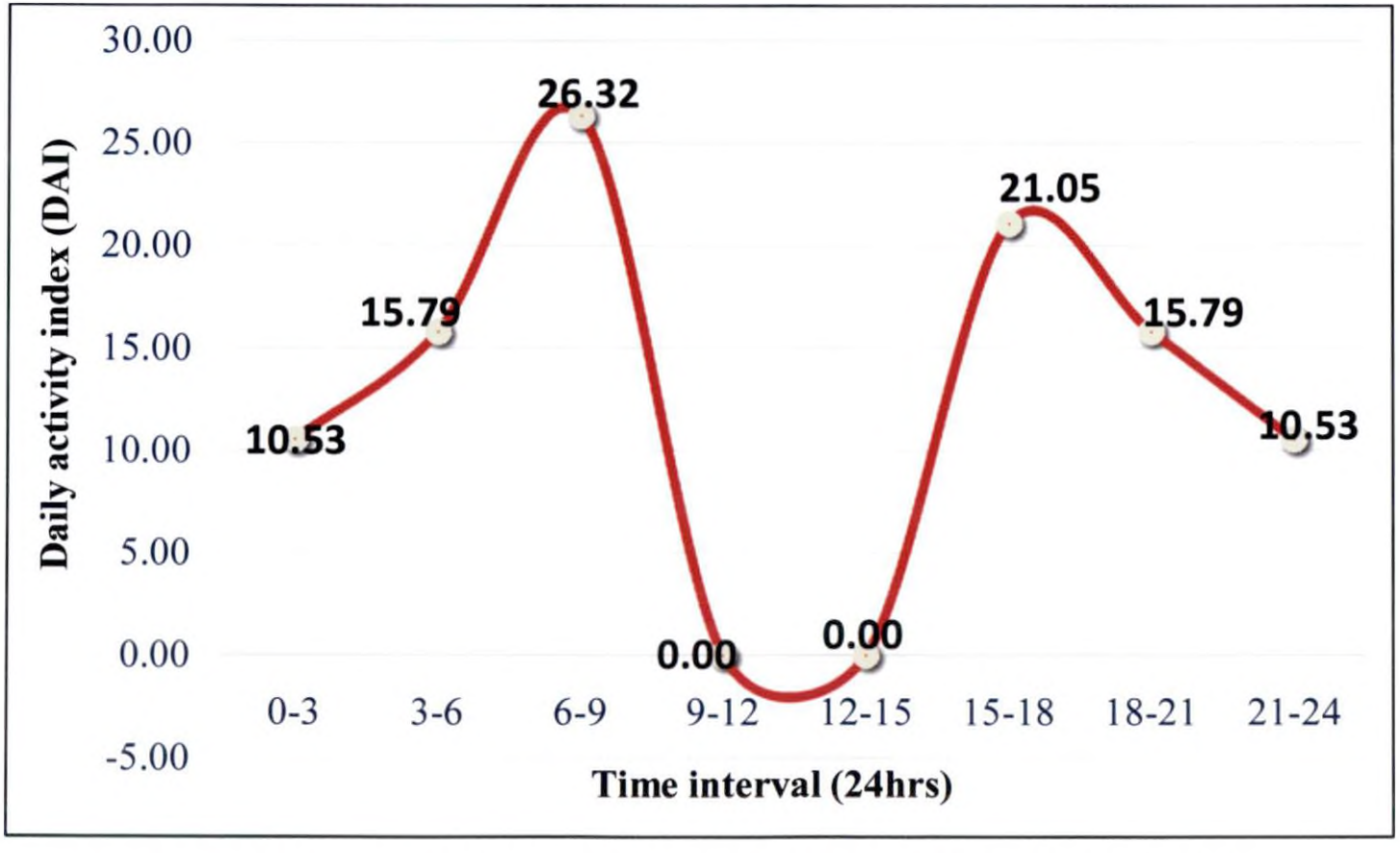


Figure 17. Daily Acivity Index (DAI) of Sloth Bear in Parambikulam TR using camera trap data

Table.18 Camera trap details of Sloth Bear in Parambikulam TR

Place	No of individuals captured	Time of capture (24hrs)	Date
1. Aanapadi	1	0.5	21-01-2013
2. Aanapadi	2	17.52	09-07-2012
3. Aanapadi	1	15.37	24-11-2012
4. Aanapadi	1	6.33	06-11-2012
5. Kannimara	2	16.20	29-04-2012
6. Kariyan shola	2	6.2	12-09-2012
7. Kariyan shola	1	19.22	01-01-2013
8. Kottala	1	18.31	28-08-2012
9. Orukomban	1	23.46	29-08-2012
10. Sungam	Adult and cub	11.05	26-04-2012
11. Sungam	1	18.2	01-03-2012
12. Thellikkal	Adult and cub	5.41	29-04-2012
13. Thellikkal	1	8.25	07-08-2012
14. Tram way	1	0.51	28-04-2012
15. Thellikkal	1	6.21	03-07-2012
16. Vengoli	1	17.4	28-12-2012
17. Vengoli	1	5.58	25-11-2012
18. Vengoli	1	6.17	06-11-2012
19. Kuriyarkutty	1	8.13	07-09-2012

Discussion

DISCUSSION

5.1 DISTRIBUTION AND RELATIVE ABUNDANCE OF SLOTH BEAR IN DIFFERENT HABITATS AT PARAMBIKULAM TIGER RESERVE

Sloth Bear's habitat preference is dependent upon the food availability (Bargali *et al.*, 2004). The present study on the distribution of Sloth Bear using indirect evidences revealed the presence of Sloth Bear in all the major habitat types in Parambikulam Tiger Reserve (PKTR) such as evergreen forests, moist deciduous forests, teak plantation and *vayals* & bamboos. Two kilometer day transects were walked searching for the Sloth Bear scats. Though the Sloth Bear was present in most of the major habitat types at Parambikulam, it was primarily confined to the moist deciduous forests and teak plantation. Total of 112 Sloth Bear scats were obtained from the Tiger Reserve.

Habitat use index (HUI) was calculated as a measure to represent distribution and habitat preference of Sloth Bear in different habitat in PKTR. It was higher in the moist deciduous forest (43.32%), followed by teak plantation (38.25%), evergreen and *vayals* and bamboos. A distribution map of scats collected from various habitats at Parambikulam TR during the study period also clearly shows that the Sloth Bear was distributed primarily in the moist-deciduous and teak plantations. Easa (2001), who studied the Sloth Bears at Parambikulam in the past also got a similar distribution pattern for the Sloth Bears, with the most of the bear scats obtaining from the teak plantations (63.04%) followed by moist deciduous forests (32.61%).

Earlier studies elsewhere in India had shown that the Sloth Bears avoid the human habitations within and close to the forests. For example Baskaran *et al.* (1997), who studied the Sloth Bears at Mudumalai Wildlife Sanctuary, opined that Sloth Bears avoided the termite mounds present at the *Acacia* dominated thorny forests, probably because of heavy grazing of livestock and other human activities there. Joshi *et al.* (1995) also found that Sloth Bears were either absent or occurred at low densities in areas with high human use, despite high termite densities in the lowlands of Nepal.

5.1.1 Seasonal variation in the distribution of Sloth Bear at Parambikulam TR

The present study revealed that there was a clear seasonal variation in the distribution of Sloth Bears at Parambikulam TR. In summer the bears preferred the moist deciduous forest (44.3%) than the teak plantations, while in the rainy season the pattern was vice-versa, with more of the bear presence in teak plantations (58.06%). The preference of the Sloth Bears to the moist deciduous forests in the summer could be due to the fact that the summer months are the fruiting season for most of the moist deciduous trees (Sasidharan, 1997), thus making the fruits in plenty in the moist deciduous forests. Moreover, during the summer months, the Sloth Bear may probably be avoiding the termite mounds, which are primarily located in the teak plantations, as the summer season makes the digging of the termite mound difficult. Joshi *et al.* (1995) reported an altitudinal movement of Sloth Bears, between the dry and wet seasons at Royal Chitwan National Park in Nepal. Sloth Bears preferred alluvial grasslands during dry season, however, in wet season they moved to upland sal (*Shorea robusta*) forests.

5.2 FOOD AND FEEDING HABITS OF SLOTH BEAR IN PARAMBIKULAM TIGER RESERVE

The Sloth Bears are primarily crepuscular to nocturnal animals (Prater, 1971) and thus most of the diet studies on the Sloth Bear have been though the scat analysis (Baskaran *et al.*, 1997; Easa, 2001 and Yoganand *et al.*, 2006).

5.2.1 Food components in the diet

Sloth Bears are omnivorous animals feeding both on plant as well as animal matters (Prater, 1971). In the present study also it has been found feeding on both plant and animal matters.

5.2.1.1 Plant matter in the diet

The frequency of occurrence of plant matter in the diet of Sloth Bear was to the tune of 64.23%. However, the plant matter was seen in the diet of the Sloth Bear, primarily in the summer season (56.22%), than monsoon (8.01%). This is due to the fact that the summer (December to May) coincides with the flowering and fruiting season of the majority of the plants, which in turn ensure the availability of the fruits to the animals.

A total of 112 scats of the Sloth Bear collected during a period of 12 months from Parambikulam TR. On examination of these scats it was found that Sloth Bears consume ten different species of fruits belonging to nine families. The plant species include *Cassia fistula* (Fabaceae), *Zizyphus oenoplina* (Rhamnaceae), *Glycosmis pentaphylla* (Rutaceae), *Holigarna arnottiana* & *Mangifera indica* (Anacardaceae), *Ficus spp.*, (Moraceae), *Syzygium cumini* (Myrtaceae), *Grewia tiliifolia* (Tiliaceae), *Bridelia retusa* (Euphorbiaceae) and *Cordia dichotoma* (Boraginaceae) and unidentified grass species (Graminae). Easa (2001) recorded only six species in the diet of Sloth Bear at Parambikulam TR in an earlier study. All the six species reported by Easa (2001) have been recorded in the present study too. These include *Cassia fistula, Ziziphus rugosa, Glycosmis pentaphylla, Ficus spp and Mangifera indica.* Apart from those six species, an additional four more species have been identified in the diet of Sloth Bear at Parambikulam TR. Ramesh *et al.*, (2012) recorded 18 species, while Baskaran *et al.* (1997) reported 20 plant species in the diet of Sloth Bear at Mudumalai TR. Out of which two species and two genera have been common in the diet of Sloth Bear both at Parambikulam and Mudumalai. The two common

species between these two sites were *Cassia fistula* and *Syzygium cumini*, while the genera that are common to these locations were *Zizyphus* and *Cordia*. Sreekumar and Balakrishnan (2002) recorded 15 plant species in the diet of Sloth Bear at Neyyar Wildlife Sanctuary in Kerala. However, the species such as *Artocarpus intergrifolia, Artocarpus hirsuta, Zizyphus rugosa, Baccauria courtallensis, Aporosa lyndleyana, Eleocarpus tuberculata, Lantana camera, Phoenix humilis and Ixora coccina* are the additional species that have been recorded by Sreekumar and Balakrishnan (2002). Gokula *et al.* (1995), who studied the food and feeding habits of Sloth Bears at Kalakkad-Mundanthurai Tiger reserve, have recorded four species of plants in the diet of Sloth Bear. Out of the four species two were *Ficus* and one was herb. It is interesting to note that this study was done during the non-fruiting season of the trees and during the non-fruiting season *Fiucs* has been acting as key-stone species and providing the food requirements for the frugivores. The role of *Ficus* as a key-stone species during the lean season for the frugivores (Corlet, 1998) has been known from elsewhere and is once again shown here in this study.

In Madhya Pradesh, Bargali *et al.*, (2004) reported about 20 species of plants in the diet of Sloth Bear. Some of the genera that are common in the diet of Sloth Bear in the South India as well as in North India are *Cassia, Bridelia, Ficus, Syzygium* and *Zizyphus*.

5.2.1.2 Animal matter in the diet

The frequency of occurrence of animal matter in the diet of Sloth Bear was to the tune of 136.16%. The animal matter also occupied the diet of the Sloth Bear, both in summer (68.77%) and the monsoon (67.39%) seasons. The animal matters observed in the diet of Sloth Bear at Parambikulam Tiger Reserve include insects like ants, termites, honey bees and beetles. The earlier studies on the diet of the Sloth Bear in India as well as Nepal also made similar observations on the animal matter constitution in the diet of the Sloth Bear (Laurie and Seidensticker, 1977; Johnsingh,

2003; Baskaran *et al.*, 1997; Gokula *et al.*, 1995, Joshi *et al.*, 1999; Easa, 2001 and Ramesh *et al.*, 2012).

Among the animal matter termites and ants dominated. The animal matter could be seen round the year in the diet of the Sloth Bear, unlike the plant matter which was seasonal in occurrence. Similar observations were made by Baskaran *et al.*, 1997; Gokula *et al.*, 1995, Joshi *et al.*, 1997; Easa, 2001 and Ramesh *et al.*, 2010.

In Parambikulam tiger reserve, animal matter dominates in bear diet composition, however, its percentage contribution varied depending on the availability of fruits. Thus in the summer months, which is the fruiting season for the most of the tropical trees in the Western Ghats (Pascal, 1988; Sasidharan, 1997; Chacko *et al.*,2002), the Sloth Bear was found feeding on the fruits of the plants. As in other studies we also observed that Sloth Bears consume both animal and plant matter in varying quantities depending upon the availability of food in different seasons.

5.2.1.3 Seasonal changes in the feeding habit of Sloth Bear at Parambikulam TR

The seasonal changes in the diet of Sloth Bear were evident in the present study. There were changes in the plant matter consumed between the summer and monsoon seasons. In the summer the Sloth Bear fed on the fruits of the plants such as *Bridelia retusa, Cassia fistula Cordia dichotoma, Ficus spp., Glycosmis pentaphylla, Holigarna arnottiana* and *Zizyphus oenoplia.* In the monsoon season the Sloth Bear fed on the fruits of *Mangifera indica, Syzygium cumini* and *Grewia tiliifolia.* This seasonality in the food preference coincides with the fruiting phenology (Sasidharan, 1997) of these plant species. Bargali *et al.* (2004) also observed seasonality in the feeding patterns of Sloth Bear in the Central India.

5.3 SEED DISPERSAL BY BEARS

Bears are found to be effective seed dispersers in various studies (Sreekumar and Balakrishnan, 2002; Satyakumar and Viswanath, 2003; Willson and Gende , 2004 ; Koike *et al.,* 2006; Takahashi *et al.*,2008). Bear droppings contain large numbers of seeds of different species were present in the droppings. Almost all the seeds of fleshy fruits retrieved from the fecal samples were undamaged. These findings suggest that bears can act as seed dispersers for some fleshy fruited plants in tropical forests.

5.3.1 Seed germination

Although seed passage through bear digestive tracts and the composition of scats, are known to affect germination rates to some degree, the most important role of bears in seed dispersal is probably transport of seeds away from the parent plants. We tested the hypothesis that seed passage through bear digestive tracts affect germination rate of the seeds, at Parambikulam TR. Our results proved that there is a significant difference between the germination percentage of seeds collected from bear scat, when compared with the freshly collected seeds. In most of the cases the germination was enhanced when it passed through the gut of the bear. Examples include *Glycosmis pentaphylla* and *Zizyphus oenoplia*, which had a greater germination percentage by 77.73% and 56.2% respectively of the seeds that passed through the bear gut. But in the case of *Syzygium cumini*, the germination percentage was almost the same for both the passed and unpassed seeds through the bear gut, 88 and 86% respectively. In the case of *Cassia fistula* however, the The seeds passed through the gut had a germination percentage of 50.3%, while the unpassed seeds had a germination percentage of 59.7% (t = 1.09* at 0.05 level). Sreekumar and Balakrishnan (2002) reported that seeds of three species of plants collected from the scat of Sloth Bears germinated faster than the seeds not passing through the gut of the bears. These results suggest that the Sloth Bear play an important role in the population dynamics of fleshy fruited species of Western Ghats.

5.4. TIME ACTIVITY PATTERN OF SLOTH BEARS

Majority of the camera trap evidence in the Parambikulam was of single individuals, excepting on couple of occasions, when two animals were captured in a single camera trap. This was during the month of June, which coincides with the breeding season of the Sloth Bear (Eisenberg and Lockhart 1972; Yoganand *et al.*, 2006). Thus it can be assumed that Sloth Bears are solitary in habit, excepting the breeding season, when they occur in pairs.

In spite of the fact that the camera trap was kept open round the clock, the Sloth Bear images were captured primarily between 0600hrs to 0900hrs (26.32%) and again from 1500hrs to 1800hrs (21.05%), indicating that Sloth Bear primarily is a crepuscular animal, which is active during dawn and dusk. Ramesh *et al.* (2013) also observed the crepuscular behavior of Sloth Bears in Mudhumalai Tiger Reserve. Sloth Bears may have reduced their activity during the day to avoid the intense heat. In Panna National Park radio telemetry study by Yoganand *et al.* (2006) reported that the day resting habits by Sloth Bears.

Summary

SUMMARY

Sloth Bears (*Melursus ursinus*) are one of the least studied animals in Western Ghats especially in Kerala. Very little information is available on their ecology, behaviour, habits, conservation threats etc. There is only a single published work on the Sloth Bears in Kerala and three in the whole of Western Ghats. The objectives of the present study were to understand the distribution, relative abundance, food habits, diet composition, role of seed dispersal and time activity pattern of Sloth Bear. The study was carried out in the Parambikulam Tiger Reserve (Parambikulam TR) for one year from February 2012 to January 2013. The methods employed to study the Sloth Bears were, day transect survey, scat analysis and camera-trap survey, at Parambikulam TR. A total of 1050 camera-trap efforts, 240 kilometers transect walk, were carried out during the present study. The salient findings are summarised herein.

1. A total of 171 indirect evidences of Sloth Bears were recorded from 240km transect walk over a period of one year. Of which 65.5% were in the form of scats, 18.13% of termite mount diggings, 11.11% of camera trap capture and 5.26 % of foot prints at the Parambikulam TR.

2. Scat abundance was higher in the moist deciduous forest (2.1/km) and teak plantation (1.9/km) followed by evergreen and *Vayals*.

3. Habitat Use Index (*HUI*) studies indicated that moist deciduous (42.32) and teak plantation (38.25) were the most used habitat by Sloth Bears at Parambikulam TR. The Sloth Bear however used the evergreen forests (13.18) and *vayals and* bamboos (6.25) also at the Parambikulam TR, though at a lesser degree of usage.

4. There is a clear cut variation in the availability of scats across the seasons, with the summer season accounting for 72.3%, while the monsoon season recorded only 27.6% of the scats at Parambikulam TR.

5. There is also variation in the activity of Sloth Bear, between the habitats across the season. During the monsoon season, the Sloth Bear activity was more in the teak plantations (58.06%), followed by moist deciduous forest (19.35%). While at summer season the Sloth Bear activity was more in the moist deciduous forest (44.3%) followed by teak plantation (28.40%).

6. Within the Parambikulam TR the study shows that the greater Sloth Bear presence at Vengoli and Anappady. These two locations accounted for 41.96% of Sloth Bear presence according to the scat studies, while the camera trap studies recorded 36.75% of the Sloth Bear presence from Vengoli and Anappady.

7. The diet studies have shown that Sloth Bear is omnivorous in its dietary preferences, with animal matter dominating than the plant matter. Moreover, while the animal matter was fed by the Sloth Bear round the year, in summer (68.77%) and the monsoon (67.39%), the plant matter was fed only during the fruiting season of the plants.

8. A total of 15 food items were found to be fed by the Sloth Bear. This included ten plant species belonging to nine families such as Anacardiaceae, Boraginaceae, Euphorbiaceae, Fabaceae, Moraceae, Myrtaceae, Rhamnaceae, Rutaceae and Teliaceae and grass blades, while the animal matter included termites, ants, bees, beetles and unknown mammalian hairs.

9. The plant species consumed included *Cassia fistula, Zizyphus oenoplina, Glycosmis pentaphylla, Holigarna arnottiana, Ficus spp., Syzygium cumini, Grewia tiliifolia, Mangifera indica, Bridelia retusa* and *Cordia dichotoma.*

10. Among the plant species *Cassia fistula* (32.35%) dominated the diet of Sloth Bear at Parambikulam TR which was followed by *Zizyphus oenoplia* (25%) and *Glycosmis pentaphylla* (14.7%).

11. The animal matter included black ants termites red ants, bees and beetles in which the black ants (60.16%) dominated the diet followed by termites (43.75%) and beetles (12.50%).

12. Seasonality in the plant food preference of Sloth Bear was observed. In the summer season the Sloth Bear fed on the fruits of the plants such as *Bridelia retusa, Cassia fistula, Cordia dichotoma, Ficus spp., Glycosmis pentaphylla, Holigarna arnotiana* and *Zizyphus oenoplia.* In the monsoon season the Sloth Bear fed on the fruits of *Mangifera indica, Syzygium cumini* and *Grewia tiliifolia.*

13. The seeds collected from the Sloth Bear scats at Parambikulam TR showed no physical damage to most of the seeds (90%) and thus proved to be efficient seed dispersers.

14. It was also found that the germination of the seeds enhanced when it passed through the gut of the Sloth Bear, compared to the unpassed seeds. For eg. the *Glycosmis pentaphylla* and *Zizyphus oenoplia* seeds had a greater germination percentage to the tune of 77.73% and 56.2% respectively for the seeds passed through the Sloth Bear gut. Thus showing the significance of the Sloth Bear in the forest functioning and the system dynamics.

15. The present study also reiterates the fact that the Sloth Bear is a solitary and crepuscular animal.

16. Sloth Bears showed bimodal peaks in their activity; the first peak was observed from 03:00hrs to 09:00hrs in the morning and another peak was observed from 15:00hrs to 21:00hrs in the late evening.

17. The Sloth Bear helps in the seed dispersal of the following plants such as *Bridelia retusa, Cassia fistula, Cordia dichotoma, Ficus spp., Grewia tiliifolia, Glycosmis pentaphylla, Holigarna arnotiana, Mangifera indica, Syzygium cumini* and *Zizyphus oenoplia.*

18. The three plant species that are mostly preferred by the Sloth Bear, such as the *Cassia fistula, Glycosmis pentaphylla* and *Zizyphus oenoplia* (72.05%). These species may be used for the ecorestoration activity of the Tiger reserve to facilitate the survival of the Sloth Bear.

19. Out of the three most preferred plant species that are fed by the Sloth Bears, two are mostly seen as the undergrowth of teak plantation. These plants get weeded away during the fire season, when the fire-lines are taken and the vista clearing activity is carried out. So care must be taken by the tiger reserve managers to ensure that damage upon the *Glycosmis pentaphylla* and *Zizyphus oenoplia.*

20. The camera trap studies show that the stronghold of Sloth Bear in the Parambikulam Tiger Reserve. The camera traps also documented the presence of other mammals such as Tiger (*Panthera tigris*), Leopard (*Panthera pardus*), Leopard cat (*Prionailurus bengalensis*), Wild Dog (*Cuon alpines*), Asian Elephant (*Elephus maximus*), Gaur (*Bos gaurus*), Sambar Deer (*Rusa unicolor*), Spotted Deer (*Axis axis*), Barking Deer (*Muntiacus muntjak*), Mouse Deer (*Moschiola indica*), Wild Boar (*Sus scrofa*), Indian Hare (*Lepus nigricollis*), Brown palm civet (*Paradoxurus jerdoni*), small Indian civet (*Viverricula indica*), Indian Crested Porcupine (*Hystrix indica*), Bonnet Macaque (*Macaca radiata*) and Nilgiri Langur (*Semnopithecus johnii*) from the Parambikulam TR.

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Appendices

APPENDIX I

GPS locations of indirect evidences collected from Parambikulam Tiger Reserve

(Place / transect)	Habitat	Terrain	Evidence	Latitude(N)	Longitude (E)	Altitude
Vengoli	MDF	Road	scat	10°24'26.4"	76°47'04.5"	556
Vengoli	MDF	rock	scat	10°24'33.7"	76°47'05.5"	561
Vengoli	MDF	rock	scat	10°24'41.4"	76°47'07.9"	622
Vengoli	MDF	rock	scat	10°24'43.8"	76°47'09.2"	641
Vengoli	MDF	treck path	scat	10°24'42.0"	76°47'05.1"	639
Karimala	MDF	treck path	scat	10°22'03.6"	76°45'44.9"	789
Karimala	MDF	treck path	scat	10°22'03.8"	76°45'45.1"	785
Vengoli	PL	treck path	scat	10°23'45.1"	76°46'36.3"	568
Vengoli	PL	Road	scat	10°24'43.5"	74°70'71.7"	641
Vengoli	PL	Road	scat	10°24'43.2"	71°47'09.3"	662
Vengoli	MDF	treck path	scat	10°24'29.3"	76°47'00.3"	638
Vengoli	MDF	treck path	scat	10°23'46.1"	76°46'35.7"	569
Vengoli	MDF	treck path	scat	10°24'43.5"	76°47'09.6"	643
Vengoli	MDF	treck path	scat	10°24'43.6"	76°47'09.1"	642
Vengoli	MDF	rock	scat	10°24'43.2"	71°47'09.3"	662
Vengoli	MDF	rock	scat	10°24'29.3"	76°47'00.3"	638
Vengoli	MDF	rock	scat	10°23'46.1"	76°46'35.7"	569
Vengoli	MDF	rock	scat	10°24'43.5"	76°47'09.6"	643
Vengoli	MDF	treck path	scat	10°24'43.6"	76°47'09.1"	642
Vengoli	MDF	treck path	scat	10°24'43.6"	76°47'09.1"	642
Orukomban	EG	rock	scat	10°26'42.8"	76°48'57.4"	522
Anappady	MDF	treck path	Direct sighting	10°23'36.6"	76°40'27.3"	570

Anappady	MDF	treck path	scat	10°23'36.6"	76°40'27.3"	570
Anappady	MDF	treck path	scat	10°26'40.0"	76°48'41.0"	554
Anappady	MDF	treck path	scat	10°26'46.7"	76°48'50.0"	560
Anappady	MDF	treck path	scat	10°26'47.1"	76°48'50.6"	551
Vengoli	EG	stream	scat	10°25'03.0"	76°46'53.7"	693
Vengoli	MDF	rock	scat	10°25'17.9"	76°46'50.9"	746
Vengoli	MDF		scat	10°25'35.4"	76°47'57.7"	930
Vengoli	MDF	treck path	scat	10°24'16.1"	76°46'42.2"	581
Tunnel entry	MDF	shed	scat	10°24'29.1"	76°47'00.8"	573
Vengoli	EG	stream	scat	10°25'03.0"	76°46'53.7"	693
Vengoli	MDF	rock	scat	10°25'17.9"	76°46'50.9"	746
Vengoli	MDF		scat	10°25'35.4"	76°47'57.7"	930
Vengoli	EG		digging	10°24'16.3"	76°46'50.4"	610
Vengoli	MDF	treck path	digging	10°24'16.1"	76°46'50.7"	597
Vengoli	MDF	rock	scat	10°25'34.4"	76°47'17.3"	850
Vengoli top	MDF	rock	scat	10°25'18.9"	76°48'41.4"	989
Anakkal	V	treck path	scat	10°24'16.1"	76°46'50.7"	603
Anakkal	V	bridge	scat	10°25'36.1"	76°45'16.2"	521
Anappady	PL	treck path	digging	10°24'50.0"	76°44'53.5"	545
Anappady	MDF	treck path	digging	10°24'20.5"	76°44.49.3"	555
Kottala	PL	tram way	scat	10°23'29.3"	76°44'54.9"	516
Kottala	PL	treck path	scat	10°23'29.5"	76°45'28.8"	516
Kuriyarkutti	PL	treck path	scat	10°23'26.2"	76°44'51.3"	524
Kuriyarkutti	PL	treck path	scat	10°23'28.2"	76°43'44.2"	518
Kuriyarkutti	PL	treck path	digging	10°24'23.6"	76°44'49.2"	518
Karimala	MDF	treck path	scat	10°22'03.3"	76°45'45.3"	764
Orukomban	EG	treck path	scat	10°23'36.2"	76°40'27.4"	478
Orukomban	EG	treck path	scat	10°23'36.4"	76°40'27.8"	472
Vengoli	PL	treck path	scat	10°24'15.1"	76°46'41.2"	564

Vengoli	PL	treck path	scat	10°24'28.1"	76°47'00.8"	573
Vengoli	PL	rock	scat	10°25'03.2"	76°46'53.6"	586
Vengoli	PL	treck path	scat	10°24'18.2"	76°46'32.1"	578
	MDF	stream	scat	10°23'29.3"	76°45'28.5"	521
Anakkal	V	treck path	scat	10°25'36.1"	76°45'16.2"	521
anappady	MDF	old shed	scat	10°26'37.1"	76°49'06.4"	585
anappady	MDF	treck path	scat	10°26'36.0"	76°49'06.9"	581
Anappady	MDF	treck path	digging	10°26'41.4"	76°49'15.2"	592
Anappady	MDF	treck path	scat	10°26'38.6"	76°49'19.6"	595
Anappady	MDF	treck path	digging	10°26'37.6"	76°49'27.7"	583
Anappady	MDF	treck path	scat	10°26'37.9"	76°49'42.1"	594
Anappady	MDF	treck path	foot print	10°27'00.9"	76°48'46.7"	621
Anappady	MDF	treck path	scat	10°27'07.7"	76°48'52.8"	627
Anappadi tunnel entry	PL	Road side	digging	10°26'37.9"	76°49'42.1"	594
Anappadi tunnel entry	PL	Road side	digging	10°26'33.5"	76°49'45.0"	575
Anappadi tunnel entry	PL	Road side	digging	10°26'33.9"	76°49'43.2"	573
Anappadi tunnel entry	MDF	treck path	scat	10°26'32.9"	76°49'22.3"	558
Anappady	MDF	treck path	digging	10°26'31.7"	76°48'22.8"	544
Anappady	MDF	treck path	digging	10°26'23.2"	76°48'07.9"	547
Kariyanshola	EG	treck path	digging	10°27'40.8"	76°49'34.3"	726
Kariyanshola	EG	treck path	digging	10°27'41.3"	76°49'34.4"	730
Kariyanshola	EG	treck path	digging	10°27'39.7"	76°49'39.8"	706
Kariyanshola	MDF	rock	scat	10°27'19.4"	76°49'32.1"	721
Kariyanshola	MDF	rock	scat	10°27'02.4"	76°49'22.3"	653
Kariyanshola	MDF	rock	scat	10°26'52.2"	76°49'10.7"	576
Karyanshola	MDF	treck path	digging	10°27'14.5"	76°49'27.1"	695
Karyanshola	MDF	rock	scat	10°27'15.6"	76°49'28.5"	703
Karyanshola	MDF	rock	scat	10°27'17.2"	76°49'30.8"	712
Karyanshola	MDF	treckpath	digging	10°27'20.4"	76°49'33.7"	700
Karyanshola	MDF	treckpath	digging	10°27'30.7"	76°49'43.3"	703
Karyanshola	EG	treckpath	digging	10°27'31.0"	76°49'45.5"	712

Karyanshola	EG	treckpath	scat	10°27'24.7"	76°49'38.4"	714
Karyanshola	EG	treckpath	scat	10°27'24.6"	76°49'38.3"	713
Karyanshola	EG	treckpath	foot print	10°27'18.6"	76°49'40.2"	690
Karyanshola	EG	treckpath	foot print	10°27'21.6"	76°49'40.9"	701
Karyanshola	EG	treckpath	scat	10°27'21.2"	76°49'45.9"	691
Karyanshola	EG	treckpath	scat	10°27'17.2"	76°49'43.3"	672
Anappady tunnel entry	PL	treckpath	digging	10°27'05.6"	76°49'38.2"	642
Anappady tunnel entry	PL	treckpath	digging	10°26'25.8"	76°48'57.1"	593
Anappady tunnel entry	PL	road	scat	10°26'24.9"	76°48'57.1"	619
Anappady tunnel entry	PL	road	digging	10°26'17.1"	76°48'53.1"	602
Anappady tunnel entry	PL	road	scat	10°26'08.8"	76°48'51.4"	579
Anappady tunnel entry	MDF	treckpath	scat	10°26'08.0"	76°48'49.9"	576
Anappady tunnel entry	MDF	treckpath	digging	10°26'03.1"	76°48'35.1"	562
Thellikkal	MDF	rock	scat	10°26'37.2"	76°48'50.2"	482
Thellikkal	MDF	stream	foot print	10°25'40.8"	76°45'01.0"	499
Thellikkal	MDF	mdf	scat	10°25'52.9"	76°45'05.7"	522
Thellikkal	MDF	mdf	foot print	10°26'16.9"	76°45'33.7"	524
Thellikkal	V	mdf	foot print	10°26'40.1"	76°45'20.5"	529
Kannimara	PL	plantation	scat	10°26'17.5"	76°45'08.3"	517
Kannimara	PL	plantation	foot print	10°26'14.4"	76°45'08.6"	515
Kannimara	PL	plantation	scat	10°25'59.3"	76°45'02.4"	520
Kannimara	PL	plantation	scat	10°25'53.4"	76°45'05.6"	532
Kannimara	PL	plantation	digging	10°25'51.8"	76°45'04.9"	502
Seechali vayal	PL	bamboo	digging	10°26'58.1"	76°49'13.1"	570
Seechali vayal	V	bamboo	digging	10°27'12.8"	76°49'17.7"	610
Seechali vayal	V	bamboo	digging	10°27'13.0"	76°49'17.8"	620
Seechali vayal	V	bamboo	digging	10°27'16.9"	76°49'21.5"	641
Seechali vayal	V	vayal	foot print	10°27'23.6"	76°49'26.0"	667
Seechali vayal	V	vayal	foot print	10°27'14.4"	76°49'01.5"	651
kannimara	PL	plantation	scat	10°25'53.4"	76°45'05.6"	532
Kannimara	PL	plantation	digging	10°25'51.8"	76°45'04.9"	502
vengoli	PL	treck path	scat	10°24'28.1"	76°47'00.8"	573

vengoli	PL	rock	scat	10°25'03.2"	76°46'53.6"	586
vengoli	PL	treck path	scat	10°24'18.2"	76°46'32.1"	578
Anappady	MDF	treck path	scat	$10^0$26'40.0"	$76^0$48'41.0"	554
Anappady	MDF	treck path	scat	$10^0$26'46.7"	$76^0$48'50.0"	560
Anappady	MDF	treck path	scat	$10^0$26'47.1"	$76^0$48'50.6"	551
Anappadi tunnel entry	PL	Road side	digging	10°26'33.5"	76°49'45.0"	575
Anappadi tunnel entry	PL	Road side	digging	10°26'33.9"	76°49'43.2"	573
Anappadi tunnel entry	MDF	treck path	scat	10°26'32.9"	76°49'22.3"	558

MDF- Moist deciduous forest, PL-Teak plantation, V- Vayals, EG- Evergreen forest

APPENDIX II

Camera trap details and GPS locations of indirect evidences collected from Parambikulam TR

Place / Transect	Camera No.	No of individuals trapped	Location Type	Forest type	Latitude (N)	Longitude (E)	Altitude(m)
1. Aanapadi	9	1	trek path	MDF	10° 24' 56.6"	76° 47' 20.0"	678
2. Aanapadi	7	1	trek path	MDF	10° 26' 37.8"	76° 49' 33.3"	596
3. Aanapadi	8	2	trek path	MDF	10° 26' 44.6"	76° 48' 35.7"	561
4. Aanapadi	8	1	Trek path	MDF	10° 27' 10.6"	76° 44' 30.9"	540
5. Kannimara	8	2	Trek path	Plantation	10° 27' 10.6"	76° 44' 30.9"	540
6. Kariyan shola	5	1	Trek path	MDF	10° 23' 41.7"	76° 43' 41.1"	520
7. Kariyan shola	5	2	Trek path	EV	10° 24' 0.2"	76° 41' 38.2"	492
8. Kottala	6	1	Trek path	EV	10° 24' 18.5"	76° 42' 48.1"	512
9. Orukomban	8	1	Trek pa	MDF	10° 27' 12.4"	76° 44' 32.8"	534
10. Sungam	8	1	Trek path	Plantation	10°2634.4"	76°48'54.4"	544
11. Sungam	5	2	Rocky terrain	Plantation	10°24'41.4"	76°47'07.9"	639
12. Thellikkal	7	2	Stream	MDF	10°27'39.7"	76°49'39.8"	706
13. Thellikkal	8	1	Rocky terrain	MDF	10°26'46.7"	76°48'50.0"	560
14. Tram way	5	1	Stream	MDF	10° 27' 10.2"	76° 44' 30.6"	533
15. Thellikkal	3	1	Treck path	plantation	10°26'31.7"	76°48'22.8"	544
16. Vengoli	4	1	Treck path	MDF	10°27'31.0"	76°49'45.5"	712
17. Vengoli	5	1	Rocky terrain	MDF	10°26'08.8"	76°48'51.4"	579
18. Vengoli	2	1	Treck path	Plantation	10°25'59.3"	76°45'02.4"	520
19. Kuriyarkutty	3	1	Rocky terrain	MDF	10°24'43.6"	76°47'09.1"	642

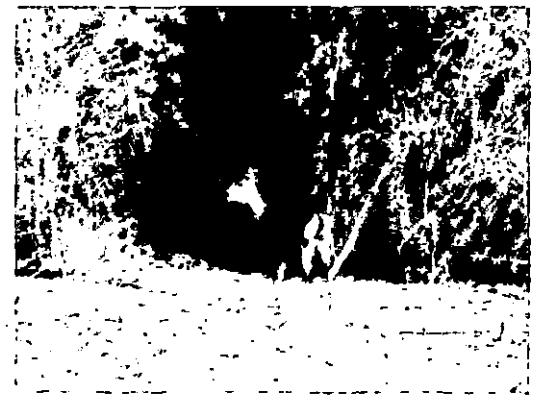
APPENDIX - III

List of Wild animals Direct sighted (S) OR Camera trapped (C) during the survey				
Mammals				
Sl No.	**Species**	**Scientific name**	**Direct Sighted (S)**	**Camera trapped (C)**
1.	Tiger	*Panthera tigris*	S	C
2.	Leopard	*Panthera pardus*	-	C
3.	Wild Dog	*Cuon alpines*	S	C
4.	Sloth Bear	*Melursus ursinus*	S	C
5.	Gaur	*Bos gaurus*	S	C
6.	Asian Elephant	*Elephas maximus*	S	C
7.	Sambar Deer	*Rusa unicolor*	S	C
8.	Spotted Deer	*Axis axis*	S	C
9.	Barking Deer	*Muntiacus muntjak*	-	C
10.	Mouse Deer	*Moschiola indica*	-	C
11.	Wild Boar	*Sus scrofa*	S	C
12.	Indian Hare	*Lepus nigricollis*	S	C
13.	Stripe necked mongoose	*Herpestes vitticollis*	S	C
14.	Brown palm civet	*Paradoxurus jerdoni*	-	C
15.	Small Indian civet	*Viverricula indica*	-	C
16.	IndianCrested Porcupine	*Hystrix indica*	-	C
17.	Bonnet Macaque	*Macaca radiate*	S	C
18.	Nilgiri Langur	*Semnopithecus johnii*	S	C
19.	Leopard cat	*Prionailurus bengalensis*	-	C
20.	Nilgiri tahr	*Nilgiritragus hylocrius*	S	-
21.	Malabar giant squirrel	*Ratufa indica*	S	-
Reptiles				
22.	Mugger	*Crocodylus palustris*	S	-
23.	Travancore tortoise	*Indotestudo travancorica*	S	-
24.	Monitor lizard	*Varanus indicus*	S	-
25.	Common bronze back tree snake	*Dendrelaphis tristis*	S	-

A. Stripe necked mongoose

B. Spotted Deer

C. Gaur



D. Sambar Deer

E. Tiger

F. Nilgiri Langur

Wild animals Direct sighted during line transect survey

APPENDIX - IV

DATA SHEET FOR PHENOLOGICAL OBSERVATION OF FRUIT TREES IN PARAMBIKULAM TIGER RESRVE

Place:_____ **Date:**_____

Latitude:N _____ **Longitude:E** _____ **Alt:**

Date	Species	Girth(cm)	Height(m)	Flowering	Fruiting	Remarks

APPENDIX - V

DATA SHEET FOR SLOTH BEARS SCAT SURVEY- PARAMBIKULAM TIGER RESERVE

Sl no	Date	Place	Latitude (N)	Longitude (E)	Altitude	Habitat	Plant matter	Animal matter	Others

APPENDIX VI

Poster presented at Students Conference on Conservation Science (SCCS), Bangalore

Ecology and feeding behaviour of Sloth bear (*Melursus ursinus*) in Parambikulam Tiger reserve, Kerala

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INTRODUCTION

Sloth bear is a threatened species [Vulnerable according to IUCN (2011)]

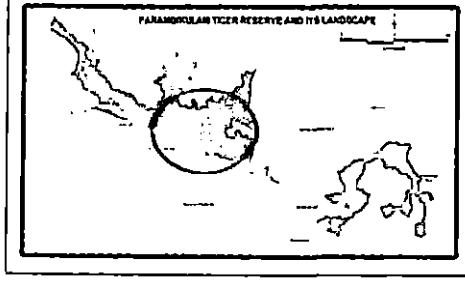
The baseline data such gathered wouldbe useful for the scientific management of the remaining populations and their habitat

Enabling the long-term conservation of the species

METHODS

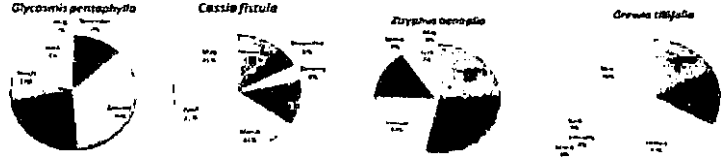
Stratified Random Sampling
Line Transect
Scat Analysis (Desai *et al.*, 1997)

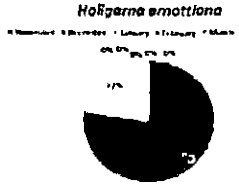
STUDY AREA

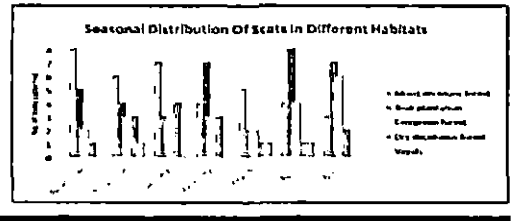


RESULTS

Percentage of seeds of different plant species in different months in bear scats







PLANT SPECIES IN THE BEAR DIET

CONCLUSION

Most of the scats consist of mostly fruits of different species in which Cassia fistula dominates mainly during March –April

There were seasonal differences in the distribution of sloth bear as evident from the distribution of scats in different habitat

Maximum scats collected from moist deciduous forests followed by teak plantation

Dispersal of large no. of seeds by sloth bear is evident from the study

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ECOLOGY AND FEEDING BEHAVIOUR OF SLOTH BEAR (*Melursus ursinus*) IN PARAMBIKULAM TIGER RESERVE, KERALA

By

SAJEER, K.V

(2011-17-102)

ABSTRACT OF THE THESIS

Submitted in partial fulfillment of the requirement for the degree of

Master of Science in Forestry

Faculty of Forestry

Kerala Agricultural University

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2013

ABSTRACT

A field study was conducted to evaluate the ecology and feeding habits of Sloth Bear (*Melursus ursinus*). The study was conducted from February 2012 to January 2013 in Parambikulam Tiger Reserve, Palakkad, Kerala.

There is a variation in the activity of Sloth Bear, between the habitats across the season. During the monsoon season, the Sloth Bear activity was more in the teak plantations (58.06%), followed by moist deciduous forest (19.35%). While at summer season the Sloth Bear activity was more in the moist deciduous forest (44.3%) followed by teak plantation (28.40%). The diet studies have shown that Sloth Bear is omnivorous in its dietary preferences, with animal matter dominating than the plant matter. Moreover, while the animal matter was fed by the Sloth Bear round the year, the plant matter was fed only during the fruiting season of the plants. About 10 natural plants such as *Cassia fistula, Zizyphus oenoplina, Glycosmis pentaphylla, Holigarna arnottiana, Ficus spp., Syzygium cumini, Grewia tiliifolia, Mangifera indica, Bridelia retusa and Cordia dichotoma* and some insects like ants, termites, beetles and bees were observed to be consumed by Sloth Bear. These plant species were consumed in the form of, ripe fruits and also their seeds. Among the plant species *Cassia fistula* (32.35%) dominated the diet of Sloth Bear at Parambikulam TR which was followed by *Zizyphus oenoplia* (25%) and *Glycosmis pentaphylla* (14.7%). Seasonality in the plant food preference of Sloth Bear was observed. In the summer season the Sloth Bear fed on the fruits of the plants such as *Bridelia retusa, Cassia fistula, Cordia dichotoma, Ficus spp., Glycosmis pentaphylla, Holigarna arnottiana* and *Zizyphus oenoplia.* In the monsoon season the Sloth Bear fed on the fruits of *Mangifera indica, Syzygium cumini* and *Grewia tiliifolia.* The seeds collected from the Sloth Bear scats at Parambikulam TR showed no physical damage to

most of the seeds (90%) and thus proved to be efficient seed dispersers. The camera trap records revealed the solitary nature and crepuscular activity of Sloth Bear. It was also found that the germination of the seeds enhanced when it passed through the gut of the Sloth Bear, compared to the unpassed seeds. For eg. the *Glycosmis pentaphylla* and *Zizyphus oenoplia* seeds had a greater germination percentage to the tune of 77.73% and 56.2% respectively for the seeds passed through the Sloth Bear gut. Thus showing the significance of the Sloth Bear in the forest functioning and the system dynamics. The three plant species that are widely used by the Sloth Bear, such as the *Cassia fistula, Glycosmis pentaphylla* and *Zizyphus oenoplia* (72.05%) may be used for the eco-restoration activity of the Tiger reserve to facilitate the survival of the Sloth Bear.