DHOLE (*Cuon alpinus*) DISTRIBUTION AND PREY COMPOSITION IN SOUTH WAYANAD FOREST DIVISION, KERALA

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(15-02MS-002)

DISSERTATION

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KVASU CENTRE FOR WILDLIFE STUDIES

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POOKODE, WAYANAD,

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DECLARATION

I hereby declare that this dissertation titled **"Dhole (*Cuon alpinus*) distribution and prey composition in South Wayanad Forest Division, Kerala"** is a bonafide record of research work done by me during the course of my Master's research program and that the dissertation has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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Certified that this dissertation, titled **"Dhole (*Cuon alpinus*) distribution and prey composition in South Wayanad Forest Division, Kerala"** is a bonafide record of research work done independently by **Samuel George (15-02MS-002)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to him.

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EXTERNAL EXAMINER

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1. INTRODUCTION

The Dhole or Indian Wild dog (*Cuon alpinus* Pallas 1811) is a canid found in Central, South and Southeast Asia. Though phylogenetically more close to the members within the genus Canis, morphological and behavioural differences are significant enough to consider a separate genus for the species and hence included in a monotypic genus "Cuon Hodgson". Social behavior and anatomy of Dholes distinguish them from other canids invariably (Hodgson 1838; Pocock 1936). They are highly social animals, without rigid dominance hierarchies when compared with grey wolves (*Canis lupus*) and other canids. Dhole packs exhibit high degree of cooperation during hunting and they have their own strategies to hunt down prey. They are diurnal in habit and hunts mainly during mornings and evenings (Johnsingh, 1982; Acharya, 2007).

In most of its range Dholes coexists with other apex carnivores like tigers and leopards. Even though these sympatric carnivores compete for the prey, they avoid mutually by ecological separations and variable niche occupancy like differential prey selection where different carnivores prefer prey animals belonging to different species, age, sex and size classes (Johnsingh, 1992; Karanth and Sunquist, 1995; Karanth and Sunquist, 2000). Despite the wide distribution, the current estimated population status of the species is below 2500 and considered as "Endangered" by IUCN (Kamler *et al.,* 2015).

India is having the highest population of Dholes in the world. Even though 60% of Dholes have been disappeared from their historic ranges, they occur throughout in almost all protected areas of North-East India, Central India, Western Ghats and Eastern Ghats (Johnsingh 1985). Western Ghats which is a biodiversity hot spot in the world supports good populations of Wild Dogs. Although many studies have been conducted on the ecology and phylogenetics of this species in Western Ghats, a comprehensive data on feeding habits and population data of Dholes in Western Ghats, especially outside protected areas is unavailable.

Many studies suggest that herbivore population varies across different habitat types and the prey species availability for carnivores vary significantly across different habitat types. Dholes are recorded to inhabit various kinds of habitats, including different kinds of forest and even in human modified habitats like agricultural landscapes, plantations etc. However the feeding habit of this species across various habitat types is not well studied in most of its range. Wayanad being a mosaic of different landscape features, harbors different type of forests and other habitat types, along different elevations and comparing the prey species composition of Dhole in different habitat types gives an insight into the feeding behavior of this species.

The present study is designed to identify the prey species composition of Dhole across various habitat types in Wayanad. A baseline data on the status and distribution of Dhole in Wayanad will be obtained by mapping the distribution of Dhole in Wayanad. The present study also aims at identifying the major threats to Dhole populations and to suggest possible management plans and mitigation measures to prevent the species from going extinct.

The following were the objective of study.

a. To identify the prey composition of Dhole (*Cuon alpinus*) in South Wayanad Forest Division.

b. To map the critical habitats of *Cuon alpinus* in South Wayanad Forest Division.

2. REVIEW OF LITERATURE

2.1. DISTRIBUTION AND STATUS OF DHOLES

Dholes (*Cuon alpinus*) are pack hunting canids, once historically distributed through Tyan-Shan and Altai mountains, and Maritime Province of the Soviet Union southward through Mongolia, Korea, China, Tibet, Nepal, India and South-east Asia, including the Malayan Peninsula, Sumatra and Java (Cohen 1978).

Johnsingh (1985) studied the distribution and status of Dholes in South Asia. Out of the nine sub species, five were found in South Asia and three were commonly reported. Even though Dholes had disappeared from their former habitats they were found in almost all protected areas throughout North-East India, Central India, Western Ghats and Eastern Ghats.

Even though Dholes have been known to be habitat generalists which occur in a wide variety of vegetation types like tropical dry and moist deciduous forests, evergreen and semi-evergreen forests, temperate deciduous forests, boreal forests, dry thorn forests, grassland–scrub–forest mosaics, temperate steppe, and alpine steppe, they are considered as endangered by the International Union for Conservation of Nature and Natural Resources. Their distribution range has been narrowed to some parts of Bangladesh, Bhutan, Cambodia, China, India, Indonesia and Lao People's Democratic Republic due to depletion of prey base, habitat loss, persecution due to livestock predation, disease transmission from domestic dogs, and possibly interspecific competition (Kamler *et al*., 2015).

2.2. TAXONOMY

Hodgson (1838) described the genus *Cuon* in the family Canidae under the order Carnivora with the type specimen as *Canis primaevus*.

Pocock (1936) studied the anatomy of skin and skull and monographed the genus *Cuon*. The author described the Asiatic Wild Dog or Dhole as *Cuon javanicus*.

Cohen (1976) synonymized the whole nine old species in to *Cuon alpinus* the Dhole, Asiatic Wild Dog or Red Dog as the only extant species of genus *Cuon*.

Ginsberg and Macdonald (1990) noted that there were 11 subspecies of wild dogs, of which three subspecies occurred within India viz. *C. a. dukhunensis*, found south of the river Ganga, *C. a. primaevus*, seen in Kumaon, Nepal, Sikkim and Bhutan, and *C. a. laniger*, occurring in Kashmir and Ladakh. It was opined that *C. a. adustus*, a subspecies found in northern Myanmar, might range into adjacent parts within India. *C. a. infuscus* was identified as the other subspecies found in Myanmar that might occur within Indian limits.

Within the southern Dhole group, Iyengar *et al*. (2005) found two major phylogeographic genetic groupings on the mainland, and stated that the subspecific status of Dholes of Sumatra and Java was unclear and required further study.

2.3. ECOLOGY AND SOCIAL BEHAVIOUR

Pack size of Dholes varied in different studies. The largest pack observed by Venkataraman *et al.* (1995) consisted of 25 individuals while the largest pack reported was 40 by Davidar (1975). These large sized packs may occur through temporary fusion of packs or philopatry with neighbouring packs with recently shared genealogies for hunts, as explained by Fox (1984).

Johnsingh (1982) studied the reproductive biology and social behaviour of Dholes in Bandipur. The average number of adults in a pack found in the study area was 8.3 individuals. Almost all dens of Dholes were found close to water sources. The oestrous period of Dholes extended from September to February and

whelping from November to April. Gestation period was recorded to be about 60-62 days. Dhole pack had a home range of 20 km² (Johnsingh 1982) and was highly territorial and no packs hunted in the core area of other pack territory.

In a study conducted in Mudumalai by Venkataraman *et al.* (1995), the individual home ranges of two Dhole packs appeared to be larger than that of Bandipur (Johnsingh, 1982) - 53km² and 84 km² respectively.

Acharya (2007) conducted a radio-telemetric study which revealed that Dhole packs restricted themselves to a small area (15-20 km²) during the denning and nursing season. Ranges increased (30-60 km²) gradually during post-denning season. Home range sizes increased during the dispersal and pre-denning season. Ideally a pack of Dhole was noted to have an average range of 60-70 km² with a small core area of 20 km² in the centre.

2.4. DIET COMPOSITION AND CO-EXISTENCE WITH OTHER PREDATORS

Cohen *et al*. (1978) studied the food habit of Dholes in Mudumalai and found that the most common prey was the Common Hare (*Lepus nigricollis*) followed by Chital (*Axix axis*), Sambar (*Rusa unicolar*), Field Rat (*Millardia meltada*) and Wild Pig (*Sus scrofa*). Domestic cattle, Gaur, Muntjac and Mouse Deer were found to be preyed upon very negligibly. Even though the abundance of cattle in the study area was too high, Dholes did not prefer cattle flesh.

Johnsingh (1992) studied the prey selection of three large sympatric carnivores of Bandhipur Tiger Reserve. Even though all three predators were capable of killing large preys they preferred preys in different weight categories according to the predator weight. 42 per cent of the tiger kill had prey weighing above 100 kg, 69 per cent of leopard kill had prey weighing less than 50 kg and Dholes had one per cent of the kills above 100 kg category, 25 per cent of the kill in 50-100 kg category and 74 per cent in less than 50 kg category. Dholes

preferred Chitals and Sambar stags more whereas tigers and leopards preferred does.

Study of Karanth and Sunquist (1995) conducted a study on prey selection by tiger, leopard and Dhole in tropical rain forests and found that tigers preferred preys weighing more than 176 kg like Gaurs and Sambars, whereas leopards and Dholes preferred prey weighing in between 30-175 kg. Average weight of prey killed by tiger, leopard and Dhole were 91.5 kg, 37.6 kg and 43.4 kg, respectively. Tigers preferred adult males of Chital, Sambar, Wild Pig and young Gaurs whereas Dholes preferred adult males of Chitals and Sambars. Leopards were observed to have no preference.

Karanth and Sunquist (2000) studied behavioral correlates of predation by tiger, leopard and Dhole in Nagarhole and observed that the three predators selectively killed different prey types in terms of species, age, size and age-sex classes. Hunting activity pattern of Dholes was different to some extent when compared to the felids. Dholes were noted to be almost diurnal. All three predators used the same areas and similar habitats. In general, the activity patterns of all predators were more related to the activity pattern of their principal prey rather than to mutual avoidance.

Biswas and Sankar (2002) studied the food habit of tigers in Pench National Park, Madhya Pradesh. The study revealed that the major part of their diet constituted Chital (47.3%), followed by Sambar (14.5%) and Wild Pig (10.9%). Tigers killed medium-sized and large-sized prey if there was choice. Sambar and Wild Pig were hunted more than their availability and Chital according to its proportion. Common Langur was consumed the least than in proportion to its availability. Gaur and Nilgai were not observed to be included in tiger diet. The average weight of prey killed by tiger was 82.1 kg in the study area. Tigers mostly depended on wild ungulates than domestic livestock.

Reddy *et al.* (2004) studied the prey selection of Indian tigers in Nagarjunasagar Srisailam Tiger Reserve. The study revealed that the most

common prey was Wild Pig followed by Chital and Sambar. Only less than 7 per cent of the diet was composed of livestock. Tigers preferred smaller prey and avoided livestock predation in tropical dry deciduous forests where natural prey density was very low and livestock biomass was high.

Acharya (2007) observed that Dhole consumed a minimum of seven prey types in Pench Tiger Reserve and the most frequent prey consumed by them were Sambar (50%), which was significantly higher than its availability, followed by Chital (38%), which was the most abundant prey there. Sambar was the only preferred prey species observed during the study and around 6 per cent of the scat samples contained more than one prey species.

The study conducted by Andheria *et al.* (2007) on the diet and prey profiles of three sympatric large carnivores, the tiger, leopard and Dhole, in Bandipur Tiger Reserve showed that there was high overlapping in the dietary niche although these predators killed 11-15 vertebrate prey species. The largest ungulates such as Gaur and Sambar contributed 73 per cent of biomass intake by tigers whereas other medium sized prey like Chital and Wild Pig formed 65 per cent and 83 cent biomass intake of leopards and Dholes, respectively.

Shirbhate (2007) found 11 prey species in the diets of leopards of Melghat Tiger Reserve including small mammals like Indian Hare. Based on the biomass, leopards preferred Sambar followed by Wild Pig, domestic animals, Chital and Four-horned Antelope. Based on the frequency, leopards preferred Indian Hare followed by Sambar, Wild Pig, Langurs and domestic animals. 49.62 per cent of the scats contained two prey species. The average biomass consumed by a leopard per day during the study period was 1.3037 kg.

Shirbhate (2008) found 12 prey species in diet of Tigers of Melghat Tiger Resrve from 98 scats. The scat analysis revealed that tigers preferred Sambar based on the biomass in their diet followed by Wild Pig, domestic animals, Chital and Four horned antelope in their sequence of preference. On the basis of prey occurrence, tiger preferred Sambar followed by Indian Hare, Wild Pig, Four

horned antelope and Chital. The study concluded that tigers did not prey on gaurs which had more weight than the predators and preferred smaller prey like Indian Hare. The average biomass consumed by a tiger per day during the study period was 2.2856 kg.

Borah *et al.* (2009) studied food habits of Dholes in Satpura Tiger Reserve and identified seven prey species from scat analysis. Sambar (46.97%) occupied the highest per centage in prey frequency and Muntjac and Jungle Fowl had the lowest. In terms of biomass, Sambar (68.03%) had the highest and Jungle Fowl (0.28%) had the least contribution.

Dharaiya and Soni (2010) studied the ecology of leopards in Girnar Wildlife Sanctuary, Gujarat. The study revealed that both the sympatric species, leopards and lions competed for the habitat and prey base where both the resources were rare. Leopards mainly depended on the smaller and arboreal preys whereas lions generally did not prey on them. Leopards used areas nearer to the human settlements that were rarely used by lions.

A study by Gopi *et al.* (2010) in Western Arunachal Pradesh for conserving the endangered Asiatic Wild Dog recorded that the animals fed more on Wild Pig (36%) in terms of biomass followed by Sambar (34%), Barking Deer (14.7%) and Gaur (10.8%). The prey species were taken proportionately to their availability.

Kamler *et al.* (2012) studied the diet, prey selection and activity of Dholes in Northern Laos and showed that the major prey in Dhole's diet was ungulates (87% of biomass) and it also consisted of other carnivores (6%) and rodents (6%) too. Dholes were observed to be almost diurnal. Though their activity pattern was different from all ungulates, they preferred Muntjac and Sambar more.

The study of Selvan *et al.* (2013a) in Kalakad-Mundanthurai Tiger Resrve found 10 prey species in Dhole's diet and among these Sambar was consumed the

highest in terms of per centage and biomass followed by the Wild pig. Jungle Fowl was the least consumed.

Selvan *et al.* (2013b) studied prey selection and food habits of three sympatric large carnivores in a tropical lowland forest of the Eastern Himalayan Biodiversity Hotspot. The study revealed that biomass consumption for three sympatric predators varied from 254.3 kg for Dholes to 599.1 kg for tigers and there was a high overlap of prey consumption between tiger-leopard (85.3%) and tiger-Dhole (77.5%). Dholes preferred Wild Pig and Barking Deer in spite of their lower availability.

A study by Bashir *et al.* (2013) on the status of Dhole on high elevation habitats of Khangchendzonga Biosphere Reserve, Sikkim, found that Dhole diet was composed of unidentified rodents, Himalayan Tahr, Serow, Goral and some vegetable matter. 98.7 per cent of the biomass consisted of mountain ungulates like Serow, Himalayan Tahr and Goral. The frequency of occurrence of rodents was higher in the diet of Dholes. Serow (91-100 kg) was the largest prey consumed followed by Himalayan Tahr (80 kg) and Goral (30 kg).

Devkota *et al.* (2013) studied diet of Snow Leopard (*Panthera uncia*) in Shey Phoksundo National Park, Nepal. The study revealed 11 items of prey from the study area. Blue Sheep (30%) dominated more in the diet of Snow Leopards among the wild prey followed by rodents and then Himalayan Marmots on the basis of frequency of prey occurrence. Seventy per cent of the diet of Snow Leopard comprised of wild preys and thirty per cent comprises of livestock. Plant materials were also found in the scats.

Hayward *et al.* (2014) stated that two-third of the food biomass of the Dhole (*Cuon alpinus*) consisted of Sambar, Chital and Wild Pig, of which Sambar was preferred more and the preferred weight range (130-190 kg) of prey overlapped with that of leopards and tigers in Asia.

Aryal *et al.* (2015) conducted a study on the habitat selection and feeding ecology of Dhole in the Himalayas and found that Blue Sheep (13%) comprised more in the 80 per cent of wild prey species diet and livestock comprised the rest 20 per cent of the diet of Dholes.

Nurvianto *et al.* (2016) conducted a study on the feeding habits of Dholes in the Baluran National Park, Indonesia, and identified 20 prey species and ungulates contributed 95 per cent of prey species.

2.5. HAIR ANALYSIS FROM THE SCATS

Koppiker and Sabnis (1976) studied the macroscopic and microscopic structural parts of hairs of 21 Indian mammal species. A species identification key for the hair of these species was made using Camera Lucida diagrams for the distinct parts of medulla and proximal, medial and distal parts of each species.

Koppiker and Sabnis (1981) facilitated hair identification technique for some artiodactylan species using hair impression. Camera lucida diagrams were made by observing the hair impressions using microscope.

Mukherjee *et al.* (1994a) recommended that at least 20 hairs in random should be analysed from a single scat sample to check for multiple prey species in the scat in their study on standardisation of scat analysis techniques for leopards in Gir, India. The authors found that 48 per cent of the scat samples analysed had single prey species and rest of the scat samples had multiple prey species.

Mukherjee *et al.* (1994b) studied the different characteristics of hair and improved the prey species identification technique to analyse the scats of Asiatic Lion *Panthera leo persica*. Cuticular pattern of many species were found to be similar and hence it alone could not be taken into consideration for the species identification. A combination of hair characteristics were recommended to be taken into consideration for the species identification.

Soni *et al.* (2004) studied how to distinguish between different species of big cats among the genus *Panthera* by comparing the scale pattern, scale margin structure, scale distances and the medullary configuration. The authors suggested medullary configuration as the ideal character to distinguish between species.

Marinis and Asprea (2006) developed a hair identification key for the wild and domestic ungulates of Southern Europe by photographing the clearly visible cuticle and medulla of the hair of mammals and described the relevant differences between domestic forms and their relative wild ancestors as well as the effect of age and season on the microscopic structure of hair.

Bahuguna *et al.* (2010) stated that it was mandatory to observe more than one characteristic of hair to identify the species. Only the guard hair, the most robust of all hair type, was recommended to be used in making species identification reference. Cuticular structure, medullary structure, cross section of hair and hair measurements were taken into consideration for making the key for species identification.

Dharaiya and Soni (2012) studied the identification of hair of some mammalian prey of large cats in Gir. Cross section of hairs, cuticular imprints and hair measurements like width and length were the parameters used for species identification. Cuticular and medullary structures were suggested as the important parameters used for the hair identification. Species identification using cuticular pattern alone could lead to misidentification due to the damage caused to cuticle while passing through the gut of the predator.

2.6. SCAT ADEQUACY AND BIOMASS ESTIMATION

Floyd (1978) developed the formula to calculate the biomass consumed in wolves (*Canis lupus*) by feeding captive wolves with prey ranging from Snowshoe Hare (*Lepus americanus*) to adult deer (*Odocoileus virginianus*). The formula developed was $Y = 0.035 + 0.020\ X$, where Y = weight of prey species consumed per field collectible scat, and X = average weight of an individual of

species. The average number of collectable scats produced per prey species, the relative biomass and number of each prey killed were computed.

Weaver (1993) refined the Floyd's equation to $Y = 0.0439 + 0.008X$ by feeding mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and moose (*Alces alces*) carcasses to 3 captive gray wolves instead of feeding small prey like snowshoe hares (*Lepus americanus*). The mass (kg) of prey per collectable scat (Y) increased as the body mass of prey (X) increased.

Selvan *et al.* (2013) have successfully utilized the Brillouin's index (Brillouin 1956) for scat adequacy test by plotting it against number of scat samples for all predators.

3. MATERIALS AND METHODS

3.1. STUDY AREA

The present study was carried out in the South Wayanad Forest Division of Wayanad District, which is adjacent to Nilgiri Biosphere reserve. The plateau Nilgiri is the meeting place for three different mountain ranges of Peninsular India, the Sahyadri, joining it opposite to Mukkurthi peak, the southern Ghats across the Palghat Gap in the south, and the Eastern Ghats in the north-eastern corner. Wayanad is inserted along the North West corner of the Nilgiris and lies between North latitude 11° 26′ to 12°00′ and East longitude 75°75′ to 76°56′ and makes the southernmost tip of Deccan Plateau with an elevation ranging from 600-2100m above sea level. It is an east-sloping mid elevation plateau descending steeply in the west to Kerala plains and merging with the Mysore plateau to the east. Wayanad district spreads across an area of 2131 sq.km with 885.92 sq.km under forest cover.

The landscape can be topographically divided into two major parts, the southwestern and northeastern part. The south western corner of the plateau is characterized by a range of high ridges called Camel Hump Mountains. A hill range called the Brahmagiris erect at the north-eastern corner of Wayanad. This forms the western and south-western border of the Coorg plateau. Individual Mountain peaks like Banasuramala, Kurichiyarmala, Ambamala, Sugandhagiri and Lakkidi forms a wall to the western side, steeply sloping to the Kerala plains on the west side. The east and north-eastern sides of the plateau is flat and open with an undulating terrain with occasional hillocks.

Forests in Wayanad is administratively divided into three major forest Divisions *viz*, Wayanad Wildlife Sanctuary (Sulthan Bathery, Muthanga, Kurichiad and Tholpetty Ranges 344.44 km²), North Wayanad Forest Division (Mananthavady, Periya and Begur ranges 214.29 km²) and South Wayanad Forest Division (Kalpetta, Meppady and Chedeleth ranges 325.339 km²). Aralam

Wildlife Sanctuary and Kottiyoor Forests of Kannur district and Brahmagiri Wildlife Sanctuary of Karnataka marks the boundary in the north and north eastern parts of the district and the southwest parts are continuous with the Peruvannamuzhi, Thamarasseri and Vazhikadavu forest ranges of Kozhikode and Malappuram districts. Southeastern side of the district is bordered by Bandipur tiger Reserve in Karnataka and Mudumalai Tiger Reserve in Tamil Nadu. A small part of Meppadi Range makes border with Gudallur Reserved Forest of Nilgiri district to the southeast. North-eastern corner of Wayanad, across the Kabini River is bordered by Nagarhole Tiger Reserve (Fig. 1). The most densely populated area in the district is the mid-level plateau, which covers a major part of the land and the natural vegetation of these areas are mostly replaced by Coffee, Tea, Eucalyptus, Banana and Rubber plantations.

South Wayanad landscape is dominated by West coast tropical evergreen forests (Evergreen) and West coast tropical semi-evergreen forest (semi-evergreen) in most of its range, however high elevation areas above 1200 m like Elambaleri, Chembra, Vellarimala, Manikkunnumala, Settukunnu, Karavanthode, Kurichyarmala, Ambamala, Sugandhagiri, Banasuramala etc are characterized by Southern montane wet Temperate forests and Southern wet montane grassland mosaic (Shola-grassland ecosystem). Southern dry mixed deciduous forests (Moist deciduous) and are found in Irulam and Padri Reserve Forests of Chedleth Range. Riparian forests makes a separate forest type in the reserve forests of Kuruva Island, which is a delta formed by Kabini River in Chedleth Range. Teak, acacia and Eucalyptus plantations are also found in the protected and non-protected forest regions.

Sampling locations: The present study was carried out in Reserved Forests, plantations and private lands adjacent to forest areas in South Wayanad.

3.2. SAMPLING METHODS

Non-invasive methods were employed for sample collection to determine the food habits of Dhole. Transects were laid along various regions in Meppadi, Kalpetta and Chedleth Ranges of South Wayanad Forest Division.

Dhole scats were collected from selected trails by actively searching for them on the forest or plantation tracks, path junctions, and plain rocks. A total of 28 selected trails with length of 138.94 km were surveyed in the study area. Dhole scats were easily distinguishable from the other scats of large carnivores. Dholes defecate communally in some particular sites called latrine sites to show their pack strength. Dholes do not have the habit of scratching on tracks or trees near the defecation site whereas tigers and leopards do have (Johnsingh, 1982, 1983; Acharya, 2007). Scat samples were collected in a zip lock cover from the field sites using gloves. Scat samples from individual dogs were taken from each latrine sites. The date, place, GPS and the number of scats in a pile (number of scats per latrine site) was labeled on the zip lock cover. A total of 80 scat samples were collected during the study period. The hair samples were taken out from the each scat collected separately and washed thoroughly with small amount of detergent, dried and used for prey species identification.

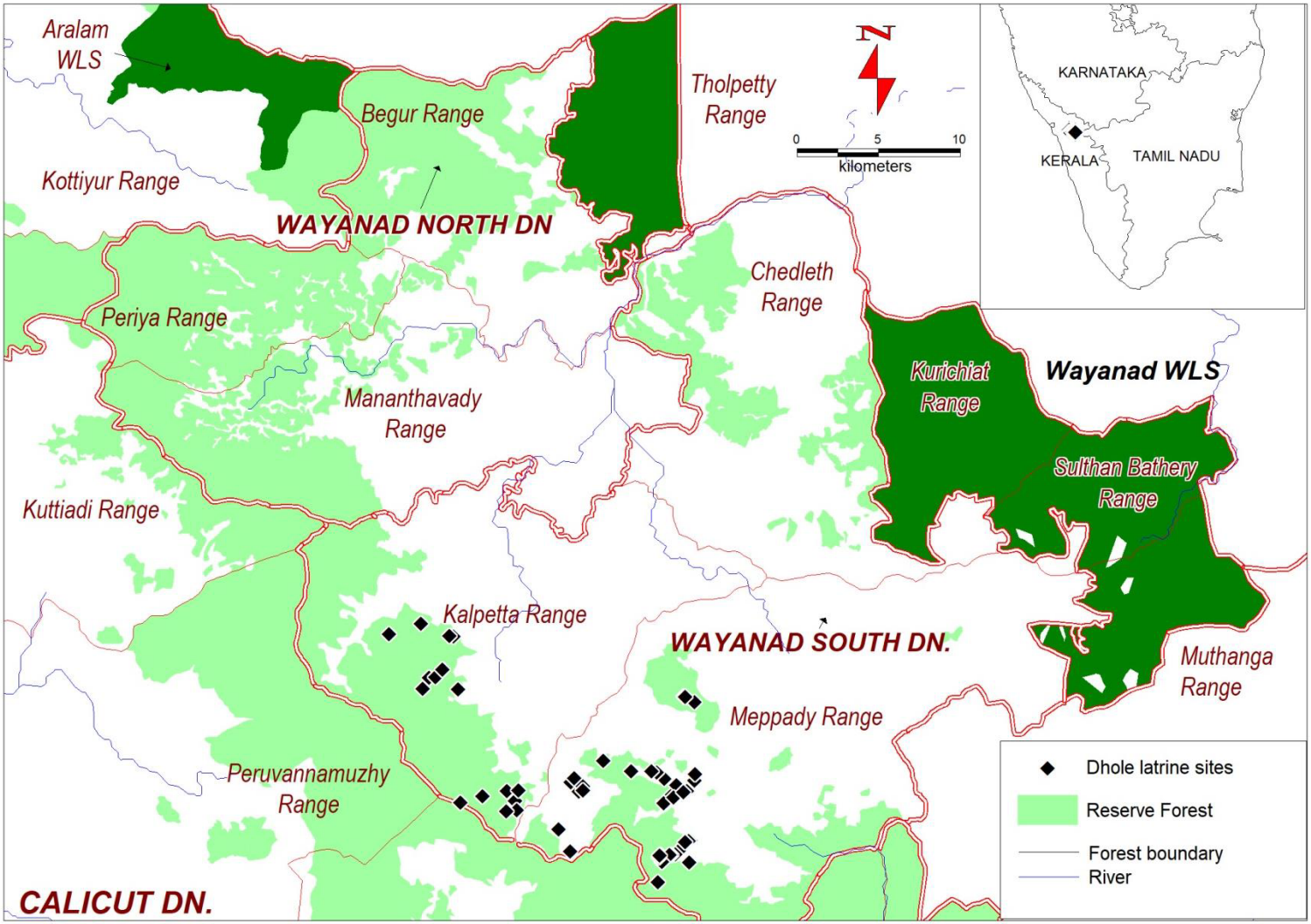


Fig.1. Map showing Dhole latrine sites in South Wayanad Forest Division

Table-1: Place name with distance walked in different places of South Wayanad Forest division

Trails No	Location	Zone	Distance Walked (km)
1	50 Acre	Lakkidi	4.68
2	900 Acre	Aranamala	11.38
3	Aanapara	Chembra	3.23
4	Aisha plantation	Vythiri	5.86
5	Aisha plantation	Vythiri	1.66
6	Amba	Lakkidi	3.88
7	Amba	Lakkidi	2.41
8	Aramala	Vythiri	2.62
9	Chembra	Chembra	6.49
10	Pookode	Lakkidi	15.12
11	Elambilery	Chembra	11.44
12	Elikka-Banasura	Kurichyarmala	13.2
13	Kurichyarmala	Kurichyarmala	7.64
14	Ladysmith	Kurichyarmala	4.69
15	Lakkidi	Lakkidi	4.22
16	Lakkidi	Lakkidi	1.25
17	Manikkunnumala	Manikkunnumala	8.58
18	Pampumpara	Lakkidi	4.89
19	Thalimala	Vythiri	2.1
20	Vythiri resort - Jungle park	Vythiri	6.42
21	Vythiri resort road	Vythiri	1.64
22	Padri	Padri	0.71
23	Irulam	Irulam	0.52
24	Irulam	Irulam	0.74
25	Vandikadavu	Vandikadavu	3.14
26	Kolavally	Vandikadavu	2.32
27	Aranamala	Aranamala	4.5
28	Aranamala	Aranamala	3.61
	Total		**138.94**

3.3. PREY SPECIES IDENTIFICATION

The undigested hair remains in the scats of Dhole were used for the identification of prey species of carnivores (Sunquist, 1981; Mukherjee, Goyal & Chellam, 1994a & b; Karanth & Sunquist, 1995). Prey species were identified

based on macroscopic and microscopic features of the hair from scats in comparison with standard reference slides made from the hair samples collected from Thiruvananthapuram Zoo and literature Bahuguna *et al.,* 2010. The identification was based on the general appearance of the hair colour, relative length, relative width, texture, basal configuration, cortex pigmentation, medullary width and patterns as described by earlier works (Koppikar & Sabnis, 1981; De Marinis & Asprea, 2006; Dharaiya & Soni, 2012).

3.3.1. PREPARATION OF STANDARD HAIR REFERENCE

The guard hair samples collected from the known captive prey species from Thiruvananthapuram Zoo were washed thoroughly in water with small amount of detergent and kept for drying.

3.3.1.1. CUTICULAR PATTERN

The dried guard hair samples were dipped in gelatin solution with a small quantity of methylene blue for better contrast. A thin layer of gelatin is made in to a cast on a clean new micro slide with a glass rod. The hair samples treated with gelatin and methylene blue is placed above gelatin layer on the micro slide immediately and pressed gently using a forceps. The micro slide is kept for drying without any disturbance for 5 minutes. The cuticular impression thus formed on the gelatin layer was examined using a microscope (Zeiss Axio Lab.A1) after removing the hair gently from the micro slide. Cuticular patterns of three different regions of hair- proximal, medial and distal were photographed under 10X and 40X objective lenses using a stereo microscope. This procedure is done for each species and different parameters of cuticle like scale margins, scale distances and scale patterns were noted.

3.3.1.2. MEDULLARY PATTERN

The dried guard hair samples were cut into small pieces and treated with xylene in a petridish for 2-3 hours, to avoid the air containing chambers which

creates obstructions while examining the medulla through the microscope. Xylene percolates into the hair cavities and removes the air from it and medulla becomes easily visible. The xylene treated hair samples of three different regions of hair- proximal, medial and distal were taken in a micro slide and temporarily fixed with xylene and examined using microscope and photographed immediately. The medullary pattern, mean thickness of medulla, cortex and relative width of hair at different regions of hair for each species were noted. Whenever the clear medulla is got, the hair is fixed permanently in Canada balsam and labeled.

3.3.2. HAIR ANALYSIS FROM SCAT SAMPLES

Twenty hairs were taken separately from each scat samples for examining the cuticular and medullary patterns to check for multiple prey species (Mukherjee *et al.,* 1994a). The different parameters of cuticular and medullary patterns mentioned above were observed for 80 scat samples. Photographs were taken using the same procedure used for the standard hair reference.

3.4. PER CENT OCCURRENCE, PER CENT BIOMASS AND RELATIVE NUMBER OF PREY CONSUMED

The frequency of occurrence (per cent of a particular species in the total number of prey items found) was calculated. The frequency of occurrence (expressed as a per cent of scats in which a particular prey item is found) is a commonly used measure of prey intake and composition. However, if the body sizes of different prey species are different, frequency of occurrence can be a misleading metric because of the surface to volume ratio problem (Floyd *et al.,* 1978). The number of scat produced for a prey species depends on the body size and relative surface area. Smaller species tend to have larger surface area in relation to volume that results in production of more scat compared to larger prey types. This leads to an overestimation of the proportion of small prey and underestimation of large prey in predator diet profiles when the frequency of occurrence is used as a measure. To overcome this problem, earlier studies of wolves (*Canis lupus*) by (Floyd *et al.,* 1978) developed regression equations

based on feeding trials in captivity using known prey of different body sizes. Karanth & Sunquist (1995) successfully adopted these regressions in their dietary studies of Dholes in India.

The regression equations relate the average live weight of a prey animal consumed (X) to the weight of consumed prey represented by one field-collectible scat Y=0.035+ 0.02X. The term 'Y' is used as a correction factor and multiplied to the observed frequency of occurrence data, to correct the over-representation of smaller prey (Floyd *et al*., 1978). The live weights of different prey species (X) used in our analyses were based on Karanth & Sunquist (1995). Using the correction factor Y, the relative biomass (D, the proportion of meat of a specific prey item in the predator's overall diet) and the relative number of a prey species consumed (E, the proportion of numbers of that prey taken among all prey numbers consumed by the predator) were estimated.

3.5. BRILLOUIN'S DIVERSITY INDEX

The prey species diversity was estimated from the scats of Dhole. Since the samples are not random this method of diversity estimation has been followed (Karanth and Sunquist, 1996; Selvan, K.M., et al., 2013). Brillouin's index is defined as

$$H = \frac{1}{n}\log\frac{n!}{\prod_{i=1}^{k} n_i!} = \frac{\log n! - \sum_{i=1}^{k}\log n_i!}{n}$$

where n_i is the number of observations from the sample in the i^{th} of k (non-empty) categories and n is the sample size.

The maximum value of H is

$$H_{max} = \frac{\log n! - (k-d)\log c! - d\log(c+1)!}{n}$$

where c = INT(n/k) and d = MOD(n, k).

Finally, **Brillouin's index of relative diversity** is $J = H/H_{max}$.

4. RESULTS

4.1. ENCOUNTER RATE OF SCATS ACROSS HABITAT

Encounter rate of Dhole scats across habitat varied, with higher encounter rate in the Shola grassland (1.76/km), followed by Tea and Cardamom plantation. Encounter rate was least in the Mixed plantations (0.32/km; Fig. 2). Though the encounter rate varied among habitats it was not statistically significant across habitats (Wilcoxon signed rank test- Median=0.54; df=5; p>0.05).

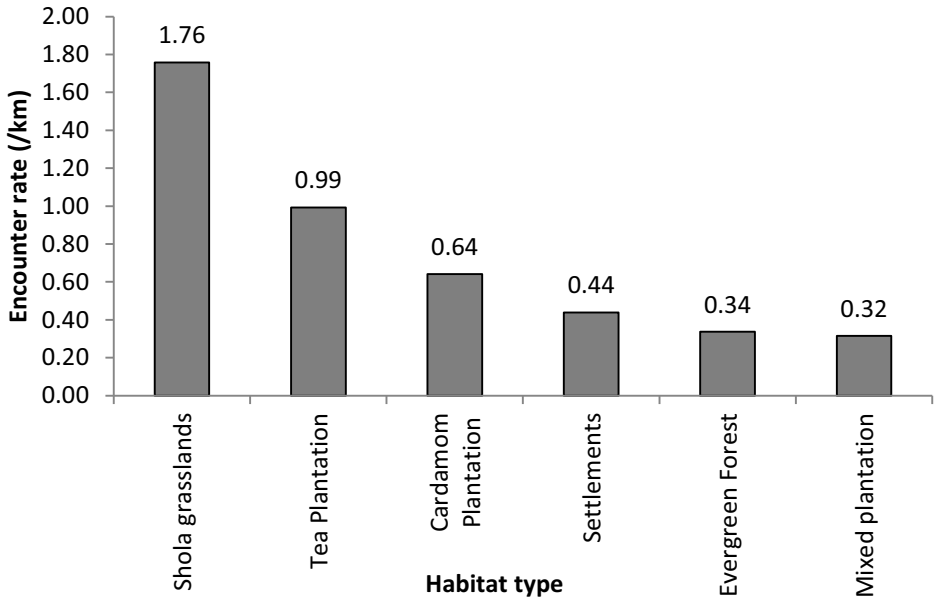


Fig. 2. Encounter rate of Dhole scats across habitats of South Wayanad Forest Division during the study period (May 2017 to July 2017)

4.2. ENCOUNTER RATE OF SCATS IN DIFFERENT ZONES

Encounter rate of Dhole scats varied between different zones. The encounter rate of Dhole scats in Aranamala was higher (9 scats/km; Fig. 3) when compared to other places, whereas Irulam, Padri and Vandikadavu had the least (zero scats/km) encounter rates. The average encounter rate of Dhole scats for the entire study was 2.74 scats per kilometer.

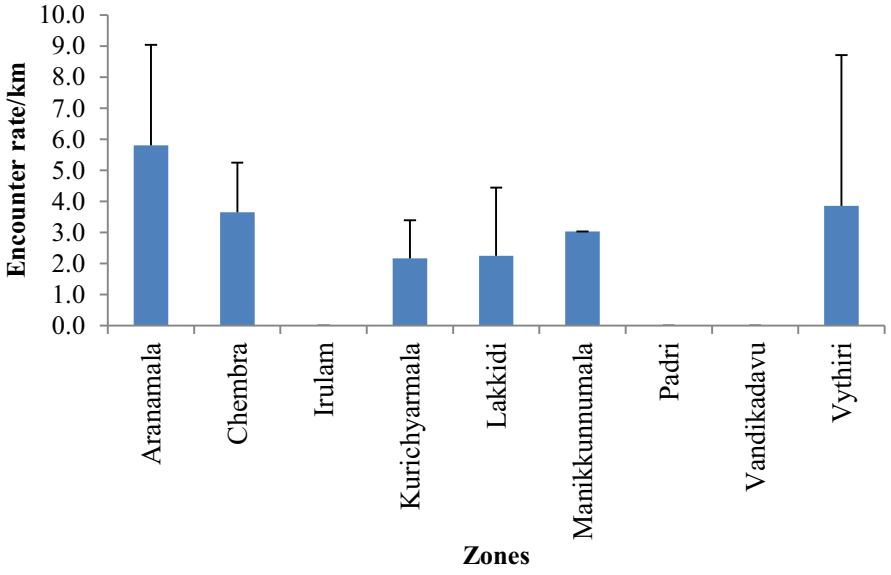


Fig. 3. Encounter rate of Dhole scats in different places of South Wayanad Forest Division during the study period (May 2017 to July 2017)

4.3. PACK SIZE

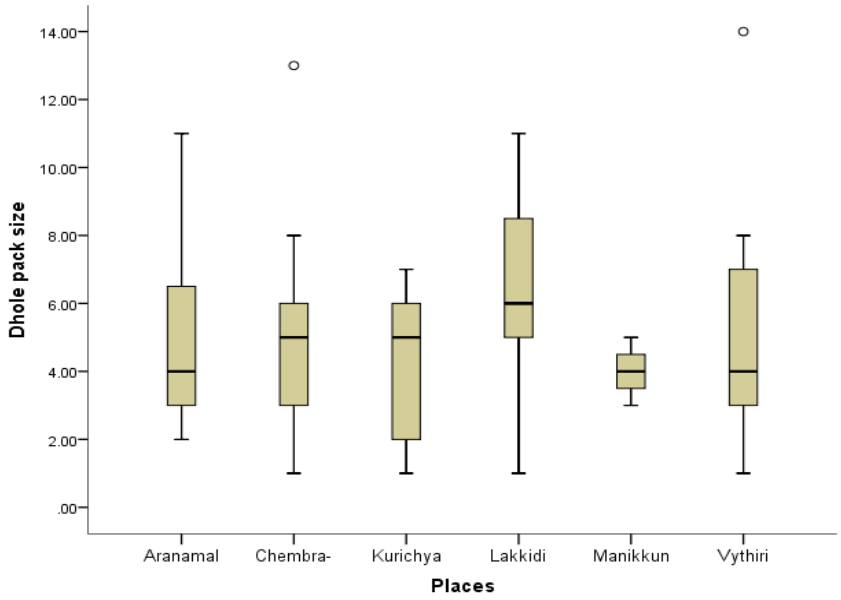


Fig. 4. Mean pack size and standard error in different places of South Wayanad Forest Division

Dhole pack size ranged from 1 to 14 individuals with mean pack size of 5.2±0.42. Since the pack size data is positively skewed the median of pack size

was compared in different places, the median pack size was higher in Lakkidi (six individuals) and it was least in Aranamala, Manikkunnumala, and Vythiri with four individuals respectively. Pack size varied significantly among different places (Wilcoxon Signed Rank Test Z=-3.191; df=5; $p<0.01$).

4.4. NUMBER OF PREY SPECIES

A total of 80 Dhole scats were analyzed for prey species composition. Most samples contained single prey species (75%) and multiple prey species were recorded from few samples (25%).The number of prey species recorded in the Dhole scats were plotted against the cumulative number of scats analyzed (Fig. 5). The number of prey species tends to increase rapidly and then stabilizes when the sample size was 65. A total of 12 (11 identified and one unidentified) prey species were recorded from the samples. The prey species recorded were Gaur (*Bos gaurus*), Sambar (*Rusa unicolor*), Chital (*Axis axis*), Barking deer (*Muntiacus muntjak*), Indian spotted chevrotain or Mouse deer (*Moschiola indica*), Indian Wild Pig (*Sus scrofa cristatus*), Black-naped Hare (*Lepus nigricollis*), Bonnet Macaque (*Macaca radiata*), Indian Crested Porcupine (*Hystrix indica*), Jungle cat (*Felis chaus*) and domestic cattle (*Bos indicus*).

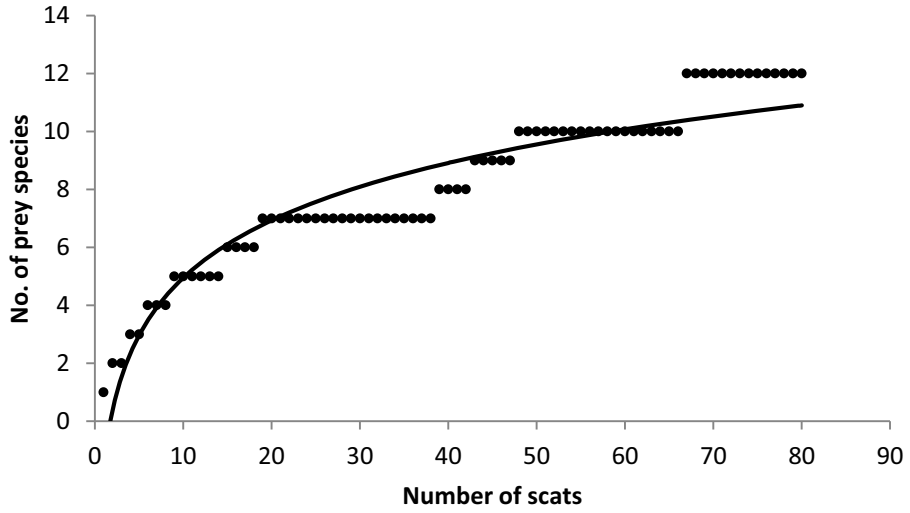


Fig. 5. Number of prey species recorded with cumulative number of scats analysed (n=80) at South Wayanad Forest Division

4.5. BRILLOUIN'S INDEX OF DIVERSITY

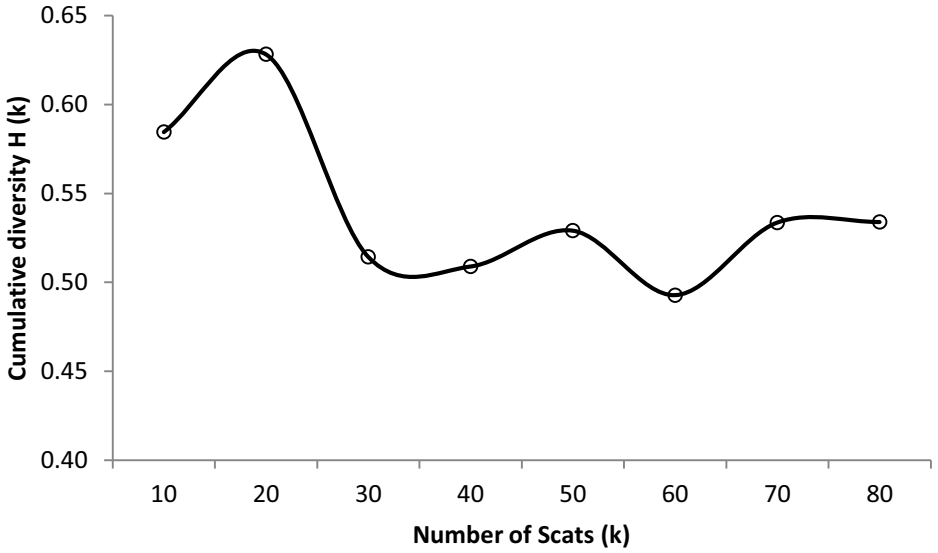


Fig. 6. Cumulative Brillouin's index of diversity H(k) of Dhole prey species based on scat analysis with increase in sample size (k, n=80) at South Wayanad Forest Division

Scat adequacy test was performed using Brillouin's index of diversity (Fig. 6). Initially diversity value was high 0.63 and then lowered to 0.51, the relative contribution of each prey species got stabilized in the diets of Dhole at 65th scat sample. The total diversity of prey species was 0.55.

4.6. PREY SPECIES COMPOSITION

Microscopic analysis of Dhole scat (n=80) revealed 10 wild prey species, domestic cattle and one unidentified prey species (probably of rodent species).The results indicate that wild dogs preferred sambar (55.45%) and wild pig (27.72%) more than other prey species, together constituting 83.17% of diet (Fig. 7). Barking deer, gaur, chital and black naped hare individually constituted less than 4% of the diet. Bonnet macaque, Indian crested porcupine, Indian spotted chevrotain and jungle cat were recorded to be the least preferred prey species individually constituting less than 1.5% of the diet. Domestic cattle constituted 1% of the total prey composition.

Comparison for per cent of frequency and relative biomass contribution of prey species showed significantly higher biomass contribution for Sambar (74.42%) than per cent of frequency (55.45%). On contrary the per cent biomass(17%) was lower than per cent frequency (27.7%) for Wild pig and results were statistically significant for both prey types (χ^2=12.472; df=1; p<0.000).Both prey species together constituted higher biomass (91.4%), other prey species constituted only 8.6% of the total biomass. There is no significant variation in the per cent of frequency and biomass of other prey species (Wilcoxon signed Rank test Z=-1.89; p>0.05).

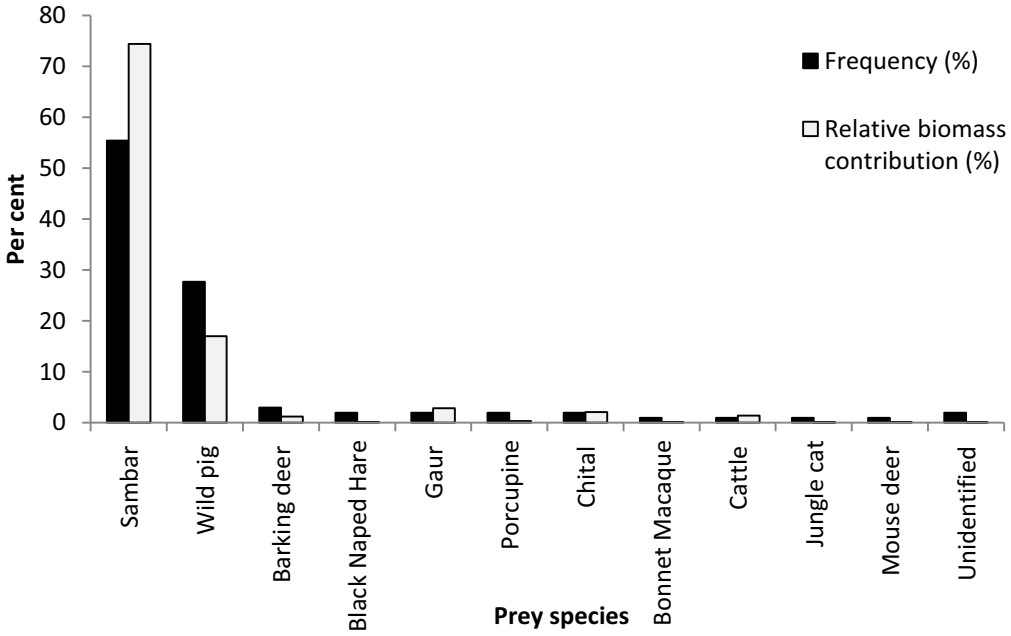


Fig. 7. Prey species composition (per cent of frequency and per cent biomass) of Dhole based on scat analysis (n=80) South Wayanad Forest Division

4.7. RELATIVE NUMBER OF PREY CONSUMED

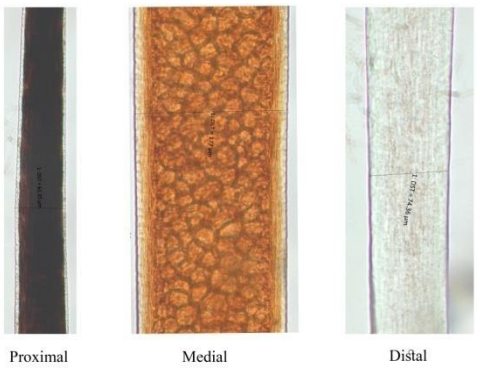
The relative importance of different prey types varied substantially when the three measures of prey intake (simple frequency of occurrence, corrected relative biomass consumption and per cent of frequency of different prey species killed by Dholes) were used for comparisons. Sambar constituted higher biomass (74.42%) than other prey species. Barking deer was recorded three times in the

samples (3.75%), but its relative biomass contribution was low (1.21%). Though per cent occurrence of Gaur, Chital and Black naped hare were same (2.5%), relative biomass contribution of Gaur (2.84%) and Chital (2.1%) were higher than Black-naped Hare.

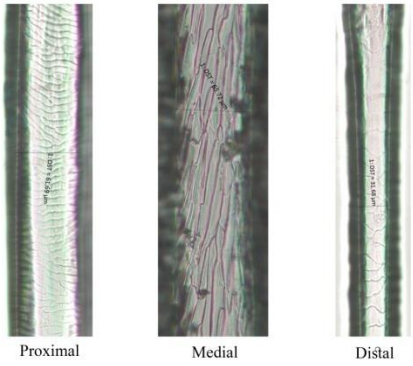
Table-2: Prey species composition in Dhole scat, relative biomass contribution and production of scats in each prey species in South Wayanad Forest division, Kerala (data sorted based on frequency in descending order)

Species	Body weight (kg, X)	Frequency of occurrence (F)	Occurrence %	Frequency (%)	Weight of prey eaten/ scat (Y)	Prey biomass consumed (F*Y)	% Relative biomass contribution (F*Y in %)
Sambar deer	70	56	70	55.45	1.44	80.36	74.42
Wild pig	31	28	35	27.72	0.66	18.34	16.98
Barking deer	20	3	3.75	2.97	0.44	1.31	1.21
Black-naped Hare	3	2	2.5	1.98	0.10	0.19	0.18
Gaur	75	2	2.5	1.98	1.54	3.07	2.84
Porcupine	8	2	2.5	1.98	0.20	0.39	0.36
Chital	55	2	2.5	1.98	1.14	2.27	2.10
Bonnet Macaque	8	1	1.25	0.99	0.20	0.20	0.18
Cattle	75	1	1.25	0.99	1.54	1.54	1.42
Jungle cat	4	1	1.25	0.99	0.12	0.12	0.11
Indian spotted chevrotain	5	1	1.25	0.99	0.14	0.14	0.13
Unidentified	0.2	2	2.5	1.98	0.04	0.08	0.07

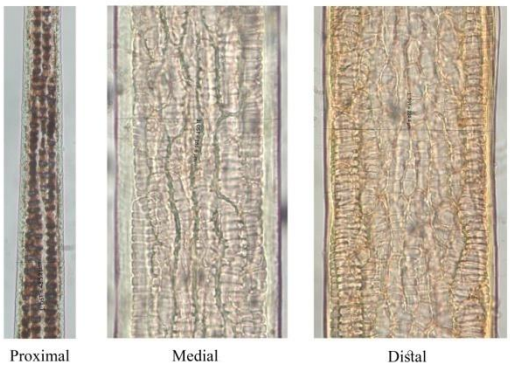
Cuticular Pattern of Barking deer



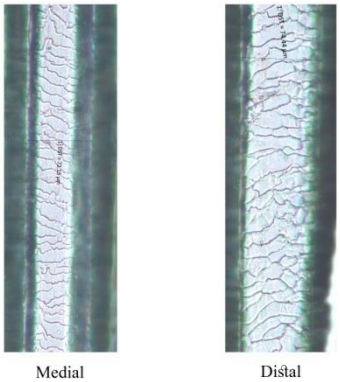
Medullary Pattern of Barking deer



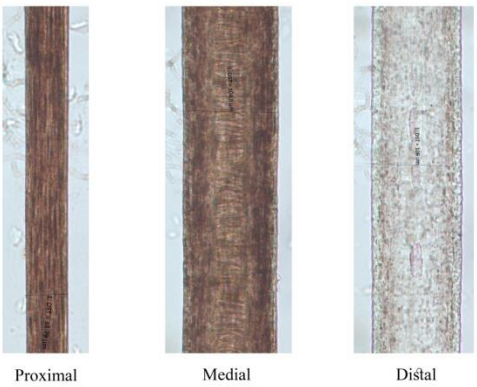
Cuticular Pattern of Black-naped Hare



Medullary Pattern of Black-naped Hare

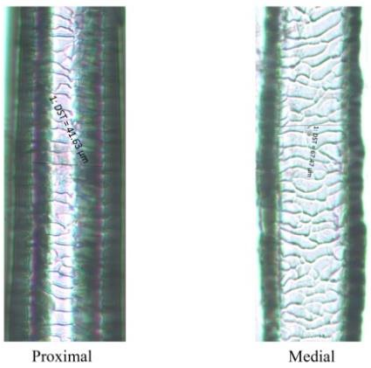


Cuticular Pattern of Bonnet macaque



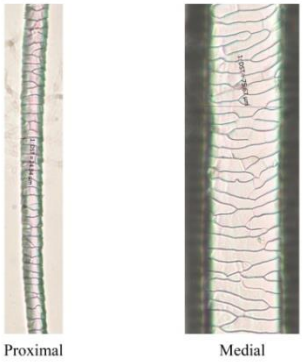
Medullary Pattern of Bonnet macaque

PLATE 2: **Cuticular and Medullary structures of hairs of Dhole prey species from South Wayanad Forest Division**

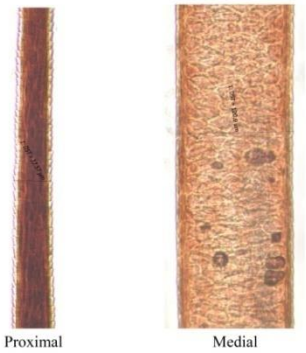


Cuticular Pattern of Cattle

Medullary Pattern of Cattle

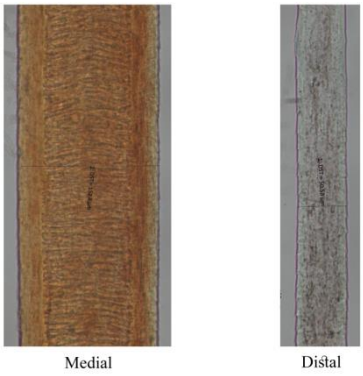


Cuticular Pattern of Chital



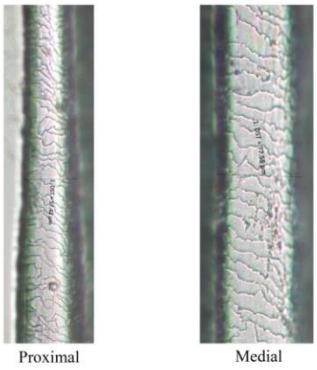
Medullary Pattern of Chital

Cuticular Pattern of Gaur

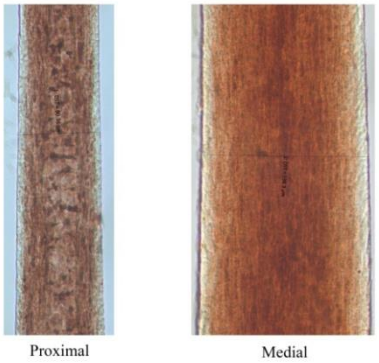


Medullary Pattern of Gaur

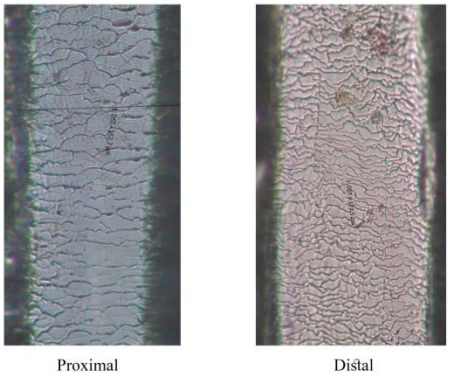
PLATE 3: **Cuticular and Medullary structures of hairs of Dhole prey species from South Wayanad Forest Division**



Cuticular Pattern of Porcupine

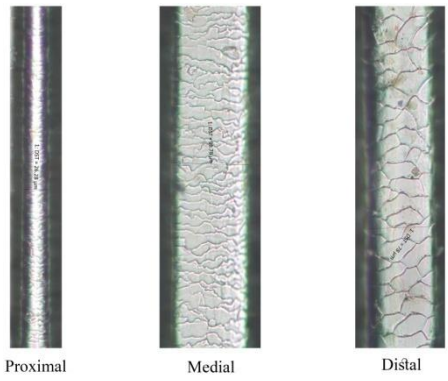


Medullary Pattern of Porcupine

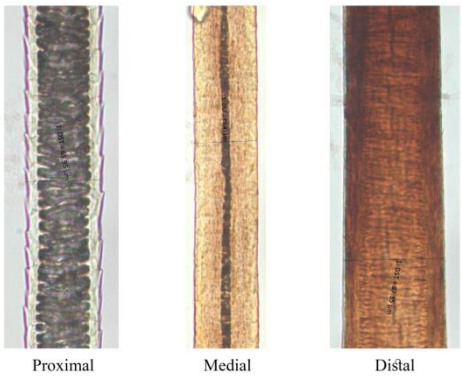


Cuticular Pattern of Wild pig

Medullary Pattern of Wild pig

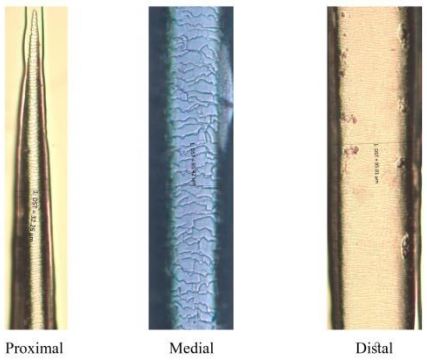


Cuticular Pattern of Jungle Cat

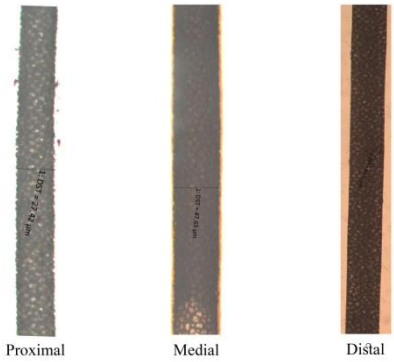


Medullary Pattern of Jungle Cat

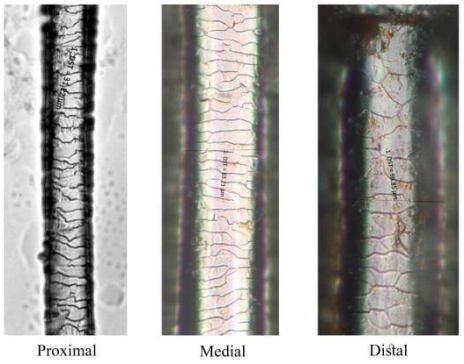
PLATE 4: **Cuticular and Medullary structures of hairs of Dhole prey species from South Wayanad Forest Division**



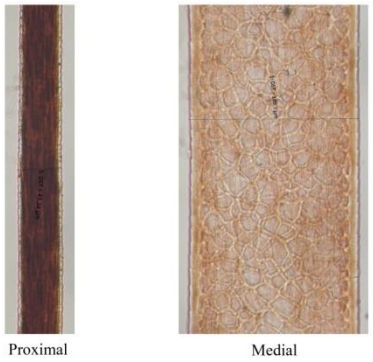
Cuticular Pattern of Mouse deer



Medullary Pattern of Mouse deer



Cuticular Pattern of Sambar deer



Medullary Pattern of Sambar deer

Medullary Pattern of Unidentified sp 1

Medullary Pattern of Unidentified sp 2

PLATE 5: **Cuticular and Medullary structures of hairs of Dhole prey species from South Wayanad Forest Division**

(A)

(B) (C)

(A) A Dhole latrine site along a forest road. (B) Pugmarks of a pack near a regularly used latrine site. (C) Dhole scats on a plane rock

PLATE 1: **Dhole latrine sites and pugmarks in the study area**

5. DISCUSSION

5.1. ENCOUNTER RATE

Encounter rates of Dhole scats were compared between different habitat types. A significant variation was not observed in the encounter rates of Dhole scats between different habitat types, however higher encounter rates were observed in Shola grasslands (1.76/km), followed by Tea and Cardamom plantations adjacent to forest areas. Encounter rate was least in the Mixed plantations (0.32/km). Encounter rate of Dhole scats varied between different zones. The encounter rate of Dhole scats in Aranamala was higher (9 scats/km) when compared to other places, No scats could be collected from Irulam, Padri and Vandikadavu regions. The average encounter rate of Dhole scats for the entire study was 2.74 scats per kilometer. The higher encounter rates of scats in Shola grasslands can be attributed to the habit of dholes to rest in open areas.

5.2. PACK SIZE

Dhole pack size ranged from 1 to 14 individuals with mean pack size of 5.2±0.42. The median pack size was higher in Lakkidi (six individuals) and was least in Aranamala, Manikkunnumala, and Vythiri with four individuals respectively. Pack size varied significantly among different places. Similar studies from Bandipur reported pack sizes ranging from 7-18 (Johnsingh1992). Studies of size of two packs of Dholes in Mudumalai varied from 4-18 and 4-25 (Venkataraman 1995).

5.3. DIET COMPOSITION OF DHOLE

In this study 12 species of prey were recorded from the study area and Sambar was observed as the predominant prey species of Dhole as evidenced by per centage occurrence (70) and per centage of relative biomass (74.42). The per cent occurrence of sambar in wild dog diet was significantly higher (70%) in the study area when compared with studies from other places in India such as

Bandipur Tiger Reserve (Andheria *et al.,* 2007), Kalakad-Mundanthurai Tiger Resrve (Selvan *et al.,* 2013), Pench Tiger Reserve (Acharya, 2007), Satpura Tiger Reserve (Borah *et al.,* 2009), Pakke Tiger Reserve (Gopi *et al.,* 2010) and Mudumalai Tiger Reserve (Ramesh *et al.,* 2012). The per cent of occurrence of Indian wild pig in Dhole diet is lower (35%) than Pakke Tiger Reserve – 47.6% (Gopi *et al*., 2010), however many other studies reported a lower per cent of occurrence for wild pig in dhole diet when compared with the present study (Andheria *et al.,* 2007; Selvan *et al.,* 2013; Acharya B.B. 2007; Borah *et al.,* 2009). Similar results were obtained with the per cent occurrence of barking deer in wild dog diet, where it is lower (3.75%) in the study area when compared with Pakke (Gopi *et al*., 2010) and KMTR (Selvan *et al.,* 2013) and higher when compared with other studies (Andheria *et al.,* 2007; Acharya B.B. 2007; Borah *et al.,* 2009; Ramesh *et al.,* 2012). Per cent occurrence of black-naped hare (2.5%) in wild dog diet is lower in the study area when compared with other areas (Acharya B.B. 2007; Borah *et al.,* 2009; Ramesh *et al.,* 2012; Gopi *et al*., 2010; Selvan *et al.,* 2013) except for Bandipur (Andheria *et al.,* 2007). Andheria *et al.,* 2007, Selvan *et al.,* 2013, Acharya B.B. 2007, Borah *et al.,* 2009 and Ramesh *et al.,* 2012 reported that chital constitutes a major prey species for wild dogs, however the present study reported only 2.5 % occurrence of Chital in wild dog diet. The per cent occurrence of gaur (2.5%) in Dhole diet is lesser than Pakke (Gopi *et al*., 2010) and KMTR (Selvan *et al.,* 2013) and higher when compared to Bandipur, Pench, Satpura and Mudumalai (Andheria *et al.,* 2007; Acharya B.B. 2007; Borah *et al.,* 2009; Ramesh *et al.,* 2012). Common langur which is a prey of Dhole (Andheria *et al.,* 2007; Acharya B.B. 2007; Borah *et al.,* 2009) has not been recorded in this study area and Pakke (Gopi *et al*., 2010).

It was found that wild dogs preyed upon twelve different prey species belonging to different size classes, this supports the view that Dholes are opportunistic predators feeding on available prey species, similar results were reported by other studies from India (Andheria *et al.,* 2007; Selvan *et al.,* 2013; Acharya, 2007; Borah *et al.,* 2009; Gopi *et al*., 2010). The present study clearly

indicates that Dholes are highly dependent on sambar, which is the most common and the largest ungulate in the study area over other prey species, followed by wild pig. The possible explanation for this can be that sambar and wild pigs are the predominant prey species in the landscape. The abundance of prey species in the landscape acts as a major factor which affects the prey preference by wild dogs. The present study area is dominated by evergreen and montane shola-grassland ecosystems with hilly terrain, which is not a suitable habitat for chital (Berwick, 1974; Chakrabarty, 1991; Sharatchandra & Gadgil, 1975), this might have added to the rarity of this prey species in the landscape. Similar studies from other continents supports the view that carnivores tends to prefer the most abundant prey, with different age and size classes (Mills, 1984 and Breuer, 2005)

The preference of sambar can also be explained where packs may be maximizing the energy intake per unit time, considering large ungulates makes more profitable prey species. This view is supported by the optimal foraging theory by MacArthur and Pianka (1996). Selective foraging or the intake of a particular prey species higher than its availability is supported in other studies by Chesson, 1978; Krebs, 1978; Sunquist and Sunquist 1989. The per cent occurrence of gaur, which is the largest ungulate in wild dog diet is very low. This can be because adult gaur is not a suitable prey for wild dogs with respect to its size, however packs were observed to occasionally hunt juveniles and calves of gaur. Prey selection by predators is explained by several other hypothesizes, most of which pertains to causal factors, such as energy benefits and costs involved (Stephen and Krebs, 1987). Proximal mechanism of selection such as search image or prey vulnerability explains the prey selection behavior in carnivores (Curio, 1976 and Taylor, 1976). Comparison for per cent of frequency and relative biomass contribution of prey species showed significantly higher biomass contribution for Sambar (74.42%) than per cent of frequency (55.45%). On contrary the per cent biomass (17%) was lower than per cent frequency (27.7%) for Wild pig. The number of scat produced for a prey species depends on the body size and relative surface area. Smaller species tend to have larger surface area in

relation to volume that results in production of more scat compared to larger prey types.

Wild dogs and tigers are reported to be socially dominant over leopards (Karanth and Sunquist, 2000), however studies from Nagarhole suggests that Dholes take smaller prey species like chital, in landscapes with high tiger density (Karanth and Sunquist 1995). Spatial and temporal separation between coexisting predator species is reported by Johnsingh (1992), Karanth and Sunquist (1995, 2000) and Dharaiya and Soni (2010). It is also reported that the ecological densities of sympatric predators directly depends on how the prey species communities are structured. Niche occupancy of large carnivores is further discussed in studies by Rabinowitz (1989). Prey selection and behavioral mechanisms were inferred as the key factor enabling the coexistence of tiger, leopard and wild dogs in same habitat (Seidensticker 1976; Johnsigh 1983, 1992 and Selvan *et al*. 2013). Prey selection is applicable only when the availability of prey species in appropriate size classes is not a limiting resource. Karanth and Sunquist (1995) reported that dholes and leopards preyed upon animals below 176 kg in regions with high tiger density, but the present study from South Wayanad reports sambar as the principle prey species for Dholes. Kerala Forest Department tiger census data 2016 reported six individual tigers from South Wayanad Forest Division (Annon, 2016). Hence the tiger density in the landscape is lower than Wayanad Wildlife Sanctuary and other adjoining landscapes, making wild dogs and leopards the dominant predator in the study area.

Larger predators are reported to prey on smaller prey species when the larger prey species density is low (Reddy *et al.,* 2004), which can also be a reason for wild dog packs to feed on smaller prey species. Behavior, demography and distribution of prey species are found to influence the co-operative hunting strategies in highly social carnivore species like the wild dog (Venkataraman *et al.*, 1995). Number of individuals within a pack is also identified as a major factor which influences the hunting and foraging behavior of Dholes. Larger packs tend to hunt larger prey species, where the success rate is high. Hayward *et al*.2006b

stated that prey selection by African wild dog (*Lycaon pictus*) was largely dependent on the pack size. However an opposite prediction is obtained via Resource Dispersion Hypothesis, which states that the existence of large group sizes in social carnivores may not bring out the advantages of a large number of individuals hunting co-operatively, where smaller preys doesn't satisfy the minimum nutritional needs of the group.

Analysis of the scat samples revealed that Dholes occasionally prey upon domestic cattle, which constituted 1.25% of Dhole diet. Physiological and reproductive status influences the feeding habits of animals. Scarcity of natural food and competition within landscapes force carnivores to move to fringes, which in turn results in contact with domestic animals. However domestic cattle doesn't make a significant prey species for Dholes in the present study area, indicating that packs opportunistically hunt cattle alongside other prey species.

6. SUMMARY

Dhole (*Cuon alpinus*) distribution and prey composition in South Wayanad Forest Division was studied from May 2017 to July 2017. Dhole scats were collected from the forest trails and roads. A total of 28 selected trails with length of 138.94 km were surveyed in the study area. Encounter rate of Dhole scats across habitat varied, with higher encounter rate in the Shola grassland (1.76/km), followed by Tea and Cardamom plantation. Encounter rate was least in the mixed plantations. Encounter rate of Dhole scats varied between different zones. The encounter rate of Dhole scats in Aranamala was higher (9 scats/km), where the vegetation is mostly Shola grassland and Cardamom plantation. Dhole scats were not recorded in Irulam, Padri and Vandikadavu, where the vegetation is dry and moist deciduous. Dholes where found to be summer visitors in deciduous forests of Irulam, Padri and Vandikkadavu regions of South Wayanad Forest Division. The average encounter rate of Dhole scats for the entire study was 2.74 scats per kilometer.

Dhole pack size ranged from 1 to 14 individuals with mean pack size of 5.2±0.42. Since the pack size data is positively skewed the median of pack size was compared in different places, the median pack size was higher in Lakkidi (six individuals). Pack size varied significantly among different places.

A total of 80 Dhole scat samples were collected during the study period. Prey species were identified based on macroscopic and microscopic features of the hair from scats in comparison with standard reference slides made from the hair samples collected from known species. Coprological analysis found 12 species as Dhole's prey belonging to different size classes, this supports the view that Dholes are opportunistic predators feeding on available prey species. Twenty five per cent of the scats samples were found to be having multiple prey species.

The relative contribution of each prey species got stabilized in the diets of Dhole at 65th scat sample. The total diversity based on Brillouin's index of

diversity of prey species was 0.55. Sambar (70%) was the principal prey species which is the most common and the largest ungulate in the study area over other prey species, followed by Wild pig (35%). Dholes occasionally prey upon domestic cattle, which constituted 1.25% of Dhole diet. The lesser per cent of livestock in the diet of Dhole indicating lower level of conflict by Dhole in the study area. The abundance of prey species, remaining forest patches supports higher predator density. But present land use changes, clearing of revenue forest areas into buildings, resorts, schools and colleges are potential threat to forest and Dhole in South Wayanad Forest Division.

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DHOLE (*Cuon alpinus*) DISTRIBUTION AND PREY COMPOSITION IN SOUTH WAYANAD FOREST DIVISION, KERALA

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(15-02MS-002)

Abstract of Dissertation Submitted in Partial Fulfillment of the Requirement for the Degree of

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8. ABSTRACT

Dhole (*Cuon alpinus*) distribution and prey composition in South Wayanad Forest Division was studied from May 2017 to July 2017. Dhole scats were collected from the forest trails and roads. A total of 28 selected trails with length of 138.94 km were surveyed in the study area. Encounter rate of Dhole scats across habitat varied, with higher encounter rate in the Shola grassland (1.76/km), followed by Tea and Cardamom plantation. The average encounter rate of Dhole scats for the entire study was 2.74 scats per kilometer.

A total of 80 Dhole scat samples were collected during the study period. Prey species were identified based on macroscopic and microscopic features of the hair from scats in comparison with standard reference slides made from the hair samples collected from known species. Coprological analysis found 12 species as Dhole's prey belonging to different size classes, this supports the view that Dholes are opportunistic predators feeding on available prey species. Twenty five per cent of the scats samples were found to be having multiple prey species.

The relative contribution of each prey species got stabilized in the diets of Dhole at 65th scat sample. The total diversity based on Brillouin's index of diversity of prey species was 0.55. Sambar (70%) was the principal prey species which is the most common and the largest ungulate in the study area over other prey species, followed by Wild pig (35%). Dholes occasionally prey upon domestic cattle, which constituted 1.25% of Dhole diet. The lesser per cent of livestock in the diet of Dhole indicating lower level of conflict by Dhole in the study area. Land use changes and conversion of revenue forest areas into human habitation are threats to Dhole and its prey species in South Wayanad Forest Division.

Acad. Form No. 19

KERALA VETERINARY AND ANIMAL SCIENCES UNIVERSITY

Faculty of College of Veterinary and Animal Sciences

PROGRAMME OF RESEARCH WORK FOR DISSERTATION FOR MASTERS DEGREE

(Vide Rule 25(b) of Post Graduate Regulations 1998)

1. Title of Dissertation

Dhole (*Cuon alpinus*) distribution and prey composition in South Wayanad Forest Division

2a. Title of departmental/KVASU research project of which this forms a part

Nil

2b. Code No. if any, and order by which the departmental/KVASU research project is approved

Nil

3a. Name of the student

Samuel George

3b. Admission No.

15-02MS-002

4a. Name of the Major Advisor (Guide)

Dr. George Chandy

4b. Designation

Course Director,
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5. Objectives of the study

a. To identify the prey composition of Dhole (*Cuon alpinus*) in South Wayanad Forest Division.

b. To map the critical habitats of *Cuon alpinus* in South Wayanad Division.

6. Practical/Scientific utility

The Dhole, Asiatic wild dog, Indian wild dog or red dog (*Cuon alpinus*) is an endangered canid native to Central, South and South East Asia. India is holding the largest population of wild dogs distributed in most of the Indian Sub-continent, along the Central Indian highlands, the Western and the Eastern Ghats. Social behavior and anatomy of Dholes distinguish them from other canids invariably. Dholes form large packs, with a social structure more flexible than Grey Wolves (*Canis lupus*). Despite the wide distribution, the current estimated population status of the species is below 2500 adult individuals (IUCN). Habitat degradation along with other natural and anthropogenic factors is pushing the species to the verge of extinction in India and elsewhere. Although many studies have been conducted on the ecology and phylogenetics of this species in Western Ghats, a comprehensive data of feeding habits and prey preference of Dholes in Wayanad is unavailable. Many studies suggests that herbivore populations varies across different habitat types and the prey species availability for carnivores vary significantly across different habitat types. Wayanad being a mosaic of different landscape features, harbors different type of forests along different elevations and comparing the prey species preference of dhole in different habitat types gives an insight into the feeding behavior of this species. The present study is designed to identify the prey species composition of Dhole in South Wayanad Forest Division. A baseline data on the status and distribution of Dhole in Wayanad will be obtained by mapping the distribution of Wild dogs in Wayanad. The present study also aims at identifying the major threats to dhole populations and to suggest possible management plans and mitigation measures to prevent the species from going extinct.

7. Important publications on which the study is based

Koppiker and Sabnis (1976 & 1981) studied the macroscopic and microscopic structural parts of hairs some Indian mammal species. A species identification key for the hair of these species was made using Camera Lucida diagrams for the cuticule and medulla of proximal, medial and distal parts of each species.

Mukherjee *et al.* (1994a & b) implemented the prey species identification using the hair identification technique from the scats and recommended that at least 20 hairs in random should be analysed from a single scat sample to check for multiple prey

species in the scat in their study on standardisation of scat analysis techniques for Leopards and Asiatic Lions in Gir, India.

Dharaiya and Soni (2012) studied the identification of hair of some mammalian prey of large cats in Gir. Cross section of hairs, cuticular imprints and hair measurements like width and length were the parameters used for species identification. Cuticular and medullary structures were suggested as the important parameters used for the hair identification. Species identification using cuticular pattern alone could lead to misidentification due to the damage caused to cuticle while passing through the gut of the predator..

Karanth and Sunquist, (1995) conducted a study in Nagarhole National Park states that Tiger prefers preys weighing more than 176 kg whereas Leopard and Dhole prefers prey weighing in between 30 - 175 kg.

Acharya (2007) observed that Dhole consumed a minimum of seven prey types in Pench Tiger Reserve and the most frequent prey consumed by them were Sambar (50%), which was significantly higher than its availability, followed by Chital (38%), which was the most abundant prey there. Sambar was the only preferred prey species observed during the study and around 6 percent of the scat samples contained more than one prey species.

Borah *et al.* (2009) studied food habits of Dholes in Satpura Tiger Reserve and identified seven prey species from scat analysis. Sambar (46.97%) occupied the highest percentage in prey frequency and Muntjac and Jungle Fowl had the lowest. In terms of biomass, Sambar (68.03%) had the highest and Jungle Fowl (0.28%) had the least contribution.

Selvan *et al.* (2013) studied Prey selection and food habits of three sympatric large carnivores in a tropical lowland forest of the Eastern Himalayan Biodiversity Hotspot. It reveals that Biomass consumption for three sympatric predators varied from 254.3 kg for dholes to 599.1 for tigers and there was a high overlap of prey consumption between tiger-leopard (85.3%) and tiger-dhole (77.5%).

Hayward *et al.* (2014) two-third of the food biomass of the dhole(*Cuon alpinus*) consist of sambar, chital and wild boar, in which sambar is preferred more and the preferred weight range of 130 - 190 kg of prey overlaps with leopards and tigers in Asia.

The optimal foraging theory by Mac Arthur and Pianka (1966) predicts that a predator

should go for the most profitable prey when they are abundant in the environment.

Floyd (1978) developed the formula to calculate the biomass consumed in wolves (*Canis lupus*) by feeding captive wolves with prey ranging from Snowshoe Hare (*Lepus americanus*) to adult deer (*Odocoileus virginianus*).. The average number of collectable scats produced per prey species, the relative biomass and number of each prey killed were computed.

8. Outline of the technical programme

a. Prey species identification

Scat samples of Dholes will be taken from different regions of Wayanad and will be subjected to coprological analysis. Hair samples collected from the scats will be used to identify the corresponding prey species.

b. Occurrence mapping

Indirect signs like scats and pugmarks and direct sightings will be used to identify the presence of Dholes. GPS readings taken at each location will be used to map the critical habitat.

c. Habitat threat assessment

Major threats to dhole populations and possible conflict issues in the study area will be identified through a questionnaire survey among the forest staffs and the settlements around.

9. Main items of observations to be made

1. Prey composition of Dholes in different habitat types will be identified through scatological analysis.

2. Prey species abundance in the study area will be estimated.

3. Major threats to Dhole populations will be recognized.

10. Facilities

Equipments:

1. Compound microscope

2. GPS

3. Sampling tubes

4. Markers

5. Stickers

Chemicals for hair analysis:

1. Ether alcohol
2. Xylene
2. Ethyl lactate
3. Canada balsom
4. Gelatine Powder

11. Duration of study: One semester

12. Financial estimate:

Sample collection	=	Rs. 5000
Travelling	=	Rs. 15000
Chemicals	=	Rs. 5000
Miscellaneous	=	Rs. 5000
Tracker	=	Rs. 10000
Total	**=**	**Rs. 40000**

13. Signature of the student:

14. Signature of the Guide:

Place: Pookode

Date:

15. Name, designation and signature of members of the advisory committee:

1. Dr. George Chandy (Course Director and Guide)

Officer in Charge,
KVASU-Centre for Wildlife Studies,
Kerala Veterinary and Animal Sciences University, Pookode, Wayanad.

2. Dr. Abdul Azeez C.P. (member)

Assistant Professor,
KVASU-Centre for Wildlife Studies,
College of Veterinary and Animal Sciences, Pookode.

3. Dr. Biju S. (Member)

Assistant Professor,
Department of Livestock Production Management,
College of Veterinary and Animal Sciences, Mannuthy, Thrissur.

Appendix 1

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Appendix II

Time frame of Work

Semester I

1. Collection of literature

Semester II

2. Collection of literature

Semester III

1. Collection of literature
2. Review of literature
3. Planning of research programme
4. Submission of synopsis

Semester IV

1. Preparation of manuscript
2. Research work
3. Interpretation of results
4. Dissertation preparation and submission

CERTIFICATE

Certified that the research project has been formulated observing the stipulations laid down under the Prevention of Cruelty to Animals Act (Amendment, 1998)

Place: **Dr. George Chandy**

Date: **(Guide)**

CURRICULUM VITAE

Name of the Candidate	**:**	Samuel George
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Major Field of Specialization	**:**	Wildlife Studies
Permanent Address	**:**	Mookanamparambil House Vellapady, Kodakara P.O., Thrissur, Kerala Pin: 680684 Email id-samuhawkz28@gmail.com
Educational Status	**:**	B.Sc. Zoology
Professional Experience	**:**	Nil
Publication Made	**:**	Nil
Membership in Professional Bodies	**:**	Nil