UTILISATION OF THE WATERHOLES BY WILD ANIMALS IN WAYANAD WILDLIFE SANCTUARY

BY

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(2017-17-004)

THESIS

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DECLARATION

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I, hereby declare that this thesis entitled **"Utilisation of the waterholes by wild animals in Wayanad Wildlife Sanctuary"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Certified that this thesis, entitled **"Utilisation of the waterholes by wild animals in Wayanad Wildlife Sanctuary"** is a record of research work done independently by **Mr. Sachinkrishna, M. V. (2017-17-04)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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Sachinkrishna, M. V

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Introduction

INTRODUCTION

The Western Ghats is one of the 36 biodiversity hotspots in the world. It is a stretch of mountains having a length of 1600 km, starting from the south side of the Tapti river in Gujrat and runs parallel to the western coast passing the states of Maharashtra, Goa, Karnataka, Kerala and ends at Kanyakumari in Tamil Nadu. The forests of Western Ghats are known for its high species richness and endemism (Myers *et al*., 2000).

Wayanad Wildlife Sanctuary is bio-geographically one of the richest tracts of Western Ghats. It was established in 1973 and occupies an area of 344.44 km^2. The sanctuary is contiguous with the Mudumalai Tiger Reserve of Tamil Nadu and Bandipur Tiger Reserve of Karnataka. The sanctuary supports a large population of herbivores such as Asian Elephant (*Elephas maximus*), Gaur *(Bos gaurus*), Sambar Deer (*Rusa unicolor*), Spotted Deer (*Axis axis*), Barking Deer (*Muntiacus muntjak*), Mouse Deer (*Moschiola indica*), Wild boar (*Sus scrofa*), and three species of primate such as Tufted Gray Langur langur (*Semnopithecus priam*), Bonnet Macaque (*Macaca radiata*) and Slender Loris (*Loris lydekkerianus*). The large predators present in Wayanad is Tiger (*Panthera tigris*), Leopard (*Panthera pardus*), Asiatic Wild Dog (*Cuon alpinus*) and Sloth bear (*Melursus ursinus*). (Narasimen *et al*., 2014). Other mammals such as Jungle Cat (*Felis chaus*), Indian Pangolin (*Manis crassicandata*), Malabar Giant Squirrel (*Ratufa indica*), Indian Hare *(Lepus nigricollis*) are also sen in this area (Easa, 1999). One hundred and forty three species of butterflies are reported from the Sanctuary (Vishnudas *et al*., 2009). The camera trap studies revealed that there are 75 individual tigers (Narasimen *et al.,* 2014) as well as 224 wild elephants (Sivaram *et al*., 2010) are there in the Sanctuary. Moreover, it is reported to have local migrations of elephants and other animals from adjacent forest areas of Muthumalai and Bandipur to Wayanad (Anonymous, 2014). The decline in area wise population in elephants may adversely affect the long-term viability of that ecosystem (Joshy and Singh, 2009). The elephant corridors of north Karnataka along the Brahmagiri Hills pass

through North Wayanad. Thirunelli reserved forest and Kudrakote reserve forest also coming under this corridor (Varma *et al*., 2005).

Water is the most important requirement of life. The distribution of an animal in a particular season may have a direct relationship with the availability of water in that season. So that an animal's water requirements have implications for all aspects of ecology and conservation (Hayward and Hayward, 2012). Providing sufficient water in the forest is considered as a key managerial intervention. Different species may have different water requirements so that to reduce the competition for water and other related resources, they follow a temporal pattern of waterhole usage. The provisioning of water should be done after proper scientific studies as it can alter the distribution of wild animals and hence affects the ecology of the habitat (Smith and Grant, 2007)

In Wayanad Wildlife Sanctuary, the forest department has done many activities to maintain water availability in the forest in dry months. The sanctuary has natural and artificial waterholes. Many of them will dry up in the summer months, but about 20 % of them will hold water throughout the year. The forest department is making enormous efforts to maintain water availability in these waterholes and to maintain the pasture. Desilting of waterholes, clearing the undergrowth around the water bodies, removal of weeds from the swamps, etc. are some of the management activities done by the forest department. But the usage of these waterholes by the wild animals are not systematically studied so far. There are very few studies have been conducted in the water-related aspects of wildlife management in India. Most of them were discussing the time activity pattern of animals.

This study is the preliminary phase analysis to know the trend of waterhole usage by wild animals in Wayanad Wildlife Sanctuary. The pattern of water utilisation by various animals will be evaluated. The findings regarding the preference for natural and artificial waterholes will help appraise the capability of waterholes to support the wild animals in the sanctuary. It can also be used to

identifying the key areas of management of water resources in the sanctuary and to determine future management prescriptions.

The main objectives of this study are as follows

- Mapping of the natural waterholes/ swamps (*vayals*) and waterholes in the Wayanad Wildlife Sanctuary
- To assess the utilisation pattern of the waterholes by the wild animals

Review of literature

REVIEW OF LITERATURE

2.1 WATER SOURCES AND WILDLIFE DISTRIBUTION

Water sources alter the way animals use landscapes. The movement and migration of an animal or animal group largely depend upon the availability of resources like natural food and water (Joshi, 2009; Eisenberg and Lockhart, 1972; Joshi and Singh, 2007; Redfern *et al.*, 2005). The spatial and temporal distribution of wild animals is directly linked with the distribution of natural as well as artificial waterholes. The movements of large mammals such as elephants can greatly influence the overall distribution of small herbivores, hence their movement can be considered as an important ecological factor. The migration of large mammals is mainly decided by the availability of water (Joshi and Singh, 2009). The availability of forage in dry seasons is a limiting factor for the herbivores. Hence, the distribution of surface water will decide the movement of animals in lean periods (Franz *et al.*, 2010). During the dry season, the wild ungulates drink more frequently to meet their body requirements (Western 1975). McNab (1963) says that the size of the home range of a particular animal may increase with its body size and energy requirements.

There are around 21000- 25000 Asian elephants in India (Joshi, 2009). The seasonal movement of elephants is largely decided by the rainfall pattern (Johnsingh *et al.*, 2015). Usually, the elephant home range may contain at least one river system (Joshi, 2009). Because the water requirement for elephants is comparatively high due to loss of water through cutaneous and respiratory evaporation (Dunkin *et al.*, 2013). Hamilton (1972) reports the size of the home range for an African elephant as 14 to 52 Sq. km at Lake Manyara NP, Tanzania. The provisioning of artificial water sources will tend to increase the range of habitat utilization (Purdon and Aarde, 2017; Loarie *et al.*, 2009). In tropical deciduous forests of India, having high herbivore population density, the forage and water may not be available in large quantities, which may be resulting in a non-uniform distribution of animals (Lakshminarayanan *et al.*, 2015). The movements of

elephants in the dry season will be more concentrated near the water sources (Joshi and Singh, 2009). The elephants can detect the smell of water and seems to move towards water bodies or wet areas (Sukumar, 1990). Joshi and Singh (2009) said that in Corbett Tiger Reserve, around 200 elephants were found to be aggregate on the banks of the river Ramganga in the dry season and these were dispersed into the hills by the onset of monsoon. Similar aggregation can be seen in the banks of the Kabani river in the Nilgiri biosphere reserve.

Asian elephants prefer to drink water at least once a day. They found to be taking 100 liters of water at a time and about 150 liters in dry periods (Eisenberg and Lockhart, 1972; Johnsingh *et al.,* 2015). The elephant groups with calves will use waterholes more frequently (Wittermyer, 2011). Usually, the herd prefers early morning and evening hours to drink water. But the variation in this temporal arrangement has seen when the herd is having calves. The timing of waterhole utilisation also varies with temperature, humidity, rainfall, and season (Joshi, 2009). These patterns can be changed with the changes in environmental factors such as rainfall (Sukumar, 1989).

The elephants sometimes cover their bodies with mud or dry soil or spray water on to the body to combat the high atmospheric temperature (Joshi, 2009). This may take place mostly during the dark hours (Eisenberg and Lockhart, 1972). In summer months, they are found to lay down in the water for hours to cool their bodies (Joshi, 2009). In the dry season, the elephants found to be digging small pits on the dry river bed or waterhole by beating their leg forward and backward, to collect water (Eisenberg and Lockhart, 1972). Human interference is found to be having a promising influence in determining the waterhole usage of elephants.

When a herd starts bathing, the adult cow will enter the water first and make sure it's safe for others, then only the other members including calves enter the waterhole. Even after entering into the waterhole, they will wait for some time, listening to any kind of unfamiliar sound or a symbol of threat (Joshi, 2009).

In Rajaji NP, during the wet season, the elephants seemed to be moving to the upper areas, where the lower lands become swampier (Joshi, 2009).

A study conducted in Nagarhole National Park by Lakshminarayanan *et al.*, (2015), shows that the elephant population was not found to be uniformly distributed in the dry season. The elephant activity was found to be larger near the riparian habitat, whereas it can provide both water and forage. It also offers shade that may help elephants in thermoregulation. The study also revealed that there is a very weak relationship with the density of artificial waterholes and the probability of waterhole used by elephants.

Some populations of African elephants are found to be drinking at night while some populations in the day time, concerning their local conditions (Risk related to heat stress or human interference). Most of the elephant herds have specialized drinking spots in rivers as well as waterholes.

In the Rwenzori National Park, Uganda, African elephants are observed to be drinking for 1-3 times a day (Wyatt and Eltringham, 1974).

Valeix *et al* (2007) studied the waterhole usage of African elephants in Hwange National Park, Zimbabwe. They stated that the elephant peaks its waterhole usage at dusk, and they also forced smaller mammals to shift their temporal arrangement of waterhole usage.

In Kruger National Park, South Africa, the peak elephant activity in waterholes was recorded from 13:00 hours to 24:00 hours. One herd of elephant observed to return to the waterhole every 12-36 hours. The study revealed that, when the elephant used artificial waterhole, they covered more area of the habitat than when they use only natural water sources (Purdon and Aarde, 2017).

Loarie *et al.*, (2009) studied the effect of fences and artificial water in determining the wild African elephant movement. They stated that, during the dry season, the elephant herds didn't move much away from the water sources. They

kept as close to the waterholes in the night hours, and far during the day time. The movement of African elephants in Amboseli National Park shows a clear linkage with the seasonality. The radio collar studies reveal that they range more from the water source during the wet season rather than the dry season. They were found to be raging within the radius of 10 km from the water source in the dry season and 40 km during the wet season (Western and Lindsay, 1984).

The distribution of wild ungulates such as Chital *(Axis axis),* Muntjac *(Muntiacus Muntjac),* Sambar deer *(Rusa unicolor),* Gaur *(Bos gaurus) etc.* are found to be decided not only by the availability of water, but also by the availability of grazing lands (Smit *et al.*, 2007). Schaller (1967) identified the availability of water as a main delimiting factor of Chital distribution. The activity pattern studies show that Chital visits waterholes once or twice a day to meet their water requirements around dawn and dusk (Fuchs, 1977). The peak drinking hours found to be between 7:30 hours and 8:00 hours. But during drought season, they also drink at midday hours (Eisenberg and Lockhart, 1972). Even though, it can keep a long time without drinking water directly, as it meets the water requirements from grasses and dews (Johnsingh and Manjrekar, 2015). The grazing grounds are often seen in the vicinity of water holes (Eisenberg and Lockhart, 1972).

The Sambar deer is also found to be using the waterholes in all the seasons. They have a comparatively high requirement of water than the other ungulates such as Spotted Deer or Muntjac, but their higher body mass and movability allows them to forage much away from the water sources. The waterholes are a location where the individuals or small groups of Sambar deer gather together in the evening hours before dispersing to feed. They usually wallow in mud or wet sand near the river bed or the side of waterholes. It is more frequent during the dry seasons as they like to spend more time in the water. They also found to be refusing from drinking water if any sign of threat of the presence of predator or humans is found (Eisenberg and Lockhart, 1972). An interesting finding has been done by Johnsing (1983) that the Sambar deer seek refuge in waterholes when they are chased by wild dogs. It found to be successful in shallow waterholes rather than deep ones.

The Muntjac is species that have a low water requirement among the other ungulates. It found to be drinking at midday hours (Eisenberg and Lockhart, 1972).

Similarly, there are very fewer data are available about the water requirements of Mouse deer, where Eisenberg and Lockhart (1972) found some Mouse deer inhabiting in the bush around a permanent waterhole.

The Wild Boar (*Sus scrofa*) is another water-dependent ungulate that has been seen near permanent water sources. They used to drink as well as wallow in the mud. Similar to elephant boars also wallow to cover their bodies in mud to protect themselves from flies. It also helps them in thermoregulation in dry periods. They also used to dig for tubers and earthworms in the wet soil near the waterholes.

Gaur, another massive herbivore is also an obligate drinker and consumes water twice a day. Dawn and dusk are mostly preferred for drinking water (Sankar *et al.*, 2001). This may because their predators are more nocturnal (Hayward and Hayward, 2012)

The carnivores are also dependent on water to some extent. Jackals (*Canis aureus*) tend to be localized in the vicinity of permanent water sources. This might be due to the availability of prey near the waterholes. It's observed that the jackal hunts the small water birds from the vicinity of waterholes (Eisenberg and Lockhart, 1972).

The activity of Sloth Bears (*Melursus ursinus*) is also found to be near to permanent water bodies (Eisenberg and Lockhart, 1972).

For Leopard (*Panthera pardus*), waterholes are perfect hunting grounds. It's observed that leopards catch spotted deer, wild boars, etc. from the edge of waterholes. Sometimes it also feeds on turtles (Eisenberg and Lockhart, 1972).

The small carnivores like mongooses, civets, Jungle cats, etc. tend to have their home ranges near permanent water sources (Eisenberg and Lockhart, 1972).

In primates, many species show dependency on waterholes. The Northern plain Gray langur (*Semnopithecus entellus*) have at least one permanent water source in their territory. In dry seasons, they mainly meet their water requirements from fresh fruits and leaves. Even though sometimes they descent to ground and drink water from waterholes. Not all individuals drink water at the same time. Some individuals remain upon the tree branches and look around for the signs of predators (Eisenberg and Lockhart, 1972).

Epaphras *et al.,* (2007), studied the utilisation of waterhole by wildlife in Rauha National Park, Tanzania. The study revealed that wildlife preferred both artificial and natural waterholes to meet their water requirements. And the water quality was also better in manmade waterholes rather than natural ones. The impact of grazing of these herbivores is more severe in the vicinity of the waterhole. As far as biodiversity is concerned, artificial waterholes are less diverse as compared to natural waterholes.

A camera trap study conducted by Hayward and Hayward (2012) in different waterholes in Africa revealed that around 25 species of mammals were found to be using waterholes.

The artificial waterholes in the drier areas will confine the animals within the range of that waterhole and prevent their migration to unprotected areas (Edwards *et al.*, 2017). Western (1975) says that in dry periods in Amboseli National park, Kenya, 99% of herbivores occurred within 15 km of the surface water source. So, in arid ecosystems like Africa, the frequency of waterhole plays an important role in the distribution of wild herbivores. The distribution of water-dependent species will be skewed concerning the water availability and the species' which water is not a daily requirement will be more widely and randomly distributed through the forest (Redfern *et al.*, 2003). The species having high biomass density will be having high water requirement (Smith, 1988). The availability of water also helped to reduce Intra and inter-species fights (Epaphrus, *et al.,* 2007). But the gathering of large herbivores such as elephants in high

densities in waterholes will lead to a monopolistic utilization of waterhole and thus increasing the competition for water in dry seasons (Valeix *et al.,* 2008). This is prevalent in the areas where having a limited number of water sources. A co-existence has been made by many prey-predator species by adopting a temporal partitioning of water resources in many places (Schoener, 1974).

The distribution patterns of herbivores are also found to be changing in dry season concerning the difference in surface water and food availability (Smit *et al.*, 2007), (Redfern *et al.,* 2003). The vegetation near permanent water sources is facing high grazing or browsing pressure (Shannon *et al.*, 2009). The provision for artificial waterholes in the forest will help to distribute the wildlife population into wider areas and thus the pressure on the vegetation can be reduced (Epaphrus *et al.,* 2007). Closely located waterholes will increase the crowding of wild animals in the waterhole area and thus lead to degradation of woody vegetation in that area (Franz *et al.,* 2010). To reduce the grazing pressure, the artificial waterholes must be relocated to new areas annually by about 5 km. Thus, we can avoid the problem of permanent vegetation damage in the area (Epaphrus *et al.,* 2007).

Large waterholes can accommodate a greater number of animals than the smaller ones as it can allow a few numbers of species at a time. So that a temporal pattern of waterhole usage is adopted by the animals to avoid species drinking in close proximity to the other species. And also, most of the animals found to be using the waterhole during dawn and dusk (Edwards *et al.*, 2017).

The waterholes can also act as hunting grounds for carnivores (Wakefield and Attum, 2006; Edwards *et al.*, 2017). The carnivores such as tiger, leopard, wild dog, etc. are using the waterhole not only to meet their water requirements but to hunt herbivores such as spotted deer or Sambar deer, etc. (Eisenberg and Lockhart, 1972). The vegetation around waterholes can be a hiding place for predators (Wakefield and Attum, 2006).

Materials and methods

MATERIALS AND METHODS

3.1 STUDY AREA

Wayanad, coming under the Nilgiri Biosphere reserve is under the administration of three forest divisions, North Wayanad, South Wayanad, and Wayanad wildlife Division. The district Wayanad shares its boundary with Karnataka and Tamil Nadu. The eastern and southeastern part of Wayanad shares boundary with the Muthumalai Tiger reserve of Tamil Nadu, northern part with Bandipur Tiger reserve and northwestern part with Nagarhole Tiger reserve (between 11^0 20' and 12^0 7' N latitude and between 75^0 28' and 76^0 36' E longitude). These four contiguous protected areas have a total area of 2,184 km^2. The total area of Wayanad district is about 520.78 km^2 in which the Wayanad Wildlife Sanctuary occupies an area of 344.44 km^2 (Figure 1).

The term Wayanad is derived from two words, Vayal and Nadu. Vayal means swamp and Nadu means land. Hence it collated as a single term Wayanad means, the land of swamps.

Wayanad Wildlife Sanctuary is bio-geographically one of the richest tracts of Western Ghats. It lies between 76^0 02' and 76^0 27' East Longitude and 11^0 35' and 11^0 51' North Latitude in Wayanad district. The eastern and western plateau of Wayanad differs in topography and climate. The Wayanad plateau is at an elevation of 900-1600m. The northern part with an elevation of 700-1600m differs from the south-western slope of uneven peaks ranging from 1000-2000m vegetation types include wet evergreen forests confined to the northern part and deciduous forests in the areas bordering adjacent state. Natural forests are surrounded with bamboo thickets and plantations of teak and eucalyptus.

The Wayanad Wildlife Division as an administrative unit has 344.44 km^2 of the Wildlife Sanctuary area, comprising two discontinuous units of 77.67 km^2 (called WS-I) and 266.77 km^2 (called WS-II). It has been declared as a sanctuary in 1973. The WS-I consists of Tholpetty range which is contiguous with Nagarhole

Tiger reserve of Karnataka. The WS-II comprises three ranges *ie.*, Sulthan Bathery, Muthanga, and Kurichyat.

The annual rainfall limits between 1123.90 mm to 2168.20 mm. There are three major seasons in Wayanad, the dry season (January to April), the first wet season (May to August) and the second wet season (September to December). The average monthly minimum temperature varies from 14°C to 19.4°C and the maximum temperature ranges between 24°C to 31°C.

The area is drained by a number of tributaries of the Kabani river flowing to the east. The Kurichyat range in WS-II has two major rivers viz., Kannaram puzha and Kurichyat river which drains into the Kabani river. The southern side of WS-II is drained by the Noolpuzha thodu and Mavinhalla river which also joints to Kabani. There are many seasonal streams in the sanctuary, which dries up in the summer season. In the Tholpetty range, the major perennial river is Bavali puzha. It has a network of streamlets draining from the sanctuary area. The Bavali puzha ultimately joins with the Kabani river.

3.1.1 Swamps

The swamps in the sanctuary, locally called as *vayals*, is an edaphic climax ecosystem characterised by clayey soils. It is waterlogged in rainy months and the predominant vegetation is grasses. *Axonopus compressus, Paspalum spp., Eragrostis spp.* etc. are some common grass species found in the *vayals* of Wayanad Wildlife Sanctuary. Some shrubs like *Ageratum conyzoids*, *Chromolaena odorata*, *Parthenium spp* are also found in *vayals*. The woody vegetation in these marshlands is normally less. Trees like *Terminalia paniculata, T. tomentosa, Phyllanthus emblica, Tamilnadia uliginosa* are seen along the fringes of the *vayals*.

There are 171 *vayals* in the sanctuary distributed in all the four ranges of the division (Kurichyat range- 34, Muthanga- 44, Sulthan Bathery- 45, Tholpetty- 48). An area of 929.576 ha. has been covered by the *vayals* in the sanctuary.

Vayals are the places where a large number of herbivores usually gather. The forest department is employing various management activities in *vayals* such as the removal of unwanted species such as weeds from *vayals* to improve the quality of the habitat.

3.1.2 Waterholes

The waterholes are small to medium-sized bodies which constructed artificially to preserve water for the wildlife population in the sanctuary. There are about 168 artificial waterholes in the sanctuary, covers an area of 11.74 ha. The average dimension of waterholes is 28m x 23m. The depth of the waterholes dug is 2 m. Not all the waterholes will sustain water in the summer months. All the artificial waterholes will retain water up to January. Some will dry up in the summer season. Around 80 percent of them hold water till February, 60 percent will retain water till March and only 20 percent of them will hold water throughout the year

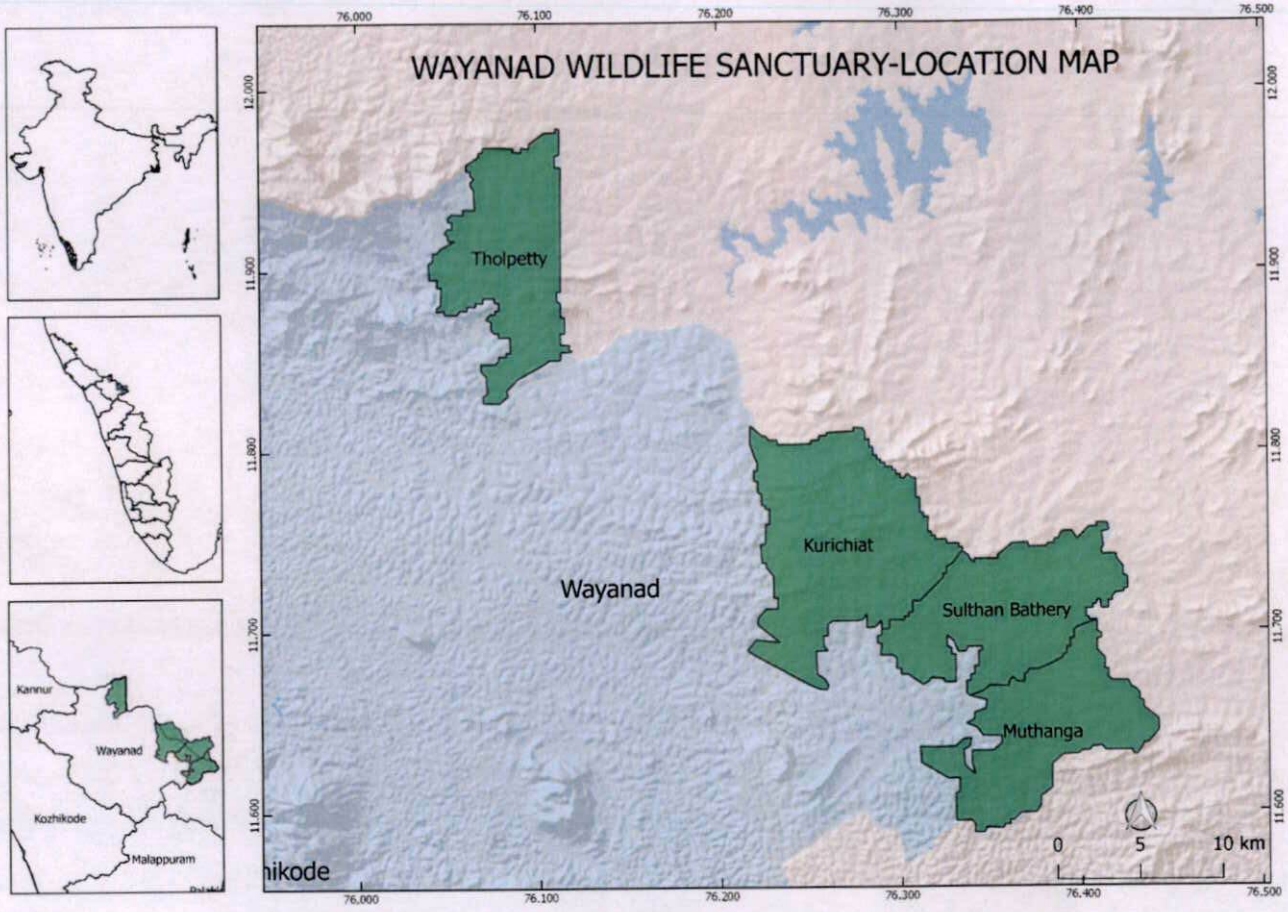

Figure 1. Location map of Wayanad Wildlife Sanctuary

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Plate 1. Edavambam vayal in Sulthan Bathery range

Plate 2. Karadimunda waterhole in Muthanga range

3.2 METHODS

3.2.1 Period of observation

A reconnaissance survey has been done during September 2018. Wayanad Wildlife Sanctuary encompasses 171 *vayals*, 168 artificial waterholes, and 42 check dams. From these, a total of 30 waterholes (15 *vayals* and 15 artificial waterholes) have been selected for the present study. *Vayals*/swamps are considered as the natural waterhole and ponds made by the forest department is taken as an artificial waterhole.

Table 1. Number of waterholes, *vayals* and check dams in Wayanad Wildlife Sanctuary

Sl. No.	Range	*Vayals*	Waterholes	Check dams
1.	Kurichyat	34	39	7
2.	Muthanga	44	46	16
3.	Sulthan Bathery	45	45	6
4.	Tholpetty	48	38	13
	TOTAL	**171**	**168**	**42**

Intensive fieldwork has been carried out in those identified waterholes and *vayals* from September 2018 to May 2019. The study was mainly focused on two seasons such as rainy and non-rainy season. A minimum of 20 days was spent in all ranges in two seasons each for the completion of the fieldwork.

3.2.2 Site selection

The waterholes and *vayals* for the study have been selected with the help of the reconnaissance survey conducted prior to the study. Among the 171 *vayals*, 15 were selected based on the opinion of forest department officials and by the indirect evidence of animals around the waterholes. Camera trapping was the method followed for analyzing the animal usage in waterholes.

Table2. Selected study sites from Wayanad Wildlife Sanctuary

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Range	Vayal	Waterhole
Kurichyat	1. Doddapaalam 2. Kommancherry 3. Manneduppamkuni 4. Nedumundakkolly	1. Chaddakulasi 2. Manneduppamkuni 3. Nedumundakkolly 4. Pavagaddha
Muthanga	5. Ayamangalam 6. Kaakkappadam 7. Kaundan vayal 8. Nallur	5. Ayamangalam 6. Kaakkappadam 7. Karadimunda 8. Kaundan waterhole
Sulthan Bathery	9. Arakunji 10. Edavambam 11. Kaatichakkalam	9. Nallathanni 10. Pulachallam 11. Vilanganpaara
Tholpetty	12. Aralagadhapaalam 13. Ayyappanpara 14. Dasanghatta 15. Doddady	12. 36th Pond 13. 38th Pond 14. 70th Pond 15. Doddady

3.2.3 Camera Trap Survey

Camera trapping technique was used to monitor the activity of wild animals at different *vayals* and waterholes in Wayanad Wildlife Sanctuary. Four camera traps each at every location were installed for a period of 10-30 days. A digital camera with infrared and motion sensor (Cuddeback Attack C1 with white flash) was used for the study. Each study site (Vayal/waterhole) were examined intensely and identified suitable spots (stations) for fixing the camera traps. The traps were set up in an area is in such a way that it could capture maximum possible animal movement through the water source. The animals passing through outside the field of view of cameras were missed. It is also taken in concern that all the four cameras are almost evenly distributed through the study site. The cameras were fixed on trees at a height of 50 cm to 1 m height from the ground. The cameras were set up

in default mode with the time-delay as fast as possible between images during day time and of five seconds between images during the night. All the cameras were kept open all day and remained in the field for 10-30 days in each station. The date and time of capture were automatically recorded in the images at the time of capture. The location of each camera station was recorded using a handheld GPS machine (Garmin etrex 20x). A total of 2890 camera trap days with 69360 trapping hours were made in all the 30 study sites in Wayanad Wildlife Sanctuary.

The study was conducted in two seasons viz., wet and dry season. The wet season's field study has been conducted the months of September to November 2018 and the dry season study is conducted between February to May 2019. The same camera stations were used for both the seasons' data collection, which implies the number of camera traps and the number of trap days in each season was the same.

Plate 3 Camera trap (Cuddeback C1 with white flash)

Plate 4. Setting up camera trap in the field

Plate 5. Camera trap in the field

3.2.3.1 Time activity pattern

35

The time activity pattern of wild animals visiting the vayals and waterholes were calculated for each one-hour time interval using the following formula:

$$Time\ activity\ present\ in\ a\ given\ time\ interval = \frac{No.of\ individuals\ of\ a\ species\ recoreded\ in\ a\ given\ time\ interval}{Total\ No.of\ individuals\ recorded\ for\ the\ same\ species} \times 100$$

Using the data from above, a graph was plotted with percent of activity against time interval.

3.2.4 Statistical Analysis

3.2.4.1 Test of preference

Paired t -test is used to find out the preference for natural and artificial water sources by wild animals in Wayanad Wildlife Sanctuary. The paired t-test used to determine whether the mean difference between two variables is zero.

H_0= There is no significant difference between means of two variables.

If the p-value is greater than 0.05, we reject the null hypothesis and we can say that there is significant difference between the means of two variables.

3.2.4.2 Test of randomness

Run test is used to find the randomness in data. It is a statistical test that examines whether a portion of data is occurring randomly from a distribution.

H_0= There is randomness in the distribution of two continuous observations.

3.2.4.3 Test of dependence

36

G -test is used to find out the independence between two variables. It analyses whether the proportions of a given variable in independent of another variable.

H_0= The relative proportions of one variable are independent of the second variable.

Results

RESULTS

4.1 USAGE OF WATER SOURCE BY WILD ANIMALS IN WAYANAD WILDLIFE SANCTUARY

There were 117 camera trap stations in selected 30 study locations in the sanctuary. The total camera trap effort was 2890 days (69360 hours). The details are given in Table 3.

Table 3. Number of trap days in each forest range of Wayanad wildlife Sanctuary

Range	No. of trap days	
	Wet	Dry
Sulthan Bathery	308	221
Muthanga	330	632
Kurichyat	339	501
Tholpetty	323	236

Table 4 shows the list of animal species found during camera trapping in artificial and natural water sources. The present study revealed 21 species of wild animals using natural and artificial water sources in the sanctuary area (Plate19 and Plate 20)..

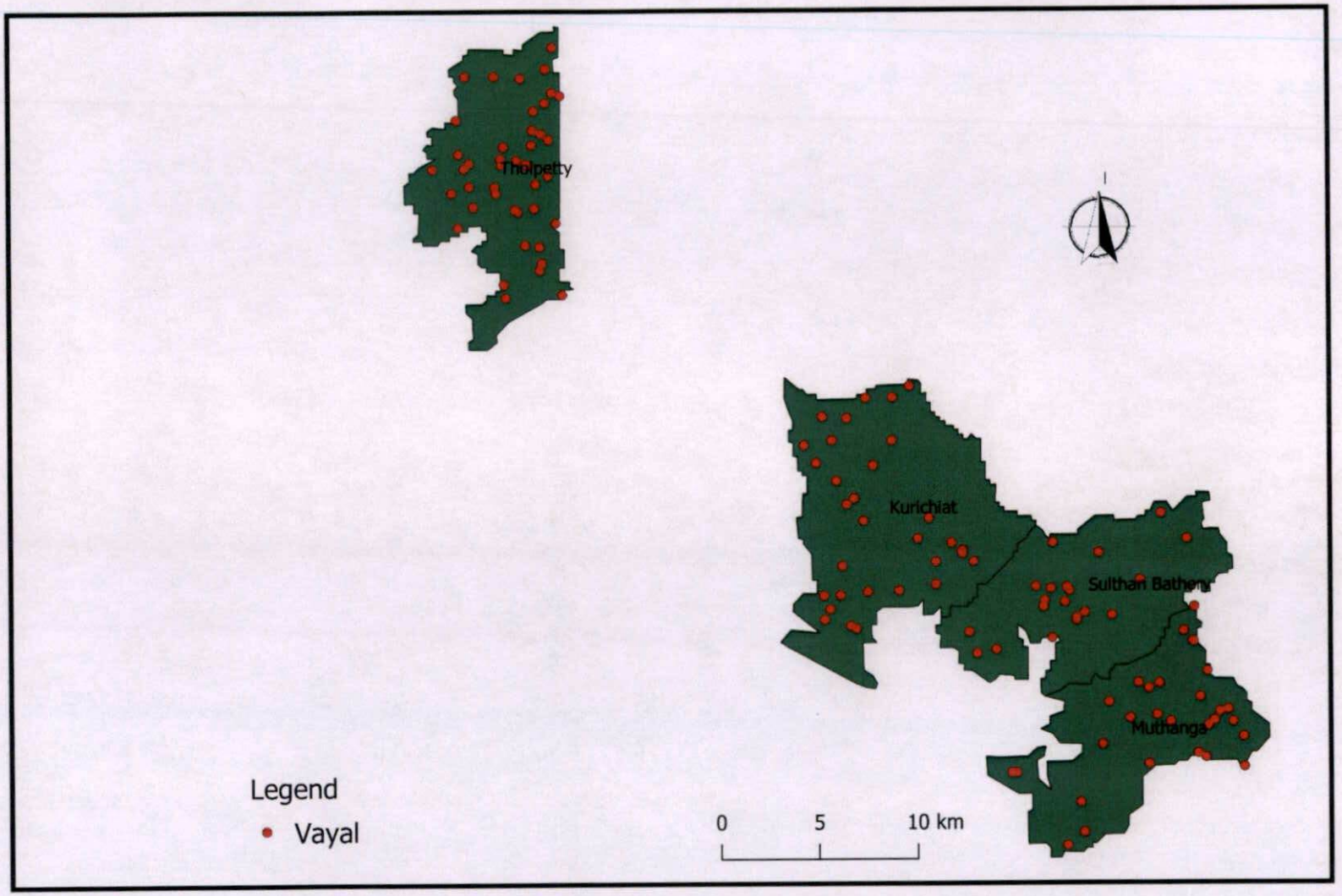

Figure 2. Location of *vayals* in Wayanad Wildlife Sanctuary

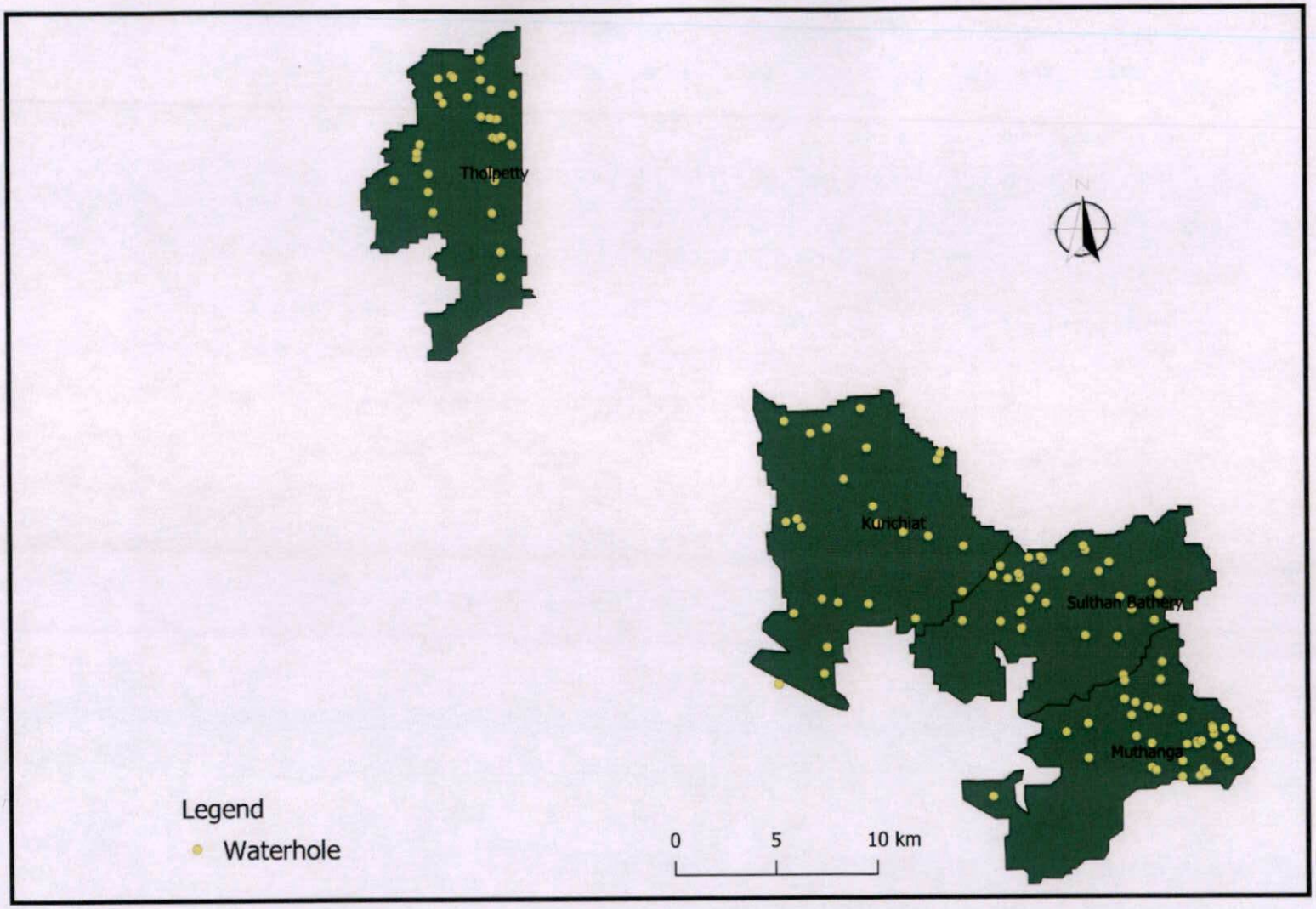

Figure 3. Location of Waterholes in Wayanad Wildlife Sanctuary

Table 4. List of animal species found during camera trapping in artificial and natural water sources

Sl. No.	Common Name	Scientific Name
1.	Asian Elephant	*Elephas maximus*
2.	Barking Deer	*Muntiacus muntjak*
3.	Black-footed Gray Langur	*Semnopithecus hypoleucos*
4.	Black-naped Hare	*Lepus nigricollis*
5.	Bonnet Macaque	*Macaca radiata*
6.	Brown Palm Civet	*Paradoxurus hermaphroditus*
7.	Common Palm Civet	*Paradoxurus hermaphroditus*
8.	Gaur	*Bos gaurus*
9.	Indian Porcupine	*Hystrix indica*
10.	Leopard	*Panthera pardus*
11.	Mouse Deer	*Moschiola indica*
12.	Ruddy Mongoose	*Herpestes smithii*
13.	Sambar Deer	*Rusa unicolor*
14.	Sloth Bear	*Melursus ursinus*
15.	Small Indian Civet	*Vivericula indica*
16.	Spotted Deer	*Axis axis*
17.	Stripe-necked Mongoose	*Herpestes vitticollis*
18.	Tiger	*Panthera tigris*
19.	Tufted Gray Langur	*Semnopithecus priam*
20.	Wild Boar	*Sus scrofa*
21.	Wild Dog	*Cuon alpinus*

The current study revealed that the preference for natural waterholes by wild animals were comparatively higher than that for the artificial waterholes in Wayanad Wildlife Sanctuary. The mean of frequency of animal visits to the *vayals* and waterholes shows a comparable figure, but it is slightly skewed towards the *vayals*. The mean value of animal visit to the *vayals* were a higher than that of

artificial waterholes. There are small variations in the frequency of animal visit in water sources between two seasons viz., dry and wet. Fig. 4 to Fig. 7 shows the frequency of animal visits to the *vayals* and artificial waterholes in Wayanad Wildlife Sanctuary.

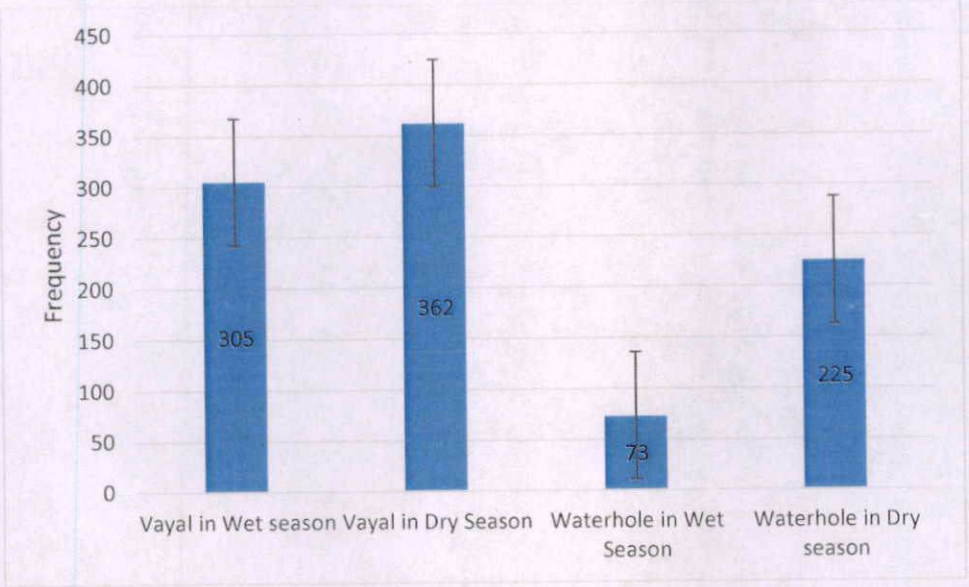

Figure 4. Frequency of animal visit to *vayals* and artificial waterholes in different seasons in Sulthan Bathery range

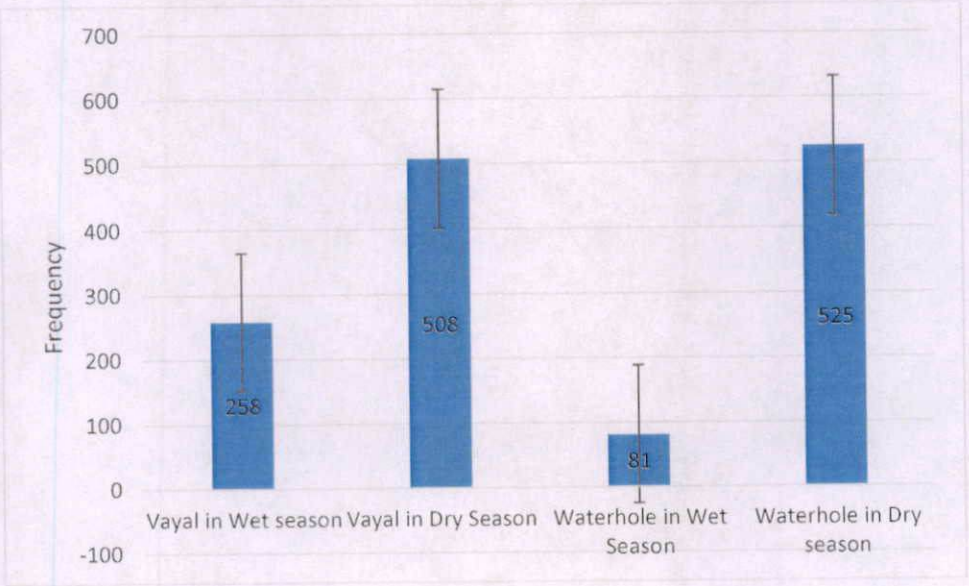

Figure 5. Frequency of animal visit to *vayals* and artificial waterholes in different seasons in Muthanga range

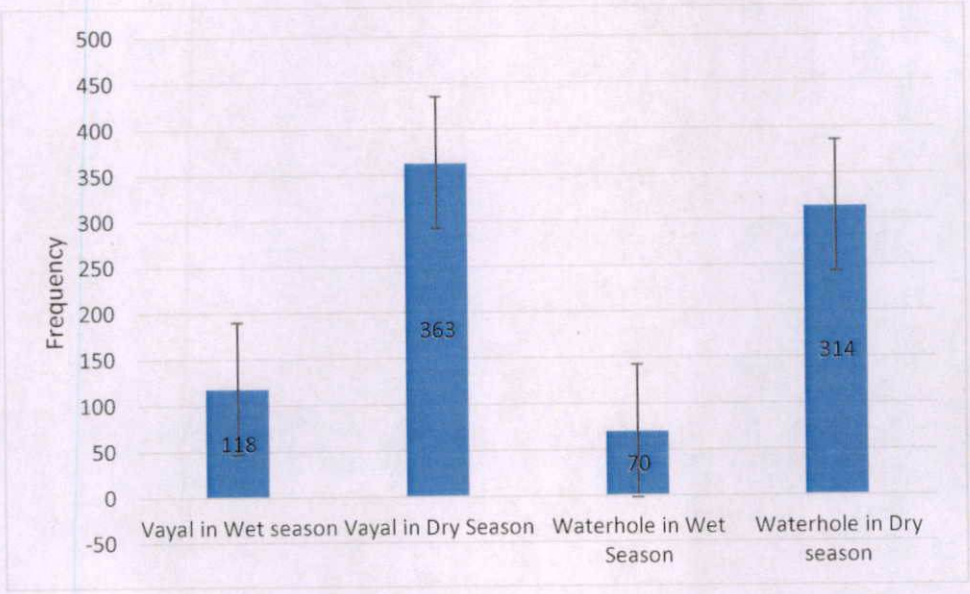

Figure 6. Frequency of animal visit to *vayals* and artificial waterholes in different seasons in Kurichyat range

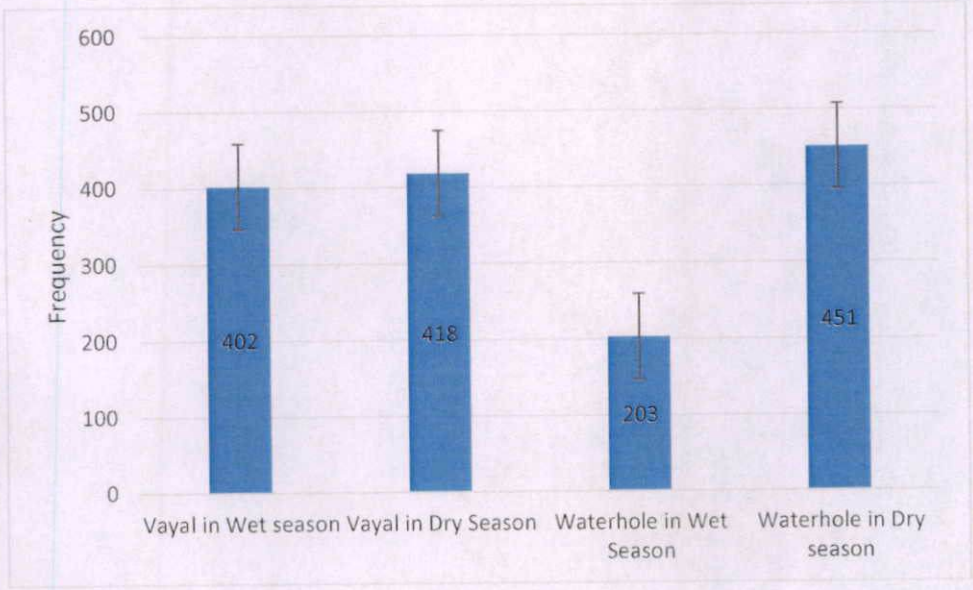

Figure 7. Frequency of animal visit to *vayals* and artificial waterholes in different seasons in Tholpetty range

In Sulthan Bathery range, the animal visiting frequency in *vayals* in the wet season was found to be 305 and that of artificial waterholes was 73 (Fig. 4). In the dry season, the frequency of animal visits in waterholes was increased to 225 and that of the *vayals* was 362. The *vayals* of Muthanga range has an animal visiting frequency of 258 in the wet season and 508 in the dry season. While in artificial waterholes of the same range have a very low animal visiting frequency (81) in the wet season, but have a high frequency (525) in the dry season (Fig. 5). The scenario was not different in Kurichyat range, as the wet season animal visiting frequency in *vayals* and waterholes were 118 and 70 respectively and it increases to 363 and 314 in the dry season (Fig. 6). The condition is a tad different in Tholpetty range. The frequency of animal visit in *vayals* and waterholes in the wet season were 402 and 203 respectively (Fig. 7). The change in the utilisation frequency of *vayals* and artificial waterholes between the dry and wet season was small when compared to other ranges. In the dry season, the vayal has a frequency of visit of 418 and waterhole had 451.

The number of species visiting the water sources is also varying with the seasons. According to Fig. 8 to Fig.10, the natural waterholes or *vayals* bear a greater number of species in the wet season.

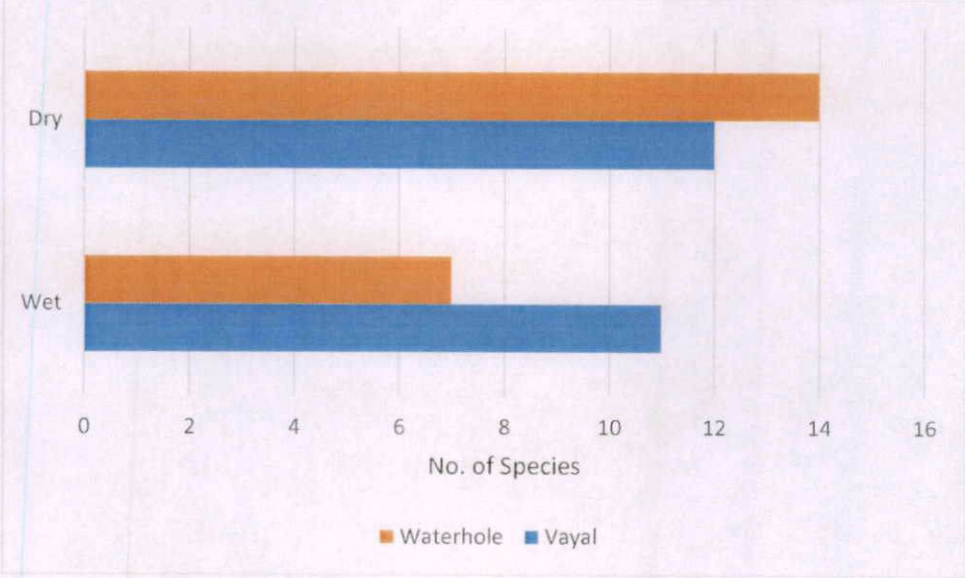

Figure 8. Number of species present in *vayals* and waterholes in different season in Sulthan Bathery range

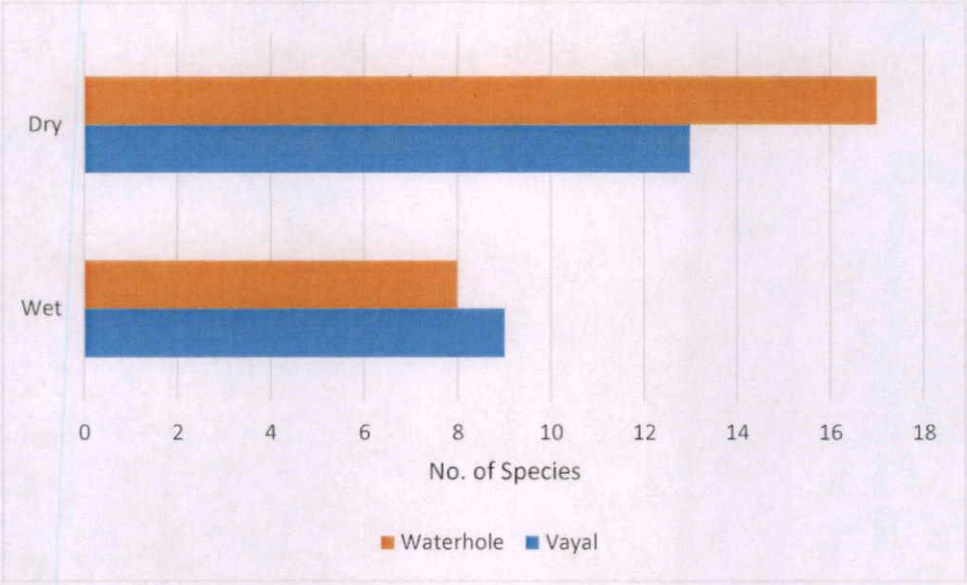

Figure 9. Number of species present in *vayals* and waterholes in different season in Muthanga range

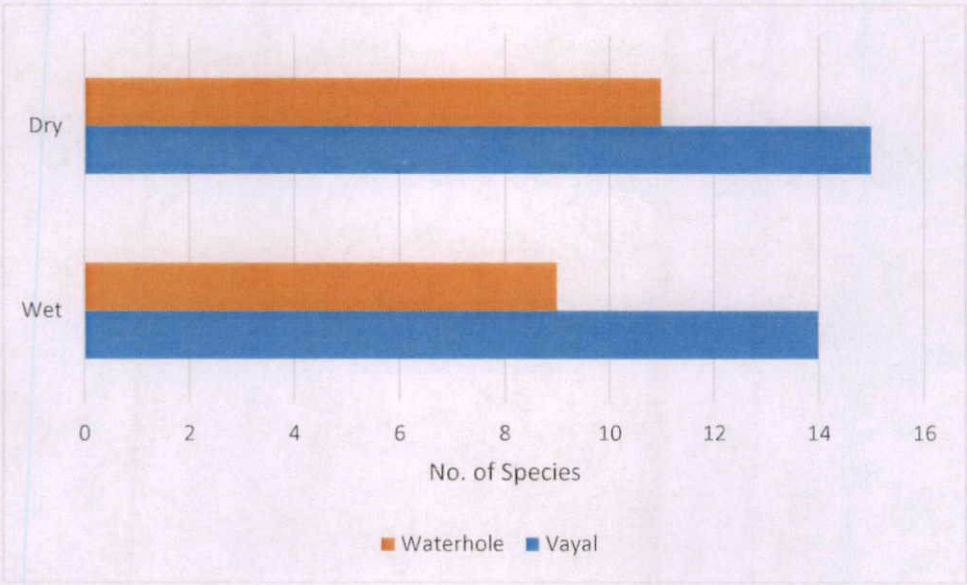

Figure10. Number of species present in *vayals* and waterholes in different season in Kurichyat range

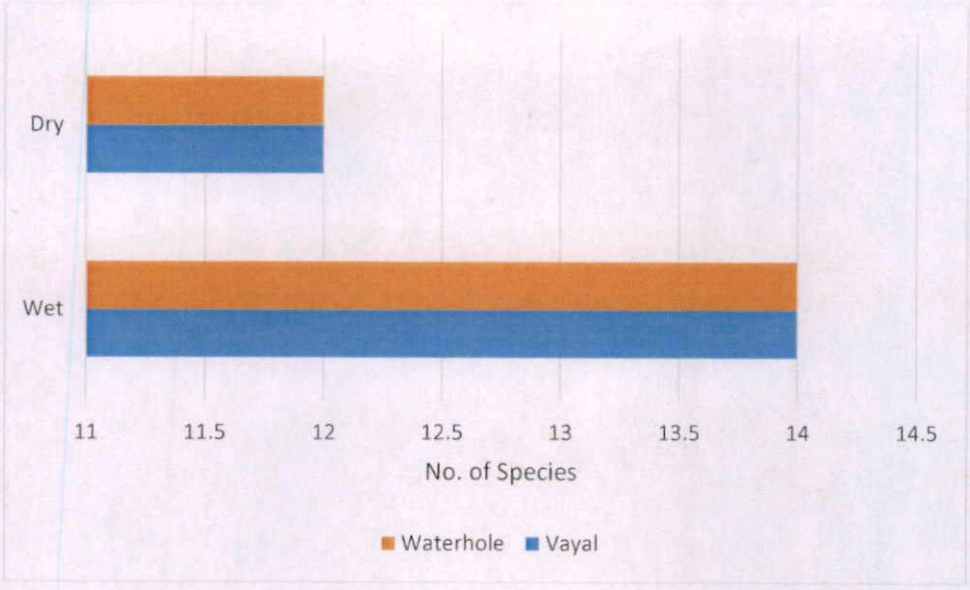

Figure 11. Number of species present in *vayals* and waterholes in different season in Tholpetty range

The number of species reported from artificial waterholes is high in the dry season in Sulthan Bathery and Muthanga ranges of the sanctuary. However, in Kurichyat range, *vayals* hold a greater number of species in both wet and dry seasons. An equal number of species were reported from *vayals* and waterholes of Tholpetty range in both the seasons (Figure 11).

The paired t-test was used to assess the preference for natural waterholes/ *vayals* and artificial waterholes by wild animals in the sanctuary. It also used to examine whether there is any change in the utilisation of the usage of these water sources in wet and dry seasons. The results are shown in the Table 5 and Table 6.

Table 5. Difference in water source usage by wildlife during wet and dry season in Wayanad Wildlife Sanctuary

	Vayal				**Waterhole**			
Range	**Wet**	**Dry**	**t Stat**	**p**	**Wet**	**Dry**	**t Stat**	**p**
Sulthan Bathery	17.94	37.17	-0.60^{ns}	0.55	5.21	16	-1.04^{ns}	0.31
Muthanga	18.42	36.28	-0.51^{ns}	0.61	4.76	30.88	-1.059^{ns}	0.30
Kurichyat	6.94	17.23	-0.75^{ns}	0.45	5.83	26.25	-1.19^{ns}	0.25

Tholpetty	23.64	24.58	-0.03^{ns}	0.97	12.68	28.18	-0.65^{ns}	0.51
ns- Not significant at α=5								

The result of the paired t-test was non-significant for all the ranges, which indicate that there is no significant difference between the means of observations made in two seasons from *vayals* as well as waterholes. So, we can assume that the usage of water sources during the two seasons are nearly uniform.

Table 6. Difference in utilisation of *vayals* and waterholes in Wayanad Wildlife Sanctuary

Range	Vayal	Waterhole	t Stat	p
Sulthan Bathery	44.62	14.14	0.84^{ns}	0.40
Muthanga	36.47	28.85	0.19^{ns}	0.84
Kurichyat	19.57	18.33	0.070^{ns}	0.94
Tholpetty	39.047	31.14	0.18^{ns}	0.85

Table 6 shows the details of the preference of animals among *vayals* and waterholes. The result indicates, there is no significant difference between the usage of *vayals* and waterholes in the sanctuary. The value of t stat is non-significant for all the four ranges of the sanctuary.

Table 7. Preference of *vayals* and waterholes by different animal species in Wayanad Wildlife Sanctuary.

Species	Vayal	Waterhole	t Stat	p
Asian Elephant	6.46	10.33	-1.36	0.18
Barking Deer	1.13	0.66	0.81	0.42
Black-footed Grey Langur	1	0.86	0.19	0.84
Black-naped Hare	1.2	1.13	0.11	0.91
Bonnet Macaque	1.46	2.26	-0.85	0.64
Gaur	5.26	4.13	0.47	0.64

Leopard	0.2	0.2	0	1
Sambar Deer	10	11.64	-0.26	0.79
Sloth Bear	0.66	0.66	0	1
Spotted Deer	167.13	91.8	2.12	0.04*
Tiger	1.066	1.2	-0.4	0.69
Tufted Gray Langur	0.86	1.66	-1.120	0.27
Wild Boar	1.93	1.35	0.97	0.33
Wild Dog	0.428	1.26	-1.38	0.17

The preference for *vayals* and waterholes by different species of animals were also examined. Spotted deer shows a significant difference between the means of water source usage frequency. The mean frequency of visit to the vayal and waterhole was 167.13 and 91.8 respectively.

4.2 ANIMALS USING THE WATER RESOURCES

4.2.1 Usage of waterholes and *vayals* by different animals

The study revealed the presence of 21 species of mammals in the natural and artificial water sources in Wayanad Wildlife Sanctuary including eight species of herbivores, four species of carnivores, five species of small carnivores and three species of primates.

Fig. 12 to Fig. 19 shows the number of various animal species in the *vayals* and waterholes in the sanctuary. The number of herbivore species are almost the same in all the locations.

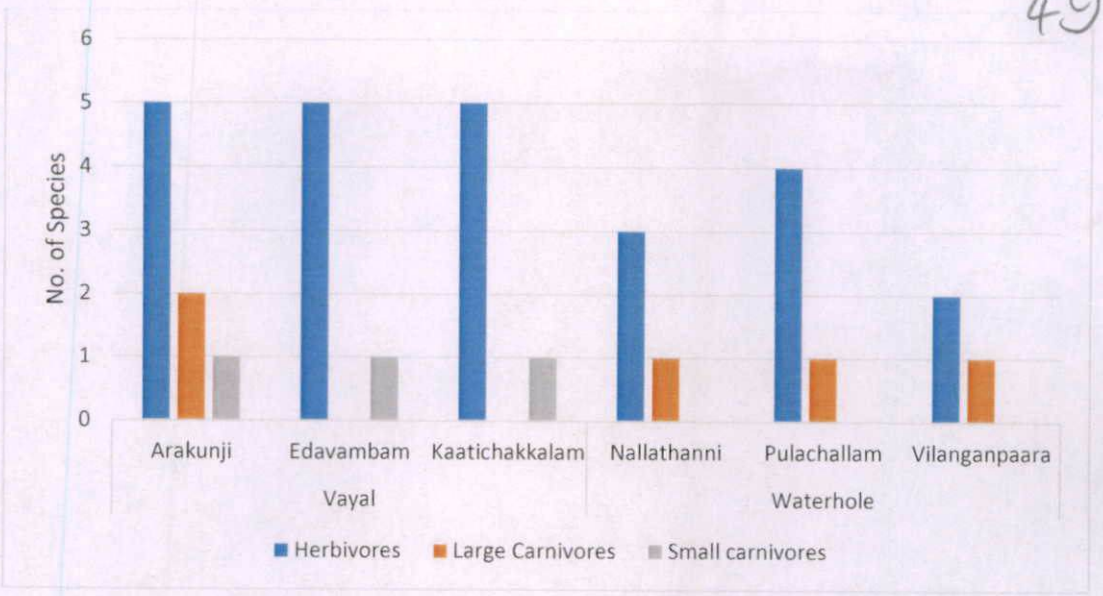

Figure 12. Number of species in different animal groups observed Sulthan Bathery range in Wet season

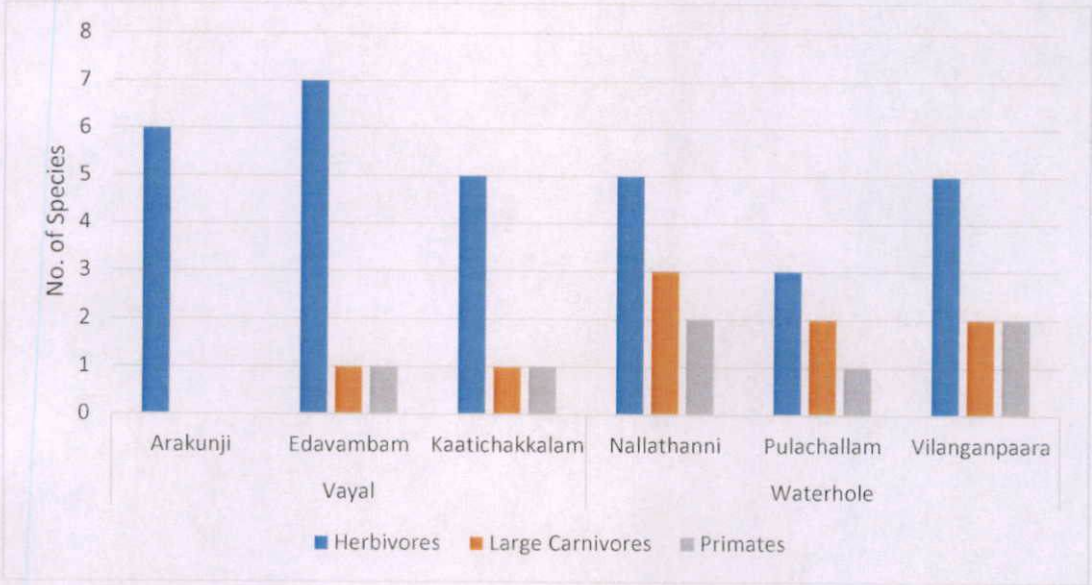

Figure 13. Number of species in different animal groups observed in Sulthan Bathery range in dry season

From Fig. 12 and Fig. 13, it is clear that, the number of herbivore species were almost similar in all the study locations in Sulthan Bathery range. No primates were reported from the range in the wet season and no small carnivores are reported

in the dry season. The Arakunji vayal supported only herbivores during the dry season. No other animal group has been reported from Arakunji vayal in the dry period. On the other hand, the waterholes reported a greater number of species in the dry season. Each waterhole has at least two species of a large carnivore in the dry season. Fig. 14 describes the animal visit in the study areas of Muthanga range in the wet season. Nallur vayal has a comparatively low number of species. The small carnivores are only reported from Kaundan waterhole. In the dry season, there were visible changes in the number of animal species. The Kaundan waterhole itself has seven species of herbivores, three species each of large carnivore, small carnivore and primate (Fig. 15). In the wet season, the waterholes of Kurichyat range shows a lesser number of carnivore and primate species. On the other hand, the *vayals* have a higher number of species in the wet season (Fig. 16). The dry season data also shows a clear dominance of *vayals* in the range, as a greater number of species were reported from *vayals*. Small carnivores like Common Palm Civet (*Paradoxurus hermaphroditus*) and small Indian Civet (*Vivericula indica*) are only reported from *vayals* in that range. In Tholpetty range, herbivore species are most reported from *vayals* in the wet season, while primates and large carnivores are most reported from waterholes.

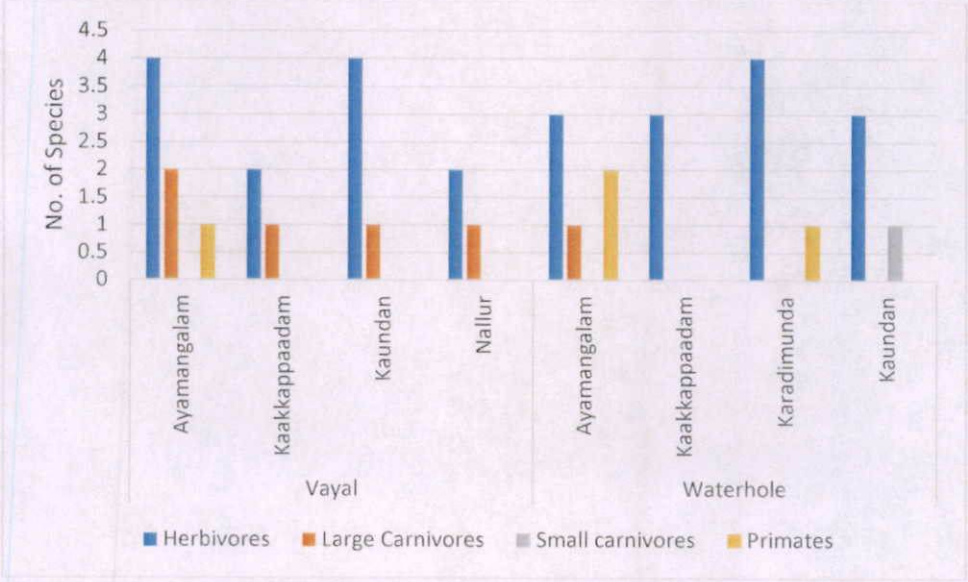

Figure 14. Number of species in different animal groups observed Muthanga range in Wet season

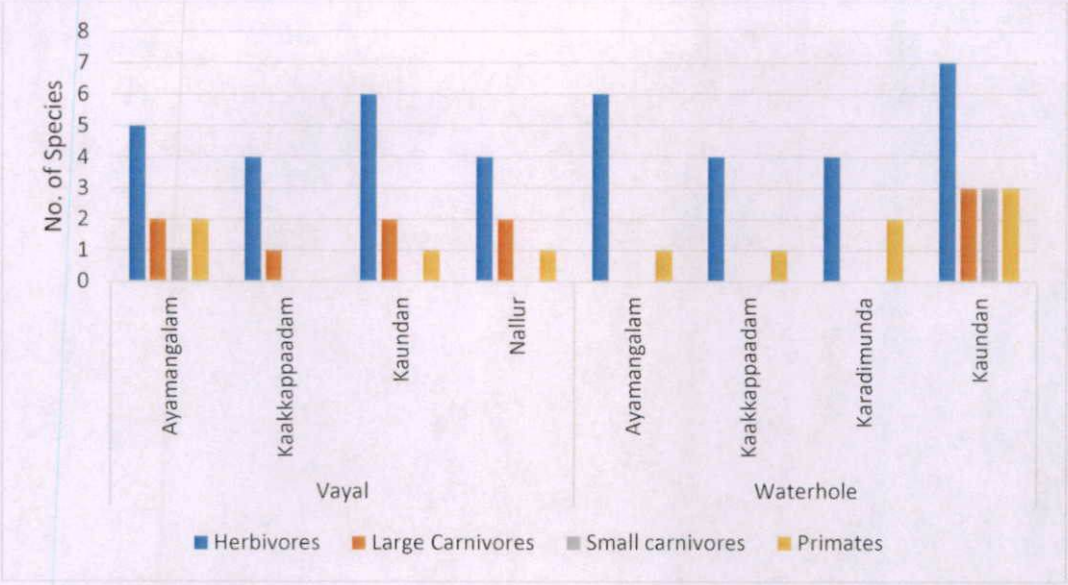

Figure 15. Number of species in different animal groups observed in Muthanga range in dry season

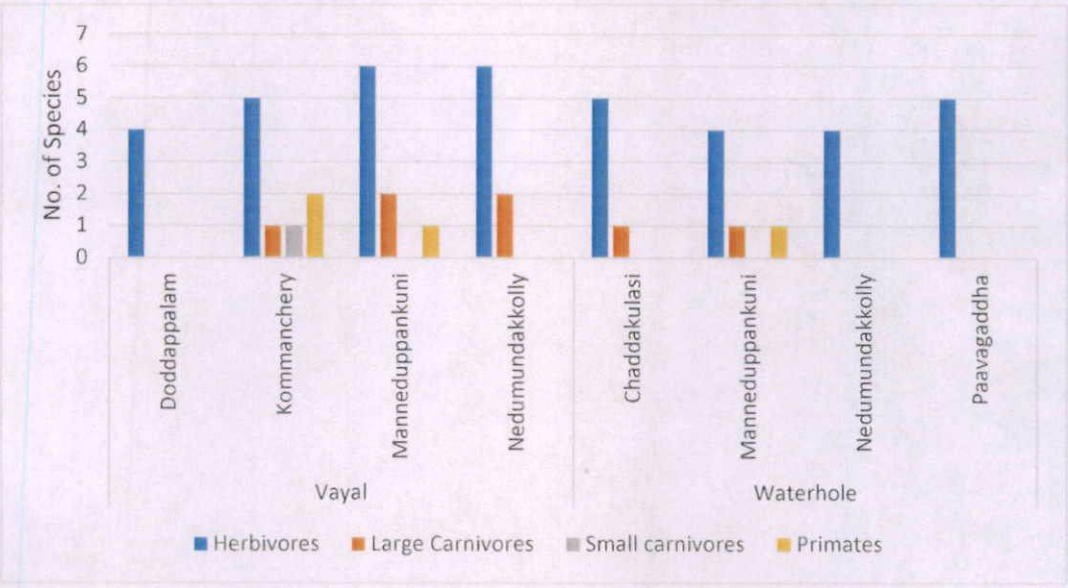

Figure 16. Number of species in different animal groups observed Kurichyat range in Wet season

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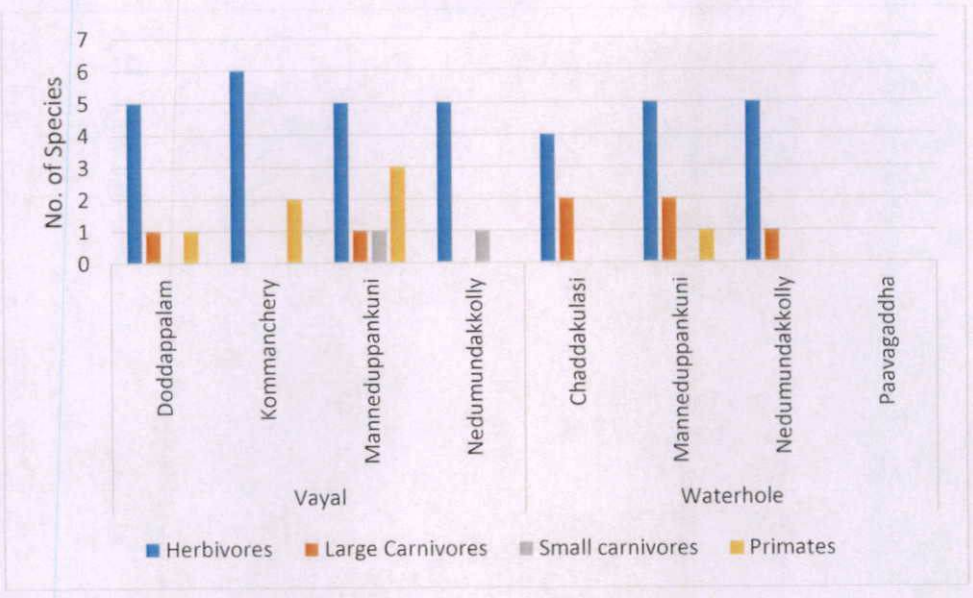

Figure 17. Number of species in different animal groups observed Kurichyat range in dry season

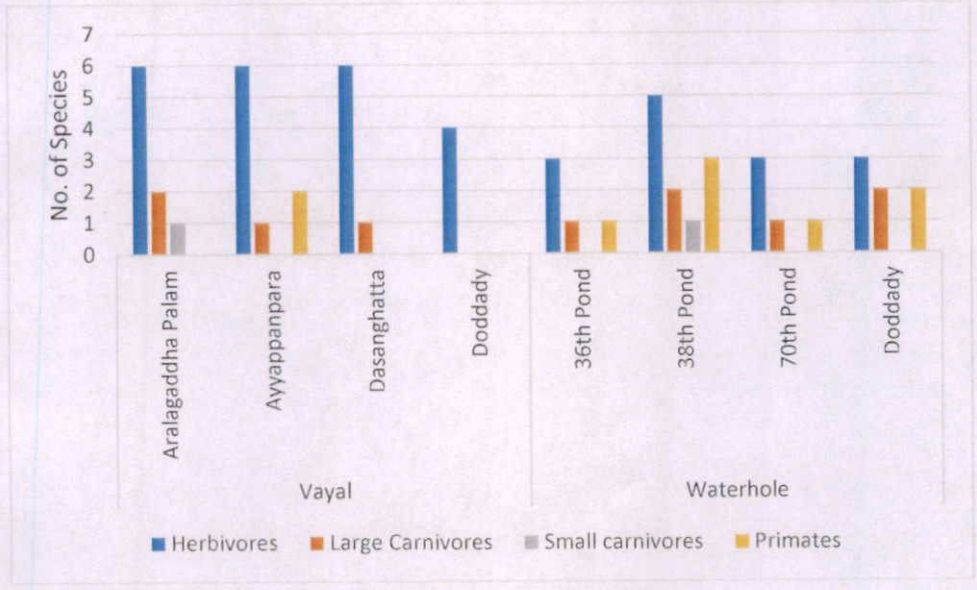

Figure 18. Number of species in different animal groups observed Tholpetty range in Wet season

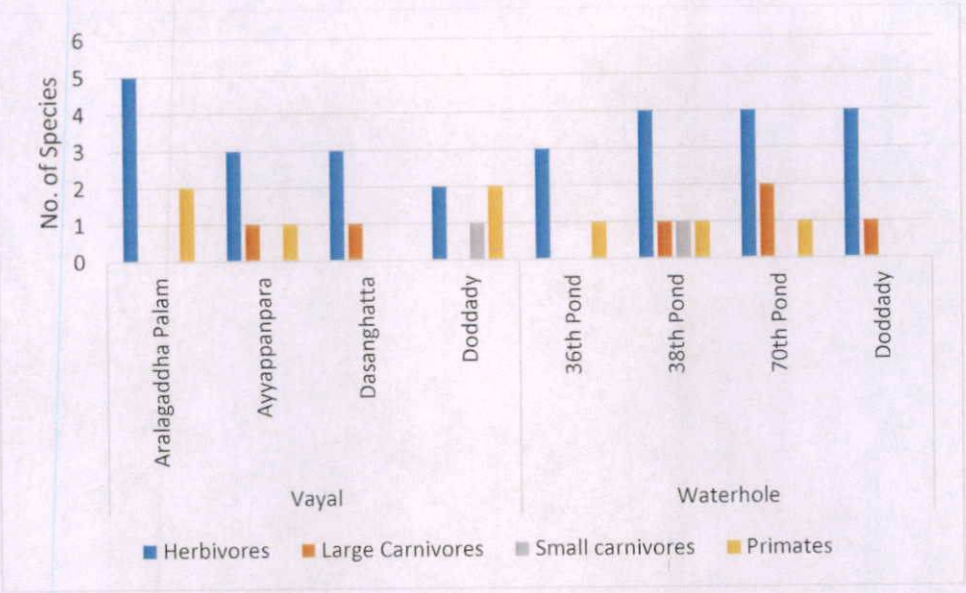

Figure 19. Number of species in different animal groups observed Tholpetty range in dry season

4.2.2 Frequency of visit of different animal species in study locations

All the species are not evenly distributed throughout the study locations. Some species of animals were only reported from some specific locations in some specific season.

The Fig. 20 represents the frequency of animal visit to *vayals* of Sulthan Bathery range in wet and dry seasons. The most frequently visited animal in the *vayals* is Spotted deer followed by Sambar deer and Gaur. The frequency of visit of Spotted deer and Asian Elephant in the *vayals* of Sulthan Bathery is nearly uniform in all the *vayals* in both the seasons.

Asian Elephant and Gaur shows a uniform utilization pattern in the waterholes of Sulthan Bathery range. The frequency of visiting the waterhole by Spotted deer is exceptionally high in Vilanganpaara waterhole in dry season. Details are given in Fig. 21.

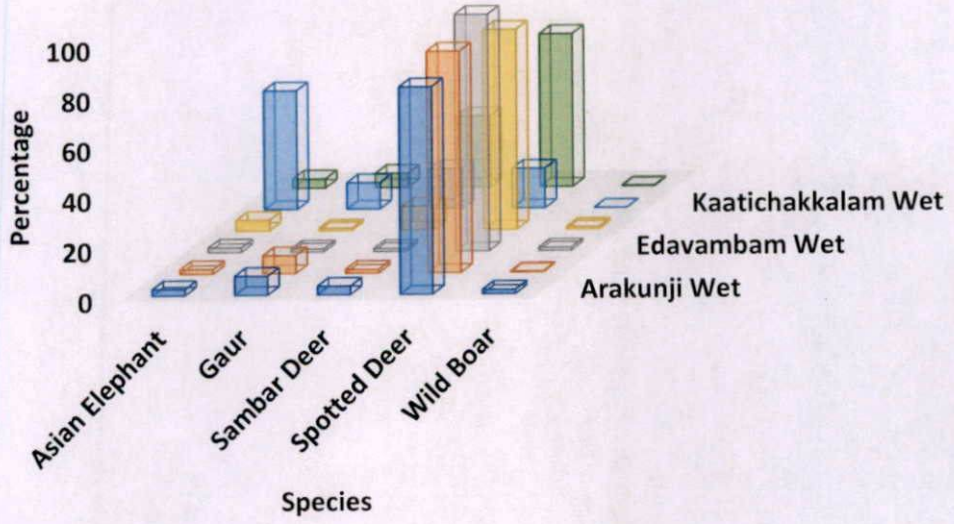

Figure 20. Percentage of visit of different animals in the *vayals* of Sulthan Bathery range

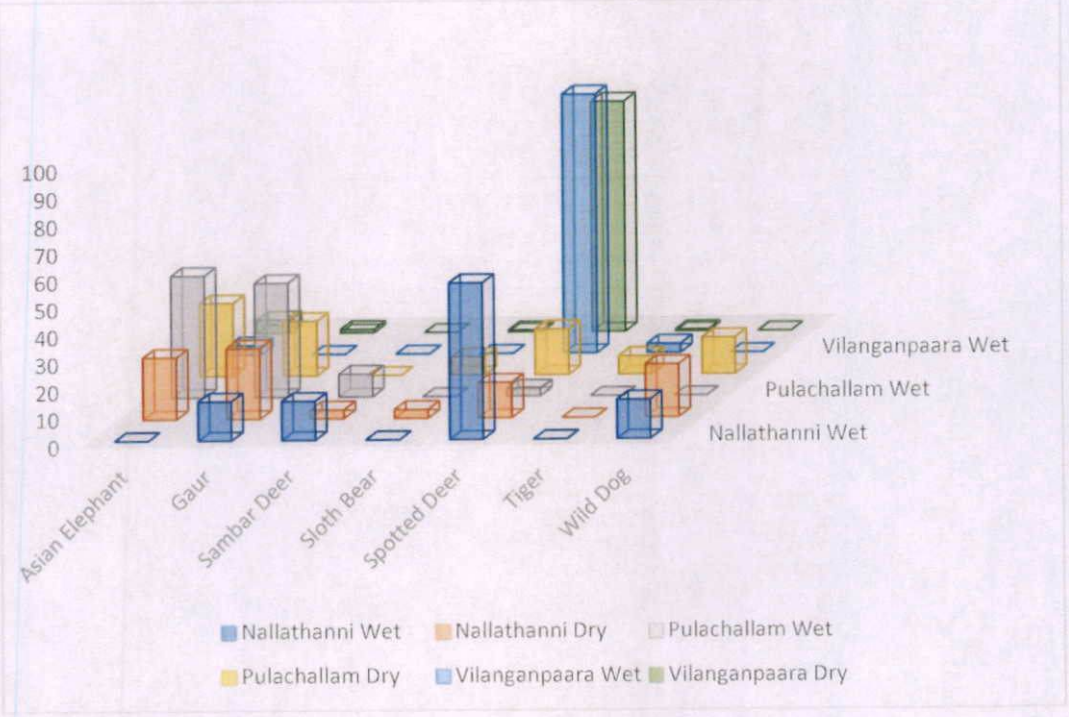

Figure 21. Frequency of visit of different animals in the Waterholes of Sulthan Bathery range

According to Fig. 22, *vayals* of Muthanga range shows very good activity of animals at the natural water sources. Herbivores like Asian elephant, Sambar deer, etc. were found to be using the *vayals* uniformly. Carnivores are also present in all *vayals* in Muthanga range. Animals like Black-naped Hare, Bonnet macaque, Indian porcupine, Stripe-necked mongoose etc. were found to be using the *vayals* in dry season only.

The animal activity of artificial waterholes in Muthanga range shows a skewed pattern of utilization as the Kaundan waterhole shows an exceptional high frequency of animal visit in dry season. Barking deer, Black-footed grey Langur, Common Palm civet, Leopard, Ruddy mongoose, Tiger etc. were only recorded from Kaundan vayal in dry season (Fig. 23).

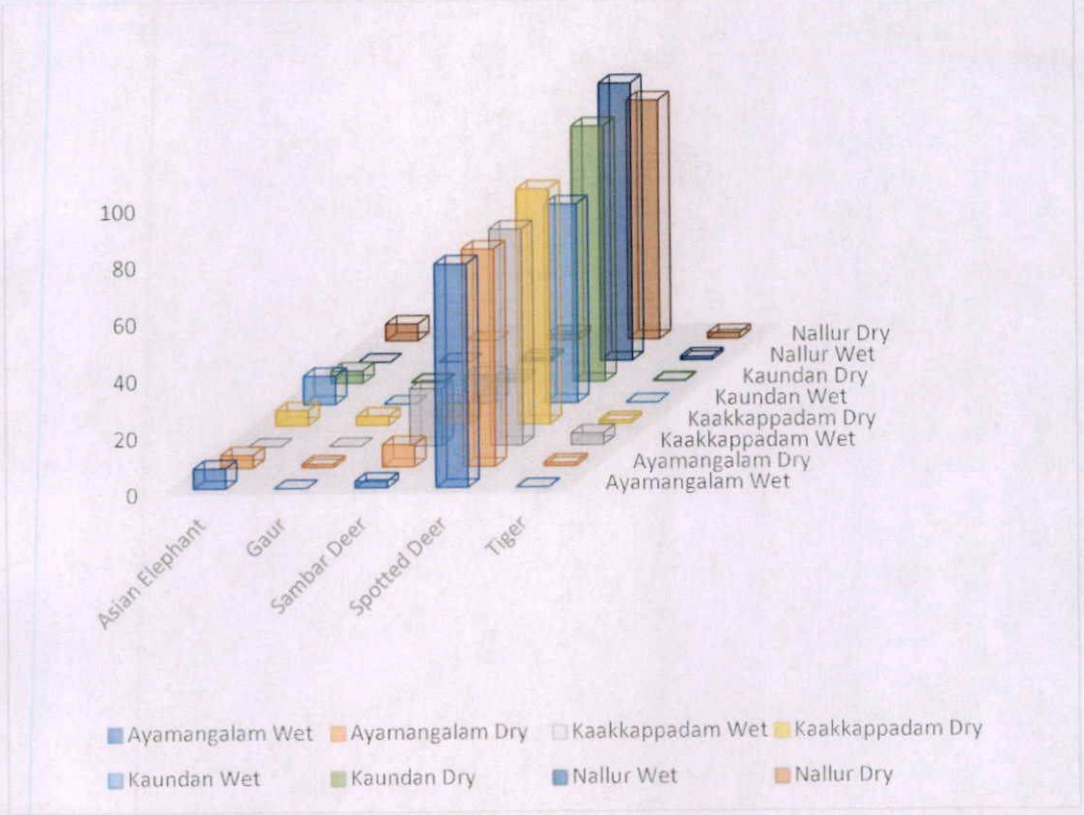

Figure 22. Frequency of visit of different animals in the *vayals* of Muthanga range

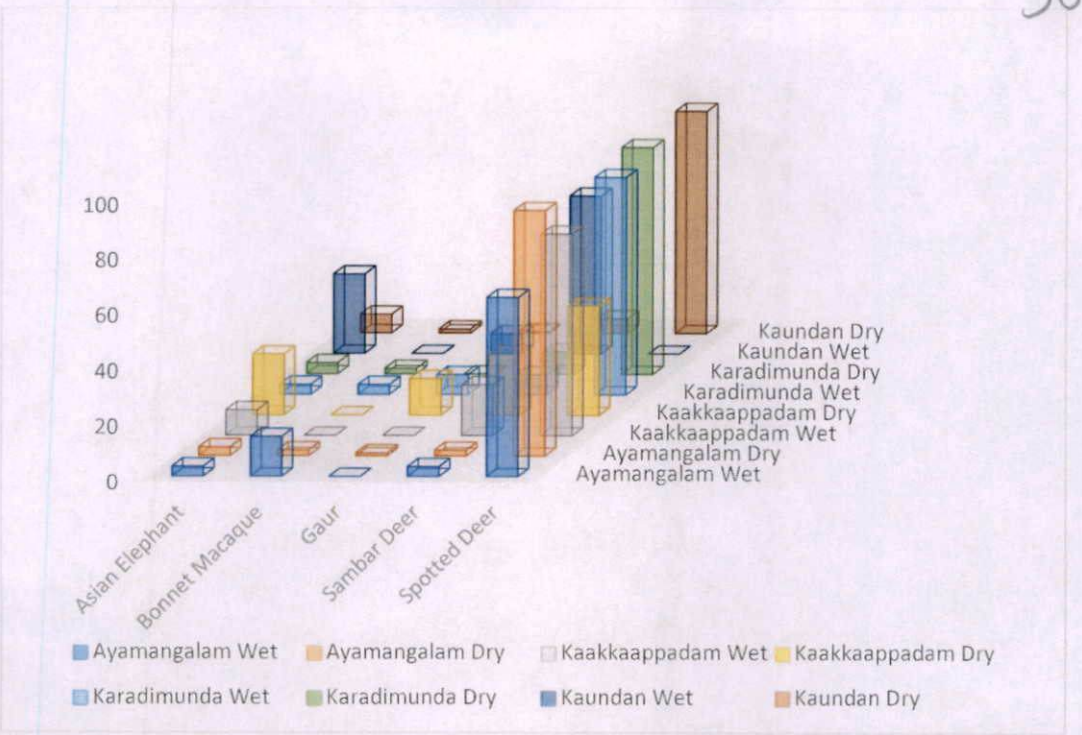

Figure 23. Frequency of visit of different animals in the Waterholes of Muthanga range

Fig. 24 shows the frequency of animals in *vayals* of Kurichyat range. The herbivores keep a similar trend of utilisation pattern as the previous ranges. The small carnivores are not observed in both seasons.

The situation is slightly different in waterholes. The animal visiting frequency in Manneduppamkuni and Nedumundakolly waterholes in dry season has a slight dominance over the other waterholes in the range (Fig. 25).

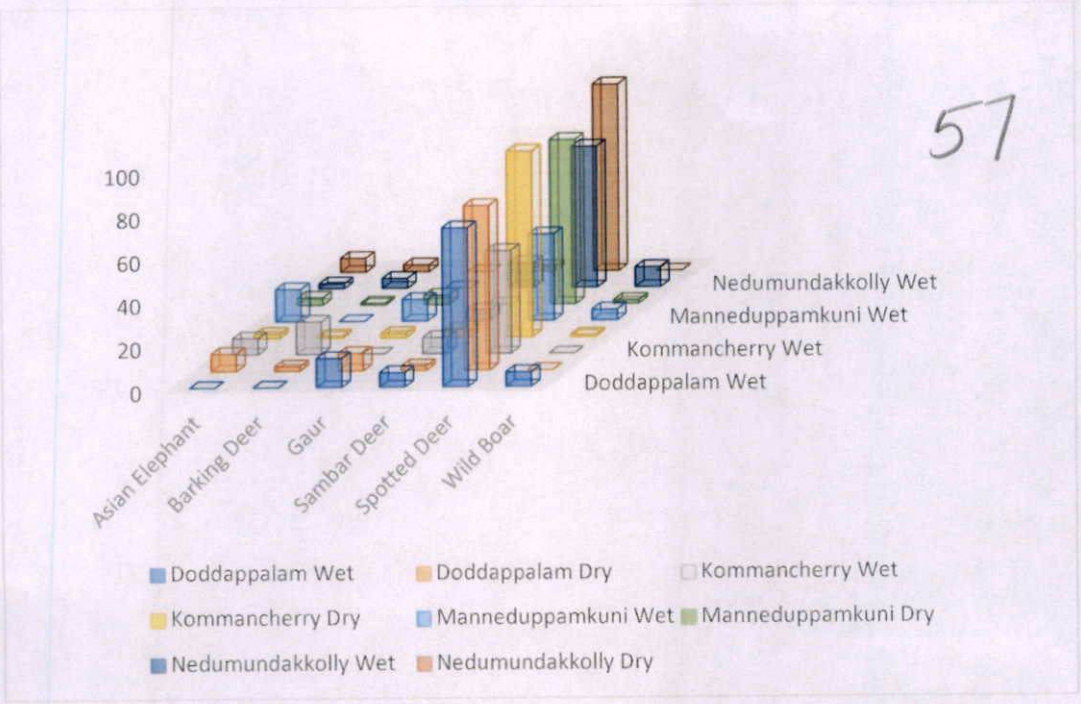

Figure 24. Frequency of visit of different animals in the *vayals* of Kurichyat range

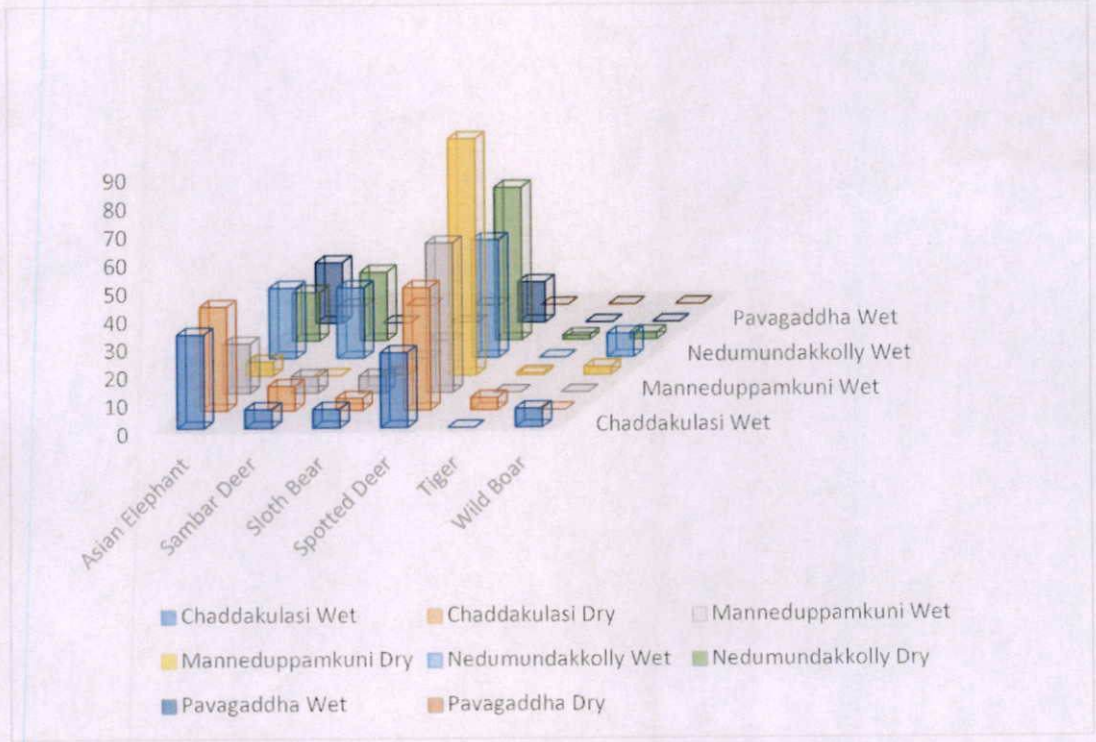

Figure 25. Frequency of visit of different animals in the Waterholes of Kurichyat range

The *vayals* of Tholpetty range a uniform activity of animals in the wet season. Asian elephant, wild boar, spotted deer, etc. shows a nearly comparable frequency of visit in the *vayals*. Sloth bear and Small Indian civet are only found during the dry season. There are only four species of animals were present in Dasanghatta vayal in the dry season, whereas, eight species of animals were found to be present there in the wet season. The wet season activity of spotted deer was very poor in the Aralagadha Palam and Ayyappanpara *vayals* (Fig. 26). Among waterholes, 70th Pond has the highest frequency of animal visits. The Asian elephant is not found to be using 36th and 38th Pond during the study period. Its highest frequency was observed at 70th Pond in the dry season. Exceptionally high counts of Sambar deer and Spotted deer are also observed from 70th Pond in the dry season. Gaur was observed from 36th Pond and was not from any other waterholes in Tholpetty range. The tiger was observed from all the study locations (Fig. 27).

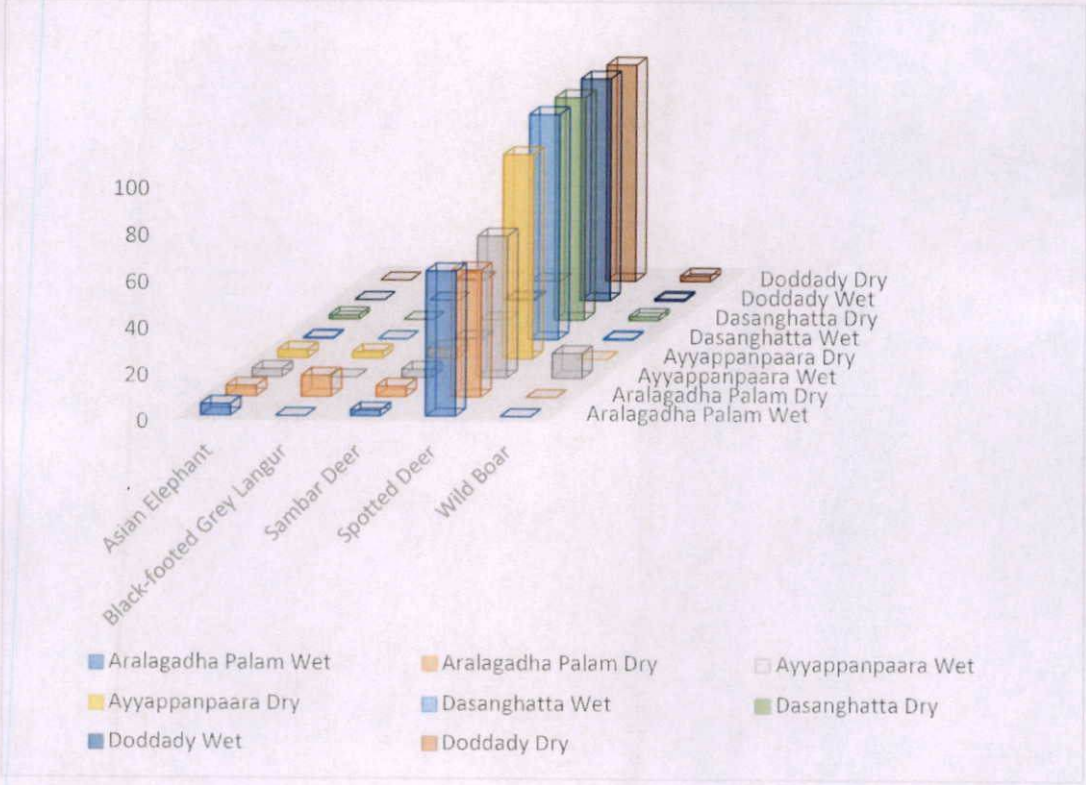

Figure 26. Frequency of visit of different animals in the *vayals* of Tholpetty range

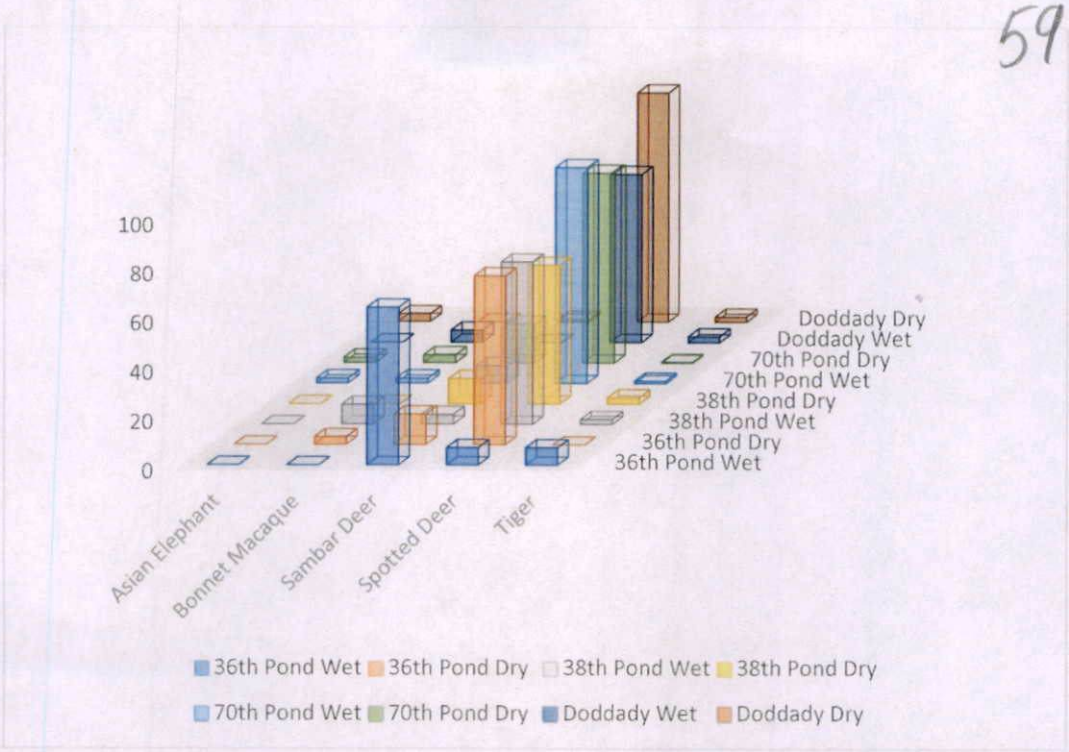

Figure 27. Frequency of visit of different animals in the Waterholes of Tholpetty range

4.3 TIME ACTIVITY PATTERN OF WATERHOLE USAGE IN WAYANAD WILDLIFE SANCTUARY

4.3.1 Period of animal activity in different *vayals*

The time of waterhole/vayal usage of animals was also studied in the present study. The pattern of usage was varying between each location. Almost all *vayals* in the sanctuary shows similar animal activity pattern in the wet season. The peak animal visit in *vayals* can be seen in the daylight hours, more precisely from 6:00 hours to 18:00 hours.

Arakunji vayal is one of the most utilised vayal in the Sulthan Bathery range. The peak animal activity in that vayal was observed during 5:00-7:00 hours in the morning and 18:00-19:00 hours in the evening. The activity in the noontime is relatively less when compared with the other hours. In Edavambam vayal, the animal activity was less in the morning hours and shows an increasing trend, peaks

at 14:00-15:00 hours. The activity around 12:00 hours is less in this vayal also. Kaatichakkalam vayal shows a very low animal visiting frequency than the other two *vayals*. The peak activity was observed at 14:00-15:00 hours and the frequency of animal visit was 12. Fig. 28 shows the details.

Fig. 29 describes the animal activity pattern in *vayals* of Sulthan Bathery range in the dry season. Arakunji vayal keeps its peak activity in the evening hours in dry season also. The activity in the noontime is almost nil in that vayal. The frequency of animal visits was increased in each location. The frequency at peak time at Arakunji vayal in the dry season was observed as 250, whereas in the wet season, the frequency of animal visit in the peak time was 119. In Edavambam vayal, the activity pattern in the dry season was the same as that of the wet season, but the frequency of visit was slightly lower as compared to the wet season. Unlike the other two *vayals*, Kaatichakkalam vayal has a different style of animal activity. The peak period of activity in that vayal was during the noontime.

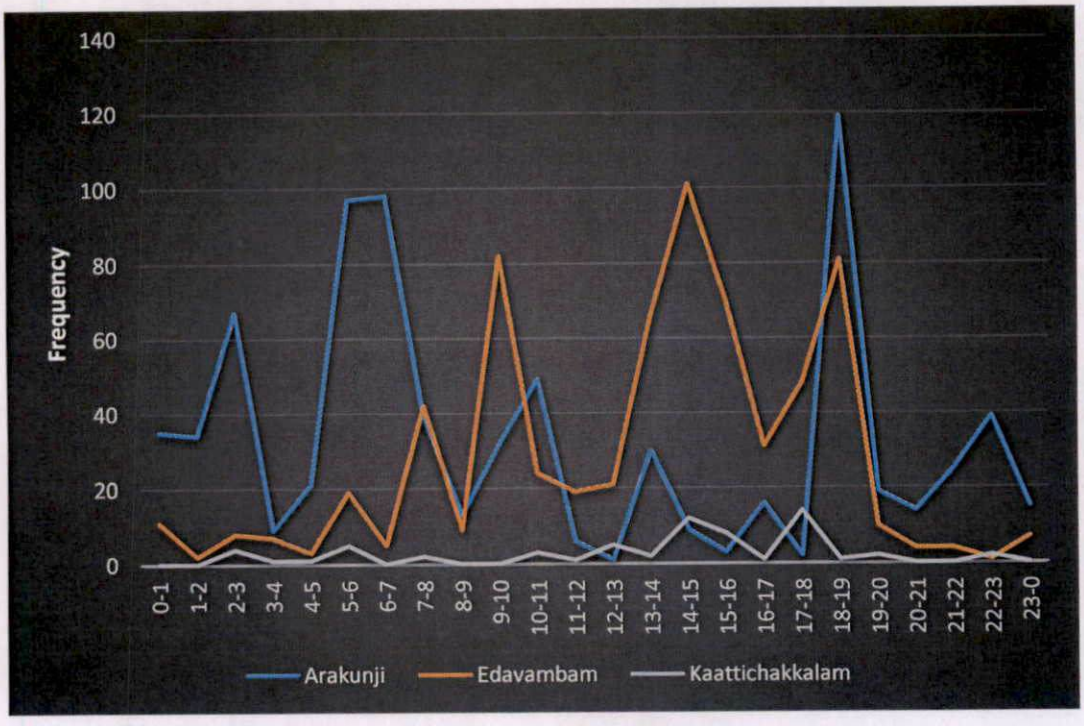

Figure 28. Temporal usage of different *vayals* of Sulthan Bathery range in wet season

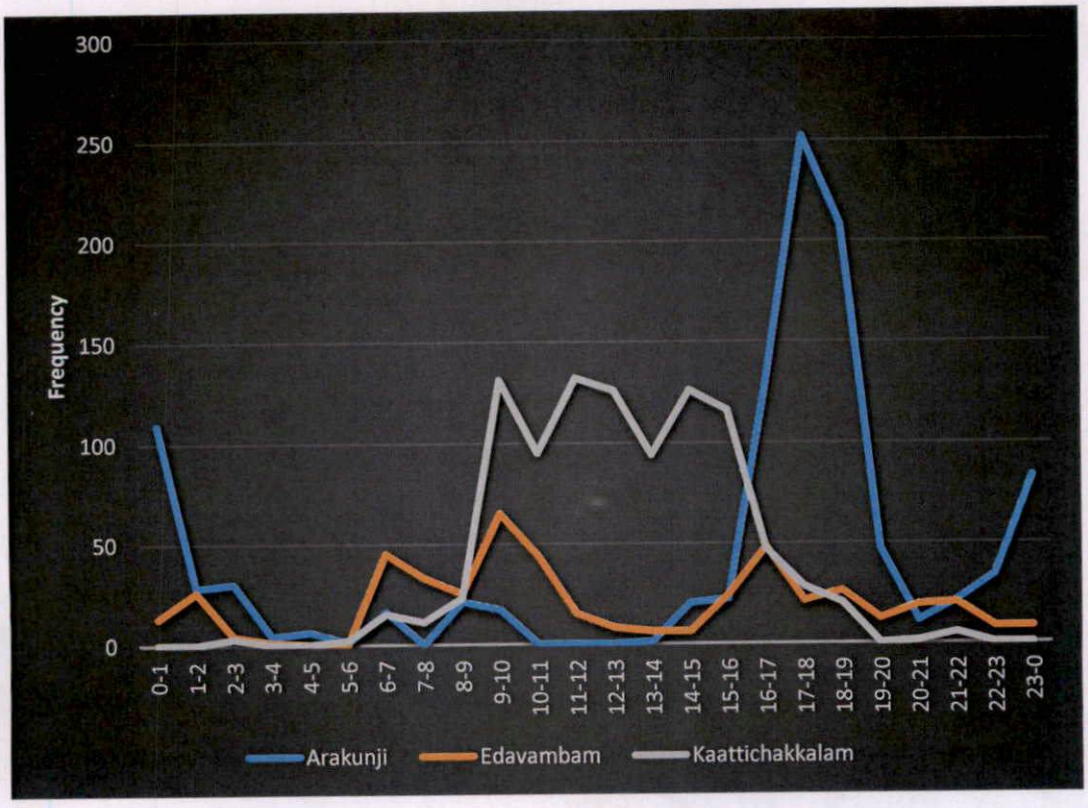

Figure 29. Temporal usage of different *vayals* of Sulthan Bathery range in dry season

The animal activity in the *vayals* of Muthanga range in the wet season is shown in Fig. 30. Frequency of animal visits in Ayamangalam, Kaakkappadam, and Kaundan vayal was following no particular pattern, but Nallur vayal shows an exceptionally high count of animal visits during 10:00-11:00 hours. The animal visit frequency in Nallur vayal was below 20 during night time, and it shows an increasing trend from 6:00 hours, peaks during 10:00-11:00 hours with a frequency of 159 and then decreases. In the dry season, the situation changes and all the *vayals* following a general trend of a high frequency of animal visit in the morning and evening hours (Fig. 31). The frequency of animal visit during the night hours were nearly 20 and the peak frequency was observed as 149 and that was recorded from Kaundan vayal at 9:00-10:00 hours. The peak frequency recorded at Ayamangalam, Kaakkappadam and Nallur *vayals* were 35, 54 and 22 respectively.

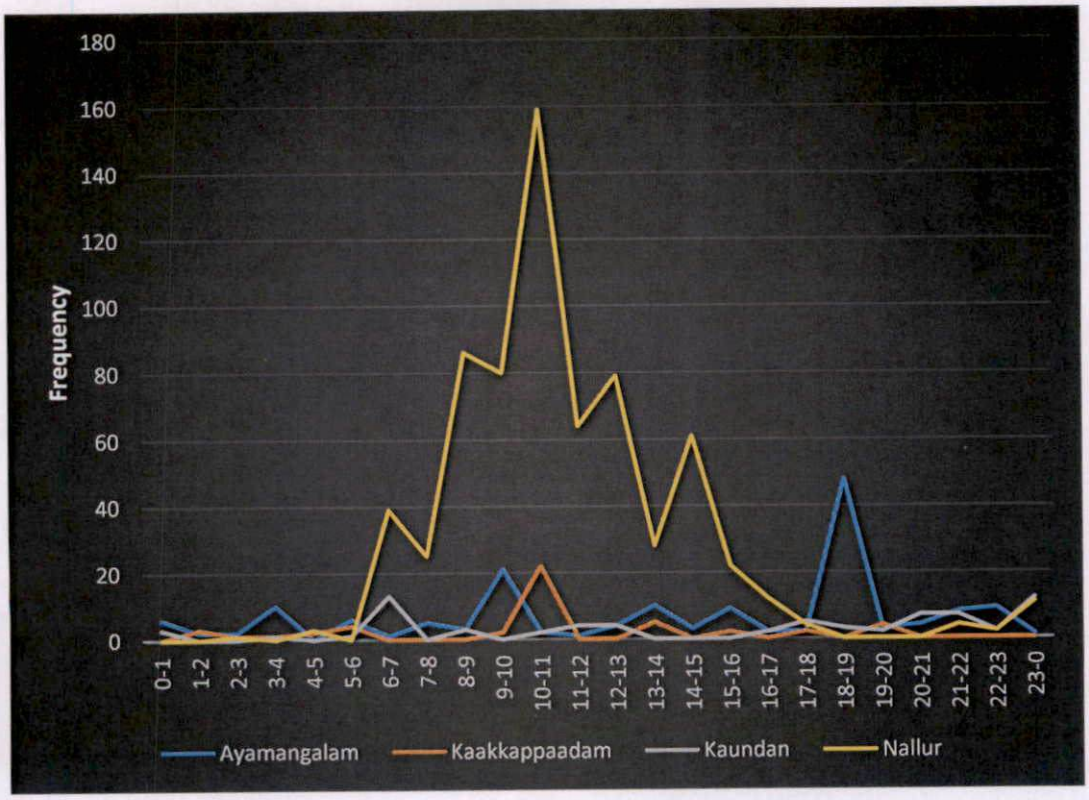

Figure 30. Temporal usage of different *vayals* of Muthanga range in wet season

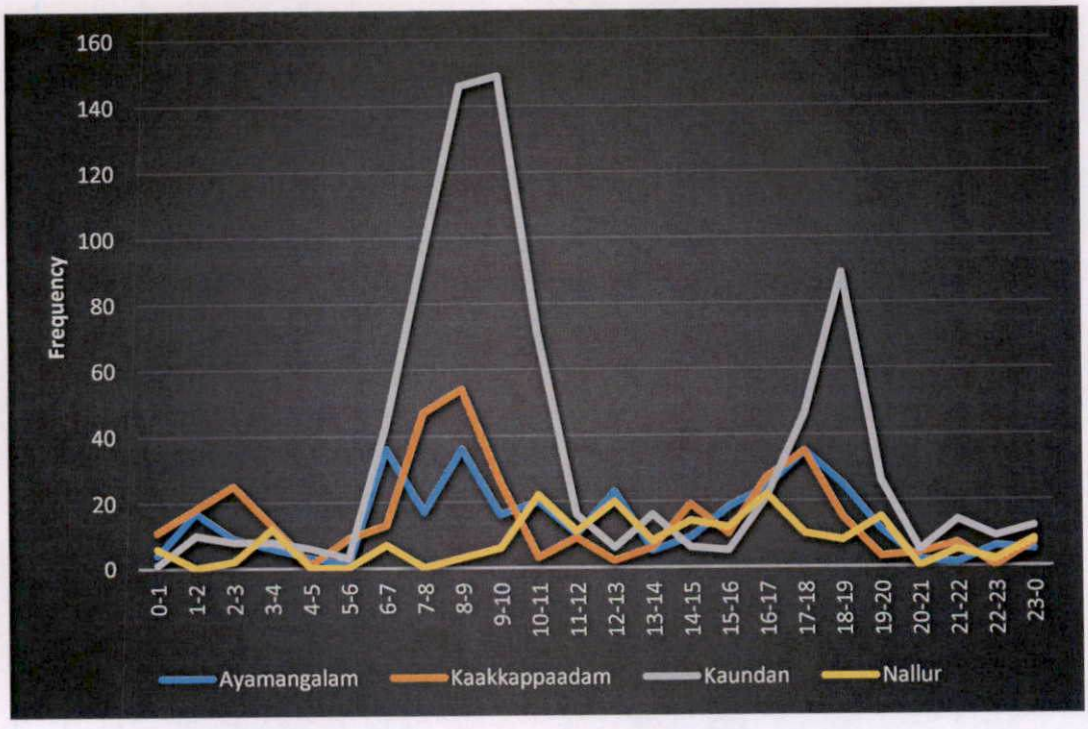

Figure 31 Temporal usage of different *vayals* of Muthanga range in dry season

Kurichyat range shows an irregular activity pattern in *vayals* during the wet season. The frequency was found to be peaking at 13:00-14:00 hours in Kommancherry and Nedumundakolly *vayals*. The peak period of animal activity in Doddapaalam vayal was found to be during 9:00-10:00 hours. Doddapaalam vayal has peak activity during morning and evening hours, but the other *vayals* peaks at noontime. The topmost period of animal activity in Manneduppamkuni was during 17:00-18:00 hours.

The animal activity pattern during the dry season in *vayals* of Kurichyat range was shown in Fig. 33. The activity during the day hours was noticeable and that was many folds higher than that of the night time. Doddapaalam and Manneduppamkuni *vayals* have the peak period of activity during noontime and that of Nedumundakolly and Kommancherry *vayals* was 8:00 and 16:00 hours respectively.

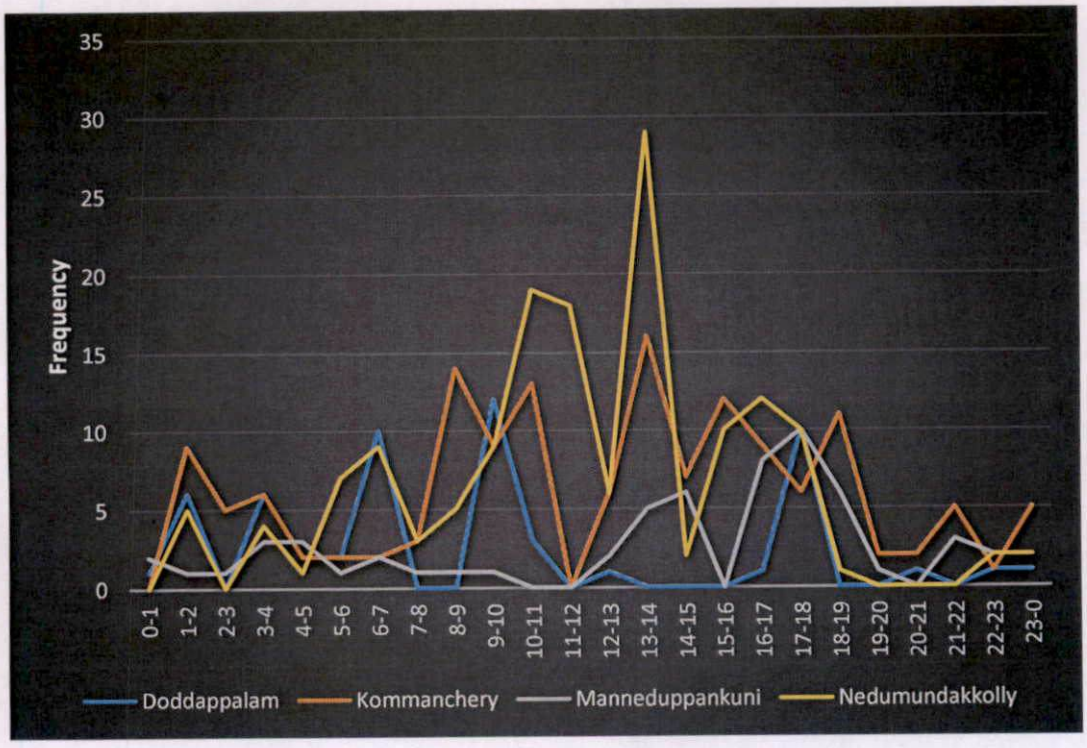

Figure 32. Temporal usage of different *vayals* of Kurichyat range in wet season

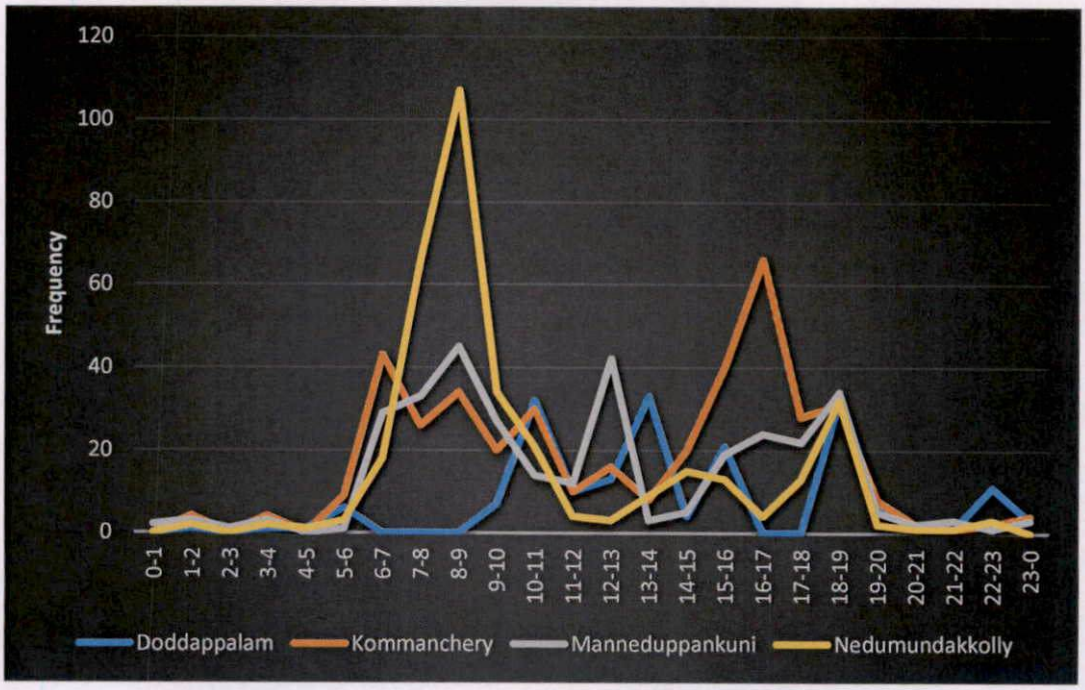

Figure 33. Temporal usage of different *vayals* of Kurichyat range in dry season

In Tholpetty range, the *vayals* show a different pattern of animal activity. The peak hours of vayal usage in the dawn and dusk time. The activity of animals in *vayals* in the noontime is very less as compared to the frequency during the other hours. And there is negligible variation in animal activity between the day and night hours. Dasanghatta vayal have the highest frequency of animal visit during 18:00-19:00 hours and the count of the animal visit was 248. The animal activity in Doddady vayal was different from other *vayals*. The peak activity of animals was observed during hours other than noontime. The count of the animal visit was below 10 from 12:00-14:00 hours (Fig. 34).

In the dry season, Ayyappanpara vayal has the highest frequency of animal visits during 6:00-7:00 hours. Doddady vayal shows an exceptionally high count during 19:00-20:00 hours, followed by Dasanghatta vayal.

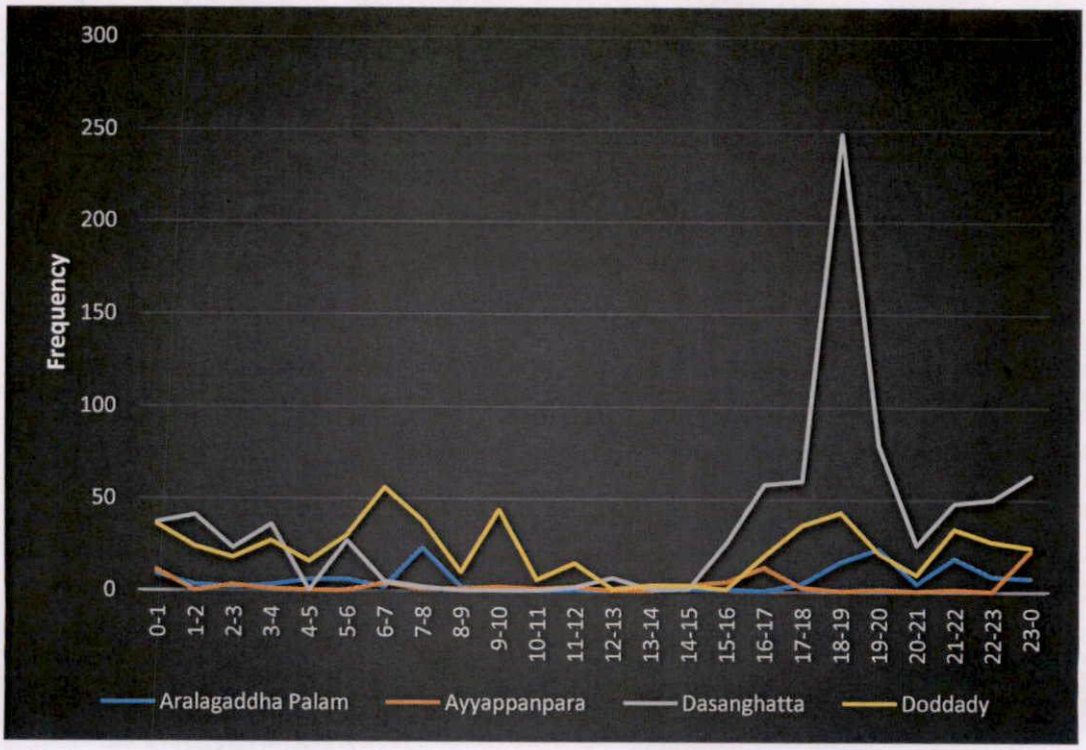

Figure 34. Temporal usage of different *vayals* of Tholpetty range in wet season

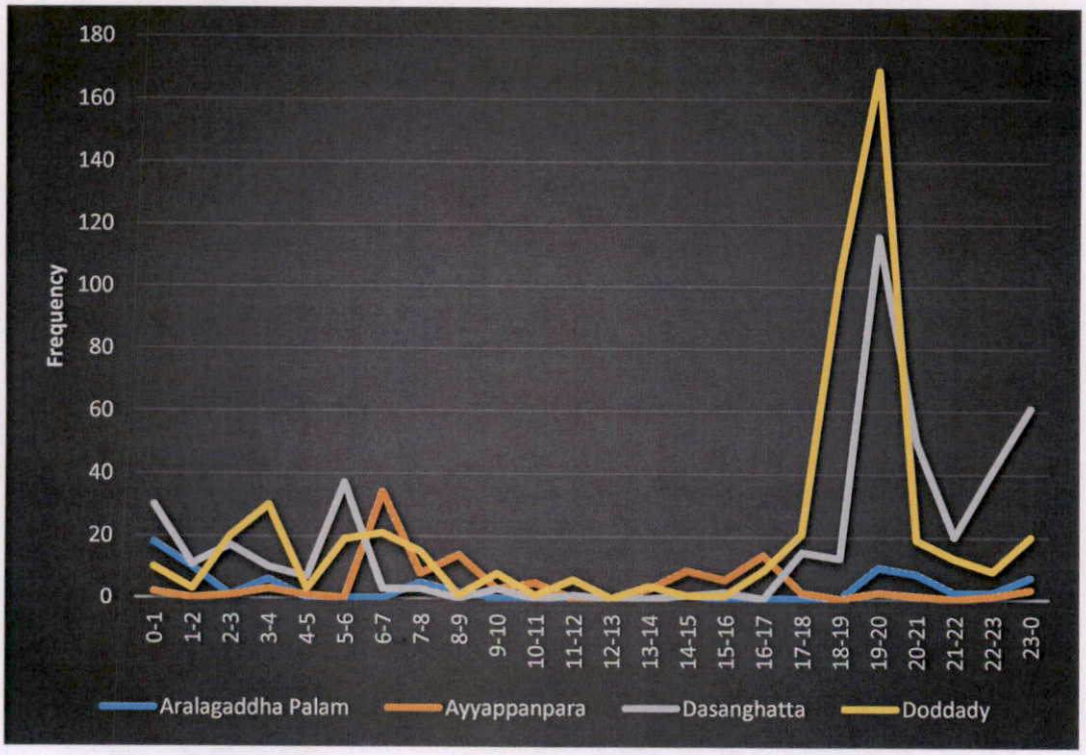

Figure 35. Temporal usage of different *vayals* of Tholpetty range in dry season

The frequency of animal visits to artificial waterholes is relatively less in the wet season. Almost all the waterholes in the sanctuary show animal activity peaks in the day time hours. Among these, the morning hours around 8:00 and evening hours around 16:00 showed high activity.

Fig. 36 shows the Pattern of animal visit in Waterholes of Sulthan Bathery range in the wet season. The maximum frequency of animal visits in waterholes was observed during the evening hours. The peak activity period in Pulachallam and Vilanganpaara waterholes was 12.00 to 15:00 hours and that of Nallathanni was 9:00-10:00 hours. It also shows that the animal visit to Nallathanni was comparatively less than other locations in the range.

The pattern of waterhole use changes in the dry season in Sulthan Bathery range. The activity of animals was maximum during dawn and dusk time and less during mid-day hours. Vilanganpaara waterhole shows an exception from this pattern as its highest frequency of animal visit was observed at 13:00-14:00 hours.

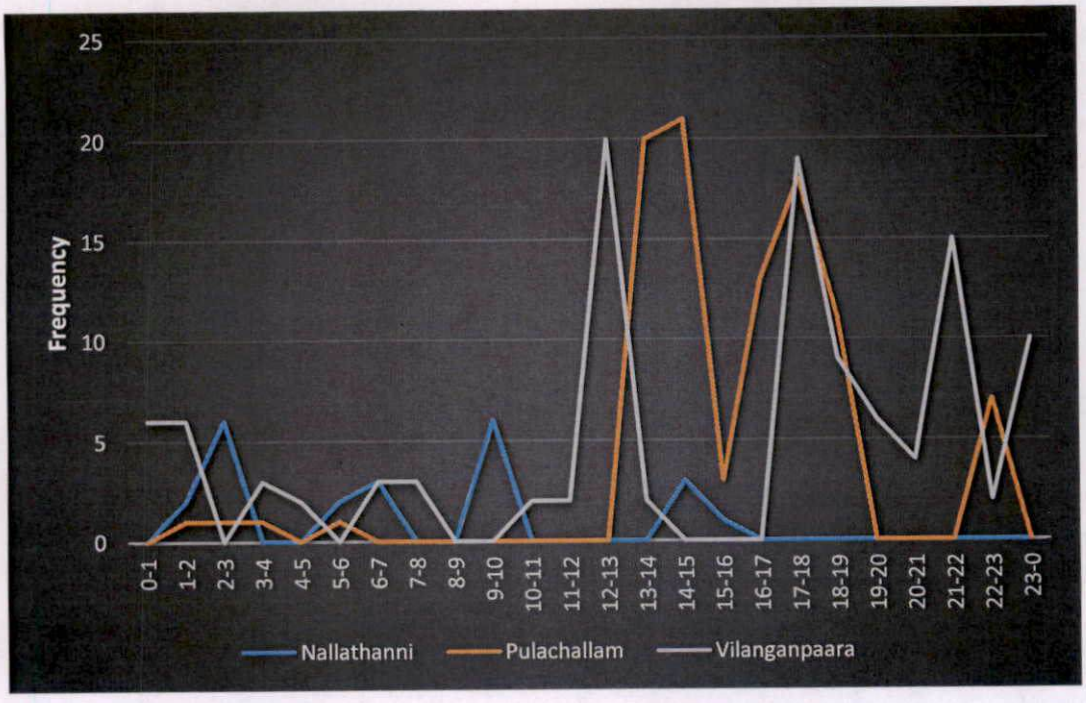

Figure 36. Temporal usage of different waterholes of Sulthan Bathery range in wet season

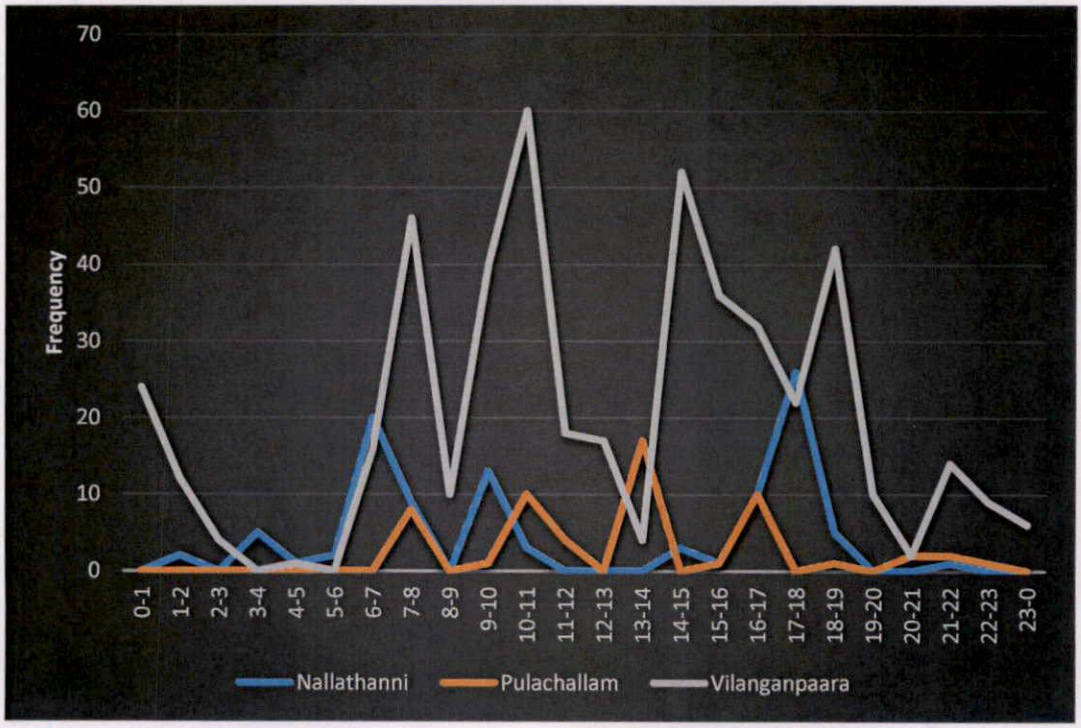

Figure 37. Temporal usage of different waterholes of Sulthan Bathery range in dry season

The general animal activity pattern in the Muthanga range shows that the top activity of animals in the waterholes in the wet season was observed during day hours. Kaundan and Kaakkappadam waterholes show higher animal activity in the mid-day hours. Ayamangalam vayal has peak activity of visit during 7:00—8:00 hours.

During the dry season, the frequency of animal visits in Kaundan vayal is very high as compared to other locations. The peak activity of visit in Kaundan waterhole was observed during 9:00-10:00 hours and the count was 312. The

Kaakkappadam waterhole was less used during the day hours.

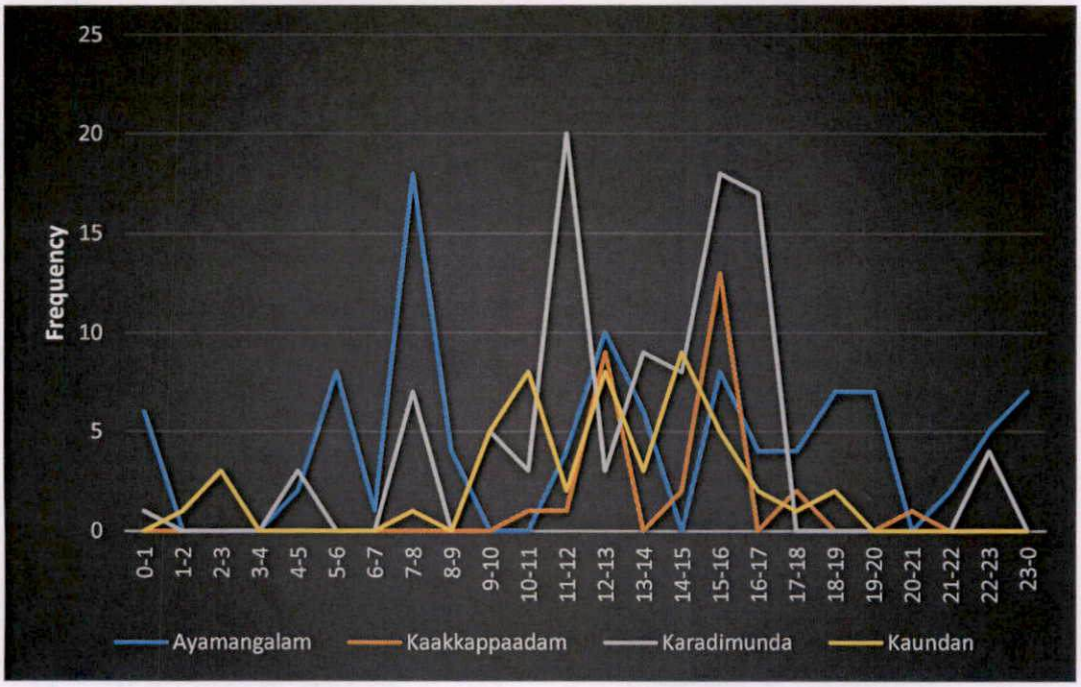

Figure 38. Temporal usage of different waterholes of Muthanga range in wet season

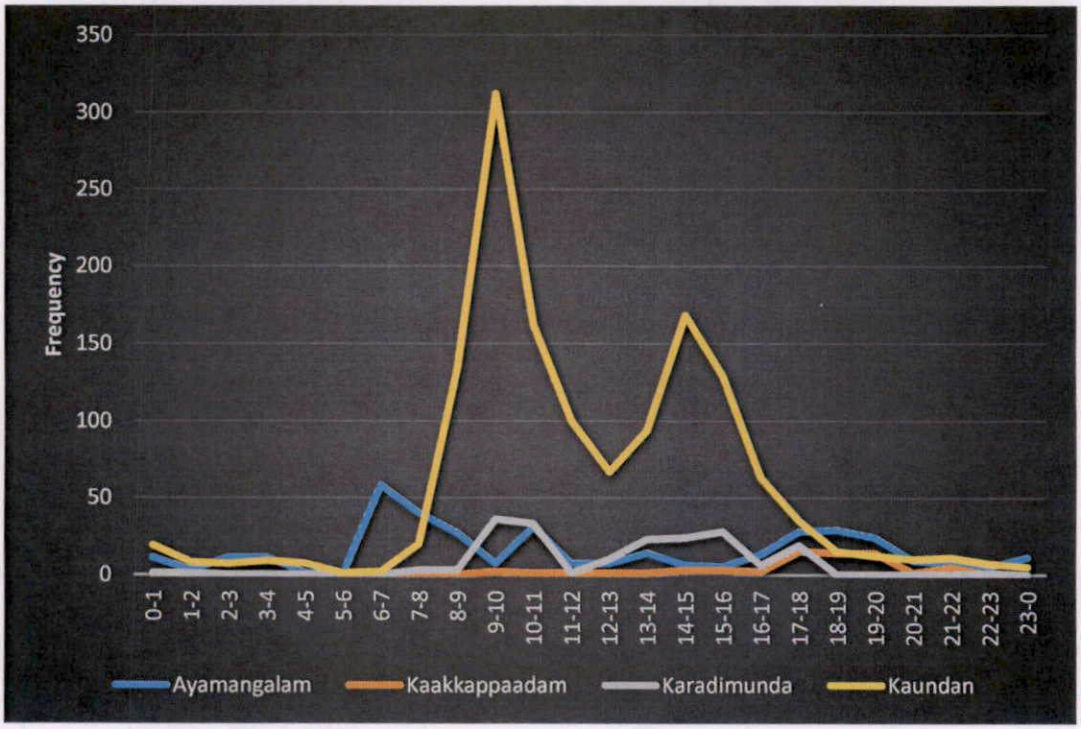

Figure 39. Temporal usage of different waterholes of Muthanga range in dry season

The waterhole usage in the Kurichyat range is not so different from other ranges in the sanctuary. In the wet season, Manneduppamkuni waterhole has the highest animal visiting frequency in the morning and evening hours. On the other hand, Chaddakulasi waterhole shows the highest frequency during mid-day hours.

During dry season also, the waterholes of Kurichyat shows peak activity during morning and evening hours. The activity in the noon hours are very less compared to that of other hours. Chaddakulasi and Manneduppamkuni waterholes have peak activity periods at 8:00-9:00 hours.

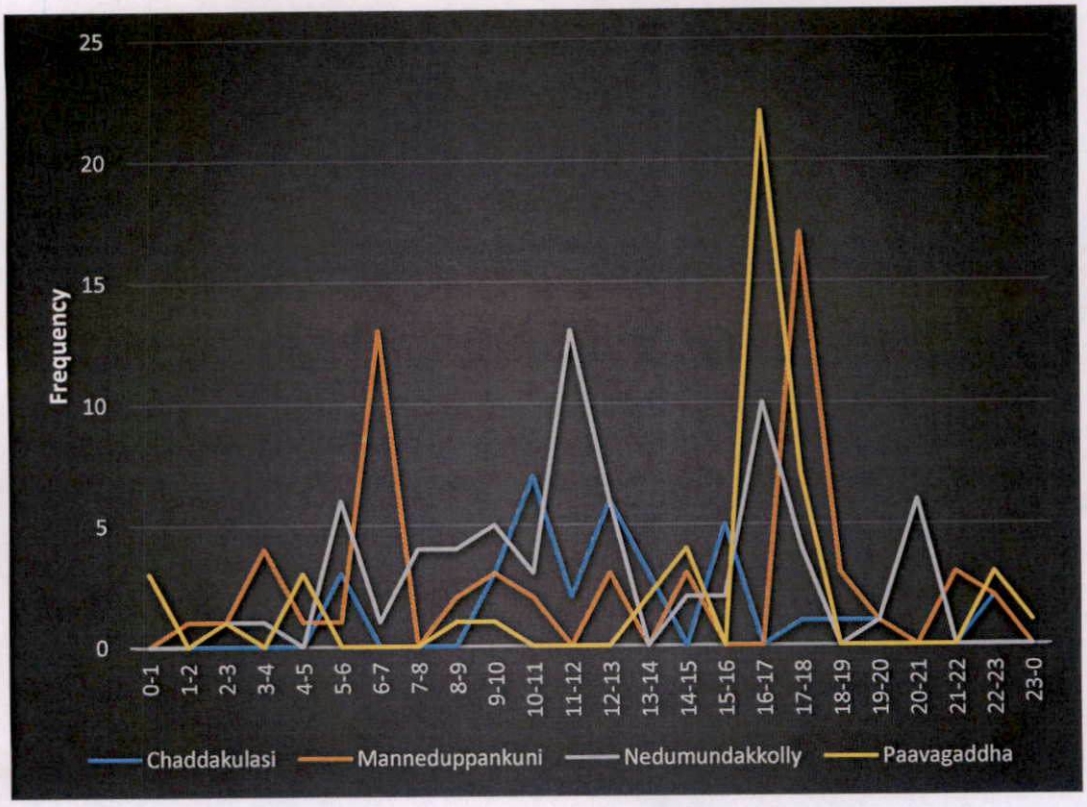

Figure 40. Temporal usage of different waterholes of Kurichyat range in wet season

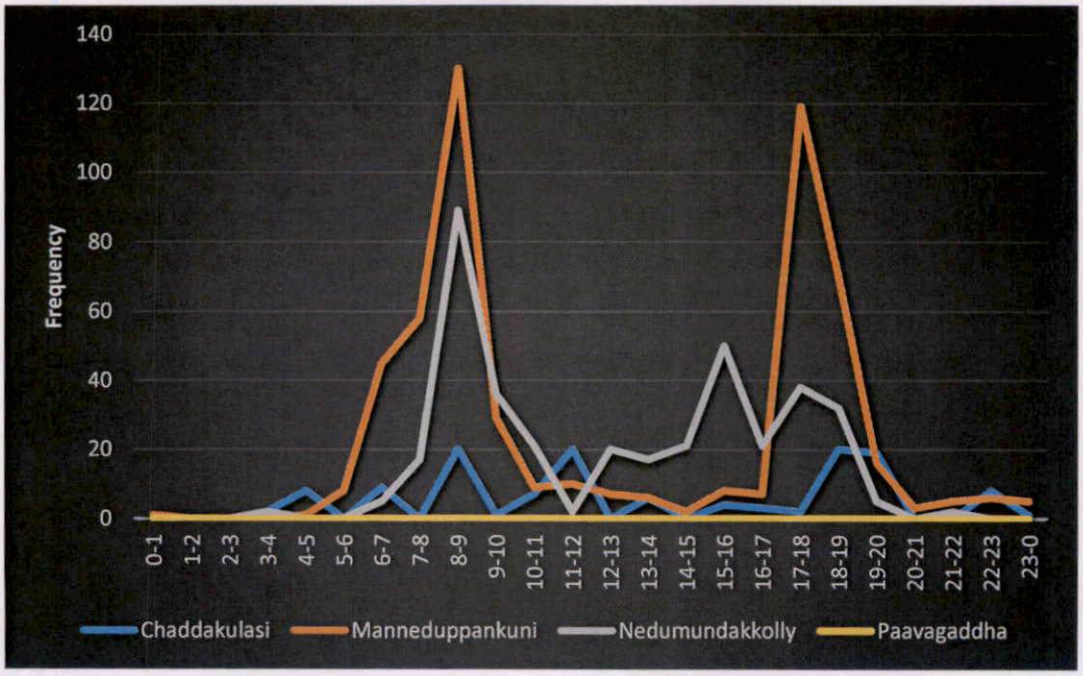

Figure 41. Temporal usage of different waterholes of Kurichyat range in dry season

The general trend of waterhole usage was irregular in the Tholpetty range in the wet season. 36th Pond has a peak animal activity time during mid-day hours. Frequency of animal visit in 38th Pond is almost linear throughout the day time. In 70th Pond, the peak activity of animals was found to be at 9:00-10:00 hours. While Doddady waterhole has a maximum frequency during the evening hours.

We could see a clear hike in the animal activity in 70th Pond. In the dry season, the peak period of animal activity was shifted to afternoon hours. There is very little frequency was observed during the night hours, and it shows a sudden increase in the frequency from 5:00-6:00 hours.

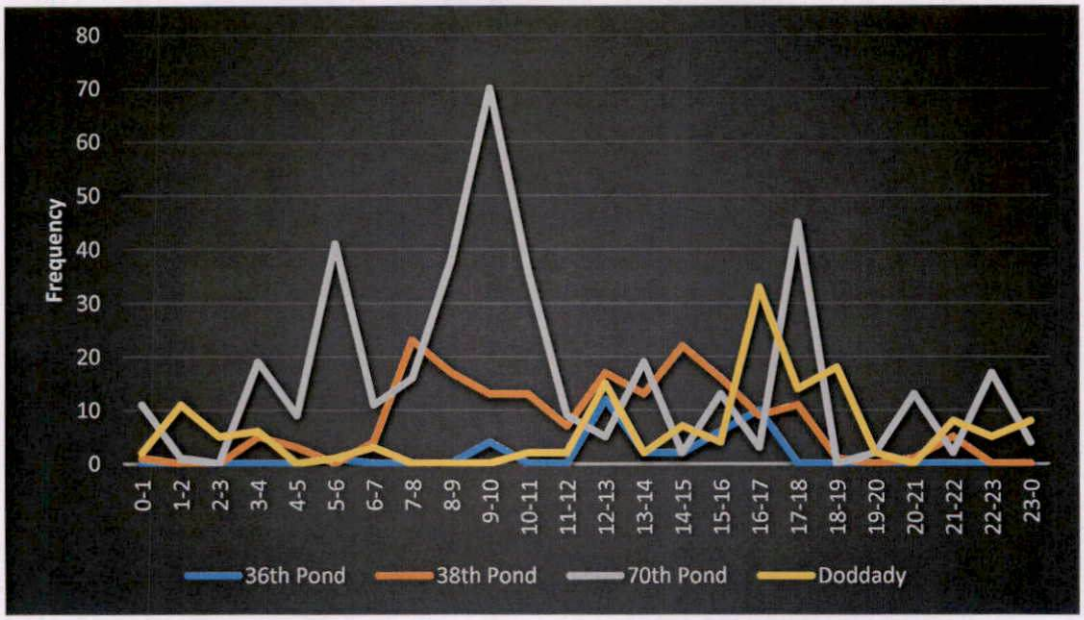

Figure 42. Temporal usage of different waterholes of Tholpetty range in wet season

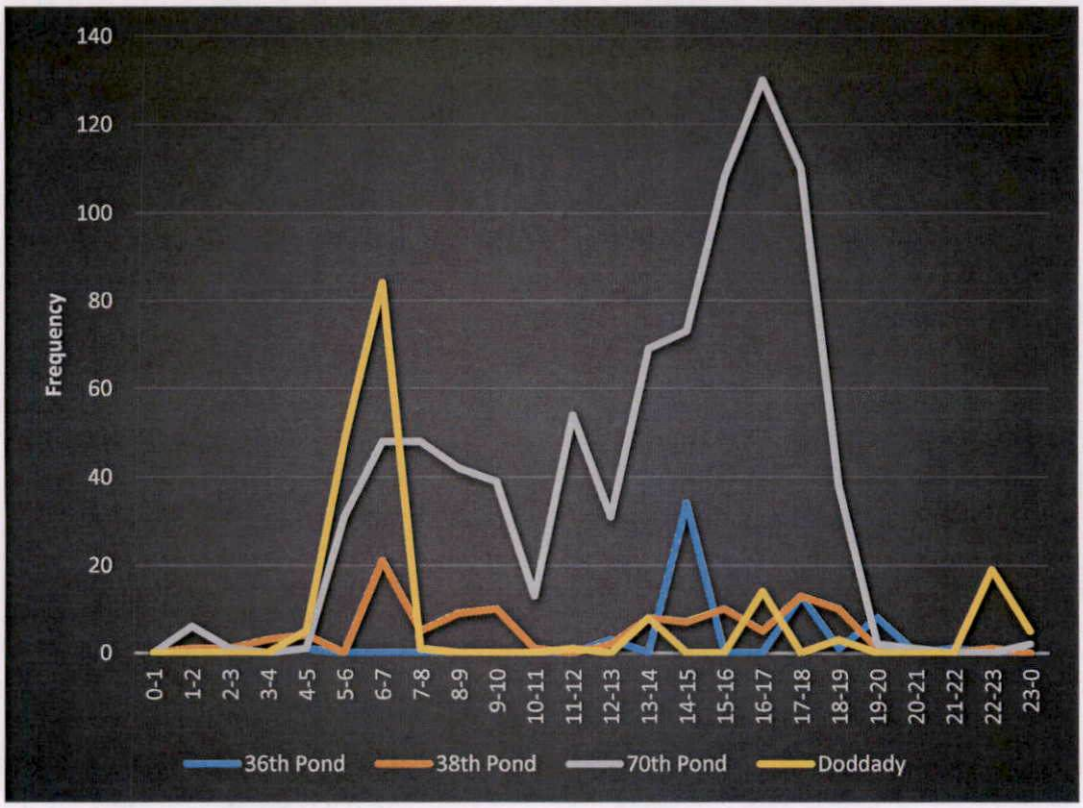

Figure 43. Temporal usage of different waterholes of Tholpetty range in dry season

4.4 DIFFERENCE IN UTILIZATION OF WATERHOLES IN WAYANAD WILDLIFE SANCTUARY

The Wayanad Wildlife Sanctuary has 168 waterholes spreading inside the sanctuary. Many of them will dry up during the peak summer season. Only 20% of the waterholes will retain water throughout the year.

Many of these waterholes is made inside the vayal/ marshy areas. In the current study, we monitored the difference in utilization of the waterholes inside the *vayals* and outside the area of the *vayals* in the sanctuary. Table 8 shows the list of waterholes selected for the analysis.

Table 8. List of waterholes situated inside and outside the area of *vayals*/swamps

Waterholes inside *Vayals*	**Waterholes outside *Vayals***
Ayamangalam	Chaddakulasi
Kaakkappadam	Karadimunda
Kaundan	Vilanganpaara
Manneduppamkuni	36th Pond
Nedumundakolly	38th Pond
Doddady	70th Pond

Generally, the frequency of animal visit was greater in the waterholes made inside the *vayals*. Out of 1824 animal visits in waterholes, 974 visits were made to waterholes inside the *vayals*. There is also variation between seasons, as the frequency of visits in wet season are more in waterholes outside the *vayals*. Details are given in Fig. 44.

Table 9. Number of species and frequency of visit to waterholes made inside and outside *vayals* in Wayanad Wildlife Sanctuary

	Waterholes inside *Vayals*	Waterholes outside *Vayals*
Number of species	18	16
Frequency of visit	974	850

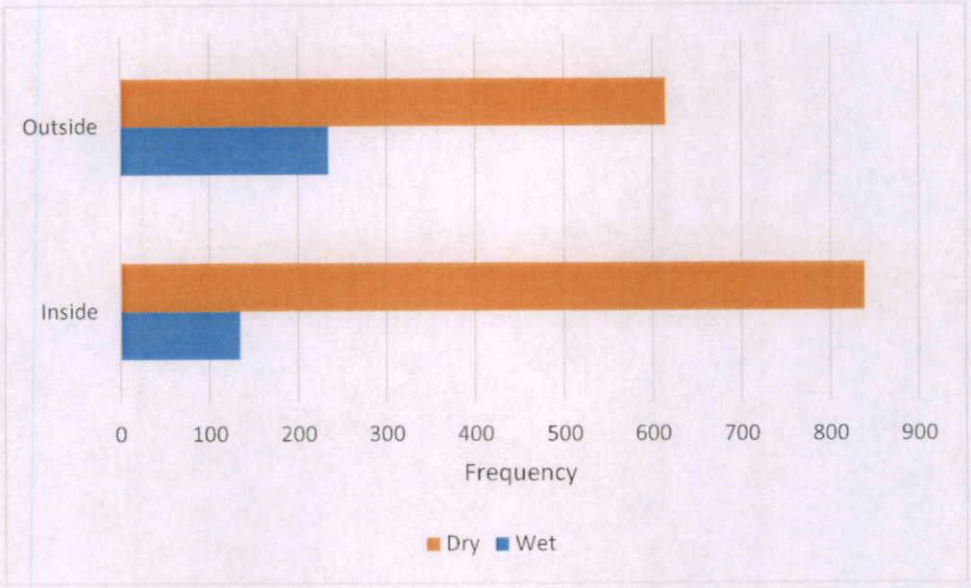

Figure 44. Frequency of animal visit to waterholes made inside and outside *vayals* in Wayanad Wildlife Sanctuary

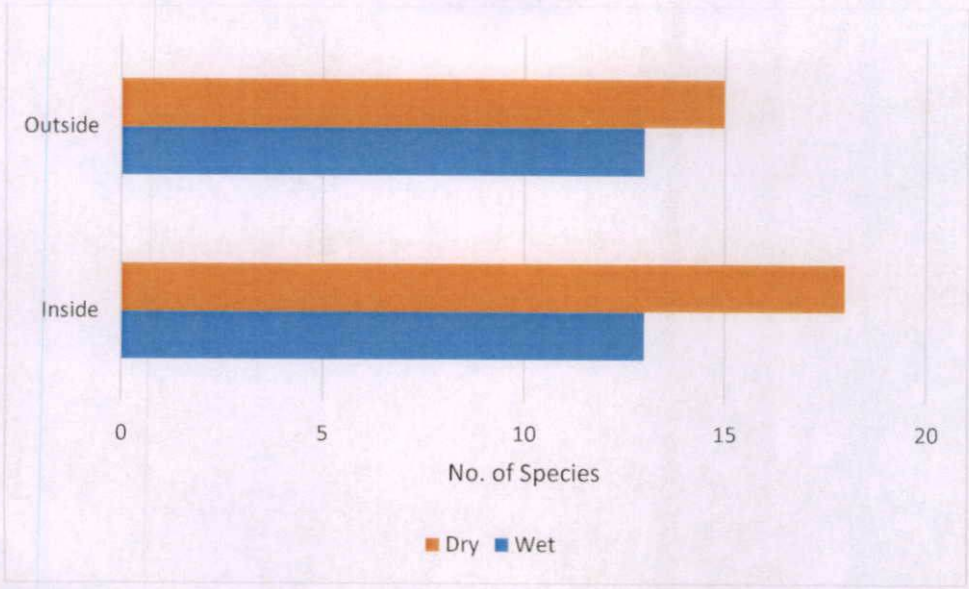

Figure 45. Number of species of animals visited waterholes made inside and outside *vayals* in Wayanad Wildlife Sanctuary

4.5 USAGE OF WATERHOLES BY WILD ANIMALS IN DIFFERENT SEASON

The waterholes in Wayanad Wildlife Sanctuary are widely visited by animals. Not all the animals visiting the waterholes are directly using the waterholes. Large mammals like Asian elephant and Gaur are visiting the waterholes to meet their water requirement, but there are other animals those where mainly depends the vegetation around the waterholes. Most of the ungulates depend the waterholes for feeding on the grasses and other bushes around the waterholes.

Fig. 46 describes the activity of animals in waterholes of Sulthan Bathery range in wet season. No animal is found to be drinking water from Nallathanni and Vilanganpaara waterholes. Many of the animal visit in waterholes were made for pastures. In dry season, where there is no much sources of water in the sanctuary,

some fraction of animals was found to be consuming the water directly from these waterholes.

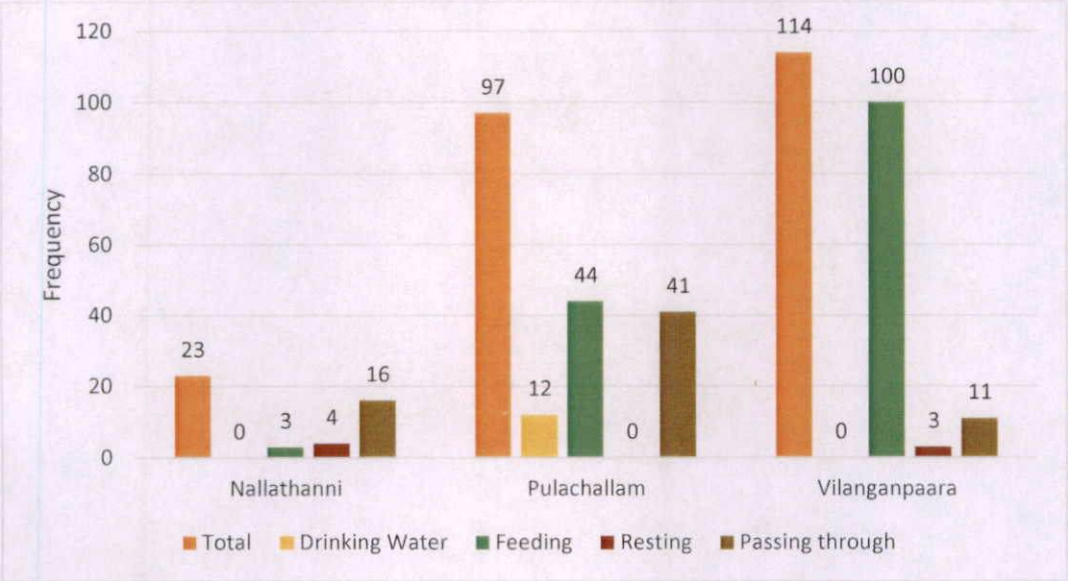

Figure 46. Frequency of animals in different activities in waterholes of Sulthan Bathery range in wet season

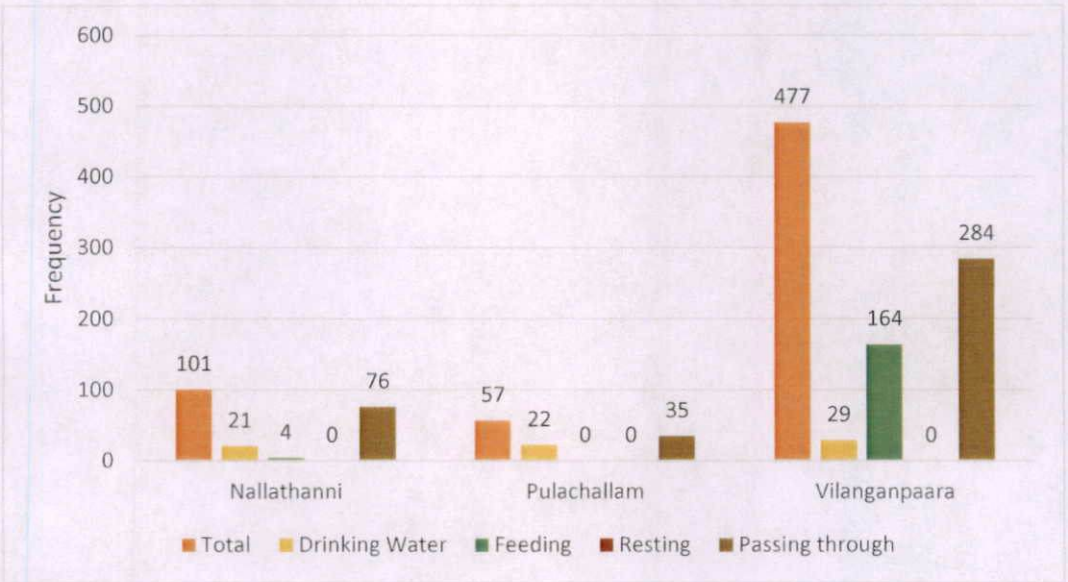

Figure 47. Frequency of animals in different activities in waterholes of Sulthan Bathery range in dry season

In Muthanga range, the usage of waterholes was not uniform. Kaakkappadam and Kaundan waterholes were less preferred by animals in the wet season. Only 29 visits were made by animals to Kaakkappadam waterhole and 24 of them were found to be grazing around the waterbody.

In dry season, the frequency of animal visit was increased in all the study locations in the range. But, the direct use of waterholes was relatively less. A total of 365 visits were made into Ayamangalam waterhole and none of them were found to be drinking water from the waterhole or bathing in it. The Kaundan waterhole shows a better performance, as, it has 103 incidence of drinking water/ bathing. A small fraction of animals was found to be resting near the waterholes.

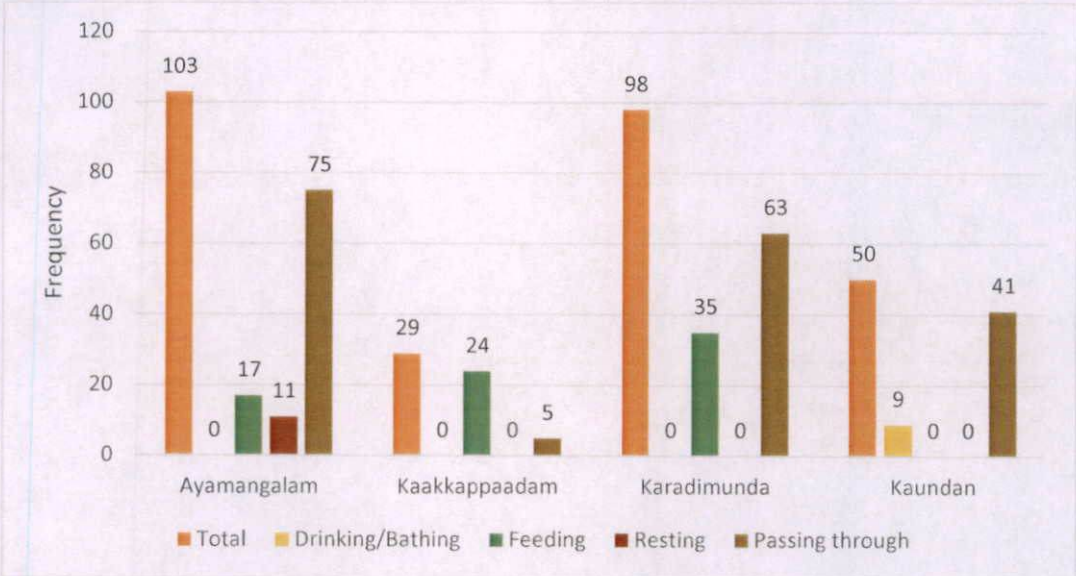

Figure 48. Frequency of animals in different activities in waterholes of Muthanga range in wet season

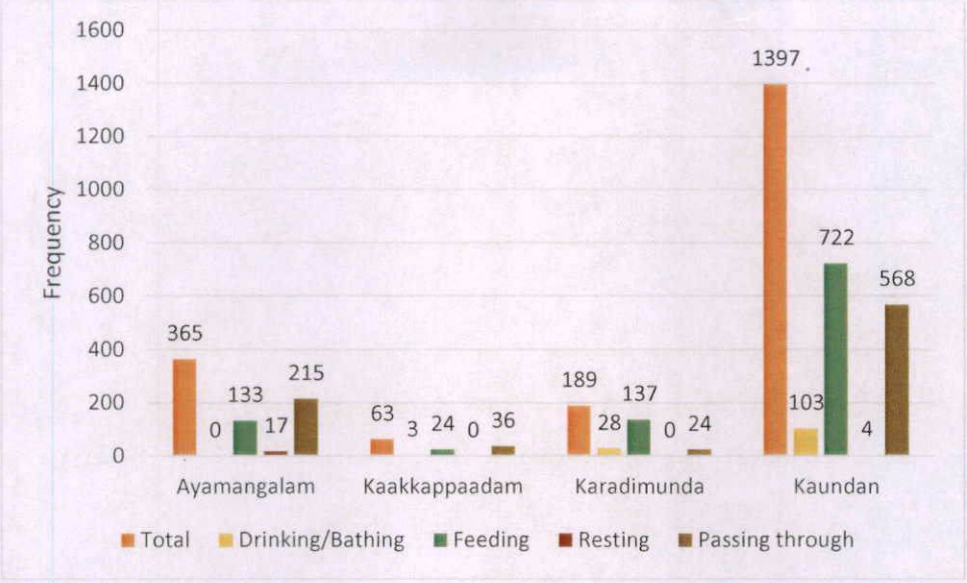

Figure 49. Frequency of animals in different activities in waterholes of Muthanga range in dry season

The direct usage of waterholes was much more prominent in waterholes of Kurichyat range. Incidence of drinking or bathing was reported from Chaddakulasi, Nedumundakkolly and Pavagaddha waterholes. Nedumundakolly was the most preferred waterhole in the range in wet season.

During dry periods, the priorities changes, and the most used one was Manneduppamkuni waterhole. A total of 547 visits were made by animals to the waterhole, but only 13 were found to be using the waterhole directly. Two hundred and thirty-two visits were done for grazing around the pond. Nedumundakolly waterhole has comparatively high frequency of drinking or bathing in the pond. The data from Pavagaddha waterhole was missing as we lost the camera traps in the dry season.

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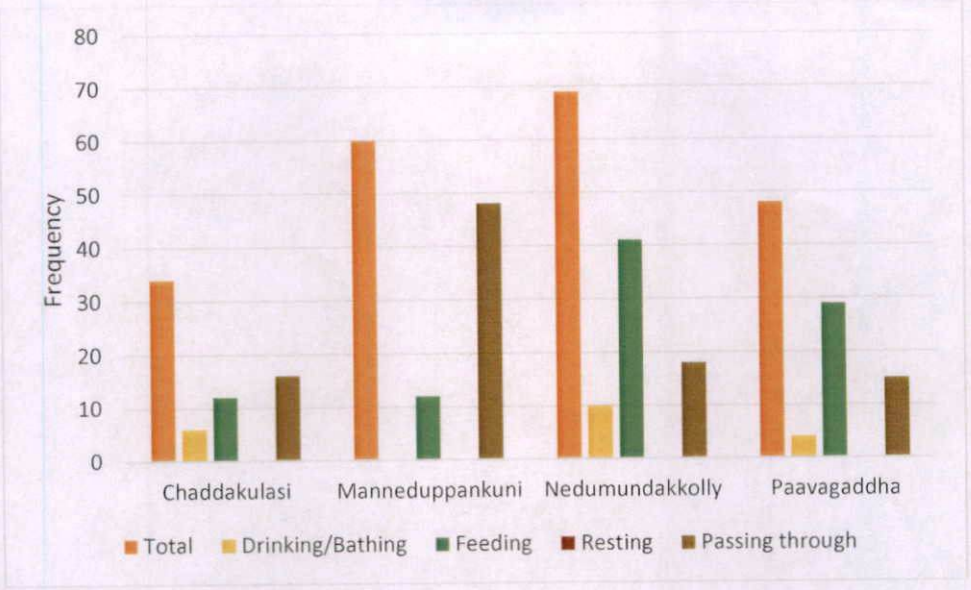

Figure 50. Frequency of animals in different activities in waterholes of Kurichyat range in wet season

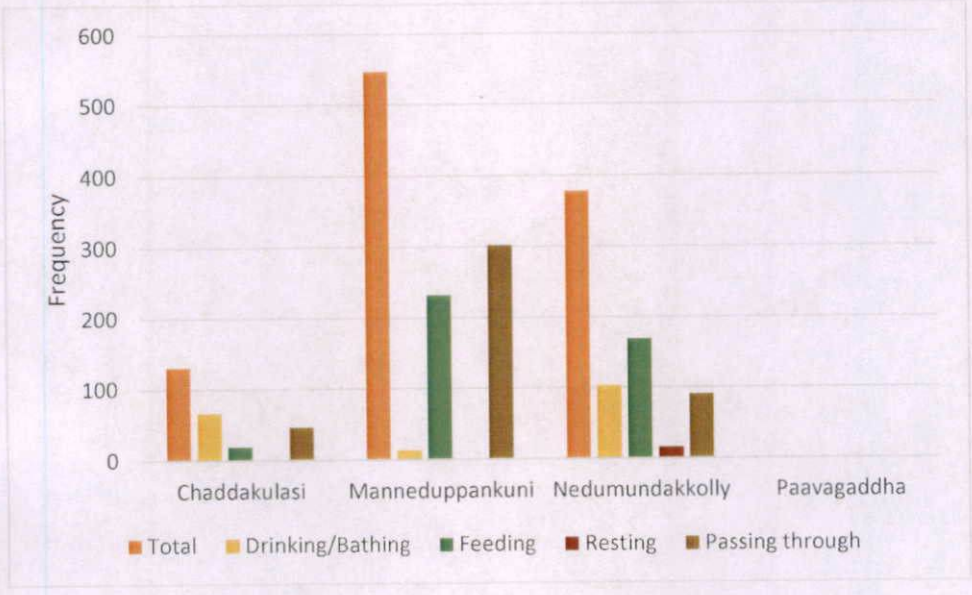

Figure 51. Frequency of animals in different activities in waterholes of Kurichyat range in dry season

The direct usage of waterholes was very little in the case of Tholpetty range also. 70th Pond is the most widely used waterhole in the range in both the season, and there were 386 visits made to the pond and only eight of them was for drinking

the water. In dry season also, the situation remains the same. No waterholes other than 70th Pond is found to be having incidence of drinking water.

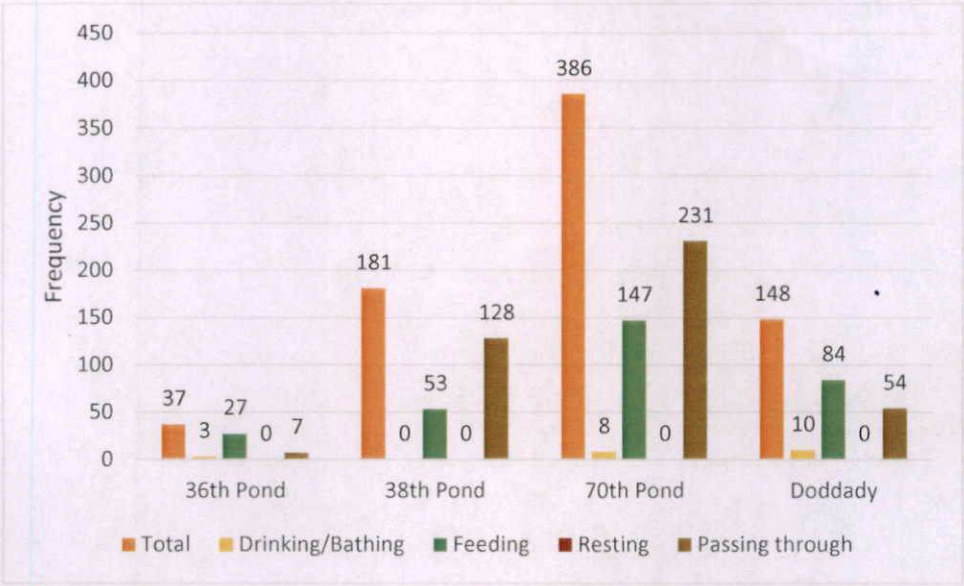

Figure 52. Frequency of animals in different activities in waterholes of Tholpetty range in wet season

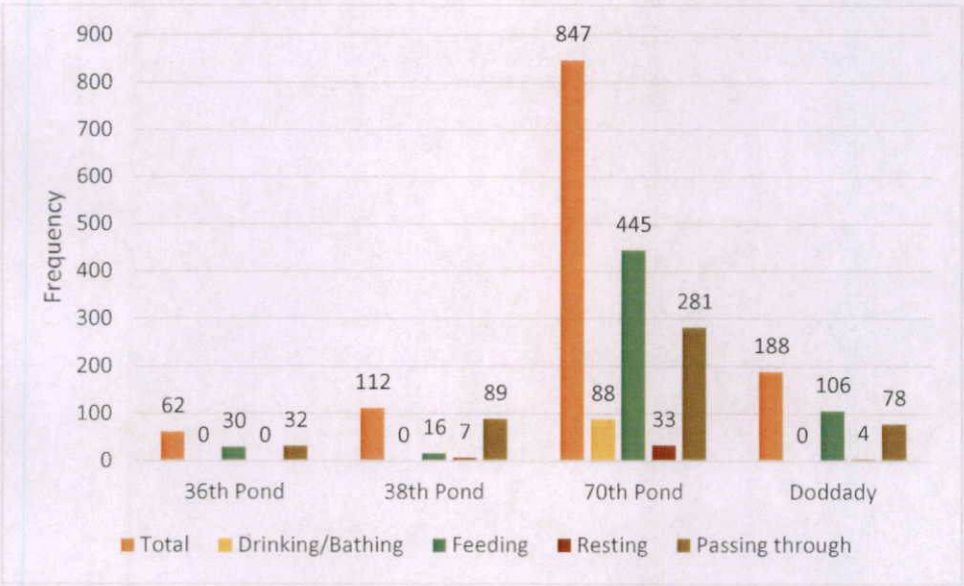

Figure 53. Frequency of animals in different activities in waterholes of Tholpetty range in dry season

4.6 TIME ACTIVITY PATTERN OF WATERHOLE USE OF ANIMALS

The camera trap images contain time and date of capture of the photograph. So that we could analyse the period of activity of each animal species. The peak frequency of animal visit in our study areas were during the daytime hours.

Fig. 54 shows the time of activity of Asian Elephant, Barking deer and Gaur at *vayals* of Wayanad Wildlife Sanctuary. It has to be noted that, all the three animals follow nearly a similar trend in time of usage of *vayals*. The activity of Asian elephant shows less during the morning hours and it increases till 18:00 hours. The Barking deer shows higher activity in *vayals* during the day light hours.

In waterholes also, there was no considerable changes in the time of activity of these animals. Gaur has a peak activity during the evening hours and barking deer is more active during the morning hours.

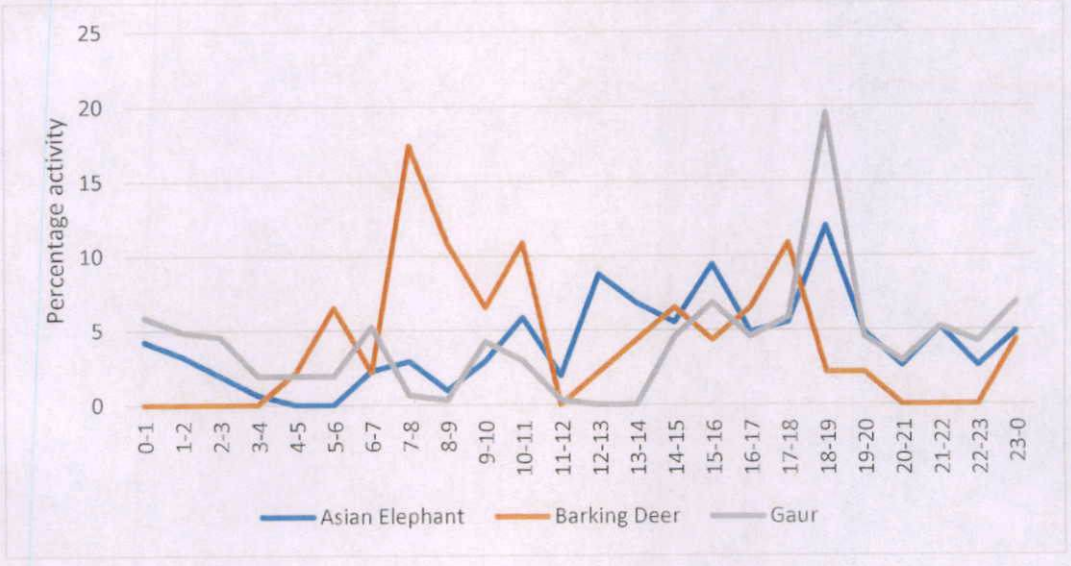

Figure 54. Time activity pattern of Asian Elephant, Barking deer and Gaur at *vayals* of Wayanad Wildlife Sanctuary.

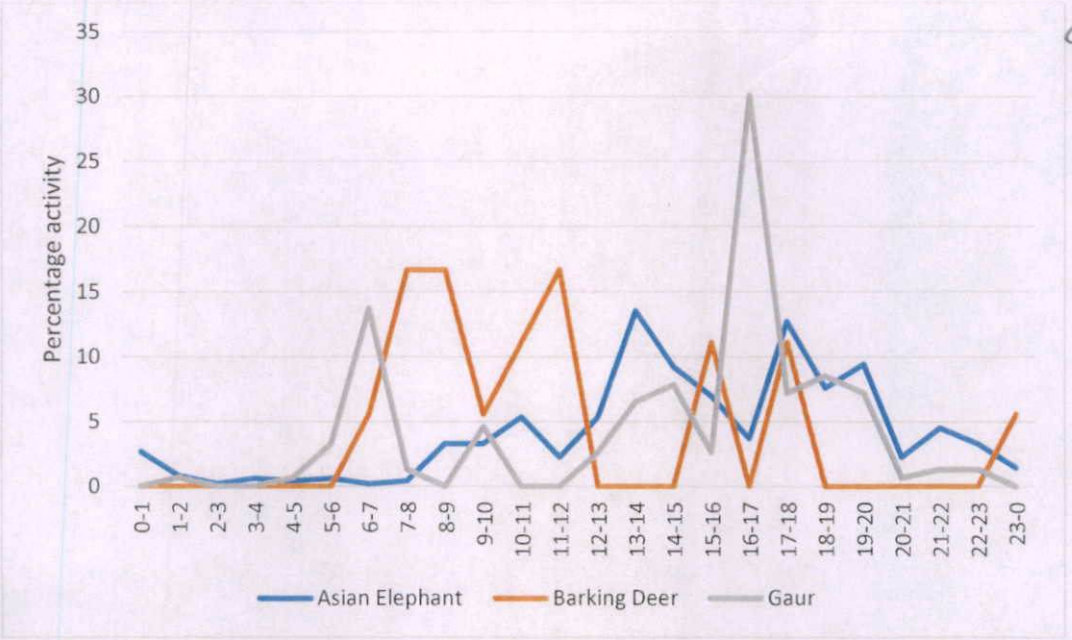

Figure 55. Time activity pattern of Asian Elephant, Barking deer and Gaur at waterholes of Wayanad Wildlife Sanctuary.

The period of active utilisation of *vayals* by sambar deer, spotted deer and Wild boar are shown in Fig. 55. The Sambar deer and Spotted deer a same pattern of activity in *vayals*. The vayal usage was showing an increasing trend from 4:00 hours and attains a peak during 9:00-10:00 hours and then shows a decrease. In the evening hours it again increases and attains the peak at 18:00 hours.

In waterholes also, the activity starts increasing from 4:00 hours and settle downs at 19:00 hours. Wild boar shows a clear peak period of activity at 18:00 hours.

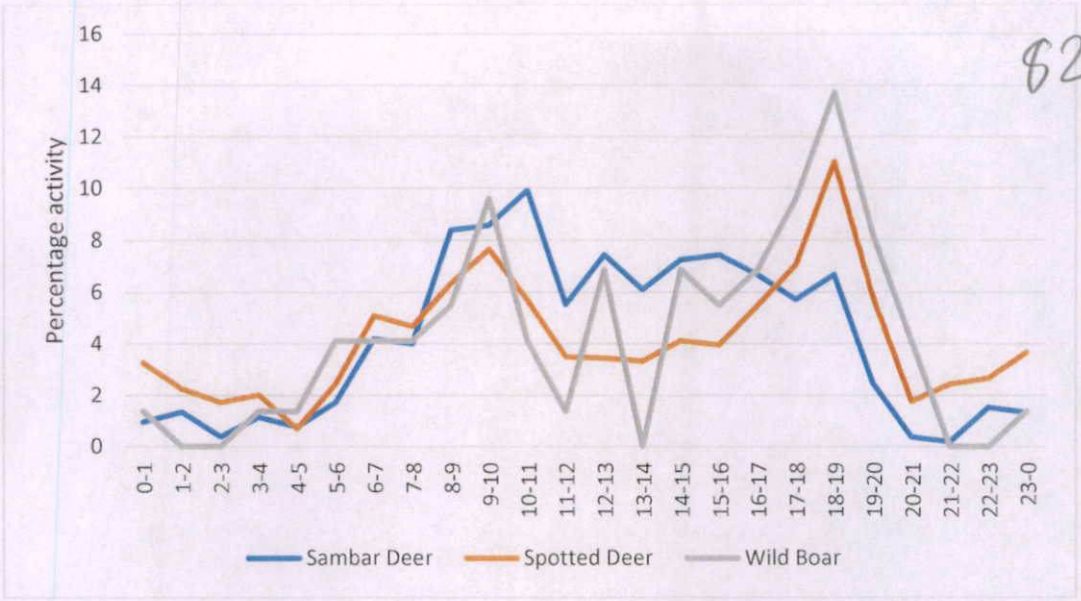

Figure 56. Time activity pattern of Sambar deer, Spotted Deer and Wild Boar at *vayals* of Wayanad Wildlife Sanctuary.

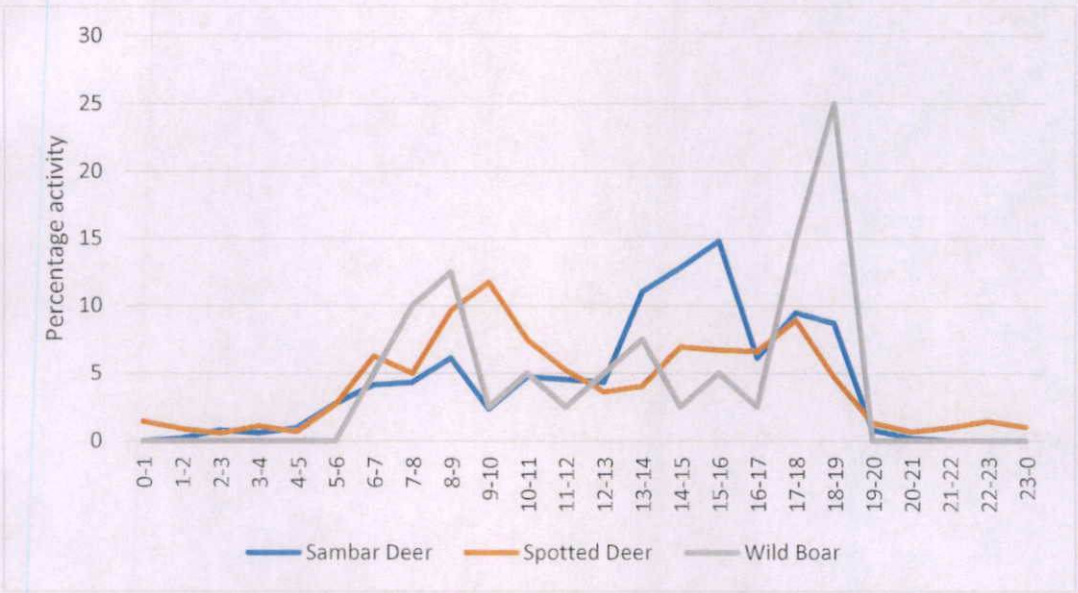

Figure 57. Time activity pattern of Sambar deer, Spotted Deer and Wild Boar at waterholes of Wayanad Wildlife Sanctuary.

The carnivores are observed to be visiting the *vayals* during all the time in a day. Wild dog was active during day hours and the Sloth Bear during evening and night hours. The presence of tiger was found during all the day in *vayals* of Wayanad

wildlife Sanctuary. The leopard was visiting the *vayals* during night time. The time activity of leopard was shifted to early morning and noon hours in waterholes. 83

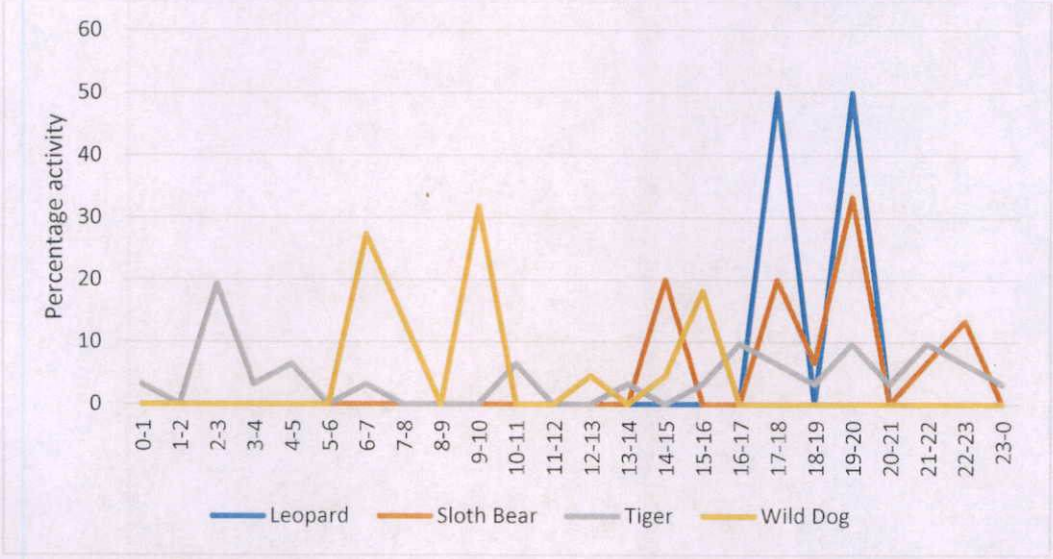

Figure 58. Time activity pattern of carnivores at *vayals* of Wayanad Wildlife Sanctuary.

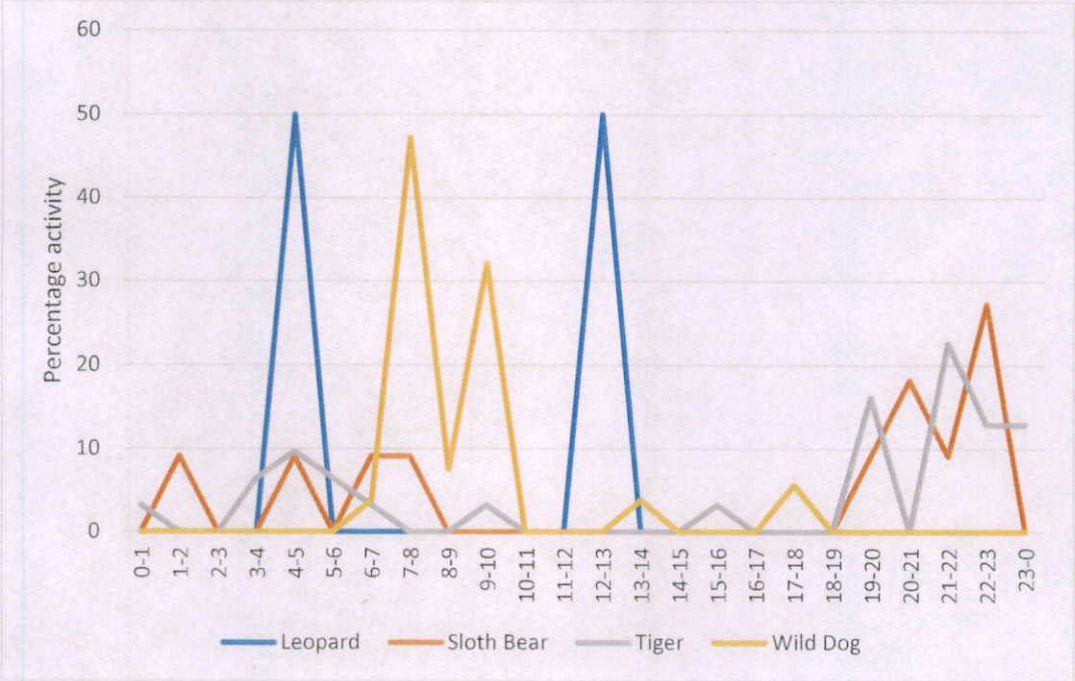

Figure 59. Time activity pattern of carnivores at waterholes of Wayanad Wildlife Sanctuary.

The period of activity of Primates like Black-footed Gray Langur, Bonnet Macaque and Tufted Gray Langur clearly confined to the day hours. 84

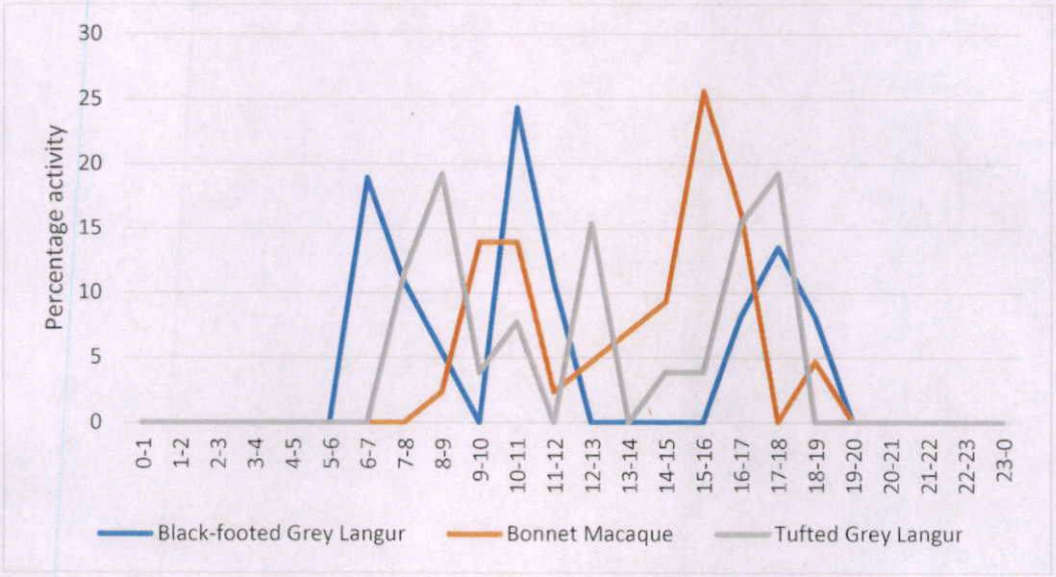

Figure 60. Time activity pattern of primates at *vayals* of Wayanad Wildlife Sanctuary.

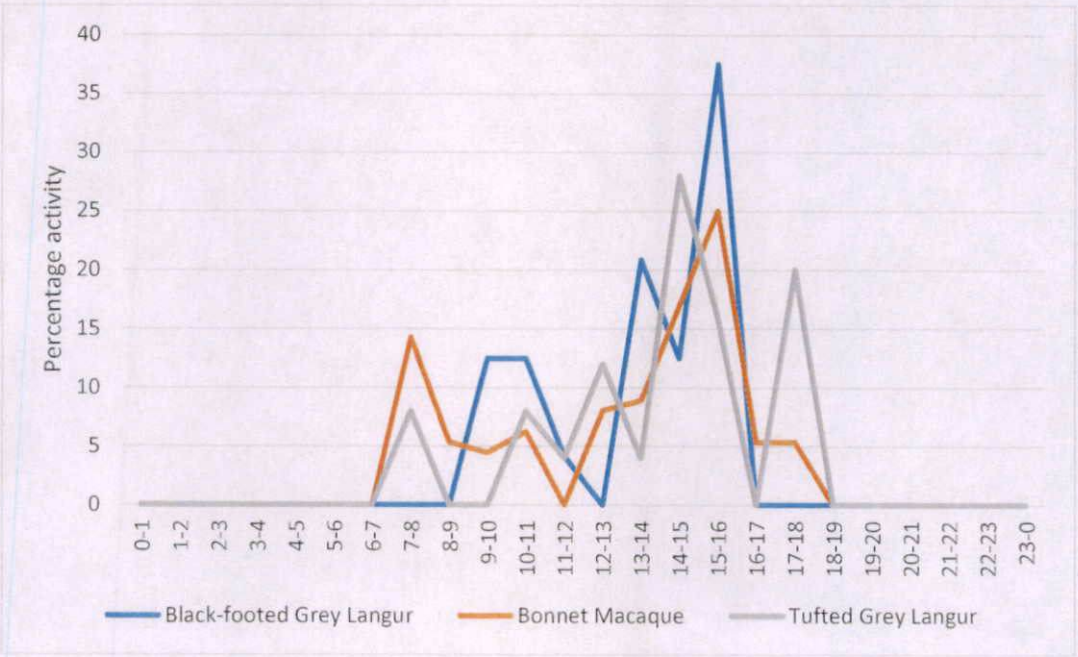

Figure 61. Time activity pattern of primates at waterholes of Wayanad Wildlife Sanctuary.

4.7 INTERACTION BETWEEN ANIMALS USING SAME RESOURCES

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4.7.1 Randomness of waterhole usage

The randomness of animal visit to the *vayals*/ waterholes describes how randomly an animal using the water resource in a particular time. It was analysed using run test. The results are given in table 10.

Table 10. Randomness of visit of animals in *vayals* of Wayanad Wildlife Sanctuary

Species	Z		P	
	Wet	Dry	Wet	Dry
Asian elephant	-2.12	0.66	0.03*	0.50
Barking Deer	-2.65		0.008**	
Gaur	-3.13	-0.20	0.001**	0.83
Sambar Deer	1.21	-3.13	0.22	0.001**
Spotted Deer	-1.04	-3.11	0.29	0.001**
Wild Boar	-2.44	-1.043	0.014*	0.29

Table 11. Randomness of visit of animals in waterholes of Wayanad Wildlife Sanctuary

Species	Z		P	
	Wet	Dry	Wet	Dry
Asian Elephant	-2.29	-1.87	0.02*	0.06
Barking Deer				
Gaur		-1.43		0.15
Sambar Deer	-1.46	-3.13	0.14	0.0017**
Sloth Bear				
Spotted Deer	-1.46	-3.13	0.14	0.0017**
Tiger				
Tufted Gray Langur				
Wild Boar				
wild Dog				

*- significant at α=5

**- significant at α=1

The activity of Asian elephant, Barking deer. Gaur and Wild boar show a non-random pattern of usage of *vayals* in wet season. The elephant shows non-

random pattern of usage in *vayals* also. The sambar deer and spotted deer exhibits non-random type of utilisation in both *vayals* and waterholes in wet season. 86

4.7.2 Interactions between animals

The interactions among animals will greatly affect their time, pattern, and extend of utilising the natural resourced. The presence of some animals in a location will delimit the activity of some other animals. To study the interaction, we used Paired G test. The results are given below.

Table 12. Interaction among different animal species using water resources in Wayanad Wildlife Sanctuary

	AE	BD	BFGL	BNH	BoM	BPC	CPC	Gaur	IP	LP	MD	RM	SD	SB	SIC	SpD	SNM	T	TGL	WB	WD
AE	...																				
BD	63	...																			
BFGL	76	89	...																		
BNH	63	99	90	...																	
BoM	93	63	75	63	...																
BPC	79	85	82	84	78	...															
CPC	91	77	82	77	93	77	...														
Gaur	51	89	97	90	59	83	80	...													
IP	55	80	72	79	55	90	67	71	...												
LP	91	91	98	92	89	82	87	96	78	...											
MD	78	99	92	99	76	85	79	93	85	92	...										
RM	80	71	75	71	81	71	87	73	64	77	72	...									
SD	66	76	91	77	72	81	85	75	63	98	86	76	...								
SB	85	85	96	86	83	81	85	92	70	99	89	76	98	...							
SIC	57	69	65	69	56	100	61	65	80	68	72	58	61	64	...						
SpD	10	97	81	95	35	85	74	67	79	89	99	69	24	78	69	...					
SNM	99	80	87	80	98	79	93	84	68	92	83	81	91	91	62	75	...				
T	85	80	92	81	83	81	86	85	66	97	86	77	98	97	62	67	92	...			
TGL	92	64	75	65	98	78	94	63	56	88	76	81	75	82	56	44	97	83	...		
WB	59	95	92	96	62	84	79	93	75	94	96	72	76	88	67	88	82	82	64	...	
WD	78	57	66	57	84	75	99	55	50	81	69	85	64	73	53	41	89	72	87	56	...

AE- Asian Elephant, BD- Barking Deer, BFGL- Black-footed Gray Langur, BoM- Bonnet Macaque, BPC- Brown palm Civet, CPC- Common palm Civet, IP- Indian Porcupine, LP- Leopard, MD- Mouse Deer, RM- Ruddy Mongoose, SD- Sambar Deer, SB- Spotted Deer, SIC- Small Indian Civet, SpD- Spotted Deer, SNM- Stripe-necked Mongoose, T- Tiger, TGL- Tufted Gray Langur, WB- Wild Boar, WD- Wild Dog

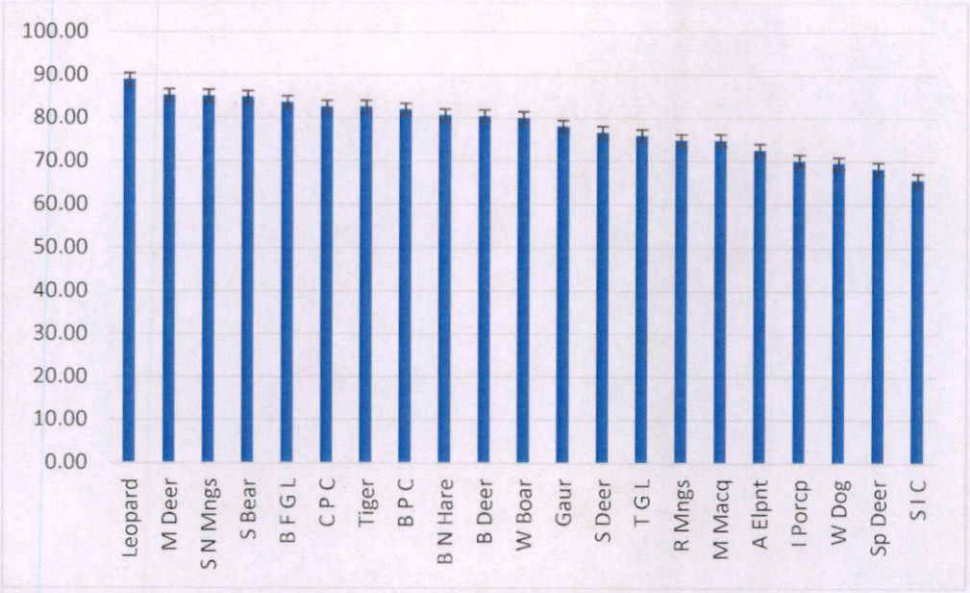

Figure 62. Percentage of influence wielded by different animal in Wayanad Wildlife sanctuary

The run test for interference shows that, Leopard is the animal which influences the activity of other animals in the sanctuary. It means that, if the Leopard is present in an area, there is less likely to influence the activity of other mammals. It was followed by Mouse deer having a percentage of 85.3. It implies that the activity of Mouse deer is being influenced by various other animals in the sanctuary by 85.3 percentage. The Spotted deer and the Asian elephants were less affecting and/or less affected by the activity of other animal species.

Discussion

5.1 USAGE OF WATER SOURCE BY WILD ANIMALS IN WAYANAD WILDLIFE SANCTUARY

The Wayanad Wildlife Sanctuary bears 171 *vayals* / swamps and 168 artificial waterholes. Not all the waterbodies in the sanctuary are capable of holding water during peak summer months. Around 80% of the waterholes will dry up by the month of February.

In our study, we could find that, there is no significant difference in the utilization of *vayals* and waterholes in Wayanad Wildlife sanctuary. In wet season, the frequency of animal visit to *vayals* were little less than that of waterholes. In Sulthan Bathery range, the frequency of animal visit to waterholes were 73 but that of *vayals* were 305. It shows the very high preference for *vayals* by the wild animals, mainly herbivores. Similarly, in other ranges also the wet season preference was skewed towards *vayals*.

The frequency of animal visit to waterbodies in shows a clear increase dry season. In many ranges, more activity was observed in waterholes than *vayals*. In Muthanga range, the dry season animal visit in *vayals* and waterholes were 508 and 525 respectively. Similarly, in Tholpetty range, the frequency of animal activity in *vayals* and waterholes were 418 and 451 respectively. It shows a slightly high preference for the *vayals* in dry season in some ranges. Dry season preference for *vayals* in Sulthan Bathery and Kurichyat follows our hypothesis that, *vayals* are more preferred by wild animals than waterholes.

There are no studies conducted in India on the preference for artificial and natural waterholes by animals. A similar research conducted by Epaphras *et al.*, (2007) in Rauha National Park, Tanzania, Africa concluded that there were no such preferences were observed among animals between natural or artificial waterholes. But in our deciduous forest ecosystem, we could see a clear preference for natural waterholes/ *vayals* over the artificial ones.

The number of animal species reported were almost equal among *vayals* and waterholes. There are 20 species of animals were observed from *vayals* and 19 species from waterholes during the entire study period. But there is difference in number of species with respect to season. More number of species were reported during dry periods in *vayals* and waterholes. In Sulthan Bathery range, the number of species observed from *vayals* is 11 and that of waterholes is 7. In the same range, 12 species from *vayals* and 14 species from waterhole is reported in dry season. The variation in number of species between wet and dry season were more in Muthanga range. In wet season, the number of species reported from *vayals* of Muthanga range is 9 and in dry season 13 species is observed from the same locations. Seven species of animals were found from waterholes of Muthanga range during wet season, whereas 17 species were found during dry months. The number of species visiting *vayals*/ artificial waterholes were more in dry season than in wet season. But in Tholpetty range, a greater number of species visiting waterbodies were reported in wet season. During wet season, 14 species of animals each were reported from the *vayals* and waterholes of Tholpetty range. But only 12 species were reported during dry season from these locations.

5.2 ANIMALS USING THE WATER RESOURCES

5.2.1 Frequency of visit of different animal species in study locations

Herbivores are the major users of *vayals* as well as waterholes. In *vayals* of Wayanad Wildlife Sanctuary, 97 % of the visits were made by different species of herbivores, followed by primates (1.6%) and large carnivores (1.1%). We could record eight species of herbivores from *vayals* during the study. Out of the total visit made by herbivores, 86.5% were made by Spotted deer (*Axis axis*), five percent by Sambar deer (*Rusa unicolor*), and 3 % by Asian elephants (*Elephas maximus*).

The waterholes of Wayanad Wildlife Sanctuary had a mean frequency of animal visit of 1942. Of these, nearly 93 % was contributed by herbivores. Seventy-

six percentage of the herbivores were Spotted deer, followed by sambar deer and Asian elephant.

It is interesting that among *vayals* and waterholes, *vayals* bear a greater number of herbivore population, while the frequency of primates, carnivores and small carnivores were more in waterholes.

Plate 6. Spotted deer grazing in Arakunji vayal, Sulthan Bathery range in dry season

Plate 7. Asian elephant drinking water from 36th pond, Tholpetty range

Plate 8. Spotted deer grazing around the waterhole at Kaundan waterhole, Muthanga range

Plate 9. Spotted deer drinking water from waterhole at Kaundan waterhole, Muthanga range

The higher preferability of *vayals* by the herbivores over artificial waterholes may be due to the presence of grass species in the *vayals*. The grasslands are capable

of providing highest nutritional value for herbivores (Neupane *et al.,* 2019; Anderson and Briske, 1995; Steinheim *et al.,* 2005)

The waterhole and its premises can be act as a hunting ground for many carnivores (Wakefield and Attum, 2006), (Edwards *et al.*, 2017). The herbivores sometimes seek refuge in waterholes when they are chased by other carnivores Johnsingh (1983)

Plate 10. Sambar deer seeks refuge in waterholes when chased by Wild dogs at 70th Pond, Tholpetty range

Vayals are also used widely by carnivores. The number of observations of large carnivores in *vayals* were 50 in Wayanad Wildlife Sanctuary.

Plate 11. Skeleton of a deer species hunted by carnivores at Edavambam vayal in Sulthan Bathery range

The frequency of primates was also seen higher in waterholes than in *vayals*. The *vayals* have lesser number of trees which are spread apart by large distance. That maybe a reason for higher occurrence of primate species in the waterhole premises.

5.2.2 Characters of *Vayals*/ waterholes which influence the animal activity

In Sulthan Bathery range, the herbivore species are almost uniformly distributed. The frequency of visit of Asian elephant was nearly similar in all the *vayals* of the range in both seasons. The frequency of visit of other species are found higher in dry season. Gaur (*Bos gaurus*) and Sambar deer shows frequency higher than that of wet season in Arakunji and Kaatichakkalam vayal. These two *vayals* are marshy in nature in both the seasons. The Arakunji vayal have a perennial stream flowing through the middle of the vayal which keep the soil moist even in extreme dry months and will support the fresh grass and other vegetation throughout the year.

Plate 12 Arakunji vayal in dry season

Plate 7 shows the photo of Arakunji vayal which supports the herbivore population with good forage even in dry season.

Nallur and Kaundan *vayals* of Muthanga range shows a high frequency of spotted deer especially in dry season. Both these *vayals* have perennial waterbodies in it. At Nallur vayal, the spotted deer found to be licking salt from mud at a stream side in the middle of the vayal (Plate 12). That spot was a unique one in the sanctuary and hundreds of ungulates were found to be using that resource.

Plate 13. Saltlick by spotted deer in Nallur vayal, Muthanga range

The use of waterholes by animals is not as uniform as that of *vayals*. The frequency of visit of smaller herbivores such as Sambar deer, spotted deer, Muntjac etc. are very less in some waterholes. The Pulachallam and Nallathanni waterholes of Sulthan Bathery range, Kaakkappadam and Karadimunda waterholes of Muthanga range, Chaddakulasi waterhole of Kurichyat range and 36th and 38th Ponds of Tholpetty range has very low frequency of ungulates as compared to other waterholes. On the other hand, Kaundan waterhole in Muthanga, Nedumundakkolly in Kurichyat and 70th Pond in Tholpetty shows a very high activity of ungulates.

The reason for the low preference for these waterholes might be the dimension of that waterhole or the quality of water in that waterholes. All the waterholes are made in such an aim to support the larger mammals like Asian Elephant, Gaur etc. So, almost all the artificial waterholes in the sanctuary have steep side walls that makes it inaccessible to the ungulates like spotted deer and sambar deer. Many of the waterholes have one or two sloppy side through which the smaller ungulates have access to water. The depth of the waterholes is also another limiting factor as many of the waterholes are having a depth of 2-3 meters (Plate 14).

Plate 14. Elephants bathing in Pulachallam waterhole, Sulthan Bathery range

The 36th and 38th ponds of Tholpetty range shows a less animal frequency as it dried up in the dry season. The Doddady waterhole also shows less animal activity. No animals are found to be using the water in the pond directly. The poor water quality can be a reason for this less preference. Eventhough the premises of the waterhole has new vegetation which attracts herbivores. Plate 17 shows the condition of water in Doddady waterhole.

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Plate 15. 36th Pond in Tholpetty range, almost dried in the month of April

Plate 16. 38th Pond in Tholpetty range, fully dries up in April

Plate 17. Doddady waterhole, Tholpetty range

The Kaundan waterhole of Muthanga range and 70th Pond of Kurichyat range supported very high ungulate population in the dry season. Plate 8 and 18 shows

that, the sides of these two waterholes were sloppy enough so that the ungulates can access the water easily.

Plate 18. 70th Pond, Tholpetty range

5.3 TIME ACTIVITY PATTERN OF WATERHOLE USAGE BY ANIMALS IN WAYANAD WILDLIFE SANCTUARY

The peak activity of animals at water sources are observed in day hours. The Asian elephant is found to be visiting the *vayals* as well as waterholes during all the hours but the frequency of visit peaks in the day time. There is no significant change in the time visit to *vayals* and waterholes. The activity of Asian elephant is nearly zero in the morning hours and increases by 7:00 hours and peak period of activity is observed around 18:00 hours in *vayals* and 13:00 to 14:00 hours in waterholes. They were preferred to drink water from the waterholes in the evening hours. In a study conducted by Purdon and van Aarde (2017), the African elephants visits the natural waterbodies in the morning hours, preferably from 11:00 hours till 22:00 hours and artificial waterholes from 13:00 hours to 24:00 hours. According to (Joshi, 2009), the Asian elephants prefer early morning and evening to drink water from

waterbodies. In our study, the drinking hours were observed to be 17:00 hours onwards. The elephants were also having a habit of covering body with wet soil (Dunkin *et al.,* 2013). That was also observed during day time hours. The elephants have a tendency to choose permanent waterbodies within their home range (Purdon and van Aarde, 2017)

The activity pattern of Gaur shows a higher frequency of visit to *vayals* or waterholes during the day time. In *vayals* the peak activity was observed during 18:00 hours and in waterholes at 19:00 hours. The peak period of drinking water was observed to be early morning hours and evening hours.

The sambar deer and spotted deer have almost same temporal pattern of activity in *vayals*. The frequency at *vayals* for both the species are higher during the morning and evening hours. The activity in the noon hours was comparatively less for both species. The wild boar shows an irregular pattern of activity in the vayal. But the peak time of activity of wild boar was observed to be at 18:00 hours in both *vayals* and waterholes.

The carnivores together show a continuous presence in the *vayals* of Wayanad Wildlife Sanctuary. Leopard (*Panthera pardus*) and Sloth Bear (*Melursus ursinus*) prefer dark hours to visit the *vayals*. Wild dog shows higher activity in day time hours and Tiger shows a uniform frequency of visit in the *vayals*. The Leopard has observed during noon time in the waterholes. But Tiger has a low activity during day time in waterholes. The peak period of visit of tiger in waterholes is found to be 19:00 onwards.

5.4 INTERACTION AMONG ANIMALS IN WAYANAD WILDLIFE SANCTUARY

The result of G test shows the interaction percentage of different animals in the sanctuary. It describes, how much the presence of an animal species will influence and/ or being influenced by the activity of other animal species using the

same resource in same time. In that analysis, we can could observe that, the presence of Leopard was affecting the activity of other animals to a great extent.

Table 8 shows that, the percentage of interaction between herbivores are comparatively low, which denote that, they were coexisting in a location by sharing the resources in much efficient way. Only 10 percent interaction was found between Asian Elephant and Spotted deer, which indicate that, the activity of Asian elephant is less affects the distribution of Spotted Deer. Similarly, the interaction between Spotted deer and sambar deer also follows the same trend. The g test value for their interaction is 24, which indicates that, the activity of Spotted deer affects the activity of Sambar deer by 24 percent or vice versa. The interaction between Leopard and other animals shows very high values close to 100. The value of interaction between Leopard and Spotted deer is 89 and that of with Tiger and Sloth bear is 97 and 99 respectively. We could can see a close positive interaction between Spotted deer and primates such as Bonnet Macaque and Tufted Gray Langur. The value of interaction between them was 35 and 44 respectively. As the g test value increases between two species, it indicates that the activity of one species will be highly influencing that of the other. And, as the value decreases, those species will be dependent each other.

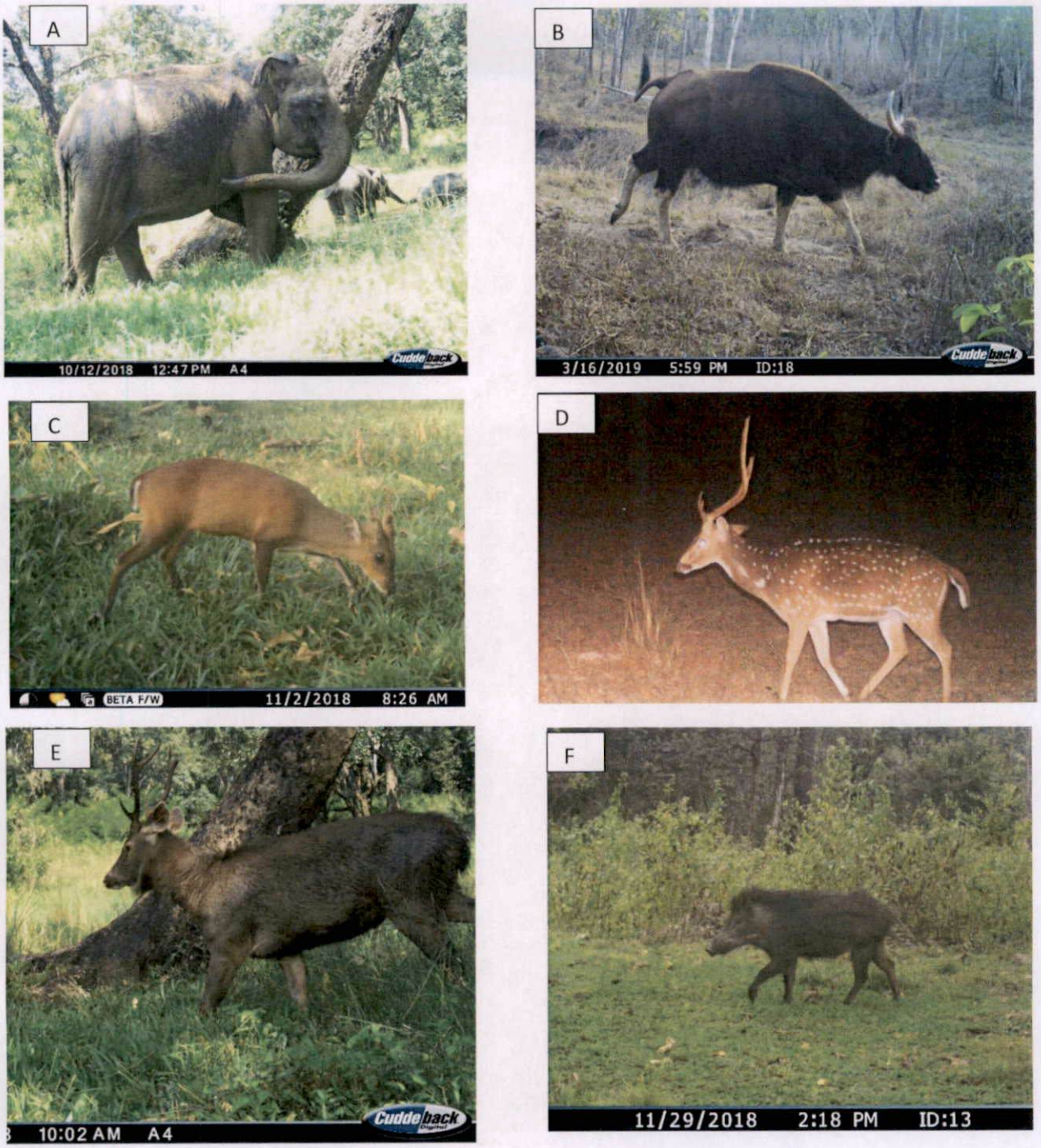

Plate 19. Camera trap images of mammals in Wayanad Wildlife Sanctuary. A-Asian Elelpahnt, B-Gaur, C-Barking Deer, D-Spotted Deer, E- Sambar Deer, F-Wild Boar

Plate 20. Camera trap images of mammals in Wayanad Wildlife Sanctuary A-Tiger, B- Leopard, C- Sloth Bear, D- Stripe-necked Mongoose, E- Ruddy Mongoose, F- Small Indian Civet

Summary

SUMMARY

Water is the most important requirement of life. The distribution of an animal in a particular season may have a direct relationship with the availability of water in that season. So that an animal's water requirements have implications for all aspects of ecology and conservation.

In Wayanad Wildlife Sanctuary, the forest department made provisions for availing water for wildlife in the dry periods. There are natural water sources such as Swamps (*vayals*) and artificial waterholes. The present study examined the preference and usage of waterholes and *vayals* in Wayanad Wildlife Sanctuary. Camera trapping was adopted to monitor the use of waterholes on the visitation of the wild animals. There are 117 *vayals* and 168 waterholes in the sanctuary. From this, 15 *vayals* and 15 artificial waterholes were selected. A set of four camera traps were installed in all the selected locations for 10-15 days. The findings of the study are summarized below.

1. The study revealed there is 21 species of animals in Wayanad Wildlife Sanctuary visiting various water sources. It includes eight species of herbivores, four carnivores, five small carnivores, three primates and one rodent.
2. The utilization of *vayals* were comparatively higher than that of waterholes.
3. There is little variation in the usage of water resources between dry and wet seasons. The *Vayals* are more used in wet season. The dry season activity varies like in Sulthan Bathery and Kurichyat range, *vayals* are more used in dry season, but in Muthanga and Tholpetty ranges, waterholes are used most.
4. There is huge difference in the animal visiting frequency in *vayals* between two seasons.
5. The frequency of visit by herbivores was higher in *vayals* than waterholes. Carnivores and other animals preferred waterholes than *vayals*.
6. Among herbivores, Spotted deer (*Axis* axis) is more frequently visiting the water sources, followed by Sambar deer (*Rusa unicolor*) and Asian Elephant (*Elephas maximus*)

7. Some *vayals* and waterholes have minimal activity in wet season but shows very high activity in dry seasons.
8. The shape and dimension of the waterhole and the water quality have great importance.
9. The time activity pattern of animals was also studied as part of this study. Most of the *vayals* and waterholes were used more in the day light hours.
10. Activity of one animal may influencing the occurrence of other animal species. Leopard is found to be having promising effect on the activity of other animal species.

References

REFERENCE

Anderson, V.J., Briske, D.D., 1995. Herbivore-induced species replacement in grasslands: is it driven by herbivory tolerance or avoidance? *Ecol. Appl.* 5(4): 1014-1024.

Anderson, V.J., Briske, D.D., 1995. Herbivore-induced species replacement in grasslands: is it driven by herbivory tolerance or avoidance? Ecol. Appl. 5 (4): 1014-1024.

Anonymous. 2014. Management plan, Wayanad Wildlife Sanctuary, Kerala Forest Dept. Available: http://www.forest.kerala.gov.in/index.php/forest/forest-mnagement/management-plans [19 Jan. 2018].

Dunkin, R.C., Wilson, D., Way, N., Johnson, K. and Williams, T.M., 2013. Climate influences thermal balance and water use in African and Asian elephants: physiology can predict drivers of elephant distribution. *J. of Exp Biol.* 216(15): 2939-2952.

Dunkin, R.C., Wilson, D., Way, N., Johnson, K. and Williams, T.M., 2013. Climate influences thermal balance and water use in African and Asian elephants: physiology can predict drivers of elephant distribution. *J. of Exp. Biol.* 216(15): 2939-2952.

Easa, P. S. 1999. Status, habitat utilization and movement pattern of larger mammals in Wayanad Wildlife Sanctuary. Kerala Forest Research Institute, Peechi.

Edwards, S., Al Awaji, M., Eid, E. and Attum, O., 2017. Mammalian activity at artificial water sources in Dana Biosphere Reserve, southern Jordan. *J. of arid environ.* 141: 52-55.

Epaphras, A. M., Gereta, E., Lejora, I. A., Meing'ataki, G. E. O., Ng'umbi, G., Kiwango, Y., Mwangomo, E., Semanini, F., Vitalis, L., wwater utilisation and importance of artificial waterholes during dry season at Ruaha National Park, Tanzania. *Wetl. Ecol Manage.* 16: 183–188.

Franz, M., Kramer-Schadt, S., Kilian, W., Wissel, C. and Groeneveld, J., 2010. Understanding the effects of rainfall on elephant–vegetation interactions around waterholes. *Ecol. Modelling*. 221(24): 2909-2917.

Fuchs, E.R. 1997. Behaviour. In: Ables, E. D. (Editor) The Axis Deer in Texas. Caesar Kleberg, Research Program and Texas A and M University, Texas. pp. 24-52.

Hamilton, D. I., 1972. On the ecology and behavior of the African elephant. PhD thesis, University of Oxford).

Hayward, M.W. and Hayward, M.D., 2012. Waterhole use by African fauna. *Afr. J. of Wildl. Res*. 42(2): 117-128.

Johnsingh, A. J. T., Williams, C. A., and Desai, A. A. 2015. In: Johnsingh, A. J. T., and Manjrekar (eds), *Mammals of south Asia Vol. 2*. University Press (India) Private Limited, Hyderabad. pp 71-94

Johnsingh, A.J.T., 1983. Large mammalian prey-predators in Bandipur. *J. of the Bombay Nat. Hist. Soc.* 80: 1-57.

Joshi, R., 2009. Asian elephant's (Elephas maximus) behaviour in the Rajaji National Park, North-West India: eight years with Asian elephants. *Nat. Sci.* 7(1): 49-77.

Joshy, R., and Singh, R. 2007. Asian Elephants are Losing Their Seasonal Traditional Movement Tracks: A Decade of Study in and Around the Rajaji National Park, India. *Gajah*. 27: 15-26

Joshy, R., and Singh, R. 2009. Movement and Ranging Behaviour of Asian elephants Elephas maximus in and around the Rajaji National Park, North-West India. *Nat. and Sci*. 7(2): 76-94.

Lakshminarayanan, N., Karanth, K.K., Goswami, V.R., Vaidyanathan, S. and Karanth, K.U., 2016. Determinants of dry season habitat use by Asian elephants in the Western Ghats of India. *J. of Zool*. 298(3): 169-177.

Loarie, S.R., Van Aarde, R.J. and Pimm, S.L., 2009. Fences and artificial water affect African savannah elephant movement patterns. *Biol. conserv.* 142(12): 3086-3098.

McNab, B.K., 1963. Bioenergetics and the determination of home range size. *The Am. Nat.* 97(894): 133-140.

Myres, N.,Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A., and Kent, J. 2000. Biodiversity hotspots for conservation priorities. *Nautre.* 403(6772): 853-858

Narasimen, R. K., Kumar, M. A, Jayam, P. P. C., Chinnaiyan, S., Nagarathinam, M., and Desai, A. A. 2013. Status of Tigers, Co-Predators and Prey in the Wayanad Wildlife Sanctuary, Kerala, India. WWF- India.

Neupane, D., Kwon, Y., Risch, T.S., Williams, A.C. and Johnson, R.L., 2019. Habitat use by Asian elephants: Context matters. *Glob. Ecol. and Conserv.* 17: 24-35.

Purdon, A. and Van Aarde, R.J., 2017. Water provisioning in Kruger National Park alters elephant spatial utilisation patterns. *J. of Arid Environ.* 141: 45-51.

Purdon, A. and Van Aarde, R.J., 2017. Water provisioning in Kruger National Park alters elephant spatial utilisation patterns. *J.of Arid Environ.* 141: 45-51.

Redfern, J.V., Grant, C.C., Gaylard, A. and Getz, W.M., 2005. Surface water availability and the management of herbivore distributions in an African savanna ecosystem. *J. of Arid Environ.* 63(2): 406-424.

Redfern, J.V., Grant, R., Biggs, H. and Getz, W.M., 2003. Surface- water constraints on herbivore foraging in the Kruger National Park, South Africa. *Ecol.* 84(8): 2092-2107.

Schaller, G.B. 1967. *The Deer and the Tiger*. University of Chicago Press, Chicago

Schoener, T.W., 1974. Resource partitioning in ecological communities. *Sci.* 185(4145): 27-39.

Shannon, G., Matthews, W.S., Page, B.R., Parker, G.E. and Smith, R.J., 2009. The effects of artificial water availability on large herbivore ranging patterns in savanna habitats: a new approach based on modelling elephant path distributions. *Diversity and Distributions*. 15(5): 776-783.

Sivaram, M., Ramachandran, K. K., Jayson, E. A., and Nair, P. V. 2010. Wild Elephant census report of Kerala State. Kerala Forest and Wildlife Department. Available: http://forest.kerala.gov.in/images/abc/ele_cen_10.pdf [19 Jan 2018].

Smit, I.P., Grant, C.C. and Devereux, B.J., 2007. Do artificial waterholes influence the way herbivores use the landscape? Herbivore distribution patterns around rivers and artificial surface water sources in a large African savanna park. *Biol Conserv*. 136(1): 85-99.

Smit, I.P.J. and Grant, C.C., 2009. Managing surface-water in a large semi-arid savanna park: effects on grazer distribution patterns. *J. for Nat. Conserv.* 17(2): 61-71.

Smith, O. R.N., 1988. *Megaherbivores: the influence of very large body size on ecology*. Cambridge university press.

Steinheim, G., Wegge, P., Fjellstad, J.I., Jnawali, S.R., Weladji, R.B., 2005. Dry season diets and habitat use of sympatric Asian elephants (Elephas maximus) and greater one-horned rhinoceros (Rhinocerus unicornis) in Nepal. *J. Zool.* 265 (4): 377-385.

Steinheim, G.,Wegge, P., Fjellstad, J.I., Jnawali, S.R.,Weladji, R.B., 2005. Dry season diets and habitat use of sympatric Asian elephants (Elephas maximus) and greater one-horned rhinoceros (Rhinocerus unicornis) in Nepal. *J. Zool.* 265 (4): 377-385.

Sukumar, R., 1989. Ecology of the Asian elephant in southern India. I. Movement and habitat utilization patterns.*J. of trop. Ecol.*5(1): 1-18.

Sukumar, R., 1990. Ecology of the Asian elephant in southern India. II. Feeding habits and crop raiding patterns. *J. of Trop Ecol.* 6(1): 33-53.

Valeix, M., Chamaillé-Jammes, S. and Fritz, H., 2007. Interference competition and temporal niche shifts: elephants and herbivore communities at waterholes. *Oecologia*. 153(3): 739-748.

Valeix, M., Fritz, H., Chamaillé- Jammes, S., Bourgarel, M. and Murindagomo, F., 2008. Fluctuations in abundance of large herbivore populations: insights into the influence of dry season rainfall and elephant numbers from long- term data. *Anim conserv*. 11(5): 391-400.

Varma, S., Venkataraman, A., Sukumar, R., and Easa, P. S. 2005. Elephant corridors of Southern India. In: Menon, V., Tiwari, S. K., Easa, P. S., and Sukumar, R. (ed.), Right of Passage: Elephant corridors of India (3rd Ed.). Wildlife Trust of India, New Delhi, pp. 208-255.

Vishnudas, K. C., Vinayan, P. A., and Anusreedha, S. 2009. Butterfly Fauna of Wayanad Wildlife Sanctuary and North Wayanad Forest Division Survey Report. Kerala Forest and Wildlife Department. Available: http://www.indiaenvironmentportal.org.in/files/file/wayanad_report.pdf [19 Jan 2018].

Wakefield, S. and Attum, O., 2006. The effects of human visits on the use of a waterhole by endangered ungulates. *J. of Arid Environ.* 65(4): 668-672.

Western, D. 1975. Water availability and its influence on the structure and dynamics of a savannah large mammal community. *E. Afr. Wildl. J.* 3: 256-286.

Western, D. and Lindsay, W.K., 1984. Seasonal herd dynamics of a savanna elephant population. *Afr. J. of Ecol.* 22(4): 229-244.

Wittermyer, G. 2011. In: Wilson, D. E., and Mittermeier, R. A. (eds), *Mammals of the World Vol. 2.* Lynx Edicions, Barcelona. pp 50-79

Wyatt, J.R. and Eltringham, S.K., 1974. The daily activity of the elephant in the Rwenzori National Park, Uganda. *Afr. J. of Ecol.* 12(4): 273-289.

Appendices

APPENDIX I

LIST OF VAYALS IN WAYANAD WILDLIFE SANCTUARY

Range	Section	Name	Extent (ha)	GPS Reading	
Muthanga	Thottamoola FS	Erayam Vayal	5	11°38'27.5"	76°21'54.1"
Muthanga	Thottamoola	Amboothy Vayal	6	11°39'06.8"	76°22'84.7"
Muthanga	Thottamoola	Vattampara Vayal	5	11°39'11.6"	76°22'40.2"
Muthanga	Thottamoola	Vengoor Vayal	5	11°38'42.0"	76°22'85.3"
Muthanga	Thottamoola	Kadukkakkuni Vayal	10	11°38'85.2"	76°22'21.9"
Muthanga	Thottamoola	Pampanpara Vayal	2.5	11°37'54.2"	76°23'11.5"
Muthanga	Karadimunda	Kakkappadam	10	11°40'01.6"	76°23'11.5"
Muthanga	Karadimunda	Sallithodu Vayal	12	11°41'21.1"	76°24'24.6"
Muthanga	Karadimunda	Koundan Vayal	10	11°40'89.2"	76°23'40.0"
Muthanga	Karadimunda	Nalloor Vayal	8	11°39'93.8"	76°25'02.0"
Muthanga	Karadimunda	Maruthuvady Vayal	3	11°40'516'	76°22'634"
Muthanga	Maragadha	Nagappan Vayal	10	11°38'40.1"	76°25'50.9"
Muthanga	Maragadha	Nalloor Vayal	20	11°39'46.9"	76°24'37.6"
Muthanga	Maragadha	Muthappan Kolly Vayal	10	11°37'48.9"	76°25'52.2"
Muthanga	Maragadha	Mangottu Vayal	5	11°39'07.9"	76°25'00.8"
Muthanga	Maragadha	Bajagadha Vayal	10	11°38'11.8"	76°24'33.9"
Muthanga	Maragadha	Kuliyanmoola Vayal	5	11°39'05.4"	76°23'47.8"
Muthanga	Maragadha	Ayamangalam Vayal	10	11°39'16.6"	76°23'25.2"
Muthanga	Noolpuzha	Madamchira	1	11°35'37.5"	76°20'54.4"
Muthanga	Noolpuzha	Varikkolly	2	11°36'50.4"	76°21'16.6"
Muthanga	Noolpuzha	Mulamkolly	3	11°36'00.1"	76°21'22.5"

Muthanga	Noolpuzha	Kuppikkundu	1	11°37'40.3"	76°19'29.2"
Muthanga	Noolpuzha	Ambalakkolly	4.29	11°37'40.4"	76°19'21.1"
Muthanga	Thottamoola	Moroor	10	11°37'40.4"	76°22'95.5"
Muthanga	Thottamoola	Chekidi Moola	4	11°39'38.3"	76°22'04.9"
Muthanga	Thottamoola	Cheriya Vengoor	3	11°38'70.8"	76°22'52.4"
Muthanga	Karadimunda	Tri Junction	6	11°41'89.2"	76°23'40.0"
Muthanga	Muthanga Forest Station	Nalloor	0.05	11°39'26.0"	76°25'25.0"
Muthanga	Muthanga Forest Station	Muthumala	0.024	11°38'5.0"	76°24'47.0"
Muthanga	Muthanga Forest Station	Karadivayal	0.037	11°39'5.0"	76°25'33.0"
Muthanga	Muthanga Forest Station	Arivayal – I	0.062	11°39'7.0"	76°25'2.0"
Muthanga	Muthanga Forest Station	Arivayal – II	0.032	11°39'22.0"	76°25'11.0"
Muthanga	Muthanga Forest Station	Kattivayal	0.04	11°38'58.0"	76°24'51.0"
Muthanga	Muthanga Forest Station	Neerkkulam	0.04	11°40'11.0"	76°22'54.0"
Muthanga	Muthanga Forest Station	Sankarankulam	0.04	11°40'10.0"	76°23'29.0"
Muthanga	Muthanga Forest Station	Njavalkulam	0.041	11°41'20.0"	76°24'27.0"
Muthanga	Muthanga Forest Station	Anakkulam	0.04	11°40'30.0"	76°24'50.0"
Muthanga	Muthanga Forest Station	Eucaly kulam	0.04	11°41'38.0"	76°24'10.0"

Muthanga	Muthanga Forest Station	Poochakkulam	0.04	11°41'38.0"	76°24'10.0"
Muthanga	Muthanga Forest Station	Manpullikkulam	0.04	11°42'19.0"	76°24'28.0"
Muthanga	Muthanga Forest Station	Sukumarankolly	0.04	11°63'14.0"	76°34'25.0"
Muthanga	Muthanga Forest Station	Achuthan moola	0.04	11°63'22.0"	76°23'40.0"
Sulthan Bathery	Ottipara	Chundakkolli	10	11°42'10.1"	76°21'24.9"
Sulthan Bathery	Ottipara	Machikudi	6	11°42'47.2"	76°20'58.8"
Sulthan Bathery	Ottipara	Manchal	10	11°42'05.1"	76°22'10.4"
Sulthan Bathery	Ottipara	Kaithalam	10	11°44'14.0"	76°24'15.8"
Sulthan Bathery	Ottipara	Kumizallam	5	11°44'57.2"	76°23'33"
Sulthan Bathery	Odappallam	Edvambam	15	11°42'19.7"	76°20'15.4"
Sulthan Bathery	Odappallam	Machikkudi	10	11°42'53.0"	76°20'54.8"
Sulthan Bathery	Odappallam	Kattichakkalam	5	11°44'08.3"	76°20'31.3"
Sulthan Bathery	Odappallam	Udimaram	5	11°43'50.8"	76°21'48.3"
Sulthan Bathery	Odappallam	Thavalaputhoor	5	11°42'50.7"	76°20'27.9"
Sulthan Bathery	Odappallam	Panthamkolli	6	11°42'54.4"	76°20'02.4"
Sulthan Bathery	Kalloor	Ponnachankolli	5	11°41'00.9"	76°18'23.4"
Sulthan Bathery	Kalloor	Chadayankolli	2	11°41'37.1"	76°18'10.0"
Sulthan Bathery	Kalloor	Maruthikuny	4	11°41'07.5"	76°18'55.6"
Sulthan Bathery	Ponkuzhy	Nenmanttuvayal	10	11°41'59.2"	76°22'83.3"
Sulthan Bathery	Ponkuzhy	Njarathalam	10	11°41'58.3"	76°22'80.2"
Sulthan Bathery	Ponkuzhy	Pallivayal	10	11°41'78.9"	76°22'26.0"
Sulthan Bathery	Ponkuzhy	Ponkuzhy vayal	7	11°42'20.6"	76°23'68.9"
Sulthan Bathery	Ponkuzhy	Vattavayal/Koovakolly	5	11°41'66.9"	76°23'11.7"

Sulthan Bathery	Ponkuzhy	Kolambikalluvayal	7	11°43'04.5"	76°22'57.5"
Sulthan Bathery	Ottippara Section	Arakunjivayal	15	11°41'27.0"	76°20'30.1"
Sulthan Bathery	Ottippara Section	Nellichode Vayal	5	11°41'56.6"	76°21'11.3"
Sulthan Bathery	Ottippara Section	Chelakolly	5	11°70'80.5"	76°34'72.5"
Sulthan Bathery	Ottippara Section	Mottavayal	5	11°42'0.8"	76°21'11.0"
Sulthan Bathery	Ponkuzhy Section	Kottamudivayal	8	11°72'34.8"	76°39'61.3"
Sulthan Bathery	Ponkuzhy Section	Kaimaramvayal	5	11°68'83.2"	76°39'062"
Sulthan Bathery	Ponkuzhy Section	Uppuchiravayal	11	11°68'62.4"	76°38'33.6"
Sulthan Bathery	Ponkuzhy Section	Thalukollyvayal	13	11°71'19.7"	76°38'78.3"
Sulthan Bathery	Ponkuzhy Section	Konamvayal	8	11°67'80.8"	76°35'39.4"
Sulthan Bathery	Naiketty Forest Station	Muthukkikuni	6.68	11°42'30.2"	76°20'17.5"
Sulthan Bathery	Naiketty Forest Station	Chakkaputhoor	5	11°72'79.1	76°33'62.4"
Sulthan Bathery	Naiketty Forest Station	Mavumthal	3	11°73'1.96"	76°35'70.3"
Sulthan Bathery	Naiketty Forest Station	Aluthakolly	3	11°71'8.37"	76°32'29.1"
Sulthan Bathery	Naiketty Forest Station	Kathiyapalam	3	11°71'50.8"	76°32'27.5"
Sulthan Bathery	Naiketty Forest Station	Erumachathakolly	2	11°73'24.4"	76°33'24.4"
Sulthan Bathery	Naiketty Forest Station	Chelakolly	3	11°42'27.7"	76°20'51.5"
Sulthan Bathery	Naiketty Forest Station	Pulachiyallam	2	11°74'1.55"	76°35'63.6"
Sulthan Bathery	Naiketty Forest Station	Kambrampalli	4	11°72'0.58"	76°32'72.9"
Sulthan Bathery	Naiketty Forest Station	Poovathumchal	5	11°73'0.94"	76°34'58.4"
Sulthan Bathery	Naiketty Forest Station	Aduppukuni	3	11°70'7.26"	76°33'94.2"
Sulthan Bathery	Naiketty Forest Station	Kalavayal	3	11°73'3.20"	76°35'65.1"
Sulthan Bathery	Naiketty Forest Station	Chiranada	1	11°74'1.64"	76°37'011"
Sulthan Bathery	Naiketty Forest Station	Chullikandy	5	11°70'8.70"	76°31'011"
Sulthan Bathery	Naiketty Forest Station	Kottankara	20	11°68'2.82"	76°32'032"
Sulthan Bathery	Naiketty Forest Station	Kalkorry	5	11°67'5.5"	76°30'930"

Kurichiat	Pazhapathoor	Valan vayal	8	11°42'16.4"	76°14'16.7"
Kurichiat	Pazhapathoor	Maruthikkuni vayal	10	11°41'58.9"	76°14'07.6"
Kurichiat	Pazhapathoor	Manneduppankuni	5	11°42'39.7"	76°14'06.3"
Kurichiat	Pazhapathoor	Mannupedavu	3	11°43'29.7"	76°14'37.0"
Kurichiat	Pazhapathoor	Kommanchery	8	11°42'40.2"	76°14'33.9"
Kurichiat	Pazhapathoor	Mundakkolli	12	11°41'43.4"	76°15'00.4"
Kurichiat	Pazhapathoor	Aana camp	3	11°41'48.3"	76°14'50.9"
Kurichiat	Vadakkanad	Anjam mile	10	11°42'46.0"	76°15'19.4"
Kurichiat	Vadakkanad	Nedumunda	3	11°42'47.6"	76°16'11.8"
Kurichiat	Vadakkanad	Paayivayal	3	11°44'46.0"	76°15'12.6"
Kurichiat	Vadakkanad	Kelachippara	3	11°44'15.5"	76°16'43.6"
Kurichiat	Vadakkanad	Manivayal	10	11°45'13.7"	76°14'44.7"
Kurichiat	Vadakkanad	Chembakaithavayal	8	11°45'24.1"	76°14'57.4"
Kurichiat	Waterfalls	Kattivayal	5	11°46'19.4"	76°15'29.0"
Kurichiat	Waterfalls	Kumichivayal	5	11°48'32.9"	76°16'30.7"
Kurichiat	Waterfalls	Doddakkulasi	10	11°48'14.0"	76°16'01.9"
Kurichiat	Waterfalls	Kurichiat	20	11°47'01.0"	76°16'00.6"
Kurichiat	Waterfalls	Doddappalam	5	11°45'53.5"	76°14'27.9"
Kurichiat	Vandikkadavu	Chikkkanchi	6	11°46'23.6"	76°13'54.2"
Kurichiat	Vandikkadavu	Usirikkandi	5	11°46'53.4"	76°13'34.1"
Kurichiat	Vandikkadavu	Edavannakulasi	4	11°47'01.6"	76°14'20.4"
Kurichiat	Vandikkadavu	Manalpoolavayal	5	11°47'38.9"	76°14'45.3"
Kurichiat	Vandikkadavu	Pavagadha	8	11°47'41.4"	76°14'04.6"
Kurichiat	Thathoor	Kattikolli	10	11°44'50.1"	76°17'02.4"
Kurichiat	Thathoor	Pulayanchira	5	11°43'56.1"	76°17'59.6"
Kurichiat	Thathoor	Chembakolli	10	11°43'36.7"	76°18'17.7"

Kurichiat	Thathoor	Parakollivayal	4	11°44'08.4"	76°17'40.2"
Kurichiat	Thathoor	Kalkettumoola	4	11°43'54.2"	76°17'57.2"
Kurichiat	Thathoor	Kattiyambaravayal	5	11°43'50.2"	76°17'58.6"
Kurichiat	Vandikkadavu Forest Station	Vastikolly	10	11°48'13.0"	76°15'17.0"
Kurichiat	Vandikkadavu Forest Station	Pachadi	2	11°42'58.0"	76°17'14.0"
Kurichiat	Vandikkadavu Forest Station	Manaladi	2.5	11°43'36.0"	76°17'14.0"
Tholpetty	Kaimaram	Karivayal	5	11°55'41"	76°06'13.8"
Tholpetty	Kaimaram	Hundikkara	15	11°56'19.7"	76°06'02"
Tholpetty	Kaimaram	Dasankatta vayal	10	11°55'47.0"	76°05'59.8"
Tholpetty	Dasankatta	Ayyappanpara I	8	11°54'49.0"	76°05'07"
Tholpetty	Dasankatta	Ayyappanpara II	4	11°54'59"	76°05'06"
Tholpetty	Dasankatta	Ayyappanpara III	4	11°54'48"	76°05'54"
Tholpetty	Dasankatta	Kuruva vayal	2	11°54'11"	76°04'56"
Tholpetty	Dasankatta	Narippara vayal	2	11°54'00"	76°04'58"
Tholpetty	Dasankatta	Doddadi I vayal	8	11°55'31"	76°06'27"
Tholpetty	Dasankatta	Doddadi II vayal	2	11°55'22"	76°05'58"
Tholpetty	Dasankatta	Hosanahalli	2	11°53'37.5"	76°04'20.1"
Tholpetty	Dasankatta	Hosalli	4	11°54'12"	76°04'13.1"
Tholpetty	Dasankatta	Bujja Vayal	3	11°54'30"	76°06'26.0"
Tholpetty	Dasankatta	Kathiyapalam Vayal	3	11°53'35"	76°06'03.0"
Tholpetty	Dasankatta	Aralagadha Vayal	3	11°53'29"	76°05'35.0"
Tholpetty	Bavali	Chambalam I vayal	4	11°51'51"	76°06'11.5"
Tholpetty	Bavali	Chambalam II vayal	4	11°52'3.2"	76°06'15.3"

Tholpetty	Bavali	Cheriya Masala vayal	4	11°53' 9.9"	76°06'39.1"
Tholpetty	Bavali	Chembakapara Vayal	3	11°51'09"	76°06'49.5"
Tholpetty	Bavali	Punchavayal	15	11°52'33.3"	76°05'47.3"
Tholpetty	Kaimaram	Mambadavu Vayal	10	11°57'30.1"	76°06'22.3"
Tholpetty	Kaimaram	Vayambu Vayal	3	11°57'17.7"	76°04'6.5"
Tholpetty	Kaimaram	Kaimaram	4	11°56'44.6"	76°06'47.0"
Tholpetty	Kaimaram	Udumpupara Vayal	10	11°58'6.6"	76°06'33.9"
Tholpetty	Kaimaram	Kakkeri vayal	8	11°57'18"	76°04'55.4"
Tholpetty	Kaimaram	Varattachira Vayal	2	11°56'50.3"	76°06'32.8"
Tholpetty	Kaimaram	1950 Pond Vayal	1	11°57'14.2"	76°05'40.1"
Tholpetty	Kaimaram	Karal Vayal	2	11°56'33"	76°06'21.0"
Tholpetty	Kaimaram	1970 Pond Vayal	1	11°57'14.3"	76°05'39.8"
Tholpetty	Thirulkunnu	Thirulkunnu	2	11°54'0.9"	76°03'42.9"
Tholpetty	Thirulkunnu	Valiya Naikkatti	2	11°55'6.9"	76°03'54.8"
Tholpetty	Thirulkunnu	Chekadi	6	11°54'41"	76°03'10.9"
Tholpetty	Thirulkunnu	Karadivayal	6	11°54'1.1"	76°03'42.9"
Tholpetty	Dasangahtta Section	Bej Camp I	3	11°54'56.5"	76°05'32.8"
Tholpetty	Dasangahtta Section	Bej Camp II	4	11°54'15.9"	76°06'04.9"
Tholpetty	Dasangahtta Section	1938 pond Area	2	11°54'49.2"	76°05'48.5"
Tholpetty	Dasangahtta Section	Naikatty I	5	11°54'50.8"	76°04'12.8"
Tholpetty	Dasangahtta Section	Naikatty II	5	11°54'42.1"	76°04'04.0"
Tholpetty	Dasangahtta Section	Aralaghadha II	3	11°53'32.8"	76°05'30.4"
Tholpetty	Tholpetty Forest Station	Poolakolly Vayal	4	11°56'85.9"	76°06'24.2"
Tholpetty	Tholpetty Forest Station	Sevalakolly Vayal	3	11°56'86.5"	76°05'41.4"

Tholpetty	Tholpetty Forest Station	Pampukolly Vayal	4	11°53'02.6"	76°03'54.0"
Tholpetty	Tholpetty Forest Station	Bhoothakallu Vayal	3	11°55'19.2"	76°05'10.7"
Tholpetty	Tholpetty Forest Station	Anacamp	4	11°56'70.0"	76°04'92.4"
Tholpetty	Tholpetty Forest Station	Cheriya Naikatty	5	11°56'04.3"	76°03'51.4"
Tholpetty	Baveli Section	1958 TP Vayal	2	11°51'04.2"	76°05'14.0"
Tholpetty	Baveli Section	Vandipara	3	11°52'30.3"	76°06'11.4"
Tholpetty	Baveli Section	Mannudi Vayal	5	11°51'26.7"	76°05'11.3"

APPENDIX II

LIST OF ARTIFICIAL WATERHOLES IN WAYANAD WILDLIFE SANCTUARY

Range	Section	Location	GPS Reading	
Kurichiat	Vandikkadavu FS	Doddakullassi	11°48' 27.1"	76°15'68.9"
Kurichiat	Vandikkadavu FS	Mele Manalpoola vayal	11°47 79.7"	76°14'98.5"
Kurichiat	Vandikkadavu FS	Thazhe Manalpoola vayal	11°47' 42.2 "	76°15'01.5"
Kurichiat	Vandikkadavu FS	73 Kulam	11°46' 98.0"	76°15'01.5"
Kurichiat	Vandikkadavu FS	Edavandakullasi	11°47 34.2"	76°14'34.7"
Kurichiat	Vandikkadavu FS	Chadakulassi	11°47 54.2"	76°13'51.7"
Kurichiat	waterfalls OP	Doddakullassi	11°48'14.4"	76°15'56.5"
Kurichiat	waterfalls OP	Doddakullassi 2	11°47'10.0"	76°16'05.7"
Kurichiat	waterfalls OP	Kummichivayal	11°45'06.0"	76°16'23.3"
Kurichiat	waterfalls OP	Kaalimalavattom	11°46'18.7"	76°15'28.5"

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Kurichiat	waterfalls OP	Alathur	11°45'0.7"	76°14'19.2"
Kurichiat	waterfalls OP	Pullumala	11°47'10.0"	76°16'05.7"
Kurichiat	waterfalls OP	Kamalappalam	11°45'34.1"	76°16'15.6"
Kurichiat	waterfalls OP	Chelappara	11°45'14.0"	76°14'12.0"
Kurichiat	waterfalls OP	Veruthodu	11°45'09.4"	76°13'54.1"
Kurichiat	Pazhapathoor	Channakkolly	11°41'01.2"	76°14'55.6"
Kurichiat	Pazhapathoor	Pazhapathoor	11°40'45.0"	76°13'41.7"
Kurichiat	Pazhapathoor	Kommanchery	11°43'02.6"	76°14'52.0"
Kurichiat	Pazhapathoor	Manneduppamkuni	11°42'39.8"	76°14'06.0"
Kurichiat	Pazhapathoor	Mundankolly	11°41'44.3"	76°15'0.35"
Kurichiat	Vadakkanad	Kadanath	11°42'54.5"	76°16'07.6"
Kurichiat	Vadakkanad	5th Mile	11°42'57.0"	76°15'18.4"
Kurichiat	Vadakkanad	Nedumunda	11°42'49.4"	76°16'11°.3"
Kurichiat	Vadakkanad	Payi Vayal	11°44'83.4"	76°1568.9"
Kurichiat	Vadakkanad	Neelanchira	11°42'30.0"	76°17'23.4"
Kurichiat	Thathoor	Kattikolly I	11°44'51.6"	76°17'04.6"
Kurichiat	Thathoor	Kattikolly II	11°44'52.0"	76°17'05.2"
Kurichiat	Thathoor	Kattikolly III	11°44'51.9"	76°17'03.5"
Kurichiat	Thathoor	Ammavayal Kavala	11°44'45.2"	76°17'44.8"
Kurichiat	Thathoor	Thannialla	11°44'28.6"	76°18'42.0"
Kurichiat	Thathoor	Mayakolly I	11°46'50.1"	76°18'0.1"
Kurichiat	Thathoor	Mayakolly II	11°47'01.2"	76°18'05.1"
Kurichiat	Thathoor	Mavinhalla	11°43'40.0"	76°19'30.2"
Kurichiat	Thathoor	Odappallam (Chappakolly)	11°43'14.3"	76°18'40.2"
Tholpetty	Kaimaram	Rock Point Pond	11°57'21.2"	76°04'52.0"
Tholpetty	Kaimaram	1950 Pond	11°57'14.2"	76°05'40.1"

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Tholpetty	Kaimaram	1970 Pond	11°57'14.3"	76°05'39.8"
Tholpetty	Kaimaram	Hundikkara I	11°56'9.9"	76°06'2.7"
Tholpetty	Kaimaram	Hundikkara II	11°56'10.0"	76°06'6.1"
Tholpetty	Kaimaram	Hundikkara III	11°56'11.8"	76°05'54.6"
Tholpetty	Kaimaram	Hundikkara IV	11°56'14.3"	76°05'39.8"
Tholpetty	Kaimaram	Dasanghatta Pond I	11°55'40.0"	76°05'59.1"
Tholpetty	Kaimaram	Dasanghatta Pond II	11°55'38.3"	76°06'6.2"
Tholpetty	Kaimaram	Camp road Pond	11°55'29.5"	76°03'59.9"
Tholpetty	Kaimaram	Narimanthikolly Pond	11°55'29.5"	76°0519.1"
Tholpetty	Kaimaram	1st Bridge Pond	11°56'48.6"	76°04'31.1"
Tholpetty	Kaimaram	2nd Bridge Pond	11°57'11°.2"	76°04'29.9"
Tholpetty	Kaimaram	Varattachira Pond	11°56'50.3"	76°06'32.8"
Tholpetty	Kaimaram	Kattappallam	11°57'47.2"	76°05'39.3"
Tholpetty	Kaimaram	Cheriya Kakkeri Pond	11°57'16.4"	76°04'31.0"
Tholpetty	Kaimaram	Kalleri Pond	11°57'18.0"	76°04'55.4"
Tholpetty	Kaimaram	Gonippara Pond	11°56'58.3"	76°05'57.1"
Tholpetty	Kaimaram	karivayal Pond	11°55'41.7"	76°06'13.8"
Tholpetty	Bavali	Champalam Pond I	11°51'52.0"	76°06'11.0"
Tholpetty	Bavali	Champalam Pond II	11°51'52.0"	76°06'11.0"
Tholpetty	Bavali	Punchavayal Pond	11°52'33.0"	76°06'11.0"
Tholpetty	Dasanghatta	Hosalli Pond	11°54'12.0"	76°04'13.1"
Tholpetty	Dasanghatta	Hosanahalli Pond	11°53'38.0"	76°04'21.1"
Tholpetty	Dasanghatta	Naikatti	11°54'41.3"	76°04'13.5"
Tholpetty	Dasanghatta	Doddady Pond	11°55'29.3"	76°06'29.1"
Tholpetty	Dasanghatta	Doodu Pond	11°55'27.3"	76°06'31.1"
Tholpetty	Dasanghatta	Baja Camp Pond	11°54'30.0"	76°06'2.6"

Tholpetty	Dasanghatta	Kathiyapalam	11°53'36.4"	76°05'57.2"
Tholpetty	Dasanghatta	1938 Pond	11°54'43.6"	76°05'54.1"
Tholpetty	Kaimaram	Aamakulam	11°56'46.3"	76°05'18.4"
Tholpetty	Thirulkunnu	Valiya Naikatti Pond	11°55'6.9"	76°03'54.6"
Tholpetty	Kaimaram	1948 Pond	11°56'36.2"	76°04'37.7"
Tholpetty	Thirulkunnu	Camp road Pond II	11°55'15.9"	76°03'54.9"
Tholpetty	Thirulkunnu	Kottamoola Pond	11°55'5.3"	76°0.3'32.9"
Tholpetty	Thirulkunnu	Chembakapadi	11°54'30.7"	76°03'17.4"
Muthanga	Thottamoola	Pankalam	11°38'84.4"	76°21'2.0"
Muthanga	Thottamoola	Cheriya Vengoor	11°38'70.8"	76°22'5.4"
Muthanga	Thottamoola	Valiya Vengoor	11°38'42.0"	76°22'5.3"
Muthanga	Thottamoola	Kurichithodu Kulam	11°37'54.2"	76°23'11°.5"
Muthanga	Thottamoola	Moroor	11°38'98.0"	76°22'95.5"
Muthanga	Thottamoola	Chekidi Moola	11°39'38.3"	76°22'04.9"
Muthanga	Maragadha	Narimunda	11°39'51.1"	76°23'15.3"
Muthanga	Maragadha	Ayamangalam I	11°39'24.6"	76°21'29.3"
Muthanga	Maragadha	Ayamangalam II	11°39'16.9"	76°23'22.9"
Muthanga	Maragadha	Ayamangalam III	11°39'11°.9"	76°23'35.4"
Muthanga	Maragadha	Njandirukki Kulam I	11°38'26.0"	76°23'47.5"
Muthanga	Maragadha	Njandirukki Kulam II	11°38'21.6"	76°23'55.0"
Muthanga	Maragadha	Bajagadha Thazhe Kulam	11°38'36.1"	76°24'37.6"
Muthanga	Maragadha	Bajagadha Kulam	11°38'10.8"	76°24'37.2"
Muthanga	Maragadha	Mangottu Kulam	11°39'07.9"	76°25'0.8"
Muthanga	Maragadha	Muthappan Kulam	11°38'12.2"	76°25'05.6"
Muthanga	Maragadha	Muthappan Vayal Kulam I	11°38'23.0"	76°25'12.3"

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Muthanga	Maragadha	Muthappan Vayal Kulam II	11°38'17.4"	76°25'17.0"
Muthanga	Maragadha	Nagappan Kulam	11°39'0"	76°25'36.2"
Muthanga	Maragadha	Nagappan Vayal Kulam I	11°38'41.5"	76°25'46.5"
Muthanga	Maragadha	Nagappan Vayal Kulam II	11°38'35.7"	76°25'52.1"
Muthanga	Maragadha	Thekkumpadav (Nallur Vayal)	11°39'20.2"	76°25'28.6"
Muthanga	Maragadha	Maragadha Camp Kulam	11°39'11.4"	76°25'56.9"
Muthanga	Maragadha	Maragadha Kulam	11°39'29.1"	76°25'47.2"
Muthanga	Maragadha	Nallur Vayal Kulam I	11°39'32.8"	76°25'25.8"
Muthanga	Karadimunda	Nallur Vayal Kulam II	11°39'29.0"	76°25'26.9"
Muthanga	Karadimunda	Nallur Vayal Kulam III	11°39'46.9"	76°24'37.6"
Muthanga	Karadimunda	Kakkappadam I	11°39'98.9"	76°23'53.0"
Muthanga	Karadimunda	Kakkappadam II	11°40'17.6"	76°23'4.0"
Muthanga	Karadimunda	Kakkappadam III	11°40'04.8"	76°23'42.1"
Muthanga	Karadimunda	Thakarappadi	11°40'11.8"	76°23'21.7"
Muthanga	Karadimunda	Karadimunda	11°40'48.6"	76°24'2.6"
Muthanga	Karadimunda	Nallur Vayal Pond I	11°39'90.0"	76°24'54.8"
Muthanga	Karadimunda	Nallur Vayal Pond II	11°39'3.6"	76°24'44.7"
Muthanga	Karadimunda	Nallur Vayal Pond III	11°39'3.8"	76°25'02.0"
Muthanga	Karadimunda	Thri Junction Kulam	11°39'8.6"	76°25'8.7"
Muthanga	Karadimunda	Kaundan Vayal Pond I	11°40'0.3"	76°23'57.4"
Muthanga	Karadimunda	Kaundan Vayal Pond II	11°40'56.5"	76°23'2.4"
Muthanga	Karadimunda	Kaundan Vayal Pond III	11°40'47.2"	76°23'4.3"
Muthanga	Karadimunda	Ponkuzhi I	11°41'17.3"	76°24'5.0"
Muthanga	Karadimunda	Ponkuzhi II	11°40'92.9"	76°24'20.3"

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Muthanga	Karadimunda	Ponkuzhi III	11°40'92.9"	76°24'20.0"
Muthanga	Maragadha	Kuliyanmoola Vayal Pond	11°39'5.4"	76°23'47.8"
Muthanga	Noolpuzha	Kuppikkund Pond	11°37'40.3"	76°19'29.2"
Sulthan Bathery	Naikatty	Chullikkandi Pond	11°42'26"	76°18'39.8"
Sulthan Bathery	Naikatty	Kelakolly	11°42'24.4"	76°19'42.4"
Sulthan Bathery	Naikatty	Mudukkikuny	11°42'39.8"	76°20'15.8"
Sulthan Bathery	Naikatty	Edavambam Vayal Pond I	11°42'14.3"	76°20'17.2"
Sulthan Bathery	Naikatty	Edavambam Vayal Pond II	11°42'12.9"	76°20'16.5"
Sulthan Bathery	Naikatty	Machikudy I	11°42'54.7"	76°20'56.4"
Sulthan Bathery	Naikatty	Machikudy II	11°42'54.7"	76°20'56.4"
Sulthan Bathery	Naikatty	Thavalaputhoor	11°43'1.3"	76°20'29.8"
Sulthan Bathery	Naikatty	Jalamalam	11°43'19.1"	76°20'40.4"
Sulthan Bathery	Naikatty	Nallathanni I	11°44'4.8"	76°20'51.7"
Sulthan Bathery	Naikatty	Cherunada I	11°44'21.0"	76°22'1.2"
Sulthan Bathery	Naikatty	Cherunada II	11°44'27.8"	76°21'57.8"
Sulthan Bathery	Naikatty	Mavunthala	11°43'45.7"	76°21'30.0"
Sulthan Bathery	Naikatty	Kattichakkalam	11°44'8.5"	76°20'29.2"
Sulthan Bathery	Naikatty	Vilanganpara	11°43'55.2"	76°19'42.3"
Sulthan Bathery	Naikatty	Kamprampally	11°43'35.1"	76°19'54.3"
Sulthan Bathery	Naikatty	Chakkaputhoor I	11°43'35.7"	76°20'13.8"
Sulthan Bathery	Naikatty	Chakkaputhoor II	11°43'35.7"	76°20'13.8"
Sulthan Bathery	Naikatty	Kulakkachira	11°43'43.0"	76°20'12"
Sulthan Bathery	Ponkuzhi	Peralmukku	11°43'26.9"	76°23'48.8"
Sulthan Bathery	Ponkuzhi	Nharathalam I	11°43'7.9"	76°24'0.4"
Sulthan Bathery	Ponkuzhi	Nharathalam II	11°43'7.9"	76°24'0.4"
Sulthan Bathery	Ponkuzhi	Thalikkolly	11°42'43.5"	76°23'16.5"

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Sulthan Bathery	Ponkuzhi	Pallivayal I	11°41'59.6"	76°22'53.4"
Sulthan Bathery	Ponkuzhi	Pallivayal II	11°41'59.5"	76°22'53.4"
Sulthan Bathery	Ponkuzhi	Nenmanattu Vayal I	11°41'59.2	76°22'53.3"
Sulthan Bathery	Ponkuzhi	Nenmanattu Vayal I	11°41'59.2	76°22'53.3"
Sulthan Bathery	Ponkuzhi	Koovakkolly I	11°41'56.7"	76°23'11°.3"
Sulthan Bathery	Ponkuzhi	Koovakkolly II	11°41'56.7"	76°23'11°.3"
Sulthan Bathery	Ponkuzhi	Ponkuzhi Vayal I	11°42'25.3"	76°23'52.9"
Sulthan Bathery	Ponkuzhi	Ponkuzhi Vayal II	11°42'25.3"	76°23'52.9"
Sulthan Bathery	Ponkuzhi	Kolambikallu Vayal I	11°43'4.5"	76°22'57.5"
Sulthan Bathery	Ponkuzhi	Kolambikallu Vayal II	11°43'4.5"	76°22'57.5"
Sulthan Bathery	Ottippara	Nellichod	11°43'45.7"	76°22'23.3"
Sulthan Bathery	Ottippara	Chiranada	11°44'0.95"	76°22'39.7"
Sulthan Bathery	Ottippara	Arakunji	11°41'53.0"	76°27'80.2"
Sulthan Bathery	Ottippara	Ottipara	11°43'26.7"	76°22'81.0"
Sulthan Bathery	Ottippara	Manjal	11°42'0.99"	76°22'0.99"

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APPENDIX III

DETAILS ON THE WATERHOLES AT WAYANAD WILDLIFE SANCTUARY, 2018-2019

Forest Range: **Section:** **Location:** **Date:** **Observers:**

Name of waterhole	Type of waterhole	Extent of waterhole	Depth of waterhole	Latitude	Longitude	Altitude	Camera ID	Date of fixing the camera	Remarks

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UTILISATION OF THE WATERHOLES BY WILD ANIMALS IN WAYANAD WILDLIFE SANCTUARY

BY

SACHINKRISHNA, M. V.

(2017-17-004)

ABSTRACT OF THE THESIS

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ABSTRACT

Utilisation of natural and artificial waterholes in Wayanad Wildlife Sanctuary (WWS) was analysed in this research work. Vayals are the natural swampy areas while the waterholes are the artificial ponds made by the forest department. The study was done with two objectives such as mapping of the vayals and the artificial waterholes in the WWS and the usage of these structures by wild animals. We used GIS tools for mapping of the vayals as well as artificial waterholes in WWS. The animal visitation was studied using the camera traps installed in the selected vayals and artificial waterholes across the four ranges of WWS from September 2018 to May 2019. The observations were made in dry season and wet season.

The geo-coordinated maps of 171 vayals and 168 artificial waterholes in Wayanad WWS were prepared. It is interesting to note that most of the artificial waterholes were made within the vayals. A total of 21 species of wild animals were found to be using the water sources in WWS. The animal visits to vayals/natural waterholes were greater than that of the artificial waterholes. However, the animal activity in these water sources in the dry season was greater than that of wet season.

The herbivores preferred vayals more than waterholes, but the frequency of visit of other animals such as carnivores, primates, etc. were found to be more in waterholes. The most abundant animal in Wayanad wildlife Sanctuary was Spotted Deer and its frequency of visit was higher in vayals than artificial waterholes. The frequency of animal visit at waterholes made inside the vayal is found to be higher than that of waterholes dug outside the vayal. The temporal activity pattern of water source usage was also studied. Most of the vayals and waterholes were used mainly during morning and evening hours. The direct usage of artificial waterholes for drinking water was rarely observed. Most of the visits made by herbivores to the waterholes were for grazing around the waterbody. The randomness of usage of water sources were also studied using Run test. Asian Elephant, Barking Deer, Gaur, and Wild Boar show a non-random usage of natural waterholes in the wet season.

In artificial waterholes, elephant shows a non-random usage in wet season and the Spotted Deer and Sambar Deer shows non-random usage in dry season.

The design of waterhole is also found to be affecting the animal activity. The side walls of many waterholes were made steep in such a way that it cannot be accessible by small animals like Spotted Deer, Barking Deer, etc. The quality of water is another factor that influences the usage. Many waterholes were not capable of holding water in the extreme dry months. The vayals kept moist throughout the year and supported the animals with good fodder in the lean periods. Constructing waterholes inside the vayals causes degradation of the swampy habitat and lead to drying up of vayals. It also affects the hydrology of that landscape.

So, the present study highlights the importance of vayals and its management in protecting that habitat. The construction of artificial waterholes should be done with proper scientific studies.