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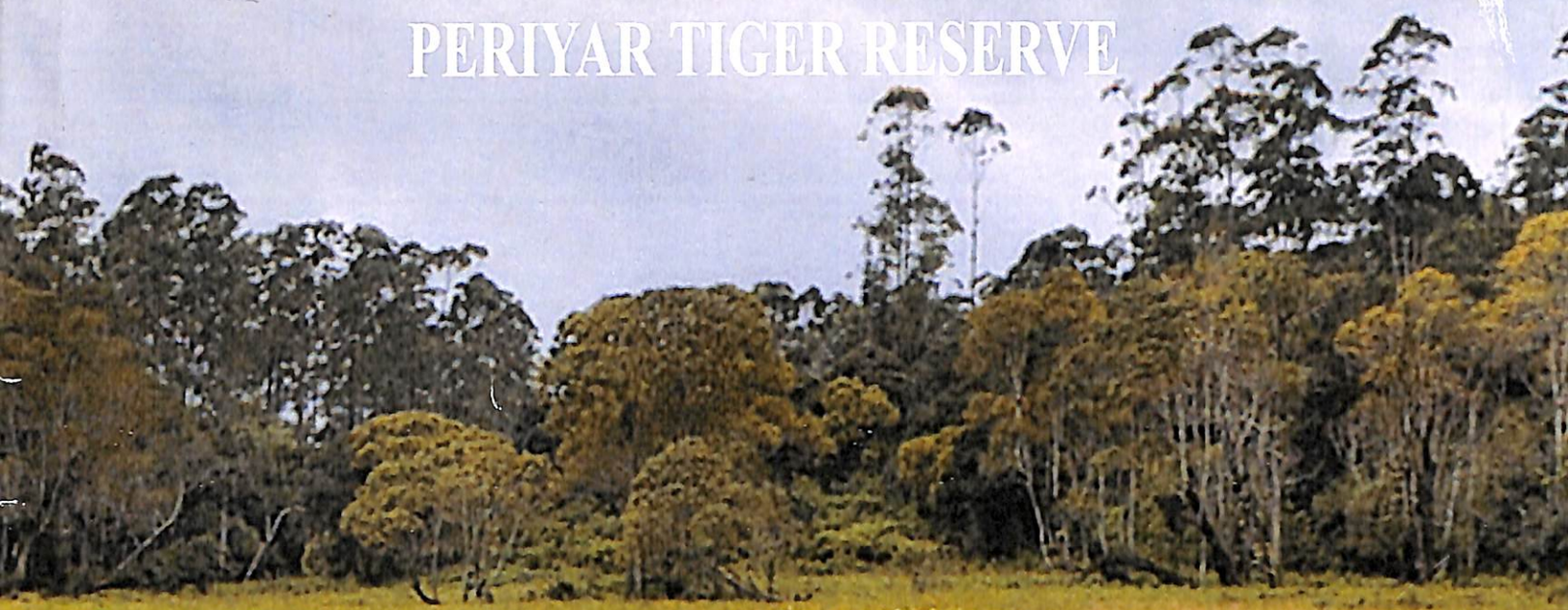
STRUCTURE, COMPOSITION, DYNAMICS AND MANAGEMENT OF 'VAYAL' ECOSYSTEM IN PERIYAR TIGER RESERVE



FINAL REPORT
Submitted to
KERALA FOREST AND WILDLIFE DEPARTMENT

Principal Investigator: Dr. K A Sreejith
Co- investigators: Dr. V B Sreekumar, Dr. K K Ramachandran

Kerala Forest Research Institute,Peechi
An Institution of Kerala State Council for Science, Technology and Environment
Thrissur, Kerala, India

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Peechi-680653, Thrissur, Kerala, India
June 2018

PROJECT SUMMARY

Project number	KFRI-RP-655/2012
Title	Structure, Composition, Dynamics and Management of Vayal Ecosystem in Periyar Tiger Reserve
Principal Investigator	Dr. K A Sreejith
Co-investigators	Dr. V B Sreekumar Dr. K K Ramachandran
Project Fellow	Sudhin PP (13-02-2013 to 15-01-2014) K P Rajkumar (05-05-2014 to 31-12-2016)
Project Assistant	T S Prasad (25-02-2013 to 10-08-2015)
Objectives	• Inventory and Mapping of Vayals in Periyar Tiger Reserve using GIS Tools • To study the vegetation characteristics, succession and ecosystem dynamics of vayal • To generate data on dependence of animal species on these ecosystem and its impact • To evolve suitable management practices to protect this ecosystem
Duration	December 2012 to December 2016
Funding Agency	Kerala Forest Department through Kerala Forest Development Fund

ACKNOWLEDGEMENT

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CONTENTS

1. SUMMARY

Marshy grasslands (vayals) of Periyar Tiger Reserve (PTR) were studied for its distribution, extent, flora and fauna: conservation and management issues. During this study, 140 vayals has been inventoried and mapped from PTR. The total extent of vayals was 281.45 ha and Anakallu vayal in Pamba Forest Range was the smallest one (0.02 ha) and Poovarashu vayal in Thekkady Forest Range was the largest vayal (28.49 ha). During floral inventory, 277 angiosperm species were recorded which belongings to 168 genera under 65 families. In majority of vayals, presence of non-marshy species was documented. Invasion of tree species and exotic species including weeds indicates the degradation of these wetland ecosystems. This invasion of non-marshy species resulted in decrease in the extent of marshy grasslands over a period of time and the process still continuing. The percentage of reduction over a ten year period varies 8-27% depending on the degradation level of vayals.

Monthly Soil moisture percentage varies from 28-118% and found to be a good indicator to understand the degradation level of the system. It is also found that the clay content of the soil is get reduced in degraded vayals which further reduce the water holding capacity of the system. Through large number soil samples studied for a period of one year, it is found that 70-74% moisture level as optimum level to be maintained which may reduce the invasion of non-swampy species and keep the system intact wetland. It is also noteworthy that among the five vayals which were studied in detail, three were below optimum level in which Pothukandam vayal require special attention which had a low moisture value of < 40% throughout the year. The study also shows that vayals having soil organic carbon contents 2 – 3 times higher than other natural forest systems in the Western Ghats, conservation and scientific management of these unique ecosystems is highly needed in climate change scenario.

From 140 vayals surveyed, 23 species of amphibians, 24 species of reptiles, 63 species of birds, and 19 species of mammals were recorded. These grass dominated marshy meadows are used by almost all mauor groups of animals like arthropods, amphibians, reptiles, birds and mammals and they are using this habitat to satisfy their different life history needs like breeding, feeding, resting, grooming etc. During this study the endemic and IUCN listed frog *Raorchestes travancoricus* was found from eight new locations and

was the first report of this rare species from a protected area. The eight locations were considered to be the last refuge for the frogs in Protected Area since the other two locations the Vagamon and Vandiperiyar were outside protected area and under severe pressure due to human intervention such as pollution, uncontrolled tourism and land conver and landuse changes.

Since vayals are wetland systems, soil moisture plays a regulating role, character and fate of the system. Decrease in soil moisture level and increase in soil erosion gradually results in degradation, drying and further invasion of non-vayal species. Hence vayal management system should focus on this root cause of decrease in soil moisture and should take necessary steps to maintain minimum level of soil moisture to keep them wet. Hence we suggest to prepare a priority list of vayals to be managed based on a primary screening based on soil moisture and clay content. This should follow intervention in hydrology to ensure proper inflow and regulate outflow in addition to restrict soil erosion, hence the wetland status and ecosystem health can be ensured.

2. INTRODUCTION

The word "Vayal" is colloquially used to address the seasonally waterlogged and grass dominated areas. These marshy grasslands are better fit in the "wetlands" category under the article 1.1 of the Ramsar convention (Ramsar Convention Manual, 2013). The Ramsar Bureau grouped wide variety of landscape units into a single definition called wetlands but their ecosystem are strongly influenced by water (Vandewalle *et al.*, 2008) and the areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters" (Ramsar Convention Manual, 2013). Pushpakaran and Gopalan (2013) suggest that these ecosystems are falls under the category "Ts" of Ramsar Convention i.e seasonal/intermittent freshwater marshes/pools on inorganic soils. Dugan (1990) simplified and classified these broad ecosystem units into seven landscape units like estuaries, open coasts, floodplains, freshwater marshes, lake and ponds, bogs and peat lands, and swamp forests. In this classification vayals are better fit into the freshwater marshes landscape unit. According to Weller (1994),the freshwater marshes are 'any area that will hold water over soil, even temporarily forms a suitable basin for the invasion of water-tolerant, rooted, soft-stemmed plats such as grasses, sedges, cattail and bulrush and it form diverse habitat for many types of animals.

Wetlands are amongst the world's most valuable and vulnerable environments on which a variety of plant and animal communities depend (Kotagama *et al.* 2006) which include invertebrates, fishes, amphibians, reptiles, birds and mammals. The availability of fresh grasses, sedges, and water makes these habitats ideal for herbivores. In Western Ghats, this unique ecosystem is not so far explored for its distribution, services, and ecological significance (Sreejith *et al.*, 2014).Considering all the above definitions for freshwater marshes, vayals are ecosystem units that may be water logged for some time or not necessarily filled with water or no standing water but the soil hold sufficient amount of water/moisture that support the growth of hydrophytes and other grasses and sedges which prefer high soil moisture.

3. STUDY AREA

The Periyar Tiger Reserve is the oldest and largest protected area in Kerala. After the construction of a dam across Periyar River in 1895 for irrigating Cumbum Valley about 26 sqkm area is sunk in water and the process created several artificial vayals in addition to the existing natural ones. For conserving the forest around the catchment area for ensuring the water supply the surrounding forest is declared as Periyar Lake Reserve. The hunting activity in this area was really high so for regulating the uncontrolled hunting activities the Travancore State came up with a regulation in hunting activities in1912. Later hunting was permitted at certain rare occasions like hunting the man eater and cattle lifter. For regulating game hunting Game Preservation Associations were formed and game wardens and other staffs were appointed and based on the first game wardens suggestion the forest around the catchment area is declared as Nellikkampatty Game Reserve in 1934. Later many management activities have been done and many animal introduction proposals had come mean while Prime Minister Jawaharlal Nehru Visited the park and later declared this place as Periyar Wildlife Sanctuary (Periyar WLS) in 1950 with an extent of 777 sqkm. The forest department promoted tourism in Periyar after 1970s and Periyar WLS become one of the best tourism destinations in short period. During this time the Project Tiger programme is developed and Periyar WLS is included in that Project in 1978 and declared as Tiger Reserve and Periyar become the 10^{th} Tiger Reserve in India. Later in 2007 148 sqkm from adjoining Goodrical range is added to PTR and the extent become 925 sqkm in which 881 sqkm is considered as critical Tiger Habitat and the remaining 44 km^2 as the buffer zone.

Periyar Tiger Reserve is situated in the Cardamom Hills and Pandalam Hills of the Southern Western Ghats between latitudes 9o 17' 56.04" and 9o 37' 10.2" N and longitudes 76o 56' 12.12" and 77o 25' 5.52" E. Being the largest protected area in Kerala, PTR provide a wide range of habitats that lies between 100 msl to 2020 msl. It is contiguous with the forest areas of Theni Forest Division, Megamalai Wildlife Sanctuary, Srivilliputhur Grizzled Squirrel Sanctuary and Tirunelveli Forest Division (in Tamil Nadu) and Kottayam, Ranni, Konni, Achenkovil, Punalur and Thenmala Forest Divisions in Kerala. Pambavalley is the lowest point (100 msl) and Kottamala is the highest peak with an altitude of 2016 msl and the average altitude of PTR is between 700–1000 msl. As per

Champion. the major habitats in PTR includes tropical evergreen forests. semi evergreen forests. moist deciduous forests and grasslands

The research activities started long back in 1800s during the British's period. They explored this landscape in search of plants (Hooker, 1872, 1897; Wight, 1838-1853; Wight, 1840; Wight and Walker-Arnott, 1834), insects (Koenig, 1779; Anderson, 1791; Hampson, 1892; Bingham, 1897; Fletcher, 1914), amphibians (Boulenger, 1882; Ferguson, 1904; Annandale, 1904; Annandale and Rao, 1916,1917; reptiles (Gunther, 1864; Beddome, 1878; Beddome, 1886; Boulenger, 1894, 1896; Ferguson, 1895; Smith, 1931, 1943), birds (Hume, 1876; Bourdillon, 1880; Ferguson, 1904; Ali and Whistler, 1937; Ali *et. al*, 1995) and mammals (Gray, 1842; Gray, 1846; Jerdon, 1867; Blanford, 1888-91; Finn, 1929). The ecological studies in Periyar were started four decade back. Horwich conducted a study on Home range and food habit of Nilgiri langur in 1972 and the study on predator and prey by Varghese in 1975 and 1981 were few among them. Srivastava (1994) and others studied the grassland ecosystems on Periyar Tiger Reserve. And many additions, discovery and rediscovery of plants were added to the flora of Periyar Tiger Reserve (Sasidharan *et al.*, 1997; Rajesh *et al.*, 1997; Sasidharan *et al.*, 1998; Sajeeev *et al.*, 1998; Sasidharan *et al.*, 2002) and first scientific documentation of fauna is done by Kurup (1969) and later KFRI did many faunal inventories (Vijayan *et al.*, 1979; Vijayan, 1980). Nair and others (1985) did long term monitoring of wildlife in 1985 and through this study the fauna like birds and mammals were well documented. Zacharias (1996a) studied the food habits of sambar deer.Zacharias (1996b) conducted a detailed study on Reptiles in Periyar Tiger Reserve and reported 45 species of reptiles falling under 11 families including 2 testudines,13 lizards and 30 snakes in that 13 are endemic to Western Ghats. The preliminary list of amphibian fauna of PTR was published by Zacharias and Bhardwaj (1996) with 16 species and study conducted by Andrews et al., 2005 in the Tiger Reserve reported 26 species of amphibians. Being the largest protected area, PTR forms about 10% of total forest area in the State, contains about 41% (1985 species) of the flowering plants of Kerala Sasidharan (1998).

MAP OF STUDY AREA

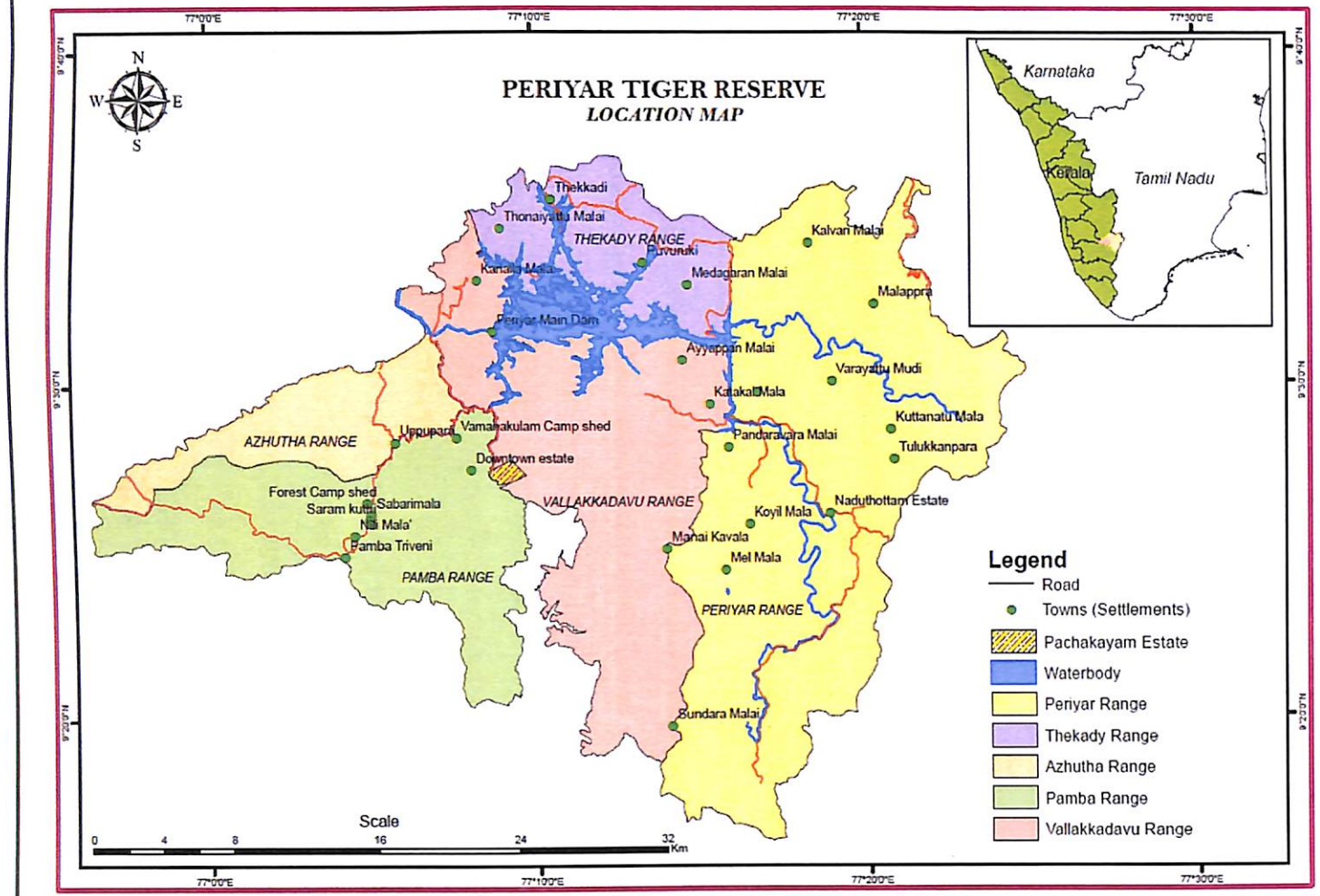

Figure 1

4. METHODOLOGY

4.1. Inventory and Mapping of Vayals

Details were collected from existing literature; sixty vayals were listed as per the Tiger Conservation Plan, field surveys were conducted to all these vayals with the help of forest watchers. During this visit baseline information on other major vayals which were not listed and near to the existing listed vayals were also collected.Boundary of the vayals were marked using Geographical positioning system. Similalry, latitude, longitude, altitude and local name of vayal were also recorded. Finally we prepared a range wise list of vayals with location details and GPS co-ordinates. ArcGIS was used for mapping and calculating the extent of each vayal.

4.2. Ecosystem dynamics

Obervation were conducted on different seasons to document floral diversity and a checklist of plants were prepared.The species were identified using regional floras and the listed species were categorized into palatable; invasive, trees, weeds based on available literature and field observation.Five vayals were randomly selected for detailed study on soil and vegetation structure, composition and dynamics. Based on the area of vayal and species composition, suitable number of sample plots (10x10m size) was laid for continuous data collection. The selected vayals are Pothukandam Vayal, Circle road vayal, Pacchakkanam Vayal, Uppupara Thavalam and Uppupara Tower vayal. In each month, list of species present, contribution different species to total density andestimation of soil moisture level were done from the permanent plot established.

Composite soil samples were collected at monthly intervals from two different depths (0-15cm, 15-30cm) from the vayals to a plastic cover and kept air tight. The collected samples were made free of plant debris and a part was used for moisture analysis. The remaining sample was airdried, slightly ground and sieved (2mm sieve) and stored for physico - chemical analyses. Soil texture was estimated by International pipette method and moisture by gravimetric method (Bouyoucos, 1962). The pH of the soils were determined in 1:2.5 (soil: water) suspension, using combined electrode (glass and calomel) in a digital pH meter. The electrical conductivity was measured in the supernatant liquid of the soil water suspension (1:2.5) with the help of Conductivity Bridge and expressed in dSm-1 at 20°C. Organic carbon was determined in soil samples passed through 100 mesh sieve by wet digestion method of Walkley and Black (1934). Available nitrogen was determined by

alkaline permanganate distillation method (Subbiah and Asija, 1956). Available phosphorus was estimated in the soil samples were extracted with Bray's No. 1 extractant and P content in the extracts was determined by ascorbic acid method in a spectrophotometer (Watanabe and Olsen 1965). To determine available potassium, soil samples were extracted with neutral normal ammonium acetate and potassium content was determined by flame photometry (Jackson, 1973). Available micronutrients were extracted using 0.1 N HCl and analyzed for Fe, Mn, Zn and Cu using atomic absorption spectrophotometer (Jackson, 1973).Optimum ranges of soil parameters, providing management potentials were determined by a boundary line approach (Walworth *et al.*, 1986; Vizcayno-Soto and Côté2004).

4.3. Fuanal diversity and Animal Dependence

These unique ecosystems are used by almost all the different groups of animals. These habitats were managed for providing fodder for the grassers and through that the prey abundance for the charismatic umbrella carnivore species like tiger is conserved. The animal dependence data is collected while visiting the vayal for mapping. The list of animals like amphibians, reptiles, birds and mammals that we saw during the visit is prepared. The chance of sighting large animals especially mammals are really difficult so their information is collected from the indirect evidences like their hoof prints, pug marks, pad marks, scrape mark, scratch mark, pellet, scat and kill etc. Monthly data was collected from the selected vayals. For birds point count method was used, for reptiles and amphibians quadrate surveys and scan searches was conducted.

4.4. Conservation and Management

Information on threats and conservation issues of these unique ecosystems and its current management activities were listed through field observation and discussion with forest officials. In addition, the data collected on ecosystem dynamics were used to suggest do's and don'ts to manage/conserve these unique ecosystems in Periyar Tiger Reserve. Since vayal is a wetland ecosystem, maintaining optimum characteristics of soil especially soil moisture is an important step towards its conservation/restoration. Hence soil moisture measurement was done by excessive sampling of more than 100 samples in each month. These values were ploted and by fitting polynomial the optimum value was identified. Based on these, management and conservation recommendation were prepared which need to be tested through field trial of long duration.

5. RESULTS AND DISCUSSION

5.1. Inventory and mapping of Vayals

As a part of this survey, we could document 140 vayals which are distributed in five Forest Ranges (Azhutha - 14, Pamba - 26, Periyar - 40, Vallakadavu - 28, Thekkady - 32). The size of vayals varies considerably (Figure 2); Anakallu vayal in Pamba Forest Range is the smallest vayal with an extent of 0.02 ha and Poovarashu vayal in Thekkady Forest Range is the largest vayal with an extent of 28.49 ha. Thekkady Forest Range having more number of bigger vayals and most of the vayals in Thekkady are having the size between 5.81 hectare and 11.61 hectares with cumulative area more than 100 hectares.

All these vayals were between 843 msl (Vallakadavu vayal in Azhutha Forest Range) to 1818 msl (Manalar APC Camp shed vayal in Periyar Forest Range) in altitude. In Periyar Tiger Reserve most of the vayals are distributed in lower altitudinal ranges, between 840-1285 msl (843-1042 msl with 75 vayals and 1043-1242 msl with 42 vayals) (Figure 2). In Thekkady Forest Range all the vayals are distributed within 843-1042 msl (Figure 3).Periyar is the only Forest Range with distribution of vayals in all the altitudinal gradients (843-1042 msl with 11 vayals, 1043-1242 msl with 7 vayals, 1243-1442 msl with 8 vayals, 1443-1642 msl with 13 vayals and 1643-1842 msl with a single a vayal (Figure 3). All the vayals in Pamba and Azhutha Forest Ranges are distributed between the altitudinal range classes 843-1042 msl and 1043-1242 msl having vayals in with 8, 2 and 18, 12 vayal respectively. In Vallakkadavu Forest Range most of the vayals are lies between 843-1042 msl with 22 vayals followed by 1043-1242 msl with five vayals and 1243-1442 msl with a single vayal (Figure3).

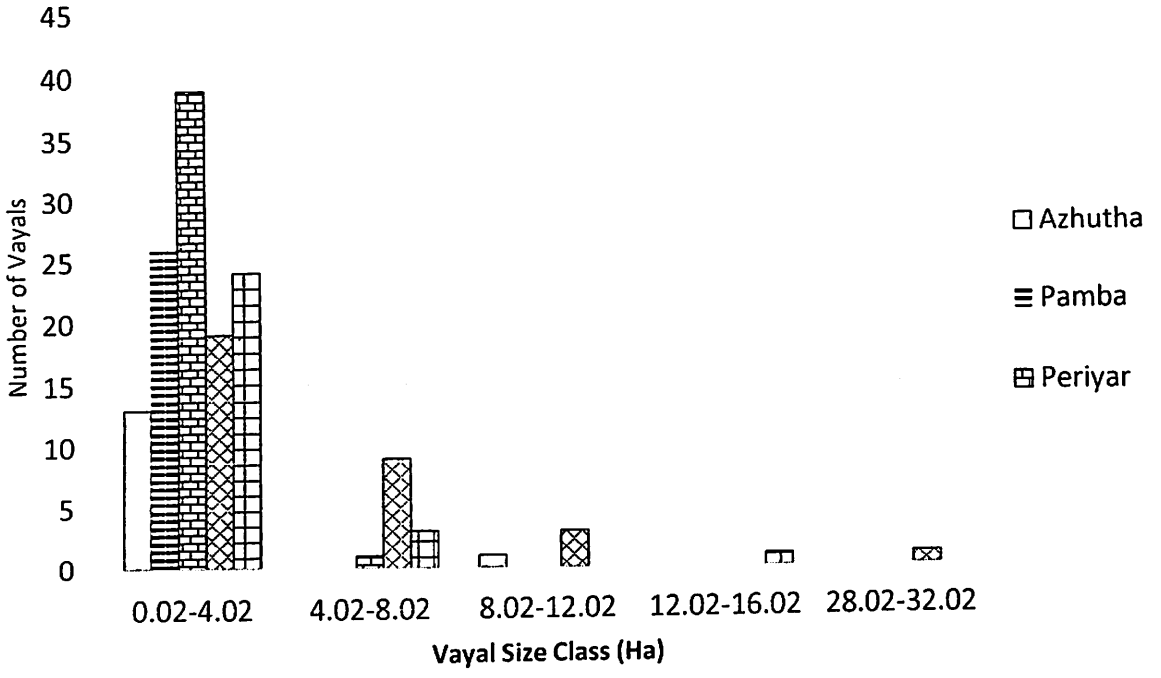

Figure 2: **Size class distribution of vayals in Periyar Tiger Reserve**

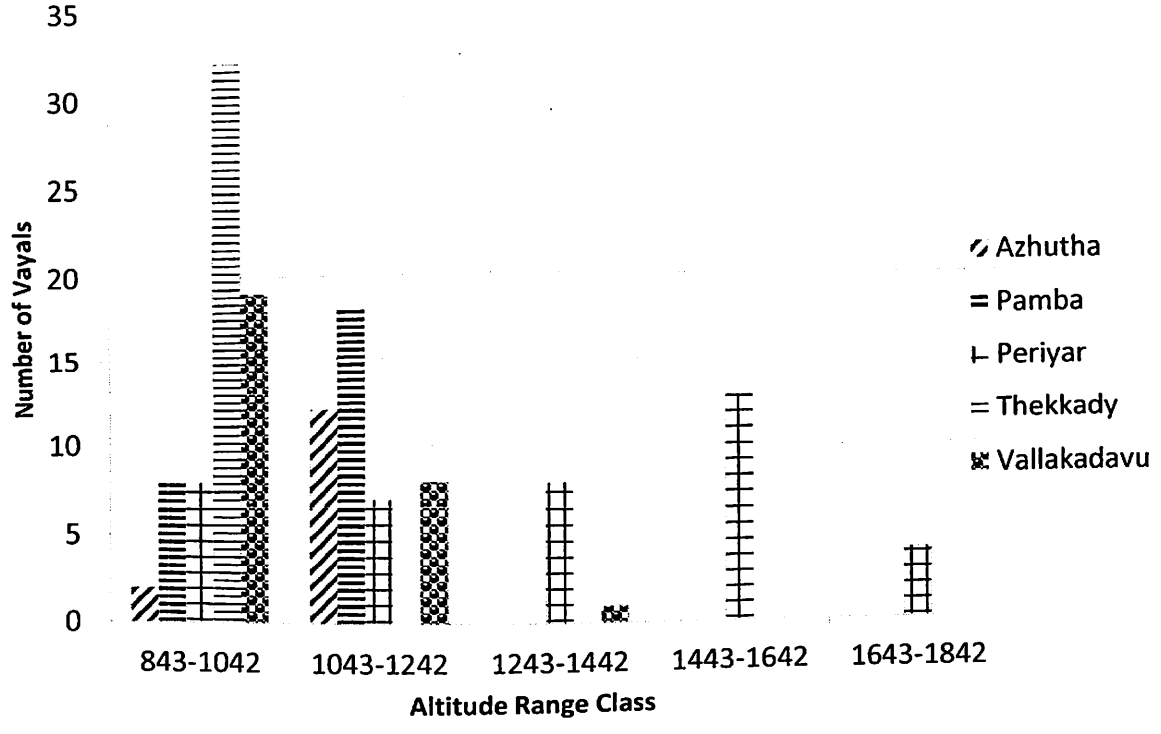

Figure 3: **Altitudinal distribution of vayals in Periyar Tiger Reserve**

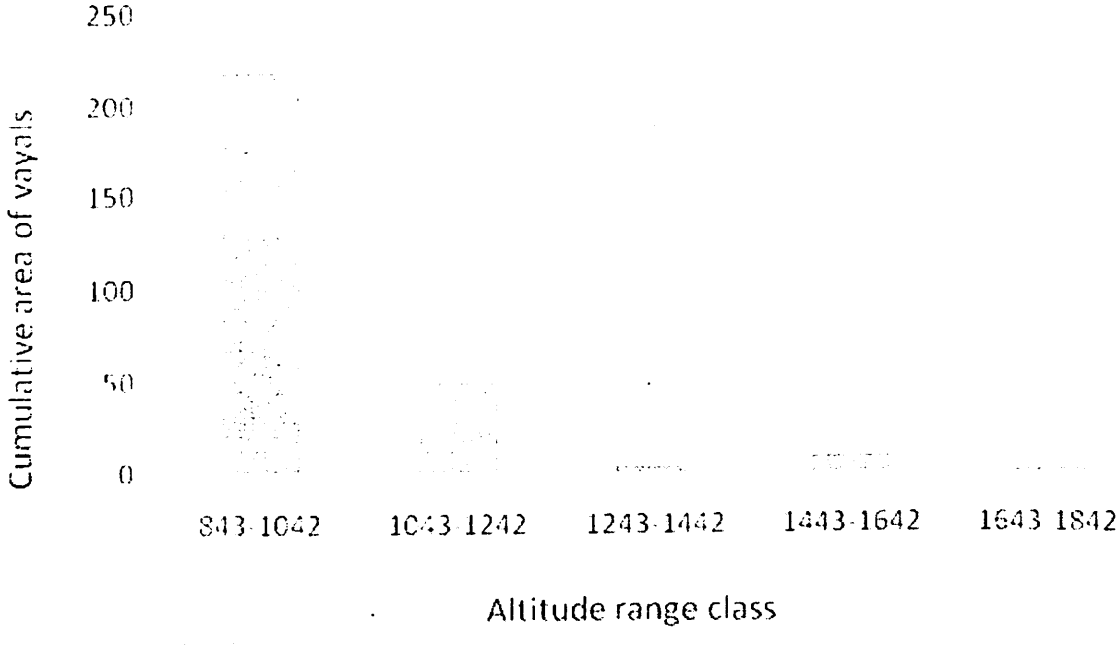

Figure 4: **Cumulative area of vayals in each altitudinal gradient in PTR**

The cumulative area of 140 vayals from all the five Forest Ranges is 281.45 hectares and the altitudinal gradient class 843-1042 msl represents more number of vayals (75 vayals) and the cumulative area is 272.63 hectares and followed by the altitudinal gradient 1043-1242 msl with 42 vayals and the area is 56.33 hectares (Figure 4). The cumulative area of vayals in 1243-1442 msl (9 vayals) and 1443-1642 msl (13 vayals) are 10.67 and 6.61 hectares respectively and the 1643-1842 msl range class is really negligible with less than 0.81 hectares.

5.1.1. **Azhutha Forest Range**

We did extensive field works in Azhutha Forest Range and recorded eight vayals that not included in the list of managed vayals in Tiger Conservation Plan. Most of the vayals that added to the list are from the vicinity of Sabarimala pilgrim trek paths. We mapped 14 vayals (Figure5) and the largest among them is Seethakulam Bit I & II vayal (8.18 ha) and the smallest is Seethakulam Zero point vayal (0.15 ha). The low altitude vayal that recorded was Vallakkadavu vayal from 843 msl and the high altitude vayal was Uppupara Thannithotti vayal at 1213 msl (Table 1). When considering the altitudinal gradient classes

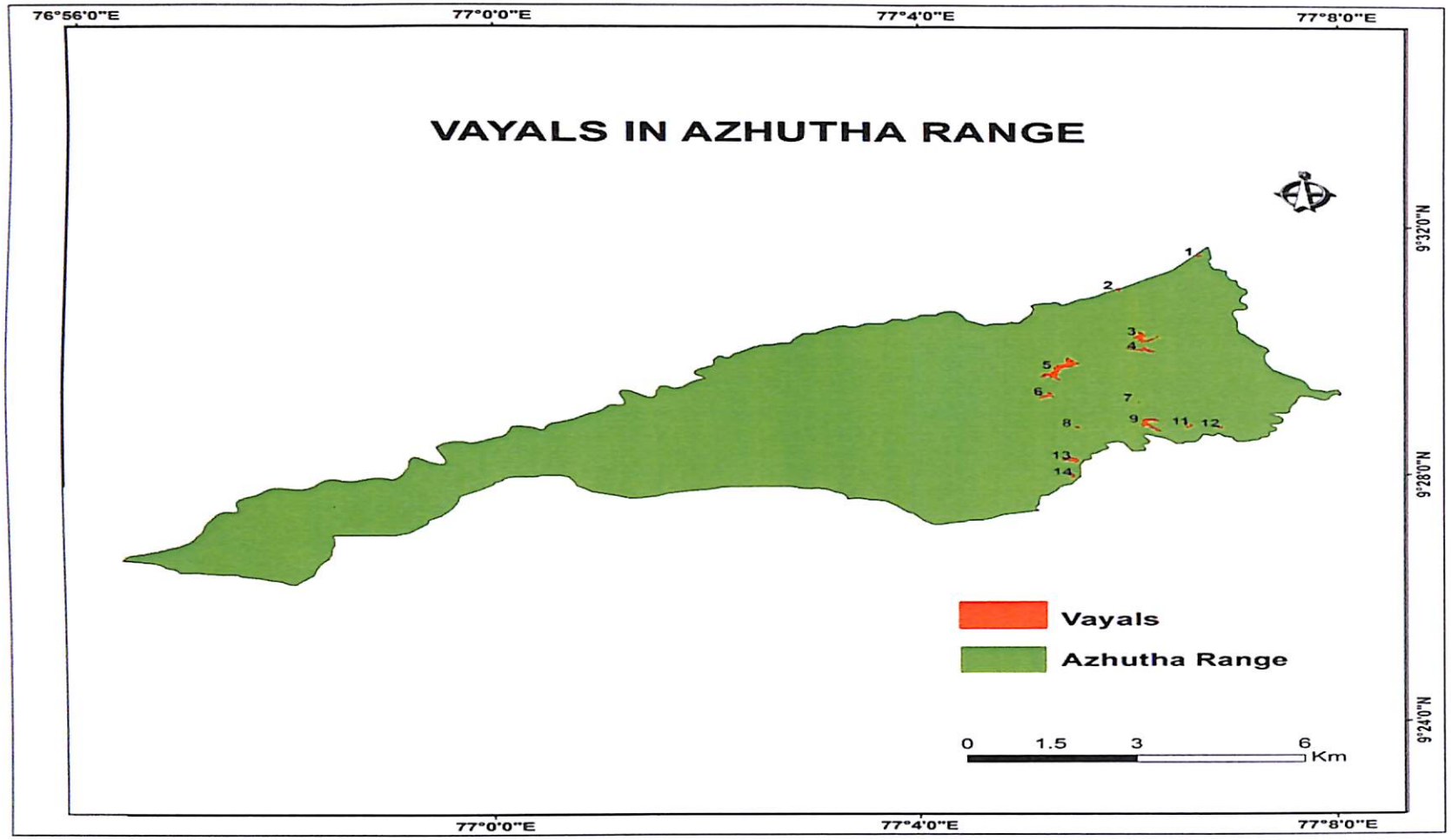

Figure 5: Distribution of vayals in Azhutha Range

Table1: **Vayals in Azhutha Forest Range**

S.No	Vayals name	Areas in ha	Altitude (m)	Latitude (Degree,Decimel)	Longitutde (Degree, Decimel)
1	Vallakadavu	0.38	843	9.525564°	77.111203°
2	65 plantation	0.28	861	9.516844°	77.098369°
3	2 nd mile	3.31	1125	9.504154°	77.102506°
4	2 nd mile top	2.09	1118	9.500239°	77.102088°
5	Seethakulam 1&2	8.18	1125	9.492468°	77.089109°
6	Thalikanam	1.53	1170	9.487971°	77.088155°
7	Jollimala 1	0.18	1197	9.486138°	77.101690°
8	Seethakulam_0_point	0.15	1196	9.479366°	77.091791°
9	Jollimala 2	3.57	1189	9.478722°	77.104928°
10	Vamanakulam 2	0.38	1164	9.480141°	77.109083°
11	Vamanakulam 1	0.51	1164	9.479432°	77.109371°
12	Vamanakulam	0.42	1212	9.479509°	77.114315°
13	Uppupara thavalam	1.95	1192	9.470129°	77.091964°
14	UppuparaThannithotti	0.49	1213	9.465822°	77.091387°
Total area		**18.94 ha**			

5.1.2. **Pamba Forest Range**

Based on Tiger Conservation Plan, there are 11 vayals; in addition to it we could list and map 26 vayals (Figure6) and now the total extent of vayals in Pamba Forest Range is 26.01 hectare (Figure 4). The largest vayal is the 20 hectare check dam vayal with an extent of 3.31 ha and the smallest vayal is Anakallu vayal with 0.02 ha area (Table 2). The vayal that recorded from lower altitude was Kozhikkanam Check dam vayal from 905 msl and the vayal from higher altitude was Anathala vayal from 1221 msl (Table 2). When considering the altitudinal gradient classes, the vayals are falling under two classes 843-1042 msl class contains 8 number and 18 are in 1043-1242 msl range (Figure 3).

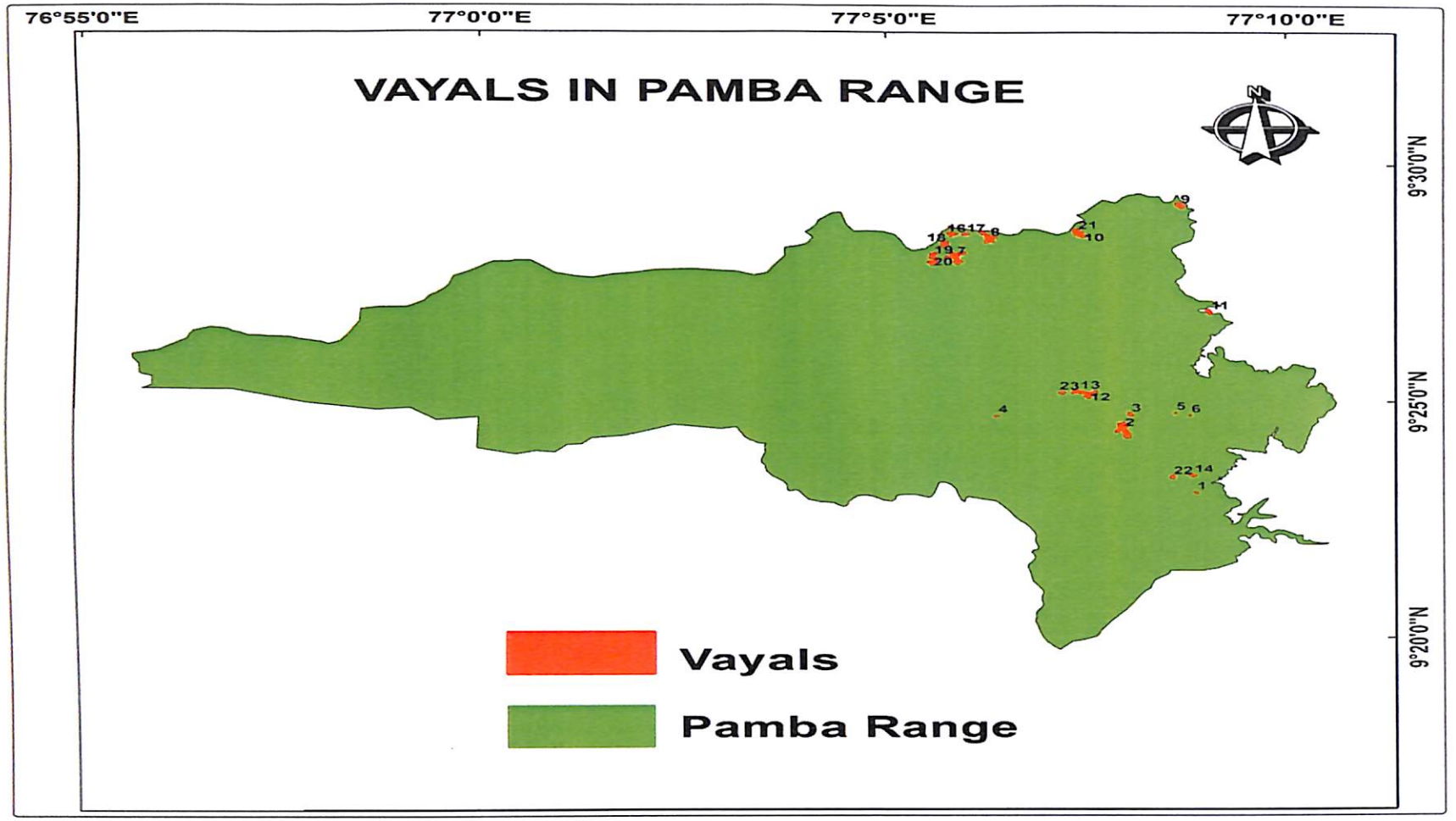

Figure6: Distribution of vayals in Pamba Forest Range

Table 2:**Vayals in Pamba Forest Range**

S.No	Vayal Name	Area (Ha)	Altitude (m)	Latitude (Degree, Decimel)	Longitude (Degree, Decimel)
1	Kozhikanam checkdam	1.7	905	9.485210°	77.144546°
2	Uppupara kalink	0.76	1201	9.475400°	77.096699°
3	Uppupara kalink 1	0.34	1198	9.475972°	77.100416°
4	Uppupara Thevaruval	0.52	1208	9.476056°	77.103783°
5	Kaduvathala	1.88	1214	9.472986°	77.104262°
6	Vamanakulam CS	1.44	1188	9.476049°	77.123586°
7	Machanmadam	0.27	1192	9.475236°	77.124664°
8	Uppupara Thavalam	1.36	1195	9.471506°	77.095364°
9	Poomaram	1.80	918	9.472289°	77.142095°
10	Uppupara tower 1	0.52	1193	9.470524°	77.092472°
11	Uppupara tower-2	1.03	1201	9.468809°	77.092578°
12	Anathala	3.1	1221	9.469516°	77.099142°
13	Pachakanam hut	0.62	1113	9.448048°	77.150397°
14	Uppupara tower-3	1.06	1213	9.466090°	77.092030°
15	Pachakanam	0.96	923	9.466003°	77.143334°
16	Vilakukallu	0.5	1118	9.419983°	77.119555°
17	P.medu seethakulam 2	1.11	1110	9.420340°	77.122394°
18	P. medu seethakulam 1	1.86	1111	9.418462°	77.125110°
19	A point	0.16	991	9.411544°	77.106210°
20	6-Th Block	0.4	965	9.411933°	77.133876°
21	Anakallu	0.02	949	9.412731°	77.143134°
22	Anapara	0.21	949	9.411866°	77.146215°
23	20-Hector checkdam	3.31	970	9.404438°	77.133388°
24	Varayadinkoka	0.53	1155	9.389960°	77.142190°
25	Substation mala	0.34	1112	9.390521°	77.146909°
26	18-5	0.21	1094	9.384449°	77.147630°
Total area		**26.01ha**			

5.1.3. **Vallakadavu Forest Range**

Vallakkadavu covers an area of 232 sqkm and this area is the core of PTR with very less tourism activities. The area having lot of Eucalyptus plantations and many of these vayals are seen in these plantations. We could document 28 vayals (Figure 7) in this Forest Range. The largest vayal that recorded is Pothukandam Bit I & II vayal with an extent of 12.50 hectare and the smallest the vayal inVallakadu Forest Range is 85th Plantation vayal with an extent of 0.16 hectares (Table 3). The vayal that recorded from lowest altitude is Quarterpalam vayal from 870 msl and the high altitude vayal is Alinchodu vayal from 1325 msl (Table 2). The vayals in Vallakkadavu belongs to three altitudinal gradient class 843-1042 msl, 1043-1242 msl and 1243-1442 msl with 22, 5 and 1 vayals respectively (Figure 3) and the same trend is reflected in the case of cumulative area of vayals in these altitudinal gradient classes the first class with 60.36 ha followed by 11.52 ha and 0.17 ha respectively (Figure 4).

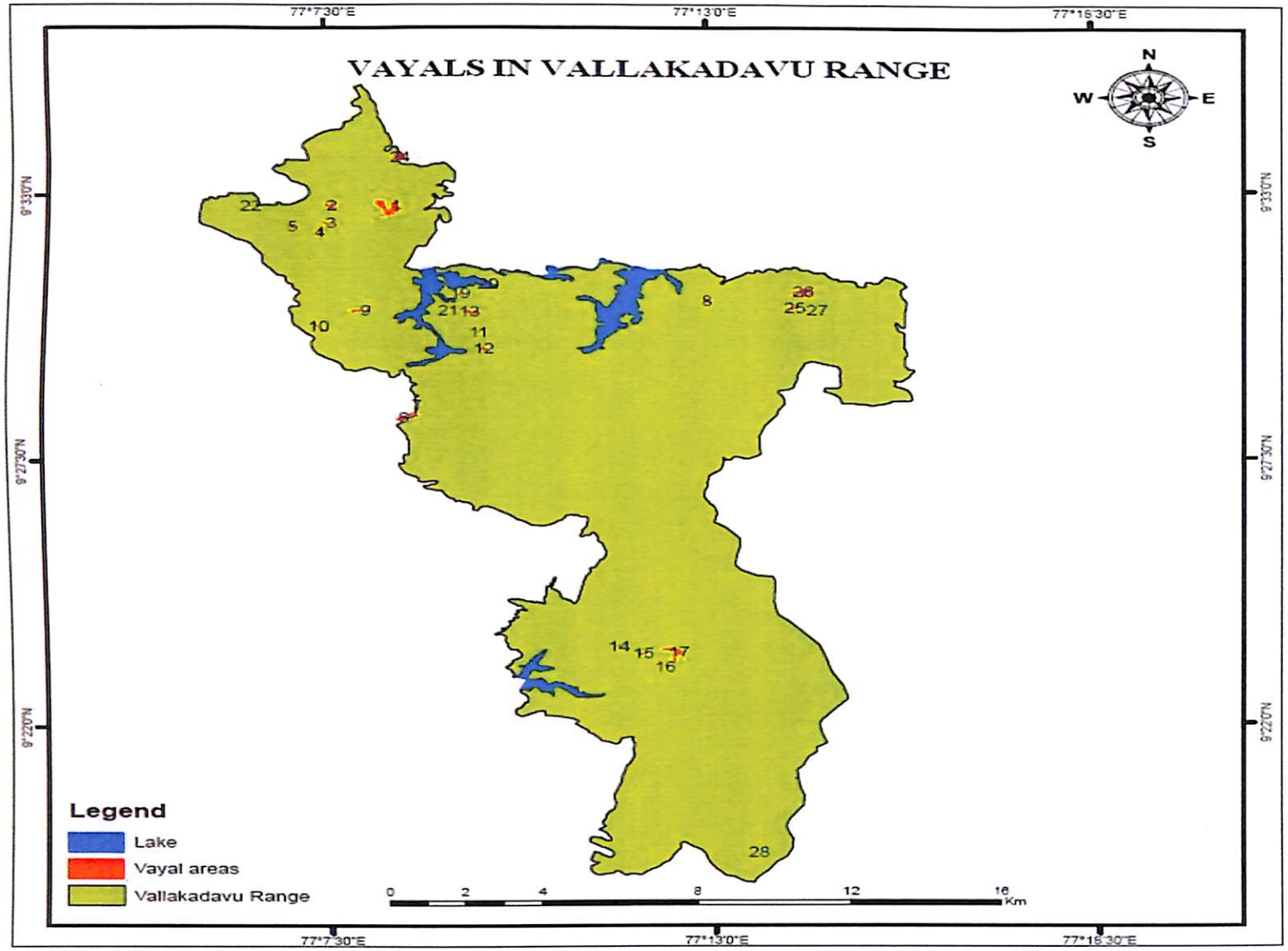

Figure7: Distribution of vayals in Vallakadavu Forest Range

Table 3: **Vayals from Vallakadavu Forest Range**

S.No	Vayal Name	Area (Ha)	Altitude (m)	Latitude (Degree, Decimel)	Longitude (Degree, Decimel)
1	Pothu Kandam Bit 1 & 2	12.5	920	9.543974°	77.140618°
2	Kumbalam Petty	1.44	933	9.545452°	77.126440°
3	Varakandam	1.10	895	9.539756°	77.125463°
4	Ambukallu kandam	1.82	892	9.536913°	77.123751°
5	Quarterpalam	1.06	870	9.538899°	77.116996°
6	Pachakanam Bit_1	4.12	926	9.473021°	77.143273°
7	Pachakanam bit 2	0.33	916	9.477012°	77.146515°
8	Chettichi_	1.17	935	9.512897°	77.215985°
9	Circle_rd_Narakakandam	1.91	926	9.509911°	77.132901°
10	Circle Road	1.48	891	9.504274°	77.123331°
11	Panakandam	0.54	902	9.502154°	77.162169°
12	Paravalavu	1.72	928	9.496779°	77.163323°
13	Kaduvakandam	2.19	895	9.508856°	77.160572°
14	2namukku_2chappathu	0.61	1044	9.393780°	77.193824°
15	5_chappatahu	0.17	1043	9.391178°	77.199395°
16	6_chappath	0.32	1043	9.388531°	77.203005°
17	Randanamukku	3.35	1042	9.391942°	77.207474°
18	Randanamukku_bit_1	0.20	1041	9.387163°	77.204497°
19	Koyathotti_plantation	0.89	913	9.515283°	77.157487°
20	Koyathotti_damsitr	1.42	892	9.518772°	77.164865°
21	Paravalavu_2nd	0.19	898	9.509515°	77.155715°
22	85plantation 2nd	0.48	1076	9.546264°	77.107170°
23	85 Plantation 1st	0.16	1069	9.546445°	77.105472°
24	Vallakadavu Thondiyar	5.45	884	9.562653°	77.142333°
25	Samikulam shola	1.00	1160	9.510097°	77.236076°
26	Samikayam	4.98	1200	9.515276°	77.237682°
27	Samikulam	0.35	1225	9.509426°	77.239540°
28	Alinchodu	0.17	1325	9.290466°	77.285996°
Total area		**51.12ha**			

5.1.4. **Thekkady Forest Range**

Thekkady Forest Range is the smallest range in PTR covering an area of 99 sqkm. The major area of this Forest Range is occupied by the catchment area of the Periyar Lake. The lake makes many seasonal manmade vayals in this Forest Range. A total of 32 vayals (Figure 8) were mapped in that 12 vayals were managed by the forest department as per TCP. The smallest vayal recorded was Brandypara vayal (0.27 ha). Poovarashu in Thekkady Range with an extent of 30.8 hectares is the largest vayal in PTR. The Thondiyar Chembanal vayal is the vayal recorded from low altitude (877 msl) and the Kokkara Bridge small vayal is the high altitude vayal in Thekkady (1017 msl) (Table 4).When considering the altitudinal gradient class all the vayals were falls under the class 843-1042 msl and the cumulative area is 178.02 ha (Figure 4).

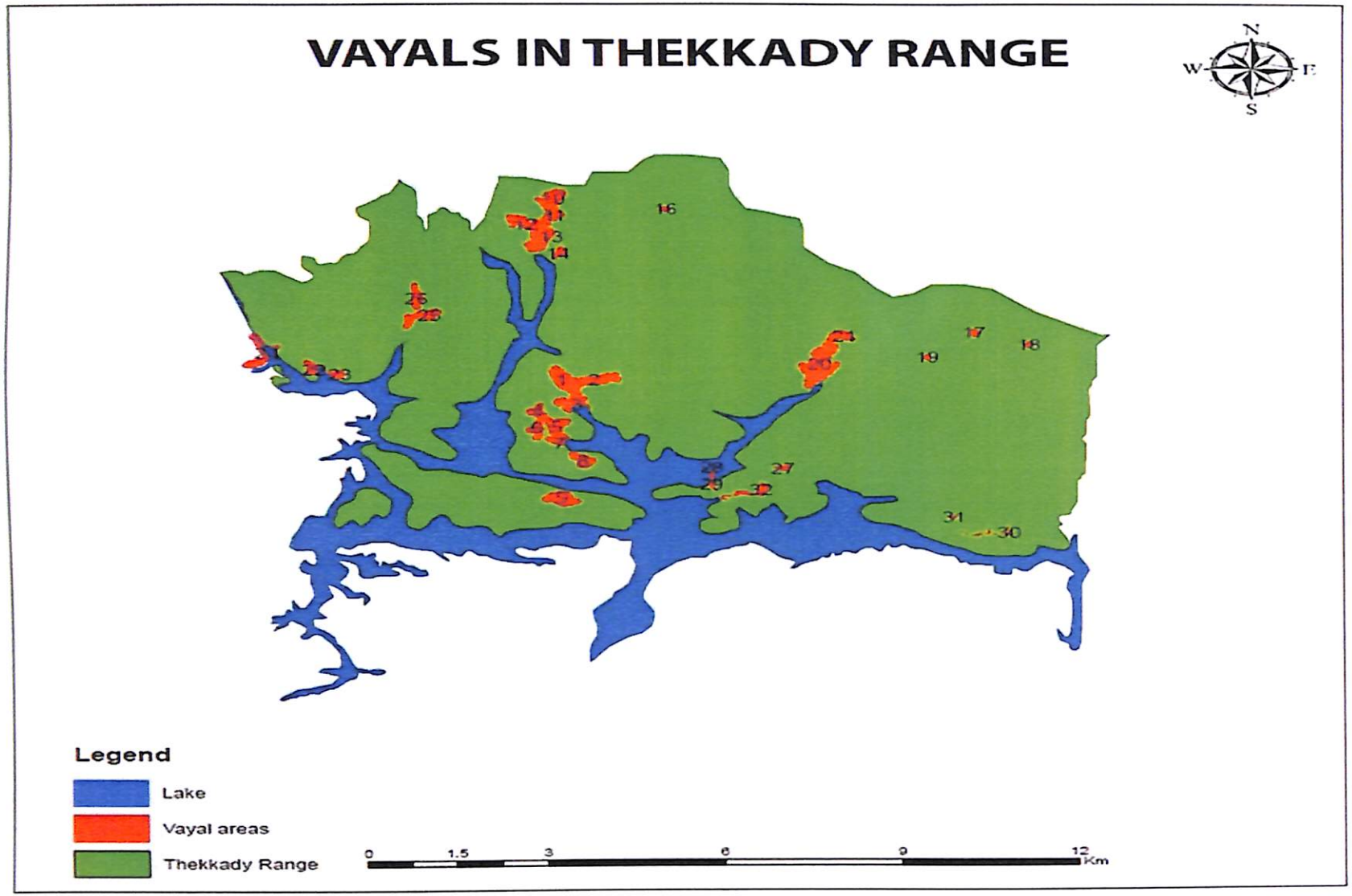

Figure8: Distribution of vayals in Thekkady Forest Range

Table 4: **Vayals from Thekkady Forest Range**

Sl.No	Vayal Name	Area (Ha)	Altitude (m)	Latitude (Degree, Decimel)	Longitude (Degree, Decimel)
1	Cheveloda	8.42	883	9.563694°	77.186035°
2	Panamkala	6.47	891	9.562407°	77.191695°
3	Nellikkyampetty	10.3	879	9.556024°	77.186004°
4	Thamburan thuruthu_B1	3.66	886	9.554118°	77.182726°
5	Thamburanthuruthu B2	5.00	885	9.553248°	77.185997°
6	Thoodipara	3.51	884	9.552788°	77.185772°
7	Manakavala	4.15	882	9.546980°	77.185181°
8	ManakavalaMachan	5.32	887	9.544153°	77.189716°
9	Kavalappara	7.1	888	9.535247°	77.183812°
10	Kokara 2nd gate 1	6.46	893	9.602884°	77.184532°
11	Kokkar 2nd gate 2nd	5.83	894	9.599625°	77.183494°
12	Kokkara watch tower 2	4.80	889	9.593606°	77.180585°
13	Kokkara watch tower	6.71	884	9.592439°	77.180955°
14	Kokkara bridge	0.79	893	9.591543°	77.184894°
15	Kokkara bridge small	0.52	1017	9.591929°	77.185913°
16	Brandy	0.27	891	9.601546°	77.201318°
17	Medhakanam	0.36	914	9.573156°	77.248105°
18	Medhakanam 1st	0.80	920	9.570682°	77.256223°
19	Kalyana para	0.36	949	9.567891°	77.240721°
20	Poovarashu	30.8	881	9.564503°	77.225722°
21	Zero point	2.98	891	9.572358°	77.228100°
22	Thondiyar Chembanal	3.48	877	9.566183°	77.147100°
23	Thondiyar Main	9.68	885	9.566498°	77.138314°
24	Thondiyar Small	1.97	880	9.566071°	77.273936°
25	Anchuruli bit 1	3.26	899	9.576525°	77.162122°
26	Anchuruli bit 2	3.84	902	9.579334°	77.163462°
27	Amayolivyl	2.30	904	9.542367°	77.217617°
28	Manalmoolavyl	1.42	901	9.541567°	77.208700°
29	KadaKaparavyl	2.21	895	9.538117°	77.208517°
30	Adupukallumoolavyl	2.17	892	9.527367°	77.250450°
31	Adupukallumoola_bit 1 vyl	0.53	930	9.531031°	77.245097°
32	Pachakadvyl	3.50	886	9.535983°	77.209883°
Total area		**148.97ha**			

5.1.5. **Periyar Forest Range**

Periyar Forest Range is the largest Forest Range in PTR. A total of six vayals were documented in Tiger conservation plan. Through extensive field survey we could add 34 (Figure 9) that not included in the TCP. Almost all the vayals were surrounded by evergreen forests. The largest vayal recorded from this forest range is Paloda vayal (5.62 ha) and the smallest vayal is Ezhanakkuzhi vayal (0.05 ha) (Table 5). The Kavikavu vayal is the low lying vayal that recorded from an altitude of 894 msl and the vayal from highest altitude is APC Camp shed vayal (1818 msl) (Table 5). Vayals of Periyar Forest Range are in five different altitudinal range classes like 843-1042 msl (11), 1043-1242msl (7), 1243-1442 msl (8), 1443-1642 msl (13) and 1643-1842 msl (1) (Figure 2). In case of the cumulative area of vayals in each altitudinal gradient classes the first class is dominated with 22.16 ha of area followed by third and fourth classes with 10.5 ha and 6.61 ha of cumulative area respectively and this is followed by second and fifth classes with 2.91 ha and 0.81 ha of cumulative area respectively (Figure 4).

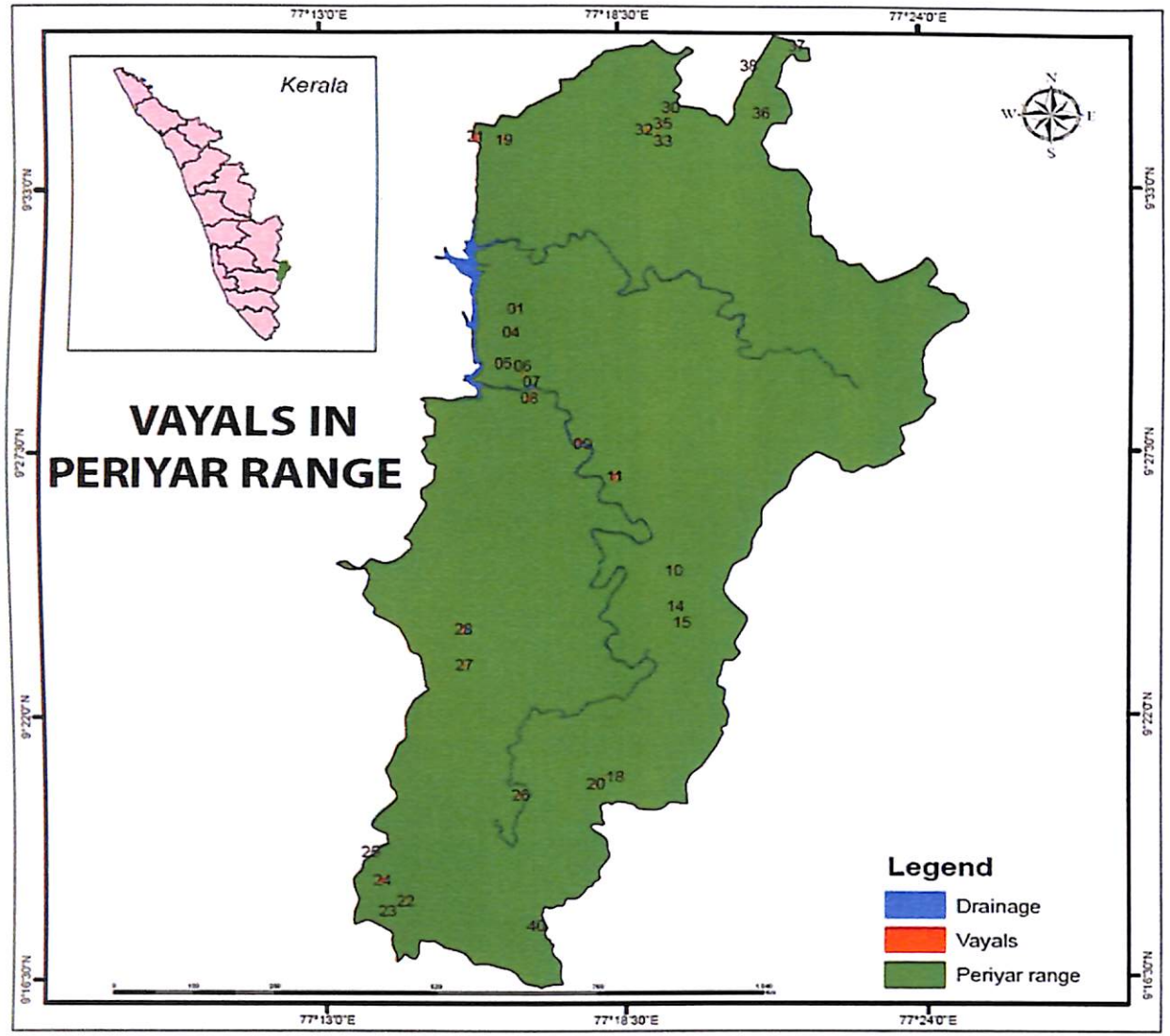

Figure9: Distribution vayals in Thekkady Forest Range

Table 5: **Vayals in Periyar Forest Range-**

S.No	Vayal Name	Area (Ha)	Altitude (m)	Latitude (Degree, Decimel)	Longitude (Degree, Decimel)
1	Anakuthi bit 1	3.50	1500	9.394717°	77.259483°
2	Anakuthi bit 2	0.62	1495	9.398483°	77.257837°
3	Anakuthi way	1.01	1336	9.383833°	77.259483°
4	APC Campshed	0.82	1818	9.599517°	77.362367°
5	Badraksham way	1.48	1387	9.309433°	77.232550°
6	Ezhana kuzhi 1	0.06	1072	9.403894°	77.323254°
7	Ezhana kuzhi 2	0.05	1084	9.416689°	77.322755°
8	Ezhana kuzhi 3	0.09	1049	9.416774°	77.322741°
9	Ezhana kuzhi 4	0.08	1044	9.417676°	77.322329°
10	Kalvarithode	1.96	929	9.565841°	77.273415°
11	Karimala 1	0.79	1647	9.569433°	77.319817°
12	Karimala 2	0.18	1635	9.570483°	77.320733°
13	Karimala 3	1.21	1631	9.572233°	77.321483°
14	Karuthamudi	2.75	907	9.475937°	77.281015°
15	Kavikavu	1.30	894	9.479477°	77.281658°
16	Kizhanugu Para bit 1	0.37	1632	9.571350°	77.317733°
17	Kizhanugu Para bit 2	0.86	1636	9.570300°	77.317233°
18	Kumarikulam truck path	0.76	1139	9.499904°	77.274746°
19	Kurishu mala 1	0.08	1702	9.592067°	77.347867°
20	Kurishu mala 2	0.07	1682	9.588933°	77.345733°
21	Manalmoola	1.29	1075	9.337885°	77.277145°
22	Manikmala	0.29	1583	9.319283°	77.230950°
23	Mavadi	2.50	911	9.569432°	77.264859°
24	Mulakupara kandam	0.22	1025	9.488723°	77.272030°
25	Nelli parakandam	2.93	937	9.450266°	77.306857°
26	Pachamvallam bit 1	0.43	1349	9.301667°	77.240917°
27	Pakuzhipalam	0.39	1630	9.576233°	77.351300°

Table 5 (Cont'd): **Vayals in Periyar Forest Range**					
28	Palode	5.62	960	9.459634°	77.296862°
29	Parayadithode	0.14	1057	9.398500°	77.324992°
30	Poosanikakuchi bit 1	0.17	1494	9.346499°	77.307162°
31	Poosanikakuchi bit 2	0.11	1508	9.346461°	77.306564°
32	Poosanikakuchi bit 3	0.55	1524	9.344947°	77.302590°
33	Poosanikakuchi	1.19	1591	9.341787°	77.299843°
34	Thavalakulam	0.52	1629	9.575033°	77.324333°
35	Tiger Lake View	0.16	1271	9.508938°	77.275700°
36	Tiger Pool	0.54	1273	9.507906°	77.276424°
37	Tiger Three	0.06	1270	9.508071°	77.276496°
38	Umukku moola	0.18	1355	9.298717°	77.237700°
39	Vaikapadappu	0.64	899	9.485095°	77.278493°
40	Chemakkavally	0.44	1305	9.293450°	77.281500°
Total area		**36.41**			

5.2. Vegetation characteristics and ecosystem dynamics

Durign floral inventory 277 angiosperms (Appendix 1) were recorded from 140 vayals which belongings to 168 genera under 65 families. The dominant families were Poaceae (27 species), Asteraceae (23), Cyperaceae (23), Fabaceae (20), Commenilaceae (18) (Figure 10). The dominant species in vayal ecosystem were *Arundinella purpurea, Arundinella mesophylla, Paspalum conjugatum, Hedychium coronarium, Rhynchospora corymbosa, Apocopis mangalorensis, Chrysopogon aciculatus*etc. Among the angiosperms recorded, 18 were exoticswhile 21 species were weeds, 50 species were trees and 52 species were identified as Grasses/Sedges (Table 6- 10)

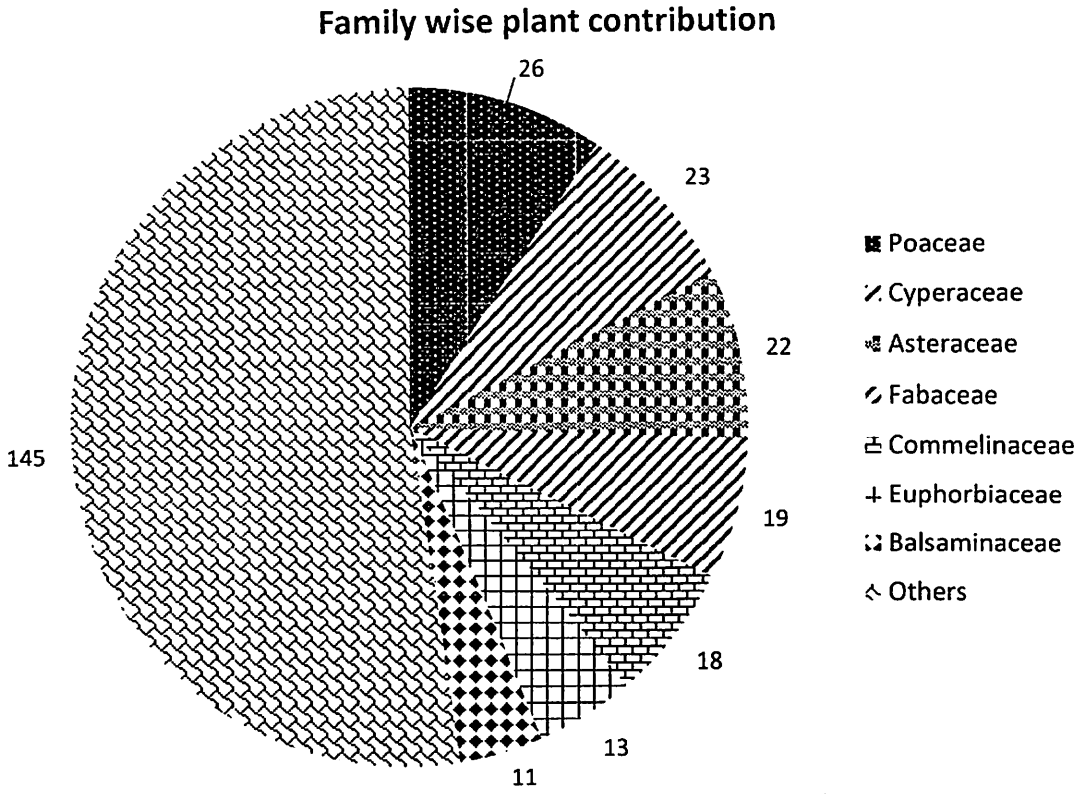

Figure 10: Family wise plant contribution in vayals

Table 6: Sedges recorded from vayal

Sl. No.	Sedges
1	*Citrus sp.*
2	*Cyperus bulbosus* Vahl
3	*Cyperus compactus* Retz
4	*Cyperus cyperinus* (Retz.) Suringar
5	*Cyperus difformis* L.
6	*Cyperus diffusus* Vahl
7	*Cyperus distans* L. f.
8	*Cyperus dubius* Rottb.
9	*Cyperus exaltatus* Retz.
10	*Cyperus haspan* L.
11	*Cyperus iria* L
12	*Cyperus javanicus* Houtt.
13	*Cyperus procerus* Rottb.
14	*Cyperus rotundus* L.
15	*Fimbristylis aphylla* Steud.
16	*Kyllinga brevifolia* Rottb.
17	*Kyllinga bulbosa* P. Beauv.
18	*Kyllinga melanosperma* Nees.
19	*Kyllinga nemoralis* (J. R & G. Forst.) Dandy ex Hutch. & Dalz
20	*Kyllinga polyphylla* Willd. ex Kunth,
21	*Rhynchospora corymbosa* (L.) Britton
22	*Schoenoplectiella juncoides* (Roxb.) Lye
23	*Schumannianthus virgatus* (Roxb.) Rolfe

Table 7: Grasses recorded from vayal

Sl. No.	Species
1	*Alloteropsis cimicina*(L.) Stapf
2	*Apocopis mangalorensis* (Hochst. ex Steud.) Henrard
3	*Arundinella ciliata* (Roxb.) Nees ex Miq.
4	*Arundinella purpurea* Hochst. ex Steud.
5	*Bambusa bambos* (L.) Voss
6	*Brachiaria semiundulata* (Hochst.) Stapf
7	*Chrysopogon aciculatus* (Retz.) Trin
8	*Chrysopogon hackelii* (Hook.f.) C.E.C. Fisch.
9	*Coelachne simpliciuscula* (Steud.) Munro ex Benth.
10	*Cymbopogon citratus* (DC.) Stapf
11	*Cymbopogon flexuosus* (Nees ex Steud.) W.Watson
12	*Cynodon dactylon* (L.) Pers
13	*Dactyloctenium aegyptium* (L.) Willd
14	*Eleocharis dulcis* (Burm. f.) Trin. ex Hensch.
15	*Eragrostis nutans* (Retz.) Nees ex Steud
16	*Ischaemum barbatum* Retz.
17	*Leersia hexandra* Sw.
18	*Ochlandra travancorica* (Bedd.) Gamble
19	*Ochlandra wightii* (Munro) C.E.C. Fisch.
20	*Oryza meyeriana* (Zoll. & Mor. ex Steud.) Baill.
21	*Oryza rufipogon*Griff.
22	*Panicum repens* L.
23	*Paspalum conjugatum* P.J.Bergius
24	*Paspalum distichum* L
25	*Paspalum scrobiculatum* L.
26	*Spermacoce pusilla* Wall.
27	*Themeda cymbaria* Hack.
28	*Themeda tremula* (Nees ex Steud.) Hack.

Table 8: Invaded tree species recorded from vayal

Sl. No.	Tree Species	Sl. No.	Tree Species
1	*Actinodaphne bourneae*Gamble	26	*Lagerstroemia microcarpa* Wight
2	*Agrostistachys borneensis*Becc.	27	*Macaranga indica* Wight
3	*Annona squamosa* L.	28	*Macaranga peltata* (Roxb.) Mull.-Arg.
4	*Bambusa bambos* (L.) Voss	29	*Maesa indica* (Roxb.) A. DC.
5	*Briedelia retusa* (L.) A. Juss	30	*Mallotus resinosus* (Blanco) Merr.
6	*Butea monosperma* (Lam.) Taub.	31	*Melicope lunu-ankenda*(Gaertn.) T.G.Hartley
7	*Careya arborea* Roxb.	32	*Ochlandra travancorica* (Bedd.) Gamble
8	*Chionanthus mala-elengi*(Dennst.) P. S.	33	*Ochlandra wightii* (Munro) C.E.C. Fisch
9	*Cinnamomum macrocarpum* Hook. f	34	*Olea dioica* Roxb.
10	*Cinnamomum malabatrum* (Burm. f.) J.Presl	35	*Phyllanthus emblica* L
11	*Citrus medica* L.	36	*Polyalthia coffeoides* (Thwaites) Hook. f. & Thomson
12	*Cullenia exarillata*A.Robyns	37	*Polyalthia longifolia* (Sonn.) Thwaites
13	*Delonix regia* (Hook.) Raf.	38	*Psidium guajava*L.
14	*Elaeocarpus tuberculatus* Roxb.	39	*Racosperma auriculiforme* (Benth.) Pedley
15	*Erythrina suberosa* Roxb.	40	*Sapindus emarginatus* Vahl
16	*Erythrina subumbrans* (Hassk.) Merr	41	*Sterculia guttata* Roxb. ex G. Don
17	*Eucalyptus grandis* W.Hill.	42	*Strychnos nux-vomica*L
18	*Eurya nitida* Korth.	43	*Syzygium cumini* (L.) Skeels
19	*Ficus hispida* L. f	44	*Tabernaemontana gamblei* Subr.&A.N.Henry
20	*Grewia tiliifolia* Vahl	45	*Tectona grandis* L. f.

Table 8 (Cont'd): Invaded tree species recorded from vayal			
21	*Holigarna nigra* Bourd.	*46*	*Terminalia paniculata* Roth
22	*Hydnocarpus macrocarpa* Warb.	*47*	*Vernonia arborea* Buch.-Ham
23	*Hydnocarpus pentandra* (Buch.-Ham.) Oken	*48*	*Vernonia travancorica* Hook. f
24	*Knema attemiata* Warb	*49*	*Xanthophyllum arnottianum* Wight
25	*Lagerstroemia microcarpa* Wight	*50*	*Ziziphus oenoplia* (L.) Mill.

Table 9: Weeds recorded from vayal

Sl. No.	Species	Sl. No.	Species
1	*Ageratina adenophora*(Spreng.) R.M.King & H. Rob.	*12*	*Euphorbia hirta* L.
2	*Asclepias curassavica* L	*13*	*Lantana camara* L
3	*Bidens pilosa* L.	*14*	*Melastoma malabathricum* L
4	*Chromolaena odorata* (L.) R.M.King &H. Rob.	*15*	*Mikania micrantha* Kunth
5	*Cleome viscosa* L	*16*	*Mimosa diplotricha*Sauvalle
6	*Clidemia hirta* (L.) D. Don	*17*	*Parasopubia delphiniifolia* (L.) H.-P. Hofm. & Eb. Fisch
7	*Conyza japonica* (Thunb.) Less.ex Less	*18*	*Pistia stratiotes* L
8	*Cyperus compactus* Retz	*19*	*Scoparia dulcis* L
9	*Cyperus haspan* L	*20*	*Stachytarpheta jamaicensis* (L.) Vahl
10	*Cyperus iria* L	*21*	*Tridax procumbens* L
11	*Euphorbia heterophylla L.*		

Table 10: Exotic plant species recorded from vayal

Sl. No.	Species	Sl. No.	Species
1	*Ageratina adenophora*(Spreng.) R.M.King & H. Rob	*12*	*Euphorbia hirta* L.
2	*Asclepias curassavica* L	*13*	*Lantana camara* L
3	*Bidens pilosa* L	*14*	*Melastoma malabathricum* L
4	*Chromolaena odorata* (L.) King & Robins.	*15*	*Mikania micrantha* Kunth
5	*Cleome viscosa* L	*16*	*Mimosa diplotricha*Sauvalle
6	*Clidemia hirta* (L.) D. Don	*17*	*Parasopubia delphiniifolia* (L.) H.-P. Hofm. & Eb. Fisch
7	*Conyza japonica* (Thunb.) Less	*18*	*Pistia stratiotes* L
8	*Cyperus compactus* Retz	*19*	*Scoparia dulcis* L
9	*Cyperus haspan* L	*20*	*Stachytarpheta jamaicensis* (L.) Vahl
10	*Cyperus iria* L	*21*	*Tridax procumbens* L
11	*Euphorbia heterophylla* L.		

Table 11: Palatable plant species recorded from vayal

Sl. No.	Species
1	*Alloteropsis cimicina*(L.) Stapf
2	*Apocopis mangalorensis* (Hochst. Ex Steud) Henrard
3	*Arundinella ciliata* (Roxb.) Nees ex Miq.
4	*Arundinella purpurea* Hochst. ex Steud.
5	*Bambusa bambos* (L.) Voss
6	*Brachiaria semiundulata* (Hochst.) Stapf
7	*Chrysopogon aciculatus* (Retz.) Trin
8	*Chrysopogon hackelii* (Hook.f.) C.E.C. Fisch.
9	*Coelachne simpliciuscula* (Steud.)Munro ex Benth
10	*Cymbopogon citratus* (DC.) Stapf
11	*Cymbopogon flexuosus* (Nees ex Steud.) W.Watson
12	*Cynodon dactylon* (L.) Pers
13	*Dactyloctenium aegyptium* (L.) Willd.
14	*Eleocharis dulcis* (Burm. f.) Trimen ex Hensch
15	*Eragrostis nutans* (Retz.) Nees ex Steud
16	*Ischaemum barbatum* Retz

Table 11(Cont'd): Palatable plant species recorded from vayal	
17	*Leersia hexandra* Sw
18	*Ochlandra travancorica* (Bedd.) Gamble
19	*Ochlandra wightii* (Munro) C.E.C. Fisch.
20	*Oryza meyeriana* (Zoll. & Moritzi) Baill.
21	*Oryza rufipogon* Griff.
22	*Panicum repens* L
23	*Paspalum conjugatum*P.J.Bergius
24	*Paspalum distichum* L
25	*Paspalum scrobiculatum* L
26	*Spermacoce pusilla* Wall.
27	*Themeda cymbaria* Hack.
28	*Themeda tremula* (Nees ex Steud.) Hack.

Through continuous monitoring for a period of one year, we could collect data on the structure, composition and dynamics of vegetation in vayals. There are species which are adapted to marshy habitat, with narrow niche which are expected to be the original vegetation in a healthy wetland systems like vayals. But the presence non-vayal species such as trees, exotic weeds, also could document with varying level of contribution. The dominant species and its contribution level varies in different vayals (Table12). The dominant species listed in table are species found in marshy grasslands and are suitable to specific habitat. Among dominant species majority of them are palatable to herbivores (Table 11) but few of them are non-palatble too (Eg. *Rhynchospora corymbosa*, *Pogostemon auricularious*). This indicates that still the vayals mainatains its original vegetation and are valuable source of food for herbivores and plays a major role in maintaining the density and diversity of herbivores in PTR.

On the other hand, it is interesting to see two important vegetatation parameters such as total number of species in each vayal and the contribution level of non-vayal species to the system. This will give an insight to the extent of change to the system in terms of species composition and contribution. Total number species in a vayal varies from 25-52. The contribution of non-vayal species to the total number species also calculated using available literature and field observations which ranges 18% to 46% (Table 13).

When we look at the total number of species. Pothukandam vayal having 52 species and out of which 23 are non-vayal species. Similar situation could also seen in Thavalam and Circle Road vayals also. When the moisture content gets decreased, a wetland system can be degraded and the system will gradually become suitable for non-marshy species. But the total degradation of the system and replacement wetland species to other species is a long-term process hence could not be visible initially as the current dominant species based on contribution level still marshy grassland species as shown in the table. But the invasion of non-vayals species is happening from the boundary towards centre in many cases as indicated by the presence of large number of non-vayal species at boundary. When the moisture level remain below optimum for a longer period, the system will gradually develop into a non-marshy grassland by dominating non-vayal species and exotic weeds. Hence the presence of non-vayal species in majority of vayals even they are not dominant among vegetation, is a sign of degradation and it demands proper conservation and management strategies. It is also noteworthy that there are vayals such as Nelliparakandam, 85 plantation second, Kalyana para etc. which are already in a worse situation where the dominance of weeds and non-vayal species can be seen which needs immediate management and conservation measures.

Table 12: Species contribution in different vayals (%)

Dominant species	Pothukandam	Pachakanam	Thavalam	Crcle road	Tower 2
Chrysopogon aciculatus (Retz.) Trin	34			22	
Rhynchospora corymbosa (L.) Britton	24	16		21	
Centella asiatica (L.) Urb.	9				
Arundinella purpurea Hochst. ex Steud.	6	22	10	11	14
Arundinella mesophylla Nees ex Steud		14	10	9	
Paspalum conjugatum P.J.Bergius		19	10	10	13
Pogostemon auricularius (L.) Hassk.			8		
Apocopis mangalorensis (Hochst.ex Steud.) Henrard					12
Chrysopogon hackelii (Hook.f.) C.E.C. Fisch.					9
Others	27	29	62	27	52
	100	100	100	100	100

Table 13. Number of species in vayals of Periyar Tiger Reserve

Vayal name	Total Species no	Vayal species no	Non-Vayal species no	Percentage Contribution of Non vayal species
Pothumkandam vayal	52	29	23	44
Pachakanam vayal	30	22	8	27
Tower2 vayal	27	22	5	19
Thavalam vayal	25	15	10	40
Circle road vayal	26	14	12	46

Surrounding vegetation of vayal are site specific. In general, vayals are surrounded by natural forest, grassland and eucalyptus plantation (Appendix2; Plate7).When comparing the soil moisture dynamics of vayal and surrounding vegetation it is expected to a very high value of moisture in vayals since they are marshy systems. There are vayals in which surrounding vegetation is different in both boundaries such as circle road vayal. This vayal is surrounded by Eucalyptus plantation by one side and grassland by other side. Soil moisture value for three vegetation type in circler road vayal was observed for one year and the value is ploted in Figure 11.

The result indicates that the vayal is having slightly high value for moisture content through out the year but the difference between vayal and other systems are narrow in serval points. During February and September the moisture value of vayal is almost equivalent to surrounding Eucalyptus plantation. This narrow difference in soil moisture indicates the degradation of vayal which can be clearly visible in boundaries of vayals were non-vayal species are invading towards vayal.

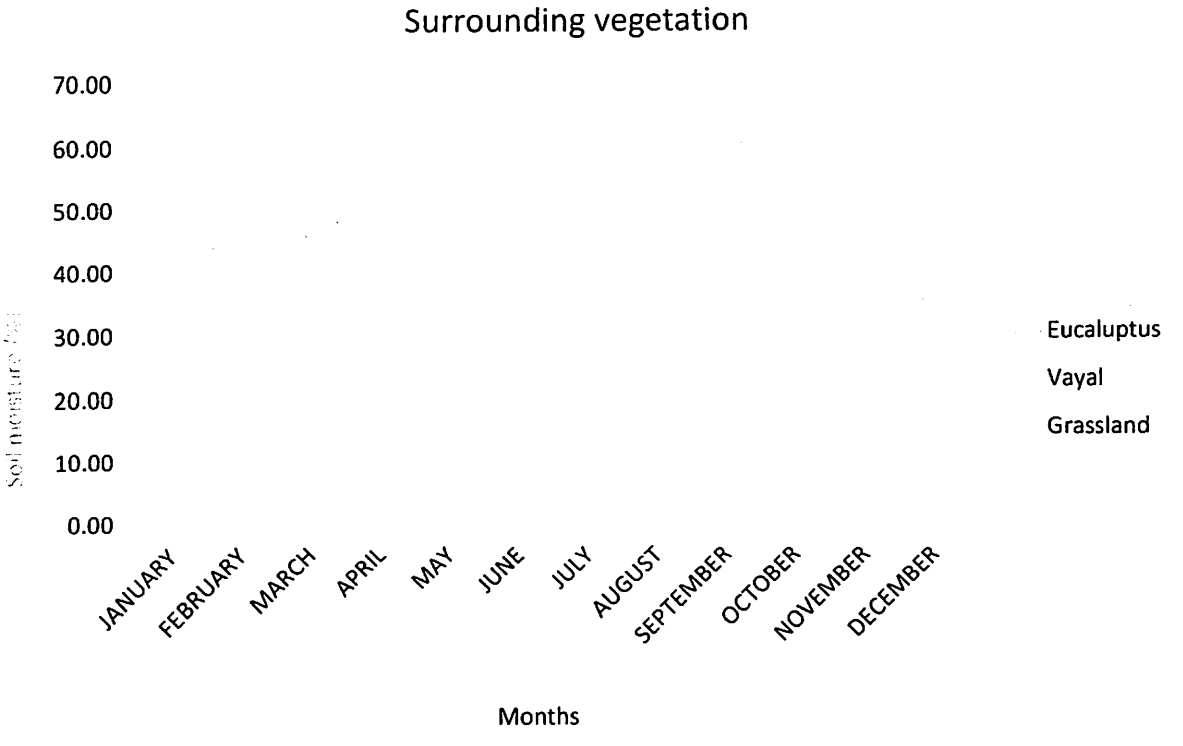

Figure 11: Soil moisture dynamics in circle road vayal and surrounding vegetation

During field observation, it is noticed that in majority of vayals there is invasion of non-vayals species, especially in the boundary towards centre. Since this may result in gradual degradation and decrease of total extent in vayals, we analysed the change detection in selected vayals over a period 10 year. In five vayals studied, all of them showing a decreasing trend during this period. The percentage of reduction varies from 8-27%. This is a clear indication that the current management and conservation strategies which mainly focus on weeding may not sufficient to hold on the gradual degradation of the system.

Table14:Change detection of Vayals in Periyar Range

S.No	Name of Range	Name of the Vayal	10-03-2007	06-05-2012	21-02-2017	Change in %
1	Azhutha	Thavalm uppupara	1.96	1.77	1.62	-17.35
2	Vallakadavu	Pothu kandam bit 1 & 2	12.9	12.5	11.3	-12.4
3	Vallakadavu	Circle Road	1.76	1.48	1.31	-25.57
4	Vallakadavu	Pachakanam	4.29	4.00	3.93	-8.392
5	Pamba	Tower 2	0.87	0.70	0.63	-27.59

5.3. Soil characteristics and dynamics

5.3.1. Soil moisture content

Since marshy grassland/vayals are wetland ecosystems, maintaining optimum soil moisture is having primary importance. Monthly soil moisture content was found varying between vayals and the values were plotted in (Figure12). It was maximum in Pachakanamvayal with118% in the month of June and lowest soil moisture content was recorded (28%) from Pothukandam vayal during December. In Pothukandam vayal highest moisture content was observed in the month of august (39.68 %) and lowest in the month of December (28.23 %). Pachakanam vayal which had the highest soil moisture contents was found to have maximum contents in the month of June (118 %) and lowest in May (69.98%). In Uppuparthavalam vayal soil moisture content varied between 95.42% in the month of September to 53.07%in October. In Uppupara tower vayal highest soil moisture content was observed in the month of September (66.09%) and lowest soil moisture in the month of March (41.65%). In circle road vayal highest soil moisture content in the month of September (61.51%) and lowest soil moisture content in the month of March (45.8%).

Moisture/water content determines the fate of wetland systems, hence it is important to understand the minimum moisture level that should be required to maintain them in a marshy state. For this purpose, an extensive monthly sampling was done in different vayals in each month and estimated its moisture content. Based on these data a

polynomial was fitted and the optimum range of moisture was assessed using a boundary line approach. Accordingly, the optimum moisture ranges for the vayal systems was found to be 70-74% as derived from twelvelve month data and representative graph for different season were provided (Figure 13-15). The monthly moisture contents of the analysed vayal systems indicates three of them never exceeds 60% soil moisture level and based on which they are in different levels of degradation (Figure 12). The results clearly indicates that among the five studied vayals, three were below optimum level in which Pothukandam vayal require special attention which had a moisture value of < 40% throughout the year.

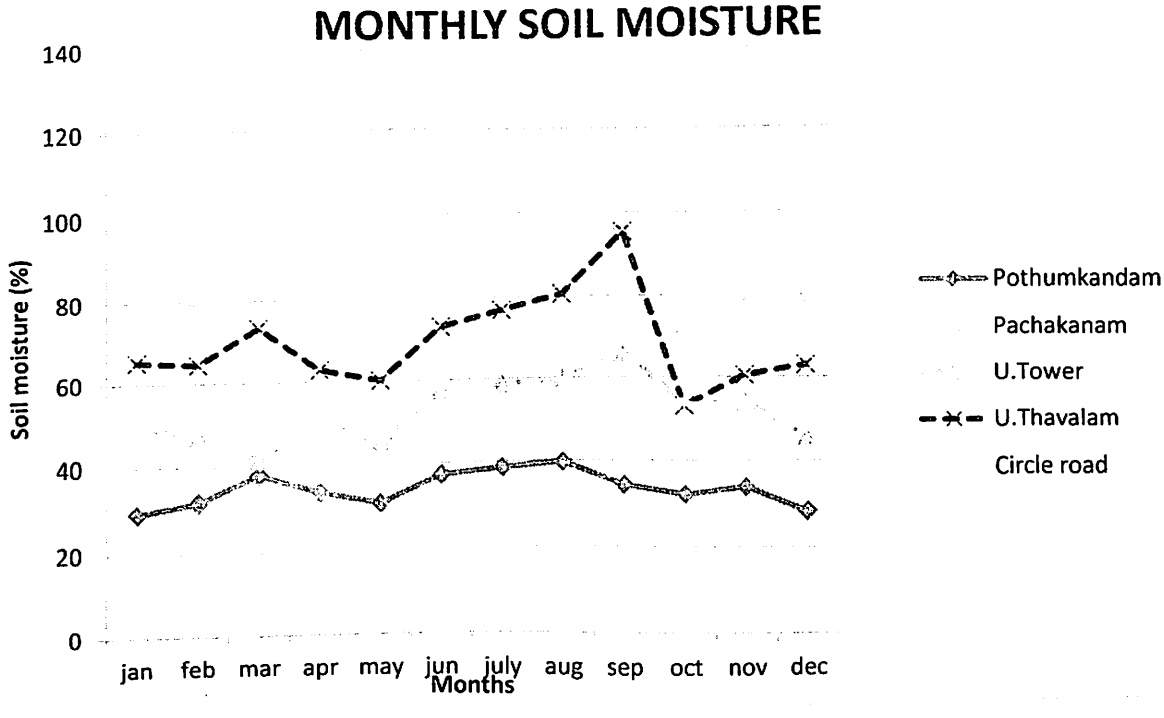

Figure 12: Soil moisture dynamics in different vayals

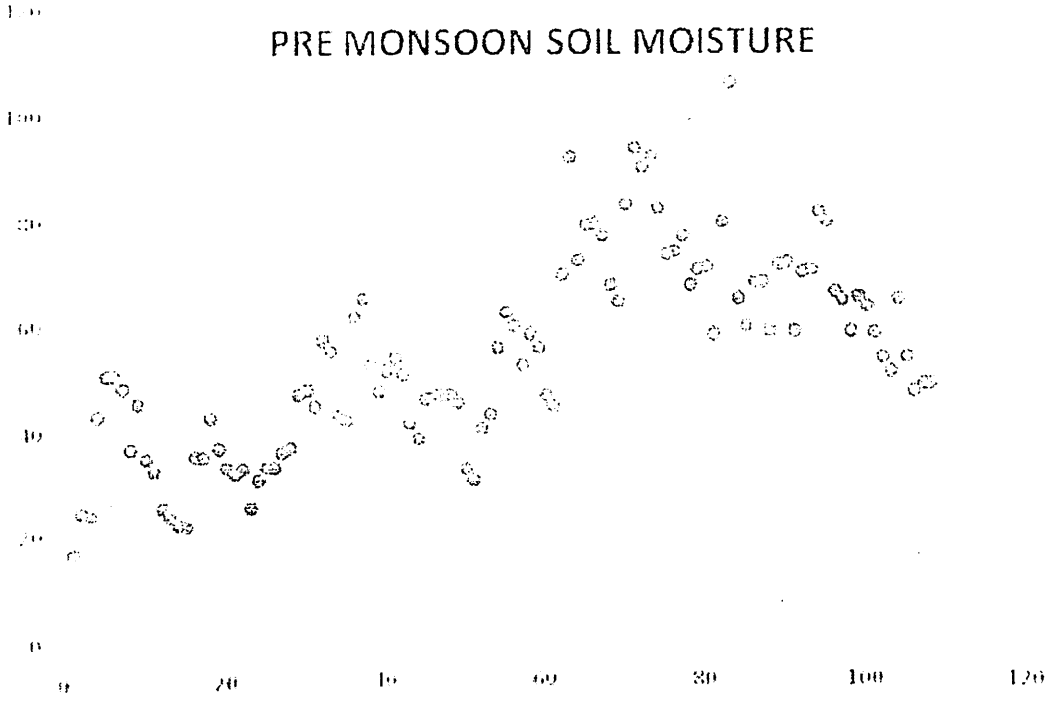

Figure 13: Second order polynomial for deriving optimum value for soil moisture (Representative Graph) for vayals of Periyar Tiger Reserve

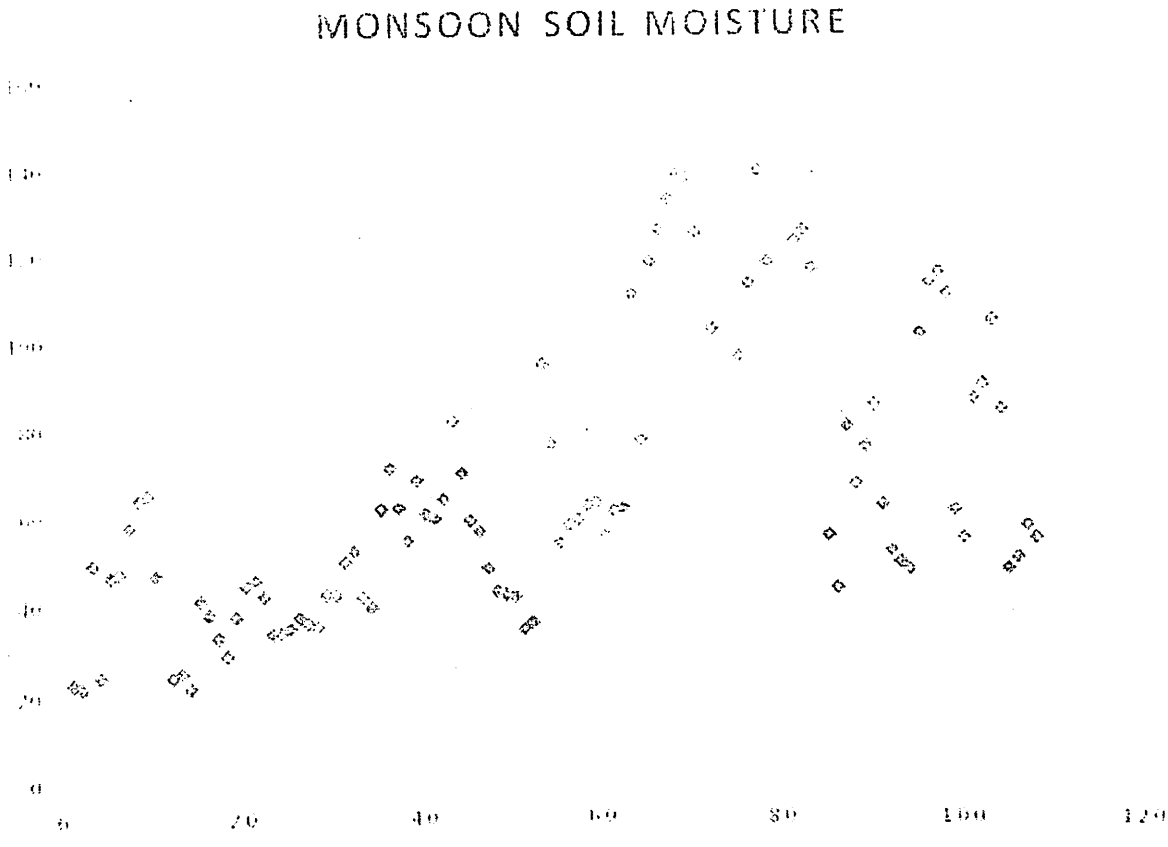

Figure 14: Second order polynomial for deriving optimum value for soil moisture (Representative Graph) for vayals of Periyar Tiger Reserve

Table 14: Soil texture Analysis

Plots	Clay	Silt	Sand	Soil texture
	(%)			
Pachakanam	27.58	13.39	59.03	Sandy clay
Uppupara Tower	24.39	16.69	58.92	Sandy clay
Uppupara Thavalam	22.55	17.88	59.56	Sandy clay
Circle road	20.55	6.98	72.47	Sandy clay
Pothumkandam	3.61	5.28	91.09	Sand

5.3.3. Soil pH

All the vayals Pachakanam, Pothukandam, Uppupara Thavalam,Uppupara Tower and circle road were acidic in nature. The pH values ranged from 3.97 (Post monsoon, Uppupara) to 5.3 (Pre monsoon, Pachakanam). In Pachakanam vayal high pH value was observed in pre monsoon season (5.3) and the low pH value in post monsoon season (4.4). In Uppupara thavalam vayal the pH value was high in monsoon season (4.83) and low in post monsoon season (4.18). High pH value was observed in Uppupara tower during monsoon (4.8) while the values dropped below 4.0 during post monsoon season. High pH value was observed in circle road vayal in the post monsoon season (4.8) and low pH value in pre monsoon season (4.5) (Fig16).Vayal systems being a submerged system leaches most of the basic ions leaving the soils in an acidic state.

0.14 pre monsoon), d. Uppupara Thavalam (0.68 pre monsoon; 0.109 monsoon), and in Circle road there was no significant variation in the EC values between different season(Fig17). Electrical conductivity is a measure of salt content and the variations in EC during different seasons can be attributed to the season water flows to these systems during different periods. Pothukandam vayals with a high EC during the monsoon indicates a washing down and subsequent accumulation of salts during monsoon. However such long term accumulation trends will lead to a saline layer determinal to rhizosphere in the subsoil. When management strategies by way of water retention is planned in such vayal systems, it should be ensured that they get a continuous flow of good quality water with minimal salts.

5.3.5. Organic carbon

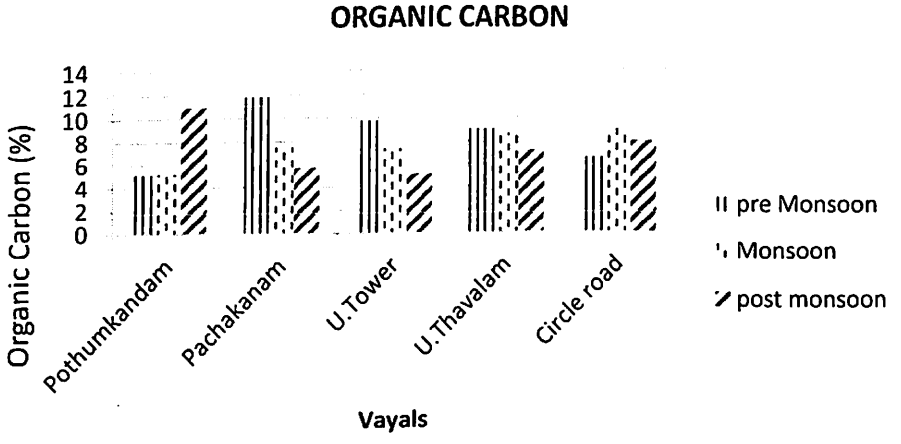

Figure 18: Organic carbon across five selected vayals in three seasons

The value of organic carbon was found to be in the range 5.0 to 11.8. High organic carbon contents in pachakanam vayal was observed during the pre-monsoon season (11.79%) and low value in the post monsoon season (5.66%). In pothumkandam vayal the value was ranged between 5.1 (pre monsson) and 10.93 (post monsoon). High organic carbon in Uppupara tower was observed in pre monsoon season (9.73%) and low in the post monsoon season (5.07%). High organic carbon in Uppupara thavalam vayal was observed in the pre monsoon season (8.99%) and low value in the post monsoon season (7.15%). Theorganic carbon in circle road vayal observed in the monsoon season was

8.95% and low value in the pre monsoon season (6.5%) (Fig18).Apart from Pothukandam and circle road vayal, all other studied system had higher organic carbon contents during the premonsoon period. This is due to the insitu addition of litter and root residues during the drier period of premonsoon. However, Pothukandam and circle road vayals were exceptions wherein post monsoon periods were higher in organic contents which may be due to insitu additions along with washing in of organic debris. Globally there is a continuous search for terrestrial carbon sinks for offsetting the rising atmospheric CO_2 concentrations. The study shows that vayal systems have soil organic carbon contents 2 – 3 times higher than the natural forest systems (organic carbon content: 2 - 3%) in the Western Ghats. Further, being submerged the organic debris decompose relatively slower, hence offers a good potential for carbon storage.

5.3.6. Available Nitrogen

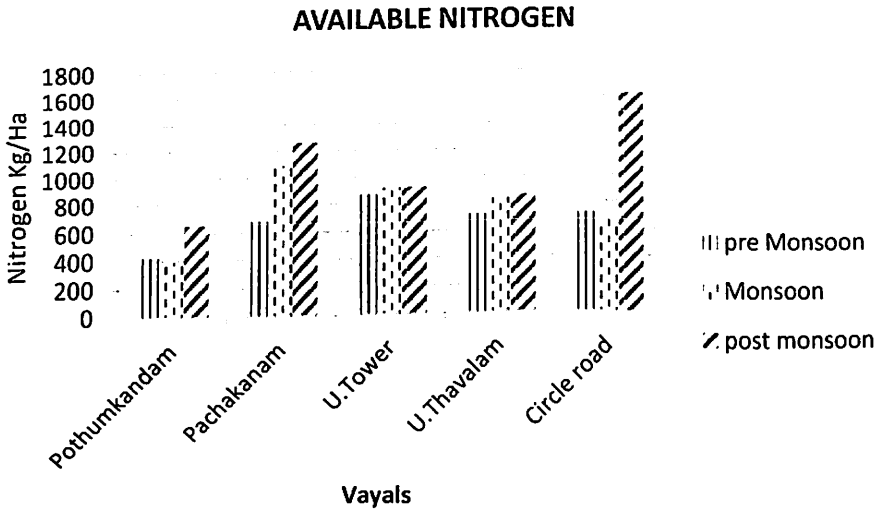

Figure 19: Available nitrogen across five selected vayals in three seasons

Irrespective of the studied vayals, the nitrogen contents were found to be high in these systems during post monsoon period and low during the monsoon months. The available nitrogen values were very high and ranged from 393.88 to 1613.68 kg/ha. The high nitrogen is primarily from organic carbon decomposition. The organic debris added during the pre-monsoon and post monsoon period decomposes slowly and releases nitrogen in these soils. This nitrogen provides the stimulus for fresh plant growth during

the post monsoon and pre monsoon periods. Processes which disrupt this cycle or planting trees along the vayal borders/invasion of nitrogen competitive species may put pressure on this ecosystem and degrade them. Unlike nitrogen, other primary (P, K), secondary (Mg) and micronutrients (Fe, Mn, Zn and Cu) had higher contents during the premonsoon or monsoon periods. The values of P ranged from 6.78 to 29.52 kg/ha, K from 88.37 to 274.59 kg/ha, Mg from 81.88 to 438.20 kg/ha, Fe from 68.53 to 300.84 kg/ha, Mn from 4.62 to 56.92 kg/ha, Zn from 1.23 to 5.85 kg/ha and Cu from 2.24 to 7.97 kg/ha in different vayal systems (Figure19-26).

5.3.7. Available Phosphorus

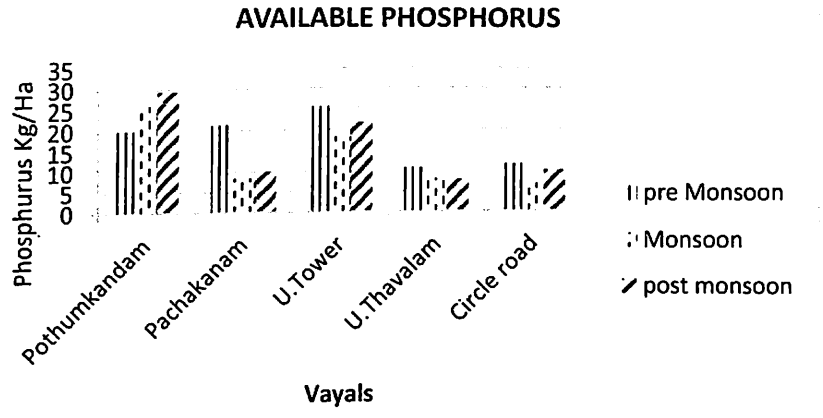

Figure 20: Available phosphorus across five selected vayals in three seasons

5.3.8. Available Potassium

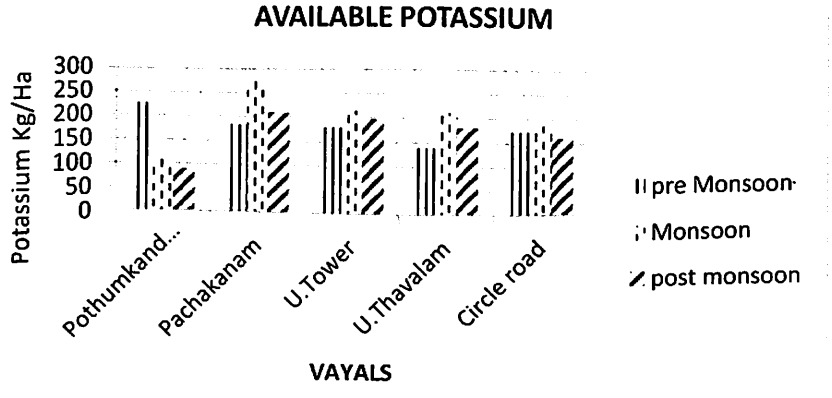

Figure 21: Available potassium cross five selected vayals in three seasons

5.3.9. Available magnesium

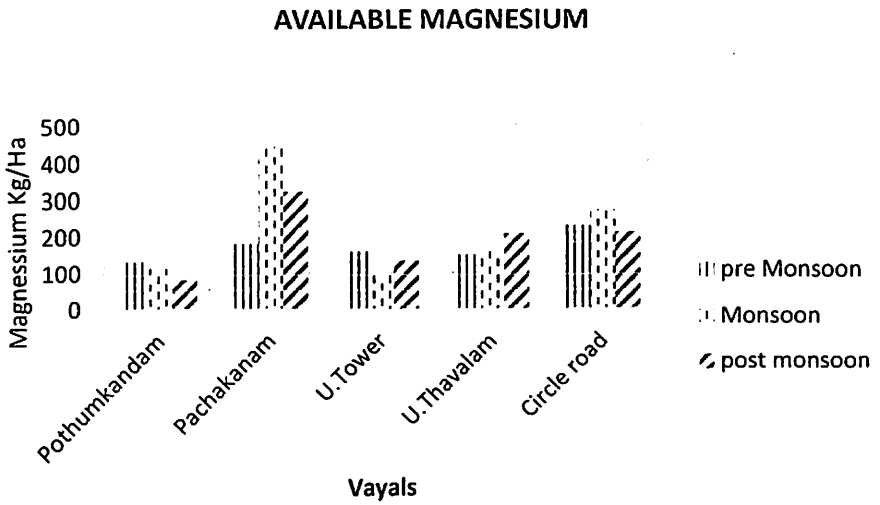

Figure 22: Available magnesium across five selected vayals in three seasons

5.3.10. Available micronutrients

Fe

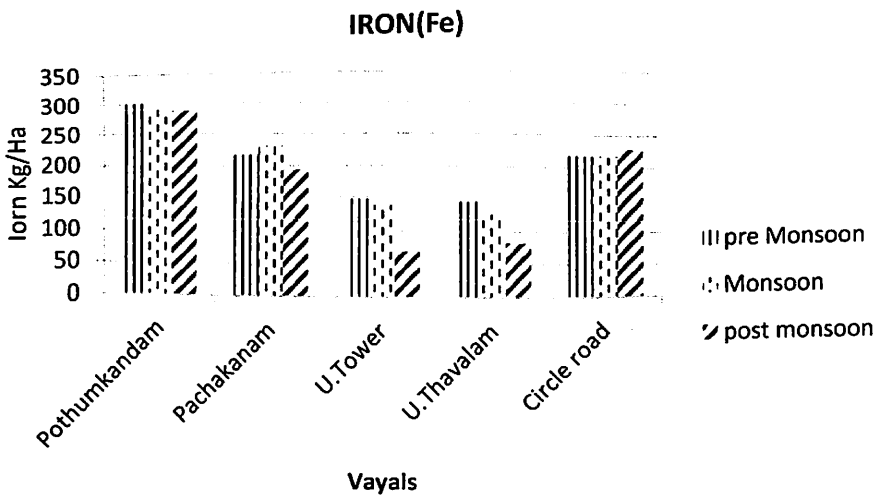

Figure 23: Available iron across five selected vayals in three seasons

Cu

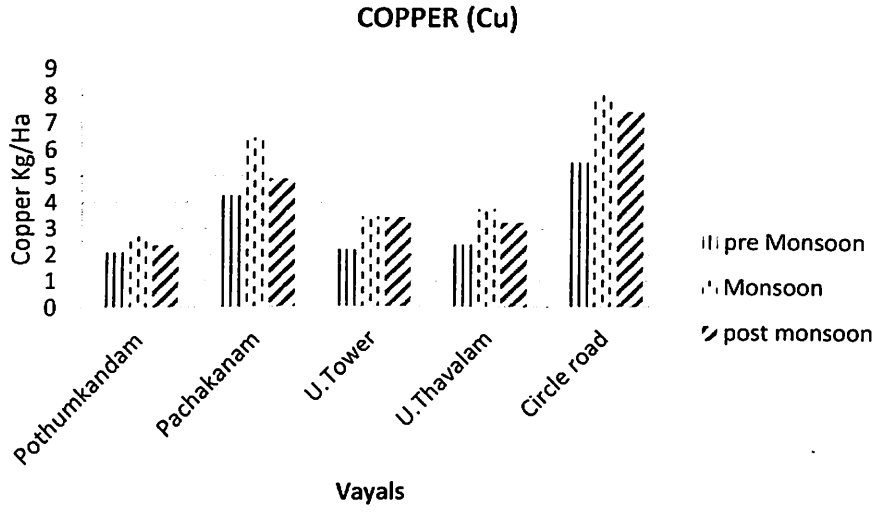

Figure 24: Available copper across five selected vayals in three seasons

Mn

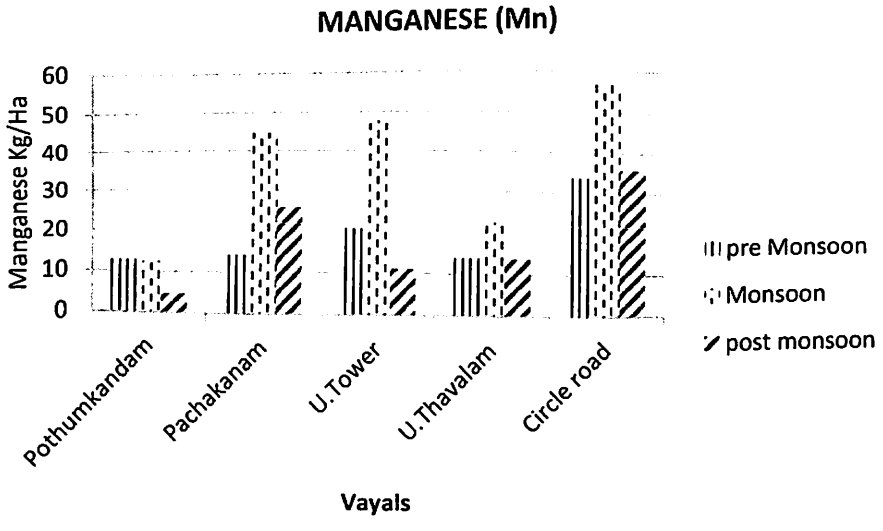

Figure 25: Available manganese across five selected vayals in three seasons

Zn

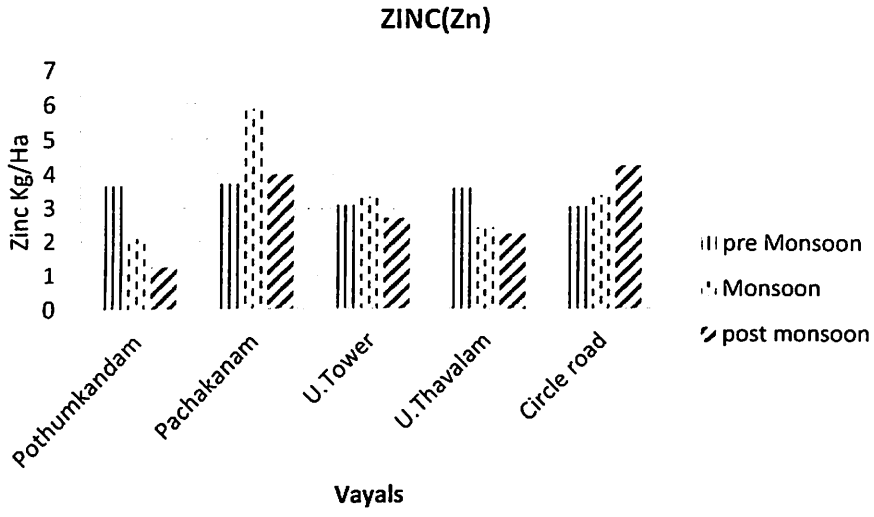

Figure 26: Available zinc across five selected vayals in three seasons

5.4. Faunal Inventory

These grass dominated marshy meadows are used by animal groups like arthropods, amphibians, reptiles, birds and mammals and they are using this habitat in different ways to satisfy their needs like breeding, feeding, resting etc. Twenty three species of amphibians, 24 species of reptiles, 63 species of birds and 19 species of mammals were recorded from the 140 vayals surveyed (Fig27)

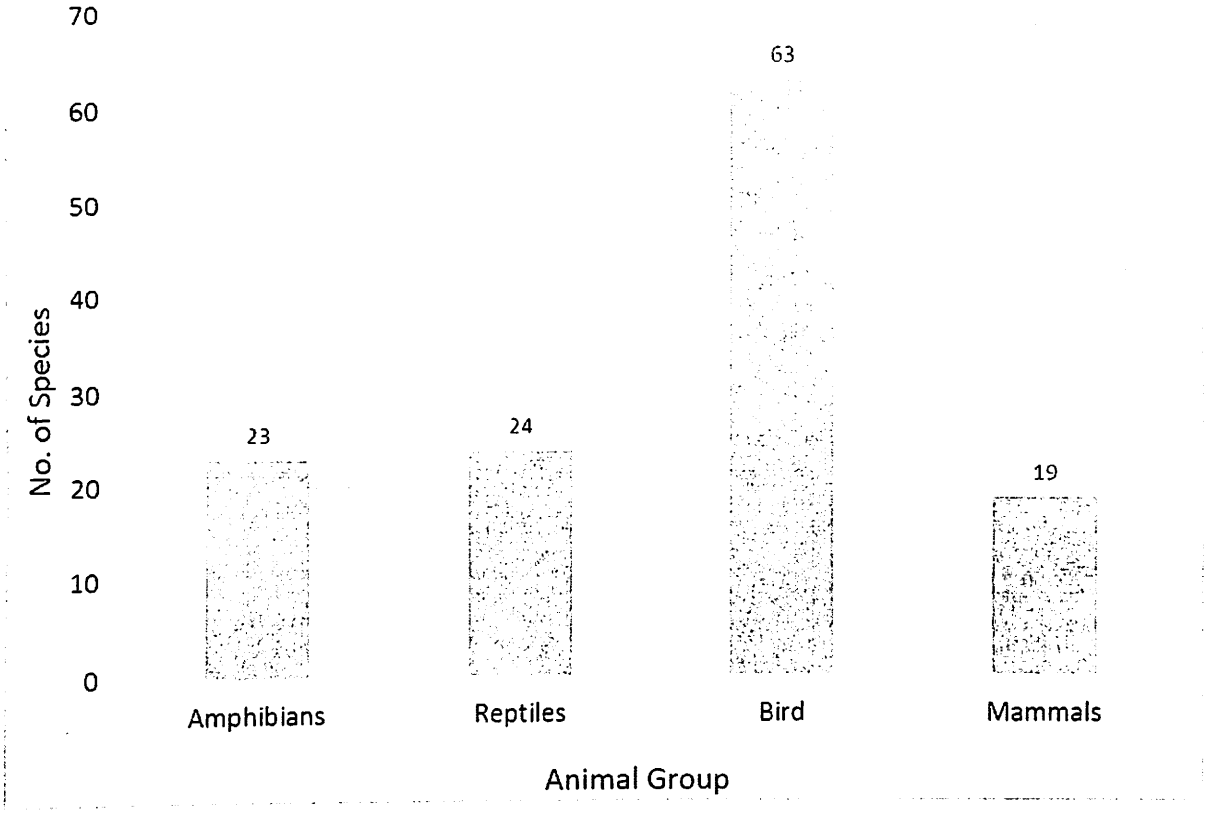

Figure 27: Number of species recorded from different animal group from vaysl of Periyar Tiger Reserve

Since, animal dependence data were collected every month only from a few selected vayals, opportunistic sighting records are also included to prepare a complete checklist of animals visiting vayals. The number of species recorded from each group is compared with the total number of species in that group recorded from PTR. The long term monitoring and opportunistic data collection resulted in 23 species of amphibians from vayals across five Forest Ranges compared to about 50 species of frogs recorded so far from PTR (Das *et al.*, 2015). Twenty four out of 48 species of reptiles recorded from PTR were seen in the vayals. Considering the very low proportion of the vayals in the total extent, the vayals harbor about 50% of the herpetofaunal diversity indicating the conservation significance of this unique ecosystem. In addition, this study could record 63 species of birds (323 species from PTR) and 19 species of mammals (66 species from PTR) in the vayals.

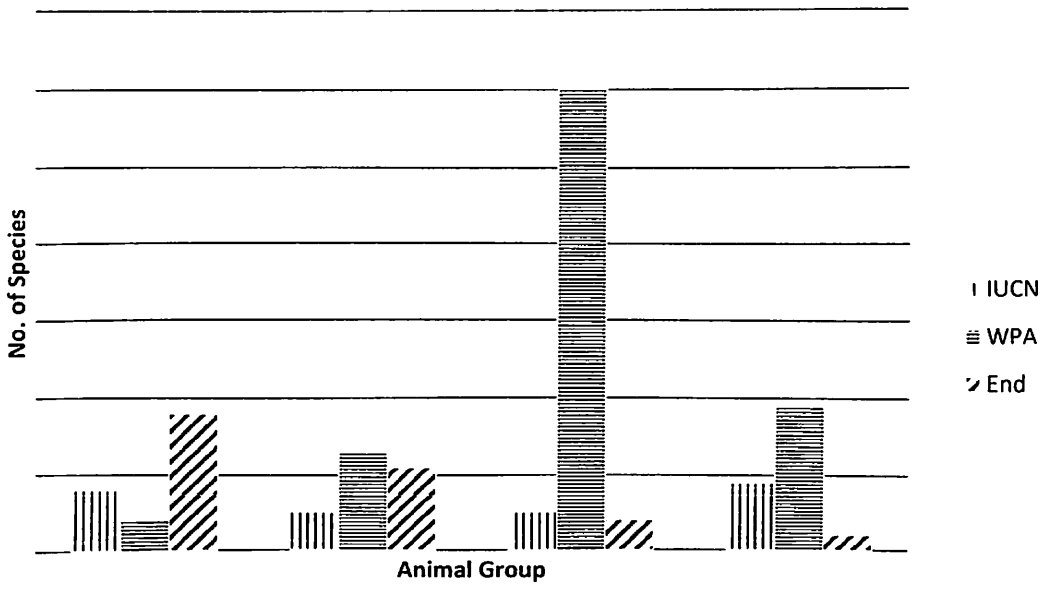

Figure 28: Representation of IUCN listed, scheduled and endemic animals present in vayal (IUCN-International Union For Conservation of Nature and Natural Resources Red listed species, WPA-Wildlife (Protection) Act 1972 scheduled animals, Endemic-Endemic to Western Ghats)

Since amphibians and reptiles are very specific to their microhabitat, their territory will be very small and the same makes them more vulnerable to threats. Almost 90% of the frogs recorded from Kerala are endemic to Western Ghats (Das, 2015). About 72% of the frogs recorded from vayals are endemic to Western Ghats (Table 16). Reptiles are another group showing high degree of endemism. About 45% of the reptiles recorded from vayals are endemic to Western Ghats. This is followed by birds (7.93%) and mammals (5.88%) (Figure 28). Any change in the structure and composition of the vayals would adversely affect the herpetofauna of the area, probably leading to the local extinction.

5.4.1. Amphibians

The amphibian diversity in PTR is not well documented. The known amphibians belong to two orders; order Anura the frogs and toads, and Gymnophiona the limbless amphibians called caecilians. Based on a recent study by Das *et al.* (2015), 50 species of amphibians were recorded from the study area. The list of amphibians seen during our study is given in Appendix 3.

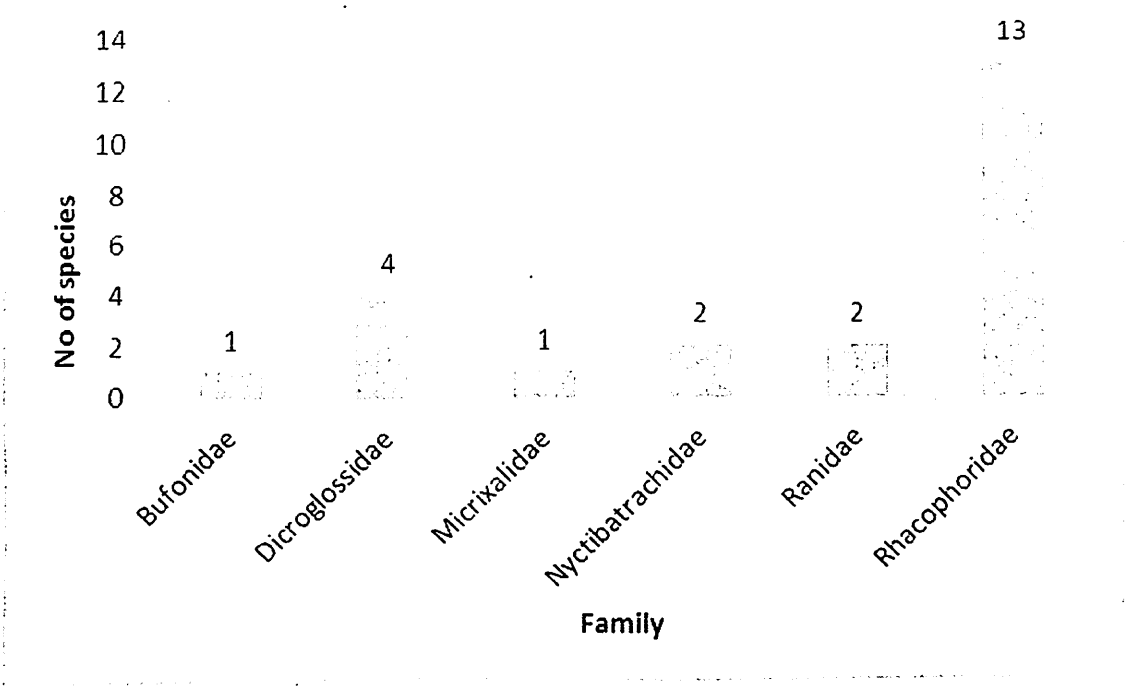

Figure 29: Family wise contribution of Amphibians in vayals of PTR

The family Rhacophoridae is the largest family which occurs in Asia and Africa represents bush frogs and gliding frogs and which is most represented in the vayals. Thirteen species of frogs recorded from the vayals belong to this family (Figure 29). The Periyar and Vallakadavu Ranges have representations of most of the frogs recorded from the vayals (Figure 30).

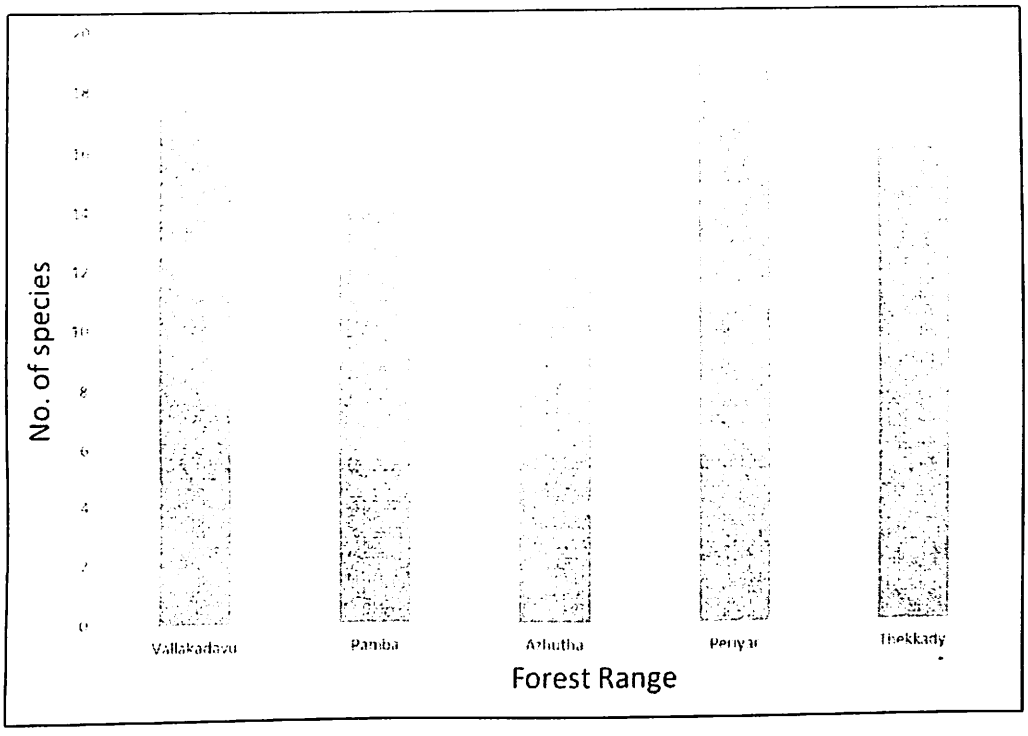

Figure 30: Amphibian species richness across vayals in different Forest Ranges of Periyar Tiger Reserve

Table 15: Frogs endemic to Kerala

Sl. No.	Family	Common name	Scientific name
1	Micrixalidae	Munnar Torrent Frog	*Micrixalus adonis*
2	Nyctibatrachidae	Gavi Night Frog	*Nyctibatrachus gavi*
3	Nyctibatrachidae	Periyar Night Frog	*Nyctibatrachus periyar*

The endemic frogs to Kerala belongs to two families, Micrixalidae and Nyctibatrachidae. The night frogs belong to the family Nyctibatrachidae and the genus is Nyctibatrachus. These two (Micrixalus and Nyctybatrchus genus) are endemic to Western Ghats (Table 15). The Micrixalidae are otherwise called as Torrent frogs as they inhabit in the torrential streams in the evergreen forests. These frogs are diurnal in nature and they call during the day time sitting on the vantage points in the streams like small exposed rocks. Their call is feeble since they inhabit the fast flowing streams. They used to wave their hind limbs to communicate with the conspecifics. This frog is seen in the streams of

Vathalamkuthy vayal. Karimala vayal. Alinchodu vayal. Chembakavally vayal. and Mukkar treck path vayals in Periyar Forest Range.

The wrinkled skinned night frogs inhabit of the perennial streams and they are unique to the geographic region. These night frogs are always have seen near to the streams and they having large eyes that facing upwards. The *Nyctibatrachus gavi* and *N. periyar* are commonly seen in the Uppupara Thavalam, Uppupara Tower, Seethakulam vayal, 20 Hectare check dam vayal.

The frog diversity in Kerala shows a high degree of endemism. There are about 151 species of frogs are known to occur in Kerala and about 90% (136 frogs) of the frogs are endemic to Western Ghats (Das, 2015). Here the list (Table 16) which endemic frogs reported from the vayals of PTR during this study.

Table 16: Western Ghats endemic frogs from vayal

Sl. No.	Family	Common name	Scientific name
1	Ranidae	Bicoloured Frog	*Clinotarsus curtipes*
2	Ranidae	Fungoid Frog	*Indosylvirana sreeni*
3	Rhacophoridae	Charpa Tree frog	*Polypedates occidentalis*
4	Rhacophoridae	Variable Bush Frog	*Raorchestes akroparallagi*
5	Rhacophoridae	Anil's Bush Frog	*Raorchestes anili*
6	Rhacophoridae	Griet Bush Frog	*Raorchestes griet*
7	Rhacophoridae	Beddome's Bush Frog	*Raorchestes beddomii*
8	Rhacophoridae	Water Drop Frog	*Raorchestes nerostagona*
9	Rhacophoridae	Travancore Bush Frog	*Raorchestes travancoricus*
10	Rhacophoridae	Jayaram's Bush Frog	*Raorchestes jayarami*
11	Rhacophoridae	Waynad Bush Frog	*Pseudophilautus wynaadensis*
12	Rhacophoridae	Malabar Gliding Frog	*Rhacophorus malabaricus*
13	Rhacophoridae	Malabar False Tree frog	*Rhacophorus pseudomalabaricus*
14	Rhacophoridae	Kalakkad Tree Frog	*Rhacophorous calcadensis*

The water drop frog is one of the common tree frog found across all the vayals that surrounded by good woody vegetation. The frog uses tall trees as perch and they call on high up in the trees. The species is easily identified because of its unique loud call it resembles the sound of water droplet. Is body is mossy in nature so they easily merge with the tree bark with mosses (Plate 1).

The genus Rhacophorus represents Gliding frogs. Four species of Gliding Frogs were described till now from Western Ghats. The species are *Rhacophorus lateralis, R. malabaricus, R. calcadensis* and *R. pseudomalabaricus.* Except *R. malabaricus* all the three species are falls under IUCN threatened category. *R. lateralis* is found only north to Wayanad. Rest of the three species was recorded from vayals. They build foam nest for breeding, the nests will be over some water pools, when the egg hatches the tadpole will drop in to the pool and they metamorphosis in to miniature adult frogs from these pools. The Malabar False Tree Frog (Plate 1) is seen in the vayals near to Gavi and Meenar. This Critically Endangered green frog breeds during the monsoon. They build foam nests on trees and the nests should be over the small pools, so they choosing the vayals for breeding. This frog is common in the newly added area from Goodrical Forest Range. So the protection of the vayals is really important for their survival.

Table 17: Frogs protected under Wildlife Protection Act 1971

Sl. No.	Family	Common name	Scientific name
1	Dicroglossidae	Skittering Frog	*Euphlyctis cyanophlyctis*
2	Dicroglossidae	Indian Bullfrog	*Hoplobatrachus tigerinus*
3	Dicroglossidae	Kerala Warty Frog	*Zakerana keralensis*
4	Ranidae	Bicoloured Frog	*Clinotarsus curtipes*

Out of the 151 species of frogs known from Kerala about 50 species are falls under different IUCN threatened categories (Das, 2015). Here the table 18 shows the threatened frogs present in the vayals of PTR.

Table 18: Frogs categorized under IUCN red list

Sl. No.	Family	Common name	Scientific name
1	Ranidae	Bicoloured Frog	*Clinotarsus curtipes*
2	Rhacophoridae	Griet Bush Frog	*Raorchestes griet*
3	Rhacophoridae	Beddome's Bush Frog	*Raorchestes beddomii*
4	Rhacophoridae	Water Drop Frog	*Raorchestes nerostagona*
5	Rhacophoridae	Travancore Bush Frog	*Raorchestes travancoricus*
6	Rhacophoridae	Waynad Bush Frog	*Pseudophilautus wynaadensis*
7	Rhacophoridae	Malabar False Tree frog	*Rhacophorus pseudomalabaricus*
8	Rhacophoridae	Kalakkad Tree Frog	*Rhacophorous calcadensis*

The *R. travancoricus* was considered to be extinct for a long time and was rediscovered in the recent past from Vagamon and Vandiperiyar (Biju and Bossuyt, 2009; Figure 31). During this study, the species was found from eight new locations from PTR. The first record of the frog was from Uppupara vayal of PTR. The frog was found actively calling on a grass culm about one to two meter height from ground. Even though the frog is seen in the open grassland and bushes near to the vayals, they are commonly seen in the marshy grassland ecosystems. The blue eyed direct developing frog is specific to the grasslands within 800 to 1900 msl in PTR. The nocturnal frog is active during the monsoon season. The eight locations were considered to be the last refuge of the species since the other two locations Vagamon and Vandiperiyar were outside Protected Area and under severe pressure from habitat destruction, landuse change, etc. (Rajkumar, *et al.* 2016).

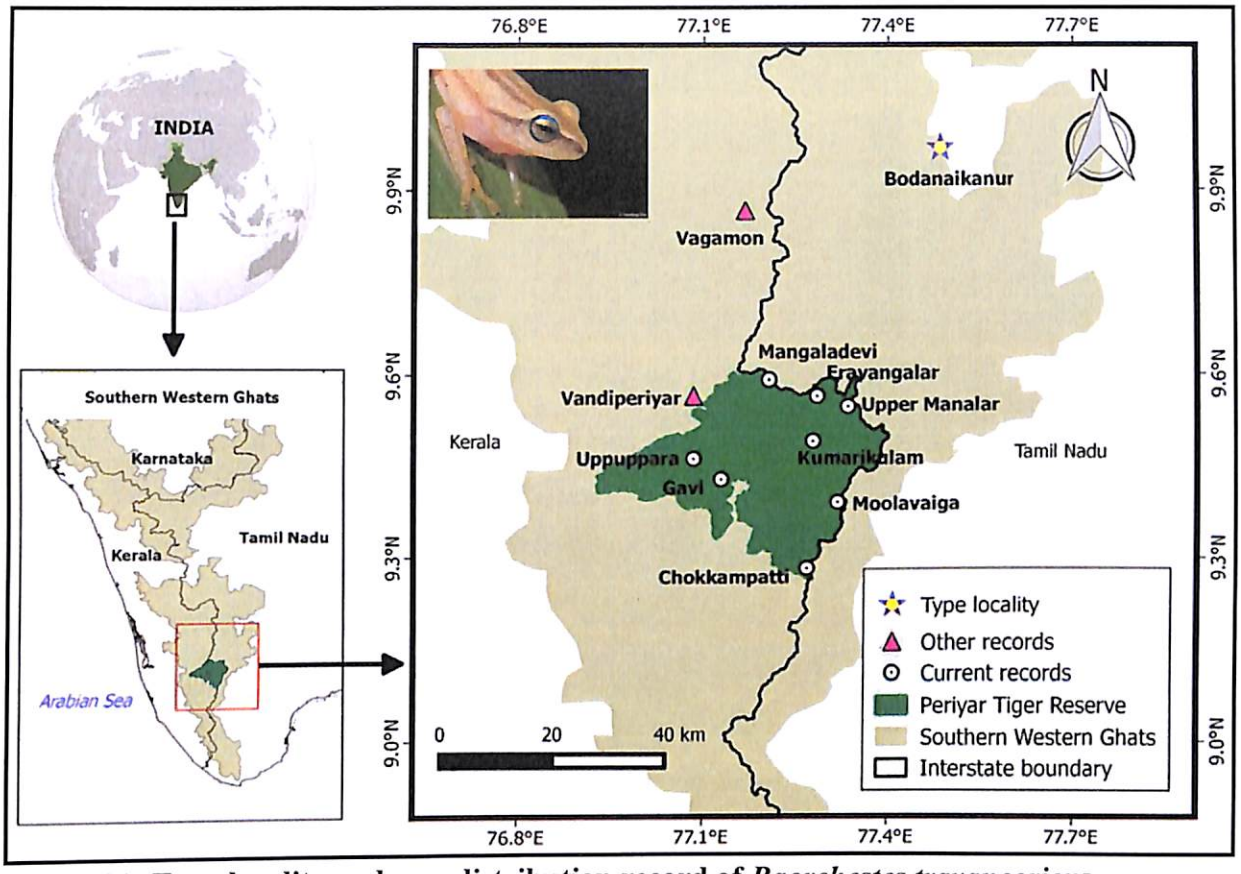

Figure 31: Type locality and new distribution record of *Raorchestes travancoricus*

5.4.2. Reptiles

Reptiles are very cryptic animals and very hard to find. These poikilothermic vertebrates use the open grass meadows in evergreen forests and other woody habitats like monoculture plantations for basking for maintaining their body temperature. The lizards like *Eutropis carinata* and *E. macularia* and *Kestlea* species are seen basking in the early morning rays in vayals. Snakes are rare to see in the day time but much active during the night and most of our observations were during the night scan searches.

About 24 species of reptiles belonging to two orders and ten families were recorded from vayals (Appendix 4). Reptiles from vayals represent about 35% of the total 68 reptiles recorded from PTR. Family Colubridae represents 11 species of reptiles followed by Gekkonidae with four species and Scincidae with four species (Figure 32).

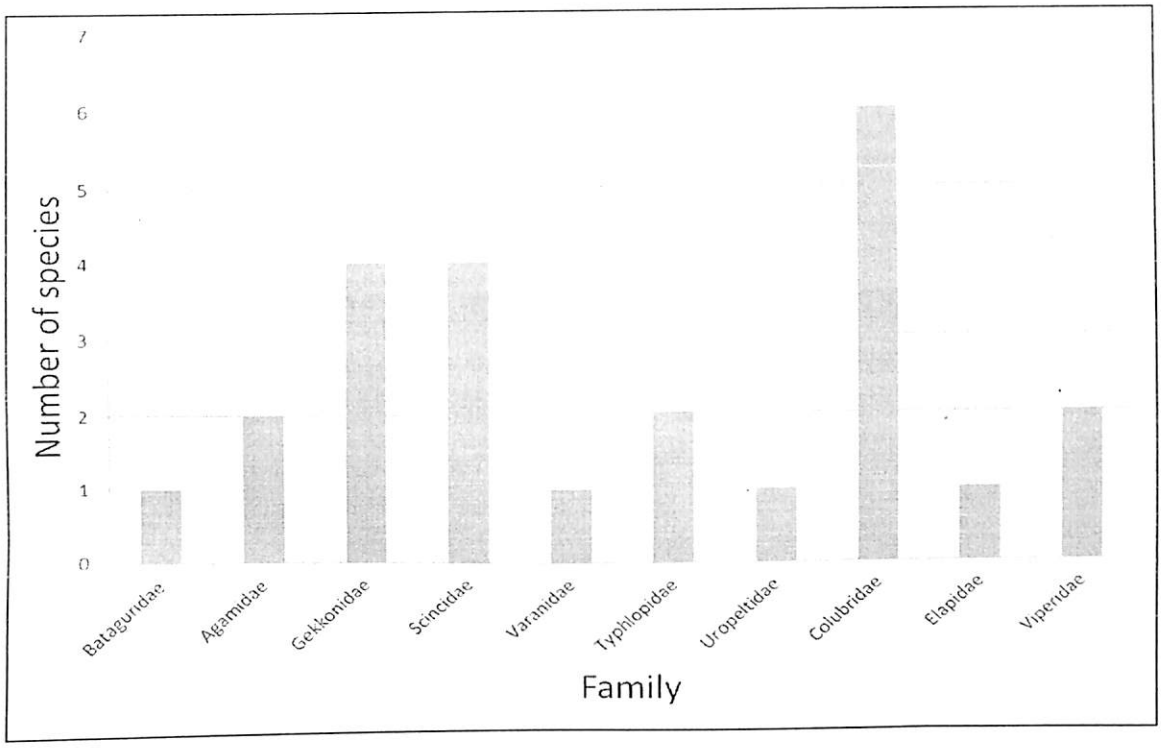

Figure 32: Family wise contribution of reptiles in vayals of Periyar Tiger Reserve

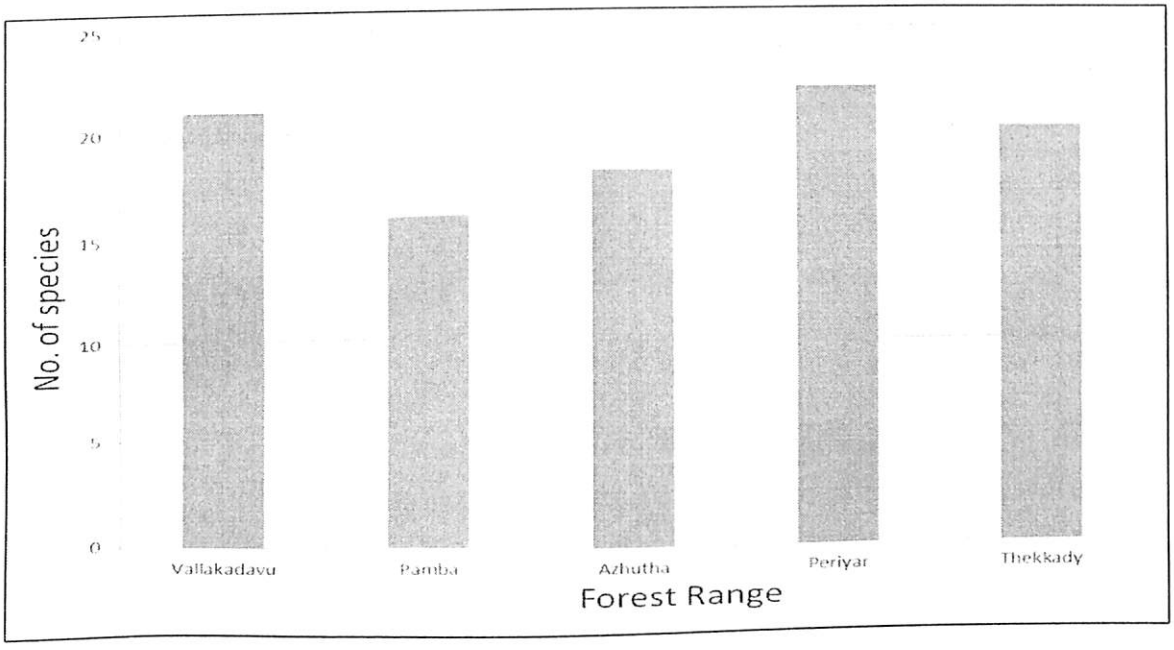

Figure 33: Number of reptile species across vayals in different Forest Ranges of PTR

Vayals in Periyar Forest Range support more number of reptiles (22 species) followed by Vallakadvu (21 species) and Thekkady (20 species). Vayals in Azhutha and Pamba Forest Ranges has 18 and 16 species respectively (Figure 33).

Table 19: Reptiles endemic to Kerala and Western Ghats

Sl. No.	Family	Common name	Scientific name
1	Agamidae	Elliot's Forest Lizard	*Calotes ellioti*
2	Gekkonidae	Wayanad Day Gecko*	*Cnemaspis wynadensis**
3	Gekkonidae	Anaimalai Gecko	*Dravidogecko anamallensis*
4	Scincidae	Travancore Ground Skink	*Kaestlea travancorica*
5	Scincidae	Side-spotted Ground Skink	*Kaestlea laterimaculata*
6	Uropeltidae	Pied-belly Shieldtail	*Melanophidium punctatum*
7	Colubridae	Beddome's keelback	*Hebius beddomei*
8	Colubridae	Hill keelback	*Hebius monticola*
9	Elapidae	Striped Coral Snake	*Calliophis nigrescens*
10	Viperidae	Malabar Pit Viper	*Trimeresurus malabaricus*
11	Viperidae	Large-scaled green pit viper	*Trimeresurus macrolepis*

***Reptile endemic to Kerala**

Out of 24 species of reptiles recorded from vayals, 11 are endemic to Western Ghats (Table 19). The *Cnemaspis wynadensis* is endemic to Kerala. Thirteen out of 24 species of reptile's recorded are protected under different schedules of Wildlife Protection Act 1972 (Table 20). *Melanochelys trijuga*, *Dravidogecko anamallensis* and *Trimeresurus macrolepis* are falls under the Near Threatened category the *Kaestlea laterimaculata* falls ubnder the Vunerable category and the *Cnemaspis wynadensis* is under the endangered category (Table 21).

Table 20: Reptiles from vayals protected under different schedules of Wildlife Protection Act 1972

Sl. No.	Family	Common name	Scientific name
1	Varanidae	Bengal Monitor	*Varanus bengalensis*
2	Typhlopidae	Brahminy Worm Snake	*Indotyphlops braminus*
3	Typhlopidae	Beaked Worm Snake	*Grypotyphlops acutus*
4	Uropeltidae	Pied-belly Shieldtail	*Melanophidium punctatum*
5	Colubridae	Indian Rat snake	*Ptyas mucosa*
6	Colubridae	Beddome's keelback	*Hebius beddomei*
7	Colubridae	Hill keelback	*Hebius monticola*
8	Colubridae	Checkered keelback	*Xenochrophis piscator*
9	Colubridae	Common vine snake	*Ahaetulla nasuta*
10	Colubridae	Ceylon cat snake	*Boiga ceylonensis*
11	Elapidae	Striped Coral Snake	*Calliophis nigrescens*
12	Viperidae	Malabar Pit Viper	*Trimeresurus malabaricus*
13	Viperidae	Large-scaled green pit viper	*Trimeresurus macrolepis*

Table 21: Reptiles from vayals included in IUCN red list

Sl. No.	Family	Common name	Scientific name
1	Bataguridae	Indian black turtle	*Melanochelys trijuga*
2	Gekkonidae	Wayanad Day Gecko	*Cnemaspis wynadensis*
3	Gekkonidae	Anaimalai Gecko	*Dravidogecko anamallensis*
4	Scincidae	Side-spotted Ground Skink	*Kaestlea laterimaculata*
5	Viperidae	Large-scaled green pit viper	*Trimeresurus macrolepis*

5.4.3. Birds

Birds are one of the other major group of vertebrates using this habitat as feeding ground. A total of 323 species of birds were recorded so far from PTR (Veeramani et al. 2005).

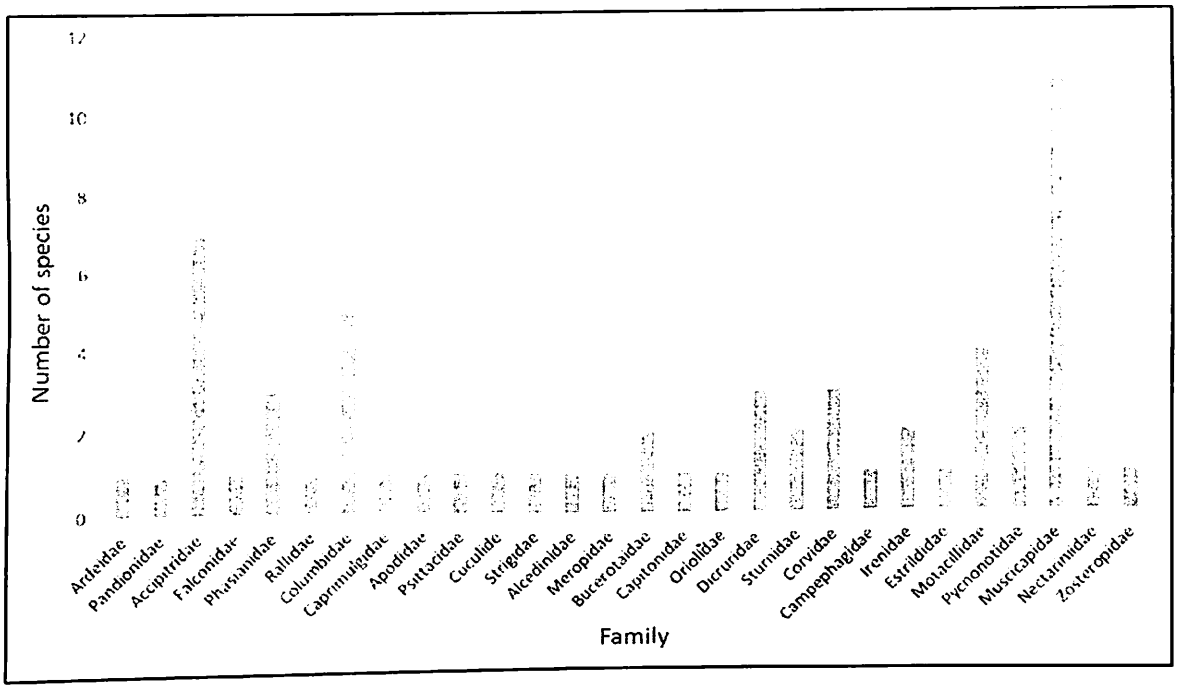

Figure 34: Family wise contribution birds in vayals of Periyar Tiger Reserve

Out of the 323 birds recorded from from PTR a total of 63 species were observed from vayals (Appendix 5). The family Muscicapidae is having higher number of representations with 11 species followed by Accipitridae and Columbidae with sven and five species respectively (Figure 34). Muscicapidae is the family of flycatchers. In a healthy habitat normally the number of flycatcher will be more when compared to other group of birds. Accipitriformes are birds of prey and family Columbidae is the Dove family.

The vayals in Vallakadavu, Pamba and Periyar support more number of birds due to the thick vegetation around the vayals. About 56 species of birds were observed from Vallakadavu and 55 and 51 species from Pamba and Periyar Forest Ranges respectively (Figure 35). The birds mostly use these vayals as a feeding ground, like the jungle myna and munia, feed on the seeds of grass found in the vayals. However, a few of the birds feed on the animals that found in the vayal.

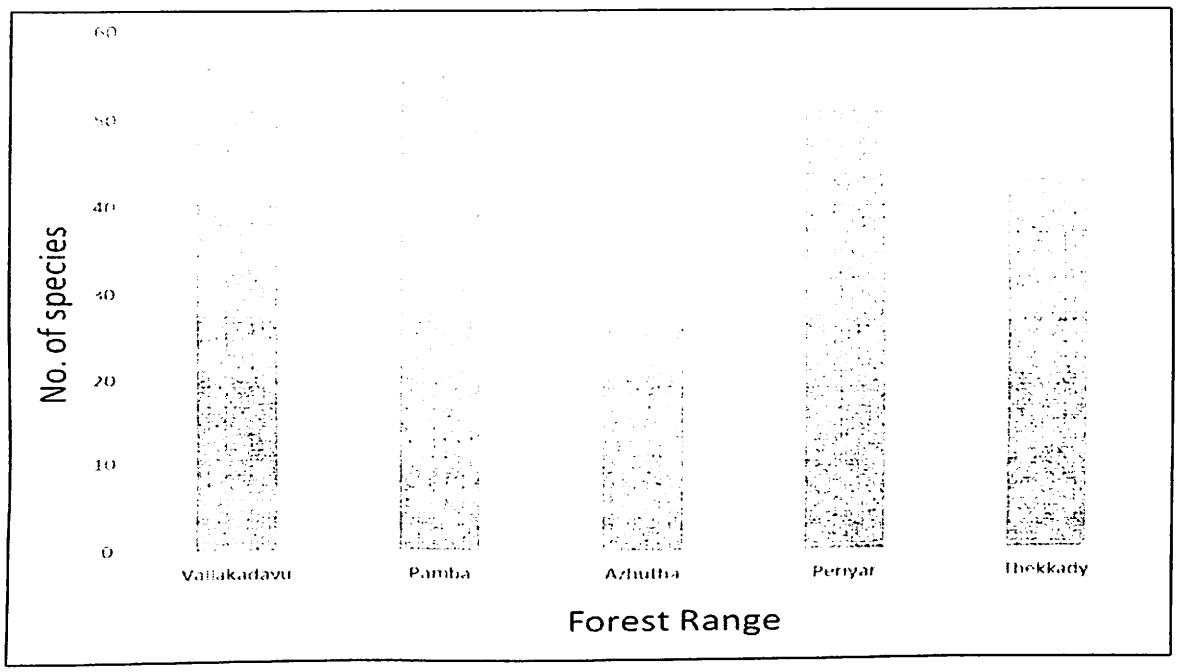

Figure 35: Number of bird species across vayals in different Forest Range of PTR

Table 22: Birds endemic to Western Ghats and categorized under IUCN red list

Sl. No.	Family	Common name	Scientific name
1	Columbidae	Nilgiri Wood Pigeon	*Columba elphinstonii*
2	Psittacidae	Blue-Winged Parakeet	*Psittacula columboides*
3	Bucerotaidae	Malabar Grey Hornbill	*Ocyceros griseus*
4	Bucerotaidae	Great Hornbill*	*Buceros bicornis*
5	Motacillidae	Nilgiri Pipit	*Anthus nilghiriensis*

*Bird not endemic to Western Ghats

Out of the 63 species recorded from vayals, four birds are endemic to Western Ghats. Five birds are categorized under IUCN red list. Nilgiri Wood Pigeon, Malabar Grey Hornbill and the Blue-Winged Parakeet are categorized as Vulnerable under IUCN threatened category. These three birds are seen in almost all the vayals. But the Malabar Grey Hornbill's are not seen in vayals that surrounded by eucalyptus plantations and open grass lands. The other vulnerablr Nilgiri Pipit was seen only in the vayals that in open grassland ecosystem like Seethakulam, Uppupara Thavalam, and Uppupara Tower Vayals. Great

Hornbill are commonly seen in vayals surrounded by tall trees (like Poovarashu vayal, Kokkara vayal). So protection of the vayals in grasslands is not only important for rare and endangered frogs, it is equally important for the bird like Nilgiri Pipit.

Table 23: Birds protected under Wildlife Protection Act 1972

Sl. No.	Family	Common name	Scientific name
1	Ardeidae	Indian Pond Heron	*Ardeola grayi*
2	Accipitridae	Black Baza	*Aviceda leuphotes*
3	Accipitridae	Oriental Honey Buzzard	*Pernis ptilorhynchus*
4	Accipitridae	Black Eagle	*Ictinaetus malaiensis*
5	Accipitridae	Crested Serpent Eagle	*Spilornis cheela*
6	Falconidae	Common Kestrel	*Falco tinnunculus*
7	Phasianidae	Grey Junglefowl	*Gallus sonneratii*
8	Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus*
9	Columbidae	Blue Rock Pigeon	*Columba livia*
10	Columbidae	Nilgiri Wood Pigeon	*Columba elphinstonii*
11	Columbidae	Spotted Dove	*Streptopelia chinensis*
12	Psittacidae	Blue-Winged Parakeet	*Psittacula columboides*
13	Cuculide	Lesser Coucal	*Centropus bengalensis*
14	Strigidae	Jungle Owlet	*Glaucidium radiatum*
15	Alcedinidae	White Thoated King-Fisher	*Halcyon smyrnensis*
16	Bucetotaidae	Malabar Grey Hornbill	*Ocyceros griseus*
17	Capitonidae	White-cheeked Barbet	*Psilopogon viridis*
18	Oriolidae	Indian Golden Oriole	*Oriolus kundoo*
19	Dicruridae	Ashy Drongo	*Dicrurus leucophaeus*
20	Dicruridae	Bronzed Drongo	*Dicrurus aeneus*

Table 23 (Cont'd): Birds protected under Wildlife Protection Act 1972			
21	Dicruridae	Greater Racket-tailed Drongo	*Dicrurus paradiseus*
22	Sturnidae	Jungle Myna	*Acridotheres fuscus*
23	Sturnidae	Hill Myna	*Gracula religiosa*
24	Corvidae	White-bellied Treepie	*Dendrocitta leucogastra*
25	Corvidae	House Crow	*Corvus splendens*
26	Corvidae	Jungle Crow	*Corvus macrorhynchos*
27	Campephagidae	Scarlet Minivet	*Pericrocotus flammeus*
28	Irenidae	Common Iora	*Aegithina tiphia*
29	Irenidae	Asian Fairy Bluebird	*Irena Puella*
30	Pycnonotidae	Red wiskered Bulbul	*Pycnonotus jocosus*
31	Pycnonotidae	Red-wented Bulbul	*Pycnonotus cafer*
32	Muscicapidae	Indian Scimitar Babbler	*Pomatorhinus horsfieldii*
33	Muscicapidae	Dark-fronted Babbler	*Rhopocichla atriceps*
34	Muscicapidae	Jungle Babbler	*Turdoides striatus*
35	S:F:Monarchinae	Asian Pardise-flycatcher	*Terpsiphone paradisi*
36	S:F:Sylviinae	Franklin's Prinia	*Prinia hodgsonii*
37	S:F:Sylviinae	Common Tailorbird	*Orthotomus sutorius*
38	S:F:Sylviinae	Blyth's Reed Wrabler	*Acrocephalu dumetorum*
39	S:F:Sylviinae	Large-billed Leaf-warbler	*Phylloscopus magnirostris*
40	Nectariniidae	Little Spiderhunter	*Arachnothera longirostra*
41	Zosteropidae	Oriental White-eye	*Zosterops palpebrosus*
42	Phasianidae	Painted Bush Quail	*Perdicula erythrorhynca*

Out of the 63 species of birds recorded from vayals 42 are protected under Wildlife Protection 1972 (Table 23). Most of the birds listed in Table 23 are found in the vayal surrounded by good woody vegetation but birds like Lesser Coucal, Common Kestral and Painted Bush Quail are showing more affinity towards vayals in grasslands. Lesser Coucal is more specifically seen in vayals with tall grasses like Circle road vayal, Uppupara Thavalam Vayal, Uppupara Tower Vayal.

Table 24: Birds categorized under IUCN red list

Sl. No.	Family	Common name	Scientific name
1	Columbidae	Nilgiri Wood Pigeon	*Columba elphinstonii*
2	Psittacidae	Blue-Winged Parakeet	*Psittacula columboides*
3	Bucerotaidae	Malabar Grey Hornbill	*Ocyceros griseus*
4	Motacillidae	Nilgiri Pipit	*Anthus nilghiriensis*

5.4.4. Mammals

These unique habitats are the prime grassing lands for the larger herbivores like elephant, gaur, sambar, barking deer. Animals like wild boar and porcupine are using this area as their foraging ground. Elephants use this area also for wallowing to keep them selves cool especially during the post monsoon season. A total of 19 species of mammals belonging to 15 families were recorded (Figure 35). The scat analysis of tiger from PTR shows sambar as the most preferred prey (48.2%) followed by gaur (22.5%) and then wild boar (14.6%), porcupine (10.3%) and barking deer (4.4%).

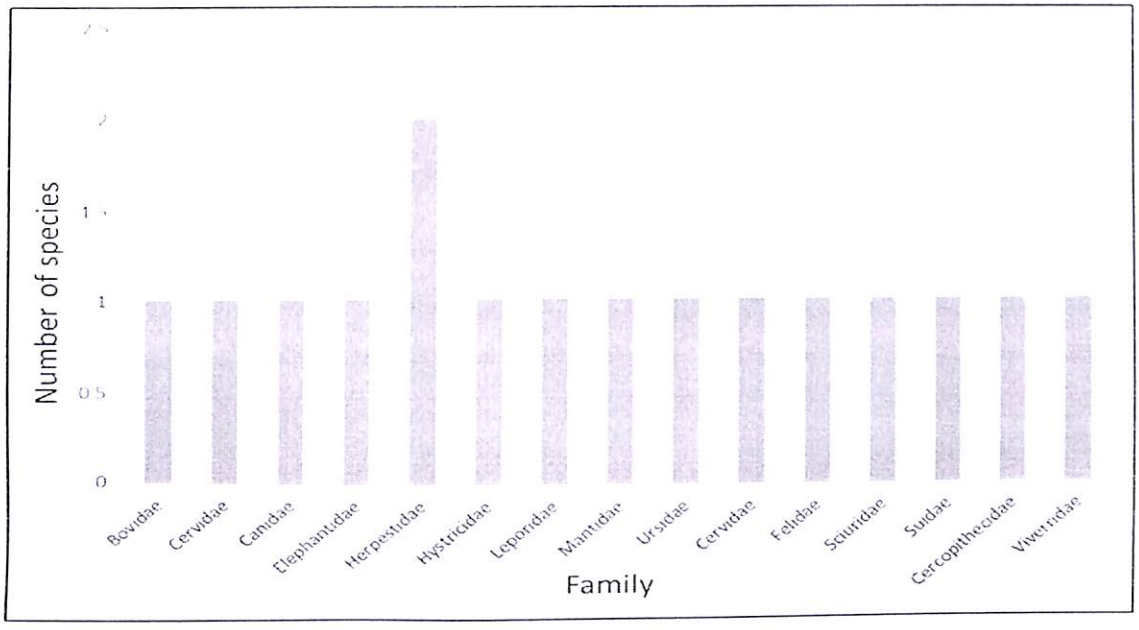

Figure 36: Family wise contribution of Mammals in vayals of PTR

A total of 19 species of mammals belonging to 15 families were recorded (Figure 36). The family Herpestidae have two species, where as all other family have only species each.

Figure 37: Number of species of mammals across vayals in different Forest Ranges of PTR

When mammals were consider, Vayals in Vallakadvu Forest Range is more diverse when compare to vayals in other ranges with 18 species followed by Periyar and Thekkady with 17 and 16 species respectively (Figure 37).

Table 25: Mammals categorized under IUCN red list and Western Ghats endemic

Sl. No.	Family	Scientific name	Common name
1	Bovidae	Bos gaurus	Gaur
2	Cervidae	Rusa unicolor	Sambar Deer
3	Canidae	Cuon alpinus	Indian Wild Dog (Dhole)
4	Elephantidae	Elephas maximus	Asian Elephant
5	Mantidae	Manis crassicaudata	Indian Pangolin
6	Ursidae	Melursus ursinus	Sloth Bear
7	Felidae	Panthera pardus	Leopard
8	Felidae	Panthera tigris	Tiger
9	Cercopithecidae	Semnopithecus johnii	Nigiri Langur*
10	Viverridae	Paradoxurus jerdoni	Brown-palm Civet*

*Wester Ghat endemic

Out of 18 mammals species recorded from vayals, nine species fall under different threatened categories of IUCN. Four species are Vulnerable as per IUCN category. These are *Bos gaurus, Rusa unicolor, Melursus ursinus* and *Semnopithecus johnii* (Table 25). All the mammals recorded from vayals are protected under different schedules of Wildlife Protection Act 1972.

Table 26: Mammals protected under Wildlife Protection Act 1972

Sl. No.	Family	Scientific name	Common name
1	Bovidae	Bos gaurus	Gaur
2	Cervidae	Rusa unicolor	Sambar Deer
3	Canidae	Cuon alpinus	Indian Wild Dog (Dhole)
4	Elephantidae	Elephas maximus	Asian Elephant
5	Herpestidae	Herpestes fuscus	Brown Mongoose
6	Herpestidae	Herpestes edwardsii	Common Mungoose
7	Herpestidae	Herpestes vitticollis	Stripe-necked Mongoose
8	Hystricidae	Hystrix indica	Indian Porcupine
9	Leporidae	Lepus nigricollis	Blacknaped Hare
10	Mantidae	Manis crassicaudata	Indian Pangolin
11	Ursidae	Melursus ursinus	Sloth Bear
12	Cervidae	Muntiacus muntjak	Barking Deer
13	Felidae	Panthera pardus	Leopard
14	Felidae	Panthera tigris	Tiger
15	Sciuridae	Ratufa indica	Indian Giant Squirrel
16	Suidae	Sus scrofa	Wild Boar
17	Cercopithecidae	Semnopithecus johnii	Nigiri Langur
18	Viverridae	Viverricula indica	Small Indian Civet
19	Viverridae	Paradoxurus jerdoni	Brown-palm Civet

5.5. Animal Dependence

The grass dominated marshy meadows are used by almost all the animal groups like arthropods, amphibians, reptiles, birds and mammals and they are using this habitat to satisfy their different life history needs like breeding, feeding, resting, grooming and other

major activities (Table 27). These meadows are the main grassing land for the grassiers (Figure 38), feeding ground for many caterpillars, butterflies, grasshoppers, beetles, dragonflies, damselflies, frogs, toads, lizards, snakes and birds. Many of these animals are using this place as their resting ground (Figure 39); some uses for social activities and enrichment activities like play fights (Figure 40) and mud bath (Figure 41). Amphibians are the other major group of organisms highly dependent on these habitats especially for feeding and breeding activities. Most of the reptiles especially the lizards and snakes are using this area satisfying their basking activity.

Table 27: Animal groups and depenedednt activities

Sl. No.	Activity	Animal Group Involved
1	Feeding	Arthropods, Amphibians, Reptiles, Birds, Mammals
2	Nesting	Birds, Amphibians, Reptiles
3	Breeding	Arthropods, Birds, Amphibians, Reptiles, Mammals
4	Resting	Arthropods, Birds, Amphibians, Reptiles, Mammals
5	Playing	Birds, Mammals

Figure 38: Grazing by Sambar Deer

Figure 39: Herd of Gaur resting in vayal

Figure 40: Play fighting by Tuskers

Figure 41: Mud baths of Elephants later used by Gaur and Smabar Deer

The primary consumers like grasshoppers, caterpillar of butterflies and moths and other insects that feed on plants are highly dependent on this system. The other group of insects like dragonflies and damselflies are actively foraging in this habitat. Inside the dense forest, these vayals are the only suitable habitat for them to forage. They basically feed on other insects like butterflies and moths. Butterflies usually bask on the plants in the vayals during early mornings and when they get warmed, they become active and actively feed on the nectar in the grasses and other plants in vayals. The moths are active by night and they rest during the day time on the grasses or herbs or shrubs in the vayal mostly under the leaves. The dragonflies and damselflies choose some of the vantage points like tall grasses or shrubs to forage. They rest on these points and once the butterflies get active the dragonflies and damselflies starts hunting. Sometimes the butterflies and moths get flushed because of some disturbance like heavy wind, by grassiers or other mammals or by birds. Once get disturbed, they start to fly from their resting place. The dragonflies and damselflies will very quickly fly and prey on these disturbed insects.

The dragonflies and damselflies also using this water dominated ecosystem unit for breeding. The dragonflies and damselflies breed in the lentic (flowing) or lotic (stagnant) water (Subramanian, 2009). Once the pairing (copulation) happened, the females lay eggs immediately. The female chooses the site for egg laying based on the physical characters like length, depth, lentic or lotic, slow flowing or fast flowing, the fallen leaf debrises, this varies with species. The vayal offers almost all their needs like the lentic and lotic water bodies, fallen leaf and other plant debrises. Thus the fresh water system is undoubtedly best breeding site for the odonates. These odonates are considered as the bioindicators of healthy habitats (Subramanian, 2009). We have found many dragonflies and damselflies from the vayal, sometimes in their breeding posture.

Amphibians are using vayals as feeding and breeding ground especially during the monsoon season. Some of the amphibians breed in small pools in the vayal and some breed in bigger pools like check dams and manmade waterholes in vayal. The Malabar Gliding frog build nest above shallow water pools and once the egg hatches, the tadpole drop in to the pool and metamorphosise in that pool. The frog like *Euphlyctis* and *Fejervarya* use the shallow water pools for feeding and breeding. Some of the bush frogs like the endangered Travancore Bush Frog, *Raorchestes acroparallagi, R. griet, R. jayarami* are actively

vocalizing in the plants seen in the vayal and we found the juveniles later. In monsoon, the vayals become the breeding sites for many of the frogs that we recorded, from the ground dwelling frogs and toads to bush frogs. They temporally control their breeding time and vocalization to reduce the competition for space and other resources. The vocalization helps them identify species and individuals. In a system like vayal with multi species chorus, their species specific calls are helping them to recognize the conspecifics and selecting the best male for breeding.

The *Euphlyctis cyanophlyctis* and *Hoplobatrachus tigerinus* used to breed in the waterholes in the vayal. The *H. tigerinus* breed with the onset of the first monsoon showers. The males become yellowish in colour with bluish vocal sacs during the breeding season and they vocalize frequently during the monsoon showers. Recorded from many vayals in Thekkady, Vallakadvu and Periyar Forest Ranges and the vayals like Kokkara Second Gate Bit I and Bit II, Kokkara Watchtower Bit I and Bit II, Poomaram, Zeropoint and Pothukandam Vayalas are the major spots of their breeding.

Periyar Night Frog's (*Nyctibatrachus periyar*) eggs were recorded from Uppupara Thavalam Vayal. A *Nyctibatrachus* sp. calling male was seen guarding the eggs from Karimala Bit I Vayal in Periyar Forest Range. The eggs weres on a small branch of a shrub near to the small rivulet flowing through the vayal. The bush frogs are realy shy making it difficult to be observed for details of breeding. All the bush frogs belong to the family Rhacophoridae with eight genus. Three genus like genus *Pseudophilautus, Raorchestes* and *Rhacophorus* were seen in the vayals. These tiny frogs belong to *Raorchestes* and *Pseudophilautus* genus are easily disappear to the grasses when disturbed. Once lost from the eyesight in the grasses, these are difficult to be relocated. They also keep away from the lights used during night scanning. The disturbances on the plants while searching for them in the night also make them move inside the grass culm. A number of calling male frogs were seen around on the grasses and bushes in the vayal in the monsoon nights.

Three species of frogs belonging to the genus *Rhacophorus* or otherwise called as flying frogs were recorded. In Western Ghats, we have four species of flying frogs. Of these, only one is distributed north of Palghat Gap and other three are found south of Palghat Gap (Sivaprasd 2013). These three species were observed from the vayals with their breeding

activities. These flying frogs build foam nests. They build nests with the help of plant leaves usually on trees where there is a stagnant/lentic water pool. The foam nest will ensure the constant moisture level till the eggs get develop into tadpoles. The Malabar Gliding Frog (*Rhacophorus malabaricus*) is the widely distributed Rhacophorid in Western Ghats. We recorded the nests of this frog from Vanchivayal, Vallakadvu Vayal, Poomaram Vayal, Poovarshu Vayal, Kokkara Second Gate Vayal, Pachakkanam Vayal, Campshed Vayal, Pothukandam Vayal, and Quarter Palam Vayal. This frog used to nest in the water in the trench of Moolavaika camp shed. Nesting of *Rhacophorus pseudomalabaricus* the Malabar False Tree Frog and *Rhacophorus calcadensis* Kalakad Tree Frog are recorded from Alinchodu and Randanamukku vayals. The *Rhacophorus pseudomalabaricus* is common in Eravangalar camp and they used to nest on the plants in the sides of trench and on the trees near to the waterhole in front of the camp. Once we observed a few nests near to the well of Ervanagalar camp and every year they breed in the small waterhole. Tadpoles of *Clinotarsus curtipes* from vayals like Pachakkanam, Circle Road, and Kokkara Second Gate, Kokkara Watchtower, and Vallakadavu vayals. Their tadpoles are seen in the lentic water bodies like the man made waterholes. The *Duttaphrynus melanostictus*, the Common Indian Toad is a first monsoon shower breeder, which breed in small slow flowing pools and streams. This was seen from Vallakadavu Vayal, Pothukandam, Circle Road, Zero Point, and Kokkara vayals. Other than for breeding, the frogs are using these vayals as feeding ground since the frogs mainly feed on arthropods. Hence this system support good diversity of arthropods it become one of the major feeding ground for amphibians. The foregoing discussion indicates the importance of vayals in maintain a good population of diverse apmhibians.

The reptiles are using these ecosystem units for satisfying their breeding, basking, feeding and other life history needs. The lizards like skinks and calotes are the major group of reptiles found in the vayals and them mainly using this system for feeding and basking activities. During the end of summer we found egg laying of *Calotes versicolar* from the edge of Poovarasu Vayal. At night we observed resting of *Calotes ellioti* and *Calotes versicolar* from Thavlakulam, Karimala Bit I and Pothukandam, Poomaram, Pachkkanam vayals respectively. Once we were recording the avifaunal data from the Pothukandam Vayal on a misty morning while walking to the vantage point for collecting data we found

one Mountain Keelback (*Hebius monticola*) basking at a small open soil patch and when we approached it moved away quickly. The *Melanochelys trijuga* used to bask on vantage points in the waterhole like rocks, fallen logs etc. This is frequently recorded from Pothukandam Vayal.

The birds using this habitat as their feeding ground. The Lesser Coucal (*Centropus bengalensis*) is one of the rarely sighted birds that are common in the vayals. They mainly prefer the grass dominated habitats. This bird is frequently observed from the Circle Road Vayal, Uppupara Thavalam Vayal, and Seethakulam Vayal. The Raptors used hover over the vayals. The Jungle myna (*Acridotheres fuscus*) and Black Headed Munia (*Lonchura Malacca*) used to feed on the grass in flocks. Pond Heron is the other common bird that frequently recorded from vayals. Once we found the nest of Indian Scimitar Babbler (*Pomatorhinus horsfieldii*) from Pachakkanam Vayal. The nest was close to the ground on tree sapling and it covered with many other tree splings.

Mammals were using this habitat as feeding and resting ground. The elephants used to have mud bath from the vayal especially the vayals in the grassland like Uppupara Thavalam, Uppupara Kalungu, Seethakulam, Uppupara Tower vayals. The elephants mostly sending night time at the vayals in grasslands and they move down during the day time. The Sambar deer (*Cervus unicolor*) and Gaur (*Bos gaurus*) are using this habitat as their major feeding ground and during the hottest hours of a day they used to take rest in the small puddles or the small muddy areas where the elephants took mud bath (Figure 40). Early mornings and the evenings are the time when the sambar and gaur mostly found in these vayals. Once we recorded the play fighting behaviour of elephants from Uppupara Thavalam Vayal. It was a herd of 14 elephants lead by an old matriarch. There were four male elephants and two of the males are older ones and they are doing the play fight. We observed them for about three and half hour they were in a safer distance (Figure 39).

For measuring diversity over spatial scale Whittaker (1972) described three terms like alpha, beta and gamma diversity. Where the alpha diversity is the diversity in a particular area and it is expressed in number of species recorded or otherwise the species richness and the change in species diversity across similar habitats or the species unique to each area is beta diversity and the overall diversity of different habitats in an ecosystem is

gamma diversity. Here we classify the vayals into three classes based on the surrounding vegetation like vayals in tropical wet evergreen forest, moist deciduous forest and semi evergreen forest, grassland and eucalyptus plantations. We did a total of 379 man hour surveys in selected vayals across the habitats above mentioned to document the amphibian and reptile diversity. We did quadrate samplings and scan searches. Qudrates of 10×10 meter were sampled in a limited time and the scan searches were also time constrained. 75 man hour surveys was conducted in vayals in wet evergreen forest, semi evergreen forest and moist deciduous forest which includes 150 qudrate surveys and scan searches. In grasslands we did 160 man hour surveys which includes 320 qudrate surveys and scan searches and 144 man hour survey of 288 qudrates and scan searches were conducted in vayals in eucalyptus plantation. For studying the avifauna and mammal diversity Point count method was used. A total of 41.33 man hour survey was conducted in vayals in three different habitat units. 11 man hour surveys in vayals in wet evergreen forest, semi evergreen forest and moist deciduous forest, 19.33 man hours in vayals in grassland ecosystem and 11 man hours in vayals in eucalyptus plantations. When we comparing the data we found alpha diversity varies considerably.

Table 28: Amphibians in vayals recorded from three different surrounding vegetations

#	Scientific name	Vayals in Evergreen and MDF	Vayals in Grassland	Vayals in Eucalyptus
1	Common Indian Toad	✓	✓	✓
2	Skittering Frog	✓	×	✓
3	Indian Bullfrog	✓	×	✓
4	Kerala Warty Frog	✓	×	✓
5	Warty Frog Species	✓	✓	×
6	Munnar Torrent Frog	✓	×	×
7	Gavi Night Frog	×	✓	×
8	Periyar Night Frog	×	✓	×

Table 28(Cont'd): Amphibians in vayals recorded from three different				
9	Bicoloured Frog	✓	×	✓
10	Fungoid Frog	✓	✓	✓
11	Common Indian Tree Frog	✓	×	✓
12	Charpa Tree frog	✓	×	×
13	Variable Bush Frog	✓	✓	✓
14	Anil's Bush Frog	✓	×	✓
15	Griet Bush Frog	×	✓	×
16	Beddome's Bush Frog	✓	×	×
17	Water Drop Frog	✓	×	✓
18	Travancore Bush Frog	×	✓	×
19	Jayaram's Bush Frog	×	✓	×
20	Waynad Bush Frog	✓	×	✓
21	Malabar Gliding Frog	✓	✓	✓
22	Malabar False Tree frog	✓	×	×
23	Kalakkad Tree Frog	✓	×	×

When comparing the alpha diversity of vayals in three different habitat units the evergreen-semi-evergreen-MDF forests are rich in species with 18 species followed by eucalyptus and grasslands with 12 and 10 respectively (Table 28).

Table 29: Reptiles in vayals recorded from three different surrounding vegetations

#	Scientific name	Vayals in Evergreen and MDF	Vayals in Grassland	Vayals in Eucalyptus
1	Indian black turtle	✓	×	✓
2	Elliot's Forest Lizard	✓	×	✓
3	Indian Garden Lizard	✓	×	✓
4	Wayanad Day Gecko	✓	×	✓
5	Anaimalai Gecko	✓	×	×
6	Brook's House Gecko	✓	×	✓
7	Bark Gecko	✓	×	×
8	Common keeled skink	✓	×	✓
9	Bronze Grass Skink	✓	✓	✓
10	Travancore Ground Skink	✓	×	×
11	Side-spotted Ground Skink	✓	×	×
12	Bengal Monitor	✓	×	✓
13	Brahminy Worm Snake	✓	×	×
14	Beaked Worm Snake	✓	×	×
15	Pied-belly Shieldtail	✓	×	×
16	Indian Rat snake	✓	×	✓
17	Beddome's Keelback	×	✓	✓
18	Hill Keelback	✓	✓	✓
19	Checkered Keelback	✓	✓	✓
20	Common vine snake	✓	×	✓
21	Ceylon cat snake	×	×	✓
22	Striped Coral Snake	×	✓	×

Table 29 (Cont'd):Reptiles in vayals recorded from three different surrounding				
23	Malabar Pit Viper	✓	✓	×
24	Large-scaled green pit viper	✓	×	×

The cumulative alpha richness of reptiles from vayals in evergreen-semi evergreen forests are 21 followed by vayals in eucalyptus plantation with 14 and vayals in grasslands is 6. The beta diversity of reptiles between vayals in tropical wet evergreen-semi evergreen forests and Grasslands is 19 and between vayals in grasslands and eucalyptus plantation is 12 and vayals in evergreen-semi evergreen forests and eucalyptus plantation is 11. The gamma diversity of reptiles in vayals in Periyar Tiger Reserve is 24 (Table 29).

Table 30: Birds in vayals recorded from three different surrounding vegetations

#	Scientific name	Vayals in Evergreen and MDF	Vayals in Grassland	Vayals in Eucalyptus
1	Indian Pond Heron	✓	×	✓
2	Osprey	✓	×	✓
3	Black Baza	✓	×	✓
4	Oriental Honey Buzzard	✓	×	✓
5	Black Eagle	✓	✓	✓
6	White-eyed Buzzard	×	×	✓
7	Crested Serpent Eagle	✓	✓	✓
8	Crested Hawk Eagle	✓	×	✓
9	Rufus-bellied Eagle	✓	×	✓
10	Common Kestrel	×	✓	×
11	Grey Jungle fowl	✓	×	✓
12	Red Spur fowl	✓	×	✓

Table 30 (Cont'd): Birds in vayals recorded from three different surrounding vegetations				
13	Painted Bush Quail	×	✓	×
14	White-breasted Water hen	✓	×	✓
15	Blue Rock Pigeon	✓	×	✓
16	Nilgiri Wood Pigeon	✓	×	✓
17	Mountain Imperial Pigeon	✓	×	✓
18	Pompadour Green Pigeon	✓	×	✓
19	Spotted Dove	✓	×	✓
20	Great Eared Nightjar	✓	✓	✓
21	Asian Palm Swift	✓	✓	✓
22	Alpine Swift	✓	✓	✓
23	Blue-Winged Parakeet	✓	×	✓
24	Lesser Coucal	×	✓	✓
25	Jungle Owlet	✓	×	✓
26	Brown Fish Owl	✓	×	✓
27	White Thoated King-Fisher	✓	×	✓
28	Chestnut-headed Bee eater	✓	×	✓
29	Malabar Grey Hornbill	✓	×	✓
30	Great Hornbill	✓	×	✓
31	White-cheeked Barbet	✓	×	✓
32	Eurasian Golden Oriole	×	×	✓
33	Ashy Drongo	✓	×	✓
34	Bronzed Drongo	×	×	✓
35	Greater Racket-tailed Drongo	✓	×	✓

Table 30 (Cont'd): Birds in vayals recorded from three different surrounding vegetations				
36	Jungle Myna	✓	×	✓
37	Hill Myna	✓	×	✓
38	White-bellied Tree Pie	✓	×	✓
39	House Crow	✓	×	✓
40	Jungle Crow	✓	✓	✓
41	Scarlet Minivet	✓	✓	✓
42	Common Iora	✓	✓	✓
43	Asian Fairy Bluebird	✓	×	✓
44	Black Headed Munia	×	✓	×
45	Forest Wagtail	✓	×	✓
46	Grey Wagtail	✓	×	✓
47	Nilgiri Pipit	×	✓	×
48	Paddy Field Pipit	✓	✓	✓
49	Red whiskered Bulbul	✓	✓	✓
50	Red-wented Bulbul	×	✓	✓
51	Indian Scimitar Babbler	✓	×	✓
52	Dark-fronted Babbler	✓	×	✓
53	Jungle Babbler	✓	✓	✓
54	Oriental Magpie Robin	✓	×	✓
55	Asian Brown Flycatcher	✓	×	✓
56	Brown Breasted Flycatcher	×	×	✓
57	Asian Paradise-flycatcher	✓	✓	✓
58	Franklin's Prinia	✓	✓	✓

59	Common Tailorbird	✓	×	✓
60	Blyth's Reed Warbler	✓	✓	✓
61	Large-billed Leaf-warbler	✓	×	✓
62	Little Spider hunter	✓	×	✓
63	Oriental White-eye	×	✓	✓

The cumulative alpha richness is 56 in vayals in eucalyptus followed by the vayals in tropical wet evergreen-semi evergreen and moist deciduous forests with a cumulative alpha richness of 49 and the vayals in grasslands with a cumulative alpha richness of 18. The beta diversity of aves between vayals in tropical wet evergreen-semi evergreen and moist deciduous forests and Grasslands is 45 and between vayals in grasslands and eucalyptus plantation is 46 and vayals in evergreen-semi evergreen and moist deciduous forests and eucalyptus plantation is 7. The gamma diversity of aves in vayals in Periyar Tiger Reserve is 63 (Table 30).

The vayal is eucalyptus plantation with a cumulative alpha richness of 19 followed by the vayals in tropical wet evergreen-semi evergreen and moist deciduous forests with a cumulative alpha richness of 17 and the vayals in grasslands with a cumulative alpha richness of 11. The beta diversity of mammals between vayals in tropical wet evergreen-semi evergreen and moist deciduous forests and Grasslands is 8 and between vayals in grasslands and eucalyptus plantation is 8 and vayals in evergreen-semi evergreen and moist deciduous forests and eucalyptus plantation is 2. The gamma diversity of aves in vayals in Periyar Tiger Reserve is 19 (Table 31).

A total of 150 (1.5 ha) quadrates in evergreen forests, 288 (2.88 ha) quadrates in eucalyptus plantations and 320 (3.2 ha) quadrates in grasslands were studied. Shannon index for amphibians in vayals in evergreen-semi evergreen is 2.564 and in eucalyptus is 2.484 and in grassland 2.19 and the evenness is 0.934, 0.920 and 0.850 respectively and the Simpson index for diversity is 9.886, 8.768 and 4.826. Shannon index for reptiles is 2.708, 2.564 and 1.791 and the evenness is 0.895, 0.915 and 0.747 and the Simpson index is 10.664, 10.114 and 2.976 respectively.

Table 31: Mammals in vayals recorded from three different surrounding vegetations

#	Scientific name	Vayals in Evergreen and MDF	Vayals in Grassland	Vayals in Eucalyptus
1	Nigiri Langur	✓	✓	✓
2	Indian Wild Dog (Dhole)	✓	✓	✓
3	Sloth Bear	✓	×	✓
4	Brown-palm Civet	✓	×	✓
5	Small Indian Civet	✓	×	✓
6	Brown Mongoose	✓	✓	✓
7	Stripe-necked Mongoose	×	✓	✓
8	Common Mongoose	✓	×	✓
9	Tiger	✓	✓	✓
10	Leopard	✓	✓	✓
11	Asian Elephant	✓	✓	✓
12	Wild Boar	✓	✓	✓
13	Sambar Deer	✓	✓	✓
14	Barking Deer	✓	×	✓
15	Gaur	✓	✓	✓
16	Indian Pangolin	×	×	✓
17	Blacknapped Hare	✓	✓	✓
18	Malabar Giant Squirrel	✓	×	✓
19	Indian Porcupine	✓	×	✓

5.6. Management recommendations

Soil moisture is the key factor that regulating the character and fate of a vayal. Decrease in soil moisture level gradually result in drying, invasion of non-vayal species and further degradation of vayals. Rate and frequency of rainfall, presence and continuity of rivulet, slope, soil texture, management activities like weeding, plucking of plants, maintaining water hole are major factors that influencing the level of soil moisture. If the soil moisture level stays stable and enough to be wetland system, the plant composition of vayal remain restricted to marshy species. An increase in soil moisture from optimum level will not create much change in plant composition unless it goes beyond the threshold level. On the other hand, decrease will result in a visible change in plant composition and the plants which found in non-marshy areas including tree seedlings which will invade in to the system. More dry plants mainly the exotic or invasive plants will be established and the site becomes suitable for tree seedlings to germinate and establish. Once it is established then the change become permanent, it usually starts at the edges and in the coming years this invasion will reduce the size of the vayal. Following are the issues and suggested solutions in relation to management and conservation of vayals in Periyar Tiger Reserve

1. **Decrease in soil moisture and change in soil texture**
2. **Soil erosion and loss of topsoil (clay)**
3. **Invasion of non-vayal species including trees and weeds**
4. **Possible impact of surrounding Eucalyptus plantations**
5. **Lack of prioritization based on scientific data, while selecting vayals for management and conservation**

1. Most important parameter which we are not considered in current management and conservation practices of vayal is the Soil moisture.

   The management and conservation objectives for marshy grasslands should focus on the maintenance of soil that favours plants that are adapted to swamp conditions. A marshy grassland system will remain as healthy system/marshy grassland only when it could maintain minimum amount of moisture where marshy species could sustain and non-vayal species could not establish. Hence maintaining optimum soil moisture should be the key

for marshy grassland management and conservation. Failing to which is the root cause of degradation and responsible for other management issues such as invasion of non-vayal species. Considering this fact, during current study we gave more priority on collecting soil moisture data and to find out an optimum value for the same. From this study, we suggest to maintain an optimum soil moisture level of 70-74% in each vayals which will in long-run ensure the conservation of marshy grassland systems of Periyar Tiger Reserve. Hence managing hydrology is having prime importance for which following practices are suggested

a. Ensure that there is proper inflow into each vayal by managing and maintaining the rivulets
b. Ensure that major share of water available through inflow is not get eroded freely through outflow by proper regulation of outflow
c. Instead of making water hole in the centre or within vayals, it is suggested to have water harvesting system at the uphill which are parallel to vayal boundary. This will recharge the ground water in vayals and helpful to maintain marshyness of the system

2. Many vayals are facing the problem of soil erosion. Generally, a marshy system like vayal having high clay content at top soil which helps the system to remain marshy by holding available water. Any process which leading to erosion such as plucking of invaded individuals, burning the vegetation or manual removal of top soil for creating structure like water hole must be avoided. Site specific management and conservation strategy on priority basis to avoid soil erosion and maintain optimum level of clay in top soil is suggested. Strategies like construction of earthen bunds at the outflow region can be a good option.

3. Invasion of non-vayal species could observe in majority of vayals even though its degree of invasion is varying. Presence of non-vayal marshy species in a wetland ecosystem itself indicates the degradation of the system which otherwise does not suitable for non-vayal species. Hence increases in number of species especially that of non-vayal species is a clear sign of the degradation but at the same it is not the root cause of vayal degradation. In current this is managed by the process weeding, which does not address the issue at root

level and not a permanent solution for invasion. The low moisture content especially in boundaries is responsible for suitable niche development for establishment and invasion of non-vayal species which further results in decrease in extent of vayals. When the management and conservation activities are not focusing on root cause but only the management of weeds, the process of degradation will continue which may further reduce the extent of vayal in long run

4. Many of the marshy grasslands (Vayals) are surrounded by grasslands which are hilly. In some among them, large scale Eucalyptus plantations has been raised as a boundary along vayals. There are large number of literature are available to indicate that this species consumes large amount water, if it is planted and managed unscientifically. Hence these plantations may have a serious negative impact on the hydrology of those vayals and makes those vayals dry and suitable for invasion of non-vayal species which need detailed further investigation and data collection. Insufficient water supply and inappropriate hydrological regimes could be addressed which need in depth research.

5. There are 140 vayals listed and mapped during this study. Before going for any management or conservation activities, we suggest to collect soil sample from each vayals for analyzing moisture content and clay content both of them can be used as good indicator for ecosystem health. A priority list can be prepared based on moisture value and clay content for systematic planning and implementing management and conservation activities.

6. CONCLUSION AND RECOMMENDATIONS

1. Study provided baseline location map, extent, floral and faunal checklist of unique marshy grassland ecosystems of Periyar Tiger Reserve
2. First report of endemic frog species R. *travancoricus* which is listed as extinct by IUCN till June 2015 from a protected area.This study could document eight new localities for this species from marshy grasslands of Periyar Tiger Reserve
3. These unique ecosystem provides suitable habitat for about 50% of herpatofaunal diversity in Periyar Tiger Reserve hence demands high priority of conservation
4. Data on Soil moisture reveals that there are marshy grasslands which having very low moisture content and due to the same, the marshy species are replaced by non-vayal species including trees, which may result in degradation of vayals and conversion of marshy grasslands and further decrease in extent of vayals in long run.
5. Soil structure analysis also indicates that vayals are getting degraded due to reduction in clay content of soil by which the system loses its water holding capacity
6. Among five vayals where long-term soil moisture data were collected, three are found below optimum level in soil moisture level which need immediate intervention
7. Those vayals having less clay content and low moisture value are manifesting the sign of degradation. This situation makes it vulnerable for invasion of non-vayal species the process which further speed up the degradation processs.
8. Since the root cause of change in vegetation ie. Invasion of trees/weeds/non-vayal species is decrease in moisture level and water holding capacity of soil; it is recommended to focus the vayal management and conservation activities on hydrology to maintain optimum soil moisture level.
9. In order to prioritize the vayals which require management and conservation intervention, it is suggested to analyse soil moisture, texture and presence of non-vayal species as an indicator.

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Appendix

Appendix1. Total number of plants recorded from vayals in Periyar Tiger Reserve

Sl. No.	Species	Family
1	*Abutilon hirtum* (Lam.) Sweet	Malvaceae
2	*Acmella calva* (DC.) R.K. Jansen	Asteraceae
3	*Acmella paniculata* (Wall. ex DC.) R.K. Jansen	Asteraceae
4	*Acorus calamus* L.	Araceae
5	*Actinodaphne bourneae* Gamble	lauraceae
6	*Actinodaphne malabarica*N.P. Balakr.	Lauraceae
7	*Ageratina adenophora* (Spreng.) R. M. King & H. Rob.	Asteraceae
8	*Ageratum conyzoides* L.	Asteraceae
9	*Ageratum houstonianum* Mill	Asteraceae
10	*Agrostistachys borneensis* Becc.	Euphorbiaceae
11	*Alloteropsis cimicina* (L.) Stapf	Poaceae
12	*Alstonia scholaris* (L.) R. Br.	apocyanaceae
13	*Alternanthera bettzickiana* (Regel) G. Nicolson	Amaranthaceae
14	*Amorphophallus paeoniifolius* (Dennst.) Nicolson	Araceae
15	*Anaphalis aristata* (DC.)DC.	Asteraceae
16	*Andrographis atropurpurea* (Dennst.) Alston	Acanthaceae
17	*Andrographis paniculata* (Burm. f.) Nees	Acanthaceae
18	*Annona squamosa L*	Anonaceae
19	*Apocopis mangalorensis* (Hochst.ex Steud.) Henrard	Poaceae
20	*Arisaema tylophorum* C.E.C. Fisch	Araceae
21	*Artocarpus hirsutus* Lam.	Moraceae
22	*Arundinella ciliata* (Roxb.) Nees ex Miq.	Poaceae
23	*Arundinella purpurea* Hochst. ex Steud.	Poaceae
24	*Asclepias curassavica* L.	Asclipidaceae
25	*Asparagus racemosus* Willd	Liliaceae
26	*Bambusa bambos* (L.) Voss	Poaceae

Appendix 1 (Cont'd): Total number of plants recorded from vayals in Periyar Tiger Reserve		
27	*Bidens biternata* (Lour.) Merr. & Sherff	Asteraceae
28	*Bidens pilosa* L.	Asteraceae
29	*Bischofia javanica* Blume	euphorbiaceae
30	*Blumea axillaris* (Lam.) DC	Asteraceae
31	*Blumea belangeriana* DC.	Asteraceae
32	*Bombax ceiba* L.	Bombaceae
33	*Brachiaria semiundulata* (Hochst.) Stapf	Poaceae
34	*Breynia retusa* (Dennst.) Alston	Euphorbiaceae
35	*Briedelia retusa* (L.) A. Juss	Euphorbiaceae
36	*Briedelia stipularis* (L.) Blume	Euphorbiaceae
37	*Bulbophyllum sterile* (Lam.) Suresh	Orchidaceae
38	*Butea monosperma* (Lam.) Taub.	Fabaceae
39	*Caesalpinia mimosoides* Lam.	Fabaceae
40	*Calycopteris floribunda* (Roxb) Lam.ex Poir	Combretaceae
41	*Camellia sinensis* (L.) Kuntze	Theaceae
42	*Cardiospermum halicacabum* L.	Sapindaceae
43	*Careya arborea* Roxb.	Lecythidaceae
44	*Catunaregam spinosa* (Thunb.) Tirveng.	Rubiaceae
45	*Centella asiatica* (L.) Urb.	Apiaceae
46	*Chionanthus mala-elengi* (Dennst.) P. S. Green	Oleacea
47	*Chromolaena odorata* (L.) R.M.King &H.Rob.	Asteraceae
48	*Chrysopogon aciculatus* (Retz.) Trin.	Poaceae
49	*Chrysopogon hackelii* (Hook.f.) C.E.C. Fisch.	Poaceae
50	*Cinnamomum macrocarpum* Hook. f	Lauraceae
51	*Cinnamomum malabatrum* (Burm. f.) J.Presl	Lauraceae
52	*Cinnamomum verum*J.Presl	Lauraceae
53	*Citrus maxima* (Burm.) Merr.	Rutaceae
54	*Citrus medica* L.	Rutaceae
55	*Citrus sinensis* (L.) Osbeck	Cyperaceae

Appendix 1 (Cont'd): Total number of plants recorded from vayals in Periyar Tiger Reserve		
56	*Cleome viscosa* L.	Capparaceae
57	*Clidemia hirta* (L.) D.Don	Melastromaceae
58	*Coelachne simpliciuscula* (Steud.) Munro ex Benth.	Poaceae
59	*Colocasia esculenta* (L.) Schott	Araceae
60	*Commelina benghalensis* L.	Commelinaceae
61	*Commelina clavata* C.B.Clarke	Commelinaceae
62	*Commelina diffusa* Burm. f	Commelinaceae
63	*Commelina ensifolia* R. Br.	Commelinaceae
64	*Commelina erecta L.*	Commelinaceae
65	*Commelina maculata* Edgew	Commelinaceae
66	*Conyza japonica* (Thunb.) Less.ex Less	Asteraceae
67	*Costus speciosus* (J.Koenig) Sm.	Costaceae
68	*Crotalaria clarkei* Gamble	Fabaceae
69	*Crotalaria pallida* Aiton	Fabaceae
70	*Cullenia exarillata* A.Robyns	Bombaceae
71	*Curcuma montana* Roxb.	Zingiberaceae
72	*Curcuma neilgherrensis* Wight	Zingiberaceae
73	*Curcuma pseudomontana* J.Graham	Zingiberaceae
74	*Cyanotis arachnoidea*C.B.Clarke	Commelinaceae
75	*Cyanotis axillaris* (L.) D. Don ex Sweet	Commelinaceae
76	*Cyanotis cristata* (L.) D. Don	Commelinaceae
77	*Cyanotis papilionacea* (Burm. f.) Schult &Schult. f	Commelinaceae
78	*Cyathula prostrata* (L.) Blume	Amaranthaceae
79	*Cyclea peltata* (Lam.) Hook. f. & Thomson.	Menispermaceae
80	*Cymbopogon citratus* (DC.) Stapf	Poaceae
81	*Cymbopogon flexuosus* (Nees ex Steud.) W.Watson	Poaceae
82	*Cynodon dactylon* (L.) Pers	Poaceae
83	*Cyperus bulbosus* Vahl	Cyperaceae
84	*Cyperus compactus* Retz	Cyperaceae

Appendix 1 (Cont'd): Total number of plants recorded from vayals in Periyar Tiger Reserve		
85	*Cyperus cyperinus* (Retz.) Suringar	Cyperaceae
86	*Cyperus difformis* L.	Cyperaceae
87	*Cyperus diffusus* Vahl	Cyperaceae
88	*Cyperus distans* L. f.	Cyperaceae
89	*Cyperus dubius* Rottb.	Cyperaceae
90	*Cyperus exaltatus* Retz.	Cyperaceae
91	*Cyperus haspan* L.	Cyperaceae
92	*Cyperus iria* L.	Cyperaceae
93	*Cyperus javanicus* Houtt	Cyperaceae
94	*Cyperus procerus Rottb*	Cyperaceae
95	*Cyperus rotundus* L.	Cyperaceae
96	*Dactyloctenium aegyptium* (L.) Willd.	Poaceae
97	*Delonix regia* (Hook.) Raf.	Fabaceae
98	*Dendrocnide sinuata* (Blume) Chew	Urticaceae
99	*Desmodium alysicarpoides* Meeuwen	Fabaceae
100	*Desmodium heterophyllum* (Willd.) DC	Fabaceae
101	*Desmodium triflorum* (L.) DC	Fabaceae
102	*Desmodium triquetrum* (L.) DC.	Fabaceae
103	*Drosera indica* L	Droseraceae
104	*Drymaria cordata* (L.) Willd. ex Schult	Caryophyllaceae
105	*Elaeocarpus tuberculatus* Roxb	Elaeocarpaceae
106	*Eleocharis dulcis* (Burm. f.) Trimen ex Hensch	Cyperaceae
107	*Elephantopus scaber* L	Asteraceae
108	*Emilia javanica* (Burm. f.) Robs	Asteraceae
109	*Emilia scabra* DC.	Asteraceae
110	*Emilia sonchifolia* (L.) DC. Ex DC.	Asteraceae
111	*Eragrostis nutans* (Retz.) Nees ex Steud	Poaceae
112	*Eriocaulon brownianum* Mart.	Eriocaulaceae
113	*Eriocaulon odoratum* Dalzell	Eriocaulaceae

Appendix 1 (Cont'd): Total number of plants recorded from vayals in Periyar Tiger Reserve		
114	*Eriocaulon parviflorum* (Fyson) R. Ansari & N.P. Balakr.	Eriocaulaceae
115	*Eriocaulon quinquangulare* L.	Eriocaulaceae
116	*Eriocaulon thwaitesii* Korn.	Eriocaulaceae
117	*Erythrina suberosa* Roxb	Fabaceae
118	*Erythrina subumbrans* (Hassk.) Merr	Fabaceae
119	*Eucalyptus grandis* W.Hill	Myrtaceae
120	*Euphorbia heterophylla* L.	Euphorbiaceae
121	*Euphorbia hirta* L.	Euphorbiaceae
122	*Eurya nitida* Korth.	Theaceae
123	*Exacum tetragonum* Roxb	Gentianaceae
124	*Ficus hispida* L. f	Moraceae
125	*Fimbristylis aphylla* Steud.	Cyperaceae
126	*Gloriosa superba* L.	Liliaceae
127	*Grewia tiliifolia* Vahl	Tiliacea
128	*Hedychium coronarium* J.Koenig	Zingiberaceae
129	*Helicteres isora* L	Sterculiaceae
130	*Heliotropium indicum* L	Boraginaceae
131	*Heliotropium keralense* Sivarajan& Manilal	Boraginaceae
132	*Heliotropium marifolium*J.Koening exRetz	Boraginaceae
133	*Hemidesmus indicus* (L.) R. Br. Ex Schult	Periplocaceae
134	*Herissantia crispa* (L.) Brizicky	Malvaceae
135	*Hibiscus canescens* B.Heyne ex Wall	Malvaceae
136	*Holigarna nigra* Bourd	Anacardiaceae
137	*Humboldtia vahliana* Wight	fabaceae
138	*Hydnocarpus macrocarpa* Warb.	Flacourtiaceaae
139	*Hydnocarpus pentandra* (Buch.-Ham.) Oken	Flacourtiaceaae
140	*Hydrilla verticillata* (L.f.) Royle	Hydrocharitaceae
141	*Hydrocotyle sibthorpioides* Lam	Apiaceae
142	*Impatiens acaulis* Arn	Balsaminaceae

Appendix 1 (Cont'd): Total number of plants recorded from vayals in Periyar Tiger Reserve		
143	*Impatiens campanulata* Wight	Balsaminaceae
144	*Impatiens cordata* Wight	Balsaminaceae
145	*Impatiens goughii* Wight	Balsaminaceae
146	*Impatiens grandis*B. Heyne	Balsaminaceae
147	*Impatiens herbicola* Hook. f.	Balsaminaceae
148	*Impatiens maculata* Wight	Balsaminaceae
149	*Impatiens minor* (DC.) Bennet	Balsaminaceae
150	*Impatiens parvifolia* Bedd	Balsaminaceae
151	*Impatiens scapiflora* Heyne ex Roxb.	Balsaminaceae
152	*Impatiens viscosa* Bedd.	Balsaminaceae
153	*Ipomoea obscura* (L.) Ker-Gawl.,	Convolvulaceae
154	*Ischaemum barbatum* Retz.	Poaceae
155	*Ixora cuneifolia* Roxb.	Rubiaceae
156	*Justicia japonica* Thunb.	Acanthaceae
157	*Justicia procumbens* L.	Acanthaceae
158	*Kingiodendron pinnatum* (DC.) Harms	Fabaceae
159	*Knema attenuata* Warb.	Myristicaceae
160	*Knoxia sumatrensis* (Retz.) DC.	Rubiaceae
161	*Knoxia wightiana* Wall. ex G.Don	Rubiaceae
162	*Kyllinga brevifolia* Rottb.	Cyperaceae
163	*Kyllinga bulbosa* P. Beauv.	Cyperaceae
164	*Kyllinga melanosperma* Nees	Cyperaceae
165	*Kyllinga nemoralis* (J. R & G. Forst.) Dandy ex Hutch. & Dalz	Cyperaceae
166	*Kyllinga polyphylla* Willd.ex.Kunth	Cyperaceae
167	*Lagerstroemia microcarpa* Wight	Lythraceae
168	*Lantana camara* L.	Verbenaceae
169	*Leea indica* (Burm. f.) Merr.	Leaceae
170	*Leersia hexandra* Sw.	Poaceae
171	*Leucas aspera* (Willd.) Link	Lamiaceae

Appendix 1 (Cont'd): Total number of plants recorded from vayals in Periyar Tiger Reserve		
172	*Leucas hirta* (B.Heyne ex Roth) Spreng.	Lamiaceae
173	*Lindernia anagallis* (Burm. f.) Pennell	Schrophulariaceae
174	*Lindernia crustacea* (L.) F. Muell.	Schrophulariaceae
175	*Lindernia parviflora* (Roxb.) Haines	Schrophulariaceae
176	*Litsea coriacea*) Hook. f.	Lauraceae
177	*Macaranga indica* Wight	Euphorbiaceae
178	*Macaranga peltata* (Roxb.) Mull.Arg	Euphorbiaceae
179	*Maesa indica* (Roxb.) DC.	Myrcenaceae
180	*Mallotus resinosus* (Blanco) Merr.	Euphorbiaceae
181	*Melastoma malabathricum* L.	Melastromaceae
182	*Melicope lunu-ankenda* (Gaertn.) T.G. Hartley	Rutaceae
183	*Mikania micrantha* Kunth	Asteraceae
184	*Mimosa diplotricha* Sauvalle	Fabaceae
185	*Mimosa pudica* L.	Fabaceae
186	*Mitracarpus hirtus* (L.) DC.	Rubiaceae
187	*Mollugo pentaphylla* L.	Molluginaceae
188	*Murdannia crocea (*Griff.) Faden	Commelinaceae
189	*Murdannia dimorpha* (Dalz.) Brueck.	commelinaceae
190	*Murdannia gigantea* (Vahl) G.Bruckn	Commelinaceae
191	*Murdannia japonica* (Thunb.) Faden	Commelinaceae
192	*Murdannia nudiflora* (L.) Brenan	Commelinaceae
193	*Murdannia pauciflora* (G.Bruckn.) G.Bruckn	Commelinaceae
194	*Murdannia simplex* (Vahl) Brenan	Commelinaceae
195	*Murdannia spirata* (L.) Brueck.	Commelinaceae
196	*Nymphoides hydrophylla* (Lour.) Kuntze	Menyanthaceae
197	*Ochlandra travancorica* (Bedd.) Gamble	Poaceae
198	*Ochlandra wightii* (Munro) C.E.C. Fisch.	Poaceae
199	*Oldenlandia herbacea* (L.) Roxb.	Rubiaceae
200	*Olea dioica* Roxb.	Oleacea

Appendix 1 (Cont'd): Total number of plants recorded from vayals in Periyar Tiger Reserve		
201	*Oryza meyeriana* (Zoll. & Moritzi.) Baill.	Poaceae
202	*Oryza rufipogon* Griff.	Poaceae
203	*Osbeckia aspera* (L.) Blume	Melastromaceae
204	*Osbeckia brachystemon* Naudin.	Melastromaceae
205	*Osbeckia wynaadensis* C.B.Clarke	Melastromaceae
206	*Panicum repens* L.	Poaceae
207	*Parasopubia delphiniifolia* (L.)	Schrophulariaceae
208	*Paspalum conjugatum* P.J.Bergius.	Poaceae
209	*Paspalum distichum* L.	Poaceae
210	*Paspalum scrobiculatum* L.	Poaceae
211	*Persea macrantha* (Nees) Kosterm.	lauraceae
212	*Phaulopsis imbricata* (Forssk.) Sweet.	Acanthaceae
213	*Phyllanthus amarus* Schum. & Thonn.	Euphorbiaceae
214	*Phyllanthus emblica* L.	Euphorbiaceae
215	*Piper hymenophyllum* Miq.	Piperaceae
216	*Pistia stratiotes* L.	Araceae
217	*Pogostemon auricularius* (L.) Hassk	lamiaceae
218	*Polyalthia coffeoides* (Thwaites) Hook. f. & Thomson.	Anonaceae
219	*Polyalthia longifolia* (Sonn.) Thwaites	Anonaceae
220	*Premna coriacea* C.B.Clarke	verbenaceae
221	*Psidium guajava* L.	Myrtaceae
222	*Pterygota alata* (Roxb.) R.Br.	Sterculiaceae
223	*Racosperma auriculiforme* (Benth.) Pedley	Fabaceae
224	*Rhamnus wightii* Wight & Arn.	Rhamnaceae
225	*Rhynchospora corymbosa* (L.) Brit.	Cyperaceae
226	*Rotala indica* (Willd.)Koehne	Lythraceae
227	*Rotala malampuzhensis* R.V. Nair ex Cook	Lythraceae
228	*Rotala rosea* (Poir.) Cook	Lythraceae
229	*Rotala rotundifolia* (Buch.-Ham. ex Roxb.) Koehne	Lythraceae

Appendix 1 (Cont'd): Total number of plants recorded from vayals in Periyar Tiger Reserve		
230	*Rubia cordifolia* L.	Rubiaceae
231	*Sapindus emarginatus* Vahl	Sapindaceae
232	*Sauropus androgynus* (L.) Merr.	Euphorbiaceae
233	*Schoenoplectiella juncoides* (Roxb.) Lye	Cyperaceae
234	*Schumannianthus virgatus* (Roxb.) Rolfe	Maranataceae
235	*Scoparia dulcis* L.	Schrophulariaceae
236	*Sida acuta* Burm. f.	Malvaceae
237	*Sida beddomei* K.C.Jacob.	Malvaceae
238	*Sida rhombifolia* L.	Malvaceae
239	*Smilax wightii* A. DC.	Smilaceae
240	*Smilax zeylanica* L.	Smilaceae
241	*Smithia blanda* Wall.	fabaceae
242	*Smithia conferta* Sm.	Fabaceae
243	*Smithia sensitiva* Aiton.	fabaceae
244	*Solanum capsicoides* All.	Solanaceae
245	*Solanum lasiocarpum* Dunal.	Solanaceae
246	*Solanum melongena* L.	Solanaceae
247	*Solanum torvum* Sw.	Solanaceae
248	*Solanum virginianum* L.	Solanaceae
249	*Spermacoce pusilla* Wall.	Rubiaceae
250	*Stachytarpheta cayennensis* (Rich.) Vahl	Verbenaceae
251	*Stachytarpheta jamaicensis* (L.) Vahl	Verbenaceae
252	*Stachytarpheta jamaicensis* (L.) Vahl	Verbenaceae
253	*Sterculia guttata* Roxb. ex Don.	Sterculiaceae
254	*Sterculia villosa* Roxb.	Sterculiaceae
255	*Striga angustifolia* (D. Don) C.J. Saldanha	Schrophulariaceae
256	*Strychnos nux-vomica* L.	Loganiaceae
257	*Syzygium cumini* (L.) Skeels	Myrtaceae
258	*Tabernaemontana gamblei* Subr. & A.N. Henry	Apocynaceae

Appendix 1 (Cont'd): Total number of plants recorded from vayals in Periyar Tiger Reserve		
259	*Tectona grandis* L. f.	Verbenaceae
260	*Terminalia chebula* Retz.	combretaceae
261	*Terminalia paniculata* Roth	Combretaceae
262	*Themeda cymbaria* Hack.	Poaceae
263	*Themeda tremula* (Nees ex Steud.) Hack.	Poaceae
264	*Thottea siliquosa* (Lam.) Ding Hou	Aristolochaceae
265	*Torenia travancorica* Gamble.	Schrophulariaceae
266	*Tridax procumbens* L.	Asteraceae
267	*Urena lobata L.*	Malvaceae
268	*Utricularia graminifolia* Vahl.	Lentibulariacae
269	*Utricularia nayarii*. Janarth. & A.N. Henry	Lentibulariacae
270	*Vernonia albicans* DC.	Asteraceae
271	*Vernonia arborea* Buch.-Ham.	Asteraceae
272	*Vernonia cinerea* (L.) Less	Asteraceae
273	*Vernonia travancorica* Hook. f.	Asteraceae
274	*Xanthophyllum arnottianum* Wight	polygalaceae
275	*Zingiber officinale* Rosc.	Zingiberaceae
276	*Zingiber zerumbet* (L.) Roscoe ex Sm.	Zingiberaceae
277	*Ziziphus oenoplia* (L.) Mill.	Rhamnaceae

Appendix 2. Surrounding vegetation in vayals of Periyar Tiger Reserve

Ranges	Surrounding vegetation		
	Natural forests	Grasslands	Eucalyptus plantation
Azuhtha	Vallakadavu Vayal	65 Plantation	Vallakadavu Vayal
		2 nd mile vayal	*2 nd mile vayal*
		2 nd mile top vayal	2 nd mile top vayal
		Seethakulam 1&2 *vayal*	
		Thalikanam vayal	
		Jollimala 1 vayal	Jollimala 1 vayal
		Seethakulam 0 point vayal	
		Jollimala 2 vayal	Jollimala 2 vayal
		Vamanakulam 2 vayal	Vamanakulam 2 vayal
		Vamanakulam 1 vayal	Vamanakulam 1 vayal
		Vamanakulam vayal	Vamanakulam vayal
		Uppupara Thavalam vayal	
		UppuparaThannithotti vayal	
	1	13	8
	Kozhikanam checkdam vayal	Uppupara kalungu *vayal*	Kozhikanam checkdam vayal
	Poomaram*vayal*	Uppupara kalink 1*vayal*	Vamanakulam CampShed vayal
	Pachakanam hut*vayal*	Uppupara Thevaruval*vayal*	Machanmadam*vayal*

Pampa	Pachakanam*vayal*	Kaduvathala	Poomaram*vayal*
	Anakallu*vayal*	Vamanakulam CampShed vayal	Pachakanam*vayal*
		Machanmadam*vayal*	Anapara *vayal*
		Uppupara Thavalam*vayal*	20-Hector checkdam*vayal*
		Uppupara tower 1*vayal*	
		Uppupara tower-2*vayal*	
		Anathala*vayal*	
		Uppupara tower-3*vayal*	
		Vilakukallu*vayal*	
		P.medu seethakulam 2*vayal*	
		P. medu seethakulam 1 *vayal*	
		.A point*vayal*	
		6-Th Block*vayal*	
		20-Hector checkdam*vayal*	
		Varayadinkoka*vayal*	
		Substation mala*vayal*	
		18-5Vayal*vayal*	
	5	20	7
Vallakadavu	Kumbalam Petty*vayal*	Pothu Kandam Bit 1 & 2*vayal*	Pothu Kandam Bit 1 & 2*vayal*

	Varakandam*vayal*	Kumbalam Petty *vayal*	Circle_rd_Narakakandam*vayal*
	Ambukallu kandam*vayal*	Circle_rd_Narakakandam*vayal*	Circle Road*vayal*
	Quarterpalam*vayal*	Circle Road*vayal*	Koyathotti_plantation*vayal*
	Pachakanam Bit_1*vayal*	Samikulam shola *vayal*	85plantation 2nd*vayal*
	Pachakanam bit 2*vayal*	Samikayam*vayal*	
	Chettichi*vayal*	Samikulam*vayal*	
	Panakandam*vayal*	85plantation 2nd*vayal*	
	Paravalavu*vayal*	85 Plantation 1st*vayal*	
	Kaduvakandam*vayal*	Vallakadavu Thondiyar*vayal*	
	2namukku_2chappathu*vayal*		
	5_chappatahu *vayal*		
	6_chappath*vayal*		
	Randanamukku*vayal*		
	Randanamukku_bit_1*vayal*		
	Koyathotti_plantation*vayal*		
	Koyathotti_damsite*vayal*		
	Paravalavu_2nd*vayal*		
	Alinchodu*vayal*		
	19	10	5
Thekkady	Cheveloda *vayal*		Brandypara *vayal*
	Panamkala*vayal*		
	Nellikkyampetty*vayal*		
	Thamburan		

	thuruthu_B1*vayal*		
	Thamburanthuruthu B2*vayal*		
	Thoodipara *vayal*		
	Manakavala*vayal*		
	ManakavalaMachan*vayal*		
	Kavalappara*vayal*		
	Kokara 2nd gate 1		
	Kokkar 2nd gate 2nd*vayal*		
	Kokkara watch tower 2		
	Kokkara watch tower*vayal*		
	Kokkara bridge*vayal*		
	Kokkara bridge small*vayal*		
	Medhakanam*vayal*		
	Medhakanam 1st*vayal*		
	Kalyana para*vayal*		
	Poovarashu*vayal*		
	Zero point*vayal*		
	ThondiyarChembanal*vayal*		
	Thondiyar Main*vayal*		
	Thondiyar Small*vayal*		
	Anchuruli bit 1*vayal*		
	Anchuruli bit 2*vayal*		
	Amayoli*vayal*		
	Manalmoola*vayal*		
	Kadakappara*vayal*		
	Adupukallumoola*vayal*		
	Adupukallumoola_bit 1		

	vayal		
	Pachakad*vayal*		
	31	0	1
Periyar	Anakuthi bit 1*vayal*	Kumarikulam truck path*vayal*	
	Anakuthi bit 2*vayal*	Mulakupara kandam*vayal*	
	Anakuthi way*vayal*	Nelli parakandam*vayal*	
	APC Campshed*vayal*	Palode*vayal*	
	Badraksham way*vayal*	Tiger Lake View*vayal*	
	Ezhana kuzhi 1*vayal*	Tiger Pool*vayal*	
	Ezhana kuzhi 2*vayal*	Tiger Three*vayal*	
	Ezhana kuzhi 3*vayal*	Vaikapadappu*vayal*	
	Ezhana kuzhi 4*vayal*		
	Kalvarithode*vayal*		
	Karimala 1*vayal*		
	Karimala 2*vayal*		
	Karimala 3*vayal*		
	Karuthamudi*vayal*		
	Kavikavu*vayal*		
	Kizhanugu Para bit 1*vayal*		
	Kizhanugu Para bit 2*vayal*		
	Kurishu mala 1*vayal*		
	Kurishu mala 2*vayal*		
	Manalmoola *vayal*		
	Manikmala*vayal*		
	Mavadi*vayal*		
	Nelli parakandam*vayal*		
	Pachamvallam bit 1*vayal*		
	Pakuzhipalam*vayal*		

	Palodevayal		
	Parayadithodevayal		
	Poosanikakuchi bit 1vayal		
	Poosanikakuchi bit 2vayal		
	Poosanikakuchi bit 3vayal		
	Poosanikakuchivayal		
	Thavalakulamvayal		
	Umukku moolavayal		
	Chemakkavallivayal		
	34	8	0

Appendix 3. List of Amphibians recorded from the vayal in Periyar Tiger Reserve

Sl. No.	Family	Common name	Scientific name	EDC	IUCN	WPA
1	Bufonidae	Common Indian Toad	*Duttaphrynus melanostictus* (Schneider, 1799)		LC	
2	Dicroglossidae	Skittering Frog	*Euphlyctis cyanophlyctis* (Schneider, 1799)		LC	Sch. IV
3	Dicroglossidae	Indian Bullfrog	*Hoplobatrachus tigerinus* (Daudin, 1802)		LC	Sch. IV
4	Dicroglossidae	KeralaWarty Frog	*Zakerana keralensis* (Dubois, 1981)		LC	Sch. IV
5	Dicroglossidae		*Zakerana spp.*	KL	NE	

Appendix 3 (Cont'd): List of Amphibians recorded from the vayal in Periyar Tiger Reserve						
6	Micrixalidae	Munnar Torrent Frog	*Micrixalus Adonis* (Biju, Garg, Gururaja, Souche, Walujkar, 2014)	KL	NE	
7	Nyctibatrachidae	Gavi Night Frog	*Nyctibatrachus gavi* (Biju, Bocxlaer, Mahony, Dinesh, Radhakrishnan, Zachariah, Giri and Bossuyt, 2011)	KL	NE	
8	Nyctibatrachidae	Periyar Night Frog	*Nyctibatrachus Periyar* (Biju, Bocxlaer, Mahony, Dinesh, Radhakrishnan, Zachariah, Giri and Bossuyt, 2011)	KL	NE	
9	Ranidae	Bicoloured Frog	*Clinotarsus curtipes* (Jerdon, 1853)	WG	NT	Sch. IV
10	Ranidae	Fungoid Frog	*Indosylvirana sreeni* (Biju, Garg, Mahony, Wijayathilaka, Senevirathne, Meegaskumbura, 2014)	WG	NE	

Appendix 3 (Cont'd): List of Amphibians recorded from the vayal in Periyar Tiger Reserve						
11	Rhacophoridae	Common Indian Tree Frog	*Polypedates maculatus* (Gray, 1830)		LC	
12	Rhacophoridae	Charpa Tree frog	*Polypedates occidentalis* (Das and Dutta, 2006)	WG	DD	
13	Rhacophoridae	Variable Bush Frog	*Raorchestes akroparallagi* (Biju and Bossuyt, 2009)	WG	LC	
14	Rhacophoridae	Anil's Bush Frog	*Raorchestes anili* (Biju and Bossuyt, 2006)	WG	LC	
15	Rhacophoridae	Griet Bush Frog	*Raorchestes griet* (Bossuyt, 2002)	WG	CR	
16	Rhacophoridae	Beddome's Bush Frog	*Raorchestes beddomii* (Günther, 1876)	WG	NT	
17	Rhacophoridae	Water Drop Frog	*Raorchestes nerostagona* (Biju & Bossuyt, 2005)	WG	EN	
18	Rhacophoridae	Travancore Bush Frog	*Raorchestes travancoricus* (Boulenger, 1891)	WG	EN	
19	Rhacophoridae	Jayaram's Bush Frog	*Raorchestes jayarami* (Biju and Bossuyt, 2009)	WG	NE	

Appendix 3 (Cont'd): List of Amphibians recorded from the vayal in Periyar Tiger Reserve						
20	Rhacophoridae	Waynad Bush Frog	*Pseudophilautus wynaadensis* (Jerdon, 1854)	WG	EN	
21	Rhacophoridae	Malabar Gliding Frog	*Rhacophorus malabaricus* (Jerdon, 1870)	WG	LC	
22	Rhacophoridae	Malabar False Tree frog	*Rhacophorus pseudomalabaricus* (Vasudevan and Dutta, 2000)	WG	CR	
23	Rhacophoridae	Kalakkad Tree Frog	*Rhacophorous calcadensis* (Ahl, 1927)	WG	EN	

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Appendix 4. List of Reptiles recorded from the vayal in Periyar Tiger Reserve

Sl. No.	Family	Common name	Scientific name	END	IUCN	WPA
1	Bataguridae	Indian black turtle	*Melanochelys trijuga* (Schweigger, 1812)		NT	
2	Agamidae	Elliot's Forest Lizard	*Calotes ellioti* (Günther, 1864)	WG	LC	
3	Agamidae	Indian Garden Lizard	*Calotes versicolor* (Daudin, 1802)		NE	
4	Gekkonidae	Wayanad Day Gecko	*Cnemaspis wynadensis* (Beddome, 1870)	KL	EN	

Appendix 4 (Cont'd): List of Reptiles recorded from the vayal in Periyar Tiger Reserve						
5	Gekkonidae	Anaimalai Gecko	*Dravidogecko anamallensis* (Günther, 1875)	WG	NT	
6	Gekkonidae	Brook's House Gecko	*Hemidactylus brookii* (Gray, 1845)		NE	
7	Gekkonidae	Bark Gecko	*Hemidactylus leschenaultii* (Dumeril and Bibron, 1836)		LC	
8	Scincidae	Common keeled skink	*Eutropis carinata* (Schneider, 1801)		LC	
9	Scincidae	Bronze Grass Skink	*Eutropis macularia* (Blyth, 1853)		NE	
10	Scincidae	Travancore Ground Skink	*Kaestlea travancorica* (Beddome, 1870)	WG	LC	
11	Scincidae	Side-spotted Ground Skink	*Kaestlea laterimaculata* (Beddome, 1870)	WG	VU	
12	Varanidae	Bengal Monitor	*Varanus bengalensis* (Daudin, 1802)		LC	Sch. I
13	Typhlopidae	Brahminy Worm Snake	*Indotyphlops braminus* (Daudin, 1803)		NE	Sch. IV
14	Typhlopidae	Beaked Worm Snake	*Grypotyphlops acutus* (Duméril, Bibron and Duméril, 1844)		LC	Sch. IV
15	Uropeltidae	Pied-belly Shieldtail	*Melanophidium punctatum* (Beddome, 1871)	WG	LC	Sch. IV

Appendix 4 (Cont'd):List of Reptiles recorded from the vayal in Periyar Tiger Reserve						
16	Colubridae	Indian Rat snake	*Ptyas mucosa* (Linnaeus, 1758)		NE	Sch. II
17	Colubridae	Beddome's keelback	*Hebius beddomei* (Günther, 1875)	WG	LC	Sch. IV
18	Colubridae	Hill keelback	*Hebius monticola* (Jerdon, 1853)	WG	LC	Sch. IV
19	Colubridae	Checkered keelback	*Xenochrophis piscator* (Schneider, 1799)		NE	Sch. II
20	Colubridae	Common vine snake	*Ahaetulla nasuta* (Lacepede, 1789)		NE	Sch. IV
21	Colubridae	Ceylon cat snake	*Boiga ceylonensis* (Gunther, 1858)		NE	Sch. IV
22	Elapidae	Striped Coral Snake	*Calliophis nigrescens* (Günther, 1862)	LC	WG	Sch. IV
23	Viperidae	Malabar Pit Viper	*Trimeresurus malabaricus* (Jerdon, 1854)	WG	LC	Sch. IV
24	Viperidae	Large-scaled green pit viper	*Trimeresurus macrolepis* (Beddome, 1862)	WG	NT	Sch. IV

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Appendix5. List of Birds recorded from the vayal in Periyar Tiger Reserve

Sl. No.	Family	Common name	Scientific name	END	IUCN	WPA
1	Ardeidae	Indian Pond Heron	*Ardeola grayii* (Sykes, 1832)		LC	Sch. IV
2	Pandionidae	Osprey	*Pandion haliaetus* (Linnaeus, 1758)		LC	Sch. I
3	Accipitridae	Black Baza	*Aviceda leuphotes* (Dumont, 1820)		LC	Sch. I
4	Accipitridae	Oriental Honey Buzzard	*Pernis ptilorhynchus* (Temminck, 1821)		LC	Sch. I
5	Accipitridae	Black Eagle	*Ictinaetus malayensis* (Temminck, 1822)		LC	Sch. I
6	Accipitridae	White-eyed Buzzard	*Butastur teesa* (Franklin, 1831)		LC	Sch. I
7	Accipitridae	Crested Serpent Eagle	*Spilornis cheela* (Latham, 1790)		LC	Sch. I
8	Accipitridae	Crested Hawk Eagle	*Nisaetus nipalensis* (Hodgson, 1836)		LC	Sch. I
9	Accipitridae	Rufous-bellied Eagle	*Lophotriorchis kienerii* (Saint-Hilaire, 1835)		LC	Sch. I
10	Falconidae	Common Kestrel	*Falco tinnunculus* (Linnaeus, 1758)		LC	Sch. IV
11	Phasianidae	Grey Junglefowl	*Gallus sonneratii* (Temminck, 1813)		LC	Sch. II
12	Phasianidae	Red Spurfowl	*Galloperdix spadicea*		LC	Sch. IV

Appendix 5 (Cont'd): List of Birds recorded from the vayal in Periyar Tiger Reserve						
13	Phasianidae	Painted Bush Quail	*Perdicula erythrorhyncha* (Gmelin, 1789)		LC	Sch. IV
14	Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus* (Pennant, 1769)		LC	Sch. IV
15	Columbidae	Blue Rock Pigeon	*Columba livia* (Gmelin, 1789)		LC	Sch. IV
16	Columbidae	Nilgiri Wood Pigeon	*Columba elphinstonii* (Sykes, 1833)	WG	VU	Sch. IV
17	Columbidae	Mountain Imperial Pigeon	*Ducula badia* (Raffles, 1822)		LC	Sch. IV
18	Columbidae	Pompadour Green Pigeon	*Treron pompadora* (Gmelin, 1789)		LC	Sch. IV
19	Caprimulgidae	Great Eared Nightjar	*Lyncornis macrotis* (Vigors, 1831)		LC	Sch. IV
20	Apodidae	Asian Palm Swift	*Cypsiurus balasiensis* (Gray, 1829)		LC	
21	Apodidae	Alpine Swift	*Tachymarptis melba* (Linnaeus, 1758)		LC	
22	Columbidae	Spotted Dove	*Spilopelia chinensis* (Scopoli, 1786)		LC	Sch. IV
23	Psittacidae	Blue-Winged Parakeet	*Psittacula columboides* (Vigors, 1830)	WG	VU	Sch. IV

Appendix 5 (Cont'd): List of Birds recorded from the vayal in Periyar Tiger Reserve						
24	Cuculide	Lesser Coucal	*Centropus bengalensis* (Gmelin, 1788)		LC	Sch. IV
25	Strigidae	Jungle Owlet	*Glaucidium radiatum* (Tickell, 1833)		LC	Sch. IV
26	Strigidae	Brown Fish Owl	*Ketupa zeylonensis* (Gmelin, 1788)		LC	Sch. IV
27	Alcedinidae	White Thoated King-Fisher	*Halcyon smyrnensis* (Linnaeus, 1758)		LC	Sch. IV
28	Meropidae	Chestnut-headed Bee eater	*Merops leschenaulti* (Vieillot, 1817)		LC	
29	Bucerotaidae	Malabar Grey Hornbill	*Ocyceros griseus* (Latham, 1790)	WG	VU	Sch. I
30	Bucerotaidae	Great Hornbill	*Buceros bicornis* (Linnaeus, 1758)		NT	Sch. I
31	Capitonidae	White-cheeked Barbet	*Megalaima viridis* (Boddaert, 1783)		LC	Sch. IV
32	Oriolidae	Indian Golden Oriole	*Oriolus oriolus* (Linnaeus, 1758)		LC	Sch. IV
33	Dicruridae	Ashy Drongo	*Dicrurus leucophaeus* (Vieillot, 1817)		LC	Sch. IV
34	Dicruridae	Bronzed Drongo	*Dicrurus aeneus* (Vieillot, 1817)		LC	Sch. IV
35	Dicruridae	Greater Racket-tailed Drongo	*Dicrurus paradiseus* (Linnaeus, 1766)		LC	Sch. IV

Appendix 5 (Cont'd): List of Birds recorded from the vayal in Periyar Tiger Reserve						
36	Sturnidae	Jungle Myna	*Acridotheres fuscus* (Wagler, 1827)		LC	Sch. IV
37	Sturnidae	Hill Myna	*Gracula religiosa* (Linnaeus, 1758)		LC	Sch. I
38	Corvidae	White-bellied Treepie	*Dendrocitta leucogastra* (Gould, 1833)		LC	Sch. IV
39	Corvidae	House Crow	*Corvus splendens* (Vieillot, 1817)		LC	Sch. V
40	Corvidae	Jungle Crow	*Corvus macrorhynchos* (Wagler, 1827)		LC	Sch. IV
41	Campephagidae	Scarlet Minivet	*Pericrocotus flammeus* (Forster, 1781)		LC	Sch. IV
42	Irenidae	Common Iora	*Aegithina tiphia* (Linnaeus, 1758)		LC	Sch. IV
43	Irenidae	Asian Fairy Bluebird	*Irena Puella* (Latham, 1790)		LC	Sch. IV
44	Estrildidae	Black Headed Munia	*Lonchura Malacca* (Linnaeus, 1766)		LC	Sch. IV
45	Motacillidae	Forest Wagtail	*Dendronanthus indicus* (Gmelin, 1789)		LC	Sch. IV
46	Motacillidae	Grey Wagtail	*Motacilla cinerea* (Tunstall, 1771)		LC	Sch. IV
47	Motacillidae	Nilgiri Pipit	*Anthus nilghiriensis* (Sharpe, 1885)	WG	VU	Sch. IV

Appendix 5 (Cont'd): List of Birds recorded from the vayal in Periyar Tiger Reserve						
48	Motacillidae	Paddyfield Pipit	*Anthus rufulus* (Vieillot, 1818)		LC	Sch. IV
49	Pycnonotidae	Red wiskered Bulbul	*Pycnonotus jocosus* (Linnaeus, 1758)		LC	Sch. IV
50	Pycnonotidae	Red-wented Bulbul	*Pycnonotus cafer* (Linnaeus, 1766)		LC	Sch. IV
51	Muscicapidae	Indian Scimitar Babbler	*Pomatorhinus horsfieldii* (Sykes, 1832)		LC	Sch. IV
52	Muscicapidae	Dark-fronted Babbler	*Rhopocichla atriceps* (Jerdon, 1839)		LC	Sch. IV
53	Muscicapidae	Jungle Babbler	Turdoides striata (Dumont, 1823)		LC	Sch. IV
54	Muscicapidae	Oriental Magpie Robin	*Copsychus saularis* (Linnaeus, 1758)		LC	Sch. IV
55	Muscicapidae	Asian Brown Flycatcher	*Muscicapa dauurica* (Pallas, 1811)		LC	Sch. IV
56	Muscicapidae	Brown Breasted Flycatcher	*Muscicapa muttui* (Layard, 1854)		LC	Sch. IV
57	S:F:Monarchinae	Asian Pardise-flycatcher	*Terpsiphone paradise* (Linnaeus, 1758)		LC	Sch. IV
58	S:F:Sylviinae	Franklin"s Prinia	*Prinia hodgsonii* (Blyth, 1844)		LC	Sch. IV

Appendix 5 (Cont'd): List of Birds recorded from the vayal in Periyar Tiger Reserve						
59	S:F:Sylviinae	Common Tailorbird	*Orthotomus sutorius* (Pennant, 1769)		LC	Sch. IV
60	S:F:Sylviinae	Blyth's Reed Wrabler	*Acrocephalus dumetorum* (Blyth, 1849)		LC	Sch. IV
61	S:F:Sylviinae	Large-billed Leaf-warbler	*Phylloscopus magnirostris* (Blyth, 1843)		LC	Sch. IV
62	Nectariniidae	Little Spiderhunter	*Arachnothera longirostra* (Latham, 1790)		LC	Sch. IV
63	Zosteropidae	Oriental White-eye	*Zosterops palpebrosus* (Temminck, 1824)		LC	Sch. IV

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Appendix6. List of Mammals recorded from the vayal in Periyar Tiger Reserve

Sl. No.	Family	Common name	Scientific name	EDC	IUCN	WPA
1	Bovidae	Gaur	*Bos gaurus* (Smith, 1827)		VU	Sch. I
2	Cervidae	Sambar Deer	*Rusa unicolor* (Kerr, 1792)		VU	Sch. III
3	Canidae	Indian Wild Dog (Dhole)	*Cuon alpines* (Pallas, 1811)		EN	Sch. II

Appendix 6 (Cont'd): List of Mammals recorded from the vayal in Periyar Tiger Reserve						
4	Elephantidae	Asian Elephant	*Elephas maximus* (Linnaeus, 1758)		EN	Sch. I
5	Herpestidae	Brown Mongoose	*Herpestes fuscus* (Waterhouse, 1838)			Sch. II
6	Herpestidae	Common Mungoose	*Herpestes edwardsii* (Saint-Hilaire, 1818)		LC	Sch. II
7	Herpestidae	Stripe-necked Mongoose	*Herpestes vitticollis* (Bennett, 1835)		LC	Sch. II
8	Hystricidae	Indian Porcupine	*Hystrix indica* (Kerr, 1792)		LC	Sch. IV
9	Leporidae	Blacknaped Hare	*Lepus nigricollis* (Cuvier, 1823)		LC	Sch. IV
10	Mantidae	Indian Pangolin	*Manis crassicaudata* (Geoffroy, 1803)		EN	Sch. I
11	Ursidae	Sloth Bear	*Melursus ursinus* (Shaw, 1791)		VU	Sch. I

Appendix 6 (Cont'd): List of Mammals recorded from the vayal in Periyar Tiger Reserve

12	Cervidae	Barking Deer	*Muntiacus muntjak* (Zimmermann, 1780)		LC	Sch. III
13	Felidae	Leopard	*Panthera pardus* (Linnaeus, 1758)		NT	Sch. I
14	Felidae	Tiger	*Panthera tigris* (Linnaeus, 1758)		EN	Sch. I
15	Sciuridae	Indian Giant Squirrel	*Ratufa indica* (Erxleben, 1777)		LC	Sch. II
16	Suidae	Wild Boar	*Sus scrofa* (Linnaeus, 1758)		LC	Sch. III
17	Cercopithecidae	Nigiri Langur	*Trachypithecus johnii* (Fischer, 1829)	WG	VU	Sch. I
18	Viverridae	Small Indian Civet	*Viverricula indica* (Saint-Hilaire, 1803)		LC	Sch. II
19	Viverridae	Brown-palm Civet	*Paradoxurus jerdoni* (Blanford, 1885)	WG	LC	Sch. II

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9. PLATES

Plate 1: Some of the Amphibians recorded from Vayals

Raorchestes akroparallagi

Raorchestes beddomii

Rachophorus kalakkadansis

Rachophorus pseudomalbaricus

Raorchestes griet

Rhacophorus malabaricus

Pseudophilautus wynaadensis

Raorchestes nerostagona

Plate 2: Some of the Reptiles recorded from Vayals

Trimeresurus macrolepis

Trimeresurus malabaricus

Melanochelys trijuga

Eutropis carinata

Calotes ellioti

Boiga ceylonensis

Calotes versicolor

Eutropis macularia

Plate 3: Some of the Birds recorded from Vayals

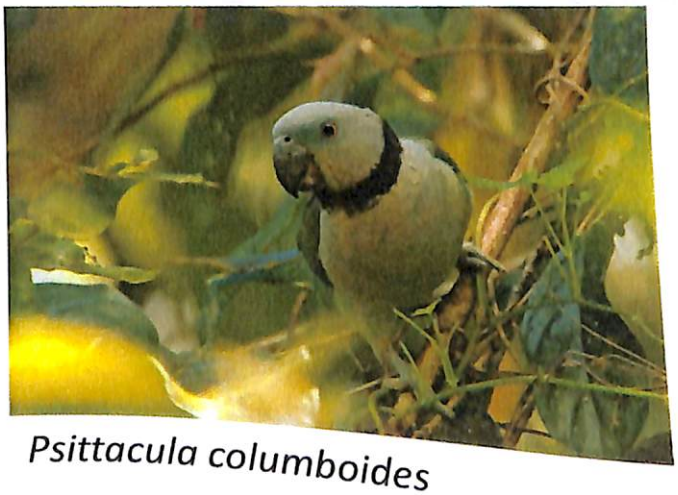
Gracula religiosa

Falco naumanni

Perdiula erythrorhyncha

Gallus sonneratii

Dendronanthus indicus



Psittacula columboides

Dendrocitta leucogastra

Anthus nilghiriensis

Acridotheres fuscus

Nisaetus nipalensis

Plate 4: Some of the Mammals recorded from Vayals

Elephas maximus

Bos gaurus

Sus scrofa

Rusa unicolor

Herpestes fuscus

Manis crassicaudata

Plate 5: Some of the vayals that surrounded by natural vegetation from Periyar Tiger Reserve

Poovarasu vayal

Anakallu vayal

APC campshed vayal

Vallakadavu vayal

Plate 6: 5 Selected vayals for monthly observation

Pothumkandam vayal

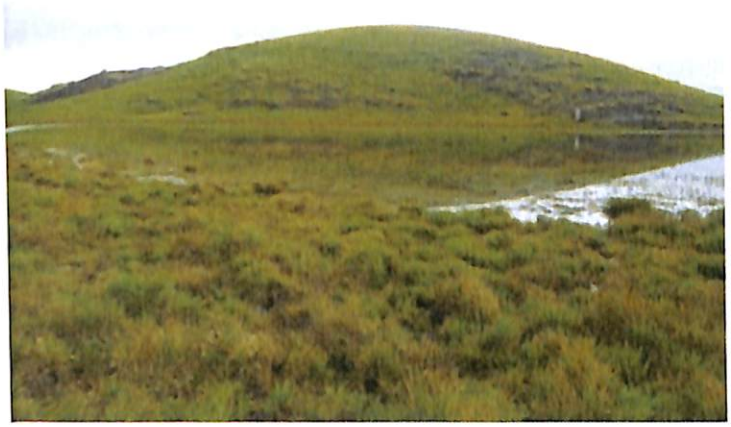
Circle road vayal

Uppupara Tower2 vayal

Uppupara Thavalam vayal

Pachakanam vayal

Plate 7: Vayals surrounded by natural vegetation, eucalyptus plantation and Grassland

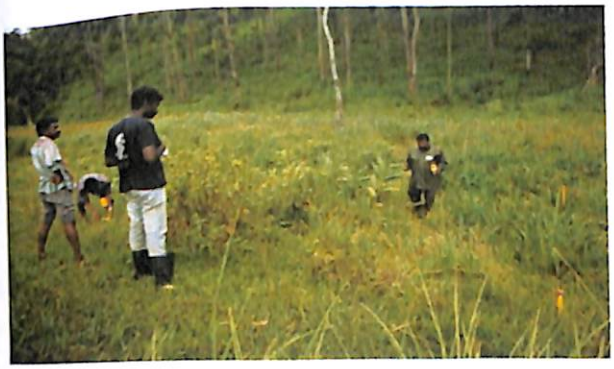


Grassland - Varayadinkokka vayal

Natural vegetation - Chembakavally vayal

Eucalyptus Plantation – 85 plantation vayal

Plate 8: Some of the field work photographs



Marking plots

Plot in Circle Road vayal

Monthly data collection

Plot in Uppupara Thavalam Vayal

Camping during field visit

Camping during field visit