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RESEARCH ARTICLE

FOOD RESOURCE AVAILABILTY TO ELEPHANT AND IMPACT ON TREE SPECIES AROUND ANAYIRANGAL RESERVOIR (MUNNAR-KERALA)

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ABSTRACT

The present study the wide-ranging mammals of Asian elephants (*Elephas maximus*) the casual and proximate factors that determine the food resource availability of elephant. We studied about elephant use of fragmented habitats and ranging patterns of focal herds in a landscape of rainforest fragments are mainly due to tea, coffee, and *Eucalyptus* plantations in the Anayirangal reservoir. There has been a little systematic research work carried out to investigate habitat use and food resource by elephants in different land uses and what are the factors that influence the elephant distribution in these land uses. Grasslands, plantations of Eucalyptus, Pine, Cardamom and Shola are the six different vegetation type selected for this study. For easy observation, the plant species were classified as first dominant grass, second dominant grass species and all remaining classified as others which includes shrubs and herbs. Dominant grass species *Pennisetium purpurem, Cymbophogon citratus, Cyanotis sp., Axnopus compressus, Ischemum indicum* and *Cymbopogon sp*. are recorded in Anayirangal reservoir. Line and belt transect method are used to study to estimated the biomass value of grass, tree density any impact on trees by elephants (debarked damage or push down) or human influence (cut tree) and also use areas of livestock animals in different elephant habitat areas. Biomass value high recorded in grassland-2 (54.3 %) very low in Cardamom plantation (0.4%). Grass biomass value high in grassland-1 (94.75%), Grassland-2(95.77%), Eucalyptus plantation (73.88%), Pine plantation (71.52%), in Shola forest (88.61%). The carbon value is high in *Cymbopogon citratus* (54.87%) followed by *Pennisetium purpurem* (54.80 %) and carbon value is low in the grass species *Arundinella purpunea*(45.82 %). The Nitrogen value is highest in *Setonia polmifolia* (4.17 %), *Oplismenus composites* (3.64) and very low in *Cymbopogon. Sp* (0.53) followed by *Cymbopogon citratus* (0.79). Human population, Encroachment and tourism reduced or fragmented the elephant habitat area. High level conflicts were recorded in BL Ram of the study area. In the total survey area, there were only four trees were seen debarking by elephant and the impact on trees by man were more. Mega herbivores like the elephant with a large home range and equally large food requirements have been among the most affected species. This study concludes that the important survival sources or factors of the elephants were highly reduced in Anayirangal reservoir through anthropogenic activities cause frequent human elephant conflicts.

INTRODUCTION

In India, Asian elephants are reported to be responsible for 100–200 human deaths annually (Thirgood *et al*., 2005). The last 20 years in Lampung have therefore been characterized by near continuous human–elephant conflict and the wholesale loss of elephant habitat (Reilly, 2002a). Asian elephants (*Elephas maximus*) still occur in isolated populations across much of their historical range, but many populations are threatened by habitat loss, poaching, and direct conflict with

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humans (Sukumar, 1992, Blake and Hedges, 2004). The species is listed as Endangered in the 2004 IUCN Red List of Threatened Species (IUCN, 2004), and is included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; UNEP-WCMC, 2003). Nevertheless, little is known about the status of Asian elephant populations.

Human Elephant Conflict (HEC) occurs when the human and elephant have overlapping interests. This arises in areas where elephants and people live close to each other and share resources such as water, food and land. The conflict is most severe in the interface between the elephant range agricultural land. Most of the time conflict may be in the form of crop raiding where elephants consume, trample and destroy food crops, cause property loss and kill or injure people (Chandrasekhar *et al*., 2003). The main reason for human – elephant conflict are habitat destruction, human population growth, land use transformation, growing interest in tourism increasing access to nature reserves, increasing livestock populations, competitive exclusion of wild herbivores.

In countries all over the world, and particularly in zones surrounding national parks and other protected areas, borders between ‘‘human” and ‘‘wild” spaces have become blurred. Wild animals frequently leave protected areas and enter nearby human settlements, and members of forest- dependent villages may enter protected areas where they come into close proximity with wildlife. The resulting human–wildlife conflict (HWC) – e.g., crop damage, livestock predation, property damage, and attack of humans – often undermines local support for conservation. Such lack of support is evidenced by damage inflicted upon wildlife by humans, including habitat degradation or ‘‘retaliation” killings in which waterholes, crops, or baited carcasses are deliberately poisoned (Bagchi and Mishra, 2006).

Human pressures on elephants caused by poaching and conflict for resources, and efforts to modify the effects of elephants on vegetation and crops, are widely reported throughout Africa and Asia (Sukumar and Gadgil, 1988; O’Connell-Rodwell *et al*., 2000). The Asian elephant is able to adapt to a wide range of habitats, from thick jungle to grassy plains and unusually where there are permanent water bodies and vegetation, they restrict to limited areas with access to food, water, minerals, and shelter. They have traditional drinking sites, returns there year after year, and they show high fidelity to traditional home ranges (Daniel and Dayang, 2005). Elephants therefore switch over largely to eating grasses, which give them adequate supply of protein to make up for whatever weight which might have lost earlier (Sukumar, 1991).

Desai (2002) reported that the elephant herds living in areas with sufficient natural resource would not raid crops even if they had the change to do so, but certain individuals, not the entire herds, may raid crops to supplement their diet even if there is no real need to do so. It is generally found that bulls or tuskers are more likely to engage in high -risk activities like crop raiding as a means of increasing their reproductive potential through better nutrition (Sukumar, 1991). Tuskers are more likely to break fences, electric fences, during active crop raiding as their tusks do not conduct electricity (Nelson *et al*., 2003). Elephant have large home range with traditional migratory routs. When their home ranges are reduced by encroachment, they lose feeding grounds and these traditional migratory routs become disrupted (Desai, 2002). The migration routes that connect already fragmented habitats are being rapidly served by human settlements. Large migratory mammals like elephants are particularly vulnerable to this fragmentation (Johnsingh *et al*., 1990).

Elephants are generalist feeders, consuming a large number of plant species. They eat 10% of their body weight each day, i.e. for adults between 170 to 200 kg of food per day, and need 80 to 200 litres of water a day, which is used more for bathing. Elephants feed on plants by plucking grasses, forbs and creepers, frequently uprooting them; by stripping leaves, fruits, twigs or bark from woody trees and shrubs; by breaking-off branches to facilitate consumption of edible parts; and by pushing over or uprooting trees and shrubs. Elephants graze and browse on the tender and palatable portions of different plants and trees. The number of plant species being consumed generally exceeds 50 species in dry habitats, more than 100 in deciduous forests, and over 200 in rainforest (Asian Nature Conservation Foundation, 2006).

It is a generalized feeder on a variety of species and generally includes the families Graminnea, Palmea, Leguinosae (subfamilies Papilionoideae, Caesalpinoideae and Mimosoideae), Malvaceae, Sterculiaceae and Teliaceae (Sukumar, 1989). The elephant likes to eat the bark of many trees and shrubs. The chemical analysis of the kind of bark consumed by elephants indicate that these may be a significant source of certain essential fatty acids and some minerals such as calcium, manganese, iron, boron, and copper (Eltringham,1991). They also consume soil, rich in minerals like sodium for its mineral content (Sukumar, 1995).

Competition for space and shared resources could have affected wildlife populations. With studies indicating that wild herbivores in particular are adversely affected by populations of livestock (Prins, 2000). According to the World Conservation Union, Human conflict occurs when wildlife requirements overlap with those of human populations, creating costs to residents and wild animals. Conflict arises from a range of direct and indirect negative interactions between humans and wildlife. These can culminate in potential harm to all involved, and lead to negative human attitudes, with a decrease in human appreciation of wildlife and potentially severe detrimental effects for conservation (De Boer and Baquete, 1998).

Pradhan *et al.* (2007b) has recently carried out a comparative study on elephants and rhinoceros diet. Generally elephant grass growing in N lacking soils, the average of dry matter biome production after two cuts per year were about 30 Mg ha-1, and fibre and lignin contents matched the desirable parameters for energy production from direct burning. Biomass yield levels were not drastically reduced, in comparison to the ones in fertilized systems. The suitability of the biomass for the

support life system in an particular area depends mainly on it. Availability of biomass could initiate the species migration and too increase in their number (Quesada, 2005). In Recent reports, stated that both of the animals ate more browse in dry season; with bark constituting an estimated 73% in the elephant diet in the cool-dry season. According to him, mainly the bark of *Mallotus phillippinensis* was present in the micro-histological analysis of elephant faecal material. Diet selection by any species is principally guided by the nutrient/mineral requirement of the particular animal. Sukumar (1990) has reported that the decreasing proportion of grass from the early rainy season to the late rainy season and the dry season can be explained by the decrease in palatability and nutrient concentration.

Large mammals like Elephant (*Elephant maximus*) and Gaurs (*Bos gaurus*) play an important role in the vegetation dynamics of forests (Sukumar, 1989). They also influence forest by trampling and debarking (Hoft & Hoft, 1970; Sheil, 1996; Strushsaker *et al*., 1996). In the abundance of leaves during the dry season they consume bark and in the process inflict heavy damage to the trees (Sukumar, 1989). Debarking affect mainly smaller trees, indicating reduced recruitment into reproductive age classes (Faber and Thorson 1996). Browsing, with or without debarking, increases new shoot size, reduces reproductive output, and increases physical or chemical defences (Danell *et al*. 1994; Scogings 2003); complete breaking of phloem transport has the greatest impact (Welch and Scott 1998), and concentrations of nitrogen, tannin and fiber are negatively related (Herms and Mattson 1992). Debarking and bark utilization is a seasonal phenomenon, associated with wet climatical phases.

In the present study emphasis the estimating the biomass and density of elephant food tree species, to access the impact of elephants on their habitat (tree species) and to identify areas of conflict for resources between elephant and humans (Including domestic livestock).

MATERIALS AND METHODS

Study Area

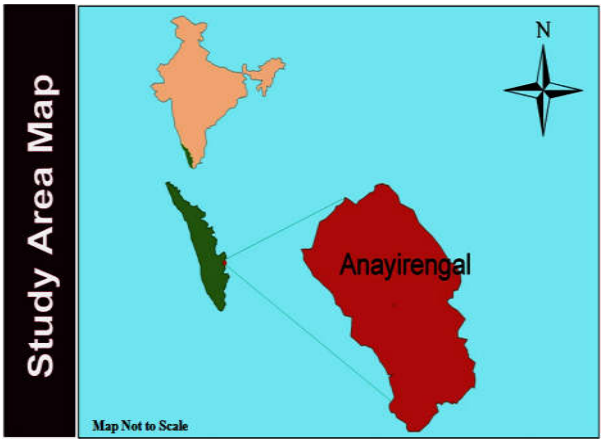

Figure 1

The study area is around Anayiragal Reservoir and covers an area of 113.5km^2. This part of the Western Ghats Landscape is part of the Davikulam forest Range of Munnar forest Division (77^0 9' 12.09"E to 77^0 16'22.68"E longitude and 100 4' 54.22"N to 90 55' 57.69" N) (Fig 1). The area is located in the eastern part of Idukky district of Kerala and comprises of valleys surrounded by hills with an altitude ranging from 1010.87 to 2444.6m from which numerous drainages emerge that finally reach the reservoir. Anayiragal dam was constructed during the year 1967, as a recharging dam of the Ponmudi Dam of Idukky district, which is a part of the Kallarkuty Hydro Electric project. Presently Kerala State Electricity Board (KSEB) maintains the reservoir. The reservoir has an area of 4 km^2. On the southern side of the reservoir is the tea estates owned by Harrison Malayalam Ltd. And further south is the Mathekettan National Park; on the eastern side is Tamilnadu part of western Ghats, north is Suryanalli and Chinakanal villages and west-the tea estate owned by Kennan Devan hill products company Ltd (KDHP). The total biomass and food tree species availability was estimated using the following standard methods.

Vegetation analysis

The total land area was divided into 83 grid (one grid is equal to 1 km^2), from this 32 grid (35% of the land area) was selected for biomass estimation. The number of grids were selected from different vegetation types (2 grid from grassland, 1 grid from Eucalyptus, 1 grid from Pine plantation, 2 grid in shola and 4 grid from Cardamom plantation) randomly based on the vegetation area. Vegetation types were classified based on the dominant plant species like Grass land I, Grassland II, Eucalyptus, Pine, Shola and Cardamom plantation. For estimating the grass biomass belt transects method was followed.

In each grid ten numbers of 10 x 5 meter quadrate was laid and within this quadrate two 1 x 1 meter sub quadrate was laid as one in the beginning and other one at the end. Between the each 10 x 5 meter quadrate 100 meter intervals were maintained. In each sub quadrate two dominant grass species (I dominant & II dominant species) were identified based on the individual and biomass. To estimate the bio mass the whole grass species were removed at ground level and it was weighed. Other than this two dominant grass whichever present in the quadrate were considered in other species category. The plant species which could not be identified in the field were collected for further identification.

In each 10 x 5 meter quadrate, the total number of tree species, Girth at Brest Height (GBH), human and elephant impacts (felling and fire wood collection; push down / debarking) were assessed. The percentage of canopy cover loss was noticed in each affected tree species.

For estimating biomass value, 250 gram of plant sample from each species was collected from individual sub plots. For some species where the total weights were less than 250, the available weighing plant sample was collected for the analysis and later it was extrapolated to 250 gram. The grass material properly packed after weighing the wet weight. Plastic bags were used for collecting the plant samples and care was taken for maintaining the moisture content, and checked for fungal contamination before transferring to lab for analysis.

Biomass Estimation

The plant material was air dried and then clipped at ground level then they were dried in hot air oven at 80^0 C to constant weight and weighed to the nearest 0.01g. After removing from the oven the samples were cooled at room temperature in desiccators before weighing (Andariese and Covington, 1986). The following formula was used for estimating the value

$$\text{Moisture content} = \frac{\text{Weight before drying} - \text{Weight after drying}}{\text{Taken samples}} \times 100$$

Carbon Analysis Method

For analyzing the organic matter about 5g of ground sample were placed in a previously weighed silica crucible and muffled slowly in an electric muffle furnace to about 550^0 C for 30 min. Then the dish was cooled using desiccators and weighed. The percentage loss in weight was calculated as organic matter using the following formula.

$$\text{Percentage of Organic matter} = \frac{\text{(Initial weight - final weight)}}{\text{Initial weight}} \times 10$$

The most accurate electric combustion method was followed to estimate the total carbon (Gibbs *et al*., 2007). Volatile solids (VS) are the components (large carbon, oxygen and nitrogen), which burn off an already dry sample in laboratory furnace at 500^0 C to 600^0 C. Leaving only ash (largely calcium, magnesium, phosphorus, potassium and other elements that do not oxidize). For most biological materials the carbon content is between 45 to 60% of the VS fraction. Assuming 55% (Adams, R.C. *et al*, 1951) the formula is

$$\text{Carbon percentage} = \frac{\text{Loss of Ignition}}{1.724}$$

Analysis of Total Nitrogen

The nitrogen content was analysed using Kjeldahl method. One gram of sample was transferred to digestion tube, with this 20 ml of concentrate H_2SO_4 was added and the digestion block was heated till it reaches the digestion temperature, then they were loaded into digester. The block temperature was maintained between 360^0 C and 410^0 C. The tube samples were turned to colourless or light green colour at the end of digestion process. A blank was also maintained simultaneously with sample. The tubes were allowed to get cool till it becomes free of fumes and used for distillation.

Distillation

For distillation 20 ml of 4% boric acid was added along with 5-6 drops of mixed indicator. The digested samples were loaded into distillation apparatus and the receiver end was kept and the hose was immersed in boric acid solution to collect the liberating ammonia. The alkali volume switch was pressed to add the selected volume (of what) to the digested sample. The stream was allowed to the digested sample by using the process / time /min switch (6 min). After ensuring the complete digestion the receiver solution was taken for titration. The procedure was repeated for other samples and bank.

Titration

The solution of boric acid and mixed indicator containing the 'distilled off" ammonia standardized with H_2SO_4 was titrated. The end point was indicated by the colour change from green to red and the titrated value of blank was also determined
And the percentage of nitrogen was calculated as follows

$$\text{Percentage of Nitrogen} = \frac{\text{(Sample value – Blank value) x Normality of } H_2SO_4 \text{ x 14 x100}}{\text{Volume of Sample x 1000}}$$

RESULT AND DISCUSSION

The present investigation was carried out to find out the availability of food resources to elephant and the impact on tree species around Anayiragal Reservoir of Kerala. In this area there is a conflict between elephant and humans including domestic livestock for sharing the resources availability were observed. From the observation, it is clear that the grass species are the prominent vegetation consumed by the elephant as a food source comparing to the tree species. It is noted that not even a single tree species were consumed by the elephants in the study area. A total of nineteen grass species were identified and most of the species belong to the family Poacea except *Cyperus pangorei* which is belonging to the Cypenaceae family. Grassland I and II, plantations of Eucalyptus, Pine, Cardamom and Sholas are the six different vegetation type selected for this study. For easy observation, the plant species were classified as first dominant grass, second dominant grass species and all remaining classified as others which includes shrubs and herbs.

Diversity

The maximum number of grass species was found in the Grassland I (Table. 1). They are *Pennisetium purpurem, Cymbophogon citratus, Cyanotis sp., Axnopus compressus, Ischemum indicum* and *Cymbopogon sp*.

There are five species *viz. Cymbopogon sp. Cyanotis sp., Oplismemus composites, Ischemum indicum* and *Axnopus compressus which were* identified as the second dominant species.

The other species present in the Grassland 1 are *Jasminum.sp* (Oliaceae), *Eupatorium odoratum L.* (Asteraceae), *Laggera alata Sch-Bip* (Asteraceae) and *Thumbergia tragrans Roxb.*(Acanthaceae), *Ageratum houstonianum Mill* (Asteraceae) and *Tylophora asthmatica W.&A.* (Asclepiadaceae), which are very minimal in numbers.

Table 1 Total grass species recorded of Anayiragal

Sl.no	Speceis
1	*Arundinella purpurea*
2	*Auxonpus compressus*
3	*Brachiiaria.sp*
4	*Cyanotis .sp*
5	*Cymbopogon.sp*
6	*Cymbopogon citratus*
7	*Cyperus pangorei (Cypenaceae)*
8	*Dicanthium foreolatum*
9	*Eragosties uniloides*
10	*Isachne.sp*
11	*Ischemum indicum*
12	*Ischemum timerens*
13	*Kyllinga triceps*
14	*Oplismemus composites*
15	*Panicum psilopodium*
16	*Paspalum conjucatum*
17	*Pennisetium purpurem*
18	*Phoenix loureirii*
19	*Setaria polmifolia*

Biomass

In the grassland I the total biomass of the first dominant grass is 94.75%, second dominant grass species contain 2.65 % and others contribute only 2.60% (Fig 2). Similarly plantation-forest mosaic of the Valparai plateau, elephants used rainforest fragments and grass biomass along rivers more than areas under plantation crops when considered relative to availability. This indicates the importance of grass biomass for elephants in such landscapes. Some degraded rainforest fragments on the plateau contained secondary vegetation providing favorable habitat and forage for elephants (Kumar *et al*., 2004).

In Grassland II, the first dominant grass species identified was *Pennisetium purpurem, Phoenix loureirii* and *Cymbopogon citratus* and the second dominant grass species recorded were *Ischemum indicum, Cymbopogon.sp, Ischemum indicum, Pennisetium purpurem, Eragroties uniloides* and *Arundinella purpunea.*

The other species includes *Tephrosia sp., Ageratum houstonianum Mill (Asteraceae), Tylophora asthmatic. (Asclepiadaceae)* and *Eupatorium odoratum L. (Asteraceae)*, which are very low comparing to the other two dominant species. In grass land II the biomass concern the first dominant grass species contributes 95.77 % and second dominant grass contributes 2.26% and others contributes only 1.61 (Fig 3).

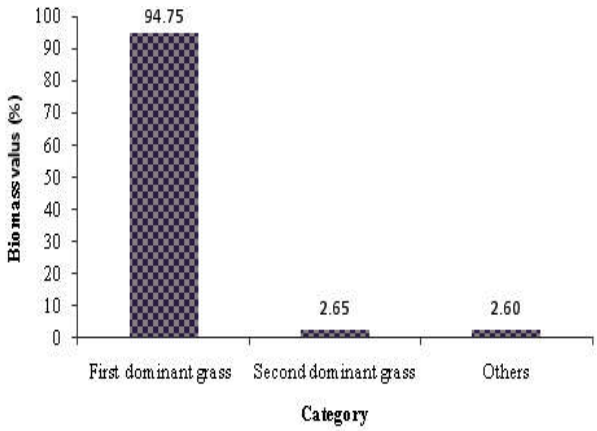

Figure 2 Biomass value in Grassland I

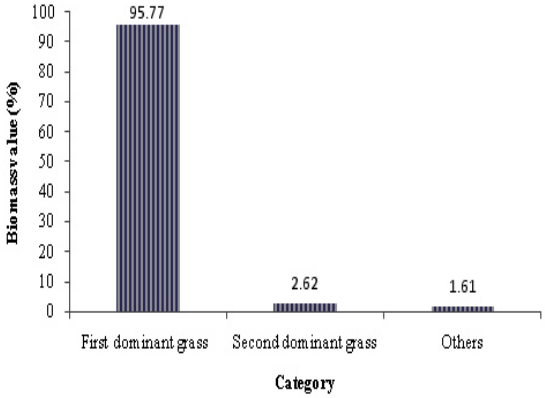

Figure 3 Biomass value in Grassland II

A total of ten grass species were identified as the dominant species in the Eucalyptus plantation. They are *Axnopus compressus, Erorostis unilodies, Cymbopogon citratus, Pennisetium purpurem, Setonia polmifolia, Panicum psilopodium, Cyperus pangorei (Cypenaceae), Kyllina triceps , Cyanotis.sp* and *Ischemum timerens.* The second dominant grass species are *Enorostis unilodies, Ischemum indicum, Cymbopogon citratus, Pennisetium purpurem, Oplismemus composites, Panicum psilopodium, Cyperus pangorei (Cypenaceae* and *Brachiiaria. sp.* The other species present in eucalyptus plantation are *Lantana sp, Ageratum houstonianum Mill (Asteraceae),Urena lobata L.(Malvaceae), Bidens pilosa L.(Asteraceae), Jasminum .sp (Oliaceae),Polygonum chinense L.(Polygonaceae), Tylophora asthmatica W.&A. (Asclepiadaceae), Eupatorium odoratum L. (Asteraceae), Vernonia divergens. Edgew (Asteraceae), Achyranthes bindentata Blume (Amaranthaceae), Teridium aelinum (Fern).* Likewise, Valparai plateau, elephants used coffee plantations more in the dry season and Eucalyptus plantations more during the wet season. Coffee plantations are used more frequently by elephants during the dry season, possibly due to the presence of grass under tree cover and browse from native shade trees. Moreover, elephant use of coffee plantation corresponds to a period of minimal human activity during most of the dry season. Natural vegetation was important in both seasons for elephants. In the present study area provided with the natural grass species and plantation for the survival of life support system to the elephants based on the climatic factors condition available in the field (Sukumar *et al*., 1995, Ananda Kumar *et al*., 2010). In Eucalyptus plantation the first dominant species contributes 73.88% of biomass, 11.36% by the second dominant species and others contributes 14.76% (Fig 4)

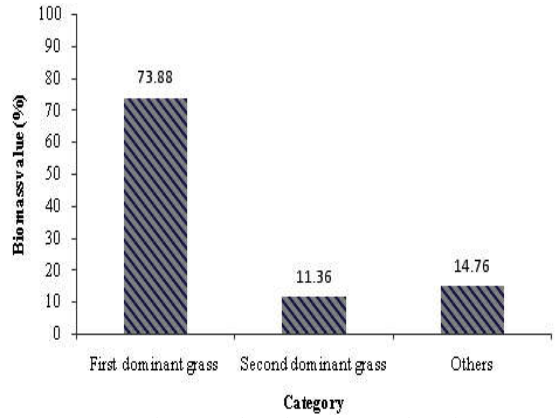

Figure 4 Biomass value of Eucalyptus Plantation

In Pine plantation the following species like *Pennisetium purpurem, Paspalum conjucatum, Panicum psilopodium* and *Cyanotis sp.* are considered as first dominant grass species and the second dominant species are *Oplismenus composites, Cymbopogon.sp, Setonia polmifolia and Panicum psilopodium*. Other species found in Pine plantation are *Lantana sp, Vernonia divergens. Edgew (Asteraceae), Eupatorium odoratum L. (Asteraceae), Urena lobata L.(Malvaceae), Ageratum houstonianum Mill (Asteraceae),Commelina bengalensis L. (Commelinaceae), Bidens pilosa L.(Asteraceae) Teridium aelinum (Fern) and Mymosacea. sp*. The first dominant grass species contributes 71.52 % of biomass, 9.09 % by second dominant grass species and 19.39% by others grass species (Fig 5).

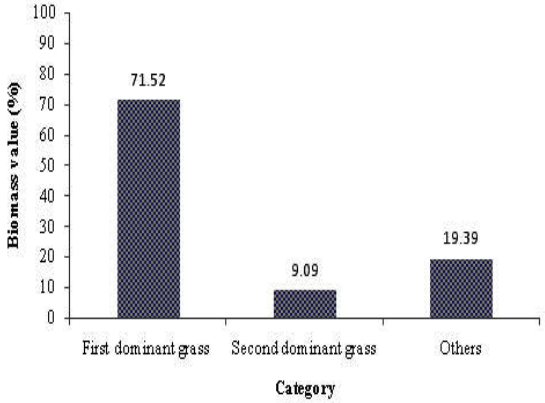

Figure 5 Biomass value of Pine Plantation

In Papathi Shola *Oplismenus composites, Cyanotis sp.* and *Setonia polmifolia* are the first dominant grass species and the second dominant grass species includes *Setonia polmifolia and Panicum psilopodium*. Other species of the Papathi Shola are *Commelina bengalensis L. (Commelinaceae), Polygonum* chinense *(Polygonaceae), Elatostemma sp. (Urticaceae), Peectranthus sp. (Lamiaceae), Teridium aelinum (Fern), Bidens pilosa L. (Asteraceae), Eupatorium odoratum L. (Asteraceae), Vernonia divergens. Edgew (Asteraceae), Thumbergia tragrans roxb (Acanthaceae), Achyranthes bidentata Blume (Amaranthaceae)* and *Jasminum sp. (Oliaceae)*. Biomass contribution from Papathi Shola is 88.61% by from first dominant species, 11.38% by second dominant species (Fig 6). Indeed, such a mosaic of habitat types could be responsible for the high density of elephants seen in the Western Ghats. Nevertheless, a considerable portion (594 km2) of the land is under monoculture forest plantations, mainly teak.

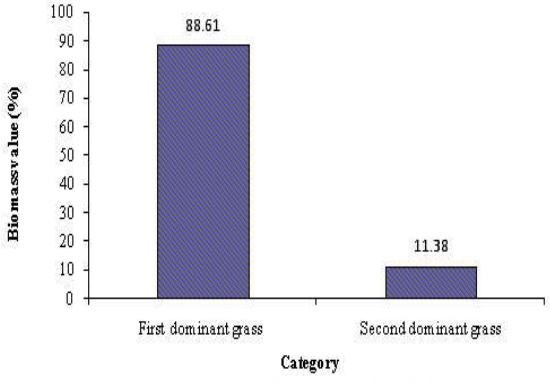

Figure 6 Biomass value of Papathi Shola

Studies on elephant habitat use in this landscape (Baskaran *et al*. 2007) and elsewhere from northeastern India (Sukumar *et al*. 2003; Baskaran *et al*. 2004) have shown lower use of monoculture forest plantations over the natural forest habitats by elephants, due to the absence or lack of diverse forage plants in such plantations. Among the all forest type the biomass value was high in grassland II (54.3%) and low in Cardamom plantations (0.4%) (Fig 7).

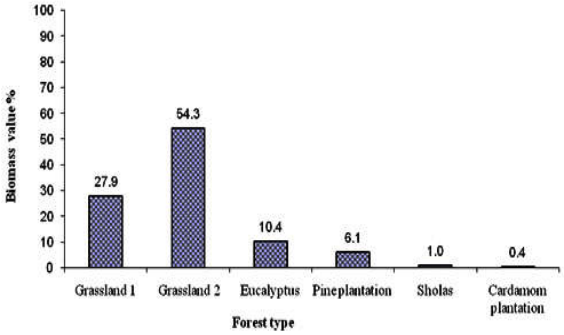

Figure 7 Biomass content in different forest types

The carbon value is high in *Cymbopogon citratus* (54.87%) followed by *Pennisetium purpurem* (54.80 %) and carbon value is low in the grass species *Arundinella purpunea* (45.82 %), followed by *Oplismenus composites* (46.28) (Fig 8).

Table 2 The total amount of Carbon % in different grass species

Sl. No.	Botanical name of Grass species	Sample weight(g)	Carbon value (%)
1	*Arundinella purpurea*	5	45.82
2	*Auxonpus compressus*	5	50.00
3	*Brachiiaria.sp*	5	46.98
4	*Cyanotis .sp*	5	50.34
5	*Cymbopogon.sp*	5	54.75
6	*Cymbopogon citratus*	5	54.87
7	*Cyperus pangorei (Cypenaceae)*	1	51.62
8	*Dicanthium foreolatum*	5	53.36
9	*Eragosties uniloides*	5	51.74
10	*Isachne.sp*	5	47.33
11	*Ischemum indicum*	3	50.27
12	*Ischemum timerens*	5	54.64
13	*Kyllinga triceps*	1	52.20
14	*Oplismemus composites*	5	46.28
15	*Panicum psilopodium*	5	46.51
16	*Paspalum conjucatum*	5	48.72
17	*Pennisetium purpurem*	5	54.98
18	*Phoenix loureirii*	5	53.01
19	*Setaria polmifolia*	5	49.30

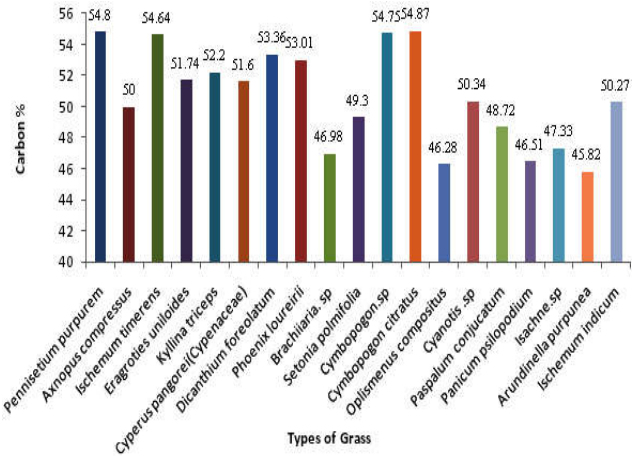

Figure 8 The total amount of Carbon in different grass species

Oplismenus composites (3.64) and very low in *Cymbopogon. Sp* (0.53) followed by *Cymbopogon citratus* (0.79)

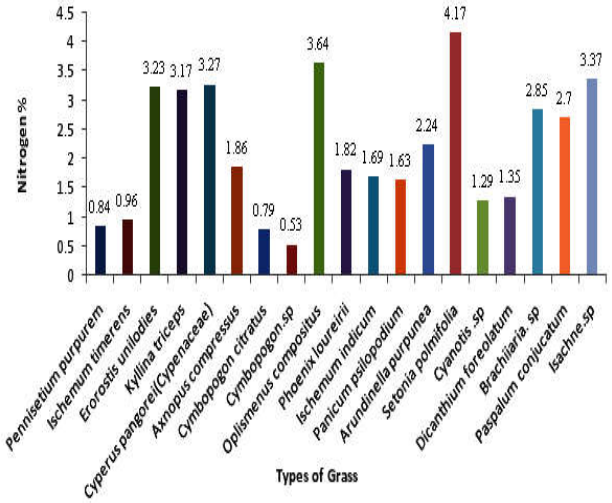

Figure 9 Nitrogen value in different Grass species

Table 3 Nitrogen % in different types of Grass

Sl. No	Botanical name of Grass species	Sample weight (g)	Nitrogen value (%)
1	*Arundinella purpurea*	1	2.24
2	*Auxonpus compressus*	1	1.86
3	*Brachiiaria.sp*	1	2.85
4	*Cyanotis .sp*	1	1.29
5	*Cymbopogon.sp*	1	0.53
6	*Cymbopogon citratus*	1	0.79
7	*Cyperus pangorei (Cypenaceae)*	1	3.27
8	*Dicanthium foreolatum*	1	1.35
9	*Eragosties uniloides*	1	3.23
10	*Isachne.sp*	1	3.37
1	*Ischemum indicum*	1	1.69
12	*Ischemum timerens*	1	0.96
13	*Kyllinga triceps*	1	3.17
14	*Oplismemus composites*	1	3.64
15	*Panicum psilopodium*	1	1.63
16	*Paspalum conjucatum*	1	2.70
17	*Pennisetium purpurem*	1	0.84
18	*Phoenix loureirii*	1	1.82
19	*Setaria polmifolia*	1	4.17

Carbon and Nitrogen Ratio

Carbon and Nitrogen ratio for different speceies are given in the parenthesis against each species. *Pennisetium purpurem* (54.8: 0.84), *Axnopus compressus* (50: 1.86), *Ischemum timerens* (54.64: 0.96), *Eragroties uniloides* (51.74: 3.23), *Kyllina triceps* (52.2: 3.17), *Cyperus pangorei* (51.6: 3.27), *Dicanthium foreolatum* (53.36: 1.35), *Phoenix loureirii* (53.01: 1.82), *Brachiiaria. Sp* (46.98: 2.85), *Setonia polmifolia* (49.3: 4.17), *Cymbopogon.sp* (54.75: 0.53), *Cymbopogon citratus* (54.87: 0.79), *Oplismenus composites* (46.28: 3.64), *Cyanotis sp.* (50.34: 1.29), *Paspalum conjucatum* (48.72: 2.7), *Panicum psilopodium* (46.51: 1.63), *Isachne sp.* (47.33: 3.37), *Arundinella purpunea* (45.82: 2.24), *Ischemum indicum* (50.27: 1.69).

Carbon and Nitrogen ratio was significant differences in grass species not observed between the different genotype levels. The Paraíso genotype presented, in absolute values, higher C/N and S/L ratios when compared to Roxo genotype. As the stems concentrate more fibre, genotypes with high biomass productivity associated to a high proportion of dry matter of stems in the total produced are more promising to material of high calorific value. In this sense, the higher the C/N ratios typically the more fibrous and lignified the material gives better conditions for the energetic use, and indicate a greater production capacity with less accumulated nitrogen (QUESADA, 2005).

Elephant Debarking Damage

In the total survey area, there were only 4 trees were seen debarking by elephant and the impact on trees by man were more (8) (Fig 8). Previous reports stated that, (Styles and Skinner (2000) mopane bark appears to be most palatable during the winter months, largely because of its lower tannin content and total phenols. During the summer months, bark would be most nutritious but accompanied by high tannins and increased total phenols. To the need of nutritious fact the elephants debark in the study area consist with damage of vegetation. Moreover predominantly Eucalyptus, Tea includes (Silver Oak) and cardamom plantations were found in the study area there is no possibility to debark with the vegetation.

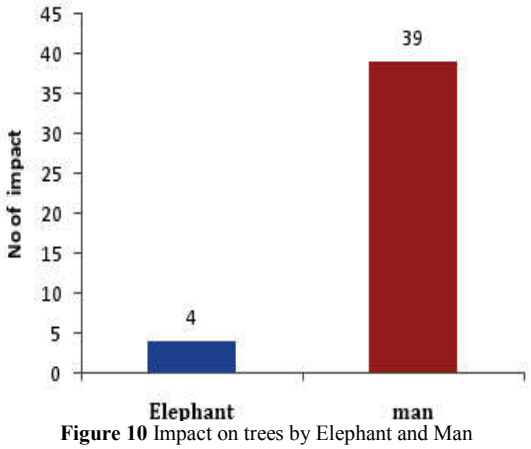

Figure 10 Impact on trees by Elephant and Man

Human Elephant Conflict

The valley of study area has patches of varied habitats like Semi-evergreen forest, Pine/eucalyptus/cardamom plantations, scrub and rocky areas etc. The new settlers of the area cultivate a variety of crops like pepper, tapioca, banana, millets etc. The main cash crops presently being cultivated in the area are cardamom, tea, coffee, pepper, banana, millets and tapioca. The vegetables like beans, tomato, taro and ginger are the main food crops. There are thirteen settlements existing in the area, out of which two settlements were established during 2002. These villages are the Chinnakkanal, Poopara and Santhappara villages, under Chinnakkanal, Santhan Para and Rajakumari Grama panchayath. The settlements are listed in table 2.

The total elephant population present in the study area is 28-32 (Rameshan and Areendran 2007). In four herds 17 elephants were counted at the Anayirangal Reservoir. Two lone Tuskers were also observed in the area. Another herd of 13 elephants were observed at Mathikettan Shola National park. One herd of four elephants at the Anayirangal area was suspected to be duplicated, and therefore the population strength was estimated at 28 - 32. Seven bulls and 25 cows were counted with the male female ratio 1:3.5/1:3. The total population of elephants seen was four herds and two lone tuskers. According to the opinion

of the villagers, these herd patterns are not permanent. The herds used to disassociate and reunite. All the herds had sub adults of different age groups. The elephants mostly inhabit in the pine and eucalyptus plantations and the small patches of the forest near to the reservoir during the daytime. The elephants are observed to be moving between Mathekettan National Park and Anayirangal area. This movement is through a narrow corridor between the villages of Thodimala and Sundal. The frequent human induced forest fires in these regions destroy the vegetation. `The human elephant conflict were seen in higher at BL Ram village near the Anayirangal reservoir, due to the over population and Cardamom plantation. Moreover the availability of water resource for the elephant near the Anayirangal reservoir therefore there was a Human - elephants conflict compared to rest of the villages.

Table 4 The list of settlements in the Anayirangal Area

Sl.No	Villages
1	Singu Kandam
2	Shambtholuvakudy
3	Tank kudy
4	Thidir Nagar
5	BL Ram
6	Kozhippennakkudy
7	Muthamn colony
8	Vetnamthery
9	Panthadikulam
10	Thondimala
11	Thalakkulam
12	301 area Adivasi Colony
13	80 acre New Adivasi Colony

The Human elephant Conflict (HEC) at Anayirangal area has been on an increasing, due to the anthropogenic activities cattle domination in elephant usage area. The increase of tourism activities, new settlements, encroachments and development of new road network were identified as the reason for this increase of Human Elephant Conflict (Rameshan and Areendran 2007). The loss and fragmentation of habitat, resulting in longer perimeter of forest area to cultivation, could bring relatively large numbers of elephants in contact with agriculture in the course of their seasonal movements (Sukumar 2003) followed by the greater anthropogenic impacts such as cattle grazing and fuel wood collection on forests in the eastern side (Kumar *et al*. 2002), could also perhaps further drive elephants to crop raiding more frequently here as reported elsewhere (Kumar *et al*. 2004b). More possible factor like greater extent of cultivation of highly palatable annual crops (as inferred from the percentage of farmers cultivating annual crops) in the eastern side could also be a reason for the higher degree of conflict (Sukumar 1989).

Conflict between Elephant and Livestock

Here most of cattle prefer the grassland I (104), followed by the secondary grass land II (27), Eucalyptus plantation (5), Pine plantation (10) and Papathi Shola (3).

The habitat linkage is crucial for large ranging animals such as elephants, which use these forest corridors for migration (Silori, and Mishra, 2001). Livestock grazing, a major biotic interference in forest corridors. Anayirangal reservoir region is well supported with all types of grasses and bushes. Moreover the settlements were seen in and around the reservoir and the human life system also based on their livestock. It is make imagination of cattle in to the elephant usage area followed by human interference leads to conflict.

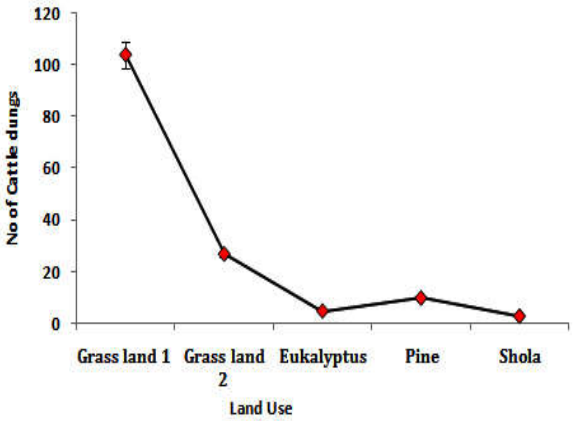

Figure 11 Cattle usage of different land use

Recommendation

Overall, the study shows that the Anayirangal Reservoir may support over approximately 28-32 elephants, ranging over about 113.5km^2 of diverse habitat types. However, a small part of the population is certainly isolated at Mathikettan Shola National park owing to land-use and topographical constraints. A higher proportion of plantation and tourism in and around Anayirangal Reservoir has resulted in several bottlenecks to the movement of elephants and greater elephant-human conflict. We make the following broad recommendations to conserve the Anayirangal region elephant populations.

(i) Complete prohibition of human encroachment in the Anayirangal Reservoir region
(ii) Removal of Eucalyptus and pine vegetation in and around Anayirangal Reservoir region and rejuvenation of elephant life supporting ecological elements to reduce the conflict.

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