CONTRIBUTION OF BAMBOO (*Dendrocalamus strictus*) IN THE DIET OF UNGULATES OF TADOBA ANDHARI TIGER RESERVE, MAHARASHTRA, INDIA

Major Project Thesis

Submitted by

ASHA

For the partial fulfillment of the

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Submitted to
Department of Energy and Environment
TERI School of Advanced Studies

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DECLARATION

This is to certify that the work that forms the basis of this project "CONTRIBUTION OF BAMBOO (*Dendrocalamus strictus*) IN THE DIET OF UNGULATES OF TADOBA ANDHARI TIGER RESERVE, MAHARASHTRA, INDIA" is an original work carried out by me and has not been submitted anywhere else for the award of any degree.

I certify that all sources of information and data are fully acknowledged in the project Dissertation.

ASHA

Date: 17th May 2018

CERTIFICATE

This is to certify that Asha has carried out her major project in partial fulfillment of the requirement for the Degree of Master of Science in Environmental Studies and Resource Management on the topic "Contribution of Bamboo (*Dendrocalamus strictus*) in the diet of Ungulates of Tadoba Andhari Tiger Reserve, Maharashtra, India" during January 2018 to May 2018. The project was carried out at Wildlife Institute of India, Dehradun, India.

The Dissertation embodies the original work of the candidate to the best of our knowledge.

Date: 17th May 2018

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ASHA

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LIST OF ABBREVIATIONS

ANOVA – Analysis of Variance

IUCN – International Union for Conservation of Nature

TATR – Tadoba Andheri Tiger Reserve

WPA – Wildlife Protection Act

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Abstract

The study was conducted in Tadoba Andheri Tiger Reserve, Maharashtra, India. The reserve area harbors varied landscapes from grasslands to dry tropical deciduous forest to mixed bamboo and water bodies, among all landscapes mixed bamboo dominates the reserve area. There is only one species of bamboo that is found here, Dendrocalamus strictus. The bamboo species found here not only dominates the area but also forms the major proportion of herbivores diet. Bamboo has unique life with respect to its reproductive phase, the grass flowers once in a life time and then dies off; therefore even after not being a threatened or endangered flora it is highly concerned. D. strictus has a life cycle of 40-45 years; the bamboo in TATR is expected to flower in 2019 after which there could be an impact on food availability to herbivores. The work was based on microhistological analyses of bamboo contribution in the diet of three ungulate species Chital (Axis axis), Sambar (Rusa unicolor) and Gaur (Bos gaurus) in TATR. Diet analysis was done by calculating percent contribution and relative frequency of different floral species compared for three ranges of core area; Moharli, Tadoba and Kolsa. The focussed floral species in the diet was D. strictus. Two way ANOVA was performed among the species and among the ranges to see the significant variance of D. strictus and other diet samples. Relative frequency showed that D. strictus contributes most in the diet of all three species of ungulates in all ranges except for Chital in Tadoba. ANOVA depicted significant difference in diet samples of ungulates irrespective of ranges and species. The results depicted that D. strictus contributes most to the diet of Gaur in Moharli followed by Sambar in Tadoba and Kolsa and Chital was found to feed on bamboo least in Tadoba.

Keywords: *Dendrocalamus strictus*, Microhistology, Relative frequency, Tadoba Andheri Tiger Reserve, Ungulates

CHAPTER 1

Introduction

Bamboo is the tallest and fastest growing grass in the world belonging to Poaceae family. It takes tree like function in the forest ecosystem (Farrelly, David 1984). There are around 1575 species of Bamboo known to world till date (Seethalakshmi and Pillai, 2000). It consists of a peculiar life cycle with respect to its reproductive phase of life. The grass has two types of flowering; sporadic and gregarious, the sporadic or irregular flowering occurs in isolated culms or in part of one culm. The flower culm dies off after seeds setting, whereas the latter one takes place once in a lifetime. Once the gregarious flowering takes place the grass dies off (Udea, 1960). The flowering of the grass takes place with respect to the temporal period and irrespective of the season. To date it's been unknown what causes the flowering of the grass on temporal context instead of season which remains mystery and provides wide field of research to botanists, ecologists and conservationists.

India is one of the regions of having varied species of bamboo from north eastern India to peninsular India. The commonly growing bamboo species found in India is *Dendrocalamus strictus* (Gadgil and Prasad, 1984) also known as solid bamboo. The species occurs in the following states of India; Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Maharastra, Madhya Pradesh, Uttar Pradesh, Chhattisgarh, Orissa, Jharkhand, Bihar, West Bengal, Assam, Tripura. Even after being fastest growing grass and not enlisted in endangered or threatened species bamboo is a highly concerned flora due to its sympatric mode of reproduction and dependency of many herbivores for their forage.

Chital (*Axis axis*), Sambar (*Rusa unicolor*) and Gaur (*Bos gaurus*) are common herbivorous prey species in Tadoba Andhari Tiger reserve (further abbreviated as TATR). According to the report Published by Wildlife Institute of India during phase IV monitoring in 2017 the individual density per km^2 for Chital was 6.69, Gaur 2.12 and Sambar 1.76 in core area of TATR (Wildlife Institute of India, 2017. Status of Tigers, Co-Predators and Prey in Tadoba Andhari Tiger Reserve).

These terrestrial ungulate prey species play an important for maintaining large carnivore population (Wolf & Ripple, 2016). Availability of prey population also gives a deterministic idea for carnivore density (Karanth et al, 2004).

TATR is a bamboo (D. *strictus*) dominated forest among all other types of forest and grassland covers. Many of the herbivore species are dependent on bamboo for their diet. The contribution of D. *strictus* in the diet of herbivorous species has never been assessed before in TATR. The diet analysis of herbivores can be done by using microhistology technique and assess the contribution of plant material in the diet since described by Baumgartner and Martin (1939). There are many other methods of studying diet of herbivores that have also been applied such as direct observation (Lamprey, 1963), pasture analysis before and after grazing (Stoddard, 1952) and examination of digestive tract contents (Norris, 1943) but each having limitations under some conditions (Tribe, 1950). Direct observation is a very cumbersome method and shows biased results where the vegetation is intermingled and hard to carry out in extreme weather conditions; whereas, examination of digestive tract requires killing of animals and cannot be applied on large number of animals or on endangered species. On the other hand, microhistology proves to be very useful technique in diet analysis of herbivores as it does not require interference with animal habits or habitat.

Diet analysis of herbivores is one of the important step towards conservation of these prey species, maintaining their population and understanding their diet preferences. The prey species in wild forms a pivotal link to a balanced food web. If the populations of these herbivore species get misbalanced there will be a severe impact on the top carnivores' population as they depend on these animals for their food. Therefore, Knowledge of diet composition is important for management decisions for diet species that can perish or on a verge of getting extinct by some natural or anthropogenic activities to maintain the population in wild and to balance food chain.

The study focusses on the contribution of bamboo (D. *strictus*) in the diet of ungulates Chital, Sambar and Gaur, the study was carried out in Moharli, Tadoba and Kolsa; core ranges of TATR situated in Nagpur, Maharashtra, India. TATR holds D. *strictus* dominated patches spread in the entire Reserve area and many herbivorous species are highly dependent on *D. strictus* for their food. The bamboo species is expected to flower in 2019 in TATR which may impact the availability of Bamboo as food to ungulates. Post flowering may enhance availability of food which may decline subsequently having negative impact on ungulates of TATR.

Figure1. Patches of Bamboo (D. *strictus*) on either side of the trail in TATR (*Image credit: Asha*).

Objective(s)

- To find the contribution of *Dendrocalamus strictus* in the diet of ungulate species Chital, Sambar and Gaur in all three ranges of TATR

CHAPTER 2

Background Study

(i) Microhistology

Microhistology is a microscopic technique based on recognition of indigestible epidermal and cuticle plant fragments of different plant species animal feces (Metcalfe, 1990). The technique is widely used for studying the diet of ungulates (Anthony and Smith, 1974; Baumgartner and Martin, 1939; Holechek and Gross, 1982; Kiley, 1966; Robins *et al.,* 1975). The principle behind microhistology is that cuticle of the plant epidermis can survive digestion and some of the epidermal plant parts in the animal feces can be recognized by comparing with known reference plant samples (Sparks and Malecheck, 1968; Dawson and Ellis, 1979; Jnawali, 1995; Steinheim *et al.*, 2005; Chapuisi, 1979).

The technique is a multistep procedure where the fecal samples are first made into composites then grinded in a microwiley mill fitted with 1mm screen. The grinded sample is then treated with Hoyer's and Hertwig's solution for slide preparation and analysis. The technique of sample preparation for microhistology has been reviewed by Holechek *et al.* (1982).The reviewed sample preparation includes soaking of fecal samples in Sodium hydroxide for 30 mins to improve the accuracy by removing pigments of plants.

There are certain problems with this technique in determining the various plant epidermal tissues in the fecal matter; therefore many sample preparation techniques have been evolved to reduce this problem. The problems have been discussed and solutions have been developed by Baumgartner and Martin (1939), Dusi (1949), Martin (1954), Croker (1959), Metcalf (1960), Storr (1961), Steward (1965, 1967), Griffiths and Barker (1966), Sparks and Malechek (1968), Williams (1969), Ward (1970), and Vavra and Holechek (1980). In grasses, blades play an important role as certain epidermal cells occur here such as bulliform cells (Metcalfe, 1960) and prickle hairs (Pratt 1930; Metcalfe 1960)**.**

Forbes are highly digestible and can result in underestimation by fecal analysis (Vavra *et al.*1978), (Vavra and Holechek, 1980), (Mc Innis *et al.*, 1983).

Whereas grasses and browsing species can be overestimated (Dearden *et al.*, 1975; Vavra and Holechek, 1980).

Microhistology has become a common technique to determine the herbivore diets from fecal matter in recent years. The technique has several advantages over other techniques for herbivore diet analysis that accounts for its popularity as a research tool. The advantages have been discussed by Croker (1959), Ward (1970), Anthony and Smith (1974), and Scotcher (1979). Applying microhistology does not require sacrifice of animal, does not interfere with animals habits, unlimited sampling can be done and can be applied on endangered species.

Although, there are number of advantages to fecal analysis but it faces some disadvantages as well, discussed by Ward (1970), Slater and Jones (1971), Owen (1975), Scotcher (1979), Smith and Shandruk (1979), Vavra and Holechek (1980), and Sanders *et al.* (1980). These include preference indices cannot be assigned, extensive reference plant sample collection is required, fecal sample collection bias can occur which may bias the result and sometimes it becomes difficult to differentiate and identify old fecal samples. Despite of its certain disadvantages fecal analysis is widely used for studying diets of herbivores (Free *et al.*, 1970; Stewart and Stewart, 1980; Hansen and Martin, 1973; Hansen *et al.*, 1973; Todd and Hansen, 1973; Anthony and Smith, 1974). It is the only practical method available for endangered species and areas with intermingled and dense vegetation (Vavra *et al.* 1978).

(ii) Ungulate species

The species undertaken for study belong to artiodactyls order which represents even toed mammals.

(a) *Chital* (*Axis axis*)

IUCN category - Least Concern

Schedule – III (WPA, 1972)

Population trend – Not known

Kingdom - Animalia

Order - Artiodactyla

Family - Cervidae

Genus - *Axis*

Species - *axis*

Chital is world's most beautiful species of deer with an attractive white spotted coat. It is endemic Cervid to South Asia and been a focus of study since the time of Hodgson (1847) and Inverarity (1895). The genus is considered to be present since from Pliocene and Pleistocene in Eurasia and considered amongst most primitive Cervids (Flerov, 1952; Mishra, 1982).

The distinctive characteristic of this species is its sleek, rufous coat sprinkled with white spot that retain lifelong. They bear a white patch below the lower jaw that runs from chin to underside of tail and inside the legs. During rutting season males become brown to dark brown in color around the neck.

In stags a pair of infraorbital glands is present below and inner corner of each eye. The glands are opened when stag is excited or alarmed. Stag bears a pair of antlers which are absent in female. The antlers branched into two, the smaller branch that sweeps forward and little outward and upward. The main beam curves backward, outward half of its length and then curves upward to a sharp tip and slightly inward.

Adult Chital respond to presence of predators by facing the side of danger, stamping by forefeet on the ground and sometimes it may also give alarm calls, raising the tail to expose the white underside.

Chital can survive in a variety of habitats but avoid the extreme environments such as deserts and dense moist evergreen forests. Chital are frequently found in grasslands, forest interface or edge areas therefore also called "ecotone" species (Krishnan, 1972). Habitat use of Chital varies seasonally depending on the availability of food. Chital prefer wooded habitat in winter and dry season (November to May) where fallen fruits and leaf litters are available. On onset of, the density of Chital increases in open grasslands (Mishra, 1982; Moe and Wegge, 1994; Khan, 1996; Raman *et al*., 1996). Chital eats a wide variety of plants and predominantly is grazer. This species in addition has also found feeding on soft plant matter, crabs in Sunderbans (Stanford, 1951) and mushrooms in Nepal (Moe and Wegge, 1994).

Figure2. Herd of Chital grazing grasses in Tadoba range of TATR
(Image credit: Asha)

(b) Sambar (*Rusa unicolor*)

IUCN Category- Vulnerable

Schedule – III (WPA, 1972)

Population trend - Decreasing

Kingdom - Animalia

Order - Artiodactyla

Family - Cervidae

Genus - *Rusa*

Species – *unicolor*

Out of seven species of deer in South Asia *Rusa unicolor* is the largest. The adult male can stand up to 140-150 cm high at shoulder. The winter coat of Sambar is grey brown to Dark brown whereas summer coat varies from brown to Chestnut brown and adult rutting males appear almost black. The tip of the tail is Black in color. Only males bear antlers which are shed annually. The adults have three tines on each antler.

Sambars are distributed throughout India except arid and desert regions of Western India (Timmins *et al*., 2015) Sambar subsits on a wider variety of plants for food than any other Ungulate in India and this could be most possible reason that it can resist in varied habitats (Bentley, 1978; Downes, 1983). Within India alone Sambar is found from arid forests of Gujarat and Rajasthan to moist deciduous forest of peninsular India till pine and oak forests at foothills of Himalayas (Sankar and Acharya, 2004; N.S. Kumar pers. comm., 2008). Sambar has been accounted to eat 130-180 species alone in India (Schaller, 1967; Johnsingh and Sankar, 1991; N.S. Kumar pers. comm., 2008). Sambar is not a specific feeder as those of other deers (Schaller, 1967). Sambar grazes and browses depending on the availability of forage (Schaller, 1967; Richardson, 1972; Martin, 1977; Bentley, 1978; Dinerstein, 1979; Kelton and Skipworth. 1987; Ngampongsai, 1987; Sankar, 1994; Semiadi *et al*., 1995).

In Sambar development of sore patch on the throat, hard antlers in males, antler rubbing may indicate rut (Johnsingh, 1983; Shea *et al.*, 1990). Stag develops a swollen neck and thick mane during rut (Downes, 1983). After rutting the sore patch disappears but the area remains devoid of hair.

Sambar has a great sense of smelling but like other Ungulates cannot distinguish immobile objects. Sambar on sensing danger can freeze in cover and remain motionless for long period of time, enabling them to remain unseen. Sambar stamps the ground with their front foot and gives loud resonating alarm calls when there is immediate danger.

Figure3. Herd of Sambar drinking water at a pond *(Image credit: Asha)*

(c) Gaur (*Bos gaurus*)

IUCN Category- Vulnerable

Schedule – I (WPA, 1972)

Population trend - Decreasing

Kingdom - Animalia

Order - Artiodactyla

Family - Bovidae

Genus - *Bos*

Species – *gaurus*

Gaur is one of the magnificent Ungulates of Asian jungles. The evolution of Gaur dates back to lower Miocene, almost 20 million years ago (Vrba, 1985; Gentry, 1992). Since then this bovid has undergone rapid radiation (Hedge, 1996). *Bos gaurus* is tallest living Oxen (Brander, 1923) and one of the four heaviest mammals. Adult male bulls can weigh up to 600-900 Kg and stand 1.6-1.9m high at the shoulder (NRC, 1983). Adult cow are about 10 cm shorter (Prater, 1971) and weigh one fourth less than adult males (Schaller, 1967).

Striking feature of Gaur is its muscular ridge on the shoulder which slopes down to middle of the back and ends in abrupt dip (Prater, 1971) and this is often called dorsal ridge. Both the sexes have crescent shaped horns and tapers sharply at the end. Gaur has a good sense of hearing but acute sense of smelling and visual senses are comparatively less developed. The lifespan of a Gaur is 30 years (Krishnan, 1972). Bulls have two prominent skinfolds also called as dewlaps; a small one is present at the chin and the larger hanging below the throat. The fore and hind legs are white or yellowish in color up to the knees forming stockings.

Gaur follows a linear hierarchal pattern of dominance (Schaller, 1967). Bulls are found to be dominant followed by adult cows then yearling bulls, yearling cows and finally calves. During any danger Gaur thumps its fore leg on the ground facing the source of disturbance and communicates to other members of group with a series of sounds and gestures (Schaller, 1967).

The distribution of Gaur is largely confined to evergreen, semi-evergreen and moist deciduous forests but sometimes they are also found in at the periphery of dry deciduous forest (Schaller, 1967).

Figure4. A herd of Gaur in Tadoba Range with yearlings in alarm position
(Image credit: Asha)

CHAPTER 3

Materials and Methodology

(i) Study area

Tadoba Andhari Tiger Reserve (TATR) is located in the Vidharbha region of Chandrapur district, Nagpur division, Maharashtra lying between 20° 04′ 53″ to

20° 25′ 51″ N latitude and 79° 13′ 13″ to 79° 33′34″ E longitude. The total area of the reserve consists of 1700 sq. km and comprises of Tadoba National park and Andhari Wildlife Sanctuary. TATR became national park in 1955 and was declared as tiger reserve in 1995.

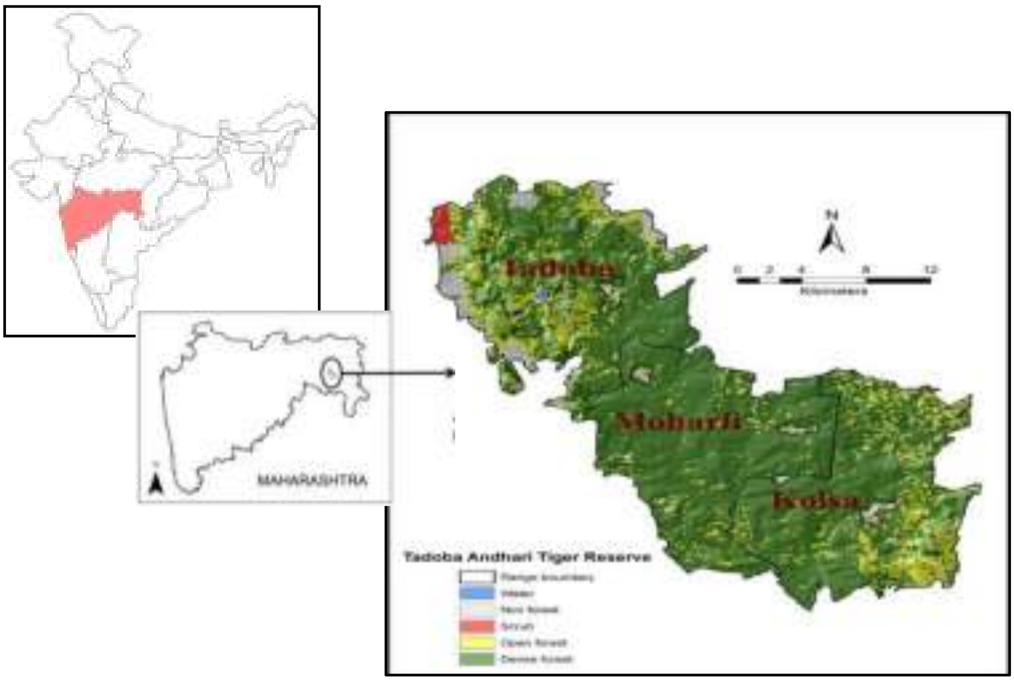


Figure5. Map of TATR Core area showing all the Ranges

(Image credit: Madhura Davate)

The region supports varied faunal diversity of carnivores namely tiger (*Panthera tigris*), leopard (*Panthera pardus*), sloth bear (*Melursus ursinus*), dhole (*Cuon alpinus*), jackal (*Canis aureus*) which is not commonly found and jungle cat (*Felis chaus*). Common langur (*Semnopithecus entellus*) is the most commonly seen primate in TATR. The ungulate species found in TATR include Barking deer (*Muntiacus muntjak*), Gaur (*Bos gaurus*), Sambar (*Rusa unicolor*), Chital

(*Axis axis*), Wild boar (*Sus scrofa*), Nilgai (*Boselapheus tragocamelus*) and Chousingha (*Tetracerus quadricornis*) (Wildlife Institute of India, 2017. Status of Tigers, Co-Predators and Prey in Tadoba Andhari Tiger Reserve).

TATR harbors much floral diversity within which includes interspersion of grasslands, dry tropical deciduous forests and dominated patches of *Dendrocalamus strictus* (Paliwal & Mathur, 2014). According to Champion and Seth's (1968) classification among all trees Teak (*Tectona grandis*) is the dominant species. Other tree species that are prominent here are Ain (*Terminalia elliptica*), Arjun (*Terminalia arjuna*), Bhera (*Chloroxylon swietenia*), Mahua (*Madhuca indica*), Tendu (*Diospyros melanoxylon*) etc. A wide variety of grasses are also found here such as *Heteropogon contortus*, *Aristida funicularis*, *Vitivera zizanioides*, etc. (Muratkar & Kokate, 2012) (Wildlife Institute of India, 2017. Status of Tigers, Co-Predators and Prey in Tadoba Andhari Tiger Reserve).

The region experiences varied weather conditions throughout the year from persistent long scorching summers to short and mild winters both being the prominent seasons. The temperature could reach to 47°C during peak summers and drops down to 8°C in winters (Accuweather, 2017). The third prominent season here is monsoon lasting from June to September. The average annual rainfall received here is 1175mm (Kumbhar *et al.* 2013). The area of study was restricted to the three ranges of core zone; Moharli, Tadoba and Kolsa.

(ii) Sample Collection

Fecal samples were collected from core zone of TATR; Kolsa, Moharli and Tadoba from 15th January to 10th February 2018. The fecal sample of three ungulate species; Chital (*Axis axis*), Gaur (*Bos gaurus*) and Sambar (*Rusa unicolor*) were collected. Two hundred seventy (270) fecal samples were collected, thirty (30) fecal samples for each species from each range making ninety (90) samples for each species. The fecal samples were collected in zip lock bags marked with GPS coordinates of collection site to cover all the possible site of ranges. Endeavor was done to collect fresh fecal samples to avoid the possibility of wrong identification of feces of Chital and Sambar. There are usually chances of wrong identification while collecting old fecal matter if DNA analysis is not performed. The collected samples were brought back to field station and sun dried for at least 72 hours.

Figure6. Fecal sample collection at Tadoba Lake site

(a)

(b)

(c)

Figure7. Fecal matter of Ungulates (a) Pellets of Sambar (b) Pellets of Chital and (c) Dung of Gaur

Reference samples (plant species) were also collected, sun dried and kept in zip lock bags. Different floral samples were collected for herbarium and dried by keeping them under several layers of newspapers and pressed by using herbarium press. 50x40 cm herbarium press was used for collection and identification of herbarium samples. The ungulates were observed while grazing and browsing prior collecting the reference samples. No animal was disturbed while collecting the samples.

(iii) Fecal Sample Preparation

The collected samples were brought to Wildlife Biology laboratory of Wildlife Institute of India for fecal sample preparation using microhistology technique. Each sample was treated as an individual sample and composite was made for each sample by picking up random pellets and dung pieces to avoid bias. The sample composites were further smashed in mortar and pestle and oven dried at 49-52°C for 24 hours. The oven dried samples were then grinded in micro Wiley mill fitted with 1mm screen. The grinded samples were then weighed as 0.5 g using digital weighing machine up to point four digits accuracy and put in 78% hydrogen peroxide for 48 hours to remove the chlorophyll content and other pigments (Tiwari and Rawat, 2013). The samples were then washed and sieved under running tap water using 100-200mm mesh to remove digested and unwanted material and collected. Collected samples were further oven dried at 49-52°C overnight for slide preparation.

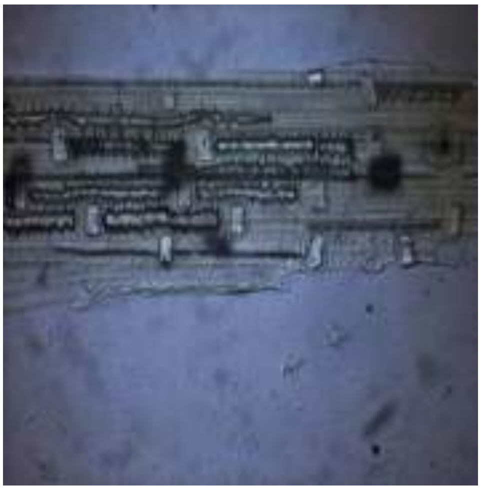
(iv) Fecal Sample Slide Preparation

The grinded washed oven dried samples were used for slide preparation. The samples were uniformly spread over the slides by hands making very thin layer and mounted in DPX solution using grounded slides and 20x50mm coverslips.

(v) Reference Material Slides

Anatomical reference key was developed to facilitate identification of epidermal tissues, silica cells, cell wall and others based on shape and dimensions of cells. Leaf blades of all plants were used to develop the reference samples slides. The reference materials were photomicrographed for easy and quick comparison with fecal samples. The slide preparation procedure was same as the fecal matter except the composite making step and weighing.

(a)



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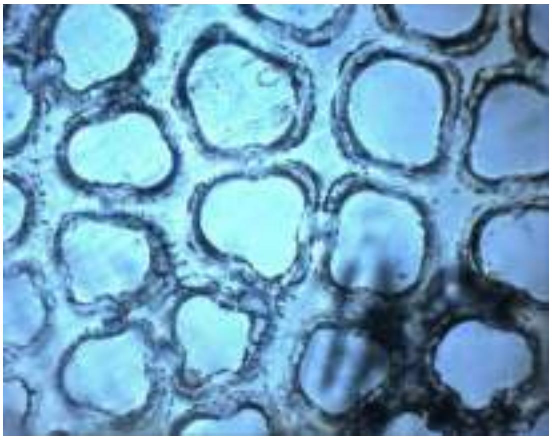

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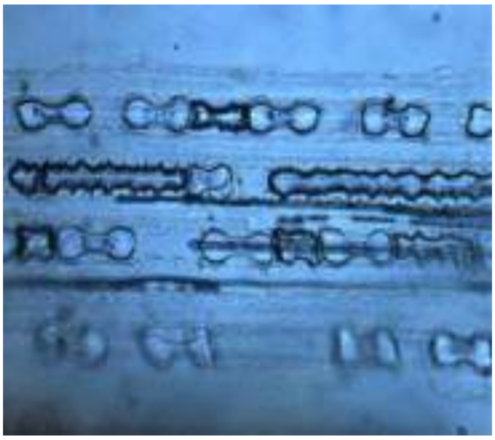
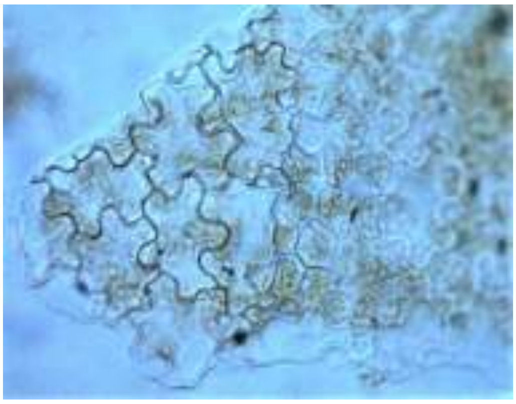


(d)

(e)



(f)

Figure8. Reference Samples images taken under x400 magnification by Leica DMR bridge Microscope (a) *Ageratum conyzoides* (b) *Dendrocalamus strictus* (c) *Eleocharis sp.* (d) *Vitiveria zizanioides* (e) *Lagerstroemia parviflora* (f) *Milletia auriculata.*

(vi) Analysis

Analysis of prepared slides was done in forensic lab using Leica DMR bridge compound microscope under 200x and 400x magnification in different field views. The identification of plant samples in fecal matter was based on structure, shape and size of cell wall and silica cells as described by Metcalf and Chalk (1950). The use of Hoyers and Hertwig's solution for performing microhistology was avoided with concern to microscopes as these compounds releases fumes that can damage the lenses of microscope. The percent contribution was calculated for all 270 fecal samples and reference samples. The percent contribution was then used to calculate the Relative Frequency (Rf) of each species in each range for every reference sample to compare the contribution of *Dendrocalamus strictus*.

$$\text{Rf} = (n1 + n2 + n3 + \ \ldots + n \div N) \times 100$$

Where, n = Number of samples in which desired plant sample occurred

N = Total number of samples observed

Further, Two way ANOVA was performed using 95% confidence interval to analyze the variance of diet samples in Ungulates among the ranges and among the species.

(a) **(b)**

(c) (d

(e) (f)

Figure9. Plant samples found in the fecal matter of Ungulates photographed at x400 magnification in Leica DMR bridge microscope (a) *Ageratum conyzoides* in fecal matter of Chital from sample ID CM 15 (b) *Dendrocalamus strictus* in fecal matter of Gaur from sample Id GM 6 (c) *Vitiveria zizanioides* in fecal matter of Chital from sample Id CM 5 (d) *Eleocharis* sp. In fecal matter of Sambar from Sample Id SK 13 (e) Monocot in the fecal matter of Gaur from sample ID GT 5 (f) Dicot in the fecal matter of Sambar from sample ID ST 29.

CHAPTER 4

Result and Discussion

The relative frequency calculated showed that *D. strictus* had the highest contribution in the diet of Ungulates within the ranges and among the ranges shown in Fig. 11 and 12 except in the diet of Chital for Tadoba range where dicots were found to contribute more than D. *strictus* shown in Fig. 10. Bamboo was also found to have maximum contribution to the diet among all the plant species available.

(i) *Comparative analysis of* **D. *strictus*** *in ranges for diet of Ungulates*

(a) Chital

The relative frequency for D. *strictus* was found to be highest in Moharli range (42.6%), least in Tadoba range (16.12%) and Kolsa being the moderate one (29.44%) as shown in Fig. 10 and 16.

(b) Sambar

The Relative frequency was found to be high for *D. strictus* among all other plant species in the diet of Sambar. The high proportion of bamboo was found in Moharli range (44.72%) followed by Kolsa (43.16%) and Tadoba (41.49%) shown in Fig. 11 and 16.

(c) Gaur

In the diet of Gaur as well bamboo formed the major component in the diet. Moharli had maximum relative frequency (48.61%) after which stands Kolsa (39.55%) and least percent of contribution was from Tadoba (37.33%) shown in Fig. 12 and 16.

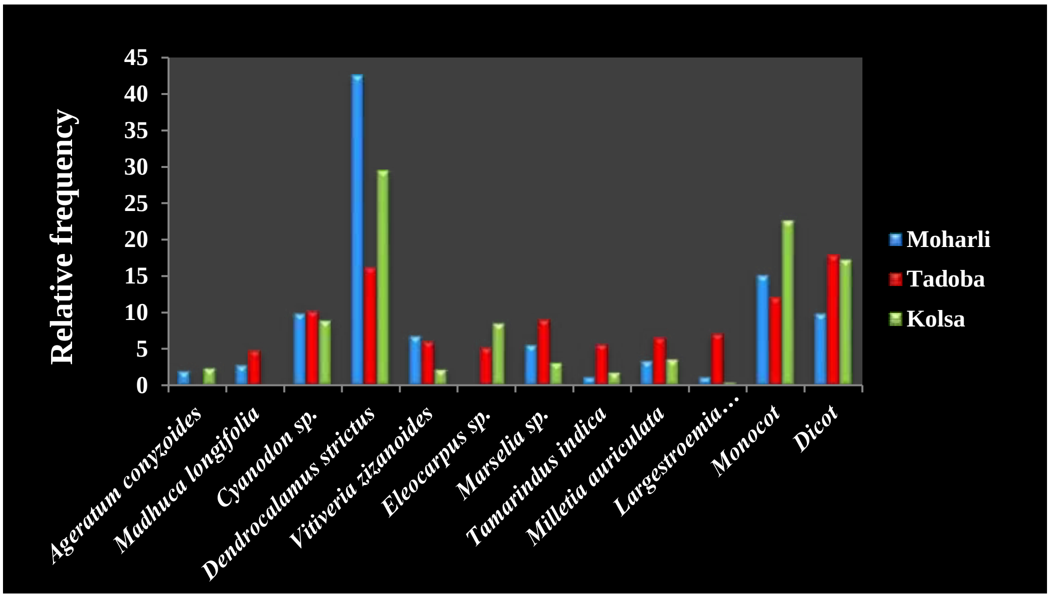


Figure10. Graph showing Relative frequency of plant samples in different ranges in the diet of Chital

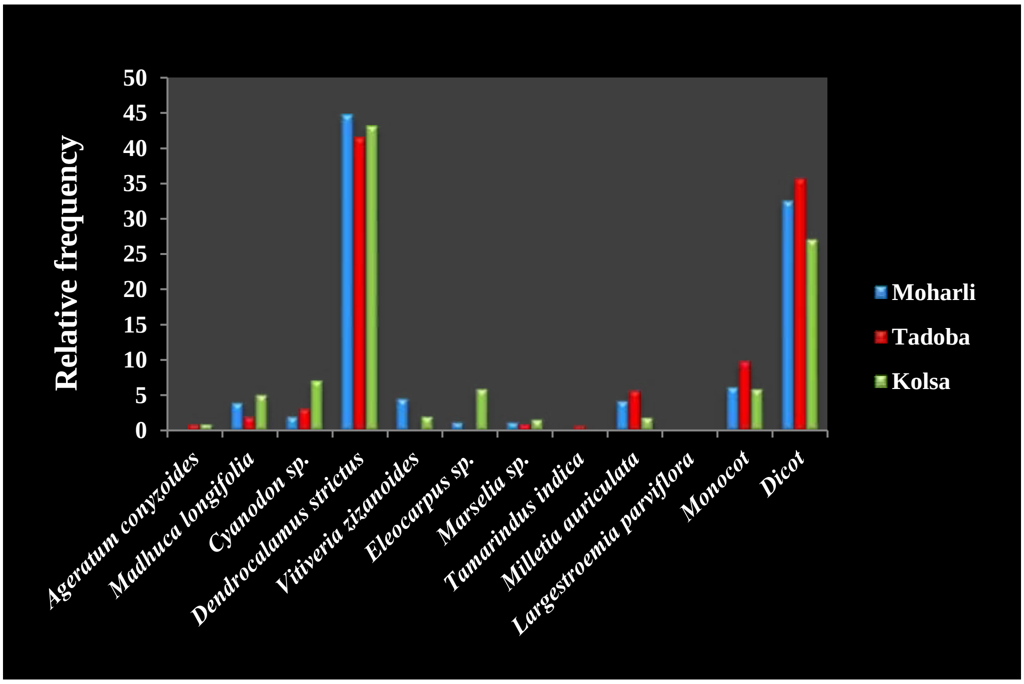


Figure11. Graph showing Relative frequency of plant samples in different ranges in the diet of Sambar.

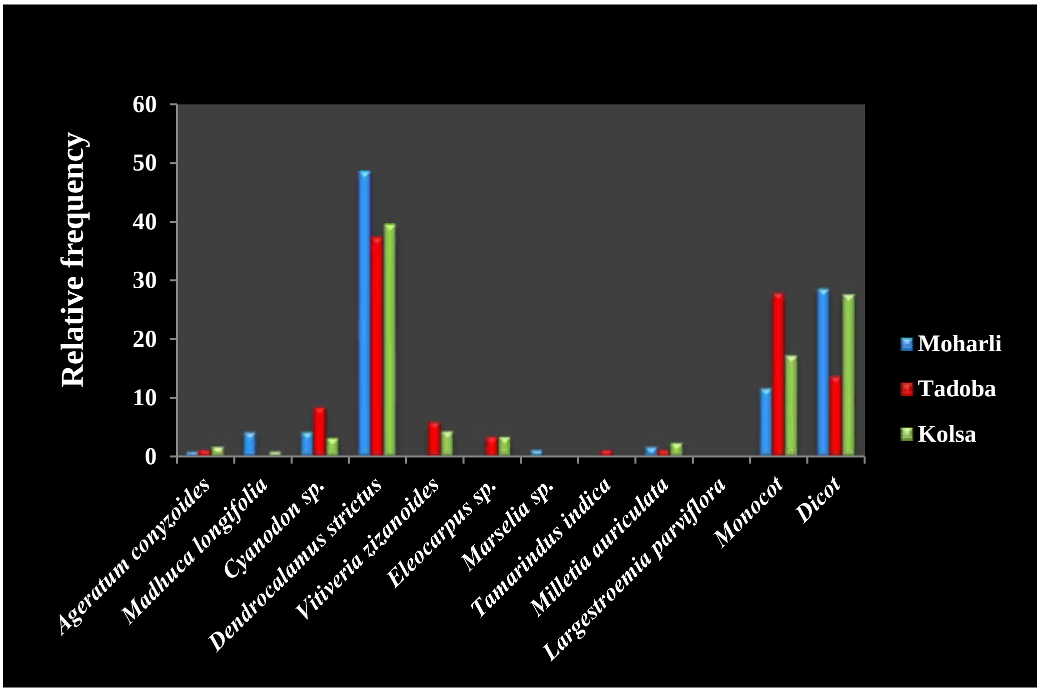


Figure12. Graph showing Relative frequency of plant samples in different ranges in the diet of Gaur.

(ii) *Comparative analysis of Ungulates within Ranges*

(a) Moharli

Gaur was found to consume more Bamboo (48.61%) than Sambar (44.72%) and Chital (42.6%) in Moharli range shown in Fig. 13 and 16.

(b) Tadoba

In Tadoba maximum contribution of Bamboo was in the diet of Sambar (41.49%), Gaur (37.33%) and least was found in Chital (16.12%) shown in Fig. 14 and 16.

(c) Kolsa

Sambar had the maximum amount of Bamboo in the diet (43.16%) followed by Gaur (39.55%) and Chital (29.44%) shown in Fig. 15 and 16.

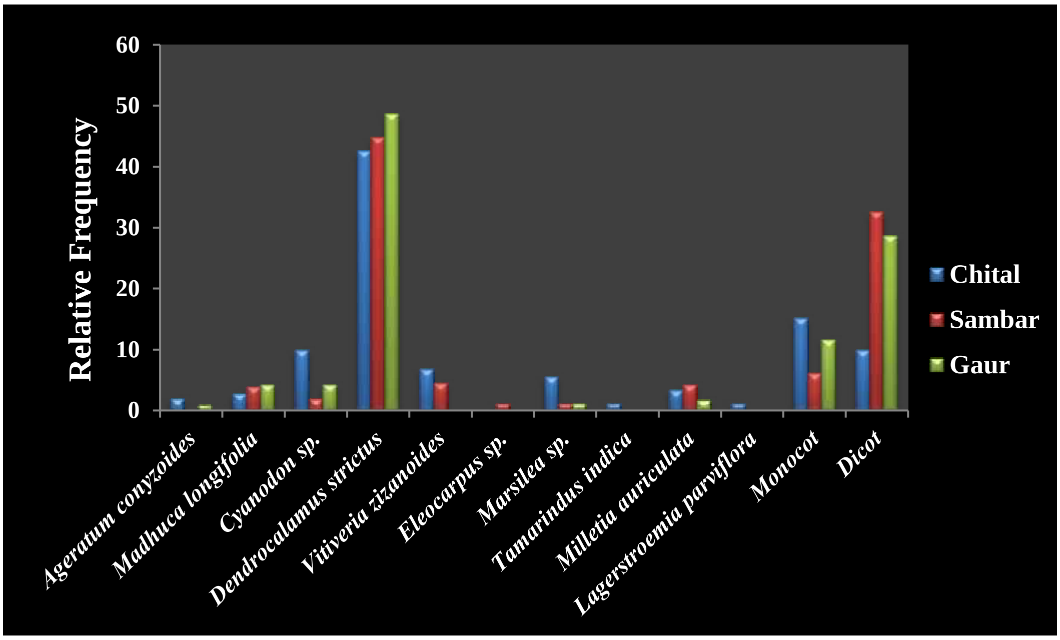


Figure13. Graph depicting Relative frequency of Plant samples in the diet Of Ungulates in Moharli Range.

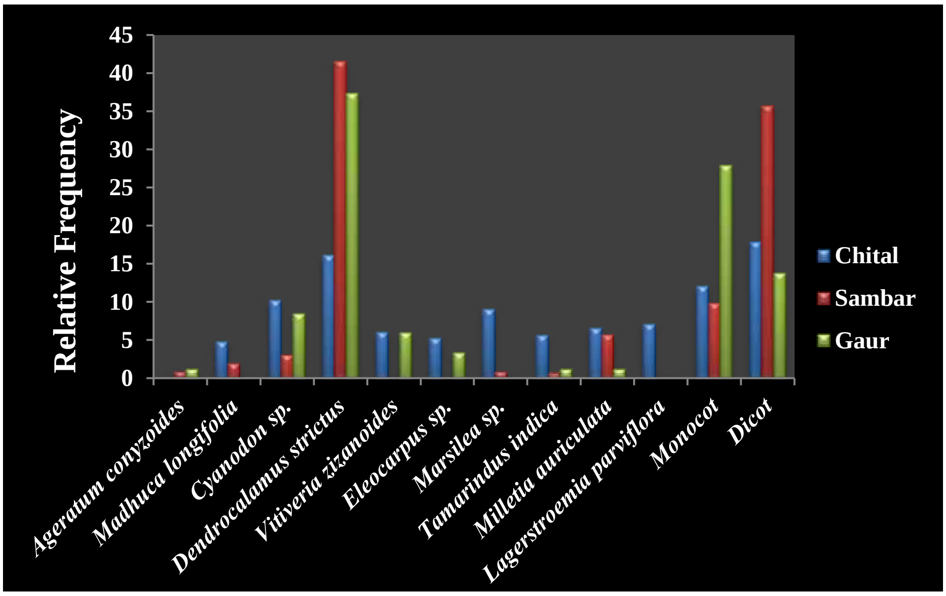


Figure14. Graph depicting Relative frequency of Plant samples in the diet of Ungulates in Tadoba Range.

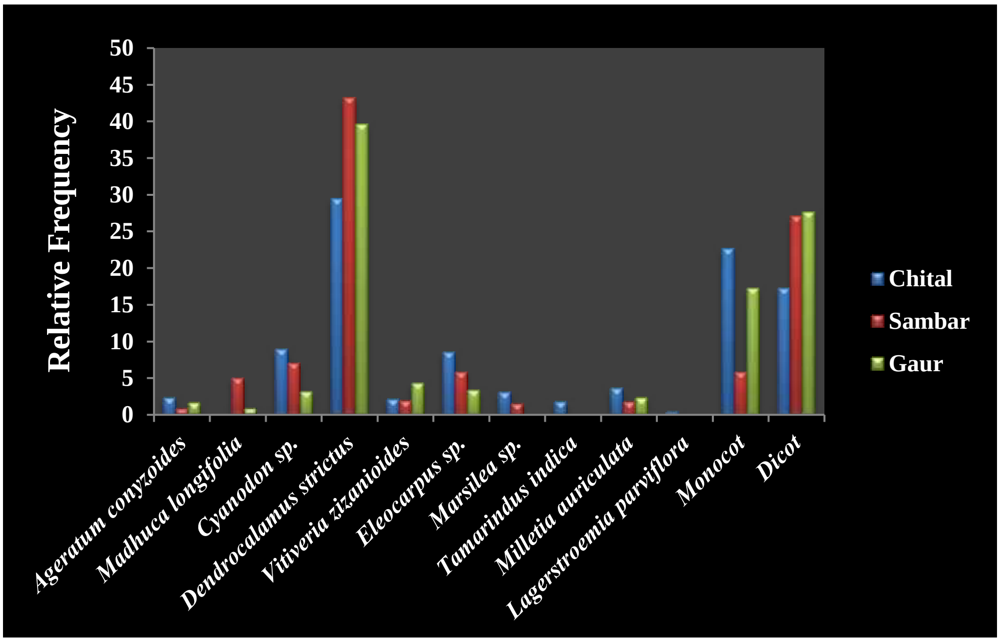


Figure15. Graph depicting Relative frequency of Plant samples in the diet Of Ungulates in Kolsa Range.

The major component of diet of all three species of Ungulates was Bamboo in all three aspects; within the ranges, among the ranges and among all plant samples. Among the three species of Ungulates in all ranges the diet of Sambar had maximum percentage of Bamboo contribution in Tadoba and Kolsa whereas in Moharli Gaur had maximum bamboo in the diet.

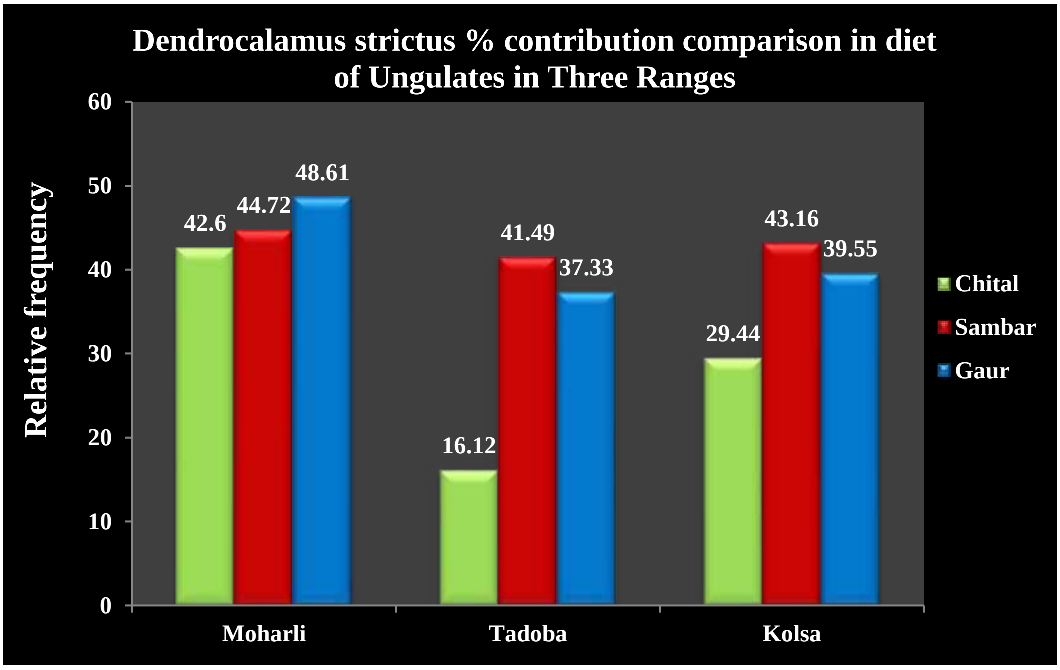


Figure16. Graph depicting Relative frequency of *Dendrocalamus strictus* in diet of Ungulates in all three ranges.

(iii) Statistical analysis

Two way ANOVA was performed for seeing the variance of diet samples in ungulates for three ranges.

(a) Chital

The two way ANOVA performed on different ranges for diet of Ungulates showed significant variation for diet samples irrespective of the ranges. For Chital the value of F was 7.746355 and P was 2.65E-05 whereas the plant species the varied the most was Bamboo with a variance value of 175.2997.

Table1. Two way ANOVA summary for Chital in all ranges

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	2235.055	11	203.1868	7.746355	2.65E-05	2.258518
Columns	0.017422	2	0.008711	0.000332	0.999668	3.443357
Error	577.0597	22	26.22999			
Total	2812.132	35				

(b) Sambar

The results of Two way ANOVA for Sambar showed F value 116.7664 and the P value 7.15E-17 for diet samples whereas there was no significant difference was found among the ranges. In Sambar the variance was high for the dicots with a variance value of 18.96243.

Table2. Two way ANOVA summary for Sambar in all ranges

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	6426.779	11	584.2527	116.7664	7.15E-17	2.258518
Columns	2.72E-06	2	1.36E-06	2.72E-07	1	3.443357
Error	110.0792	22	5.003602			
Total	6536.858	35				

(c) Gaur

The results of ANOVA showed significant difference in the diet samples with a F value 27.96995 and the P value 27.96995. The maximum variance in the diet sample was shown by Dicots with a value of 69.27403.

Table3. **Two way ANOVA summary for Gaur in all ranges**

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	5595.936	11	508.7215	27.96995	2.19E-10	2.258518
Columns	0.038739	2	0.019369	0.001065	0.998936	3.443357
Error	400.1391	22	18.18814			
Total	5996.114	35				

Two way ANOVA performed on the species within ranges showed significant variation in the diet samples irrespective of the species of Ungulates.

(a) Moharli

In Moharli the diet samples showed significant variation with F value of 27.31608 and P value 2.77E-10, whereas Dicots showed the maximum value of variance 146.8697.

Table4. **Two way ANOVA summary for Moharli in ungulates species**

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	5901.777	11	536.5252	27.31608	2.77E-10	2.258518
Columns	0.039672	2	0.019836	0.00101	0.998991	3.443357
Error	432.1102	22	19.64137			
Total	6333.927	35				

(b) Tadoba

Diet sample in Tadoba range also showed the significant differences in plant samples with F value 6.22166 and P value 0.000142 while Bamboo showed the maximum variance 185.1344.

Table5. **Two way ANOVA summary for Tadoba in ungulate species**

Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Rows	3200.607	11	290.9643	6.22166	0.000142	2.258518
Columns	0.016726	2	0.008363	0.000179	0.999821	3.443357
Error	1028.86	22	46.76635			
Total	4229.484	35				

(c) Kolsa

Kolsa had a significant difference in diet samples with F value 23.56352 and P value 1.19E-09 whereas monocots showed the maximum variance 73.3921 among the species.

Table6. **Two way ANOVA summary for Kolsa in ungulate species**

Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Rows	4407.591	11	400.6901	23.56352	1.19E-09	2.258518
Columns	4.39E-06	2	2.19E-06	1.29E-07	1	3.443357
Error	374.1029	22	17.00468			
Total	4781.694	35				

The diet samples or plant species showed significant difference irrespective of Ranges or Species but it was not just the bamboo that varied significantly, other plant samples also showed high variance which could be due to the preference of diet, availability of diet samples and other factors.

Table7. List of Food Plant species in diet of Ungulates with their families and their type.

Reference Plants	Family	Type of Food Plant
Ageratum conyzoides	Asteraceae	Forb
Cyanodon sp.	Poaceae	Grass
Dendrocalamus strictus	Poaceae	Grass
Eleocharis sp.	Cyperaceae	Aquatic flora
Lagerstroemia parviflora	Lythraceae	Tree
Madhuca longifolia	Sapotaceae	Tree
Marsilea sp.	Marsileaceae	Aquatic Flora
Milletia auriculata	Fabaceae	Tree
Tamarindus indica	Fabaceae	Tree
Vitiveria zizanioides	Poaceae	Grass
Monocot	-	Grass
Dicot	-	Trees

CHAPTER 5

Conclusion

Bamboo forms the maximum component in diet of Ungulates in all the ranges except for Chital in Tadoba range where dicots (17.84%) form major component of diet which is slightly more than bamboo (16.12%). Chital was found to have least bamboo in the diet therefore; the least impacted species after mass flowering would be Chital. If the expected mass flowering takes place in 2019 there will be subsequent decrease in the availability of food source especially in context to Sambar in Tadoba and Kolsa as it has the maximum Bamboo percent contribution in these two ranges. Gaur would be the most impacted ungulate in Moharli range since it was found to have maximum bamboo in the diet. The range that would be most impacted after mass flowering of Bamboo would be Moharli because it accounts for the maximum Bamboo contribution in the diet of Ungulates. Reduce in food source will also have an impact on the density of ungulates population in TATR which may influence the carnivore population.

The study depicted the importance of bamboo in the diet of Ungulates but there are certain limitations to the applied study, there is a possibility that other plant samples were underestimated as the samples were collected in dry season (February) when most of the areas just had Bamboo and very less presence of other plant samples. The slides prepared for the analysis in hydrogen peroxide showed less removal of pigments in Dicots whereas the solution worked better for Monocots. The other limitation was there was no DNA analysis performed for species fecal matter confirmation.

The study with several limitations also makes it open ended for further research on seasonal collection of samples and analysis. Diet Preferences of Ungulates need to be analyzed further for more specific results.

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ANNEXURE(S)

Table1. Pellet analysis of Chital in Moharli Range for Percent Contribution and Relative Frequency of different plant species.

Range - Moharli (Sp. Chital)												
Sample ID	***Ageratum conyzoides***	***Madhuca longifolia***	***Cyanodon sp.***	***Dendrocalamus strictus***	***Vitiveria zizanioides***	***Eleocharis sp.***	***Marsilea sp.***	***Tamarindus indica***	***Milletia auriculata***	***Lagerstroemia parviflora***	**Unidentified**	
											Monocot	**Dicot**
CM1	-	-	-	33.33	-	-	-	-	-	33.33	33.33	-
CM2	-	-	-	33.33	33.33	-	33.33	-	-	-	-	-
CM3	-	-	-	-	-	-	-	-	-	-	50	50
CM4	-	-	-	33.33	33.33	-	-	-	-	-	-	33.33
CM5	-	-	-	25	25	-	-	-	-	-	25	25
CM6	-	-	-	100	-	-	-	-	-	-	-	-
CM7	-	50	-	50	-	-	-	-	-	-	-	-
CM8	-	-	-	33.33	-	-	-	-	33.33	-	33.33	-
CM9	-	-	-	100	-	-	-	-	-	-	-	-
CM10	-	33.33	33.33	-	-	-	-	-	-	-	33.33	-
CM11	-	-	-	50	-	-	50	-	-	-	-	-
CM12	-	-	-	50	-	-	-	-	-	-	50	-
CM13	-	-	-	33.33	33.33	-	-	-	-	-	33.33	-
CM14	-	-	33.33	33.33	-	-	-	-	-	-	33.33	-
CM15	33.33	-	-	33.33	-	-	-	-	-	-	-	33.33
CM16	-	-	33.33	33.33	-	-	-	-	-	-	33.33	-
CM17	-	-	33.33	33.33	33.33	-	-	-	-	-	-	-
CM18	-	-	-	100	-	-	-	-	-	-	-	-
CM19	25	-	25	25	-	-	-	-	-	-	-	25
CM20	-	-	-	33.33	-	-	-	-	33.33	-	33.33	-
CM21	-	-	-	33.33	-	-	-	33.33	-	-	-	33.33
CM22	-	-	33.33	33.33	-	-	-	-	33.33	-	-	-
CM23	-	-	50	50	-	-	-	-	-	-	-	-
CM24	-	-	20	20	20	-	-	-	-	-	20	20
CM25	-	-	-	25	25	-	-	-	-	-	25	25
CM26	-	-	33.33	33.33	-	-	33.33	-	-	-	-	-
CM27	-	-	-	50	-	-	50	-	-	-	-	-
CM28	-	-	-	50	-	-	-	-	-	-	50	-
CM29	-	-	-	100	-	-	-	-	-	-	-	-
CM30	-	-	-	50	-	-	-	-	-	-	-	50
Relative frequency	1.94	2.77	9.83	42.60	6.77	0	5.55	1.11	3.33	1.11	15.11	9.83

Table2. Pellet analysis of Chital in Tadoba Range for Percent Contribution and Relative Frequency of different plant species.

Range – Tadoba (Sp. Chital)												
Sample ID	***Ageratum conyzoides***	***Madhuca longifolia***	***Cyanodon sp.***	***Dendrocalamus strictus***	***Vitiveria zizanioides***	***Eleocharis sp.***	***Marsilea sp.***	***Tamarindus indica***	***Milletia auriculata***	***Lagerstroemia parviflora***	**Unidentified**	
											Monocot	**Dicot**
CT1	-	-	-	33.33	-	-	-	-	-	33.33	-	33.33
CT2	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
CT3	-	-	-	33.33	-	-	-	33.33	-	-	33.33	-
CT4	-	-	14.28	14.28	14.28	-	-	14.28	-	14.28	14.28	14.28
CT5	-	-	-	25	-	-	25	-	25	-	-	25
CT6	-	-	25	25	-	-	-	-	-	-	25	25
CT7	-	16.66	-	16.66	-	-	-	16.66	16.66	16.66	-	16.66
CT8	-	-	-	33.33	-	-	-	-	33.33	-	-	33.33
CT9	-	-	-	16.66	16.66	-	16.66	16.66	16.66	-	16.66	16.66
CT10	-	-	20	-	20	-	20	-	-	-	20	20
CT11	-	-	-	16.66	16.66	-	16.66	-	-	16.66	16.66	16.66
CT12	-	-	-	-	20	-	20	20	-	-	20	20
CT13	-	14.28	14.28	-	-	14.28	-	14.28	-	14.28	14.28	14.28
CT14	-	-	-	33.33	-	-	33.33	-	-	-	33.33	-
CT15	-	16.66	16.66	-	16.66	16.66	16.66	-	-	-	16.66	-
CT16	-	14.28	14.28	14.28	-	14.28	14.28	-	14.28	-	-	14.28
CT17	-	25	-	25	-	-	-	-	-	-	25	25
CT18	-	16.66	16.66	16.66	-	16.66	16.66	-	-	-	-	16.66
CT19	-	20	-	20	-	20	-	-	-	-	20	20
CT20	-	-	20	20	-	20	-	20	-	-	-	20
CT21	-	-	33.33	33.33	-	-	-	-	-	-	-	33.33
CT22	-	-	20	-	20	20	20	-	-	20	-	-
CT23	-	-	16.66	-	16.66	-	16.66	-	16.66	16.66	-	16.66
CT24	-	-	20	20	20	-	-	-	-	-	20	20
CT25	-	20	20	20	-	-	-	20	20	-	-	-
CT26	-	-	-	-	-	-	-	-	-	33.33	33.33	33.33
CT27	-	-	-	33.33	-	-	-	-	-	33.33	-	33.33
CT28	-	-	14.28	-	-	14.28	14.28	14.28	14.28	14.28	-	14.28
CT29	-	-	20	-	20	20	20	-	20	-	-	-
CT30	-	-	20	-	-	-	20	-	20	-	20	20
Relative frequency	0	4.78	10.18	16.12	6.03	5.20	9.01	5.64	6.56	7.09	12.06	17.84

Table3. Pellet analysis of Chital in Kolsa Range for Percent Contribution and Relative Frequency of different plant species.

Range – Kolsa (Sp. Chital)												
Sample ID	*Ageratum conyzoides*	*Madhuca longifolia*	*Cyanodon sp.*	*Dendrocalamus strictus*	*Vitiveria zizanioides*	*Eleocharis sp.*	*Marsilea sp.*	*Tamarindus indica*	*Milletia auriculata*	*Lagerstroemia parviflora*	Unidentified	
											Monocot	Dicot
CK1	-	-	-	50	-	-	-	-	-	-	50	-
CK2	-	-	25	25	25	25	-	-	-	-	-	-
CK3	-	-	33.33	33.33	-	33.33	-	-	-	-	-	-
CK4	-	-	50	50	-	-	-	-	-	-	-	-
CK5	-	-	-	-	-	33.33	-	-	-	-	33.33	33.33
CK6	-	-	14.28	14.28	14.28	14.28	14.28	-	-	-	14.28	14.28
CK7	25	-	-	-	-	25	-	-	25	-	-	25
CK8	-	-	-	-	-	-	-	-	-	-	50	50
CK9	-	-	-	50	-	-	-	-	-	-	-	50
CK10	-	-	-	33.33	-	33.33	33.33	-	-	-	-	-
CK11	-	-	-	50	-	-	-	-	-	-	50	-
CK12	-	-	-	50	-	-	-	-	-	-	50	-
CK13	25	-	-	-	-	25	-	-	25	-	-	25
CK14	-	-	-	50	-	-	-	-	-	-	50	-
CK15	-	-	-	-	-	-	-	-	-	-	50	50
CK16	-	-	-	33.33	-	33.33	-	-	-	-	33.33	-
CK17	-	-	-	50	-	-	-	-	-	-	-	50
CK18	-	-	-	25	-	-	-	-	25	-	25	25
CK19	-	-	-	25	25	-	-	-	-	-	25	25
CK20	-	-	33.33	33.33	-	-	-	-	-	-	-	33.33
CK21	-	-	12.5	12.5	-	12.5	-	12.5	12.5	12.5	12.5	12.5
CK22	-	-	-	50	-	-	-	-	-	-	50	-
CK23	-	-	20	20	-	-	20	20	-	-	20	-
CK24	-	-	25	25	-	-	25	-	-	-	25	-
CK25	-	-	-	50	-	-	-	-	-	-	50	-
CK26	-	-	-	50	-	-	-	-	-	-	50	-
CK27	-	-	33.33	33.33	-	-	-	-	-	-	-	33.33
CK28	-	-	-	50	-	-	-	-	-	-	-	50
CK29	20	-	-	20	-	20	-	-	-	-	20	20
CK30	-	-	20	-	-	-	-	20	20	-	20	20
Relative frequency	2.33	0	8.89	29.44	2.14	8.50	3.08	1.75	3.58	0.41	22.61	17.22

Table4. Pellet analysis of Sambar in Moharli Range for Percent Contribution and Relative Frequency of different plant species.

Range – Moharli (Sp. Sambar)												
Sample ID	***Ageratum conyzoides***	***Madhuca longifolia***	***Cyanodon sp.***	***Dendrocalamus strictus***	***Vitiveria zizanioides***	***Eleocharis sp.***	***Marsilea sp.***	***Tamarindus indica***	***Milletia auriculata***	***Lagerstroemia parviflora***	**Unidentified**	
											Monocot	**Dicot**
SM1	-	33.33	-	33.33	-	-	-	-	-	-	-	33.33
SM2	-	-	-	25	25	-	-	-	-	-	25	25
SM3	-	-	-	33.33	-	-	-	-	33.33	-	-	33.33
SM4	-	-	-	100	-	-	-	-	-	-	-	-
SM5	-	-	-	50	-	-	-	-	-	-	-	50
SM6	-	-	-	50	-	-	-	-	-	-	-	50
SM7	-	-	-	50	-	-	-	-	-	-	-	50
SM8	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
SM9	-	-	-	-	-	-	-	-	-	-	-	100
SM10	-	-	-	33.33	-	-	-	-	33.33	-	-	33.33
SM11	-	33.33	-	33.33	-	-	-	-	-	-	-	33.33
SM12	-	-	-	50	-	-	-	-	-	-	-	50
SM13	-	-	-	100	-	-	-	-	-	-	-	-
SM14	-	-	33.33	33.33	-	-	-	-	-	-	33.33	-
SM15	-	-	-	33.33	-	33.33	-	-	-	-	-	33.33
SM16	-	-	-	33.33	-	-	-	-	33.33	-	-	33.33
SM17	-	50	-	50	-	-	-	-	-	-	-	-
SM18	-	-	-	50	-	-	-	-	-	-	-	50
SM19	-	-	-	50	-	-	-	-	-	-	-	50
SM20	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
SM21	-	-	-	50	50	-	-	-	-	-	-	-
SM22	-	-	-	33.33	33.33	-	-	-	-	-	-	33.33
SM23	-	-	-	50	-	-	-	-	-	-	-	50
SM24	-	-	-	50	-	-	-	-	-	-	S+++-	50
SM25	-	-	-	25	-	-	-	-	25	-	25	25
SM26	-	-	-	50	-	-	-	-	-	-	-	50
SM27	-	-	-	100	-	-	-	-	-	-	-	-
SM28	-	-	-	50	-	-	-	-	-	-	-	50
SM29	-	-	25	25	25	-	-	-	-	-	-	25
SM30	-	-	-	33.33	-	-	33.33	-	-	-	33.33	-
Relative frequency	0	3.88	1.94	44.72	4.44	1.11	1.11	0	4.16	0	6.11	32.49

Table5. Pellet analysis of Sambar in Tadoba Range for Percent Contribution and Relative Frequency of different plant species.

Range – Tadoba (Sp. Sambar)												
Sample ID	*Ageratum conyzoides*	*Madhuca longifolia*	*Cyanodon sp.*	*Dendrocalamus strictus*	*Vitiveria zizanioides*	*Eleocharis sp.*	*Marsilea sp.*	*Tamarindus indica*	*Milletia auriculata*	*Lagerstroemia parviflora*	Unidentified	
											Monocot	Dicot
ST1	-	-	-	50	-	-	-	-	-	-	-	50
ST2	-	-	-	33.33	-	-	-	-	33.33	-	-	33.33
ST3	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
ST4	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
ST5	-	-	-	50	-	-	-	-	-	-	-	50
ST6	-	-	-	33.33	-	-	-	-	33.33	-	-	33.33
ST7	-	-	-	50	-	-	-	-	-	-	-	50
ST8	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
ST9	-	-	-	50	-	-	-	-	-	-	-	50
ST10	-	-	-	50	-	-	-	-	-	-	-	50
ST11	-	25	25	25	-	-	-	-	-	-	25	-
ST12	-	33.33	-	33.33	-	-	-	-	-	-	-	33.33
ST13	-	-	-	50	-	-	-	-	-	-	-	50
ST14	-	-	-	20	-	-	-	20	20	-	20	20
ST15	-	-	-	50	-	-	-	-	-	-	-	50
ST16	25	-	-	25	-	-	-	-	25	-	-	25
ST17	-	-	-	50	-	-	-	-	-	-	50	-
ST18	-	-	-	50	-	-	-	-	-	-	-	50
ST19	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
ST20	-	-	-	50	-	-	-	-	-	-	-	50
ST21	-	-	33.33	33.33	-	-	-	-	-	-	-	33.33
ST22	-	-	-	100	-	-	-	-	-	-	-	-
ST23	-	-	-	25	-	-	25	-	25	-	-	25
ST24	-	-	-	50	-	-	-	-	-	-	-	50
ST25	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
ST26	-	-	-	-	-	-	-	-	-	-	-	100
ST27	-	-	-	33.33	-	-	-	-	33.33	-	-	33.33
ST28	-	-	-	100	-	-	-	-	-	-	-	-
ST29	-	-	33.33	33.33	-	-	-	-	-	-	-	33.33
ST30	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
Relative frequency	0.83	1.94	3.05	41.49	0	0	0.833	0.66	5.66	0	9.83	35.66

Table6. Pellet analysis of Sambar in Kolsa Range for Percent Contribution and Relative Frequency of different plant species.

Range – Kolsa (Sp. Sambar)												
Sample ID	***Ageratum conyzoides***	***Madhuca longifolia***	***Cyanodon sp.***	***Dendrocalamus strictest***	***Vitiveria zizanioides***	***Eleocharis sp.***	***Marsilea sp.***	***Tamarindus indica***	***Milletia auriculata***	***Lagerstroemia parviflora***	**Unidentified**	
											Monocot	**Dicot**
SK1	-	-	-	33.33	-	33.33	-	-	-	-	-	33.33
SK2	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
SK3	-	-	33.33	33.33	33.33	-	-	-	-	-	-	-
SK4	25	-	25	25	-	-	-	-	-	-	-	25
SK5	-	50	-	50	-	-	-	-	-	-	-	-
SK6	-	33.33	-	33.33	-	-	-	-	-	-	-	33.33
SK7	-	-	50	50	-	-	-	-	-	-	-	-
SK8	-	-	25	25	-	-	25	-	-	-	25	-
SK9	-	-	20	20	-	-	20	-	20	-	-	20
SK10	-	33.33	-	33.33	-	-	-	-	-	-	-	33.33
SK11	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
SK12	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
SK13	-	-	-	50	-	50	-	-	-	-	-	-
SK14	-	-	-	50	-	-	-	-	-	-	-	50
SK15	-	-	-	100	-	-	-	-	-	-	-	-
SK16	-	-	-	33.33	-	33.33	-	-	-	-	-	33.33
SK17	-	-	25	25	25	25	-	-	-	-	-	-
SK18	-	33.33	-	33.33	-	-	-	-	-	-	-	33.33
SK19	-	-	-	50	-	-	-	-	-	-	-	50
SK20	-	-	-	50	-	-	-	-	-	-	-	50
SK21	-	-	-	33.33	-	-	-	-	33.33	-	-	33.33
SK22	-	-	-	50	-	-	-	-	-	-	-	50
SK23	-	-	-	33.33	-	33.33	-	-	-	-	-	33.33
SK24	-	-	-	50	-	-	-	-	-	-	-	50
SK25	-	-	-	50	-	-	-	-	-	-	-	50
SK26	-	-	-	100	-	-	-	-	-	-	-	-
SK27	-	-	-	50	-	-	-	-	-	-	50	-
SK28	-	-	-	50	-	-	-	-	-	-	-	50
SK29	-	-	-	50	-	-	-	-	-	-	-	50
SK30	-	-	33.33	33.33	-	-	-	-	-	-	-	33.33
Relative frequency	0.833	4.99	7.05	43.16	1.94	5.83	1.5	0	1.77	0	5.83	27.05

Table7. Pellet analysis of Gaur in Moharli Range for Percent Contribution and Relative Frequency of different plant species.

Range – Moharli (Sp. Gaur)												
Sample ID	*Ageratum conyzoides*	*Madhuca longifolia*	*Cyanodon sp.*	*Dendrocalamus strictus*	*Vitiveria zizanioides*	*Eleocharis sp.*	*Marsilea sp.*	*Tamarindus indica*	*Milletia auriculata*	*Lagerstroemia parviflora*	Unidentified	
											Monocot	Dicot
GM1	-	-	-	100	-	-	-	-	-	-	-	-
GM2	-	-	50	50	-	-	-	-	-	-	-	-
GM3	-	25	-	25	-	-	-	-	-	-	25	25
GM4	-	-	-	50	-	-	-	-	-	-	-	50
GM5	-	33.33	-	33.33	-	-	-	-	-	-	-	33.33
GM6	-	-	-	100	-	-	-	-	-	-	-	-
GM7	-	-	-	100	-	-	-	-	-	-	-	-
GM8	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GM9	25	-	-	25	-	-	-	-	25	-	-	25
GM10	-	-	-	50	-	-	-	-	-	-	-	50
GM11	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GM12	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GM13	-	-	-	50	-	-	-	-	-	-	-	50
GM14	-	-	-	50	-	-	-	-	-	-	-	50
GM15	-	-	25	25	-	-	-	-	-	-	25	25
GM16	-	-	-	50	-	-	-	-	-	-	-	50
GM17	-	-	-	100	-	-	-	-	-	-	-	-
GM18	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GM19	-	33.33	-	33.33	-	-	-	-	-	-	-	33.33
GM20	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GM21	-	-	25	25	-	-	-	-	-	-	25	25
GM22	-	-	-	50	-	-	-	-	-	-	-	50
GM23	-	-	-	50	-	-	-	-	-	-	50	-
GM24	-	-	25	25	-	-	-	-	25	-	25	25
GM25	-	-	-	100	-	-	-	-	-	-	-	-
GM26	-	-	-	50	-	-	-	-	-	-	-	50
GM27	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GM28	-	33.33	-	33.33	-	-	-	-	-	-	-	33.33
GM29	-	-	-	50	-	-	-	-	-	-	-	50
GM30	-	-	-	33.33	-	-	33.33	-	-	-	-	33.33
Relative frequency	0.83	4.16	4.16	48.61	0	0	1.11	0	1.66	0	11.66	28.61

Table8. Pellet analysis of Gaur in Tadoba Range for Percent Contribution and Relative Frequency of different plant species.

Range – Tadoba (Sp. Gaur)												
Sample ID	*Ageratum conyzoides*	*Madhuca longifolia*	*Cyanodon sp.*	*Dendrocalamus strictus*	*Vitiveria zizanioides*	*Eleocharis sp.*	*Marsilea sp.*	*Tamarindus indica*	*Milletia auriculata*	*Lagerstroemia parviflora*	Unidentified	
											Monocot	Dicot
GT1	-	-	-	33.33	-	33.33	-	-	-	-	33.33	-
GT2	-	-	-	50	-	-	-	-	-	-	-	50
GT3	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GT4	-	-	-	50	-	-	-	-	-	-	-	50
GT5	-	-	-	33.33	33.33	-	-	-	-	-	33.33	-
GT6	-	-	50	50	-	-	-	-	-	-	-	-
GT7	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GT8	-	-	-	100	-	-	-	-	-	-	-	-
GT9	-	-	-	50	-	-	-	-	-	-	50	-
GT10	-	-	33.33	33.33	-	-	-	-	-	-	33.33	-
GT11	-	-	-	50	-	-	-	-	-	-	50	-
GT12	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GT13	-	-	33.33	33.33	-	-	-	-	-	-	33.33	-
GT14	-	-	20	20	20	-	-	-	-	-	20	20
GT15	-	-	33.33	33.33	-	-	-	-	-	-	33.33	-
GT16	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GT17	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GT18	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GT19	-	-	-	33.33	-	33.33	-	-	33.33	-	-	-
GT20	33.33	-	-	33.33	-	-	-	-	-	-	33.33	-
GT21	-	-	-	50	-	-	-	-	-	-	50	-
GT22	-	-	-	50	-	-	-	-	-	-	50	-
GT23	-	-	-	33.33	33.33	-	-	-	-	-	33.33	-
GT24	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GT25	-	-	25	25	-	-	-	-	-	-	25	25
GT26	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GT27	-	-	-	33.33	33.33	-	-	-	-	-	33.33	-
GT28	-	-	25	25	25	-	-	-	-	-	25	-
GT29	-	-	33.33	33.33	-	-	-	-	-	-	33.33	-
GT30	-	-	-	-	33.33	33.33	-	33.33	-	-	-	-
Relative frequency	1.11	0	8.44	37.33	5.94	3.33	0	1.11	1.11	0	27.88	13.72

Table9. Pellet analysis of Gaur in Kolsa Range for Percent Contribution and Relative Frequency of different Plant species.

Range – Kolsa (Sp. Gaur)												
Sample ID	***Ageratum conyzoides***	***Madhuca longifolia***	***Cyanodon sp.***	***Dendrocalamus strictus***	***Vitiveria zizanioides***	***Eleocharis sp.***	***Marsilea sp.***	***Tamarindus***	***Milletia auriculata***	***Lagerstroemia parviflora***	**Unidentified**	
											Monocot	**Dicot**
GK1	-	-	25	25	-	-	-	-	-	-	25	25
GK2	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GK3	-	-	-	25	-	-	-	-	25	-	25	25
GK4	-	-	33.33	33.33	-	-	-	-	-	-	33.33	-
GK5	-	-	-	50	-	-	-	-	-	-	50	-
GK6	-	-	-	50	-	-	-	-	-	-	50	-
GK7	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GK8	-	-	-	50	-	-	-	-	-	-	50	-
GK9	-	-	20	20	20	-	-	-	20	-	-	20
GK10	-	-	-	50	-	-	-	-	-	-	-	50
GK11	-	-	-	25	-	25	-	-	-	-	25	25
GK12	-	-	-	50	-	-	-	-	-	-	-	50
GK13	-	-	-	100	-	-	-	-	-	-	-	-
GK14	-	-	-	25	-	-	-	-	25	-	25	25
GK15	-	-	-	50	-	-	-	-	-	-	-	50
GK16	-	-	-	50	-	-	-	-	-	-	-	50
GK17	-	-	-	50	-	-	-	-	-	-	-	50
GK18	-	-	16.66	16.66	16.66	16.66	-	-	-	-	16.66	16.66
GK19	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GK20	-	-	-	25	25	25	-	-	-	-	25	-
GK21	-	-	-	50	-	-	-	-	-	-	-	50
GK22	-	-	-	33.33	33.33	-	-	-	-	-	-	33.33
GK23	-	-	-	33.33	33.33	-	-	-	-	-	-	33.33
GK24	-	-	-	50	-	-	-	-	-	-	-	50
GK25	-	-	-	50	-	-	-	-	-	-	-	50
GK26	-	25	-	25	-	-	-	-	-	-	25	25
GK27	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GK28	50	-	-	50	-	-	-	-	-	-	-	-
GK29	-	-	-	33.33	-	-	-	-	-	-	33.33	33.33
GK30	-	-	-	33.33	-	33.33	-	-	-	-	-	33.33
Relative frequency	1.66	0.83	3.16	39.55	4.27	3.33	0	0	2.33	0	17.22	27.61