IMPACT OF *Mikania micrantha* ON THE FORAGE AVAILABILITY AND USE OF CHITAL (*Axis axis*) IN NORTHERN PART OF CHITWAN NATIONAL PARK, NEPAL

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Central Department of Zoology

Institute of Science and Technology

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Kirtipur, Kathmandu, Nepal

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DECLARATION

I hereby declare that the work presented in this thesis has been done by myself, and has been not submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

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RECOMMENDATION

This is to recommend that the thesis entitled "**Impact of *Mikania micrantha* on the forage availability and use of Chital (*Axis axis*) in Northern part of Chitwan National Park, Nepal**" has been carried out by **Krishna Rana** for the partial fulfillment of Master's Degree of science in Zoology with special paper Ecology and Environment. This is her original work and has been carried out under my supervision. To the best knowledge, this thesis work has been not submitted for any other degree in any institution.

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LETTER OF APPROVAL

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CERTIFICATE OF ACCEPTANCE

This thesis work submitted by **Krishna Rana** entitled "**Impact of *Mikania micrantha* on the forage availability and use of Chital (*Axis axis*) in the Northern part of Chitwan National Park, Nepal**" has been approved as a partial fulfillment for the requirements of Master's Degree of Science in Zoology specializing in Ecology and Environment.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CNP:	Chitwan National Park
D.W. :	Distilled water
IDW:	Inverse Distance Weighting
GPS:	Global Positioning System
PV:	Prominence value
IUCN:	The International Union for Conservation of Nature

ABSTRACT

Mikania micrantha has been creating serious problem in protected areas by invading natural habitats and threatening to biological diversity and ecosystem services. It has decreased the forage availability of herbivore species. The study was conducted in northern part of Chitwan National Park from October 2021 to January 2022 to assess the impact of *Mikania micrantha* on forage availability and use of Chital. GPS coordinates were taken on each 5*5 m quadrate and *Mikania micrantha* cover percentage was calculated by visual estimation. The GPS coordinates were interpolated in ArcGIS 10.7 for IDW measurement and prominence value of each study site was calculated for abundance of *Mikania micrantha.* Riverine forest was found to be most invaded habitat by *Mikania micrantha* with 76% of the studied plot covered with *Mikania micrantha* followed by Grassland with 70% and Sal forest was least invaded with 56% of plot studied had *Mikania micrantha* presence. IDW of each study area and prominence value showed that Icharni Island had highest abundance of *Mikania micrantha* and least abundance was seen in Chitrasen. Microhistological technique was used to determine the diet of Chital. Microphotographs of 101 plants was prepared and 1260 fragments of 42 pellet sample was analyzed. A total of 49 species of plants belonging to 24 family was constituted in the diet of Chital. The animal fed on 12 grass species, 11 shrub, 17 tree species, 6 forbs and 3 climbers. Grass contributed 56% while browse contributed 39% in the diet of Chital. *Imperata cylindrica* was the most occurred plant species in the pellet of Chital indicating it as most important food of the animal. Dietary niche breadth of Chital was lowest in Icharni Island (0.394) whereas it was highest in Chitrasen Community Forest (0.632). The Jacob's electivity index showed most preference to grasses by chital. Linear regression analysis revealed that increase in *Mikania micrantha* cover percentage decreased the cover percentage of native forage. The invasion impact of *Mikania micrantha* was observed in Riverine forest along the forest edge. The understory shrubs of riverine forest was most affected by the invasion of the plant. Grassland was smothered by the *Mikania micrantha* restricting its growth. Sal forest was least affected by it.

1. INTRODUCTION

1.1 Background

Chital, also called spotted deer (*Axis axis*) is one of the six deer species found in Nepal. It is listed as Least Concerned in IUCN Red List (Duckworth et al. 2015) and in Nepal also it is in Least Concerned Category (Jnawali et al. 2011). It belongs to the order Artiodactyla and the family Cervidae. Chital is considered as the most primitive Cervids present during Pliocene and Peistocene in Europe and Asia (Schaller 1967). It is distributed in Srilanka and Peninsular India to Uttar Pradesh, Nepal, Sikkim and Bengal (Tak & Lamba 1984). It is widely distributed along the Tarai-Bhabar region of Nepal including Bardia National Park, Chitwan National Park, Parsa National Park, Shuklaphanta National Park and adjoining forest (Sharma & Chalise 2014). Chital has been introduced to the Andaman Islands, India, during 1925–1930 (Banerji 1955), Argentina, Armenia, Australia, Brazil, Croatia (islands of Brijuni; Mitchell-Jones et al. 1999), Moldova, Pakistan, Papua New Guinea, Ukraine, Uruguay and the USA (Raman 2013).

Chital are essentially social animals, rarely seen as solitary individuals (Sankar & Goyal 2004) and the basic social unit among chital is a matriarchal family group, normally consisting of an adult female, her offspring from the previous year, and a fawn (Ables 1974). Chital group may consist of one to 150 individuals or more, depending upon the circumstances (De & Spillett 1966, Schaller 1967). In Chitwan National Park many large groups of chital were found to be in the open areas such as grasslands while medium-sized groups were mainly found in close habitats (Bhattarai & Kindlmann 2018). Chital group size in Karnali - Bardia (Nepal) varied from one to 91 individuals with a mean group size of 10.7 (Dinerstein 1980).

Chital is particularly frequent in grassland–forest interface, edge, and other ecotones (Krishnan 1972). Eisenberg & Seidensticker (1976) opined that dry deciduous habitats with scrub is the favoured habitat, while (Karanth & Sunquist 1992) found mixed forests with teak plantations, moist deciduous patches and swampy grasslands to support high abundance of Chital. Kumar (2011) found that well-watered and well-protected moist deciduous forest patches in gently undulating terrain supported high Chital densities. Short grasslands are important because they provide little cover for predators such as Tiger (Moe & Wegge 1994). The introduced subpopulation in

Andaman Islands inhabits evergreen forests (Sankar & Acharya 2004) but native subpopulations are absent from the rainforest areas of the mainland. Chital are primarily grazers and prefer the shorter green grasses or the more palatable green shoots (De & Spillett 1966). Medium-sized chital is a mixed feeder (Johnsingh & Sankar 1991) and mainly feeds in fruit, browse and grasses (Sharma & Chalise 2014) .

Distribution of *Mikania micrantha*

Mikania micrantha, a native species of Central and South America, commonly called mile-a-minute weed (Holm et al. 1977) and included on the top 100 worst invasive species (Lowe et al. 2000). It is now major invasive species throughout tropical forest of Asia including China, India, Malaysia, Thailand, Nepal and invading in Australia (www.cabi.org). It has high sexual and vegetative reproductive capacity (Choudhury 1972) and retards the growth of other species due to allelopathic effects (Ye & Zhou 2001).

Mikania micrantha is the major invasive species in Nepal that was first reported from the eastern part in 1960s (Tiwari et al. 2005). It is commonly known as Panilahara, Birelahara, Titelahara, Bakhrelahara, Pyangrilahara, Banludejhar, Bahramase and Lahare banmara by the various dialects in different parts and community of Nepal (Tiwari et al. 2005). The weed has been rapidly invading the different tropical ecosystems of Nepal (forest, cropland, grassland and wetland) distributed Mechi to Lumbini zones (Siwakoti 2007). This weed has been reported creating a serious threat in Koshi Tappu Wildlife Reserve and Chitwan National Park (Murphy et al. 2013).This weed is the principal invasive species in Chitwan National Park and has smothered and killed various types of native plants (Sapkota 2007). The extent of invasion and its impact on biodiversity is increasing each year and it is reported to be invaded that of about 20% area of the Chitwan National Park (Khadka 2010). It has invaded most of the prime rhino habitats along the moist riverine forests and alluvial floodplain habitats at various levels (Murphy et al. 2013). The growth of *Mikania micrantha* was in control after consecutive cutting of the weeds (Kuo et al. 2002). Two or three successive manual cuttings reduced the proliferation of *Mikania micrantha* effectively (Rai et al. 2012). Controlled fire is also a management method which controls the growth of *Mikania micrantha* and promotes germination of native plant species (Aryal et al. 2018).

1.2 Rationale of the study

Invasive species are one of the major drivers of ecosystem change (Randall 1996). Among them *Mikania micrantha* has been creating serious problem in protected areas by invading natural habitats and threatening to biological diversity and ecosystem services. The single plant can release as many as 40,000 visible seeds every year and is capable to grow a new plant in a moist area (Tiwari 2005). In CNP , this invasive species was found to be the most serious weed among the eight invasive species in terrestrial ecosystem (Sapkota 2007). Due to invasion of the weed the grasses in the park have been reduced and it has negative effect on grasses, herbs, shrubs and small trees (Subedi 2012). It has severely decreased the food availability of herbivores (Sapkota 2007). Some herbivore species have started to feed little bit on *Mikania micrantha* just as an emergency food (Karki & Paudel 2013). Increased infestation of invasive weeds and reduction in forage availability in the park is most likely to affect population of herbivores and which in turn is likely to have negative impact on the predator (e.g. tiger). The study will provide baseline data on the impacts of *Mikania micrantha* on the forage availability and use of herbivores like spotted deer. It will be important in understanding the cascading effects of *Mikania micrantha* on higher trophic levels as spotted deer being one of the main prey species of them.

1.3 Objective

The general objective of the study was to assess the effect of *Mikania micrantha* on the forage availability and use of Chital.

The specific objectives of this study were to:

1. To assess the distribution and abundance of the *Mikania micrantha* in different habitats,
2. To determine diet composition of the *Axis axis*, and
3. To evaluate the impact of *Mikania micrantha* on the forage availability of the *Axis axis* in CNP.

1.4 Limitations

The study was conducted only in single season.

2. LITERATURE REVIEW

2.1 Food habit of Chital

Direct observation revealed that Chital are known to feed on 162 species of plants in Mundanthurai Plateau, South India (Johnsingh & Sankar 1991). In the Dhikala region of Corbett Nationa Park, Chital was found to feed on six different browse species and fruits of two species along with grasses (De & Spillett 1966). Similarly in same study area Chital was found to be primarily grazers and consumed at least 15 species of grasses, 38 species of browses, two types of flowers and one fruit (Tak & Lamba 1984). In Kanha National Park, Chital preferred green grasses less than four inches high, however, their diet contained 16 species of grasses and thirty-five species of browse (Schaller 2009). In Bardia National Park, it was observed through direct observation that even though Chital utilized various tree and shrub species, majority of their diet was dominated by grasses and sedge (Dinerstein 1979). Food preference of Chital was grasses in Bandipur Tiger Reserve contributing 95% in the rainy season (Prasad & Sharatchandra 1984). The food habit of Chital in Gir Lion Sanctuary and National Park was that of mixed-feeder as it utilized both grass and browse and the proportion of grasses varied between the seasons of rainy and winter from 92% to 55% respectively (Khan 1994). Ninety species of plant contributed in the diet of Chital in Van Vihar National Park and it varied from season to season while grass remained high preferable food plant (Sheikh et al. 2012).

Thus, it can be concluded that grasses are major food item of Chital throughout the year and appreciable amount of browse is present in dry season in the diet of Chital.

2.2 Distribution and impact of *Mikania micrantha*

The distribution of *Mikania micrantha* is rapidly increasing in its non-native region. *Mikania micrantha* was reported from 15 lowland provinces of Papua New Guinea with presence in many plantation fields like banana, young oil plants and ornamental plants (Day et al. 2012). The distribution *Mikania micrantha* in Taiwan was majorly in habitats with good light condition and often occurred in agricultural fallows and wasteland and less distribution in managed area suggesting its occurrence was determined by disturbances (Willis et al. 2008). The abundance of *Mikania micrantha* in Bangladesh was 10.34-45.97 indicating it to be invasive species in that area (Akter & Zuberi 2009). *Mikania micrantha* was reported from urban areas of Kolkata covering

66% of the terrestrial sites (Banerjee et al. 2017). In the protected grassland of Assam presence of *Mikania micrantha* is observed in both grassland and understory of woodland with prediction of increasing its distribution to 38.9% of the protected area (Choudhury et al. 2016). The study in Manas National Park reported that 15-20% of total park area and 30% of grassland is invaded by *Mikania micrantha* (Nath et al. 2019). In Nepal the protected areas, Koshi Tappu Wildife Reserve, Parsa National Park and Chitwan National Park has been heavily infested by *Mikania micrantha* (Baral & Adhikari 2017).

The study in riverine forest of CNP revealed that with increase in *Mikania micrantha* cover percent species richness was decreased. It was also revealed that with increase in tree crown cover and distance from forest edge invasion of *Mikania micrantha* decreased (Shrestha & Dangol 2014). Baidar et al. (2017) found that in CNP the land cover of riverine forest was most affected with 85.98% of presence points and sal forest was least affected by invasion of *Mikania micrantha*. The authors also showed agricultural land as potential habitat for weed, although it was less affected due to human intervention and removal of weed. In Kumrose buffer zone the negative effect of *Mikania micrantha* on regeneration of major tree species was indicated such that in non-invaded areas substantial numbers of regeneration of tree species were found as opposed to the invaded area with few regeneration of tree species (Ulak et al.). Similar study in Sal forest of CNP revealed that germination and growth of saplings and seedlings were restricted by *Mikania micrantha* leading to less plant diversity in invaded area (Basnet et al. 2016). They found that density of seedlings in non-invaded area was almost six times more than in invaded area which made the conclusion that *Mikania micrantha* coverage decreases the density of seedlings and saplings of tree species by restricting growth and germination of seedlings.

The study of effect of *Mikania micrantha* on communities revealed that since it invaded native plants there was reduction of fodder and fuel food which resulted in negative effects on livelihoods of buffer zone areas and tourism revenues as animas tend to move to core areas (Khadka 2017). Similar findings was made in Janakauli buffer zone community forest where most of the respondents noted decrease in fuel food and fodders due to this weed (Shrestha 2019). It was supported by Rai & Scarboroughn (2015) which further points that dependency of livelihood on core area of national park can be increased due to the invasion of *Mikania micrantha*.

Hence, it can be concluded that most studies are done on the impact of *Mikania micrantha* on the native plant species but there is a research gap between *Mikania micrantha* and its impact on herbivores like Chital.

3. MATERIALS AND METHODS

3.1 Materials

The scientific instruments and chemicals used during the field study and laboratory were:

- GPS (Garmin eTrex10)
- Compound Microscope
- Sodium Hypochlorite (4%)
- Staining substances: Gentian violet solution
- Sieve: 1 mm and 0.3 mm mesh size

3.2 Study Area

3.2.1 Geographic Location

The Chitwan National Park is located between 27° 34' to 27° 68' North latitudes and 83° 87' to 84° 74' East longitudes while the Buffer Zone extends further at 27° 28' to 27° 70' North latitudes and 83° 83' to 84° 77' to East longitudes. It spans across portions of four districts namely, Chitwan, Nawalparasi, Parsa and Makawanpur. The park is bounded by the Rapti and Narayani River in the north, Parsa National Park in the east and Madi settlements and India border in the south.The park has been designated as UNESCO's World Heritage Site in 1984 because of its outstanding biological significance. Geographically east-central region of northern part of Chitwan National Park was selected.

3.2.2 Climate

The forest has a range of seasons: summer, monsoon, and winter with a subtropical climate. The summer season, hot and dry period of the year extending from late February to mid-June. The monsoon season is hot and humid and lasts from mid-June to late September. Winter extends from late October to late February and is a cool season (CNP 2013).

3.2.3 Biodiversity

Flora

4 types of Sal forest associations (lowland Sal, mixed Sal, degraded Sal and hill Sal), 3 types of riverine forest associations (*Trewia-Bombax*, *Acacia- Dalbergia*, and mixed riverine), 2 types of short grassland associations (flood plain grassland and short grassland), 3 types of tall grassland associations (swampy tall grass, tall grass and wooded tall grass), 2 types wetlands (rivers and lakes), exposed surface and the cultivated lands has been identified. After Sal forests, grasslands cover (12%), riverine forests (7%), exposed surface (5%) and water body (3%). *Themeda villosa* forms a tall grass cover in clearings in the Sal forest; *Saccharum-Narenga* associations grow as mixed and pure stands of tall grass, Kans (*Saccharum spontaneum*) is one of the first species to colonize newly created sandbanks; *Arundo-Phragmites* associations form dense tall stands along stream beds on the floodplain and around lakes; Dhaddi (*Themeda* spp.) grows prolifically in areas within the park which were occupied by villages prior to their evacuation in 1964; various short grasses and herbs grown on exposed sandbanks during the dry months and become much more prolific with the outset of rain in May (e.g. *Polygonum plebeium*, *Persicaria* spp. and sedges such as *Cyperus*, *Kyllinga* and *Mariscus spp.*); Dubo (*Cynodon dactylon*) and Kure Ghans (*Chrysopogon aciculatus*) and other short grasses grow in highest areas near riverine forest all the year round; and low-lying stands of Kans (*Saccharum spontaneum*), which are destroyed by repeated flooding early in the monsoon (CNP 2013).

Fauna

CNP harbors 68 species of mammals, 55 species of herpeto fauna, over 525 birds. The large mammals in CNP include Rhino (*Rhinoceros unicornis*), Tiger (*Panthera tigris*), Elephant (*Elephas maximus*), Leopard (*P. pardus*) and four species of deer (*Axis axis*, *A. porcinus*, *Cervus unicolor* and *Muntiacus muntjak*), gaur bison (*Bos gaurus*), sloth bear (*Melursus ursinus*), primates (*Semnopithecus hector*, *Macaca mulatta*). Small mammals in CNP include the order rodentia (family: *Rattus rattus*, *Mus booduga* etc), Family: felidae (*Felis chaus*, *Prionailurus viverrinus*), Family: Viverridae (*Paguma larvata*, *Viverra zibetha*, *Vivericula indica*), Family: Herpestidae (*Herpestes edwardsi*, *Herpestes javanicus*), different species of order chiroptera. The park is especially renowned for its protection of one horned rhinoceros (*Rhinoceros unicornis* Linnaeus,

1758), the Royal Bengal tiger and gharial crocodile (*Gavialis gangeticus* Gmelin, 1789). Likewise, Maskey frog (*Tomopterna maskeyi*) is the species endemic to the park. Similarly Black-necked stork (*Ephippiorhynchus asiaticus*), Lesser-Adjutant (*Leptoptilos javanicus*), Grey-headed Fish Eagle (*Ichthyophaga ichthyaetus*) and the Brahmini duck (*Tadorna ferruginea*) are the bird species symbolic to the park (CNP 2013).

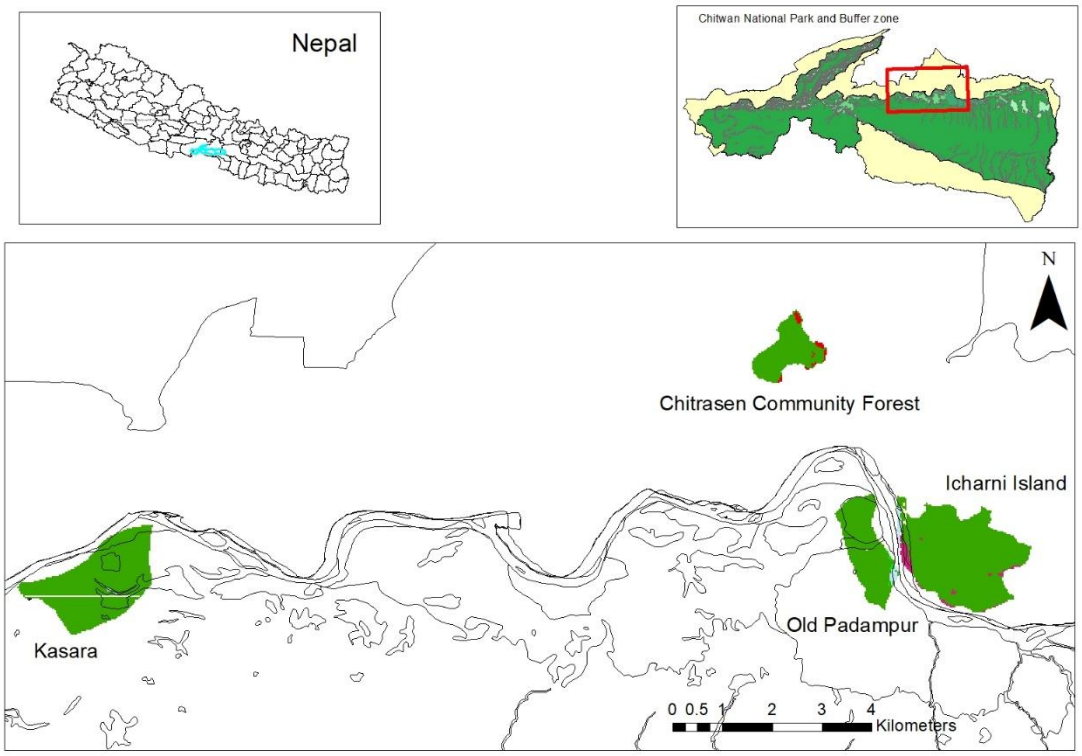

Figure 1: Map of Chitwan National Park with four study sites.

3.3 Methods

3.3.1 Habitat Characterization and *Mikania* Survey

In the beginning habitats of northern part of the park was classified into Sal forest, Riverine forest and grasslands (including both short and tall grassland) based on the existing habitat maps and literature and observation of vegetation physiognomy. Based on the classification four sites was selected; Icharni Island, Old Padampur Area, Chitrasen Community Forest and Kasara. Each site was divided into blocks of different habitats i.e. riverine forest, Sal forest and grassland. Various quadrates of 5*5 m were randomly assigned with 100 m distance between each quadrate in each block to measure

cover of *Mikania* and native plants. The field data collection was done from October 2021 to January 2022.

3.3.2 Pellet and reference plant collection

Pellet of Chital was collected opportunistically by identifying as tear-shaped and elongated (Dinerstein 1980) and bottom end rounded (Jhala et al. 2009). Fresh pellets, less than two days old, identified on the basis of texture and moisture content were collected in paper bags to avoid moisture and labeled with GPS location, date and status of the sample. The samples were air dried to remove moisture and prevent fungal growth.

Parts of potential food plants that could be reached by the Chital for feeding and encountered during survey were collected for the preparation of reference slides. Bite observation was not conducted. The plant species were labeled with either Nepali or Tharu name or both. All the collected plant materials were identified with the help of various literature (Dangol & Shivakoti 2001, NTNC-BCC& CNP 2020).

3.3.2.1 Microhistological Analysis

The microhistologcal technique introduced by (Baumgartner & Martin 1939) was used in determining plant composition of Chital fecal matter. This method involves microscopic recognitions of indigestible plant fragments mainly epidermal features, which are the characteristics of plant groups (Metcalfe & Chalk 1950, Metcalfe 1960). This method involves preparation of reference and faecal slides and their interpretation.

3.3.2.2 Slide Preparation

The method introduced by Norbury (1988) was adopted to prepare the micro-histological slides. The plant samples were identified up to species level and then dried in the oven at 60 °C for 48- 72 hours in the laboratory of the Central Department of Zoology. The dried samples were powdered separately through pestle and mortar and the powder was sieved in mesh of size 1 mm to 0.3 mm. The powder remained on the 0.3 mm sieve was chosen as final reference sample for slide preparation. Same procedure was followed for fecal samples. Each of 0.5 gm of powdered sample was taken in a Petri dish and bleached with 50 ml of 4% Sodium hypochlorite for 6-24 hours at room temperature to remove mesophyll tissues and to render the epidermis identifiable. The bleached contents were then rinsed with distilled water thoroughly in

a sieve and then treated with few drops of staining substance-gentian violet solution for 10 seconds and again well rinsed. The stained fragments were mounted on standard microscope slides in a glycerin medium and covered with a cover slip (Fig 2). Both reference slides and fecal pellet slides were observed immediately after preparation at different magnifications; 10X and 40X with a compound microscope and each fragments were photographed using phone camera.

3.3.2.4 Slide Interpretation

At first the key features of the reference plants such as; structure, shape, size and arrangement of epidermal cells, stomata, vascular vessels, trichomes, etc. were photographed through 10X and 40X microscope. Then for each fecal sample, non-overlapping and distinguishable 30 fragments were observed moving the slide from right to left in the microscope. Each fragment of the fecal sample slide was identified by comparing it with the reference plants photographs.

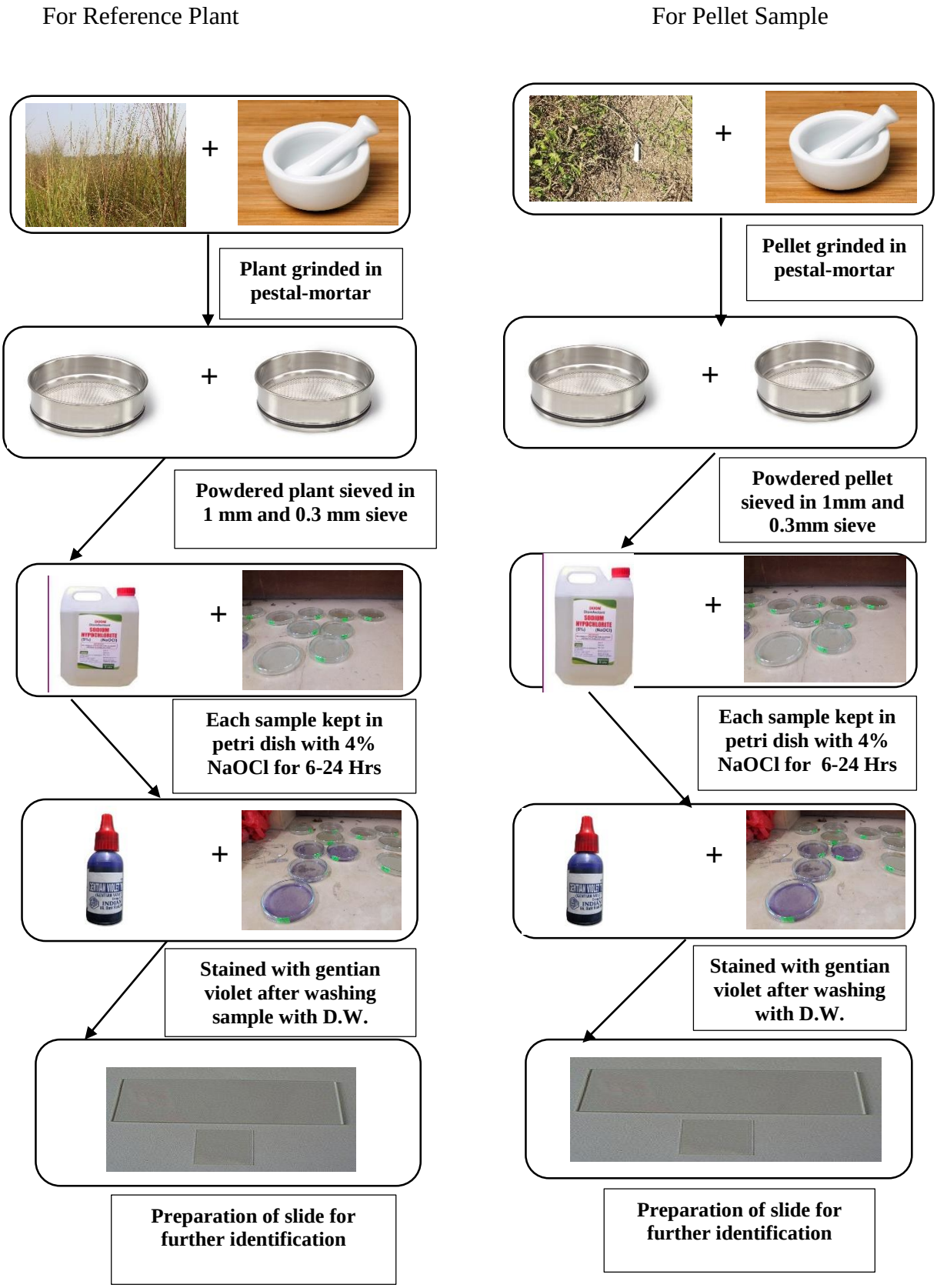

Figure 2: Flow chart of Slide preparation for microhistological analyses.

3.3.3. Determination of Impacts

Frequency of vegetation both herbs and shrubs was measured using quadrats in both invaded and non-invaded areas. For each plot *Mikania micrantha* coverage through visual estimation (0- no invasion, 1-20%- very low invasion, 20-40% for moderate invasion, 40-60% for high invasion, 60-80% for very high invasion and > 80% represents total invasion) (Adhikari et al. 2022) and canopy coverage of native plants by visual estimation was obtained in order to determine impacts of *Mikania micrantha* on forage availability for Chital.

3.4 Data analysis

3.4.1 *Mikania micrantha* distribution and its abundance

Total *Mikania micrantha* cover map was prepared using geographical coordinates recorded during the field study. The Inverse Distance Weighting (IDW) algorithm (Hengl 2009) in Arc GIS 10.7 was used to interpolate values of expected *Mikania micrantha* cover on the basis of total *Mikania micrantha* cover field data. IDW algorithm of interpolation is used to evaluate the values of target variables at a new location.

The prominence values (PV) of *Mikania micrantha* were calculated and used to quantify the abundance of *Mikania micrantha* at the different type of habitats using the method developed by (Dinerstein 1979). The prominence value reflects the relative availability of plant species in the habitats and is defined as the mean percentage cover of a species multiplied by the square root of the frequency of the occurrence of that species in the vegetation samples plot (Dinerstein 1979). The prominence value for *Mikania micrantha* was calculated using the following formula (Jnawali 1995).

$$PVs = Ms\ (\sqrt{f}\ s)$$

Where PVs is prominence value for species s, Ms is mean percentage cover of species s, and fs is frequency of occurrence of species s.

3.4.2 Diet composition

To analyze the diet data, four levels of classifications were constructed into which plant fragments were assigned: (1) Functional group (F.G.): (i) grasses, (ii) forbs, (iii) shrubs,

(iv) climbers and (v) trees; (2) Broad taxonomic group (B.T.): (i) monocots and (ii) dicots; (3) family; and (4) species.

Diet composition was expressed into percentage of occurrence (O %) (Cavallini & Lovari 1991).

Percentage Occurrence (O %) = $\frac{number\ of\ fragments\ of\ each\ food}{Total\ number\ of\ plant\ fragments\ read}$ X 100

3.4.2.1 Niche Breadth

To evaluate degree of selectivity of plant species included in the diet, Levin's measure of Niche Breadth (Levins 1968) described by (Krebs 1999), which measures how uniformly resources are being utilized, was used. The equation is

$$B = \frac{1}{\sum_{i=1}^{n} pi2}$$

Where,

B= Levin's Measure of Niche Breadth

pi= Percentage of total samples belonging to species i (i= 1, 2……, n)

n= total number of plant species in all samples.

Diversity was standardized to a scale of 0.0 to 1.0 by using Hurlbert's method (Krebs 1999).

$$Bs = \frac{B-1}{n-1}$$

Where, Bs= Levins's standardized niche breadth, and n is the number of possible resource states.

A low value of Bs indicates that the animal is selective of specific forage.

3.4.2.2 Food Preference

Food preference of Chital was determined by calculating Jacob's Electivity Index (Jacobs 1974) using the following equation

$$D = \frac{r-p}{r+p-2rp}$$

Where, r = proportion of plants in the diet

P = proportion of plants available

The value varies from -1 (avoidance) to +1 (preference) and values close to zero indicates that the forage was used in proportion to its availability.

3.4.3 Impact of *Mikania micrantha* on forage availability of Chital

Linear regression analysis was done in order to determine the impact of *Mikania micrantha* on forage availability of Chital. All the statistical analysis was done in Ms Excel 2013.

4. RESULTS

4.1 Distribution and abundance of *Mikania micrantha*

Three different habitat types were studied in which altogether 244 plots were evaluated. Sixty nine percent of the studied plots had presence of *Mikania micrantha* and 13% of the plots was estimated to be very highly invaded (>60% coverage). According to habitat types, invasion was relatively higher in the Riverine Forest, where *Mikania micrantha* presence was found to be in 76% of studied plots. Severe invasion (> 60% coverage) was observed in 16% of the plots. Most of the invasion was recorded along the forest edge and roadways. Around 70 % grassland plots had *Mikania micrantha* presence. Tall grassland was observed to be more encroached by the weed than short grassland. The least invasion was in Sal Forest with only 56% of plots had *Mikania micrantha* presence. In Sal Forest very high invasion was in fewer plots (7%) as this habitat had less understory coverage (Table 1).

Table 1: Percentage coverage in different habitat types by *Mikania micrantha* in Northern Part of Chitwan National Park.

Habitat Types	**Total no. of assessed plots**	***Mikania* cover (%)**				**Total plots invaded**
		0	<20	20 – 60	>60	
Riverine forest	98	24	20	38	16	74
Grassland	86	25	18	31	12	61
Sal forest	60	26	19	11	4	34
Total	244	75	57	80	32	169

Icharni Island

Icharni Island is a mosaic of riverine and grassland habitat. Riverine forest consisted of *Trewia nudiflora* as major tree species with *Litsea monoptela, Maesa chisia, Ehretia accuminata* and *Antidesma accuminata* as associated tree species. Shrubs like *Pogostemon benghalensis, Murraya koenigii, Callicarpa macrophylla, Colebrookia oppositifolia* dominated the understory cover. *Piper longum* and *Parthenocissus semicordata* were associated creepers with *Mikania micrantha*. In affected areas

Mikania reached to the branches of trees covering it and restricting its growth. The understory plants were dominated by *Mikania*. Tall grassland was mainly dominated by *Saccharum spontaneum* and *Saccharum benghalense*. Herbaceous plants *Ageratum conyzoides, Flemingia* sp., *Brachiaria* sp. were also present. This habitat was degraded as grasses were not growing much and presence of *Mikania micrantha* was prominent. It had covered the grasses reaching up to the height of tall grasses. *Imperata cylindrica* was the main grass of short grassland. The associated grasses were *Cynadon dactylon* and *Hemarthria compressa* were associated species. The distribution of *Mikania micrantha* was less dense in this grassland as compared to the tall grassland. High presence of *Mikania micrantha* was observed along the forest edge near to the river bank.

The IDW map of Icharni Island showed along the forest edge severe invasion of *Mikania micrantha* was observed. Very low or no *Mikania micrantha* presence was observed in core parts of the forest. In these areas the canopy cover of trees were high along with less understory plants. The prominence value indicates that the abundance of *Mikania micrantha* is very high in Icharni with presence in almost all area. Moderate to high invasion (20-60%) can be estimated in most of the areas. It also indicates that it can outgrow other native plants threatening their survival (Fig.3 & Table 2).

Table 2: Prominence Value of *Mikania* in Different Study area.

Study Area	Mean Cover % (Mx)	Frequency (fx)	Prominence value (PV)
Icharni	35.8	46	242.8
Padampur	26.4	45	177.1
Chitrasen	25.15	29	133.1
Kasara	22.6	50	159.8

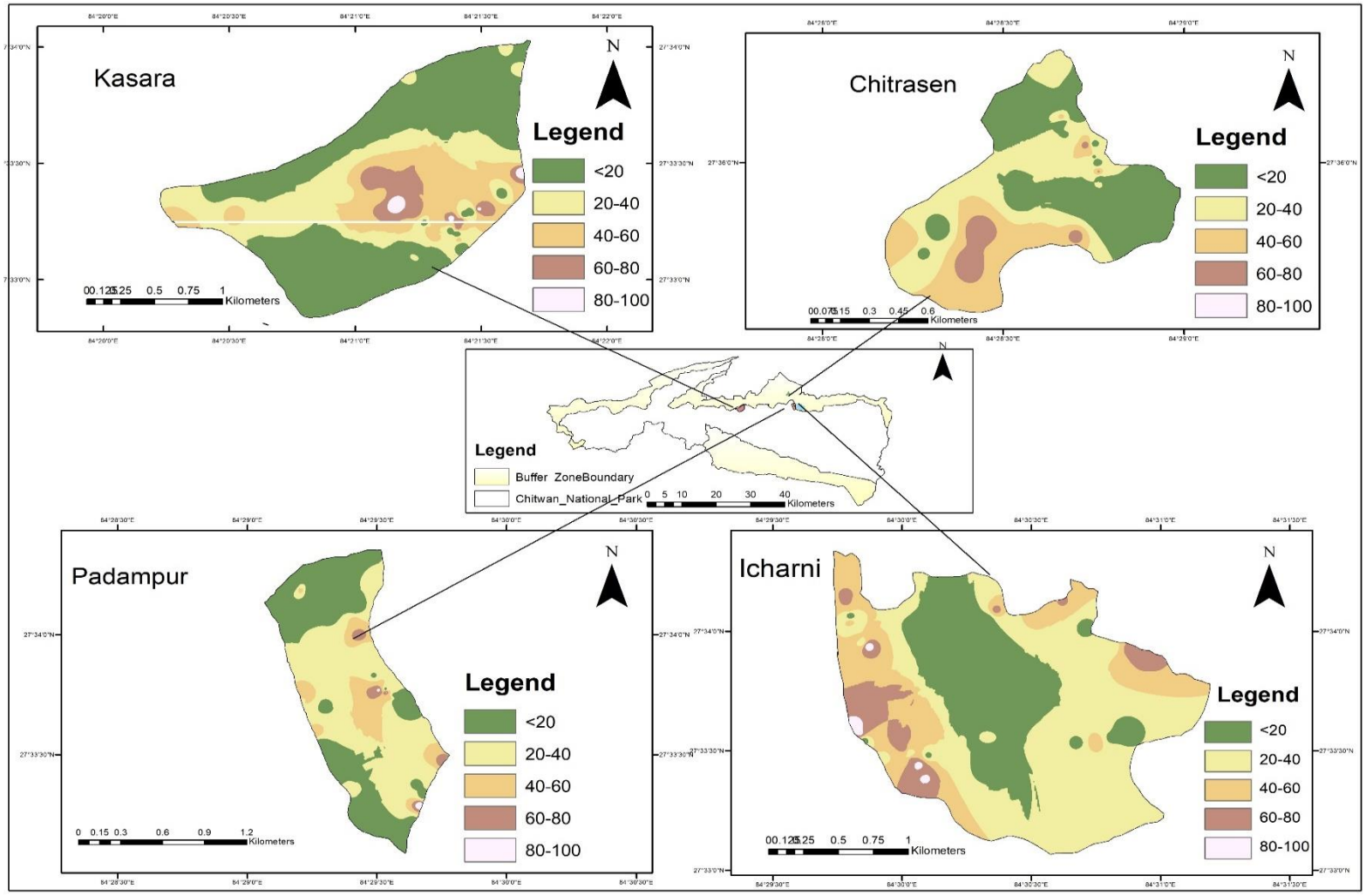

Figure 3: IDW map of Mikania micrantha in different study sites.

Old Padampur area

Grassland and riverine forest (Patch1) was studied in this area. Among grassland one recently managed area and uncontrolledarea was studied. The managed area was dominated by *Imperata cylindrica*. It also included herbaceous plants like *Scoparia dulcis, Sida rhombifolia* and *Hyptis suaveolens*. The uncontrolled area consisted of late successional tall grassland with *Saccharum spontaneum* and *Saccharum benghalense* as dominant species. *Mikania* invasion was more prominent in tall grassland as compared to the managed grassland. Although the *Saccharum* sp. were not as degraded as in the Icharni Island. The riverine forest was mainly covered by trees like *Trewia nudiflora, Dysoxyln gobara, Litsea monopetala.* The major shrub species were *Pogostemon benghalensis, Colebrookea oppositifoila* and *Murraya koenigii* with herbs like *Coffee benghalensis, Stephania japonica* and *Centella asiatica*. *Drynaria molllis* and *Dryopteris cochleata* were major ferns present in the habitat. *Mikania* smothered the trees and shrubs making them unable to grow.

The IDW map of Padampur determined that *Mikania micrantha* was severely infested along the forest edge near to the river bank and alongside the road. Very less or absence was observed in high canopy coverage farther away from the forest edge. It was also observed that area with absence of this weed had high presence of *Drynaria molllis* and *Dryopteris cochleata* ferns. The prominence value of *Mikania micrantha* suggested that its abundance is high in Padampur. It shows the notable presence of *Mikania micrantha* in the core area of CNP. Low to moderate invasion (20-40%) can be estimated in most areas. The dominance of this invasive species is high which can have severe effect on local species (Fig. 3 & Table 2).

Chitrasen Community Forest

Sal forest was dominated in this study area with some patches of riverine forest alongside the river. *Shorea robusta* was major tree species with *Holarrhena pubescens, Derris elliptica* and *Mallotus phillippensis* as other associated tree species. *Clerodendrum viscosum, Helicteres isora, Pogostemon benghalensis* and *Leea macrophylla* were major shrub species. *Desmostachya bipinnata, Vernonia cinerea* and *Albizia llucidor* were some of major herb species. *Mikania micrantha* was mostly present in the area alongside edge of forest or road. It was less present in the inner side of the forest where *Chromolaena odorata* was more dominated. The trees were not as

impacted by *Mikania micrantha* as in riverine forest. But the shrubs were affected as it was spread throughout the understory cover.

Fifty percent of the area was estimated to have presence of *Mikania micrantha* according to the IDW map. Total invasion (>80%) was not observed. The areas with very low or no presence of *Mikania micrantha* was observed in the core area of forest. Area with high cover of *Chromolaena odorata* and less understory cover or ground cover had low or no presence of *Mikania micrantha*. The prominence value is lowest among the four study area. It has low abundance in Sal forest. Very low to no invasion (0-20%) can be estimated in most areas of Chitrasen (Fig. 3 & Table 2).

Kasara area

Riverine forest, Sal forest and grassland around Lami Taal was studied. Riverine forest consisted of *Trewia nudiflora* as major tree with *Ehretia laevis*, *Antidesma acuminatum* and *Bombax ceiba* as associated tree species. *Callicarpa macrophylla*, *Colebrookea oppositifoila* and *Pogostemon benghalensis* were some major shrub species. Herbs like *Artemisia dubia*, *Coccinia grandis* and *Bridelia* sp. were present. Sal forest was dominated by *Shorea robusta, Cleistocalyx operculatus, Lagerstroemia parviflora* and *Ehretia acuminate*. The major shrub species were *Clerodendrum viscosum* and *Helicteres isora.* Grassland consisted mainly of *Themeda caudata, Narenga porphorycoma* and *Saccharum spontaneum*. Riverine and grassland was most affected by *Mikania micrantha* with plants smothered and trees covered by it. Sparse invasion was observed in Sal forest similar to Chitrasen Community Forest.

The IDW revealed that 50% of the area had *Mikania micrantha* presence. Low invasion or absence of the weed was mostly observed in Sal forest and core area of riverine forest. In both habitats high canopy coverage and low understory coverage was associated with little invasion or absence of *Mikania micrantha*. The prominence value estimated that there is high abundance of this invasive plant suggesting its notable presence. It also suggests that there is moderate invasion (20-40%) in most areas which includes mainly riverine and grassland habitat. It can have negative effect on native plants such as restricting their growth, unable to regenerate (Fig 3 & Table 2).

4.2 Diet Composition

A total of 1260 plant fragments of 42 pellet samples from four different sites; Icharni Island (n=16), Old Padampur Area (n=12), Kasara (n=10) and Chitrasen Community Forest (n=4) were analyzed through microhistological technique. Forty-nine species belonging to 24 different families were identified in the fecal pellets. Chital was found to be feeding on all the functional categories of plants. The animal fed on 12 grass species, 11 shrub, 17 tree species, 6 forbs and 3 climbers (Table 3). Out of 1260 plant fragments, 710 fragments belonged to the grasses contributing the higher proportion of diets of Chital followed by shrubs with 266 fragments, trees with 163 fragments and forbs had 62 fragments. Climbers contributed the lowest with only 10 fragments visible in the pellet sample. 49 plant fragments were remained unidentified.

Grasses were key forage plants contributing 56% of the diet. *Imperata cylindrica* (11.67%) had highest percentage occurrence followed by *Cynodon dactylon* (6.43%), *Digitaria spp.* (5.95%) and *Phragmites karka* (5.32%) which contributed to the diet of Chital. All these food plants belongs to the grass family. *Desmotachya bipinnata* was had low occurrence (1.43) among the grass species (Table 3).
Pogostemon benghalensis (2.86%), *Coffee benghalensis (2.70%)* and *Achyranthes aspera (2.38%)* were major shrub plants in the diet. *Sida rhombifolia* had the lowest percentage occurrence (0.32%) contributing least in the diet of Chital (Table 3).

Among tree species the major contributors were *Litsea monoptela* (2.46%), *Trewia nudiflora* (1.43%), *Shorea robusta* (1.35%) and *Ehretia acuminata* (1.11%) as the food of the animal. Least occurrence was of *Acacia pennata* (0.16). Overall the browse species (i.e. shrubs and trees) contributed 34% in the diet of Chital (Table 3).
Forbs and climbers had less proportions in the diet. *Alternanthera sessilis* (1.59%) and *Mukia maderaspatana* (0.32%) and *Piper longum* (0.32%) were major forbs and climbers in the diet respectively (Table 3).

Table 3: Percentage composition of various plant categories (F.C. = Functional Category; B.C. = Broad Category, Family, Species) identified in pellets of Chital in

F.C.	B.C.	Family	Species	Percentage Occurrence
Grasses	Monocots	Poaceae	*Brachiaria* sp.	4.13
			Phragmites karka	5.32
			Cynodon dactylon	6.43
			Desmostachya bipinnata	1.43
			Digitaria sp.	5.95
			Hemarthria compressa	4.05
			Imperata cylindrica	11.67
			Narenga porphorycoma	3.81
			Saccharum benghalense	3.10
			Saccharum spontaneum	5.56
			Themeda arundinacea	2.94
			Themeda caudata	2.38
Forbs	Monocots	Costaceae	*Costus speciosus*	0.87
		Cyperaceae	*Cyperus* sp.	1.11
	Dicots	Amaranthaceae	*Alternanthera sessilis*	1.51
		Solanaceae	*Solanum surattense*	0.16
			Solanum anguivi	0.87
		Scrophulariaceae	*Scoparia dulcis*	0.40
Shrubs	Dicots	Amaranthaceae	*Achyranthes aspera*	2.38
		Lamiaceae	*Callicarpa macrophylla*	1.90
			Clerodendrum viscosum	2.22
			Pogostemon benghalensis	2.86
		Rubiaceae	*Coffee benghalensis*	2.70
		Fabaceae	*Flemingia* sp.	1.75
		Malvaceae	*Grewia sapida*	2.22
			Helicteres isora	2.14
			Sida rhombifolia	0.32
			Urena lobata	0.87
		Vitaceae	*Leea macrophylla*	1.75
Climbers	Monocots	Cucurbitaccae	*Mukia maderaspatana*	0.32
		Piperaceae	*Piper longum*	0.32
		Smilacaceae	*Smilax aspera*	0.16
Trees	Dicots	Fabaceae	*Acacia catechu*	0.56
			Acacia pennata	0.16
			Albizia llucidor	0.79
			Derris elliptica	0.32
		Boraginaceae	*Ehretia acuminata*	1.11

		Phyllanthaceae	*Antidesma acuminatum*	0.32
			Bridelia sp.	0.95
		Lythraceae	*Lagerstroemia parviflora*	0.48
			Woodfordia fruticosa	0.24
		Lauraceae	*Litsea monopetala*	2.46
		Myrsinaceae	*Myrsine semiserrata*	0.32
		Lamiaceae	*Premna integrifolia*	0.87
		Anacardiaceae	*Semecarpus anacardium*	0.56
		Dipterocarpaceae	*Shorea robusta*	1.35
		Myrtaceae	*Cleistocalyx operculatus*	0.56
		Euphorbiaceae	*Mallotus philippensis*	0.48
			Trewia nudiflora	1.43
Unidentified			49	3.89

The niche breadth of (Bs) Chital indicates the generalized feeding strategy by utilizing broad categories of forage plants. The niche breadth (Bs) value was highest in Chitrasen Community Forest (0.632). On the other hand niche breadth (Bs) was lowest in Icharni Island (0.394) among the four study sites. (Fig 4).

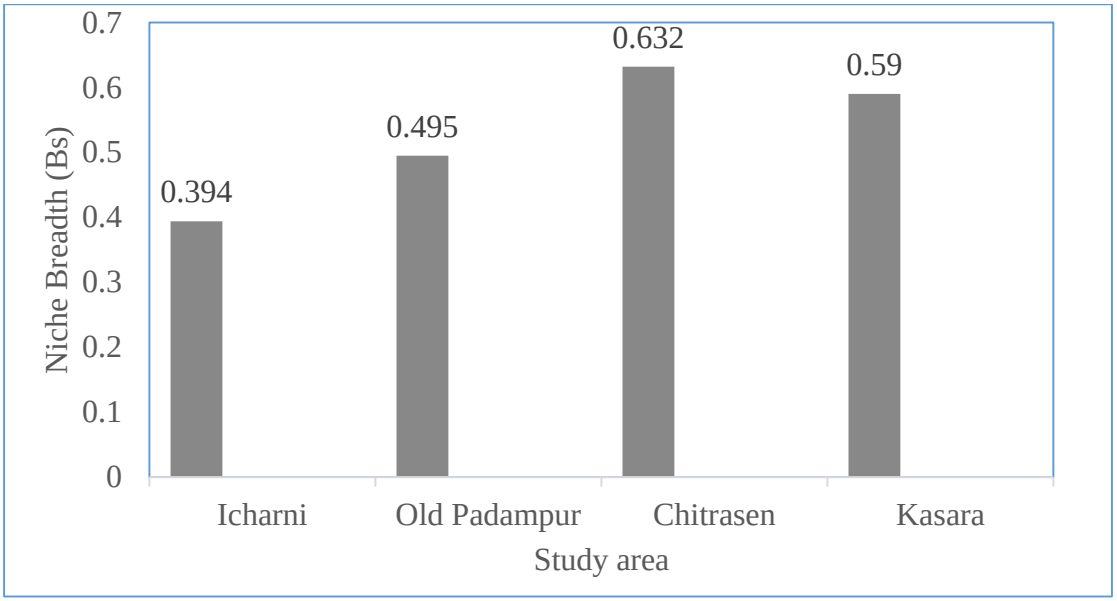

Figure 4: Niche Breadth (Bs) values of Chital in different Study Sites of CNP, Nepal.

Jacob's electivity index showed that they strongly preferred grasses in Icharni Island followed by trees. Forbs and shrubs were relatively not a food of choice for Chital. Similarly, in Padampur Chital had more preference for grasses. The consumption of forbs and shrubs were less in proportion to their availability. Trees were consumed in

equal amount of proportion to the availability of plants. In Chitrasen, high food preference was grasses and forbs, shrubs and trees were almost consumed in their proportion amount of availability. Preference for grasses was shown in Kasara while shrubs and trees were utilized in equal proportion to their availability. Forbs were mostly avoided (Fig 5).

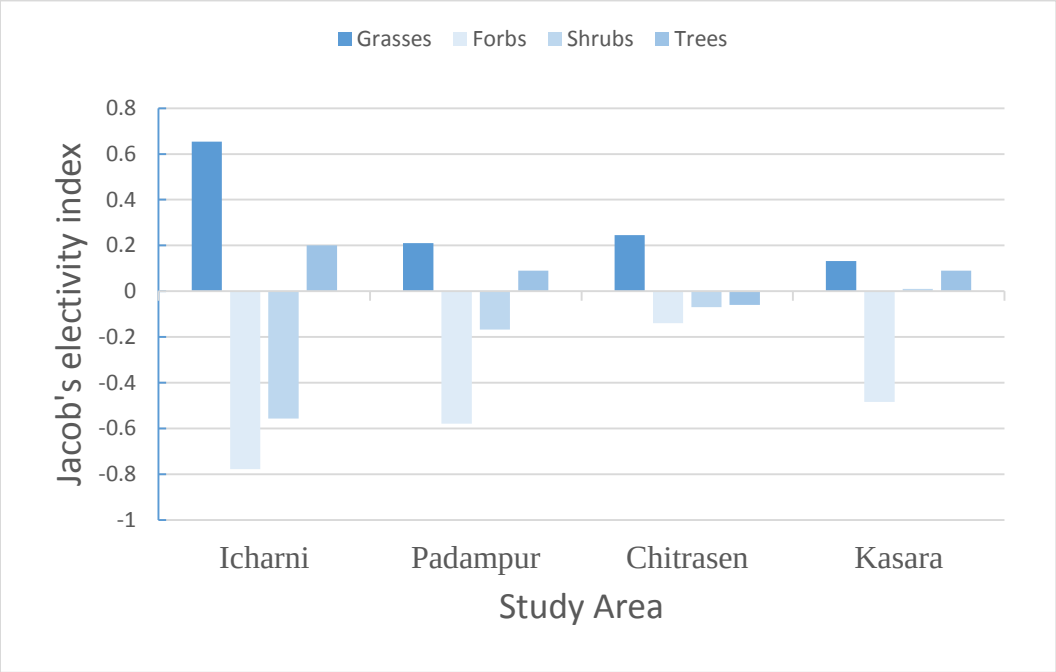

Figure 5: Food plants preferences of Chital in four study area in CNP, Nepal.

4.3 Impact of *Mikania micrantha* on forage availability of Chital

The result showed that there was a negative relationship between percentage *Mikania micrantha* cover and percentage native forage cover. Plant cover was found to reduce with increase in *Mikania micrantha* cover. This occurrence was similar in all the four study sites (Fig 6).

In Icharni Island, most of the invaded areas were present in Riverine forest. Trees like *Litsea monoptela* and *Trewia nudiflora* were effected by *Mikania* as it was intertwined with the branches of trees making them unable to open out. *Pogostemon benghalensis, Murraya koenigii, Callicarpa macrophylla and Colebrookia oppositifolia* were prominent shrubs highly effected by *Mikania micrantha*. The shrubs were covered by the weed restricting their movement and growth. In highly invaded areas the shrubs were dried and wilted. The understory plants were mostly affected by *Mikania*

micrantha in riverine forest. In case of grassland, tall grassland was found to be most affected by the invasive plant. It climbed the tall grasses of *Saccharum spp.* reaching upto its height. This invasive plant had coiled the grasses which restricted their width to span. The short grassland of *Imperata cylindrica* was also smothered by *Mikania micrantha*. Similar result was also obsereved in the riverine and grassland of Padampur and Kasara.

In Sal Forest of Chitrasen and Kasara, *Mikania micrantha* seem to have less effect on trees compared to the riverine forest but it had equal impact on the understory plants. Most of the affected shrubs were *Clerodendrum viscosum, Helicteres isora, Pogostemon benghalensis* and *Leea macrophylla.*

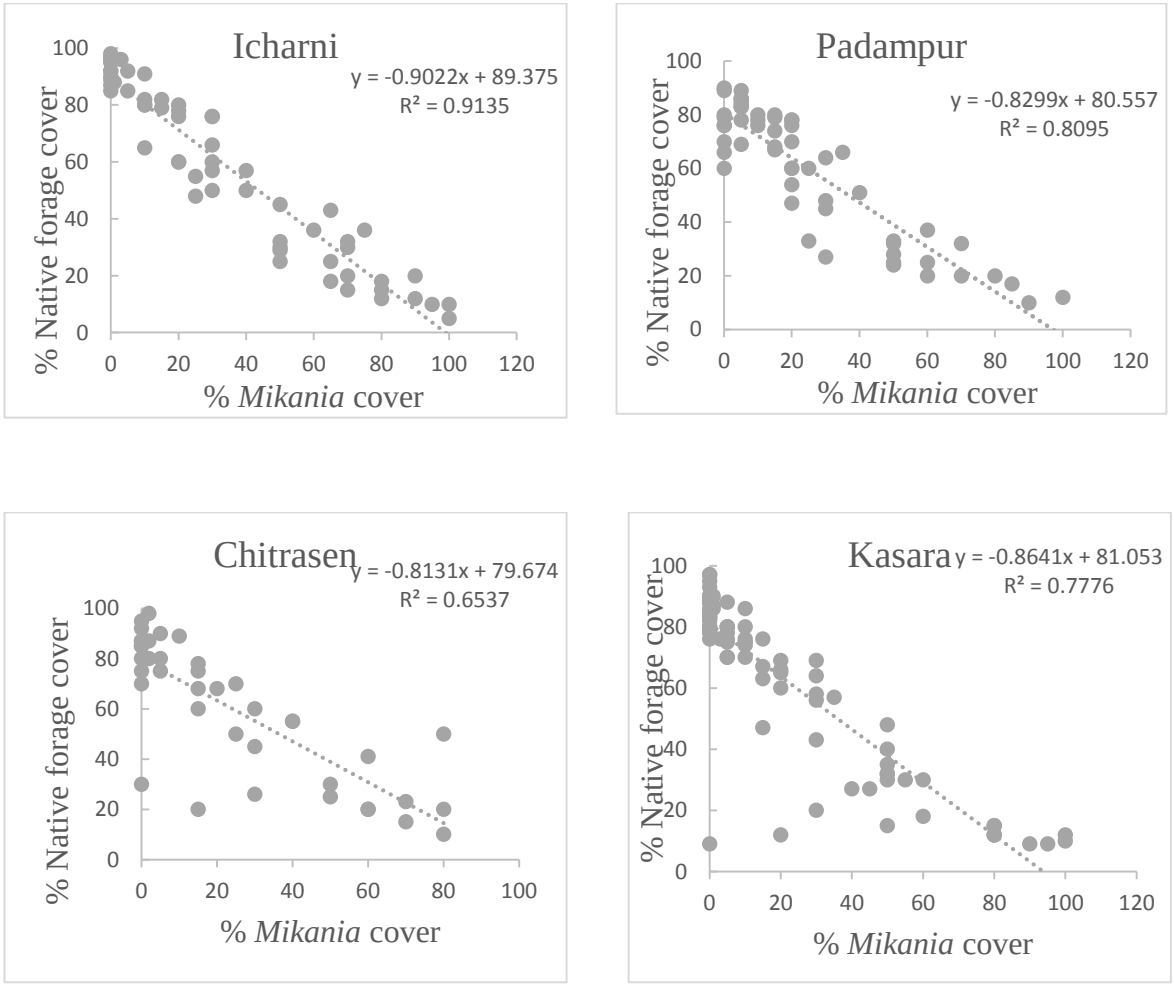

Figure 6: Scatter plot of native plant cover versus Mikania micrantha percentage cover.

5. DISCUSSIONS

The study revealed that riverine forest was the most intensively invaded habitat by *Mikania* with 76% of the plots had presence of *Mikania micrantha* which was followed grassland where 70% of plot had presence of *Mikania micrantha*. The least invaded habitat was Sal forest where only 56% of the studied plot had *Mikania micrantha* presence. Likewise, Sapkota (2007) found that 60% and 35% of riverine forest and grassland in Icharni Island was invaded by *Mikania micrantha* respectively. Similarly, Murphy et al. (2013) reported that in CNP 63.1% of studied plot of riverine forest had *Mikania micrantha* which is highest among all the habitats . While the distribution of *Mikania micrantha* was low in grassland and Sal forest had least invasion of *Mikania micrantha*. Similar pattern was followed in the study of (Baidar et al. 2017, Dai et al. 2020) where they found that Maxent model showed riverine forest had highest presence of *Mikania micrantha* followed by grassland and Sal forest. In riverine forest this invasive species can get adequate amount of moisture, sunlight and support for climbing which explains its high presence (Baidar et al. 2017). In tall grassland, *Sachharum spp*. were highly impacted as they were enveloped by *Mikania micrantha* reaching up to its height as riparian grassland with less tree and shrub were most favourable for *Mikanian micrantha* presence (Sapkota 2007). . It was also observed that areas with low or sparse understory plants had low *Mikania micrantha* presence because high shrub population provides sufficient environment for establishment and growth (Shrestha & Dangol 2014). It was observed that plots with higher canopy coverage had less invasion whereas low canopy coverage facilitated with higher coverage of *Mikania micrantha* since light is a critical abiotic resource for plants (Tilman 1986) that differs considerably among micro- and macrohabitats (Chazdon & Fetcher 1984). Differences in light availability across habitat boundaries have important implications for the distribution of plant individuals and species (Didham & Lawton 1999). Previous work also indicates that *Mikania micrantha* density is highest in areas with low canopy coverage which provides way for high light availability (Sapkota 2007).

IDW map of *Mikania micrantha* showed that higher invasion was observed along the forest edge and roads of forest. Higher invasion of *Mikania micrantha* was seen in mostly forest edge alongside the river and roads because their chance of dispersal is increased by vector pathways such as roads and waterway (Davies & Sheley 2007) since roadsides generally provide occasion for the establishment of invasive species

(Rentch et al. 2005), hence, play an important role in accelerating the movement of invasive plants through forests often because frequent disturbances make resources available (Mortensen et al. 2009) . Such disturbances can be associated with creating new roads and road maintenance (Bender et al. 1984). Low invasion in the core areas of forest was observed since invasive species have lower chances of their dispersal in the interior part of the forest (Hansen & Clevenger 2005).

High prominence value of *Mikania micrantha* was calculated in Icharni Island which indicates the high abundance of invasive species since flood-plains and riparian zones like Icharni Island are often considered to be vulnerable ecosystems for plant invasion, as a result of both anthropogenic and climatic disturbances that alter hydrological flow regimes (Sher et al. 2002). Significant prominence value of *Mikania* in protected core areas of CNP Old Padampur and Kasara could be since there are many routes such as human-dominated boundaries, connecting roads and rivers for an invasive plant to pass in a protected ecosystem (Adhikari et al. 2015). Few studies have also speculated that seeds from invasive were carried over short or long distances by vehicles visiting the park (Lonsdale & Lane 1994, Gabbard & Fowler 2007, Von der Lippe & Kowarik 2007). Low prominence value of the weed in Chitrasen Community Forest could be since sal is a light demanding species and requires complete overhead light from early stages of development (Baidar et al. 2017).

A total of 49 species belonging to 24 family was determined by microhistological analysis of pellet samples. The result revealed that grass is the most important food for Chital, constituting 56% of the diet while browse species constituted only 39%. *Imperata cylindrica* had the highest percentage occurrence among all food plants (11.67%). Chital forage on both grasses and browse (Schaller 1967) although its preference varies from month to month (Johnsingh & Sankar 1991). In the present study, the winter diet of Chital comprised of 56% of grasses which is in agreement to the grass proportion of 55% in Chital diet in Gir Lion Sanctuary and National Park (Khan 1994). Whereas in Bandipur Tiger Reserve grass contributed 67-68% of diet (Prasad & Sharatchandra 1984). However in Van Vihar National park the winter diet of Chital consisted of only 35% of grass (Sheikh et al. 2012). In Bardia National Park the winter food diet containing grasses like *Imperata cylindrica, Saccharum spontaneum* and *Cynodon dactylon* were in common with the present study (Dinerstein 1979). Schaller (1967) found *Saccharum sponatneum, Themeda* spp. through direct

observation as food plants of Chital in Kanha National park which is parallel to this study but did not observed *Imperata cylindrica* as food plant. Since in the Terai region, many grasses become less palatable when they start to mature (Dinerstein 1979). The reason behind the dominance of grasses like *Imperata cylindrica* may be due to the management of grassland throughout the Chitwan National Park which produces more palatable grasses. There is appreciable percentage of browse in the winter diet of Chital since most grasses are not fully grown during dry season (Schaller 1967). Similar findings was observed by (Sheikh et al. 2012) as browse species comprised 51% in Van Vihar National park. In many studies consumption of invasive plants like *Lantana camara* and *Ageratum conyzoides* was reported by direct observation (Narendra Prasad & Sharatchandra 1984, Johnsingh & Sankar 1991) but in this study occurrence of *Mikania micrantha* was failed to report which may be due to the digestive efficiency of deer is very high so the ingested plant parts are almost degraded (Korschgen 1980) and the biasness subjected to microhistological analysis, like sample preparation (Vavra & Holechek 1980), poor training of technician (Holechek et al. 1982) and differential digestibility of diet components (Holechek & Valdez 1985).

The niche breadth (B) of Chital is lowest in Icharni Island (0.394) which shows more selective behavior than in other study sites. The diet breadth (B) of Chital in Gir Lion Sanctuary for winter season was 0.38 which is higher than the diet breadth in monsoon (B= 0.15) due to low food availability and poor quality of forage (Khan 1994). The differences in niche diet breadth among the four study sites are since, average individual home range size appears to be mainly shaped by the interplay of diet niche breadth and body mass (Huang et al. 2021). In CNP, Mishra (1982) found that the no significant changes was observed in the movement pattern of Chital concluding that their home range is stable and Riverine forest was found to be important element of their of the range throughout the year. This explains different values of diet breadth between the different study sites.

The Jacob's electivity index (D) estimated that food of preference is grasses as it utilized more grasses than available during winter season. Less preference was shown to browsers since their presence is high during this season than the grasses but Chital utilized in fair proportion. This is supported by the average presence of 96% of grass in the rumens of Chital in different months which verifies the importance of grass in the

diet of Chital(Schaller 1967). In Chitwan high water table and availability of moisture makes plant to grow all year round providing forage grasses for Chital (Jnawali 1995).

In the diet composition of Rhino in CNP *Saccharum spontaneum, Saccharum benghaensis* and *Coffee benghalensis* was reported as important forage plants which was found in the diet of Chital (Jnawali 1995). The dry season diet of swamp deer in Bardia National Park consisted of *S. spontaneum, Themeda* spp. and *I. cylindrica* as main food plants and hog deer diet consisted mainly of *S. spontaneum* which is similar to the present study (Wegge et al. 2006). But there is lack of study of diet composition of other sympatric ungulates in CNP.

The cover of native plants decreased with increase in *Mikania micrantha* cover along all the three habitat. In Icharni Island most of the small trees, shrubs and herbs were highly smothered and no new stems were sprouting from roots of grasses in invaded areas (Sapkota 2007). Native plants have resistance to invasion upto 35% of *Mikania micrantha* coverage and above that they could not survive (Shrestha & Dangol 2014). The coverage of *Mikania micrantha* has significantly reduced growth of saplings and seedlings in invaded areas (Basnet et al. 2016). Higher species richness in non-invaded forest compared to invaded forest has been studied by (Kaur & Malhotra 2012). Murphy et al. (2013) recorded *Mikania micrantha* across 44% of habitats sampled in Chitwan National Park, with 15% having more than 50% coverage by the weed; the highest densities were recorded in riverine forest, tall grass and wetland habitats. Data from regular monitoring in the Baghmara and Chitrasen buffer zone community forests suggest a negative impact on Rhino habitat by *Mikania micrantha* (Murphy et al. 2013). However in this study, managed grassland where uprooting of *Mikania* is done on regular basis were found to be less effected by the invasive plant as regular cleaning prevented the regeneration of *Mikania* to some extent (Siwakoti 2007). In Kumrose Buffer Zone, regeneration of tree species such as *Dalbergia sissoo*, *Acacia catechu* and *Bombax ceiba* were recorded in non-invaded forest whereas absence of regeneration in invaded forest was observed (Ulak et al. 2016). In invaded areas of tropical grassland of Rajiv Gandhi Orang National Park, alteration of grassland with complete dominance of invasive plants was observed leaving only small patches of grass (Choudhury et al. 2016) . Invasion of *Mikania micrantha* in crucial habitat for endangered Pygmy hog, Hispid hare and Bengal Florican in Manas National Park of India has likely to cause shrinkage in the habitat (Nath et al. 2019). Simiarly, *Mikania micrantha* has reduced

the food availability of mammalian herbivores like Rhino in Chitwan National Park which leads to be major driver for animals to leave protected area (Lamichhane et al. 2014).

6. CONCLUSION

The distribution and abundance of *Mikania micrantha* was studied in three different habitat types of CNP in which riverine forest had 76% of presence followed by grassland with 70% and Sal forest with 56% of *Mikania micrantha* presence. Inverse distance weighting showed that Icharni Island has most invaded areas as compared to other site. The prominence value also shows that the availability of *Mikania micrantha* is most in Icharni Island. The winter diet of Chital constitute of 49 species of plant belonging to 24 different family. The percentage occurrence of grass was 56% whereas browse accounted for 39%. *Imperata cylindrica* was most important food of Chital occurring 11.67% in the diet of Chital. The percentage cover of *Mikania micrantha* had negative relation with percentage cover of native forage. With increase in *Mikania micrantha* cover percentage native plants cover percentage decreased. It shows negative impact on the forage of herbivores as *Mikania micrantha* plays important role in reducing the native species by restricting their regeneration and growth.

6.1 Recommendation

Based on this study, following recommendations are put forward.

- Distribution of *Mikania micrantha* and other invasive species should be assessed in other invaded parts of Nepal.
- Detailed food habits of this species with other sympatric species should be conducted in CNP and other landscapes in other season too in order to know the impact of invasive species.
- Consistent management of grassland should be done in order to reduce the negative effect of *Mikania* and increase forage availability.

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APPENDICES

Appendix 1

Plants collected from Chitwan National Park for reference library preparation.

S. No.	Famiy	Scientific Name	Local Name
1	Fabaceae	*Acacia catechu*	Khayar
2	Fabaceae	*Acacia pennata*	AreliKada
3	Amaranthaceae	*Achyranthes aspera*	Datiwan
4	Asteraceae	*Ageratum houstonianum*	Nilogande
5	Fabaceae	*Albizia llucidor*	Padkeshirish
6	Amaranthaceae	*Alternanthera sessilis*	Bhringa
7	Phyllanthaceae	*Antidesma acidum*	Archal
8	Phyllanthaceae	*Antidesma acuminatum*	Kalobelauni
9	Asteraceae	*Artemisia dubia*	Titepati
10	Poaceae	*Brachiaria* sp.	Namleghas
11	Phyllanthaceae	*Bridelia* sp.	Gayo
12	Leguminosae	*Butea monosperma*	Palas
13	Lamiaceae	*Callicarpa macrophylla*	Dahikamala
14	Apiaceae	*Centella asiatica*	Ghodtapre
15	Asteraceae	*Chromolaena odorata*	Seto Banmara
16	Myrtaceae	*Cleistocalyx operculatus*	Kemona
17	Lamiaceae	*Clerodendrum viscosum*	Bhati
18	Cucurbitaccae	*Coccinia grandis*	Golkakri
19	Rubiaceae	*Coffee benghalensis*	coffee jhar
20	Lamiaceae	*Colebrookea oppositifoila*	Dhursel
21	Zingiberaceae	*Costus speciosus*	Bedlaure
22	Poaceae	*cyanadon dactylon*	Dubo
23	Cyperaceae	*Cyperus* sp.	Mathe
24	Fabaceae	*Derris elliptica*	Derri
25	Poaceae	*Desmostachya bipinnata*	Kush
26	Poaceae	*Digitaria* sp.	Banso
27	Dilleniaceae	*Dilenia pentagyna*	Tatari

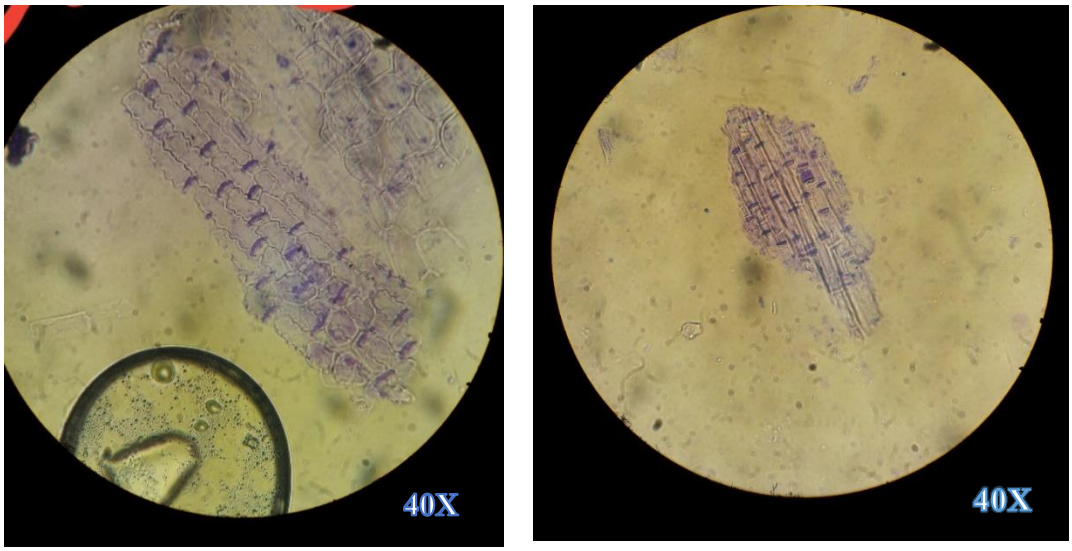
28	Dioscoreaceae	*Dioscorea bulbifera*	Gitthatarul
29	Polypodiaceae	*Drynaria molllis*	Unyo
30	Aspidaceae	*Dryopteris cochleate*	Neuro
31	Meliaceae	*Dysoxyln gobara*	Lasune/Dhamina
32	Boraginaceae	*Ehretia laevis*	Dhatrung
33	Elaeagnaceae	*Elaeagnus infundabularis*	Mahaniplant
34	Equisetaceae	*Equisetum debile*	Akhale
35	Fabaceae	*Flemingia* sp.	Bhatmaspate
36	Zingiberaceae	*Globba racemosa*	Banbesar
37	Malvaceae	*Grewia sapida*	Farsa
38	Malvaceae	*Helicteres isora*	Simthi
39	Poaceae	*Hemarthria compressa*	Ghodedubo
40	Apocynaceae	*Holarrhena pubescens*	Dudhkhirra
41	Lamiaceae	*Hyptis suaveolens*	Bansilam
42	Poaceae	*Imperata cylindrica*	Siru
43	Lythraceae	*Lagerstroemia parviflora*	Botdhairo
44	Verbenaceae	*Lantana camara*	Kadebanmara
45	Vitaceae	*Leea macrophylla*	Galgale/Galeni
46	Scrophulariaceae	*Lindernia ciliate*	Karauti ghaas
47	Lauraceae	*Litsea monopetala*	Kutmero
48	Primulaceae	*Maesa chisia*	Belauni
49	Euphorbiaceae	*Mallotus philippensis*	Sindure
50	Asteraceae	*Mikania micrantha*	Laharebanmara
51	Fabaceae	*Mimosa pudica*	Lajjawati
52	Rutaceae	*Murraya koenigii*	Currypatta
53	Primulaceae	*Myrsine semiserrata*	Kalikath
54	Poaceae	*Narenga porphorycoma*	Phaank
55	Asteraceae	*Parthenium hysterophorus*	Pati Jhar
56	vitaceae	*Parthenocissus semicordata*	Charchare
57	Poaceae	*Phragmites karka*	Narkat
58	Phyllanthaceae	*Phyllanthus urinaria*	Bhuiamala
59	Piperaceae	*Piper longum*	Pipla

60	Lamiaceae	*Pogostemon benghalensis*	Rudilo
61	Araceae	*Pothos cathcartii*	Money Ghas
62	Lamiaceae	*Premna integrifolia*	Gidaari
63	Poaceae	*Saccharum benghalense*	Baruwa
64	Poaceae	*Saccharum spontaneum*	Kaas
65	Scrophulariaceae	*Scoparia dulcis*	Chinijhar
66	Anacardiaceae	*Semecarpus anacardium*	Bhalayo
67	Dipterocarpaceae	*Shorea robusta*	Sal
68	Malvaceae	*Sida rhombifolia*	Khareto/Jhadu
69	Smilacaceae	*Smilax aspera*	Kukurdino
70	Solanaceae	*Solanum anguivi*	Bihi
71	Solanaceae	*Solanum surattense*	Kantakari
72	Menispermaceae	*Stephania japonica*	Batulipate
73	Myrtaceae	*Syzygium cumini*	Jamun
74	Poaceae	*Themeda arundinacea*	Dhaddi
75	Poaceae	*Themeda caudata*	Ureli
76	Euphorbiaceae	*Trewia nudiflora*	Bhellar
77	Malvaceae	*Urena lobata*	Balu Jhar
78	Apocynaceae	*Vallaris solanacea*	Dudelahara
79	Asteraceae	*Vernonia cinerea*	Marchajhar
80	Lythraceae	*Woodfordia fruticose*	Dhairo
81	Rubiaceae	*Xeromphis spinosa*	Mainkada
82	Rhamnaceae	*Ziziphus mauritiana*	Bayar
83	-	-	Asare
84	-	-	Badampate
85	-	-	Baspate
86	-	-	Kanike Kuro
87	-	-	Khajuro
88	-	-	Kurilo
90	-	-	Kuro
91	-	-	Kut
92	-	-	Lawahati

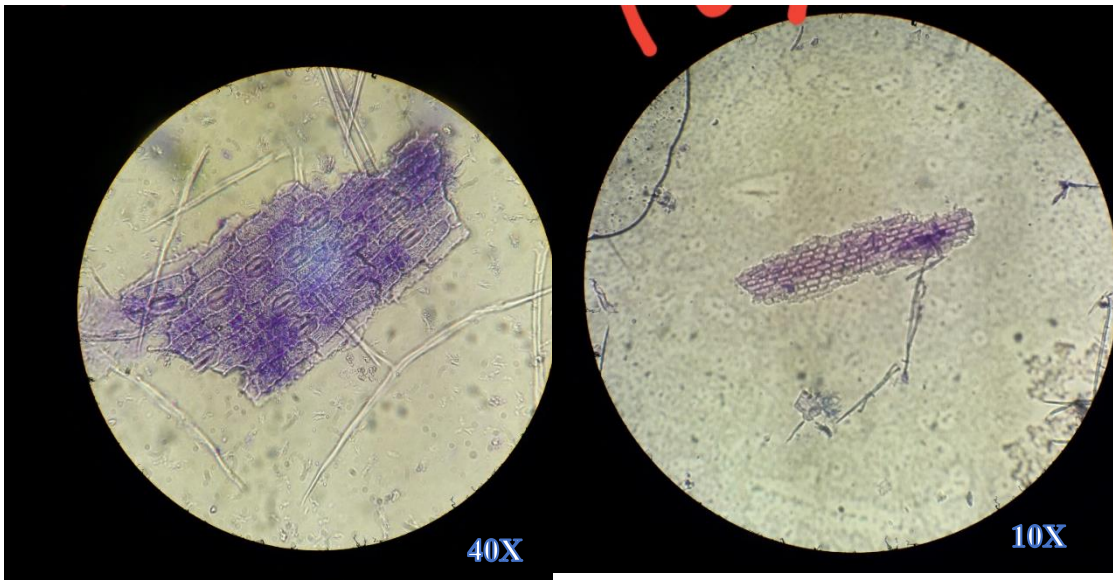
93	-	-	Lovejhar
94	-	-	Panilahara
95	-	-	Tuki Phool
96	-	-	Unknown shrub
97	-	-	Unknown shrub
98	-	-	Unknown tree
99	-	-	Unknown shrub
100	-	-	Unknown shrub
101	-	-	Unknown shrub

PHOTO PLATES

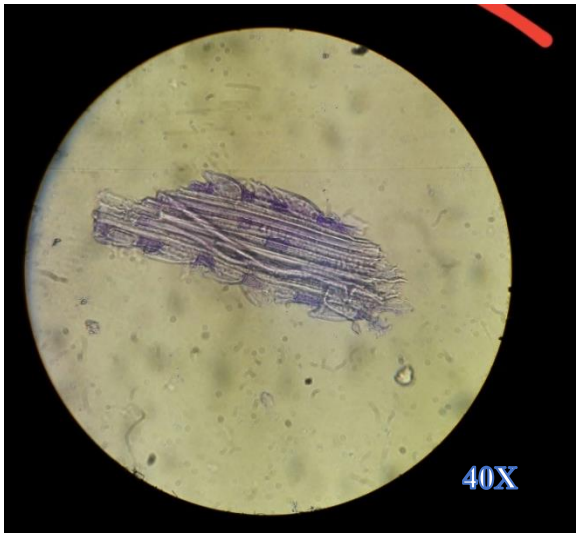
I. Selected histological photographs of principal food plants of Chital in CNP, Nepal.

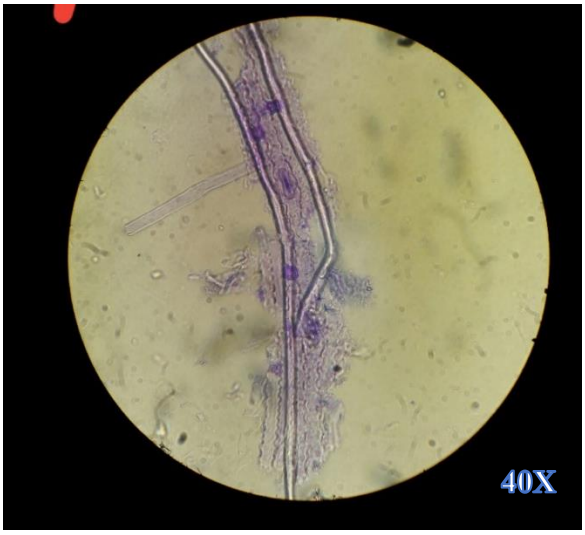


a) *Digitaria* Sp. (Banso)



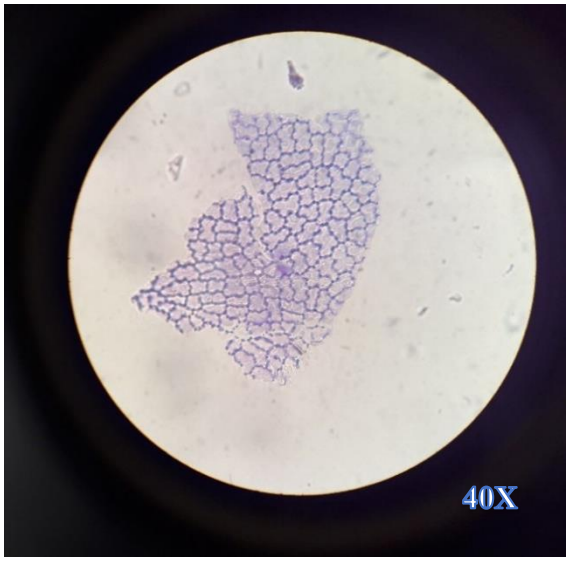
b) *Themeda arundinaceae* (Dhaddi)

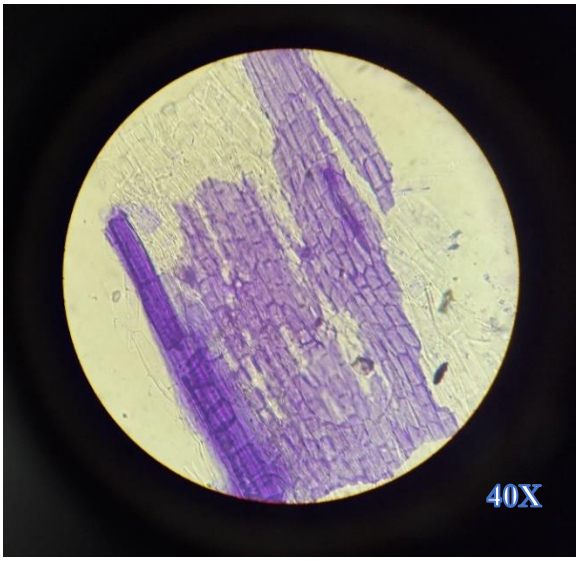




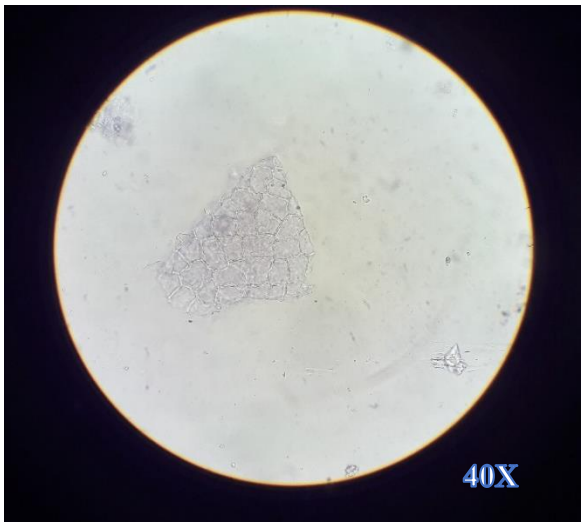
c)*Saccharum spontaneum* (Kaans)

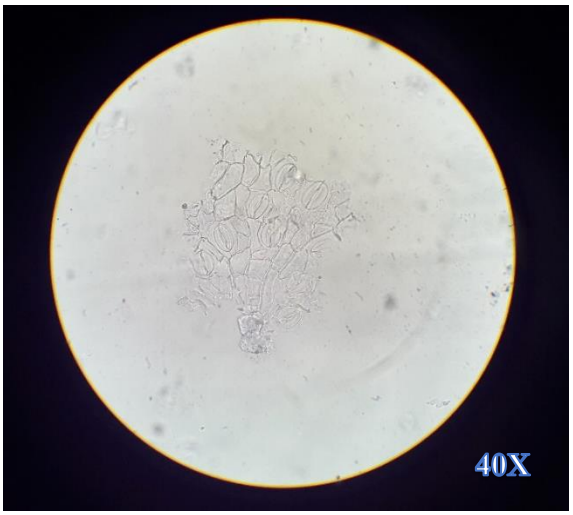
d)*Imperata cylindrica* (Siru)



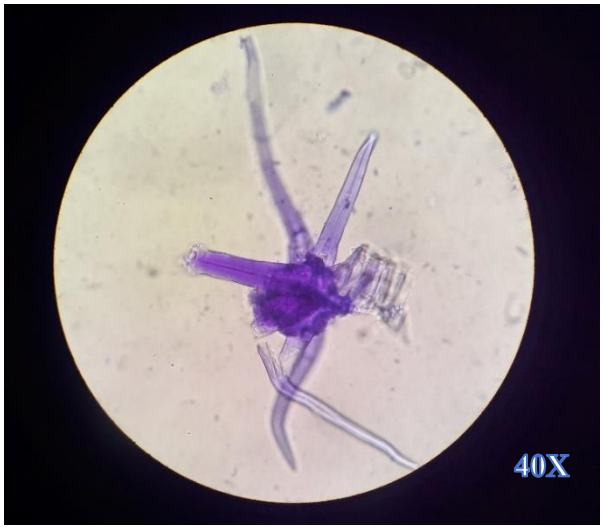


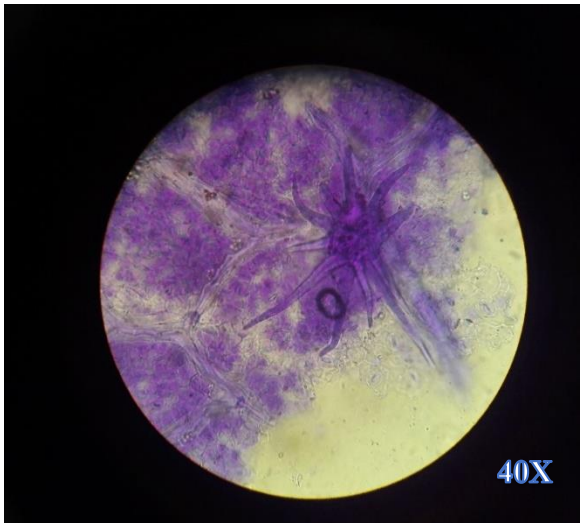
e) *Antidesma acuminatum* (Kalobelauni)



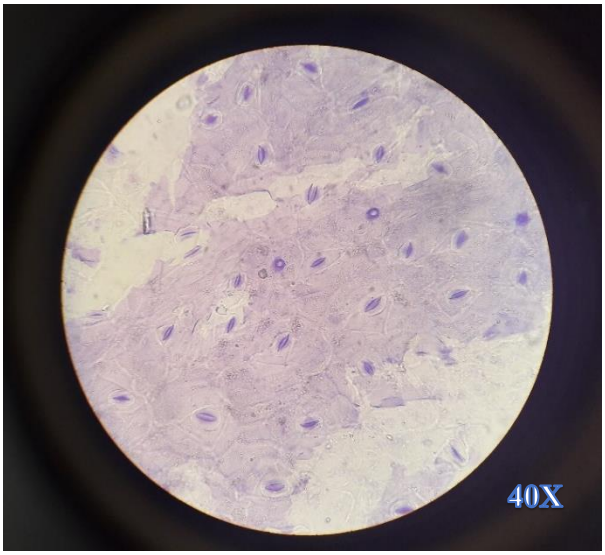


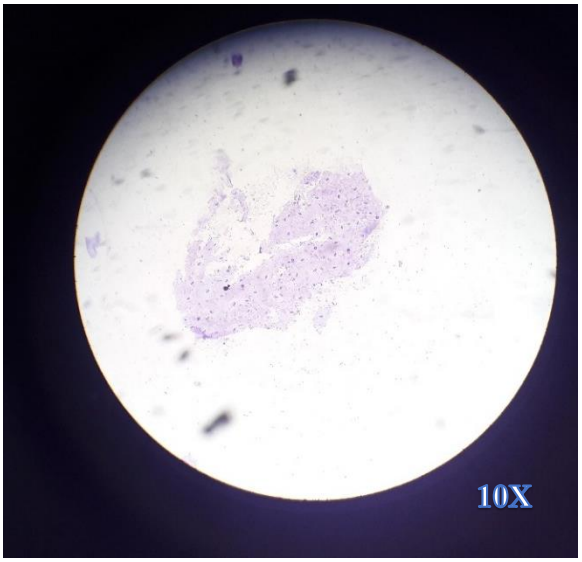
f) *Trewia nudiflora* (Bhellar)



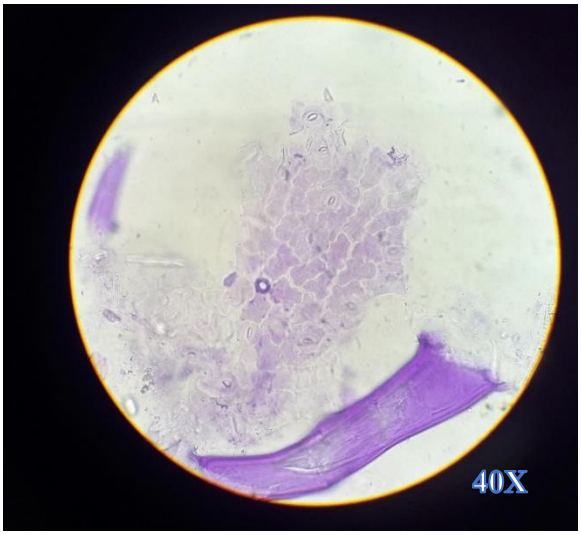


g) *Helicteres isora* (Simthi)





h) *Piper longum* (Pipla)



i) *Clerodendrum viscosum* (Bhati)

II) Photographs from study area

a) Chital foraging around Lamital

b) Group of Chital in Icharni Isand

c) Pellets of Chital

d) *Mikania* infested small tree

e) rassland smothered by *M. micrantha*

f) Data collection in riverine forest