BUTTERFLIES OF RATAPANI WILDLIFE SANCTUARY

Report

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FOREWORD

Dr. Dharmendra Verma
PCCF/Member Secretary,
MP State Biodiversity Board

It gives me immense pleasure to inform you that Ratapani Wildlife Sanctuary has organized its first Citizen Science-based Butterfly Survey with the support of Tinsa Ecological Foundation and Wild Warriors. The release of the technical report is the first scientific documentation of butterflies across four ranges of Ratapani Wildlife Sanctuary.

It is a gigantic task considering the vast geographical area of Ratapani, wide variations of habitats, and 100 participants from varying age groups from across the country. I congratulate Ratapani WLS team for all arrangements and support provided to the organizers. I congratulate Wild Warriors for organizing a smooth application process and team making. I congratulate Tinsa Ecological Foundation team members for reconnaissance surveys and designing the citizen science program into scientific documentation, identification of teams and trails, data compilation, and report writing.

The collaborative effort is the first of its kind in Madhya Pradesh and teams have done yeoman service in generating a vast wealth of data on the diversity and distribution of butterfly species across the Ratapani WLS. The data generated and ably analyzed in this report will be a handy tool in informed decision-making regarding management initiatives by Ratapani WLS.

In the years to come, I expect Ratapani WLS to collaborate and do the seasonal studies of the same and extend this model to other taxa for better documentation and management interventions. The entire team of Ratapani WLS, Tinsa Ecological Foundation, Wild Warriors, and participants deserves our congratulations and appreciation for this wonderful work.

I wish Good luck to the team in its future ventures.

Madhya Pradesh Forest Department

Bhopal, Madhya Pradesh

Dr. Sanjay Shukla
APCCF, IT Department

***Butterflies** are almost worldwide in their distribution and are highly sensitive indicators of the health of the environment and play vital roles in the food chain as well as being pollinators of plants. No living form is more beautiful and charismatic than butterflies. Their glowing vibrant colors and delicate flickering movements are a treat to watch. But, the number of these beautiful butterflies is dwindling with the ever-increasing use of pesticides and other chemicals in farming and allied activities. However, there are still islands of conservations in the form of protected areas-national parks and wildlife sanctuaries, where we still see a good wealth of butterfly diversity.*

Though butterflies are among the most known and loved insects, and the faunal list of Indian butterflies has been thoroughly worked on, not much is known about the biology and ecology of the majority of the butterfly species. In the protected areas of Madhya Pradesh which provide a home to a wide diversity of butterflies, there have not been many surveys done based on sound scientific protocols. The butterfly survey in Ratapani Wildlife Sanctuary is a nice initiative and was done following the sound scientific methodology. This survey would help in future conservation efforts of butterflies as baseline information. Mr Vijay Kumar, DFO Obedullahganj, and his team deserve all the appreciation for organizing the maiden butterfly survey so meticulously involving butterfly lovers from across the country.

This survey report will be of great help in strengthening and spreading scientific knowledge about the beautiful world of butterflies.

ACKNOWLEDGEMENT

We are thankful to the Shri. Ramesh Kumar Gupta (PCCF-HoFF), Shri. Alok Kumar (PCCF-WL, CWLW), Shri. Ravindra Saxena (CCF, Bhopal) of MP Forest Department for their unconditional support toward this citizen science initiative. We would like to extend our sincere gratitude to Dr. Dharmendra Verma, Member Secretary, MP State Biodiversity Board (MPSBB), Bhopal, for funding this first scientific study on Butterflies in the form of a Citizen Science Initiative in Ratapani Wildlife Sanctuary.

We are thankful to Mr. Vijay Kumar (DFO, Ratapani WLS), Mr. Pradeep Tripathi (SDO, Ratapani WLS), Mrs. Ruhi Haq (SDO, Singhori WLS), Mr. Pushpendra Singh Dhakad (SDO, Obedullahganj Territorial), Range Officers, and all field staff of Ratapani Wildlife Sanctuary for arrangement and support extended for participants and organizing team.

We are thankful to Mr. Aseem Srivastava, APCCF for joining the introductory session and motivating the participants. We are delighted to have Mr. K. Raman (APCCF), Mr. N.S Dungriyal (Retd. APCCF) and Mr. Shubh Ranjan Sen (APCCF) on field during the survey to motivate the participants. We are thankful to Mr. Ramnish Geer (JD, CBI) and Dr. Sanjay Shukla (APCCF) to join the teams on field and being part of concluding session.

We are thankful to all members of Tinsa Ecological Foundation and Wild Warriors who managed the whole process smoothly on ground. We are delighted to Ms. Pinal Patel (President) and Mr. Sameer Gautam (Vice-president) of Tinsa Ecological Foundation for the orientation and introduction to first scientific documentation using Citizen Science initiative.

We sincerely thank all forest guards and their daily-wages staff who stayed with the teams and welcomed the participants. We are thankful to all participants from 15 states who were involved in first scientific documentation and contributed to this gigantic work.

EXECUTIVE SUMMARY

Butterflies are a beautiful and intrinsically valuable part of the central Indian forest's rich biodiversity. They have been around for at least 50 million years, and have evolved to develop a highly diverse group of invertebrates. Butterflies are extremely sensitive indicators of the health of the environment and play crucial roles in the food chain as well as being pollinators of plants. They are the flagship species for conservation in the ecosystem. Conservation action is reliant on information about the distribution and abundance of butterflies. Monitoring their populations provide detailed insights into how insect populations are being impacted by land use and climate change.

The landscape of Ratapani Wildlife Sanctuary, Madhya Pradesh comprises different habitats with various plant communities, which makes it an ideal and pioneer area of the central Indian forest to study how the butterfly abundance may indicate the habitat conditions. The first butterfly survey of Ratapani Wildlife Sanctuary, Madhya Pradesh was organized from 10th to 12th September 2021. The survey was a collaborative effort of the M.P. Forest Department, TINSA Ecological Foundation (a Bhopal-based NGO), and Wild Warriors (an Indore-based NGO). The survey was designed using a scientific approach to identify and count butterflies in this area. The citizen science-driven monitoring was combined with the scientific data collection & statistical analysis method to generate scientifically sound and robust results, which can confidently put forth recommendations of conservation measures concerning forest variables.

The objectives of this butterfly survey were:

- *To establish baseline data of butterflies in Ratapani Wildlife Sanctuary.*
- *To create public awareness for butterflies and their ecological importance.*

The event commenced with the orientation of the participants by Ms. Pinal Patel, President (President), TINSA Ecological Foundation, Mr. Sameer Kumar (Vice-president), TINSA Ecological Foundation. Mr. Vijay Kumar, DFO, Obedullahganj, briefed the volunteers about the survey and their expectations from the survey in the Ratapani Wildlife Sanctuary. The chief guest for the day was Mr. Aseem Srivastava (APCCF) and Mr. K. Raman (APCCF), Mr. N.S Dungriyal (Retd. APCCF) and Mr. Shubha Ranjan Sen (APCCF).

The survey design was employed in the four ranges of the Ratapani Wildlife Sanctuary (Delawari, Barkheda, Bineka, and Dahod). Sampling units were various trails identified in the four ranges of the sanctuary. 74 trails were identified with the help of the forest ground staff and google earth imagery.

The final selection of the trails was based on the number of volunteers, accessibility of trails from camps, habitat types, and butterfly diversity at these trails during the pilot survey. These trails were then allocated to different volunteer groups (34 teams with 2-3 volunteers - an expert, a photographer, and an amateur in each team accompanied by forest staff) considering their level of expertise, fitness level, age, and accommodation available at camps. Each team had to cover a maximum of 3 and a minimum of 2 trails in two mornings and an evening. The KML file of the trails was provided to the teams in advance, which they followed on the Locus Map application on their mobile phones for navigation.

There are two main classes of data collected by monitoring programs: abundance and occupancy data. The butterfly sampling was done using the 'Pollard's walk', a type of transect walk primarily used for butterfly surveys, where the observers record butterflies within a 2.5-meter band on both sides of a transect and 5-meters ahead of the transect, while walking at a slow and steady pace. The observations were recorded in the datasheet provided which entailed the details of the butterfly species, their count, activity pattern, and remarks on the host plant species.

At the end of the survey, a checklist of 104 species of butterflies was obtained which had a few important records of species found in the study area, namely Crimson Rose, Plum Judy, Double-branded plum Judy, Common Short Silverline, Common Red flash, Vindhyan bob, Common treebrown, etc. Grass Jewel (size ranges from 15- 22 mm), the smallest butterfly was sighted in the survey. Data collected by volunteers from the Ratapani Wildlife Sanctuary was used to understand the community structure, composition, and diversity of butterflies.

Frequency indicates the number of trails in which a given species occurs and thus expresses the distribution or dispersion of various species in a community. 100 species were observed during the survey on these trails. The highest frequency of occurrence of butterflies in trails was found to be for Common Grass Yellow, Common Emigrant, Lemon Pansy, and Baronet. Results of the density of the butterflies indicated that the Common Grass Yellow was found to be the most densely occurring butterfly species in the Ratapani Sanctuary followed by Zebra Blue, Small Grass Yellow, Common Emigrant, Common Lime, and Tawny Coster. Abundance analysis indicated that Common Grass Yellow was found to be the most abundant species followed by Small Grass Yellow, Zebra Blue, Three-spot Grass Yellow, and Spotless Grass Yellow. The results suggest that Common Grass Yellow was the most dominant species found during the survey.

Species richness at 74 trails, 25 campsites, and at the 4 ranges helped understand the butterfly diversity pattern at different spatial scales. At the range level, the highest observed butterfly species richness was found at Bineka (79) and Dahod (75). Further, to find the true number of butterfly species from the study area, species richness estimators were used to determine the estimated species richness, e.g., the Bootstrap estimator depicts the species richness of butterflies to be 109.729 in the Ratapani Wildlife Sanctuary.

Butterfly species diversity was calculated using Simpson 1-D index, Shannon Index, and Evenness indices. The results suggest that Barkheda is the most diverse campsite and range. During the survey, 15636 individuals of butterflies were observed belonging to 100 species and 6 families of butterflies. The results suggest that the butterfly's diversity at Ratapani Sanctuary is good but the distribution among species is not even. The butterfly relative abundance curve for the total study area shows that the population follows a lognormal distribution at Ratapani Wildlife Sanctuary, indicating few species are common and rare, and the rest of the species are moderate in number. The butterfly population at Ratapani was found to be dominated by a small number of species. This suggests that seasonal monitoring and timely conservation efforts can prevent the extinction of rare species in Ratapani Wildlife Sanctuary. The survey has established baseline data for butterfly diversity at Ratapani Sanctuary, which will be used in the future to understand the change in butterfly population with the advent of climate change, habitat loss, anthropogenic pressure, and other driving forces.

The survey concluded with certificate distribution and keynotes from the chief guests, Dr. Sanjay Shukla (APCCF), Mr. K. Raman (APCCF), and Mr. Ramnish Geer (Joint Director, CBI), and a vote of thanks by the DFO, Mr. Vijay Kumar. The takeaway from this survey was not limited to the preparation of checklists and mass awareness and sensitization. In the bigger picture, it also provided a prototype for improved citizen science programs in wildlife and biodiversity, where properly citizen scientists can produce a large amount of scientifically sound data in a very short period, which can be utilized for the conservation and protection of forests.

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1 INTRODUCTION

Central India is associated with a rocky plateau covered by various forest types, grasslands, wetlands, and rivers manifesting functional ecosystems to support rich biodiversity. Insects have their dynamic role in the ecosystem at different trophic levels from producers to carnivores (pollination to decomposition).

The butterflies are one of the most visible and functional species in the ecosystem (Larson et al. 2001). Butterflies belong to Lepidoptera or scaly-winged insects (lepidos = scales and pteron = wings in Greek). Butterflies have fine scales on their wings that look like fine powder. These scales are colored and result in giving striking colors and patterns to many butterflies while providing cryptic colors and camouflage patterns to others. When touched by humans, the wings tend to lose some scales. If too many scales are lost, the butterfly's ability to fly will be impaired. The scales on the butterfly wings have many properties, mostly optical, that interest scientist. The patterns they make are also seen as the best animal system for understanding the developmental and genetic processes that produce morphological variation in nature. Butterflies have been used as model organisms for a variety of fields of study, spanning ecology, evolutionary biology, and conservation biology (Boggs et al. 2003).

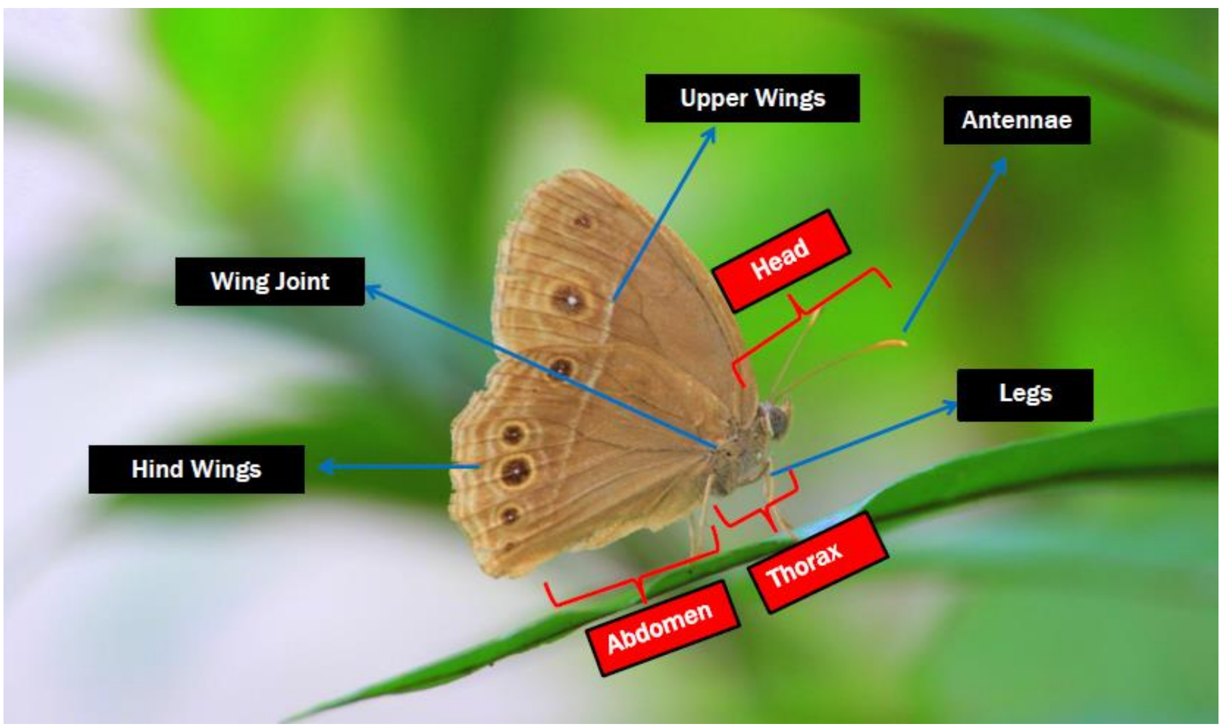


Figure 1-1: Structure of a butterfly

1.1 LEPIDOPTERA ORDER

Lepidoptera order contains over 100 families of insects worldwide, some of which are moths and some of which are butterflies. However, there are some differences in physical and behavioral characteristics that are easy to learn and recognize.

The most obvious difference is in the feelers or antennae. Most butterflies have thin slender filamentous antennae which are club-shaped at the end. Moths, on the other hand, often have comb-like or feathery antennae, or filamentous and un-clubbed. This distinction is the basis for the earliest taxonomic divisions in the Lepidoptera, separating them into the following two groups: The Rhopalocera – 'clubbed horn' (Butterflies) & the Heterocera - 'varied horn' (moths).

Most moth caterpillars spin a cocoon made of silk within which they metamorphose into the pupal stage. Most butterfly caterpillars, on the other hand, form an exposed pupa, also termed as chrysalis. There are many exceptions to this rule, however. For example, the Hawkmoths form an exposed chrysalis which is underground. Gypsy moths sometimes form butterfly-style pupae, hanging on twigs or tree bark, although usually, they create flimsy cocoons out of silk strands and a few leaves, partially exposing the chrysalis. A few Skipper butterfly larvae also make crude cocoons in which they pupate, exposing the pupa a bit. The Parnassius butterfly larvae make a flimsy cocoon for pupation and they pupate near the ground surface between debris.

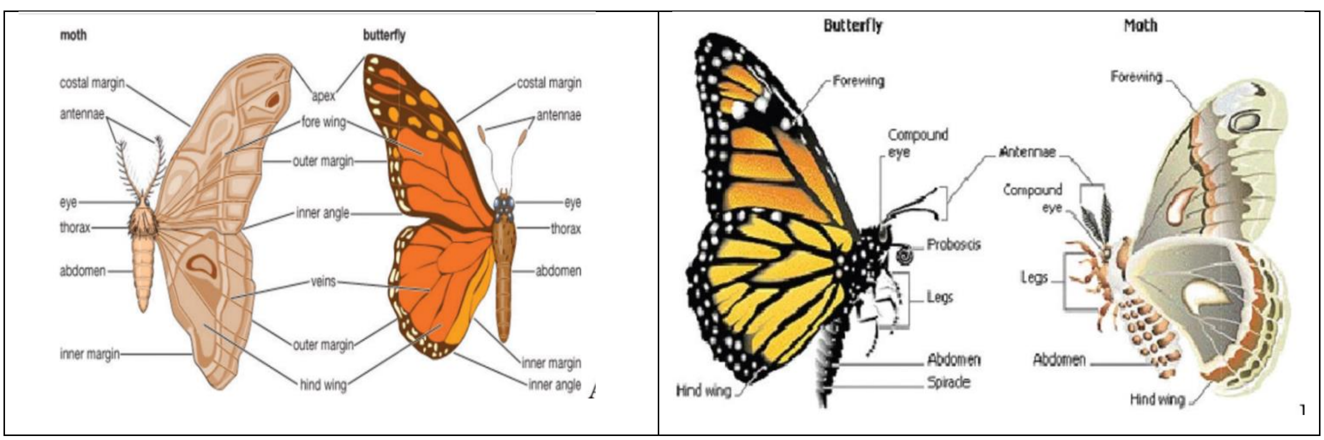


Figure 1-2: Body differentiation in Butterfly and Moths (Source: Parveen, F.K., 2017)

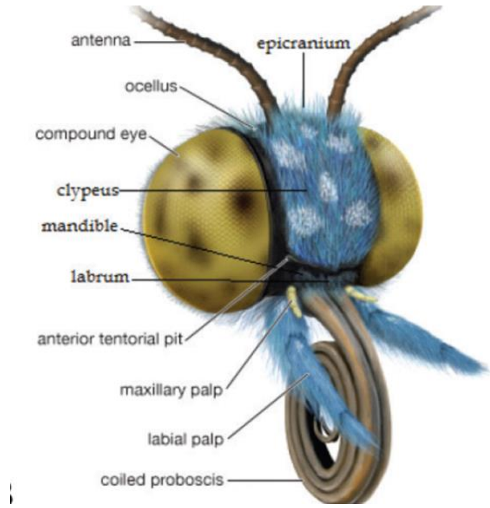


Figure 1-3: Generalise Mouthparts (Source: Parveen, F.K., 2017)

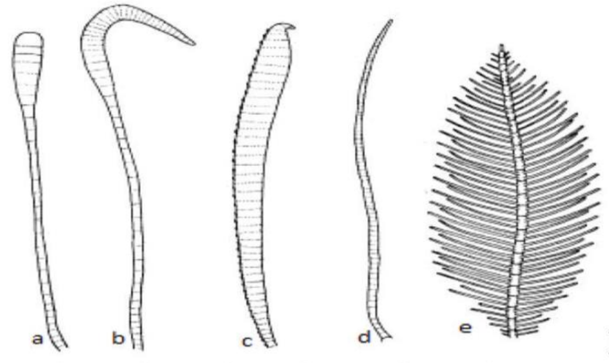


Figure 1-4: Generalize antennae of order Lepidoptera: butterflies; (a) skippers; (b) micro-and macro-moths (c, d, e) (Source: Parveen, F.K., 2017)

Figure 1-5: Compound eye of Lepidoptera. (Source: Parveen, F.K., 2017)

1.2 LIFE CYCLE OF BUTTERFLIES

The major lifecycle of butterflies varies from a few weeks to months. Over time, they perform one of the best ecological services i.e. pollination. The life cycle stages are as follows:

Egg: The egg stage usually lasts 3-7 days but this can vary quite a bit among different species of butterflies. Some species overwinter as eggs and undergo diapause to survive the many months of winter.

Caterpillar: A very tiny caterpillar hatches from the egg. The first meal for most caterpillars is the eggshell. The caterpillar is designed to be an "eating machine" and before it begins to pupate, it will increase its body mass thousands of times. Butterflies have five instars or five different stages between the hatching from the egg and the time of pupation. The number of instars varies between butterfly species. The total time that the butterfly stays in the caterpillar stage is about 2-5 weeks and varies based on the species and the growing conditions. It is believed that the caterpillar stage is the most dangerous in the life cycle of a butterfly as the mortality rates are very high. Caterpillars are subject to weather conditions, disease, parasites, and predators. Many adult butterfly species lay hundreds of eggs with only a few surviving to become adults.

Pupa: When the caterpillar is full-grown and stops eating, it becomes a pupa. The pupa of butterflies is also called a chrysalis. Depending on the species, the pupa may be suspended under a branch, hidden in leaves, or buried underground. The pupa of many moths is protected inside a cocoon of silk. This stage can last from a few weeks, a month, or even longer. It may look like nothing is going on but big changes are happening inside. Special cells that were present in the larva are now growing rapidly.

Adult: The fourth and final stage of the life cycle is the adult. Once the chrysalis casing splits, the butterfly emerges. It will eventually mate and lay eggs to begin the cycle all over again. Most adult butterflies will live only a week or two, while a few species may live as long as 18 months.

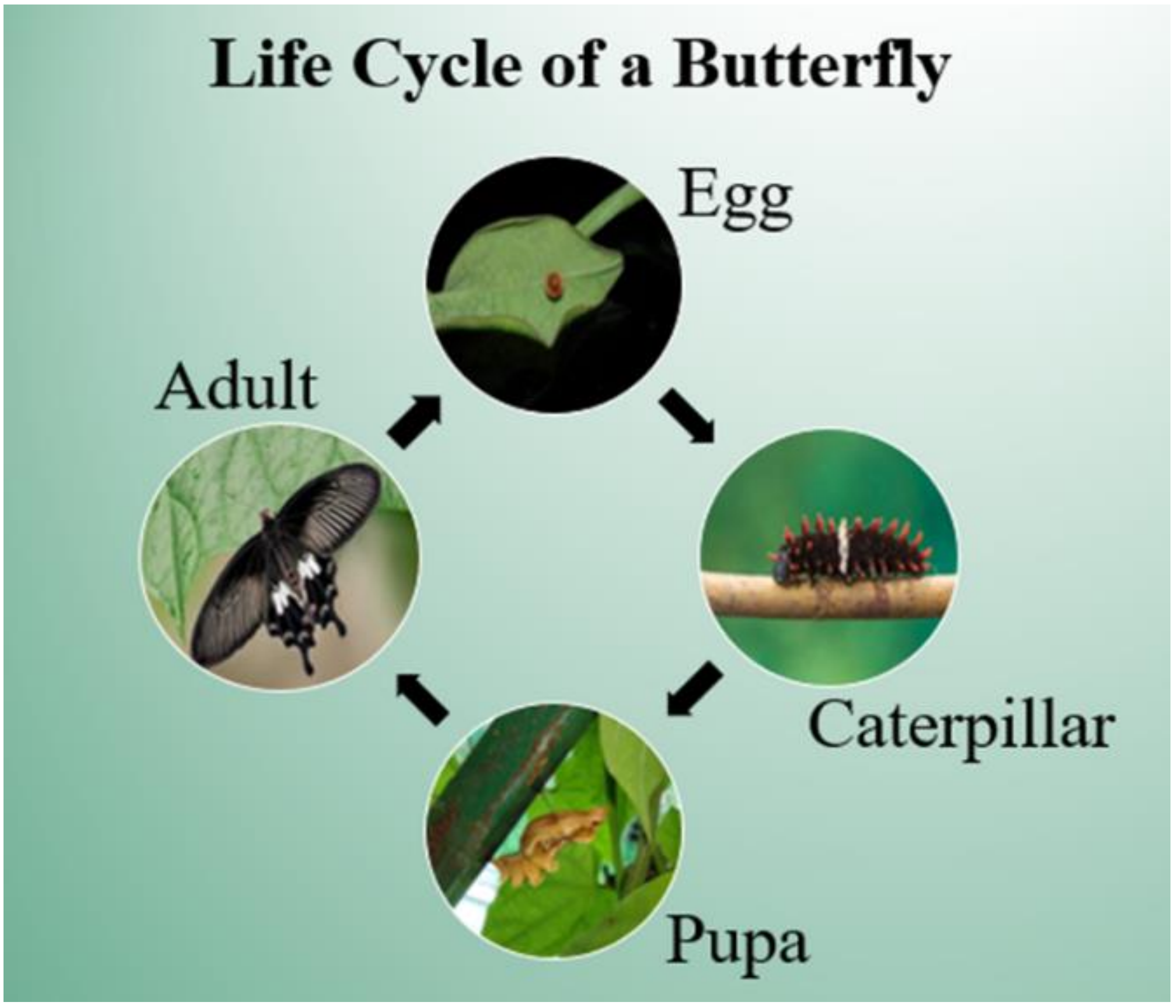


Figure 1-6: Life cycle of butterflies

1.3 HOST AND NECTAR PLANTS

Host plant: Host plants are plants that adult butterflies depend upon to raise their larval young. Female butterflies lay their eggs directly onto their host plant of choice since caterpillars cannot travel far to feed. This include trees, shrubs, herbs, climbers, and grasses. Trees like *Bauhinia racemosa, Albizia lebbeck, Aegle marmelos, Butea monosperma, and Peltophorum pterocarpum; and* shrubs like *Caesalpinia pulcherrima, Calotropis gigantea,* and *Calotropis procera,* were found frequent during the survey. The important herbs like *Barleria cristata, Mimosa pudica, Hygrophila auriculata,* and *Senna tora* act as host and nectar plants for butterflies.

Nectar Plants: A constant supply of nectar is vital to reduce the waning of native butterfly populations, and so it's important to try and deliver a range of plants that will have at least some viable nectar-producing flowers throughout the year. Wild plants like *Ocimum americanum, Boerhavia diffusa, Desmodium triflorum, Euphorbia hirta, Malvastrum coromandelianum, Melochia corchorifolia, Ludwigia adscendens, Sesamum indicum, Sesamum radiatum, Sida cordifolia, Tridax procumbens, Triumfetta rhomboidea, and Urena lobata, are important sources of nectar.*

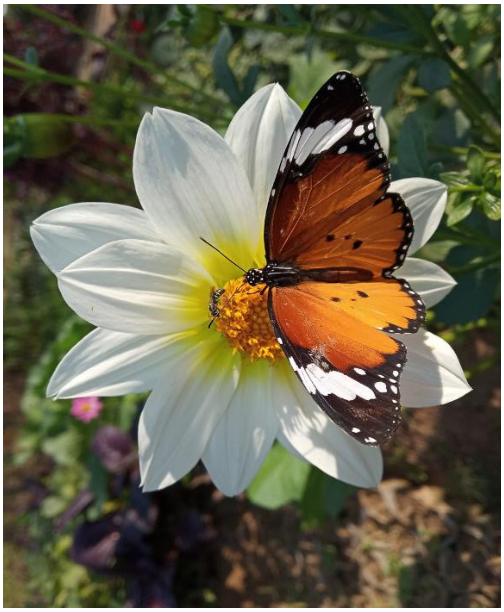


Figure 1-7: Egg and caterpillar of lime butterfly on *Limonia acidissima* and a Plain tiger taking nectar

1.4 CLASSIFICATION OF BUTTERFLIES

Butterflies are classified into two superfamilies, Hesperioidea, consisting of the 'skippers,' and Papilionoidea, or 'true butterflies.' Skippers differ in several important ways from the remaining butterflies. Skippers have the antennae clubs hooked backward, have stocky bodies, and possess stronger wing muscles and better eyes. However, Hesperioidea and Papilionoidea are considered sister taxa. Modern taxonomists place them all in the superfamily Papilionoidea (Fig 1), distinguishing the skippers from the other butterflies at the series level only.

There are about 180,000 described species of Lepidoptera, around 10% of all described species of living organisms. In butterflies (Papilionidae), there are about 17,500 described species, or 1% of known organisms (Vane-Wright, 2003). In India, there are about 1646 species of butterflies recorded (Sharma, N et al., 2020). Total of 153 species of butterflies were reported from Madhya Pradesh (Chandra et, al. 2007).

The previous research works on butterflies were carried out in the state of Madhya Pradesh by Forsyth, 1884; Bentham, 1890; Witt, 1909; Singh, 1977; Gupta & Shukla, 1987; Chaudhary, 1995; Siddiqui & Singh, 2004, and Chandra et, al. 2007.

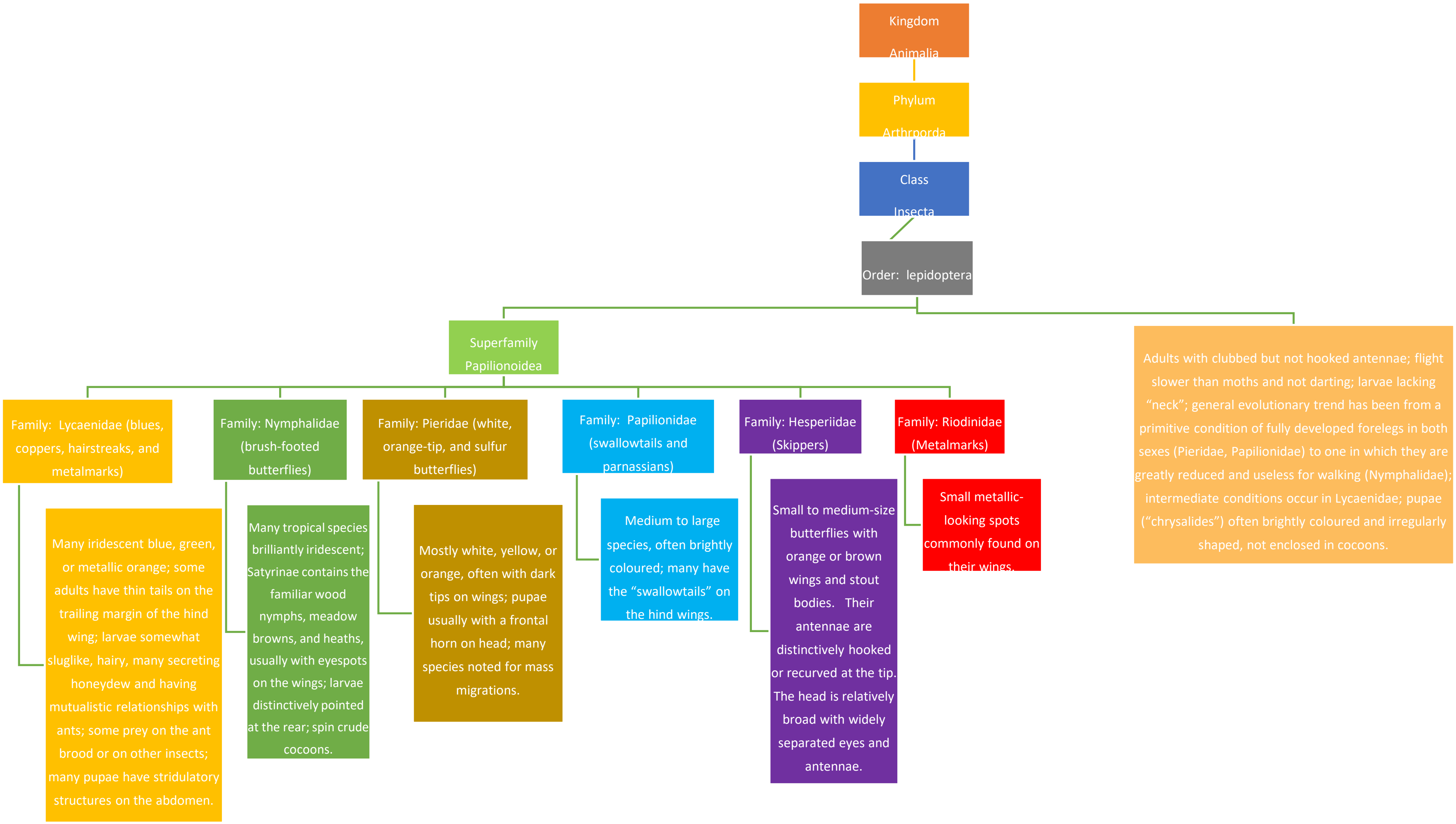


Figure 1-8: Modern classification of butterflies (Source of information: https://www.britannica.com/animal/lepidopteran/Classification)

1.5 ROLE OF BUTTERFLIES

Butterflies feed on sugar-rich nectar produced by flowers, succulent interior parts of ripe fruits, and tree sap. They utilize olfactory senses to detect their desired plant and cover wide distances just to reach it. When they are searching for food, butterflies prefer big, colorful flowers that have a landing platform. As they get to such a flower, they gather pollen on their thin, long legs as they siphon nectar with their long tube-like tongues. According to FAO (www.fao.org) nearly 90 percent of all plants need various animal pollinator to reproduce, the role of the butterfly becomes even more vital. Without these wonderful insects, many plant species would then be unable to reproduce and their populations would dramatically decrease without the butterfly's presence. This loss of plant life would affect both animals and humans. Butterflies also act as a lower member of the food chain. Butterflies provide food for number of animals such as birds, reptiles, amphibians etc. and caterpillars provide an occasional meal for spiders and ants. Eggs of some flies and wasps live as parasites inside catterpillar's body and feed on it. If populations of butterfly diminish, then population of birds, small reptiles, and other animals that rely on them as food source will also reduce. This loss will collapse the entire ecosystem. This loss of the butterfly is the beginning of the "butterfly effect." It will continue to affect the entire ecosystem, working its way up the trophic levels. Nearly two-thirds of all invertebrates can be connected back to the butterfly on the food chain (Webb, K. J, 2008). The loss of this seemingly insignificant insect could, potentially, breakdown entire ecosystems the at rely so heavily on them.

a) **Pollination:** Pollination is the process in which pollens are transferred from male parts of flower to female parts of flower and reproduce sexually even over large areas. Nectar produced from flower contains nutritious vitamins, lipids, sugar, amino acid etc. which is important food source for pollinators (Baker, H. G & Baker. I, 1973). Butterflies are also pollinators and visit the flower to eat nectar, tiny scales on the butterfly bodies brush against anthers and pollen adhere to scales. When the butterfly visits to another flower, the pollen which are attached to its scales brush into the flower's stigma.

b) **Predators:** Some butterfly larvae feed on harmful insect, for example the Hoverfly larvae. As caterpillars are predators of aphids, so they are also used as biological pest control.

c) **Genetic Variation in Plant Species:** Some butterfly species migrate over long distance and share pollens across plants which are far away from one another. This helps plants to recover against disease and gives them a better chance at survival.

d) **Intrinsic value:** Butterflies form one of the highly diverse group of insects comprising of over 18,000 species. They are known to be evolved probably around 150 million years ago. They add to the diversity of life forms on the earth and hold an intrinsic value in terms of biodiversity richness.

e) **Aesthetic value**: Butterflies are part of our natural heritage and have been studied for centuries. There are many references to butterflies and moths in literature, from the Bible through Shakespeare to modern-day literature, and from poetry to musical lyrics and folklores. Butterflies are used by advertisers and illustrators the world over as a way of indicating that something is environmentally friendly. They are often portrayed as the essence of nature or as representing freedom, beauty, or peace.

f) **Educational value:** The fascinating life cycles of butterflies are taught across the world to understand the natural world. The transformation from egg to caterpillar to chrysalis is one of the wonders of nature. Other educational aspects include the intricate wing patterns and iridescence, and as examples of insect migration.

g) **Scientific value:** Butterflies are an extremely important group of 'model' organisms used for centuries to investigate many areas of biological research, including such diverse fields as navigation, pest control, embryology, mimicry, evolution, genetics, population dynamics, and biodiversity conservation. They have proved extremely important for scientific research on climate change owing to their long history and the fact that they serve as a unique data resource on an insect group unmatched in geographical scale and timescale anywhere in the world.

h) **Ecological value:** Butterflies are bio-indicators of a healthy environment and healthy ecosystems. These collectively provide a wide range of environmental benefits, including pollination and natural pest control. They are an important element of the food chain and are prey for birds, bats, and other insectivorous animals. Butterflies also support a range of other predators and parasites, many of which are specific to individual species, or groups of species. They have been widely used by ecologists as model organisms to study the impact of habitat loss and fragmentation and climate change.

i) **Health value:** People enjoy seeing butterflies both around their homes and in the countryside. People engage in volunteering activities where they walk long distances while counting butterflies.

j) **Economic value:** Ecotourism is driven by the diversity of butterflies. Nature enthusiasts travel abroad each year looking for butterflies. Eco-tours bring valuable income to many European countries and developing countries around the world (e.g., the valley of the butterflies in Rhodes and the Monarch roost in Mexico). Chemicals secreted by butterflies for various purposes such as to deter predators and parasites, find a mate, and overcome the chemical defenses of its host plant. Each of these chemicals has a potential value and could be exploited economically.

1.6 THREATS TO BUTTERFLY POPULATIONS

Habitat change and loss as well as climate change are the biggest threats to butterflies today. These delicate insects are incredibly sensitive to climate change and habitat loss and require ideal conditions for their eggs to mature. This sensitivity, though useful for monitoring the health of our ecosystems, is a downfall for the survival of many butterfly species. An abundance of butterflies indicates a healthy ecosystem, but if there is a subtle change in the environment, it can trigger an extreme drop in the butterfly population. While climate change has caused a significant amount of damage to butterfly populations, other human actions are also implicated in the butterfly's decline. There are other threats for butterflies including invasive plants, forest fire and over grazing. The systematic study and public awareness about butterflies is very important for their conservation.

a) Impacts of pesticides

The distribution and abundance of butterflies' decline due to the habitat destruction. The use of pesticides on arable crops has profound harmful effects on farmland wildlife but its impact on butterflies is unknown. The use of insecticides has little evidence for the reduction in numbers. The use of Herbicides with chemical fertilizers and drainage reduce the butterfly number indirectly by changing the unimproved grassland in to improved pasture. Thomas, C. D & Harrison. S, 1992 explained that mostly butterfly rich farmland habitat is unimproved grassland. So, herbicides reduce the butterfly population.

b) Impact of Haze and SO^2

The smoke released from agricultural residue fires and other types of landscape burning includes trace gases such as CO2, CO, NH3, CH4, SO2, NOx (Radojevic, 2003; Ding et al., 2013) but it is the fine PM2.5 particles of black carbon and organic carbon that pose the most serious risk to air quality. Such fine particles dominate the aerosols present in vegetation fire smoke and when emitted in large quantities by very large fires they can dramatically increase the extent and severity of regional haze and smog episodes. In humans these fine particles can enter the respiratory system in sufficient numbers to cause serious morbidity and even mortality with consequential economic impacts on healthcare and tourism. However, few studies have examined the consequences of such pollution for other animal species. A few have indicated effects on insect development and population dynamics for example, impairing the development of insect larvae, was as shown by Tan et al. 2018. Observations of smoke haze prolonging development time and decreasing pupal weight of *Bicyclus anynana* (squinting bush brown butterfly). Even the smoke caused the decline of five butterfly species (Lepidoptera: Rhopalocera). However, the impact of smoke on insect flight behaviour has rarely been considered, despite flight performance largely determining dispersal capacity, which then profoundly influences metapopulation dynamics and ultimately population viability, species persistence, gene flow, and processes of natural selection. Increasing our understanding of insect flight performance in smoke-contaminated air may ultimately aid elucidate whether the air pollution associated with these fires might affect insect migration.

c) Impact of varying climate and temperature regimes

Climate change is expected to increase environmental variation in addition to shifting mean environmental conditions. This variation, both within and across generations, drives fluctuations in selection which can slow evolution in response to directional environmental change. This effect is complicated by fitness integrating environmental responses at multiple timescales. Habitat destruction and climate change are the main drivers of the global biodiversity crisis (Schweiger et.al, 2008). Climatic conditions have considerably changed all over the world, such changes of climatic conditions modify species community compositions, impacts species interactions, and shape species' distribution ranges, with shifts towards higher altitudes and latitudes. Effects from climate change on biodiversity are particularly visible in mountain regions, where species often occupy specific climatic niches, frequently combined with high ecological specialisation, hence making them highly sensitive to environmental changes. Most of these species are highly specialized on specific hostplants and to abiotic conditions (e.g. climatic niche); in addition, they are adapted in their evolution to interact with the phenologies of other taxa. Thus, marginal changes of abiotic and biotic conditions can disturb and interrupt inter-specific interactions. Butterflies are particularly sensitive to environmental changes, such as climatic shifts, because many representatives of this group of species are strictly adapted to certain environmental conditions, and their development depends on certain larval food plants and specific microhabitat structures. Therefore, this group is an ideal study system to investigate recent changes due to climate change. Species respond very differently to changes in their environment depending on their niche breadths. Studies have shown that species with a broad ecological amplitude can cope significantly better to rapidly occurring environmental changes. In contrast, specialized species that require very specific resources such as habitat structures, a specific climatic niche, or the presence of a particular larval food plant, may be much more negatively affected by environmental changes. Dispersal behaviour also plays a central role: Species with a high degree of mobility can respond much better to environmental changes such as habitat degradation and fragmentation or shifts in climate than species with a low propensity to dispersal, which usually remain in one habitat for many generations. To analyse species' specific responses on climate change, long-term observations in combination with detailed knowledge on species' ecology, behaviour and life-history are necessary. Most butterflies are taxonomically and ecologically well understood if compared with other invertebrates, and thus provide an excellent model system to analyse potential climate change effects.

1.7 CONSERVATION THROUGH CITIZEN SCIENCE MODEL

Citizen science events can be very effective in order to spread conservation importance of targeted species. The conservation of efforts must be encouraged and supported by citizens to make conservation plans. This new discipline is changing the scientific landscape for both the scientific community and the greater public. It can be classified into one of three types:

(1) Contributive, where citizens gather data.

(2) Collaborative, where citizens may also analyse or interpret this data.

(3) Co-create, where citizens participate in all levels of a project, from designing the research question to analysing data.

Contributive and collaborative science allows experiments, explorations, or inquiries to run on a large-scale, ongoing basis, which provides large and diverse data sets for research that might take place over long period. With citizen science participation, the large-scale volunteer efforts of citizen scientists allow rapid scaling for relatively little capital. Additionally, it provides opportunity for two-way engagement between the public and scientists, which can lead to increased topical literacy in participants.

There have been various efforts to conserve the butterfly population globally. Some of the major initiatives for the conservation of butterflies globally are discussed here. Cascades butterfly Project, USA is a long-term monitoring program where citizen scientists (volunteers) and National Park Service Biologists monitor subalpine butterflies and plant phenology. Similarly, Carolina Butterfly Society emphasizes on identifying and watching butterflies both in the field and garden. They organise butterflying field trips to the various biogeographic regions of the Carolina. North American Butterfly Monitoring Network's Pollard Base database (NABA) program was started by the Xerces Society in 1975, and patterned after the Audubon Society's Christmas Bird Counts. It was taken over by NABA in 1992 where it grew rapidly. NABA manages three independent monitoring programs. This includes the Seasonal Count Program, the largest volunteer-based butterfly monitoring program in existence, covering all the US, parts of Canada, and even some limited sites in Mexico. It is also the program with standardized survey protocols that has been running the longest.

U.K. Butterfly Monitoring Scheme (UKBMS) is one of the longest running insect monitoring schemes in the world. The scheme began in 1976 and now records data on over 2,000 sites per year; incorporating butterfly transects, the Wider Countryside Butterfly Survey (WCBS), and timed-counts. The resulting UKBMS dataset is one of the most important resources for understanding changes in insect populations. The Big Butterfly Count (BBC), UK is one such project, with 100,000 participants in 2018 and over 296,793 since it began in 2010.

1.8 NEED OF BUTTERFLY SURVEY AT RATAPANI WILDLIFE SURVEY

Ratapani wildlife sanctuary comprises of different habitats with various plant communities. The forest is dominated by *Tectona grandis* with common associate tree species like *Aegle marmelos, Diasporus melanoxylon, Lagerstroemia parviflora, Albizia lebbeck, Albizia procera, Terminalia elliptica, Butea monosperma,* and *Cassia fistula*. These tree species are contributing for host and nectar for butterflies. There are various herbs such as *Abutilon indicum, Sida acuta, Sida cordifolia, Senna tora, crotalaria retusa, Sesamum indicum, Verbesina encelioides* and *Tridex procumbens* which assist butterflies' population.

Butterflies are the important biotic component of the ecosystem, as they are important pollinators and visibly attractive. The ecological role of butterflies in an ecosystem is not only as herbivores, but they can also be used to monitor environmental conditions (Beccaloni & Gaston, 1995). Change in butterfly abundance may indicate change in habitat conditions. The diversity of butterfly can be the indicator of rich plant diversity as butterflies are host specific and the high diversity of plants supports organism at different trophic levels. Significant diversity and population of butterflies can be savior of habitats for mega herbivores to top predators.

1.9 OBJECTIVES OF THE SURVEY

The butterfly survey was one of the attempts of its kind. The objective was:

- To establish baseline data of butterflies in Ratapani Wildlife Sanctuary.
- To create public awareness for butterflies and their ecological importance.

2 STUDY AREA

Madhya Pradesh is the second-largest state of the country having a geographical area of 3, 08,245 sq km which constitutes 9.4 % of the country's geographical area. The diverse and rich biodiversity of this central Indian state can be allocated to its strategic position in the subcontinent. It is present in the genetic highway connecting the Western Ghats and North–East India, two of biodiversity hotspots of India. It has the largest forest area of 94,689.38 sq. km^2 in the country. Total forest and tree cover in MP is 85,487 sq. km (total forest cover 77,414 sq. km) which constitutes 27.73% of the state's geographical area (India State of forest report, 2017). The forest can be classified as reserved forest 65.36 percent (61,886 sq. km), protected forest 32.84 per cent (31,098 sq. km) and unclassified forest 1.7 percent (1,704 sq. km) of the total forest area (MP forest website). Distribution of total forest in the state is as follows: 6,563 km² is the very dense forest, 34,551 km² is the moderately dense forest, and 35,889 km² is an open forest, 6,222 km² is Scrub and 2,24,328 km² is non-forest (India State of Forest Report, 2017). Majority of these forest patches are small and fragmented. As per India State of Forest report, 2017, there are 48,950 patches of less than 1 sq. km, 1,387 patches of 1-10 sq. km, 260 patches of 10-100 sq. km and only 115 patches having area more than 100 sq. km.

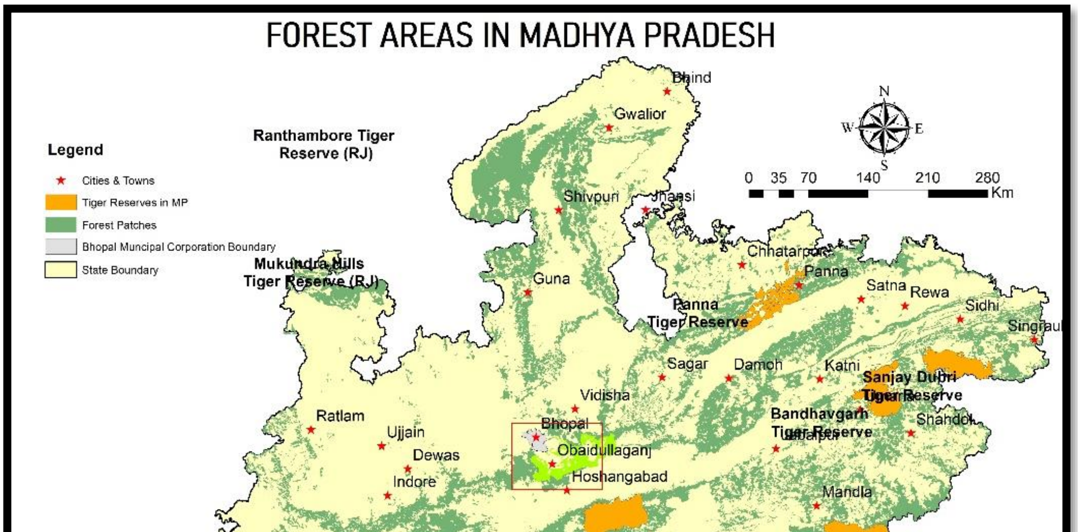


Figure 2-1: Forest patches of Madhya Pradesh

These forest patches are divided into 16 territorial forest circles, 9 National Parks, and 25 wildlife sanctuaries. Ratapani Wildlife Sanctuary is part of Obedullahganj Division of Raisen which is part of Bhopal Forest Circle. Bhopal Forest Circle of Madhya Pradesh includes 6 forest divisions (FD) i.e. Bhopal, Sehore, Raisen, Obedullahganj, Vidhisa & Rajgarh. The adjoining forest divisions of Ratapani WLS includes Sehore FD on western side, Raisen FD on eastern & Northern side and Bhopal FD on North-western side. The Bhopal Forest Circle (BFC) consists of tropical dry deciduous forests. BFC has a total forest area of about 6906.93 Km^2. Out of which reserved forest is 4076.72 Km^2, the protected forest is 2761.98 Km^{2,} and the unclassified forest is 68.23 Km^2 (MP forest website).

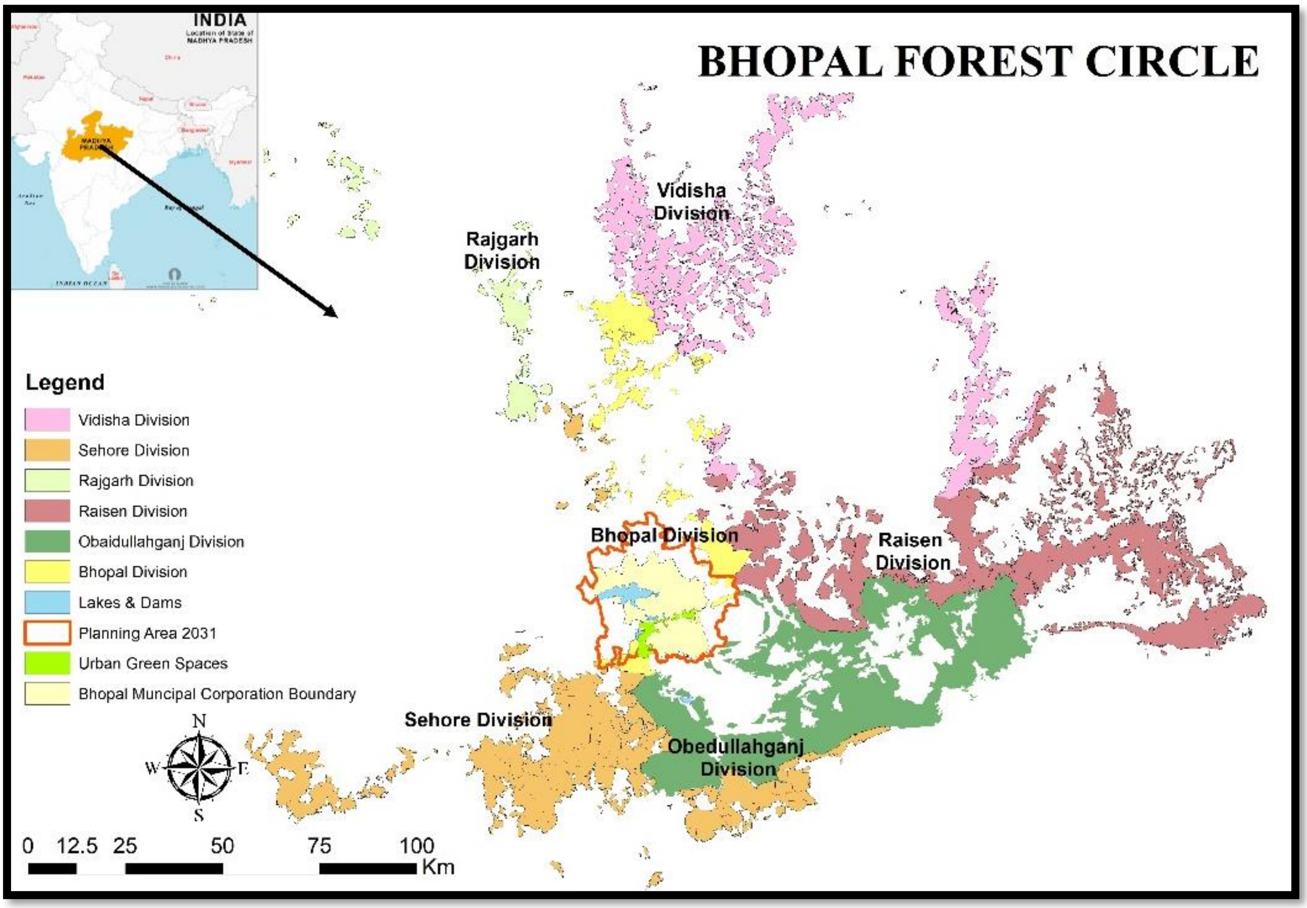


Figure 2-2: Map of Bhopal Forest Circle

2.1 ESTABLISHMENT AND LOCATION OF RATAPANI WLS

Ratapani Wildlife Sanctuary, is proposed for Madhya Pradesh's seventh Tiger Reserve since last 11 years. RWLS is located in Raisen District of Madhya Pradesh on the Vindhyan Ranges. It was designated as Wildlife Sanctuary in 1976 and later, extended in 1983 under Wildlife Protection Act, 1972. The sanctuary is extended in 825.90 sq. km of the area. The sanctuary is 70Km long and 15 km wide running parallel to the northern side of Narmada River. The RWS is part of Kheoni-Ratapani-Sighori Landscape. *Kolar* River forms the western boundary of sanctuary. Major parts of the sanctuary comprise of Vindhyan hill ranges spreading East-west. The Sanctuary situated at the distance of 45 km from the state capital Bhopal.

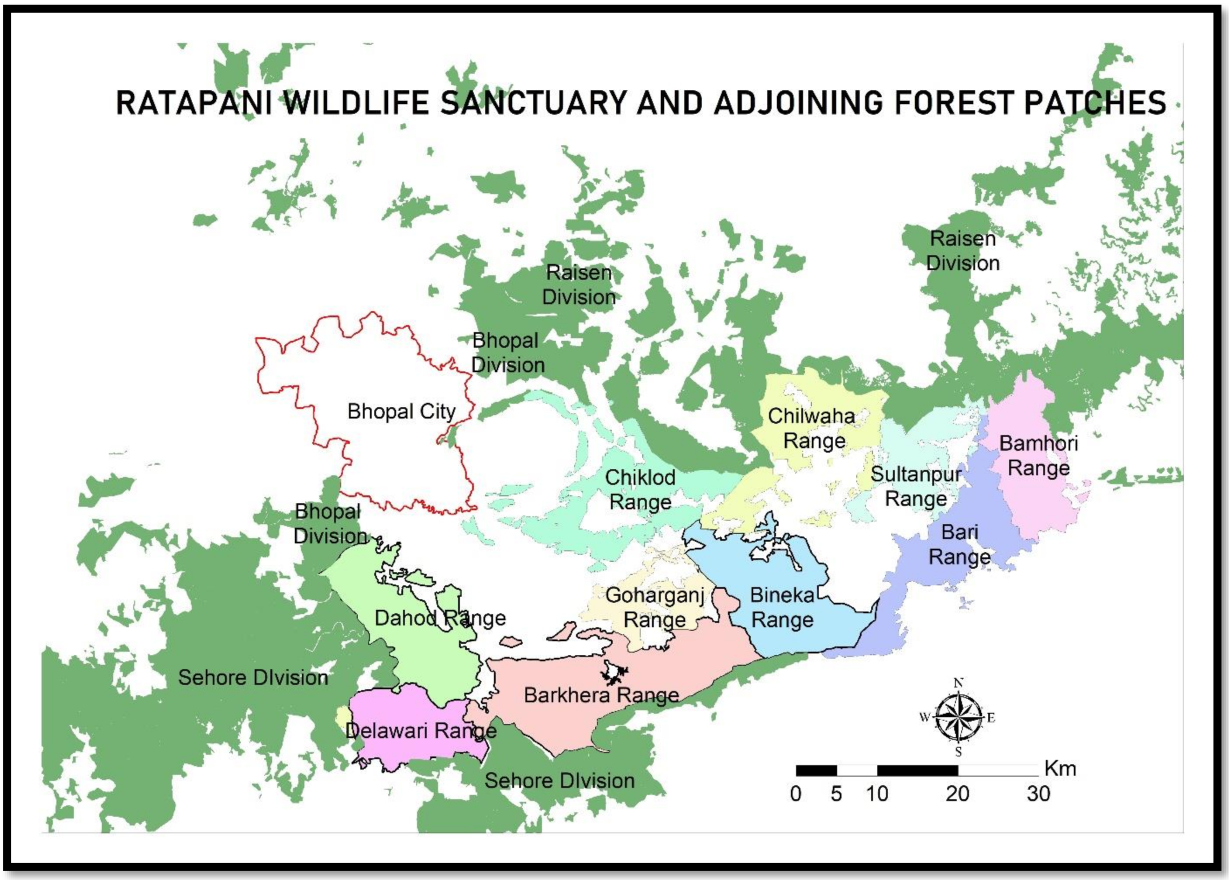


Figure 2-3: Ratapani WLS and adjoining Forest Patches

Administratively Ratapani WLS is part of Obedullaganj Forest division and includes four ranges-Dahod range, Delawari Rage, Barkheda Range and Bineka Range within Ratapani WLS. (Figure 2-3). Barkheda is the largest range among the ranges of Ratapani Sanctuary (Table 2-1).

Table 2-1: Range-wise area (in Hectares) under reserve and protected forest at Ratapani WLS

Range	Reserve Forest	Protected Forest	Total (Ha)
Dahod	799.2	15005.6	15804.8
Bineka	19003.003	1145.549	20148.55
Barkheda	13166.664	15987.695	29154.36
Baadi (part)	3804.975	163.125	3968.1
Delawari	8422.833	5092.14	13514.97
Grand Total	**45196.675**	**37394.109**	**82590.78**

2.2 PAST MANAGEMENT OF RATAPANI WLS

The management of forest patches in Bhopal Forest Circle is not known before 1868. It was supposed to be managed by Village Landlords. In 1868, for the first time, forest land management was initiated. Apart from forest lands used by village farmers, all the forest land was brought under state controlled-management. The leaseholders were compensated based on the forest area acquired by state and later with the increasing conflict land was given back to the leaseholders. With the continuing conflict forest areas have experienced everlasting destructions between 1868 - 1916. In 1914 the forest department was transferred to Bhopal Estate under Nawab Nasrullah Khan Bahadur.

In 1905, Shri Nar Singh Rao was appointed as Forest Officer, who have established a different department in 1907. He mapped Bhopal Forest Division and controlled unchecked tree felling. This was later transformed as Forest *Coops*. In 1927 Rao has developed an improved felling system and systematic forest fire safety policies.

Scientific Techniques was incorporated for the first time by Shri M.M. Sarkar in 1937, although it was not accepted by the government, yet forest management was based on these newly developed techniques which include the development of compartment and holistic mapping. It was used till 1961 for the management of forests in and around Bhopal.

Later, proper working plans were developed in 1962 by Shri B.C. Tiwari for 1962-63 to 1976-77; Working scheme was developed by Shri Senapati Joshi for 1968-69 to 1977-78; Working scheme was developed by Shri LP Dondiyal in 1972; Working Plan for 1983-84 to 1997-98 by Shri R.K. Varma; and Working plan for 2003-04 to 2012-13 was developed by Shri B.P. Gupta.

2.3 TOPOGRAPHY, GEOLOGY, AND SOIL

Topographically it can be divided into three parts: Malwa plateau in north, Vindhyan series in the middle, and Narmada valley in the south. Mainly two types of hills are met with in the tract: the trap hills and the Vindhyan and Laterites.

Vindhyan Range is escarpment of broken hills running parallel to Narmada-Son trough in east-west direction from Jobat in Gujrat to Sasaram in Bihar for a distance of over 1200 km acting as boundary of central India landscape on the north. The topography of the areas in Vindhyan hills can be described as “step” topography with one plateau steeping down onto the lower one. The elevation of the range is 300-650 m and are composed of horizontally bedded sedimentary rocks. The major agro-climatic regions of the Vindhayan Landscapes compromises of the Vindhayna Plateau, Malwa Plateau in Centre; Kaimur and Satpuda Hill Plateau on the Eastern side and Jhabua Hills on the western limit. The major part of the central vindhayan landscape compromises the Hill and steep escarpments; and flat woodlands and savannah type grassland areas. The main rock formations of the BFC is sand stone from Vindhyan origin while the soil types are laterite, black cotton and alluvium.

2.4 CLIMATE AND RAINFALL

The study area falls under the sub-tropical climatic region with three distinct seasons viz., winter season (Dec-Feb), summer season (Mar-May) and the rainy season (June – Oct). During winters the mean temperature remains around 10°C and mean maximum temperature remains 25°C and the minimum temperature goes down to 1°C in some regions. During summers, the mean minimum temperature is 22°C and mean maximum is 38°C. The maximum temperature during summer can go up to 48°C, especially in May and June which are the hottest months. Vindhyan plateau receives an average annual rainfall between 1200-1400mm, while Malwa plateau receives around 1000-1200mm. Rainfall is received from south-west monsoon from June to September (SAPCC, 2014).

2.5 AGRO-CLIMATIC REGION

Madhya Pradesh has 11 agro-climatic regions (Figure 2-4). These regions are different from each other regarding climate, soil type, crops, topography and rainfall. The Obedullahganj Division & Ratapani WLS are a part of the Vindhyan Plateau agro-climatic region.

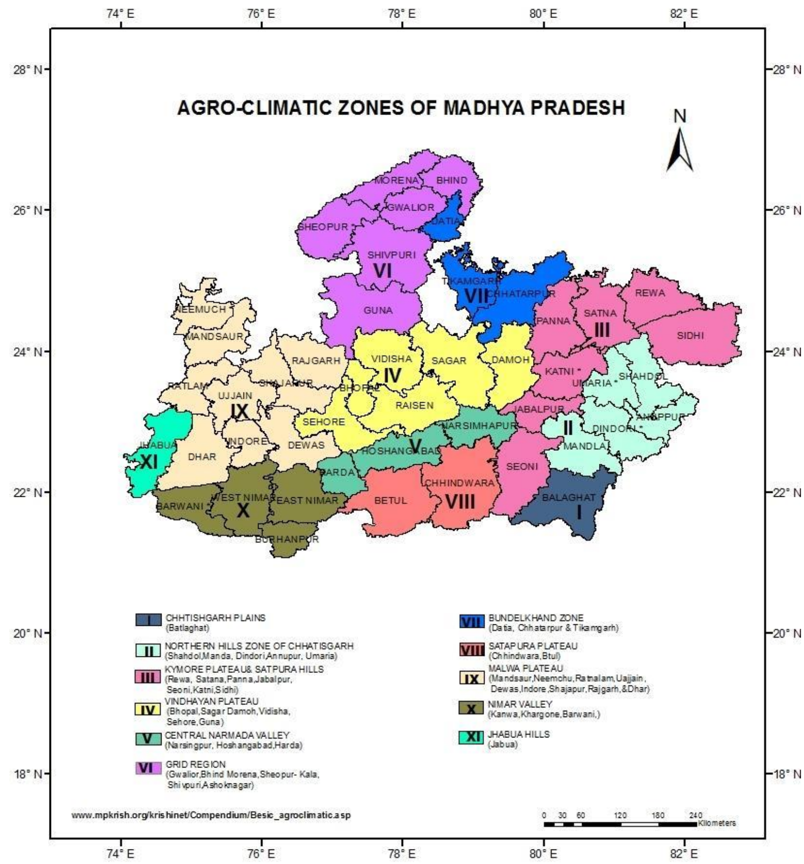


Figure 2-4: Agro-climatic zones

2.6 DRAINAGE

Vindhyan series of mountains spread all over the Raisen and Obedullaganj division. These ranges divide the area into two drainage systems. The northern portion forms the drainage basin of river Yamuna and the southern forms basin of Narmada. The Raisen area is drained by Betwa, Halali, Bina, Bewas & Tenduni rivers. The catchment area of Obedullaganj is drained by mainly Betwa, Barna, its tributaries.

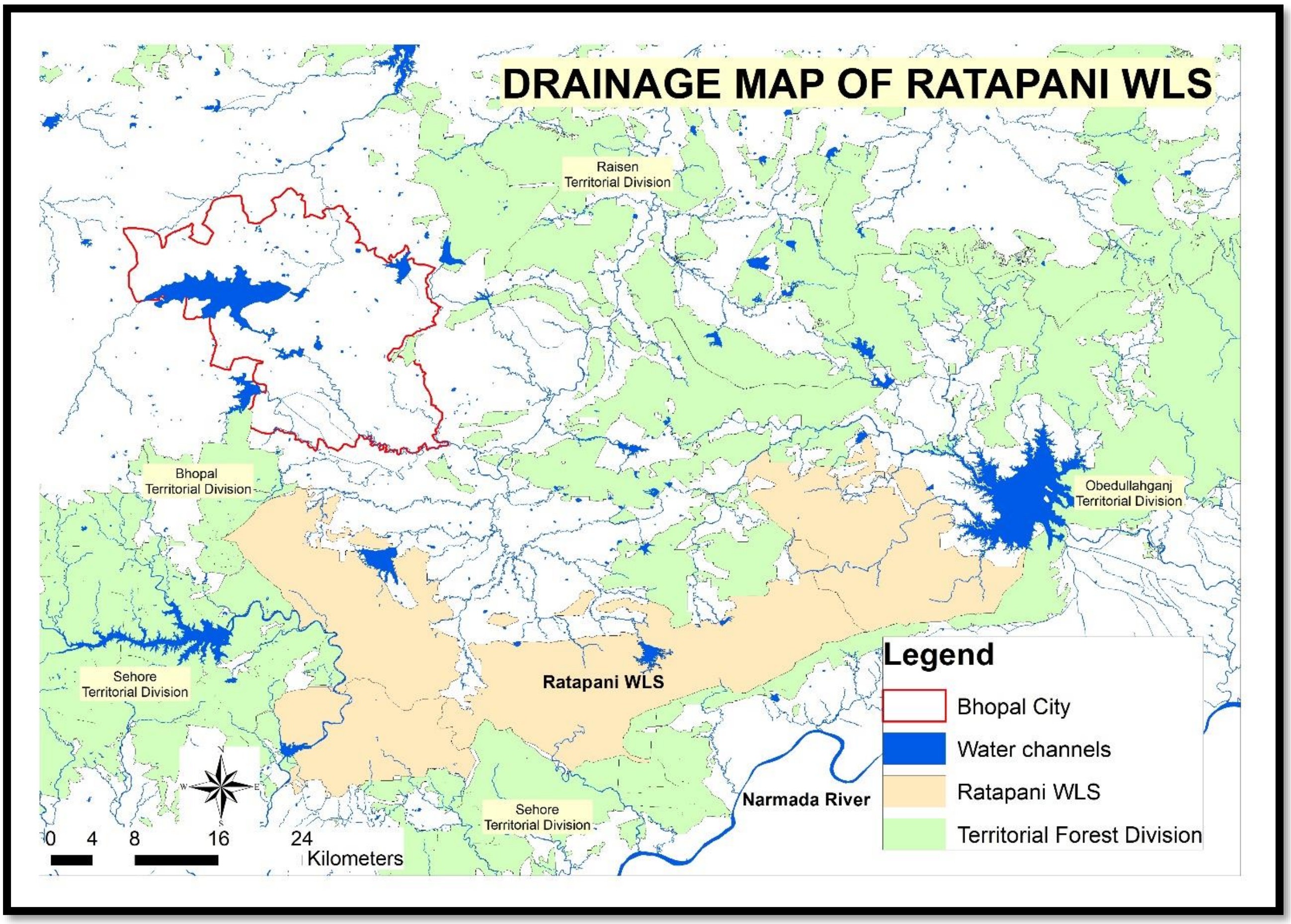


Figure 2-5: Drainage map of Ratapani Landscape

2.7 FOREST TYPES AND PATCHES

Eighteen forest types have been identified in Madhya Pradesh. These forest types belong to three groups of classification given by Champion and Seth i.e. Tropical Dry Deciduous forest, Tropical Moist Deciduous Forest and Tropical Thorn Forest. Tropical Dry Deciduous Forest is the dominant group. Within sub-groups, Southern Dry Mix Deciduous Forest is dominant (33.51%) followed by Dry Teak Forest (27.26%), Northern Mix Dry Deciduous Forest (11.81%). Rest of the forest types occupy less than 6% of forest cover (FSI, 2015). The BFC is characterized by Tropical dry deciduous forest (Group 5) and Tropical thorn forest (Group 6) (Champion and Seth, 1968).

The major sub-groups of Group 5 and Group 6 forest types found in the Bhopal Forest Circle encompasses following (Champion & Seth, 1968)

1. 5A/C 1b Dry Teak Forest
2. 5A/C3 Southern Dry Mixed Deciduous Forest

3. 5/D51 Southern Tropical Dry Deciduous Scrub
4. 5/D54 Southern Tropical Dry Deciduous Dry Grassland
5. 5/E1 *Anogeissus Pendula* Forest

The major species is Teak (*Tectona grandis*) in Dry Teak Forests while *Butea monosperma*, *Diospyros melanoxylon*, *Acacia catechu*, *Anogeissus latifolia*, *Wrightia tinctoria*, *Lannea coromandelica* and *Cassia fistula* are major species of the mixed forests. *Anogeissus pendula* Forest is dominated by *Anogeissus pendula* along with *Anogeissus latifolia.* Tree species found in Dry Deciduous Scrub forests are *Butea monosperma*, *Acacia leucophloea, Lannea coromandelica*, *Diospyros melanoxylon* and *Anogeissus latifolia*.

The forest of Ratapani is dry deciduous and moist deciduous type, with teak (*Tectona grandis*) as the main tree species. About 55% of the area is covered by teak. The remaining mixed forests consist of various dry deciduous species. Bamboo (*Dendrocalamus strictus*) overlaps the two aforementioned forest types and covers about one quarter of the forest area. As per Ashok K Rathoure, 2018, 129 tree species, 73 herbs and shrubs species, 33 climbers and parasites, 35 grasses and bamboo species are found in this area. As per the management plan of Obedullaganj Division the major forest types are

1. 5A/C 1b Dry Teak Forest
2. 5A/C3 Southern Dry Mixed Deciduous Forest
3. 5/DS1 Southern Tropical Dry Deciduous Scrub
4. 5/D54 Southern Tropical Dry Deciduous Dry Grassland

The composition of trees in different tiers are as follows

1. Upper Tier: *Tectona grandis, Terminalia tomentosa, Anogeissus latifolia, Lannea coromandalica, Pterocarpus marsupium, Bridelia retusa, Madhuca latifolia, Dalbergia paniculata, Boswellia serrata, Sterculia urens, Terminalia bellerica, Soymida febrifuga, Albizzia procera, Lagestroemia parviflora, Schleichera oleosa, Hadina cordifolia, Dalbergia sisoo, Mitragyna parvifolia, Terminalia arjuna*
2. Second Tier: *Diospyros melanoxylon, Ougenia oojeienensis, Buchnania lanzan, Emblica officinalis, Gardenia latifolia, Aegle marmelos, Swietenia chloroxylon, Acacia catechu, Ziziphus xylopyra, Writia tinctoria, Nyctanthes arbortristis, Holarrhena antidysentrica, Flacourtia indica, Cassia fistula, Caseria grabelons*
3. Third Tier: *Maytanus sylvestre, Ziziphus mauritiana Carissa opaca, Grewia tilliaefolia*,

4. Ground cover: *Ziziphus nummularia, Cassia tora, Xanthium strumarium, Woodfordia fructicosa, Helicteres isora, Ocimum basilicum,*
5. Climbers: *Ichnocarpus frutescens, Cryptolepis buchanani, Celastrus paniculata, Aburus perceterious, Asparagus racimosus,*

2.8 PROTECTED AREAS

The protected areas near the Ratapani WLS includes three other wildlife sanctuaries and one national park.

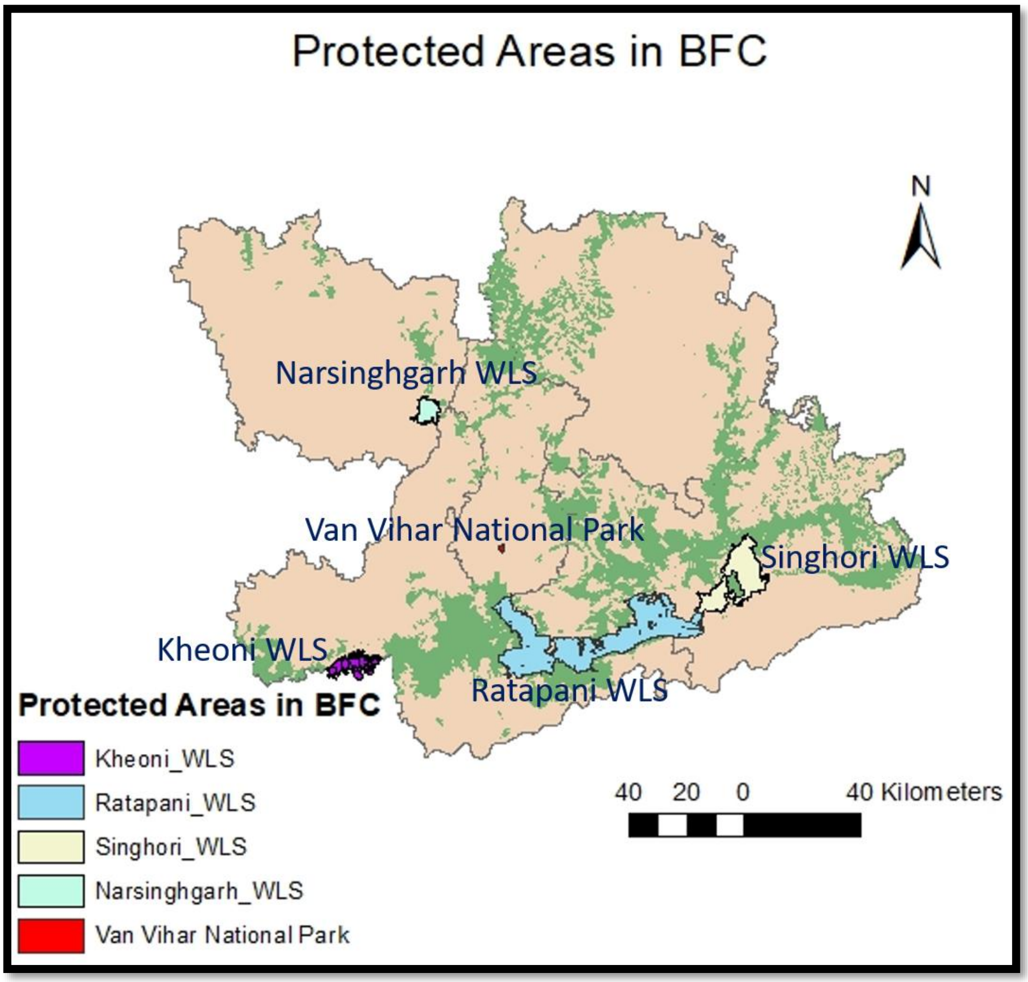


Figure 2-6: PA of Bhopal Forest Circle

Table 2-1: Protected areas in Bhopal Forest Circle

S. No.	Name Of Protected Area	Year Of Establishment	Area (Sq.Km)	District
1	Narsinghgarh WLS	1978	59.19	Rajgarh
2	Kheoni WLS	1982	122.70	Sehore, Dewas
3	Van Vihar National Park	1979	4.45	Bhopal

4	Ratapani WLS	1978	823.84	Raisen
5	Singhori WLS	1976	287.91	Raisen

2.9 FAUNA DIVERSITY

The variety of habitats including forest, grassland, scrublands and precipitous hills that have cliffs, have large rock blocks and talus at the base which provide habitat for faunal diversity are seen in this area. As per Ashok Rathoure, (2018) 35 mammals, 205 birds, 14 fish, 33 reptiles and 10 species of amphibians have been recorded in Ratapani Wildlife Sanctuary.

The mammalian diversity includes Tiger, Leopard, Sloth Bear, Hyena, Jackal, Jungle CatIndian Fox, Spotted Deer, Sambar Deer, Bluebull, Four-horned Antelope, Wild Boar, Langur and Rhesus Macaque. Smaller animals, like squirrels, mongooses, gerbils, porcupines, hares, etc. are of common occurrence. Ratapani Wildlife Sanctuary has a population of about 40+ tigers while the movement of 12 tigers has been reported in the forest area of Bhopal.

Among reptiles, important species include different kinds of lizards, chameleon, snakes, etc. Among snakes, cobra, python, viper, krait, etc. are common.

Sixty species of Butterflies have been recorded from the Ratapani WLS (*Per. Comm.* DP Srivastava, Annexure I).

Few common bird species includes common babbler, brown-headed barbet, bulbul, bee-eater, baya, cuckoo, kingfisher, kite, lark, vulture, sunbird, crow pheasant, jungle crow, egrets, myna, jungle fowl, parakeets, partridges, hoopoe, quails, woodpeckers, dove, black drongo, flycatcher, and rock pigeon.

The area is also marked with hilly cliffs providing habitat for Vultures. The vulture species commonly found includes Egyptian Vulture, Indian Vulture, White-rumped Vulture, Red-headed Vulture, Eurasian Griffon and Himalayan Griffon. They can be easily seen basking or feeding on carcasses outside forest villages.

Table 2-2: List of Schedule I mammals

S.I.	SCIENTIFIC NAME	COMMON NAME	SCH. WPA 1972	IUCN STATUS
1	*Panthera tigris*	Tiger	Sch I (Part I)	Endangered
2	*Manis crassicaudata*	Pangolin	Sch I (Part I)	Endangered

3	*Panthera pardus*	Leopard	Sch I (Part I)	Vulnerable
4	*Melursus ursinus*	Sloth Bear	Sch I (Part I)	Vulnerable
5	*Tetracerus quadricornis*	Four-horned Antelope	Sch I (Part I)	Vulnerable
6	*Gazella gazelle bennetti*	Chinkara	Sch I (Part I)	Least concern
7	*Antilope cervicapra*	Black buck	Sch I (Part I)	Least concern
8	*Mellivora capensis*	Indian Ratel	Sch I (Part I)	Least concern

2.10 VILLAGES AND ANTHROPOGENIC PRESSURE

There are 29 revenue villages and 3 forest villages inside the sanctuary. This number goes to 37 on addition of hamlets of different villages. These villages have 3301 families and a human population of 18239. While the cattle population is around 11299. There are around 34 villages situated around the sanctuary. These villages have a cattle population of around 22450 which grazes in the sanctuary illegally. All these villages are dependent for their various daily needs such as fuelwood, grazing, NTFP, medicines etc. on the WLS. The main constraint of management is illicit grazing by the cattle of surrounding villages. About 20,000 heads of cattle from in and around villages graze in the area. Illicit felling of timber, firewood and bamboo, poaching and encroachment in the forest area are other problems. Forest fire is major problem in the summer.

2.11 CROPPING AND AGRICULTURE

The major crop in the study area is Rabi (winter crops) and Kharif (summer crops); this cropping pattern depends on water from Narmada River. The crop occupying the highest percentage of the sown area of this region are Rice, Wheat, Soyabean, Peanuts, Mustard, Sesame, Cotton, Maize and Sorghum. It is observed that, the different parts of the study area were practicing different crop pattern based on the season and availability of irrigation facility. The pulses cultivated in this region were Gram; Mug, Arhar, Urad etc.

The general crop patterns practiced in the study area were maize, wheat and others. Major horticultural crops: Plantation of Chikku, Kela, Papaya, Amla and mango. The major vegetables grown in the study area were: Bhindi, Brinjal, Cabbage, Tomato, Karela and Onion.

2.12 TOURISM

The Sanctuary is famous for wildlife tourism as well as historical and scenic tourism. These includes the largest rock shelters of Bhimbetka located inside Ratapani WLS. These rock shelters were inhabited by man hundreds and thousands years ago and some of the rock-paintings of the stone age are more than 30,000 years old. It has been declared a World Heritage Site by UNESCO. The tourist places of Ratapani WLS include Bhimbetka, Delawari, Ginnorhgarh Fort, Old Military camp, Ratapani Dam, Kairi Mahadeo temple and Kherbana Mandir. Ratapani WLS tourism has collected around 1.5 crore INR in the form of tickets during 2016-till date. The sanctuary could not generate much funds during 2019-2020 and 2020-2021 during to the onset of COVID-19 pandemic. However, the sanctuary has a great potential to be developed as a tourism destination which should be further explored and promoted.

2.13 PROPOSED TIGER RESERVE

It has been a wildlife sanctuary since 1976. As of March 2008, in principle approval by the National Tiger Conservation Authority (NTCA) has been granted for upgrading it to a status of tiger reserve. It will become a tiger reserve by the notification of the Government of Madhya Pradesh.

Ratapani Wildlife Sanctuary has a population of about 40 tigers while the movement of 12 tigers has been reported in the forest area of Bhopal. The whole area will be combined as one to declare it as a tiger reserve. The area of about 3,500 sq.km of Raisen, Sehore and Bhopal districts has been reserved for this project. The 1,500 sq.km will be designated as a core area while 2,000 sq.km as a buffer zone. The declaration of the sanctuary as a tiger reserve will help in better conservation of tigers in the area which is facing the problem of illegal mining and poaching.

3 METHODOLOGY

To effectively use butterfly as indicators applying appropriate survey method for butterfly monitoring program by citizen scientist/people participatory program is really important. Survey design must include a reliable method of data collection and statistical analysis so that results are scientifically sound and robust (Nowicki et al. 2008). Major four methods that are frequently used in butterfly research and monitoring are (1) trapping and netting, (2) mark-recapture, (3) transects (Pollard walks), and (4) distance sampling.

Trapping and netting are primarily used to ascertain the presence–absence of a species or to produce species counts (Droege et al. 1998). Researchers use mark –recapture method to gain in-depth and accurate population data (Gall 1985), this method is performed by capturing individuals, marking them with fine-tipped markers, identification tags, or unique appendage clippings, releasing them, and recapturing marked and unmarked individuals. Transects or Pollard walks, are a specific type of line transect done in butterfly research (Pollard 1977), this method uses visual identification while searching along desirable transects of a specific width to count butterflies. Distance sampling uses randomly placed transects or points to collect unbiased butterfly data (Moranz et al. 2012; Henry et al. 2015).

Usually, checklist survey is employed in public participation program for butterfly surveys. Checklist survey primarily confirm presence of species and sometimes number of individuals for the survey site. However, such ''open-ended'' survey approaches frequently are inadequate to meet the rigors of statistics (Hellawell 1991). Relative abundance is difficult to estimate accurately across a series of checklist data sets (Royer et al. 1998). For continuous monitoring or indexing of actual or relative abundance a more carefully designed sampling model is essential. Keeping our objectives in mind we adopted the transect method developed by Pollard *et al.* (1975), and later adapted by Pollard (1977, 1982), as it is a quick way to assess relative abundance and species presence while reducing the need for handling individuals (Pollard 1977).

The methodology section has been divided in three phase i.e. Pre-survey Planning, Field Survey and Data Compilation.

3.1 PRE-SURVEY PLANNING

The conceptualization of the butterfly surveys, its objectives and model which was to be followed was envisaged and decided during this stage.

3.1.1 Three-day survey planning & Work responsibility division

Three days' butterfly survey from 10th September to 12th September by public participation was planned in Ratapani WLS by forest department in association with two NGOs namely Tinsa Ecological Foundation and Wild Warriers.

Tinsa Ecological foundation was given the task of designing the survey, selecting the participants, training the forest guards for the survey, executing the survey which includes deciding trails for the survey, designing datasheet for data collection, team formation, allotting trails to different team, training to participants for accurately collecting data, assembling datasheet from different team, data compilation, data analysis and disseminating report.

Wild Warriors were responsible for floating butterfly survey in social media and application process management, managing lodging and boarding of participants which includes coordinating travel plan of each participant, arranging travel from Bhopal railway station or bus station to main campsite, dispatching team to different location, bringing back all the team from different location to main campsite after two days' survey.

Ratapani WLS team was involved in field staff management to accommodate participants and guests with accommodation, food, and assistance during the survey. The field staff guided the Tinsa team in identifying the trails. They conducted the pilot survey with the Tinsa team prior to the actual survey.

3.1.2 Citizen science initiative partnerships models for survey

Citizen science, the involvement of members of the public in gathering data and undertaking research, is flourishing around the world, particularly as a means of monitoring wildlife and the environment at a large scale. Recent upsurge in citizen science has involved mass-participation projects, which seek to engage people with little or no previous experience of biodiversity monitoring. Citizen science can be defined as 'a method of integrating public outreach and scientific data collection locally, regionally, and across large geographical scales' (Cooper et al., 2007).

3.1.3 Target data and data collection method

There are two main classes of data collected by monitoring programs: abundance and occupancy data. As its name implies, abundance data are used to quantify the size or density of a particular population, whereas occupancy data simply determine presence or absence of a taxon on a particular site or in a particular cell of a survey grid. Any monitoring method that can measure abundance can also measure occupancy, but there are some monitoring methods that are only suitable to track occupancy dynamics or define ranges. Abundance data are typically collected either by marking, releasing, and recapturing individuals in a study area, or by observing and counting individuals in a defined area or along a transect. Despite the greater potential for diverse analyses of abundance data, there are situations where occupancy has decided advantages. In particular, species present at very low densities or that are very difficult to detect may not be suitable for the collection of abundance data (Bried and Pellet 2012; MacKenzie et al. 2005). Furthermore, certain monitoring techniques are only able to capture occupancy. Systematic surveys are those with the strictest protocols. Survey sites are established and usually visited multiple times within and between seasons. We designed our study and marked all the trails keeping this in mind so that this study can be replicated at any point of time. Pollard walks, sometimes called Pollard transects, are named for Ernest Pollard, who pioneered the technique (Pollard 1977) was adopted. Pollard’s goal was to develop a technique that could be used to detect long-term changes in butterfly populations, and that could make use of recorders who might not have formal training in entomology. It’s important to bear in mind that Pollard data do not return an actual population size, either over the entire generation of butterflies or restricted to the day of the survey. This is due to the fact that butterflies may be, and typically are, missed by the spotter (Haddad et al. 2008; Harker and Shreeve 2008; Pellet et al. 2012) or individuals may be counted multiple times. Although even a single Pollard survey will return information regarding distribution and phenology of butterflies. But, relative abundance data are most powerful when collected over extended period of time and used for detecting spatial or temporal changes in butterfly populations. One significant advantage to the Pollard approach to butterfly monitoring is its simplicity. The protocol, while rigorous, is uncomplicated, and can be readily taught to people who have little or no formal science training.

3.1.4 Application and Registration

Survey notification for the butterfly survey was released on 20th July 2021 on various social media platform like WhatsApp, Instagram & Facebook. Participants were invited to fill the Google form. We received tremendous response and got around 184 applications from 13 different states of India which includes Madhya Pradesh, Chhattisgarh, Delhi, Gujarat, Maharashtra, West Bengal, Uttarakhand, Haryana, Punjab, Karnataka and Uttar Pradesh. Out of these 184 application, 94 participants were selected. Out of these 94 participants, 88 managed to participate in the survey. In the selection procedure, participants were shortlisted on the basis of their previous experience of working with wildlife, or in protected areas. Equal weightage was given to both experience and non-experienced applicants. Telephonic interview was conducted with applicants without any previous experience to check their genuine inclination to participate, learn and contribute in the survey along with their awareness towards nature and its conservation.

With the intention of flawless butterfly survey, attentive pre work before survey was done by volunteers and team members of Tinsa Ecological Foundation. The butterfly survey was designed using a scientific approach. The survey design was an attempt to incorporate scientific data collection methods into the citizen science initiative to get the best of the possible scenario.

3.1.5 Trail Demarcation

To understand the ecosystem processes and diversity of the park, firstly different habitat types were identified using the field as well as mapping techniques. A land use land cover map was prepared for the study area to identify the different habitat types present. Sampling units were various trails identified in the four ranges of the sanctuary. These trails were identified with the help of the forest ground staff and Google Earth imagery. The final selection of the trails was based on the number of volunteers, accessibility of trails from camps, and butterfly diversity at these trails during the pilot survey. Habitat types were also considered while setting up trails and selecting the same. Trails were categorized into different categories depending on the physical characters, vegetation structure and composition, and difficulty level of trails. (Figure 3-1 & 3-2)

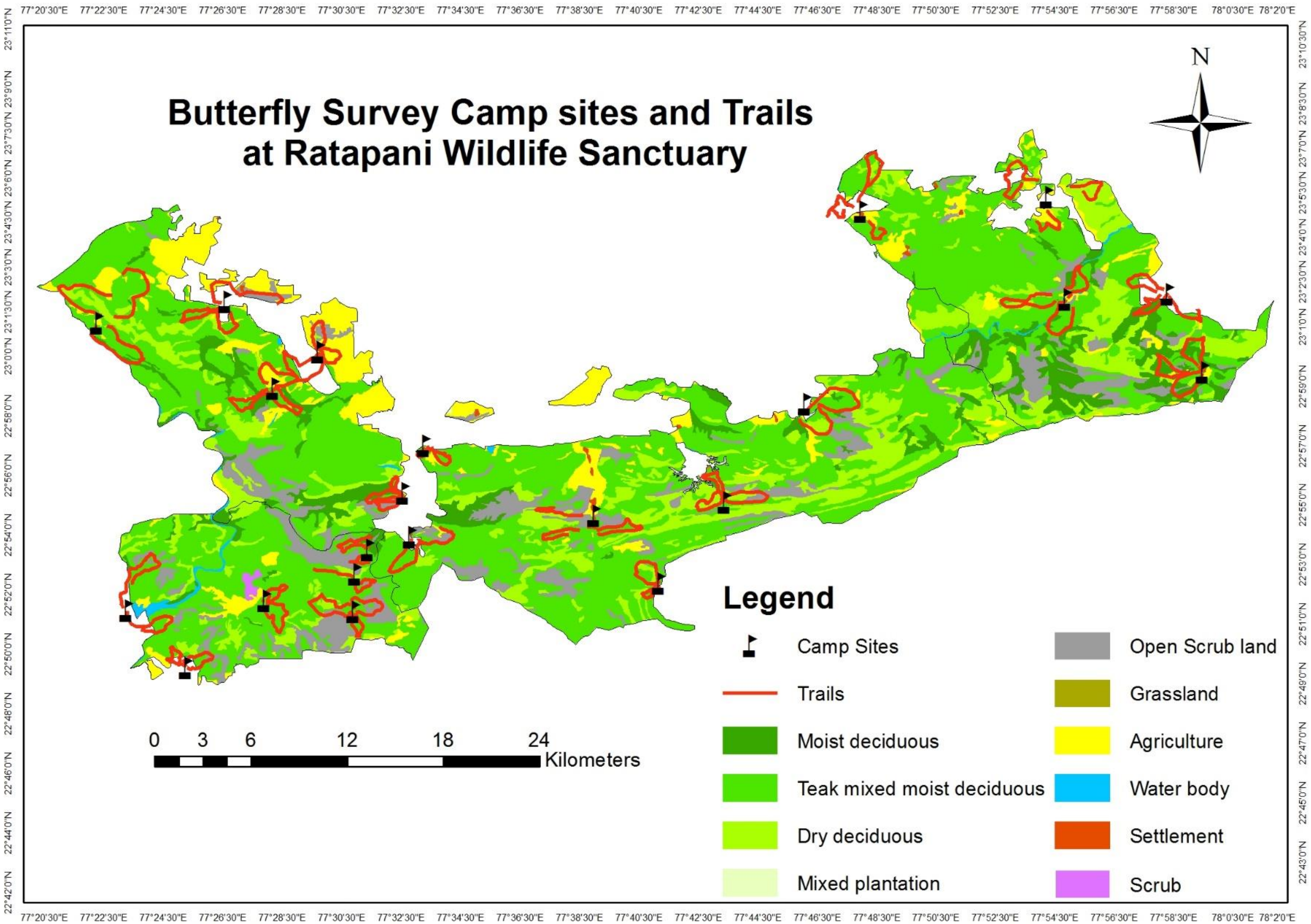
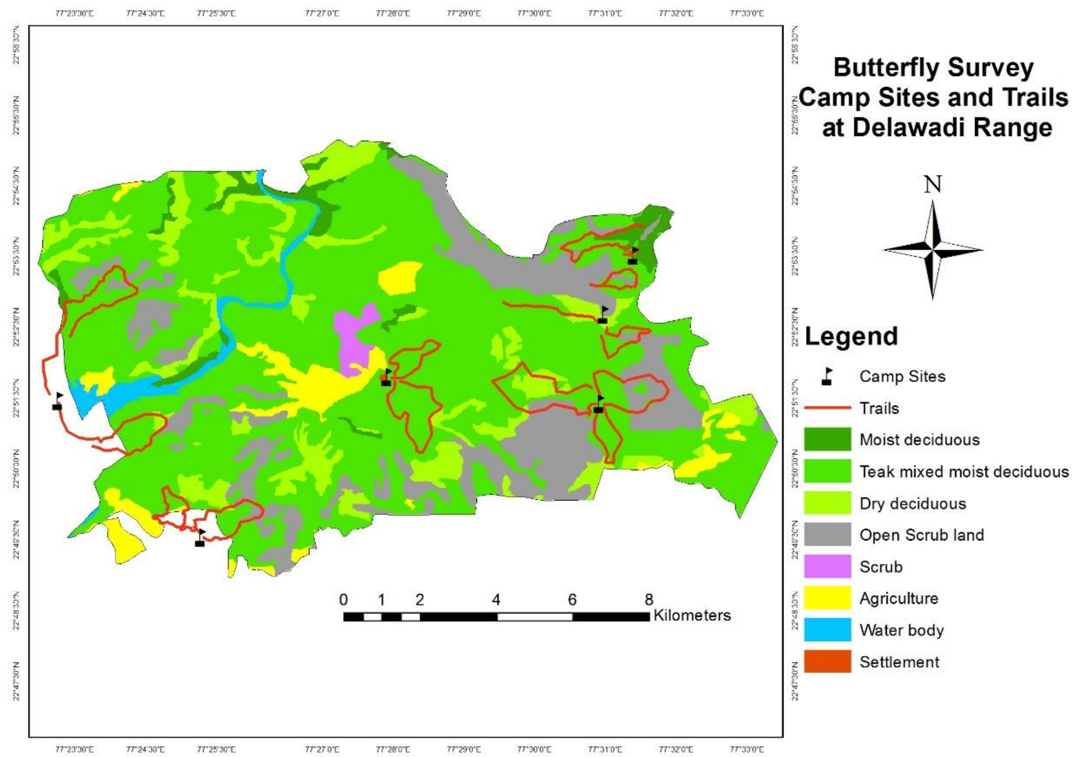
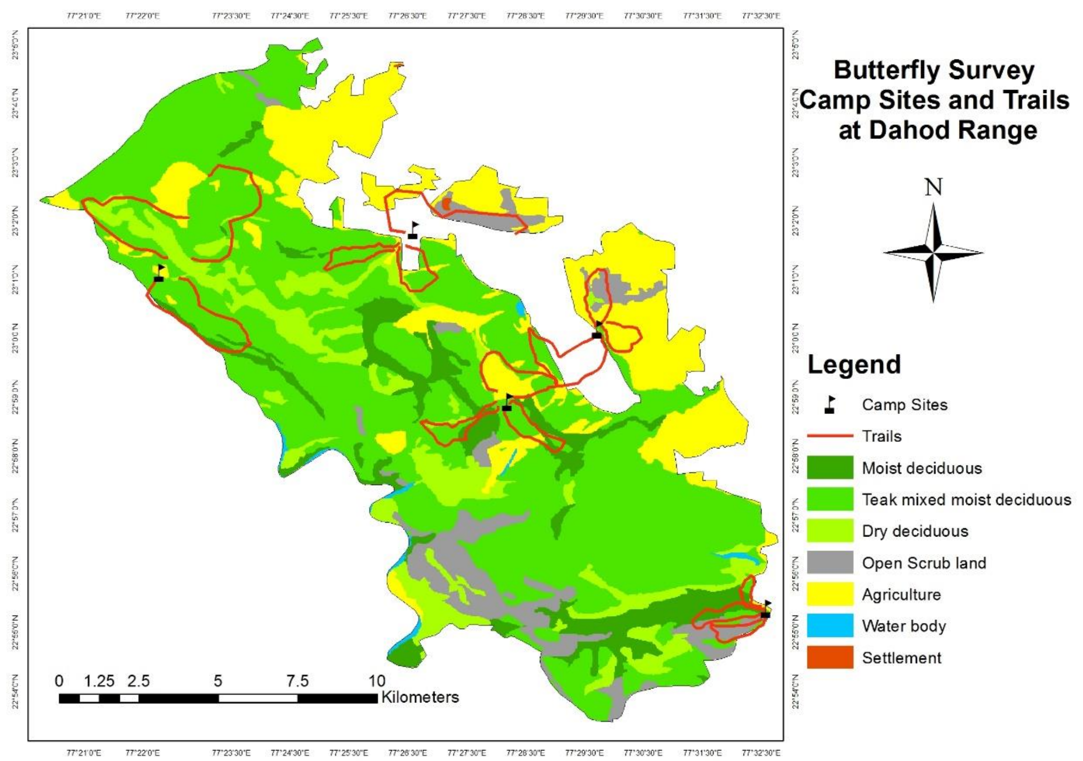


Figure 3-1: Identified trails and camp sites at Ratapani WLS

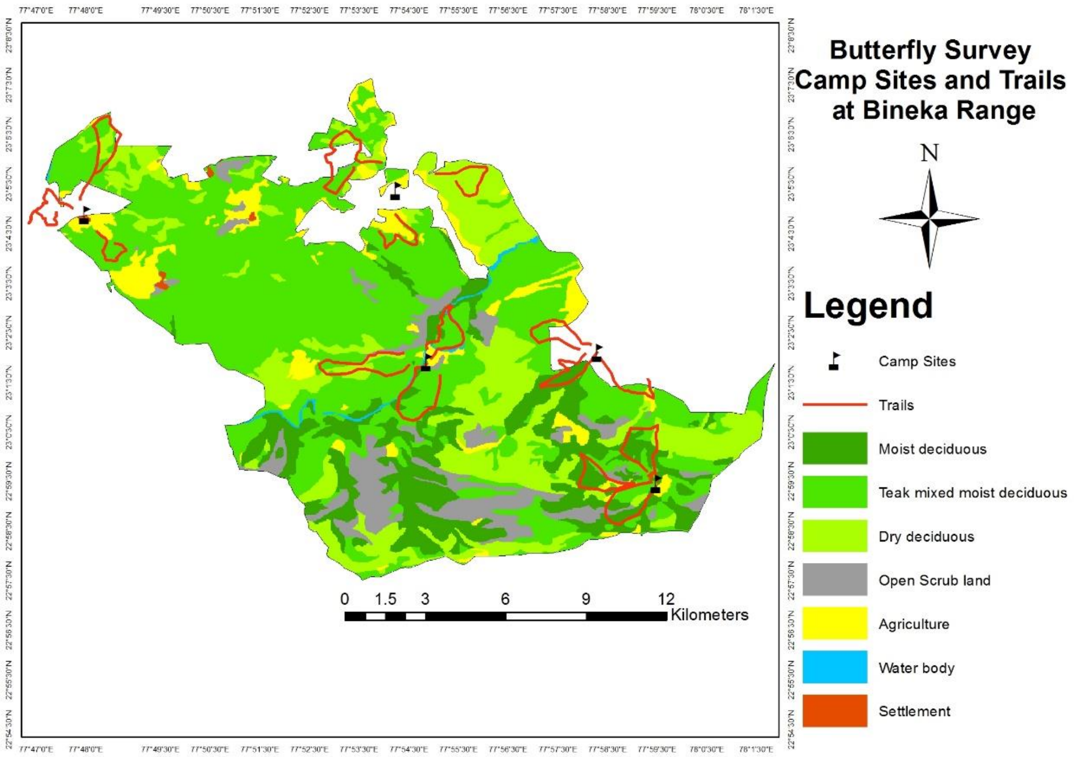
A


Butterfly Survey
Camp Sites and Trails
at Delawadi Range
N
Legend
Camp Sites
Trails
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Scrub
Agriculture
Water body
Settlement
0 1 2 4 6 8
Kilometers

B


Butterfly Survey
Camp Sites and Trails
at Dahod Range
N
Legend
Camp Sites
Trails
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Agriculture
Water body
Settlement
0 1.25 2.5 5 7.5 10
Kilometers

C



D

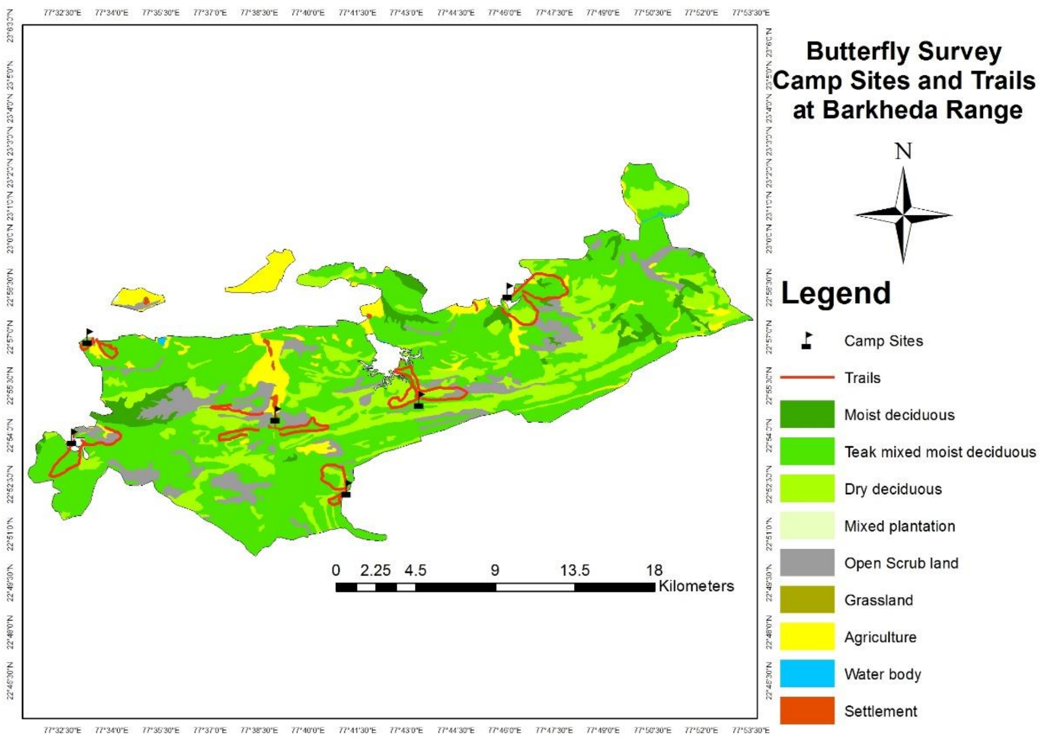


Figure 3-2: Identified Trails and Camp Sites in 4 ranges of Ratapani WLS

3.1.6 Data Sheet Designing

Datasheet entailed details of the butterfly species, their count, activity pattern, location, time and remarks on the host plant species, and apart from that, opportunistic observation section was included in the datasheet. Participants were instructed to note down family of butterfly in case they couldn't identify the exact butterfly species. Similarly, for host and nectar plant they were instructed to take a picture if they couldn't identify the plants.

Butterfly Transect Counts-Manual v1. (butterfly-monitoring.net) was adapted and followed for data collection methodology. (Appendix II)

3.1.7 Capacity Building of Forest staff

The forest department staff was formally trained before the survey. A brief introduction about the survey was given to the forest staff by team members of Tinsa Ecological Foundation. Training included efficiently reaching the trail and completing trail with respective team of participants. Training was also given for effectively using LOCUS App for navigating in the forest. They were also trained to conduct the Pollard's Walk survey for butterfly.

3.1.8 Team Formation

The participants were divided into 34 teams with 2 to 3 volunteers in each team accompanied by forest staff. Each team was created in such a manner that each team has one expert, one photographer/wildlife enthusiast, and one amateur. The teams were allotted different trails and their corresponding camps in the four ranges.

3.2 FIELD SURVEY

Participants reached Bhopal on the 10th September 2021 morning. All participants were provided transportation facility to reach the base camp i.e. the Delawari campsite by vehicles arranged by the forest department for registration and briefing. Post lunch a brief inauguration & induction session was conducted in the presence of APCCF Mr. Aseem Srivastava and DFO (Obedullaganj) Mr. Vijay Kumar. Mr. Srivastava enlightened the participants with his experience and knowledge about the butterflies and their significance in our ecosystems. He also talked about the need to conduct this survey at Ratapani WLS by citizen science initiative. A detailed training to participants for conducting the survey and team allotment was done on the same day. The new logo of Ratapani Wildlife Sanctuary was also released by APCCF Mr. Aseem Srivastava, in the presence of DFO Mr. Vijay Kumar and SDO Mr. Pradeep Tripathi.

The training session was conducted by PowerPoint presentation by Team members of Tinsa. PowerPoint presentation included the significance of this butterfly survey, the purpose of this survey, explaining pollard walk in detail and its importance, what observation to be recorded, guidance for filling datasheet, using the Locus Map App for location and noting down coordinates, and the expected outcome of this survey.

Participants were given a list of 60 butterfly species commonly found in the landscape which can help them to identify species on the field. (APPENDIX I).

APCCF Mr. Aseem Shrivastava, Sharing his experience and knowledge of butterflies with volunteers

Logo release by the guest (Mr. Aseem Shrivastava, APCCF)

DFO Mr. Vijay Kumar briefing participants about Ratapani WLS

Mrs. Pinal Patel, President Tinsa briefing participants on methodology an data entry

Participants asking their queries with Tinsa team

Flag off of the Butterfly Survey by guests

Figure 3-3: Glimpses of inaugural day of Butterfly Survey at Ratapani Sanctuary

3.2.1 Butterfly Field Survey Method (Pollard's Walk)

The butterfly sampling was done using the 'Pollard's walk', a type of transect walk primarily used for butterfly surveys, where the observers record butterflies within a 2.5-meter band on both sides of a transect while walking at a slow and steady pace and 5 meters ahead of the walk. The observations were recorded in the datasheet provided which entailed the details of the butterfly species, their count, activity pattern, and remarks on the host plant species.

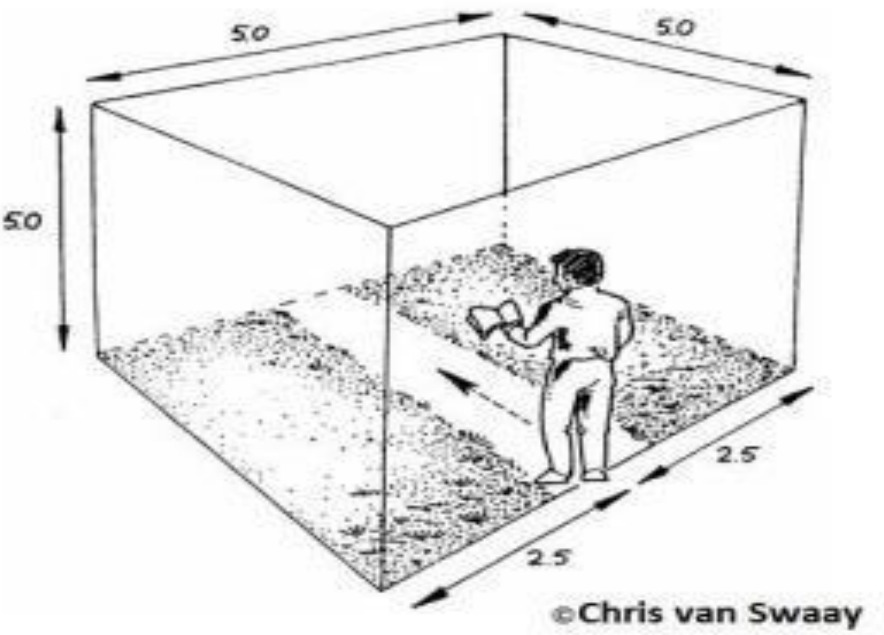


Figure 3-4: Pollard's Walk

Pollard Walk surveys employ fixed travel routes during counting. More rigorous statistical analysis of Pollard Walk transect data is possible because counts are conducted in a much more uniform manner with respect to area covered and time spent. Moreover, fixity of extent and location of transects allows subsequent or concurrent study of multiple factors (*e.g.,* floral and faunal studies on the same transect). Definite extent and permanent location also make frequent replication possible. This uniform delimitation of parameters, which allows confident longitudinal monitoring, is one of the most important features of transect sampling.

3.2.2 Data Collection during survey

Each team had to cover a maximum of 3 and a minimum of 2 trails in two mornings (7:30) and an evening (16:00) session on 11th and 12th September 2021. The KML file of the trails was provided to the teams in advance which they followed on the Locus Map application on their mobile phones for navigation. Survey was designed in a way that each trail gets replicated. Each team covered different trail at different time. The observations were recorded in the datasheet provided which entailed the details of the butterfly species, their count, activity pattern, and remarks on the host plant species. Along with that, participants were supposed to note down GPS coordinates at every 500mt by any navigation App.

Figure 3-5: Teams during field survey

3.2.3 Data Compilation/collection post survey

The most critical part of the survey was to generate data which is reliable and informative as designed so that it can be utilized for further analysis and interpretation. To accomplish this objective a scrupulous arrangement was made to collect raw data sheet and photographs of butterflies from each team. Firstly, all teams were expected to submit their raw datasheet to the respective forest guard who accompanied on the transect. On the last day of the survey four different collection desk were arranged, one for each range. Forest guards were responsible to submit respective camp data at the relevant desk. While other team members and photographers were requested to submit photographs of any rare, threatened, endemic or critical species encountered by their team. After data collection from the participants, closing ceremony was held. Participant were provided with their certificates and an interaction was held where participants and forest staff shared their experiences. The closing ceremony was honored with the presence of Dr. Sanjay Shukla (APCCF), Mr. K. Raman (APCCF), and Mr. Ramnish Geer (Joint Director, CBI) who applauded the efforts of the volunteers and the organizing team. Lastly, a vote of thanks was given by DFO, Mr. Vijay Kumar.

Figure 3-6: Closing ceremony pictures

Participant receiving certificates from the Guests

Tinsa team discussing the brief outcomes of the survey with everyone

Dr. Sanjay Shukla (APCCF) and Mr. K. Raman (APCCF) applauding the efforts of volunteers and organizers

DFO Mr. Vijay Kumar giving vote of thanks

Group Picture of Participants and Organisers

3.3 DATA COLLATION AND ANALYSIS

3.3.1 Data Entry

Data entry was a major task post survey because of its quantity. Forest department took the responsibility of data entry while team members of Tinsa cleaned (uniform names of butterflies, expansion of abbreviations, deletion of incomplete observations etc.) and collated the data in such a manner that it can be used for further analysis.

4 DATA ANALYSIS

Data collected by volunteers from the Ratapani WLS was used to understand the community structure, composition and diversity of butterflies.

4.1 COMMUNITY STRUCTURE

Communities in various habitats can be studied quantitatively by determining the density, and frequency of each species following the methods given by Müeller-Dombois and Ellenberg (1974). Transects and quadrats will be employed to quantify species and populations as described earlier. Data from Pollard's Walk survey will be used to calculate the density, frequency and abundance of butterflies in Ratapani Wildlife Sanctuary.

A. Frequency indicates the number of sampling units in which a given species occurs and thus expresses the distribution or dispersion of various species in a community. It is calculated using the following formula:

$$Frequency = \frac{Number\ of\ sampling\ units\ in\ which\ the\ species\ occurred}{The\ total\ number\ of\ sampling\ units\ studied} \times 100$$

B. Density and abundance represent the numerical strength of species in the community. Density is expressed as the number of individuals of a species per unit area and is calculated as follows:

$$Density = \frac{Total\ number\ of\ individual\ of\ a\ species\ in\ all\ the\ sampling\ units}{Total\ number\ of\ sampling\ units\ studied}$$

C. While abundance is expressed as the number of individuals per quadrat of occurrence and is calculated as follows:

$$Abundance = \frac{Total\ number\ of\ individuals\ of\ a\ species}{Number\ of\ plots\ of\ occurrence\ of\ the\ species}$$

Relative Abundance the total number of individuals of one taxon compared with the total number of individuals of all other taxa in an area, volume, or community. It can be calculated as follows:

$$Relative\ Abundance = \frac{Sum\ of\ individuals\ of\ a\ species}{Sum\ of\ individuals\ of\ all\ the\ species} \times 100$$

4.2 BUTTERFLY SPECIES RICHNESS

Species richness is the simplest method of characterising a community/population diversity. Species richness is the basis of many ecological models like Island Biogeography Theory (McArthur and Wilson, 1967), the intermediate disturbance hypothesis (Connell, 1978), as well as more recent models of neutral theory (Hubbell 2001), meta community structure (Holyoak et al., 2005), and biogeography (Gotelli et al., 2009). These theories try to generate quantitative predictions of the number of coexisting species in a community. However, even it is a simple measure of diversity; it is still difficult to estimate accurately. It is always an underestimation of the surveyed community. To counter this underestimation of species richness, there are many sampling models and estimators of asymptotic richness to estimate the undetected species (Gotelli and Colwell, 2011). For the present study, Chao 1, ACE and Jackknife estimators were used to estimate the undetected species of butterflies. The models were performed in the PAST program.

(A) Chao 1

Chao1 = S + F1(F1 - 1) / (2 (F2 + 1)), where F1 is the number of singleton species and F2 the number of doubleton species. Equation 1

(B) ACE: Abundance Coverage-based Estimator of species richness

$$S_{ace} = S_{abund} + \frac{S_{rare}}{C_{ace}} + \frac{F1}{C_{ace}} * \gamma_{ace}{}^2$$ Equation 2

Where:

$S_{rare} = \sum_{k=1}^{10} F_k$ is the number of rare species in a sample (each with 10 or fewer individuals).

$S_{abund} = \sum_{k=11}^{S_{obs}} F_k$ is the number of abundant species in a sample (each with more than 10 individuals)

$n_{rare} = \sum_{k=1}^{10} kF_k$ is the total number of individuals in the rare species.

$C_{ace} = 1 - f_1/n_{rare}$ is the sample cover estimate which is the proportion of all individuals in rare species that are not singletons.

$\gamma_{ace}{}^2$ is the coefficient of variation,

$$\gamma_{ace}{}^2 = max\left[\frac{S_{rare}}{C_{ace}} \frac{\sum_{k=1}^{10} k(k-1)f_k}{(n_{rare})(n_{rare}-1)} - 1{,}0\right]$$ Equation 3

4.3 SPECIES DIVERSITY INDICES

Biological diversity can be quantified in many different ways. The two main factors taken into account when measuring diversity are richness and evenness. Richness is a measure of the number of different kinds of organisms present in a particular area. For example, species richness is the number of different species present. However, diversity depends not only on richness, but also on evenness. Evenness compares the similarity of the population size of each of the species present.

A. Richness

The number of species per sample is a measure of richness. The more species present in a sample, the 'richer' the sample. Species richness as a measure on its own takes no account of the number of individuals of each species present. It gives as much weight to those species which have very few individuals as to those which have many individuals.

B. Evenness

Evenness is a measure of the relative abundance of the different species making up the richness of an area. A community dominated by one or two species is considered to be less diverse than one in which several different species have a similar abundance. As species richness and evenness increase, so diversity increases.

There are various indices of species diversity such as Shannon-Wiener Index, Simpson 1-D, Evenness Index, Margalef Index, Fisher's Alpha, Brillouin Index, Berger-Parker Index etc. Species diversity index for butterflies were calculated at camp scale, range scale and for Sanctuary scale.

Species diversity was calculated using Shannon diversity index, Simpson (1-D) index and Buzas and Gibson's Evenness Index.

(A) Shannon Index (H'). Species diversity was calculated using the Shannon Index :

$$H' = -\sum pi \ln pi.$$

Here, pi is the proportion of the ith species in the total sample. The number of species (species richness) in the community and their evenness in abundance (or equitability) are the two parameters that define H'.

(B) **Simpson's Index (D)** measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species). There are two versions of the formula for calculating D. Either is acceptable, but be consistent.

$D = \Sigma (n / N)^2$	$D = \frac{\Sigma n(n-1)}{N(N-1)}$

Where, n = the total number of organisms of a particular species and N = the total number of organisms of all species

Simpson's Index of Diversity 1 - D

The value of this index also ranges between 0 and 1, the greater the value, the greater the sample diversity. In this case, the index represents the probability that two individuals randomly selected from a sample will belong to different species.

(C) **Buzas and Gibson's Evenness Index** is given by e^H/S where H is Shannon Index and S is the number of species. Species evenness ranges from zero to one, with zero signifying no evenness and one, a complete evenness.

4.4 SPECIES ABUNDANCE CURVES

One of the earliest observations made by plant ecologists was that species are not equally common in a given community. Some were very abundant; other were uncommon. A graphical way was sought to describe this pattern, and so arose species abundance models (Figure 4.1). These models are strongly advocated among some ecologists because they emphasise abundance while utilising species richness information and therefore provide the complete mathematical description of the data (Gotelli and Graves, 1996).

A species abundance model is generated by graphing the abundance of each species against its rank order abundance from 1 = highest to N = lowest. One of four distributions usually arise:

a) Log normal distribution

Preston (1948) applied the truncated log-normal distribution to the biological data for the first time. Species abundances were put in a histogram of logarithmic scale and a curve was obtained which adjusted well to a large number of community data. In the histogram, the R classes obtained using log2 were called "octaves". Each octave represents the double of previous class (1,2,4,8, 16,….). The distribution is truncated on left for population samples. This area behind this point represents the species not seen in the sample and it reduces as the sample size becomes greater (Ferreira, 2008). The lognormal distribution characterizes a community with relatively few very abundant or very rare species; whereby the observed frequencies increase to a modal frequency and then decrease.

b) Geometric series

Motomura (1932) proposed the geometric series distribution of species as a purely statistical distribution for a benthic community data in a lake. It assumes that a species pre-empts a fraction k of a limiting resource. In geometric distribution, k is the fraction of the resource used by the most dominant species, leaving a fraction (1-k) free for other species. The second most dominant species will consume the same fraction k from (1-k) resource available, that is k(1-k). The third species will then consume fraction k of the resource left by the other two, until all species consumes all the resources (Ferreira, 2008).

c) Logarithmic series

The Logarithmic series distribution was proposed by Fischer (1943) to describe the species abundance of Malayan Lepidoptera in a collection made by Hughes in 1986. Number of species having different abundances are predicted by the log series as: $Sn = (\alpha * xn)/n$, where α and x are constants, and Sn is the number of species with n individuals. Log series distribution is characterised by a skewed J shaped curve having a modal value of 1 (Matthews and Whittaker, 2014). In a natural community, log series abundance distribution means most individuals belong to a few species and most of the species are represented by few individuals. The species abundance distribution appears to be strongly skewed.

d) MacArthur's Broken Stick Model

It was given by MacArthur (1957; 1960). He compared niche space to a stick of length 1, where n-1 points would randomly generate n segments with lengths proportional to the number of individuals of each species in the community. Broken stick is the only model which describes the niche partitioning process in a community in which species have continuous and non-overlapping niches (Ferreira, 2008).

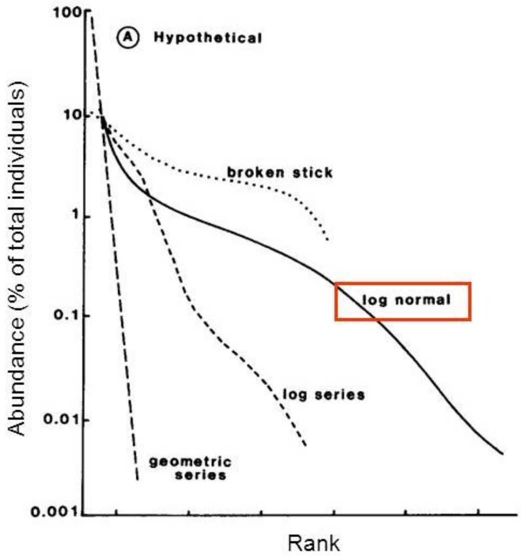


Figure 4-1: Abundance Distribution Models (Magguran, 1998)

Relative abundance distribution (RAD) models of butterfly species were made for overall study area as well as for each forest patch in PAST 3 program (Hammer et al., 2001).

5. RESULTS

5.1 FREQUENCY, DENSITY AND ABUNDANCE OF BUTTERFLIES

5.1.1 Frequency of Butterflies

There was a total of 75 trails across 4 ranges of Ratapani WLS which were surveyed for butterflies. Frequency indicates the number of trails in which a given species occurs and thus expresses the distribution or dispersion of various species in a community. A total of 100 species were observed during the survey on these trails. As per the results, 68 butterfly's species were had a frequency in the range of 1 -21, while 11 species had a frequency in the range of 21-41. Similarly, 17 species had a frequency of occurrence in a trail in a range of 41-61. The highest frequency of occurrence of butterflies in trails was found to be 4 species (61-81). These 4 species were Common Grass Yellow, Common Emigrant, Lemon Pansy and Baronet (Figure 5-1).

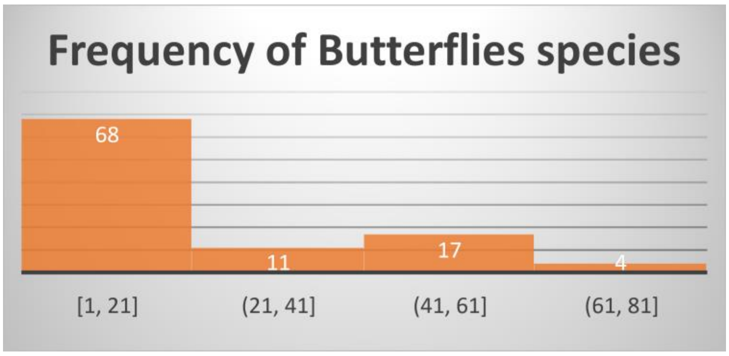


Figure 5-1: Frequency of Butterflies at Ratapani WLS

5.1.2 Density of Butterflies

Density of each of the 100 butterflies encountered during the survey was calculated. The unit of density here is number of butterflies per trail. Common Grass Yellow (D=85.75) was found to be the most densely occurring butterfly species in the Ratapani Sanctuary followed by Zebra Blue (D=19.37/trail), Small Grass Yellow (D=14.75/trail), Common Emigrant (D=8.47), Common Lime (D=5.51) and Tawny Coster (D=5.12). (Figure 5-2)

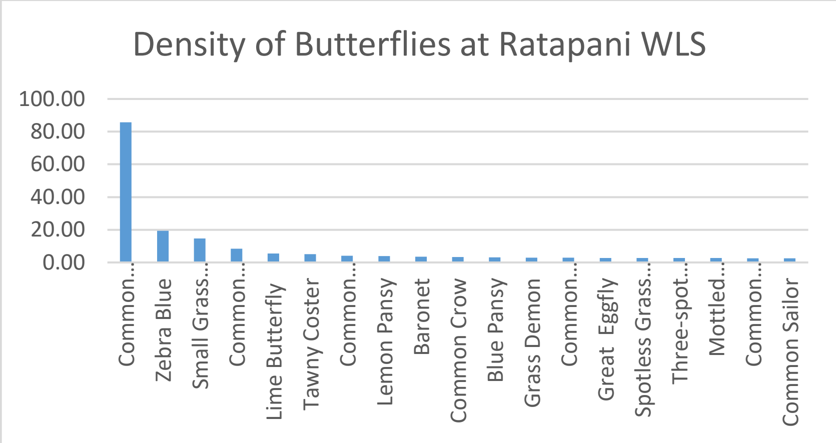


Figure 5-2: Density of Butterflies at Ratapani WLS

5.1.3 Abundance of Butterflies

Abundance of butterflies observed during the survey was calculated as the sum of individuals of a species per trail (only in which they were observed). Common Grass Yellow (A= 109) was found to be the most abundant species followed by Small Grass Yellow (A=38.14), Zebra Blue (A=32.29), Three-spot Grass Yellow (A=14.21) and Spotless Grass Yellow (A= 13.27). (Figure 5-3)

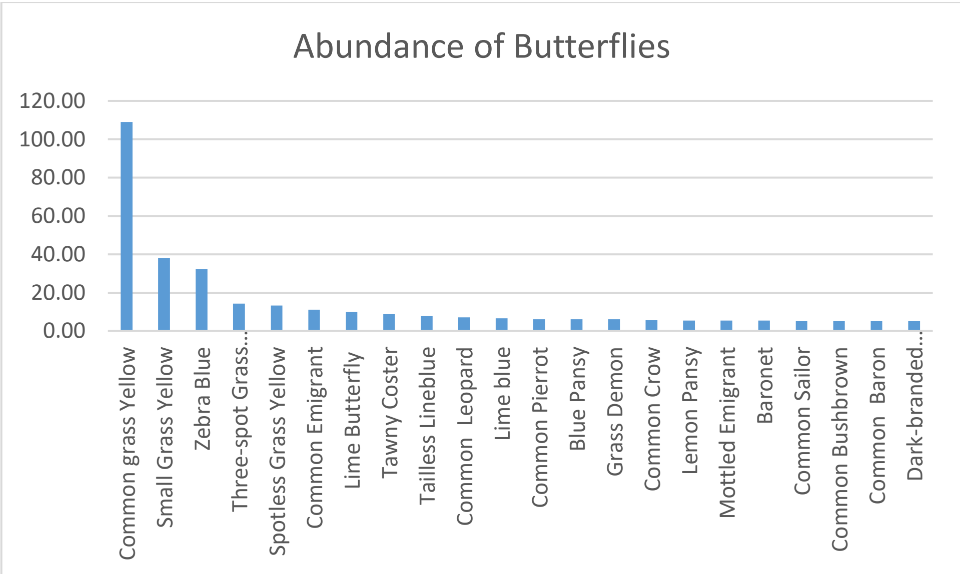


Figure 5-3: Abundance of Butterflies at Ratapani WLS

5.1.4 Relative Abundance

The abundance of a species (by any measure), divided by the total abundance of all species combined is called the relative abundance. It tells us the contribution of each species in the population. The results suggest that Common Grass Yellow (41.86%) was the most dominant species found during the survey. It contributed maximum to the total butterfly population. Zebra Blue (9.46%) was the second most prominent species in the population followed by Small Grass Yellow (7.20%), Common Emigrant (4.13%) and Common Lime (2.69%). (Figure 5-4)

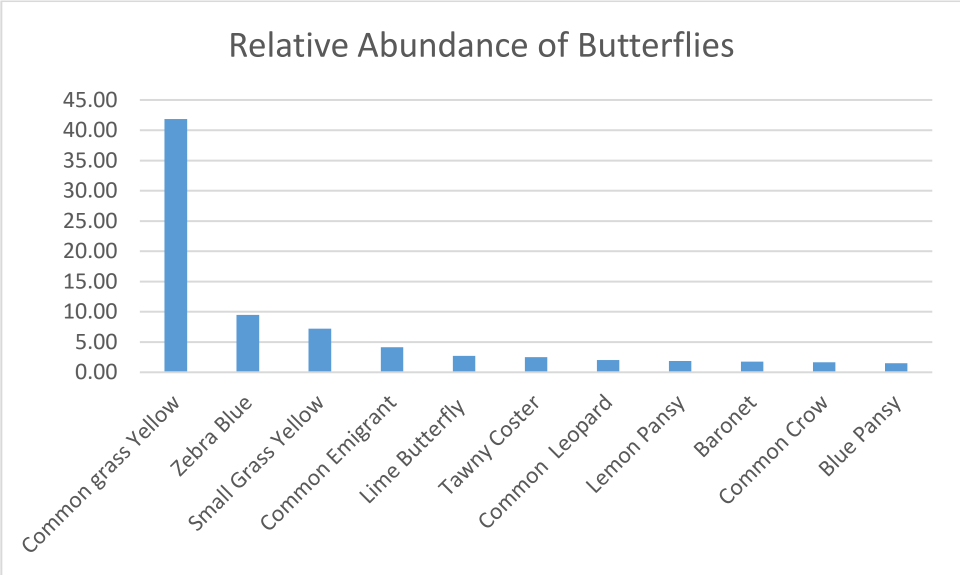


Figure 5-4 Relative Abundance of Butterflies at Ratapani WLS

5.2 BUTTERFLY SPECIES RICHNESS

The total number of butterfly species recorded during the field surveys is the observed species richness. Species richness was calculated for camps, ranges, and for the entire sanctuary using the survey data. Overall, 104 species of butterflies were found during the survey from the Ratapani Wildlife Sanctuary. 4 species were found from the free-check listing while 100 are observed during the trail surveys.

5.2.1 Species Richness at Camp Sites

There were 25 camp sites at which trails were identified and survey was conducted. Highest observed butterfly species richness was found at Bineka (55), followed by Jawra (52), Jaitpur camp (45), Ghat Khamaria (44), Dunwani (43), and Jhiri (43). While the least diverse camps were Kesalwada (16), Amkho (16), Bardha (17), PoW camp (20), Karmai Naka (23) and Bhadbhada Ghat (23) (Table 5-1, Figure 5-5). Estimated species richness of butterflies at camp sites has also been presented in Table 5-1 and Figure 5-6.

Table 5-1: Species Richness (Observed and Estimated) at camp sites

S. No.	Camp Name	Observed Species Richness	Estimated Species Richness (Chao-1)	Upper and Lower Limit (St. Error)
1	Amdoh	36	47	37.15 - 58
2	Bardha	17	20.5	15 - 39
3	Amkho	16	23.5	15 - 30
4	Bhadbhada Gate	23	29.43	23.67 - 41.33
5	Delawari Barrier	30	47.5	29.63 - 56.25
6	POW Camp	20	23.75	19 - 33
7	Mathar	28	35.86	29 - 47.5
8	Mathar Gate	29	31.5	28.86 - 44
9	Barkheda	34	36	34.13 - 44.5
10	Shahganj	36	51.17	37.62 - 60
11	Barrusot	38	39.5	38 - 48
12	Panjhir	30	32.33	30.67 - 48.5
13	Bhootpalashi	39	46.5	39.13 - 53
14	Kesalwada	16	18.5	15.75 - 30
15	Bineka	55	65	56.57 - 80.25
16	Ghat Khamaria	44	55.88	44.91 - 63.5
17	Ghodapachad	37	43.43	36.25 - 55.5
18	Dunwani	43	43.3	42.5 - 53.5
19	Jaitpur camp	45	51.88	45.25 - 64.5
20	Jaitpur 2	34	37.6	34.91 - 53.5
21	Jhiri	43	47.2	43.14 - 58
22	Imaliya Peer baba	37	37.91	37.33 - 50.75
23	Bithori	28	43.6	28.15 - 53.25
24	Jawra Camp	52	52.77	68.5 - 23.6
25	Karmai Naka	23	23.6	23 - 33

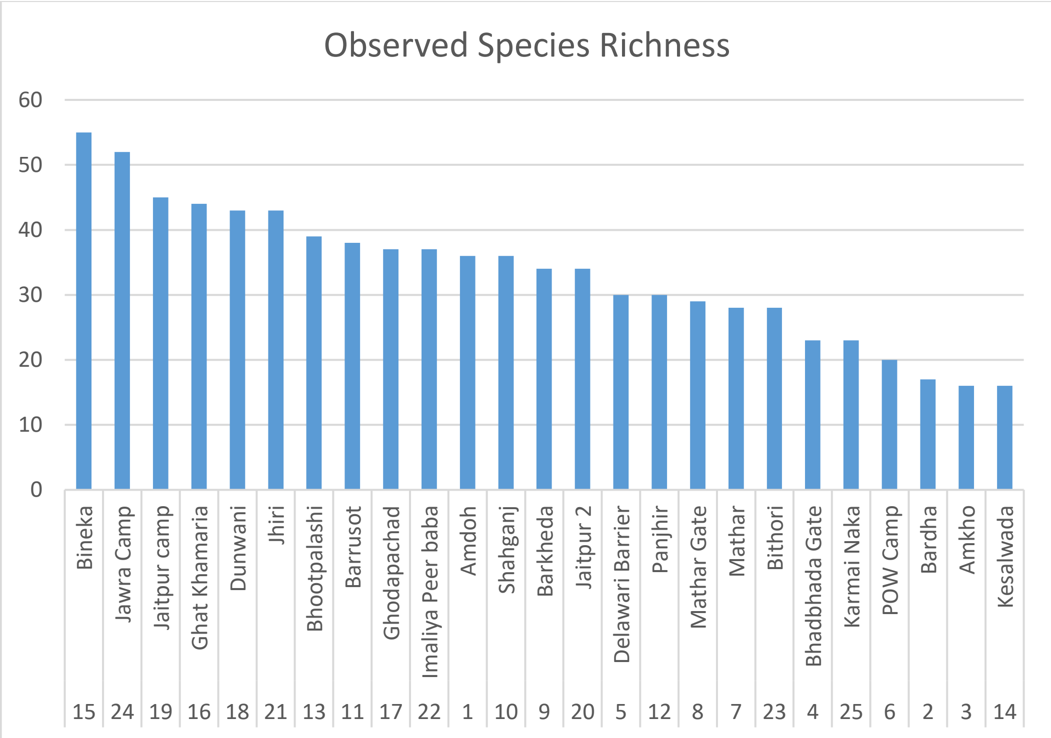


Figure 5-5: Observed Species of butterflies at camp level

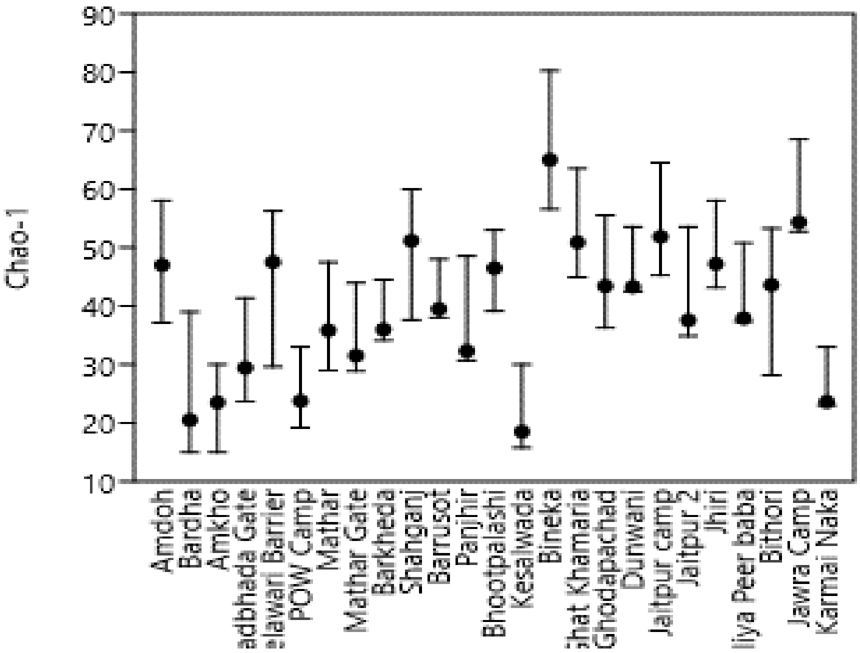


Figure 5-6: Estimated Species Richness at camp level

5.2.2 Species Richness at Range Level

Butterflies' diversity data was collected at trail scale which was then averaged out at camp scale and then to range scale. This helped us to understand the butterfly diversity pattern at different spatial scales. Below is the observed and estimated species richness of butterflies at range level (Table 5-2, Figure 5-7 & 5-8).

Table 5-2: Butterfly species richness (Observed and Estimated) at Range level

Ranges	Observed Species Richness	Estimated Species Richness (Chao-1)	Upper and Lower Limit (Chao-1)
Delawari	52	68.5	52.86 - 74
Barkheda	59	66.5	59.67 - 77.33
Bineka	79	85.5	80.62 - 101.7
Dahod	75	83.75	77.15 - 99

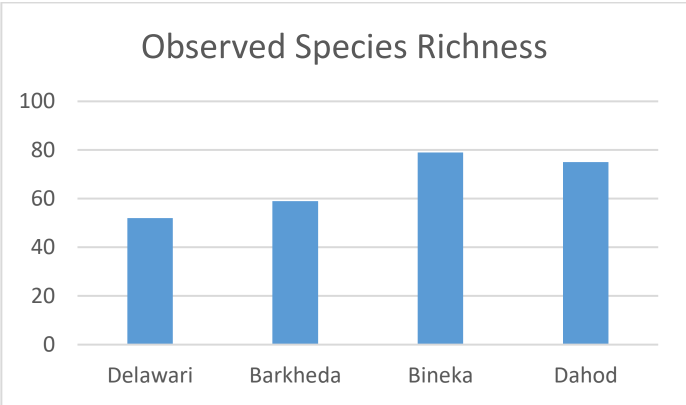


Figure 5-7: Observed Species Richness at Range Level

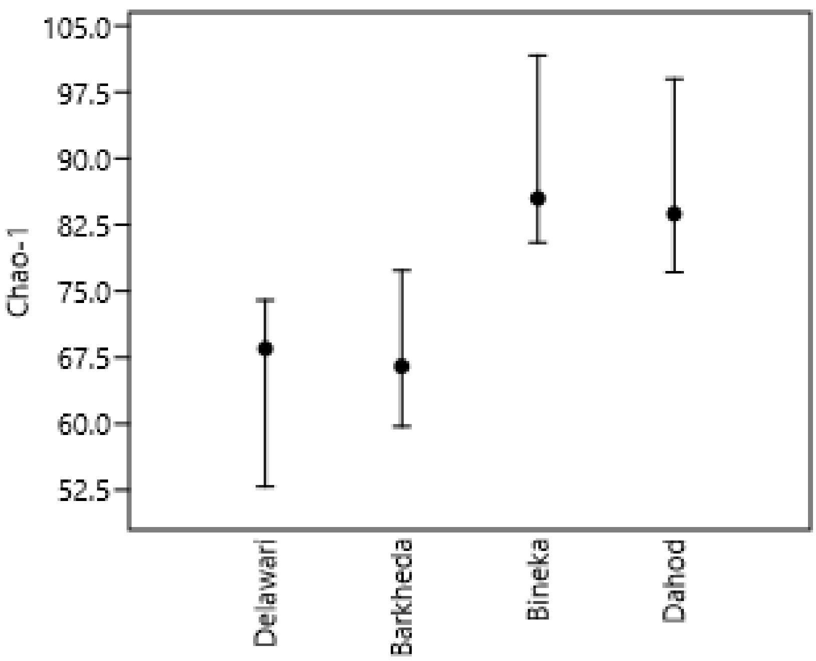


Figure 5-8: Estimated Species Richness of butterflies at Range level

The results suggest that Bineka range was having maximum number of butterfly species i.e. 79 species followed by Dahod (75), Barkheda (59) and Delawari (52) was found to be having minimum number of species of butterflies among the ranges.

5.2.3 Butterfly Species Richness at Ratapani WLS

Observed species richness of butterflies was found to 104 species in which 100 specie were observed during the surveys while 4 species were encountered and listed during free listing in and around camp sites. To find the true number of butterfly species from the study area, species richness estimators were used to determine the estimated species richness. Below is the estimated species richness of butterflies using different estimators in Ratapani Wildlife Sanctuary (Table 5-3):

Table 5-3: Estimated and Observed Species Richness of Butterflies of Ratapani WLS

Estimators	Species Richness	Standard devs:
Observed S:	100	
Chao 2:	110.729	6.43076
Jackknife 1:	119.2	7.58947
Jackknife 2:	123.493	NA
Bootstrap:	109.729	NA

5.3 BUTTERFLY SPECIES DIVERSITY

5.3.1 Species Diversity at Camp Level

Data was averaged out at camp level and analysed and species diversity indices were calculated to understand the diversity of butterflies at camp level. Simpson 1-D index, Shannon Index and Evenness indices were calculated. The results suggest that Barkheda (H=2.97, e^H/S=0.57) is the most diverse camp followed by Bithori (H=2.96, e^H/S= 0.69), Amdoh (H=2.91, e^H/S=0.51), Panjhir (H=2.87, e^H/S=0.59), Jaitpur Camp (H-2.83, e^H/S=0.38). Ghodapachad (H=2.82, e^H/S= 0.45). While the least diverse camps were Mathar (H=0.58, e^H/S= 0.06) followed by Mathar Gate (H=1.24, e^H/S= 0.12), Karmai Naka (H= 1.33, e^H/S = 0.16), Kesalwada (H = 1.35, e^H/S = 0.24) and Bhadbhada Ghat (H = 1.48, e^H/S = 0.19). (Table 5-4, 5-9)

Table 5-4: Camp wise species diversity indices of butterflies

S. No.	Camp Name	Taxa_S	Individuals	Simpson_1-D	Shannon_H	Evenness_e^H/S
1	Amdoh	36	267	0.93	2.91	0.51
2	Bardha	17	31	0.95	2.42	0.66
3	Amkho	16	114	0.68	1.70	0.34
4	Bhadbhada Gate	23	219	0.61	1.48	0.19
5	Delawari Barrier	30	128	0.80	2.29	0.33
6	POW Camp	20	182	0.69	1.83	0.31
7	Mathar	28	892	0.18	0.58	0.06
8	Mathar Gate	29	1072	0.46	1.24	0.12
9	Barkheda	34	243	0.93	2.97	0.57
10	Shahganj	36	224	0.76	2.29	0.28
11	Barrusot	38	1423	0.85	2.52	0.33
12	Panjhir	30	101	0.94	2.87	0.59
13	Bhootpalashi	39	1233	0.90	2.75	0.40
14	Kesalwada	16	96	0.52	1.35	0.24
15	Bineka	55	1020	0.77	2.16	0.16
16	Ghat Khamaria	44	833	0.72	2.14	0.19
17	Ghodapachad	37	307	0.91	2.82	0.45
18	Dunwani	43	1911	0.85	2.43	0.26
19	Jaitpur camp	45	507	0.89	2.83	0.38
20	Jaitpur 2	34	260	0.90	2.70	0.44
21	Jhiri	43	1207	0.80	2.43	0.26
22	Imaliya Peer baba	37	479	0.77	2.34	0.28
23	Bithori	28	57	0.97	2.96	0.69
24	Jawra Camp	52	1491	0.72	2.14	0.16
25	Karmai Naka	23	1066	0.48	1.33	0.16

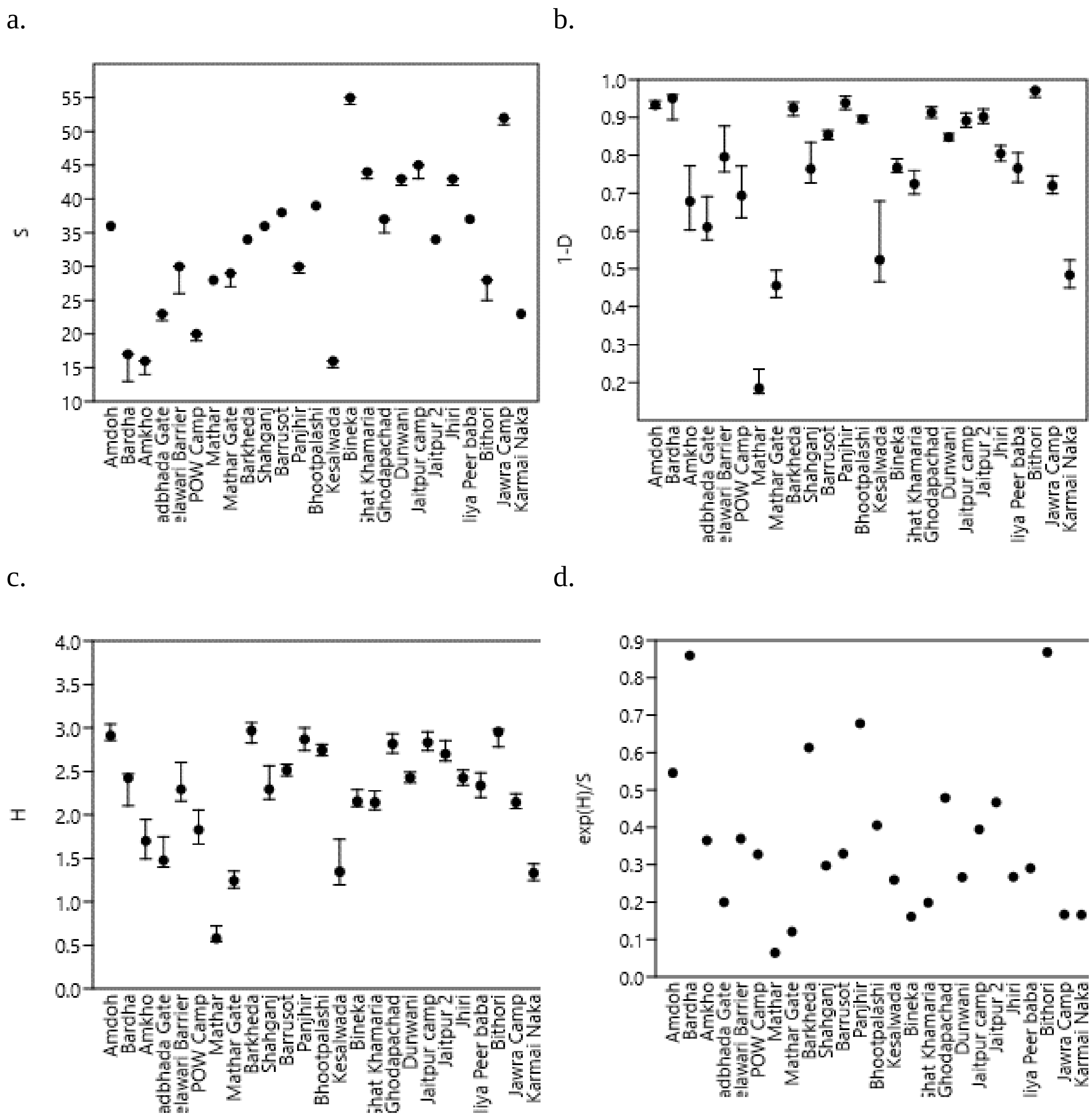


Figure 5-9: Number of species at camp sites (a), Simpson (1-D) index of camp sites (b), and Shannon-

5.3.2 Butterfly Species Diversity at Range Level

Barkheda (H = 2.95, e^H/S = 0.32) range was found to be the most diverse range during the study area followed by Bineka range (H = 2.75, e^H/S = 0.19) and Dahod range (H = 2.28, e^H/S = 0.13). Delawari range (H = 1.66, e^H/S = 0.10) was the least diverse range. (Table 5-5, Figure 5-10)

Table 5-5: Butterfly Species DIversity at Range Level

Indices	Delawari	Barkheda	Bineka	Dahod
Taxa_S	52	59	79	75
Individuals	2905	3320	4838	4300

Simpson_1-D	0.531	0.9053	0.8642	0.7155
Shannon_H	1.661	2.95	2.75	2.282
Evenness_e^H/S	0.1013	0.3239	0.1981	0.1306

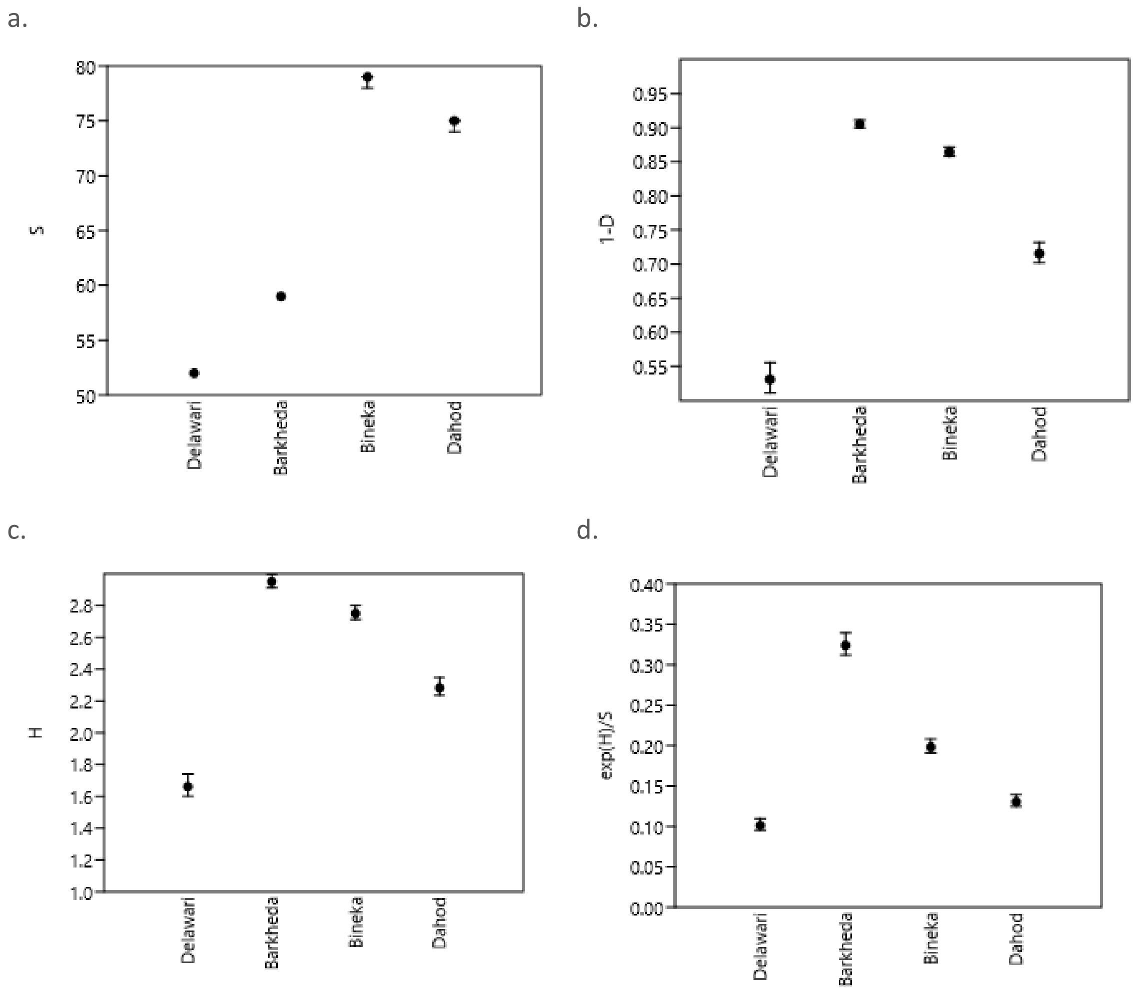


Figure 5-10: Number of species (a), Simpson (1-D) index (b), and Shannon-wiener Index (c) and Evenness index (d) of ranges Ratapani WLS

5.3.3 Butterfly Species Diversity of Ratapani Sanctuary

During the butterfly survey, a total of 15636 individuals of butterflies were observed belonging to 100 species and six families of butterflies. 4 other species of butterflies were also observed beyond the trail survey. The results suggest that the butterfly's diversity at Ratapani Sanctuary is fairly good but the distribution among species is not even as one would have wished for. In addition, in isolation the values of indices will be difficult to interpret the actual scenario of butterfly diversity. However, it will establish a baseline data for butterfly diversity at Ratapani Sanctuary which will be used in future to understand the change in butterfly population with the advent of climate change, habitat loss, anthropogenic pressure and other driving forces.

Table 5-6: Butterfly diversity at Ratapani Wildlife Sanctuary

Diversity Indices	Values
Taxa_S	100
Individuals	15363
Simpson_1-D	0.80
Shannon_H	2.62
Evenness_e^H/S	0.137

5.4 SPECIES ABUNDANCE DISTRIBUTION CURVES

Relative abundance curves of butterflies recorded during the survey in all the ranges were made in PAST program. Relative abundance curves were made for the overall butterfly population of the study area. Butterfly relative abundance curve for the total study area shows that the population follows a lognormal distribution at Ratapani Wildlife Sanctuary (Figure 5-11). In lognormal distribution, few species are common and rare. Rest of the species are moderate in number. Species abundance curves were made for species with more than 20 individuals in the data. The results showed similar pattern following lognormal distribution. There was no effect of rare species truncation from the species data for the butterfly abundance at Ratapani WLS level.

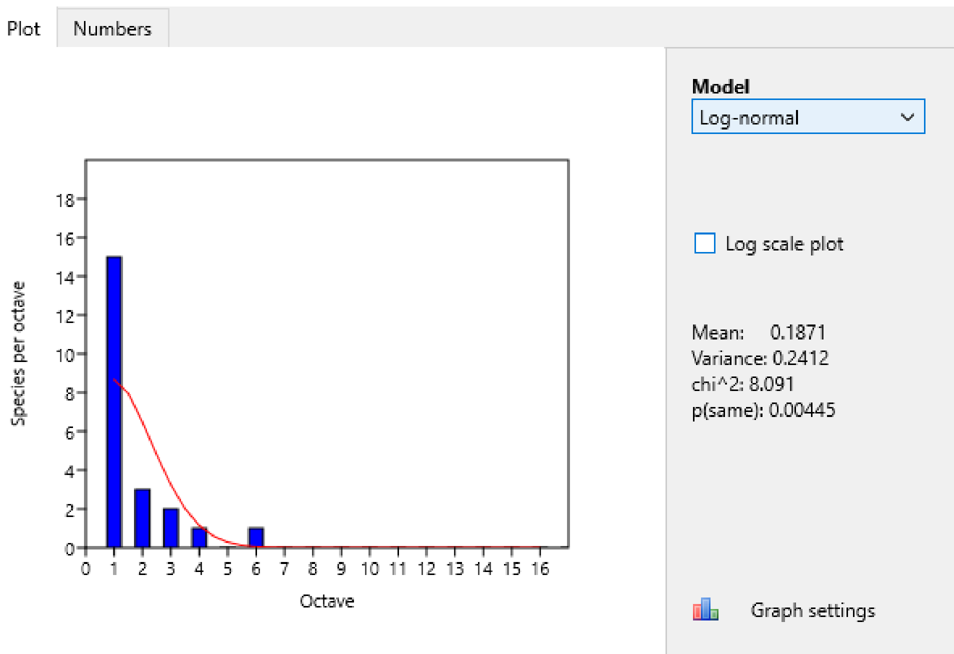


Figure 5-11: Species Abundance Distribution Model for Butterflies at Ratapani WLS level

Relative abundance curves were also made for the four forest ranges separately. In these models, butterfly species were found following lognormal distribution significantly in Bineka range (Figure 5-12), while in Delawari (Figure 5-13), Barkheda (Figure 5-14) and Dahod (Figure 5-15), butterfly population was found to be following log series of distribution.

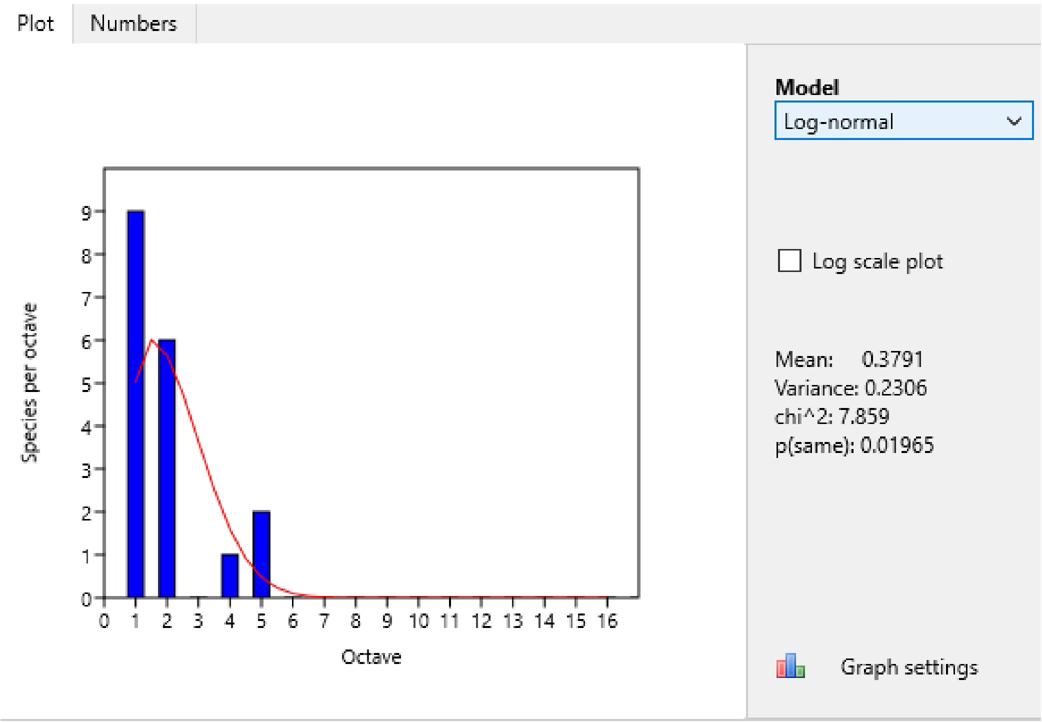


Figure 5-12: Species Abundance Distribution Model for butterflies at Bineka Range

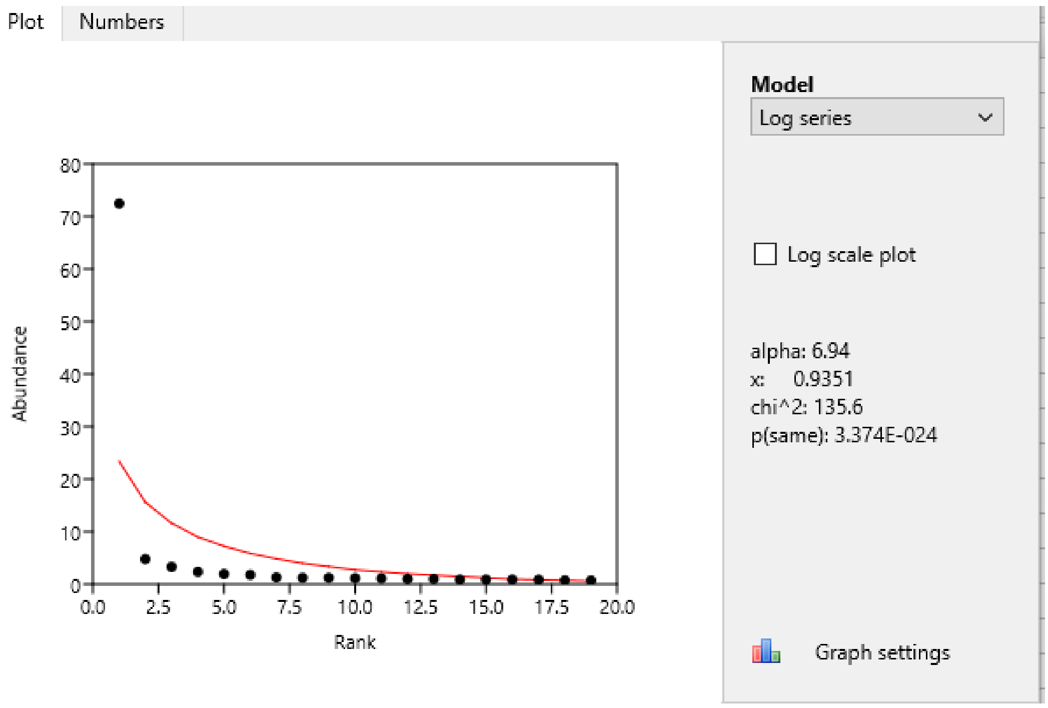


Figure 5-13: Species Abundance Distribution Model for Butterflies at Delawari Range

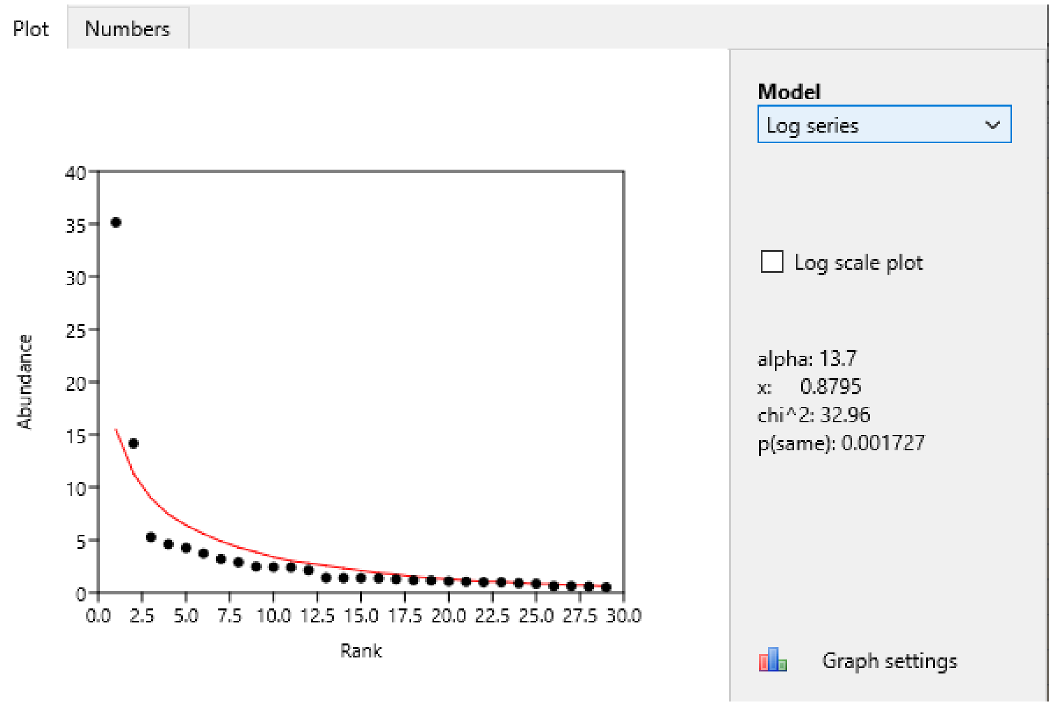


Figure 5-14: Species Abundance Distribution Model for Butterflies at Barkheda Range

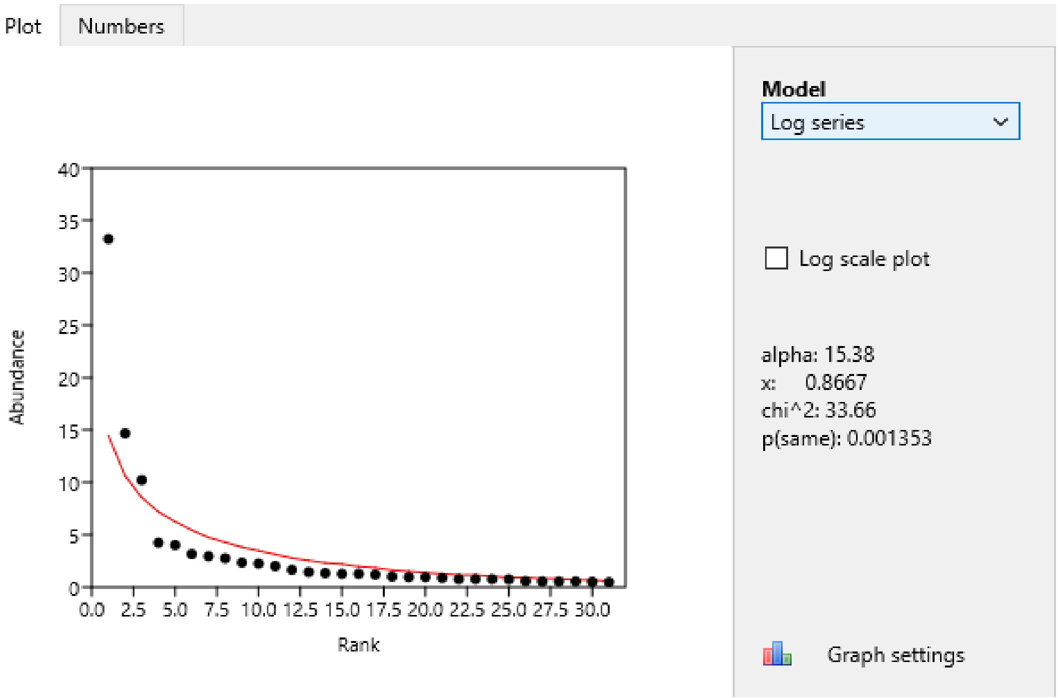


Figure 5-15: Species Abundance Distribution Model for Butterflies at Dahod Range

6. DISCUSSION

Worldwide population of insects including the butterflies are declining becoming an urgent conservation priority across the globe. This decline in insect population can lead to catastrophic effects on various ecosystems. Butterflies are one of the best choices to understand the impact of climate change, habitat degradation, land use change, and other drivers of habitat loss due to the relative ease and popularity of monitoring butterflies. Butterflies are also used as bio-indicators in ecological and environmental studies assuming butterflies faces comparable pressures from various drivers of biodiversity loss. Therefore, it is safe to establish that, continuous monitoring of butterflies can help us protect and conserve biodiversity of a region.

The results of the present study give us an insight into the status of biodiversity of Ratapani Wildlife Sanctuary. These results should be studied carefully due to its less robustness of data collected considering it was first of its kind of citizen science initiative in this landscape. While inferring these results we need to keep into consideration aspects like number of replications, observer's efficiency, how efficiently the survey methodology was followed by the volunteers and lack of seasonal data. However, this study still is able to guide us in the right direction in conserving the butterfly population. A baseline butterfly diversity data has been established which can be utilized by researchers as well as forest managers. The population structure and composition gives us information about the distribution, dispersal, dominance, rarity of various butterfly species.

Butterfly population at Ratapani was found to be dominated by a small number of species. Around 50% of the total number of individuals sampled during the survey belonged to only 2 species which are Common Grass Yellow (RA=42.60%) and Zebra Blue (RA=9.62%). Butterfly diversity was also found to be fair only (H=2.62) but not good. Species abundance distribution models shows that the butterfly community is following Lognormal distribution and Logarithmic distribution. In both the cases, community is dominated by a few species while the number of rare species are large especially in case of Logarithmic series of distribution. This suggests that if timely conservation efforts are not taken few species which are rare can go locally extinct from the Ratapani WLS. Therefore, seasonal monitoring of butterflies is of imminent need at present.

7. CONCLUSION

The present study is a humble attempt to generate scientifically sound data from a citizen science initiative and present the results in a manner to be utilized by the academia and forest managers. The study establishes the fact or sets an example that scientifically sound data can be generated by citizen scientists. Citizen science programs in wildlife and biodiversity should not be only limited to preparation of checklists and mass awareness and sensitization. If properly trained citizen scientists can produce a large amount of scientifically sound data in a very short span of time which can be utilized for the conservation and protection of forests in India. The data can be used by forest managers for informed decision making and habitat augmentation. The support of forest officials along with the efforts of citizen scientists made this program successful. There should be more such events where one can utilize the citizen scientist's knowledge and effort for the betterment of the forests and wildlife. These initiatives can be a good platform to develop public private partnership initiatives between stakeholders like forest department, wildlife enthusiasts, NGOs and corporate sector.

6. LIMITATIONS and RECOMMENDATIONS

- The number of volunteers were less in number in proportion to the size of the sanctuary. An increase in number of volunteers will lead to better team structure with superior exchange of knowledge among the volunteers.
- The survey duration should have been exceeded by 1 or 2 days so that the teams would have taken at least 3 replications of each trail.
- Transportation and access to areas with difficult terrain due to climatic conditions should have been planned beforehand.
- There is a need to develop a Public-Private-Partnership model where stakeholders such as forest department, NGOs, wildlife enthusiasts, researchers and corporate sector can contribute at a same platform for the conservation and protection of forests and wildlife.
- These kind of surveys should not be limited to any specific season but should be replicated every season for the better understanding of seasonal population variation.
- Local communities should also be involved to make these initiatives more sustainable in future.

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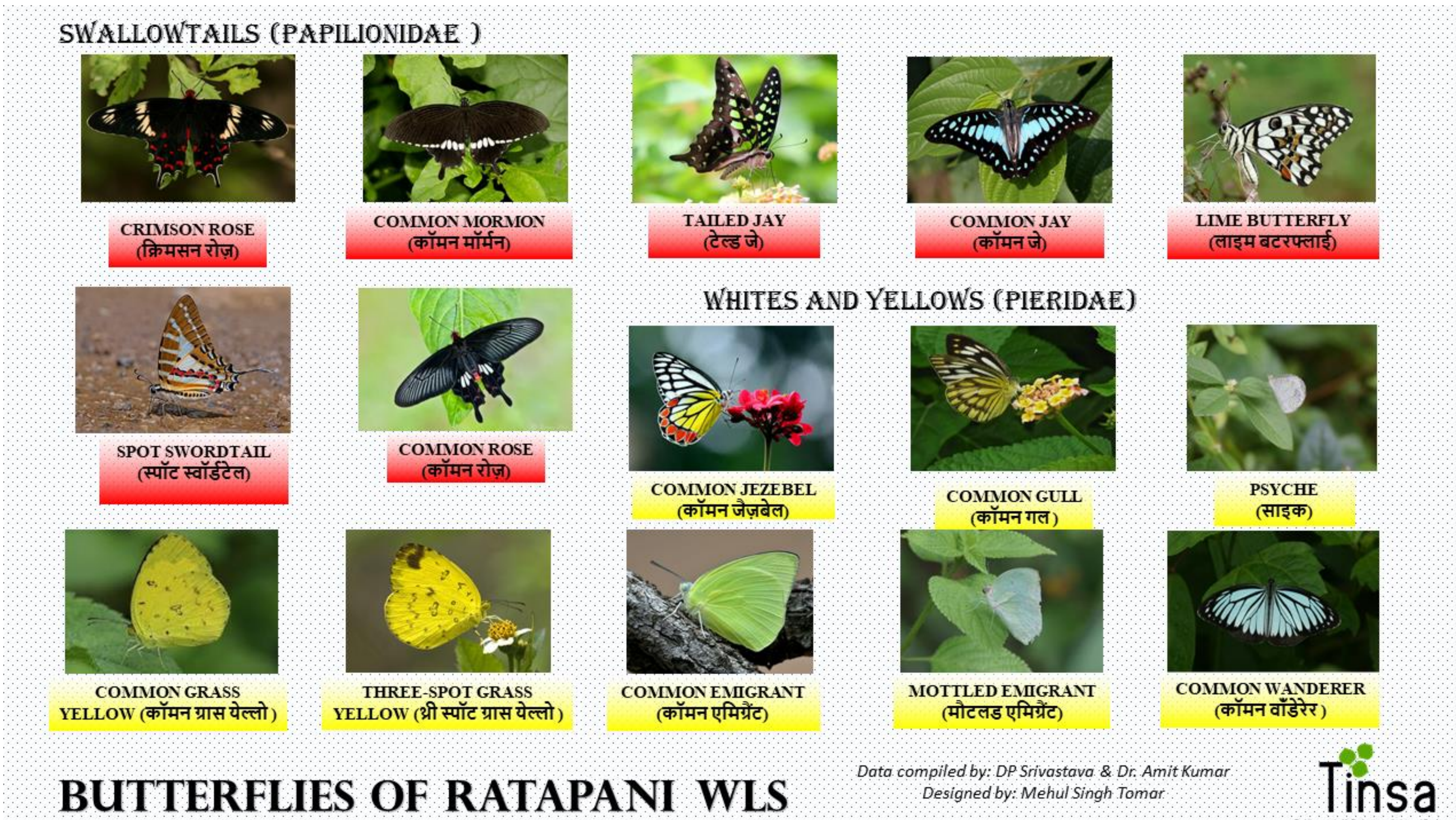
APPENDIX I: BASELINE BUTTERFLY PHOTO-LIST



BRUSH-FOOTED BUTTERFLIES (NYMPHALIDAE)

INDIAN PIONEER
(इंडियन पायनियर)

WHITE ORANGE TIP
(वाइट ऑरेंज टिप)

SMALL ORANGE TIP
(स्मॉल ऑरेंज टिप)

PEACOCK PANSY
(पीकॉक पैन्सी)

LEMON PANSY
(लैमन पैन्सी)

COMMON CASTOR
(कॉमन कैस्टर)

YELLOW PANSY
(येल्लो पैन्सी)

BLUE PANSY
(ब्लू पैन्सी)

GREY PANSY
(ग्रे पैन्सी)

CHOCOLATE PANSY
(चॉकलेट पैन्सी)

COMMON EVENING BROWN (कॉमन इवनिंग ब्राउन)

BAMBOO TREEBROWN
(बैम्बू ट्री ब्राउन)

COMMON CROW
(कॉमन क्रो)

COMMON BUSHBROWN
(कॉमन बुश ब्राउन)

TAWNY COSTER
(टौनि कोस्टर)

BUTTERFLIES OF RATAPANI WLS

Data compiled by: DP Srivastava & Dr. Amit Kumar
Designed by: Mehul Singh Tomar

Tinsa

STRIPED TIGER
(स्ट्रिप्ड टाइगर)

BLUE TIGER
(ब्लू टाइगर)

PLAIN TIGER
(प्लेन टाइगर)

DANIAD EGGFLY
(डेनियड एगफ्लाई)

GREAT EGGFLY
(ग्रेट एगफ्लाई)

BARONET
(बैरोनेट)

COMMON BARON
(कॉमन बैरन)

COMMON SAILOR
(कॉमन सेलर)

COMMON LEOPARD
(कॉमन लेपर्ड)

PAINTED LADY
(पेंटेड लेडी)

COMMON-FIVE-RING
(कॉमन फाइव रिंग)

COMMON-FOUR-RING
(कॉमन फोर रिंग)

SKIPPER (HESPERIIDAE)

RICE SWIFT
(राइस स्विफ्ट)

BROWN AWL
(ब्राउन औल)

INDIAN SKIPPER
(इंडियन स्किपर)

BUTTERFLIES OF RATAPANI WLS

Data compiled by: DP Srivastava & Dr. Amit Kumar
Designed by: Mehul Singh Tomar

Tinsa

BLUES (LYCAENIDAE)


GRASS DEMON
(ग्रास डेमन)


INDIAN PALM BOB
(इंडियन पाम बॉब)


COMMON PIERROT
(कॉमन पिएरोंट)


ROUNDED PIERROT
(राउंडेड पिएरोंट)


FORGET-ME-NOT
(फॉरगेट मी नौट)


COMMON SILVERLINE
(कॉमन सिलवरलाइन)


TINY GRASS BLUE
(टाइनी ग्रास ब्लू)


RED PIERROT
(रेड पिएरोंट)


PLAINS CUPID
(प्लेन्स क्यूपिड)


ZEBRA BLUE
(ज़ेब्रा ब्लू)


PEA BLUE
(पी ब्लू)


PALE GRASS BLUE
(पेल ग्रास ब्लू)


GRAM BLUE (ग्राम ब्लू)


COMMON CERULEAN
(कॉमन सेरुलीन)


COMMON LINEBLUE
(कॉमन लाइनब्लू)

BUTTERFLIES OF RATAPANI WLS

Data compiled by: DP Srivastava & Dr. Amit Kumar
Designed by: Mehul Singh Tomar

Tinsa
Enabling sustainable Environment, Society and Development

APPENDIX II: DATASHEET USED FOR SURVEY

Butterfly Survey, 2021 Ratapani Wildlife Sanctuary

Date ________ Start Time _______ End Time_______ Start Location_____________

End Location________ Location Id/ Range name _______ Camp ______ Team Member_________

Sr. No	**Time**	**Habitat Type**	**Coordinates (every 500 mt)**		**Species**	**Count**	**Host/Nectar plant**	**Remark (Caterpillar, Pupa, activities)**
			Latitude	**Longitude**				

Adapted from:: Butterfly Transect Counts-Manual v1.pdf (butterfly-monitoring.net.

Habitat Types: Dense to moderately dense Forest, Open Forest, Scrub land, Grassland, Agriculture, Waterbody, Grassland

Opportunistic Findings:

APPENDIX III: CHECKLIST OF SPECIES RECORDED DURING SURVEY

S No.	Family	Species	Scientific Name	Conservation Importance	
				IUCN	**WPA 1972**
1	Hesperiidae	Brown Awl	*Badamia exclamationis*		
2		Ceylon Swift	*Parnara bada*		
3		Common Banded Awl	*Hasora chromus*		
4		Common Branded Swift	*Pelopidas subochracea*		
5		Conjoined Swift	*Pelopidas conjuncta*		
6		Grass Demon	*Udaspes folus*		
7		Indian Dartlet	*Oriens goloides*	Not evaluated	
8		Indian Grizzled Skipper	*Spialia galba*	Not evaluated	
9		Indian Palm Bob	*Suastus gremius*	Not evaluated	
10		Rice Swift	*Borbo cinnara*	Not evaluated	
11		Tri-colour Pied Flat	*Coladenia indran*		
12		Small banded swift	*Pelopidas mathias*		
13		Vindhyan Bob	*Arnetta vindhiana*		
14	Lycaenidae	Angled Pierrot	*Caleta decidia*	Least Concern	
15		Common Cerulean	*Jamides celeno*		
16		Common Guava Blue	*Deudorix isocrates*	Not evaluated	
17		Common Hedge Blue	*Acytolepis puspa*	Not evaluated	
18		Common Line blue	*Prosotas nora*		
19		Common Pierrot	*Castalius rosimon*	Not evaluated	Schedule I - Part IV
20		Common Shot Silverline	*Cigaritis ictis*		
21		Common Silverline	*Cigaritis vulcanus*	Not evaluated	
22		Dark cerulean	*Jamides bochus*		
23		Dark Grass Blue	*Zizeeria karsandra*	Least Concern	
24		Forget-me-not	*Catochrysops strabo*	Not evaluated	
25		Gram Blue	*Euchrysops cnejus*	Not evaluated	Schedule II - Part II
26		Grass Jewel	*Freyeria trochylus*	Least Concern	
27		Indian Cupid	*Chilades parrhasius*	Not evaluated	
28		Leaf blue	*Amblypodia anita*		
29		Lesser Grass Blue	*Zizina otis*	Not evaluated	
30		Lime blue	*Chilades lajus*		
31		Pale Grass Blue	*Pseudozizeeria maha*	Not evaluated	
32		Pea Blue	*Lampides boeticus*	Least Concern	Schedule II - Part II
33		Plains Cupid	*Chilades pandava*	Not evaluated	

34		Red Pierrot	*Talicada nyseus*	Not evaluated	
35		Red Flash	*Rapala iarbus*		
36		Rounded Pierrot	*Tarucus extricatus*		
37		Striped Pierrot	*Tarucus nara*		
38		Tailless Lineblue	*Prosotas dubiosa*		Schedule II - Part II
39		Tiny Grass Blue	*Zizula hylax*	Not evaluated	
40		Zebra Blue	*Leptotes plinius*	Not evaluated	
41		Dull Babul Blue	*Azanus uranus*		
42	Nymphalidae	Angled Castor	*Ariadne ariadne*	Not evaluated	
43		Anomalous Nawab	*Charaxes agrarius*	Not evaluated	
44		Baronet	*Euthalia nais*	Not evaluated	
45		Black Rajah	*Charaxes solon*	Not evaluated	
46		Blue Tiger	*Tirumala limniace*	Not evaluated	
47		Blue Pansy	*Junonia orithya*	Not evaluated	
48		Chocolate Pansy	*Junonia iphita*	Not evaluated	
49		Commander	*Moduza procris*		
50		Common Nawab	*Polyura athamas*		
51		Common Baron	*Euthalia aconthea*	Not evaluated	
52		Common Leopard	*Phalanta phalantha*	Not evaluated	
53		Common Bushbrown	*Mycalesis perseus*		
54		Common Castor	*Ariadne merione*	Not evaluated	
55		Brown King crow	*Euploea klugii*		
56		Common Crow	*Euploea core*	Least Concern	Schedule IV
57		Common evening brown	*Melanitis leda*	Not evaluated	
58		Common Five-ring	*Ypthima baldus*	Not evaluated	
59		Common Four-ring	*Ypthima huebneri*	Not evaluated	
60		Common Sailor	*Neptis hylas*	Not evaluated	
61		Common Three ring	*Ypthima asterope*		
62		Common Treebrown	*Lethe rohria*		
63		Danaid Eggfly	*Hypolimnas misippus*	Not evaluated	Schedule II - Part II
64		Dark-branded Bushbrown	*Mycalesis mineus*	Not evaluated	Schedule II - Part II
65		Glassy Tiger	*Parantica aglea*	Not evaluated	Schedule II - Part II
66		Great Eggfly	*Hypolimnas bolina*	Not evaluated	
67		Grey Pansy	*Junonia atlites*	Not evaluated	
68		Lemon Pansy	*Junonia lemonias*	Not evaluated	
69		Long-brand Bushbrown	*Mycalesis visala*		
70		Painted Lady	*Vanessa cardui*	Not evaluated	
71		Peacock Pansy	*Junonia almana*	Least Concern	
72		Plain Tiger	*Danaus chrysippus*	Least Concern	

73		Short-banded Sailer	*Phaedyma columella*		Schedule I - Part IV
74		Striped Tiger	*Danaus genutia*	Not evaluated	
75		Tawny Coster	*Acraea terpsicore*	Not evaluated	
76		Yellow Pansy	*Junonia hierta*		
77	Papilionidae	Common Bluebottle	*Graphium sarpedon*		
78		Common Jay	*Graphium doson*	Not evaluated	
79		Common Mime	*Papilio clytia*		Schedule I - Part IV
80		Common Mormon	*Papilio polytes*	Not evaluated	
81		Common Rose	*Pachliopta aristolochiae*	Least Concern	
82		Common Swallowtail	*Papilio machaon*		
83		Crimson Rose	*Pachliopta hector*	Least Concern	Schedule I - Part IV
84		Indian Spot-swordtail	*Graphium nomius*		
85		Lime Butterfly	*Papilio demoleus*	Not evaluated	
86		Tailed Jay	*Graphium agamemnon*	Not evaluated	
87	Pieridae	Common Albatross	*Appias albina*		
88		Common Gull	*Cepora nerissa*	Not evaluated	Schedule II - Part II
89		Common Emigrant	*Catopsilia pomona*	Not evaluated	
90		Common grass Yellow	*Eurema hecabe*	Not evaluated	
91		Common Jezebel	*Delias eucharis*	Not evaluated	
92		Common Wanderer	*Pareronia valeria*		
93		Large Cabbage White	*Pieris brassicae*		
94		Mottled Emigrant	*Catopsilia pyranthe*	Not evaluated	
95		One-spot grass yellow	*Eurema andersonii*		
96		Pioneer	*Belenois aurota*	Not evaluated	
97		Psyche	*Leptosia nina*		
98		Small Grass Yellow	*Eurema brigitta*	Not evaluated	
99		Spotless Grass Yellow	*Eurema laeta*	Not evaluated	
100		Three-spot Grass Yellow	*Eurema blanda*		
101		White ornage tip	*Ixias marianne*	Not evaluated	
102		Yellow orange tip	*Ixias pyrene*	Not evaluated	
103	Riodinidae	Double-banded Judy	*Abisara bifasciata*	Not evaluated	
104		Plum Judy	*Abisara echerius*	Not evaluated	

APPENDIX IV: PHOTO-LIST OF BUTTERFLIES RECORDED DURING SURVEY

SKIPPER (HESPERIIDAE)


BROWN AWL
(ब्राउन औल)


CEYLON SWIFT
(सीलोन स्विफ्ट)


COMMON BANDED AWL (कॉमन बैंडेड औल)


COMMON BRANDED SWIFT (कॉमन ब्रैंडेड स्विफ्ट)


CONJOINED SWIFT
(कनजॉइंट स्विफ्ट)

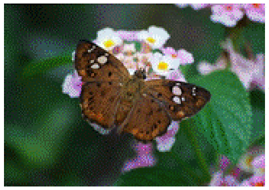

GRASS DEMON
(ग्रास डेमन)


INDIAN DARTLET
(इंडियन डार्टलेट)


INDIAN GRIZZLED SKIPPER (इंडियन स्किपर)


INDIAN PALM BOB
(इंडियन पाम बॉब)


RICE SWIFT
(राइस स्विफ्ट)


TRICOLOR PIED FLAT
(ट्राईकलर पाईड फ्लैट)


VINDHYAN BOB
(विंध्यन बॉब)


SMALL BANDED SWIFT ()

BLUES (LYCAENIDAE)

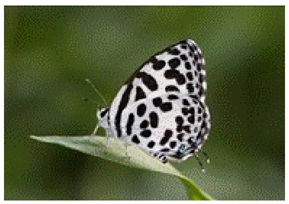
ANGLED PIERROT
(एंगल्ड पिएरोट)

COMMON CERULEAN
(कॉमन सेरुलीन)

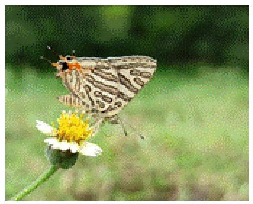
COMMON GUAVA BLUE (कॉमन गुआवा ब्लू)

COMMON HEDGE BLUE (कॉमन हेज ब्लू)

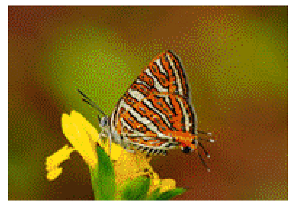
COMMON LINEBLUE
(कॉमन लाइनब्लू)



COMMON PIERROT
(कॉमन पिएरोट)



COMMON SHOT SILVERLINE (कॉमन शॉट सिलवरलाइन)



COMMON SILVERLINE (कॉमन सिलवरलाइन)

DARK CERULEAN
(डार्क सेरुलीन)

DARK GRASS BLUE
(डार्क ग्रास ब्लू)

FORGET-ME-NOT
(फॉरगेट मी नौट)

GRAM BLUE (ग्राम ब्लू)

GRASS JEWEL (ग्रास ज्वेल)

INDIAN CUPID
(इंडियन क्यूपिड)

LESSER GRASS BLUE
(लेस्सर ग्रास ब्लू)

BLUES (LYCAENIDAE)

INDIAN LIME BLUE
(इंडियन लाइम ब्लू)

PALE GRASS BLUE
(पेल ग्रास ब्लू)

PEA BLUE
(पी ब्लू)

PLAINS CUPID
(प्लेन्स क्यूपिड)

RED PIERROT
(रेड पिएरॉट)

INDIAN RED FLASH
(इंडियन रैड फ़्लैश)

ROUNDED PIERROT
(राउंडेड पिएरॉट)

STRIPED PIERROT
(स्ट्रिप्ड पिएरॉट)

TAILLESS LINE BLUE
(टेललेस लाइन ब्लू)

TINY GRASS BLUE
(टाइनी ग्रास ब्लू)

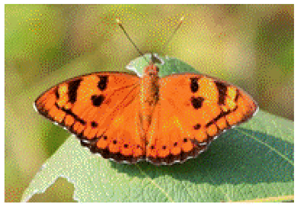
INDIAN PURPLE LEAF BLUE
(इंडियन पर्पल लीफ ब्लू)

ZEBRA BLUE
(ज़ेब्रा ब्लू)

DULL BABUL BLUE
(डल बबूल ब्लू)

BRUSH-FOOTED BUTTERFLIES (NYMPHALIDAE)

ANOMALOUS NAWAB (अनोमलस नवाब)

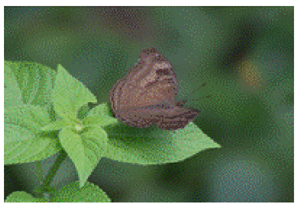


BARONET (बैरोनेट)

BLACK RAJAH (ब्लैक राजा)

BLUE TIGER (ब्लू टाइगर)

BLUE PANSY (ब्लू पैन्सी)

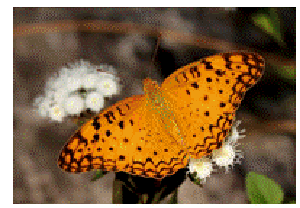


CHOCOLATE PANSY (चॉकलेट पैन्सी)

COMMANDER (कमांडर)

COMMON NAWAB (कॉमन नवाब)

COMMON BARON (कॉमन बैरन)



COMMON LEOPARD (कॉमन लेपर्ड)

COMMON BUSHBROWN (कॉमन बुश ब्राउन)

COMMON CASTOR (कॉमन कैस्टर)

COMMON CROW (कॉमन क्रो)

COMMON EVENING BROWN (कॉमन इवनिंग ब्राउन)

COMMON FOUR-RING (कॉमन फोर रिंग)

BRUSH-FOOTED BUTTERFLIES (NYMPHALIDAE)

COMMON FIVE-RING
(कॉमन फाइव रिंग)

COMMON SAILOR
(कॉमन सेलर)

COMMON THREE-RING
(कॉमन थ्री रिंग)

COMMON TREEBROWN
(कॉमन ट्री ब्राउन)

DANIAD EGGFLY
(डेनियड एगफ्लाई)

DARK BRANDED BUSHBROWN (डार्क ब्रैंडेड बुश ब्राउन)

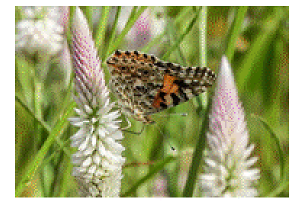
GLASSY TIGER
(ग्लासी टाइगर)

GREAT EGGFLY
(ग्रेट एगफ्लाई)

GREY PANSY
(ग्रे पैन्सी)

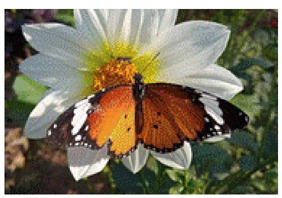
LEMON PANSY
(लैमन पैन्सी)

LONG BRANDED BUSHBROWN (लौंग ब्रैंडेड बुश ब्राउन)

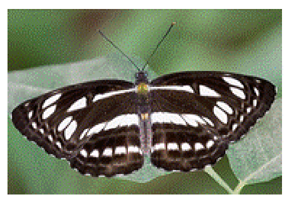


PAINTED LADY
(पेंटेड लेडी)

PEACOCK PANSY
(पीकॉक पैन्सी)



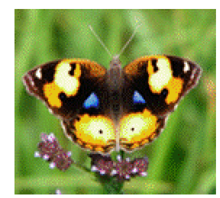
PLAIN TIGER
(प्लेन टाइगर)



SHORT BANDED SAILOR
(शॉर्ट बैंडेड सेलर)

STRIPED TIGER
(स्ट्रिप्ड टाइगर)

TAWNY COSTER
(टौनि कोस्टर)



YELLOW PANSY
(येल्लो पैन्सी)

BRUSH-FOOTED BUTTERFLIES (NYMPHALIDAE)

Angled Castor ()

Brown King Crow ()

SWALLOWTAILS (PAPILIONIDAE)

COMMON BLUEBOTTLE
(कॉमन ब्लू बॉटल)

COMMON JAY
(कॉमन जे)

COMMON MIME
(कॉमन माइम)

COMMON MORMON
(कॉमन मॉर्मन)

COMMON ROSE
(कॉमन रोज़)

COMMON SWALLOWTAIL
(कॉमन स्वालोटेल)

CRIMSON ROSE
(क्रिमसन रोज़)

TAILED JAY
(टेल्ड जे)

SPOT SWORDTAIL
(स्पॉट स्वॉर्डटेल)

LIME BUTTERFLY
(लाइम बटरफ्लाई)

WHITES AND YELLOWS (PIERIDAE)

COMMON ALBATROSS (कॉमन अल्बट्रोस)

COMMON GULL (कॉमन गल)

COMMON EMIGRANT (कॉमन एमिग्रैंट)

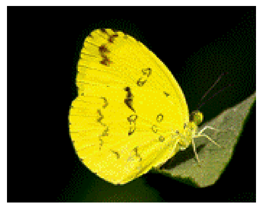
COMMON GRASS YELLOW (कॉमन ग्रास येल्लो)

COMMON JEZEBEL (कॉमन जैज़बेल)

COMMON WANDERER (कॉमन वाँडेरेर)

INDIAN CABBAGE WHITE (इंडियन कैबेज वाइट)

MOTTLED EMIGRANT (मौटलड एमिग्रैंट)



ONE-SPOT GRASS YELLOW (वन स्पॉट ग्रास येल्लो)

INDIAN PIONEER (इंडियन पायनियर)

PSYCHE (साइक)

SMALL GRASS YELLOW (स्मॉल ग्रास येल्लो)

SMALL ORANGE TIP (स्मॉल ऑरेंज टिप)

SPOTLESS GRASS YELLOW (स्पॉटलेस ग्रास येल्लो)

THREE-SPOT GRASS YELLOW (थ्री स्पॉट ग्रास येल्लो)

WHITE ORANGE TIP (वाइट ऑरेंज टिप)

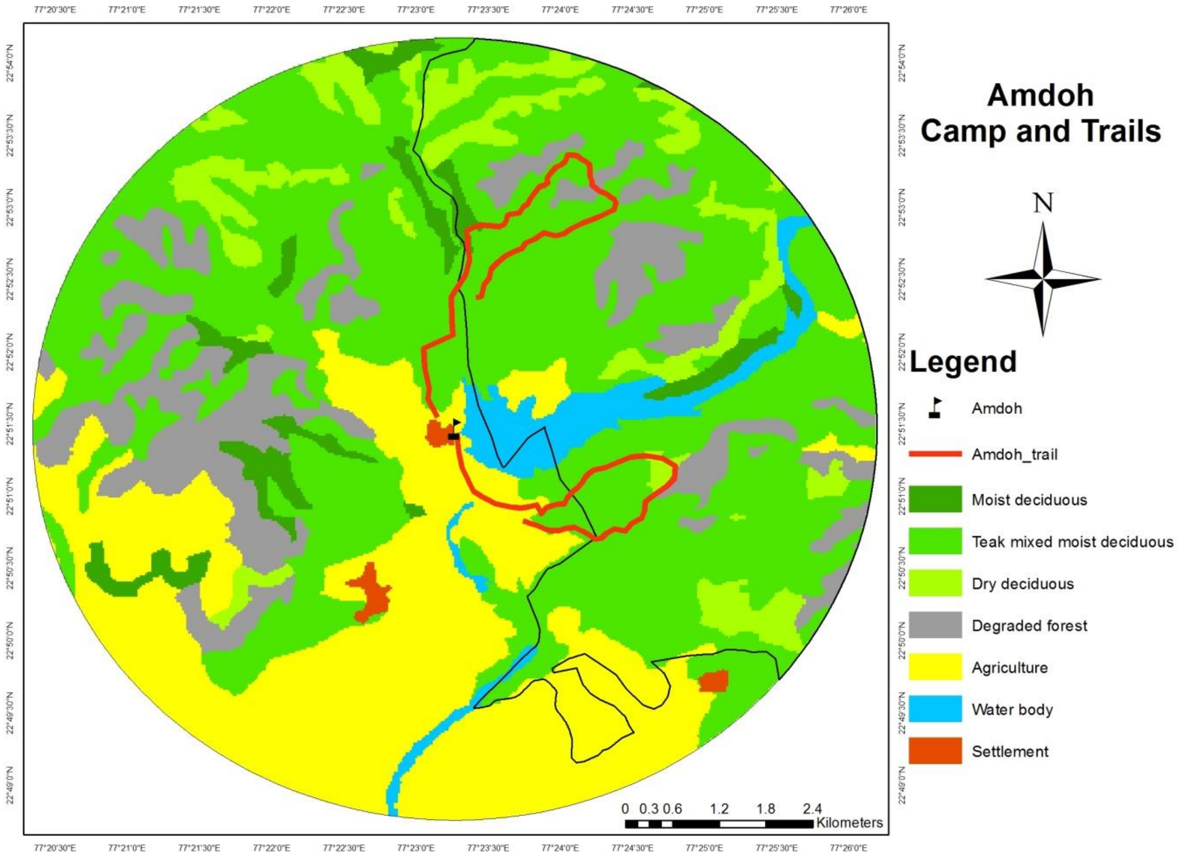
YELLOW ORANGE TIP (येल्लो ऑरेंज टिप)

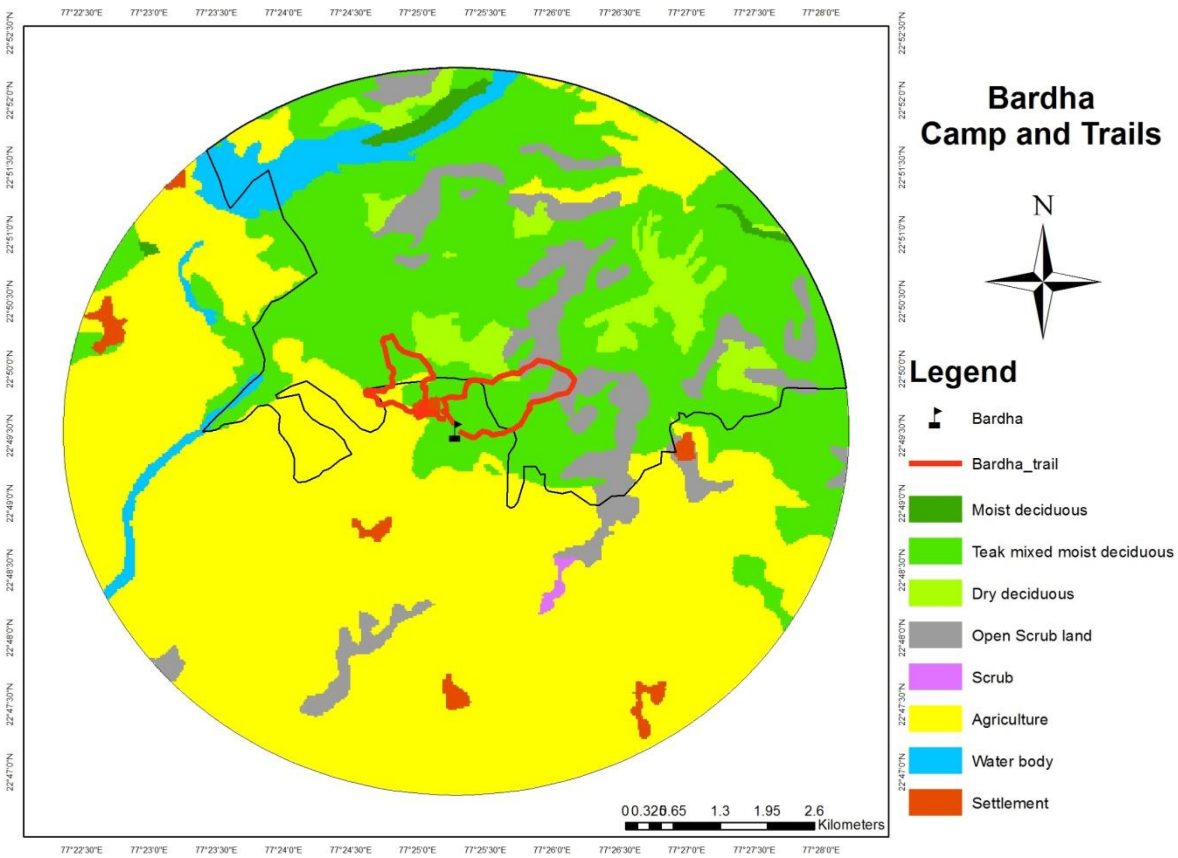
METALMARK (RIODINIDAE)

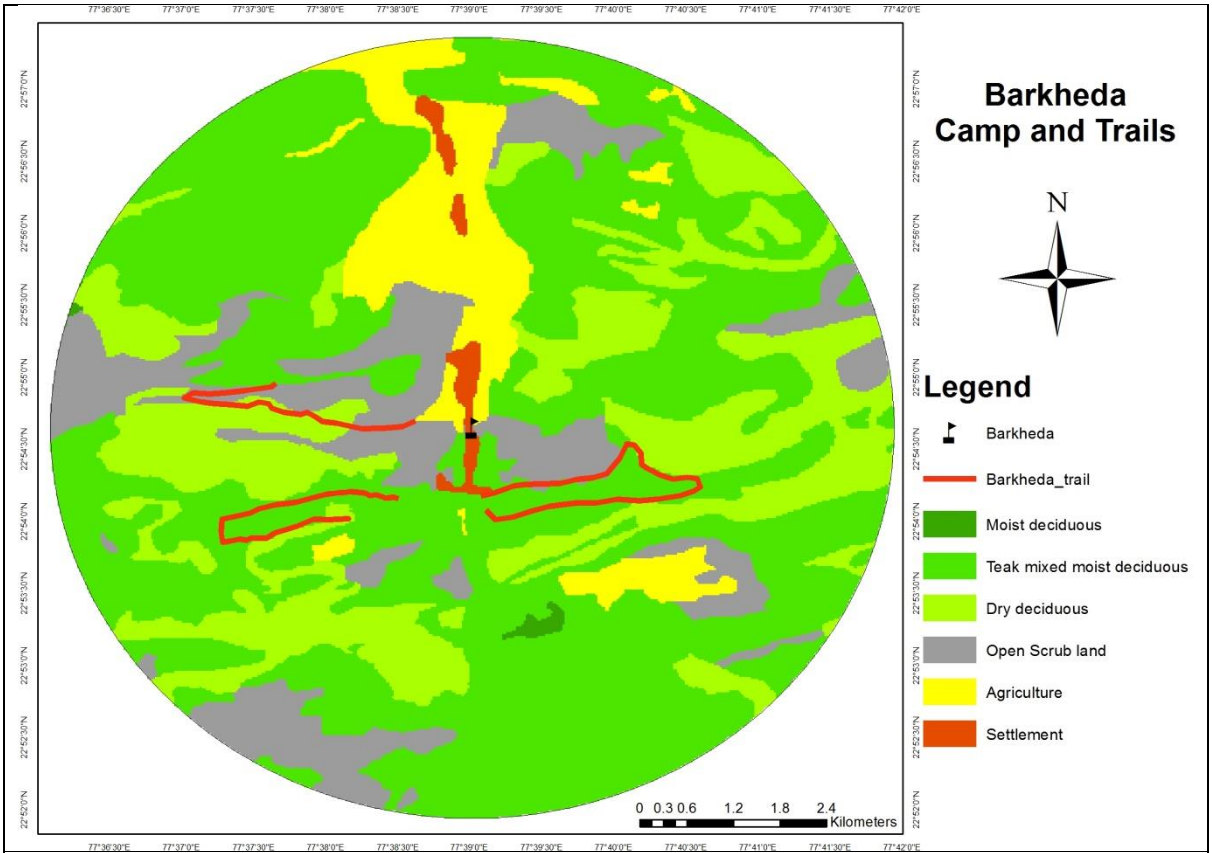
DOUBLE BANDED JUDY (डबल बैंडेड जुडी)

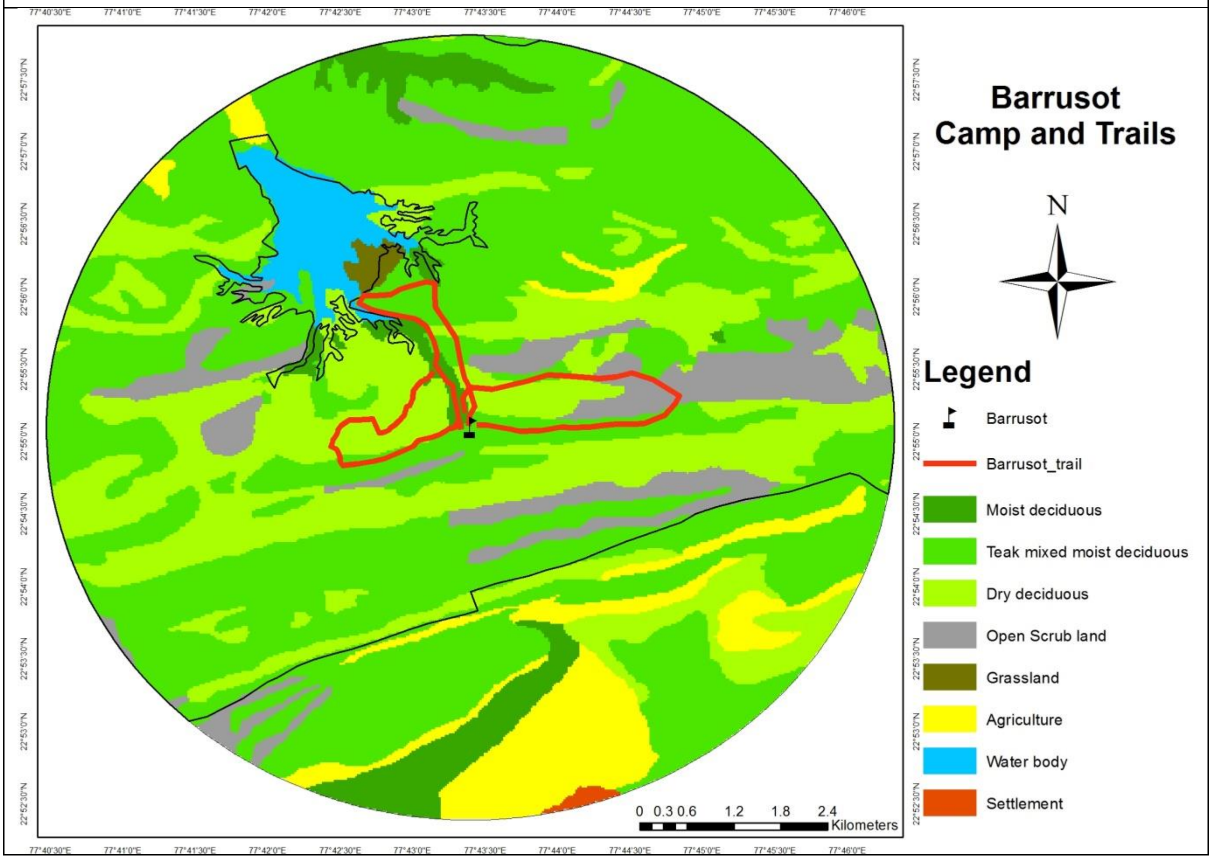
PLUM JUDY (प्लम जुडी)

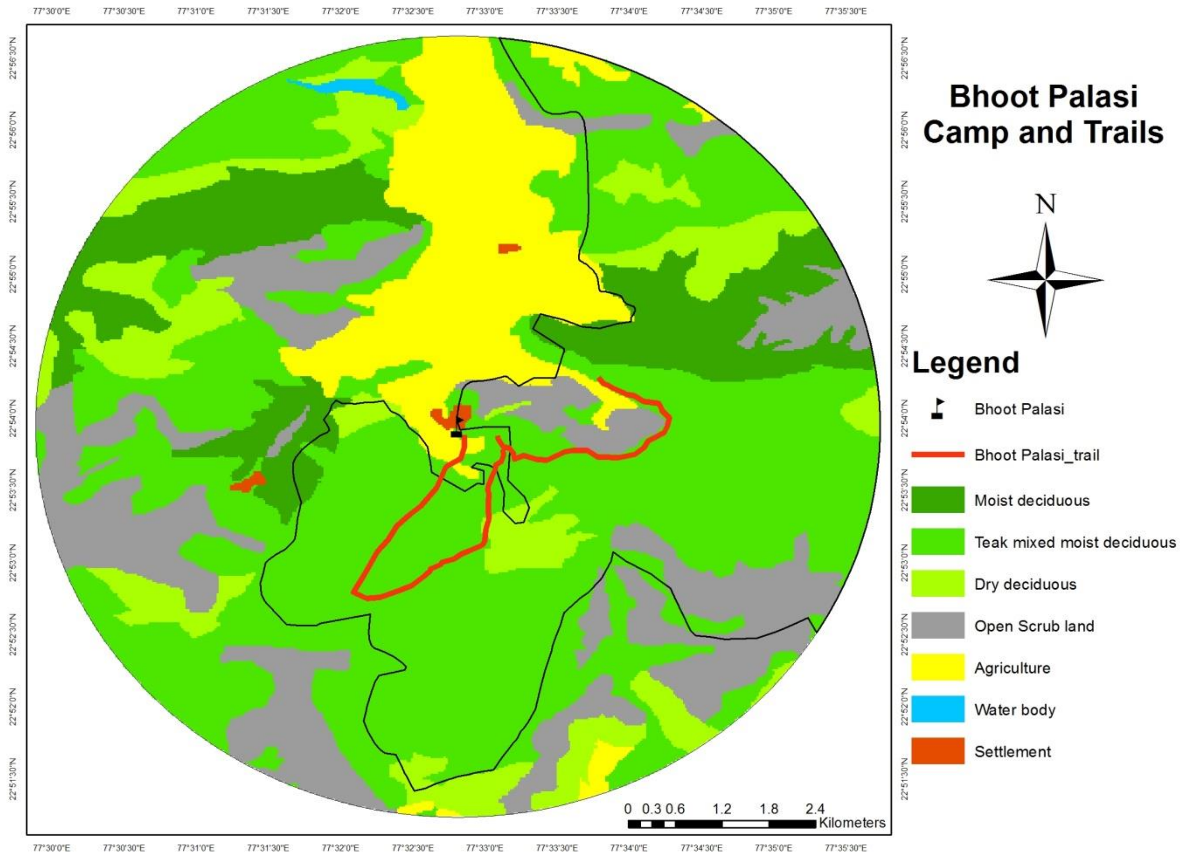
APPENDIX V: CAMPWISE MAPS FOR BUTTERFLY SURVEY

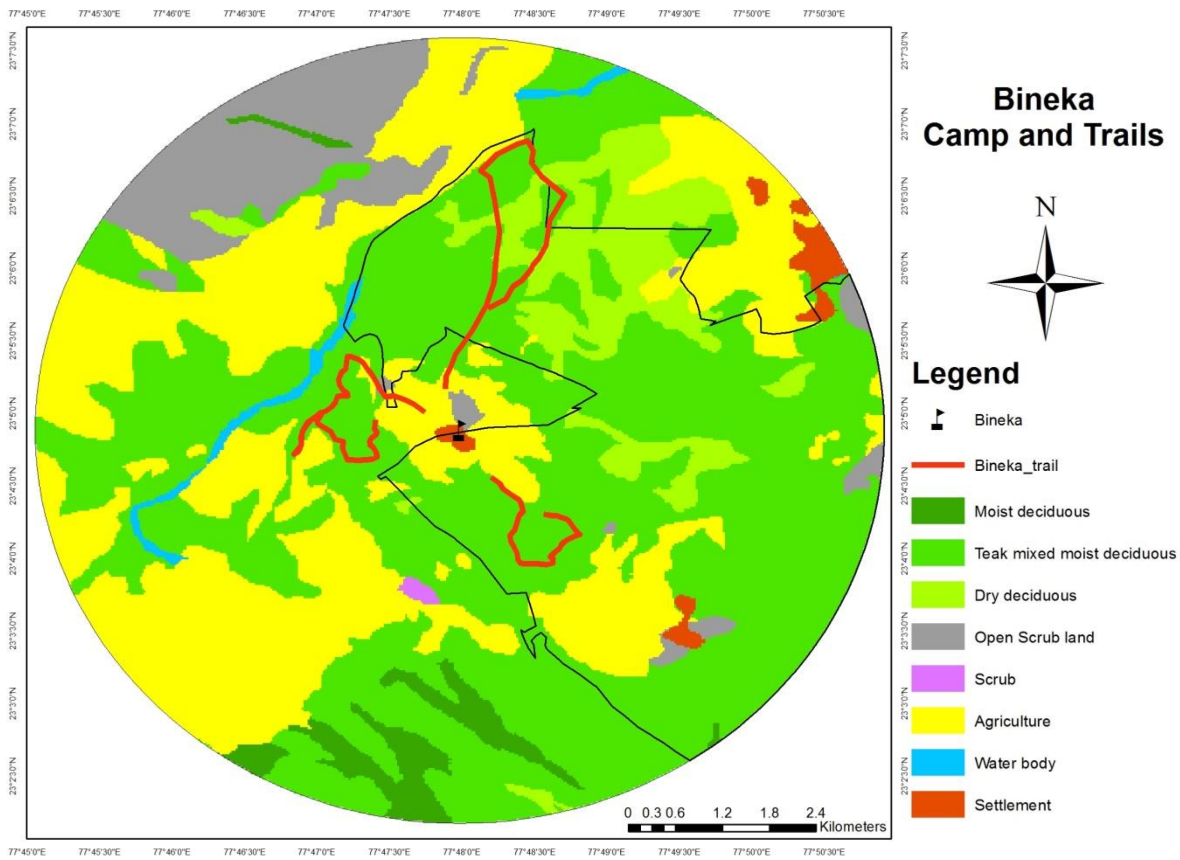


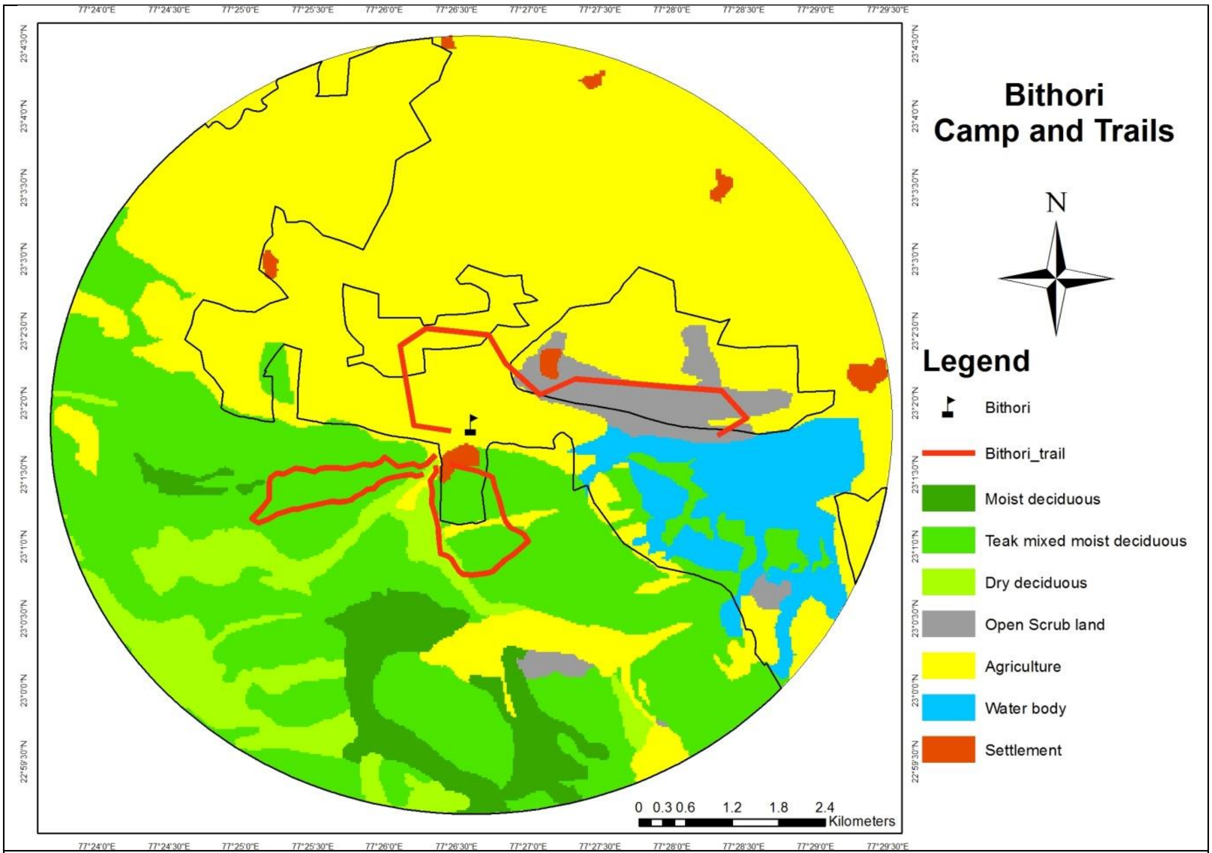


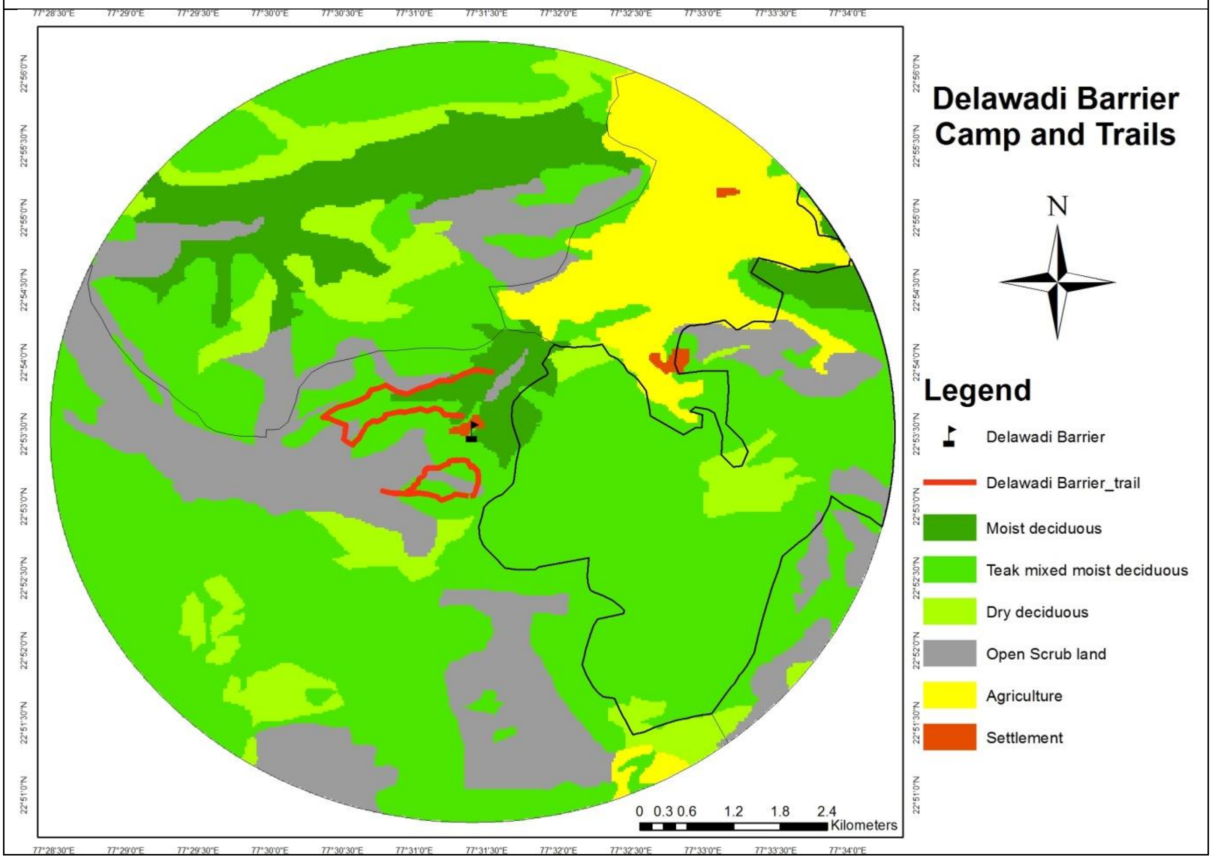

Barkheda
Camp and Trails
N
Legend
Barkheda
Barkheda_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Agriculture
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers

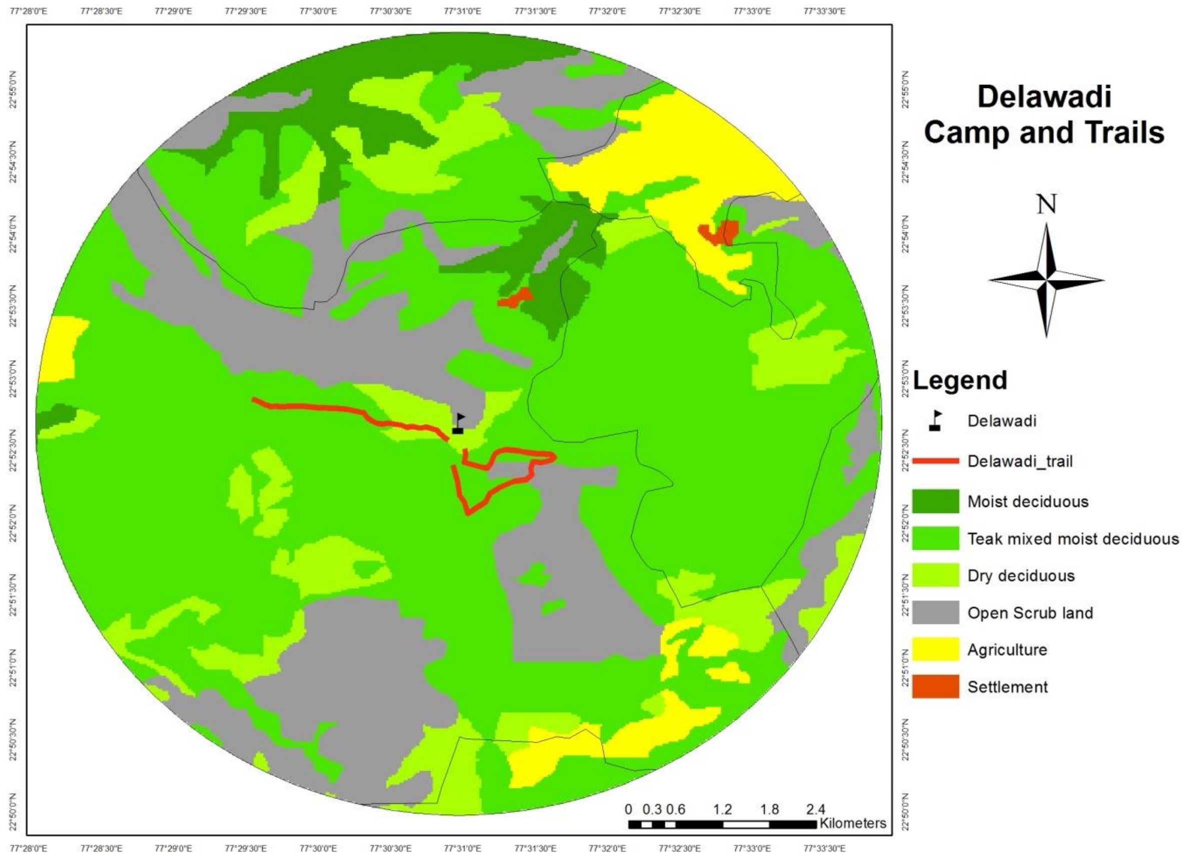

Barrusot
Camp and Trails
N
Legend
Barrusot
Barrusot_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Grassland
Agriculture
Water body
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers

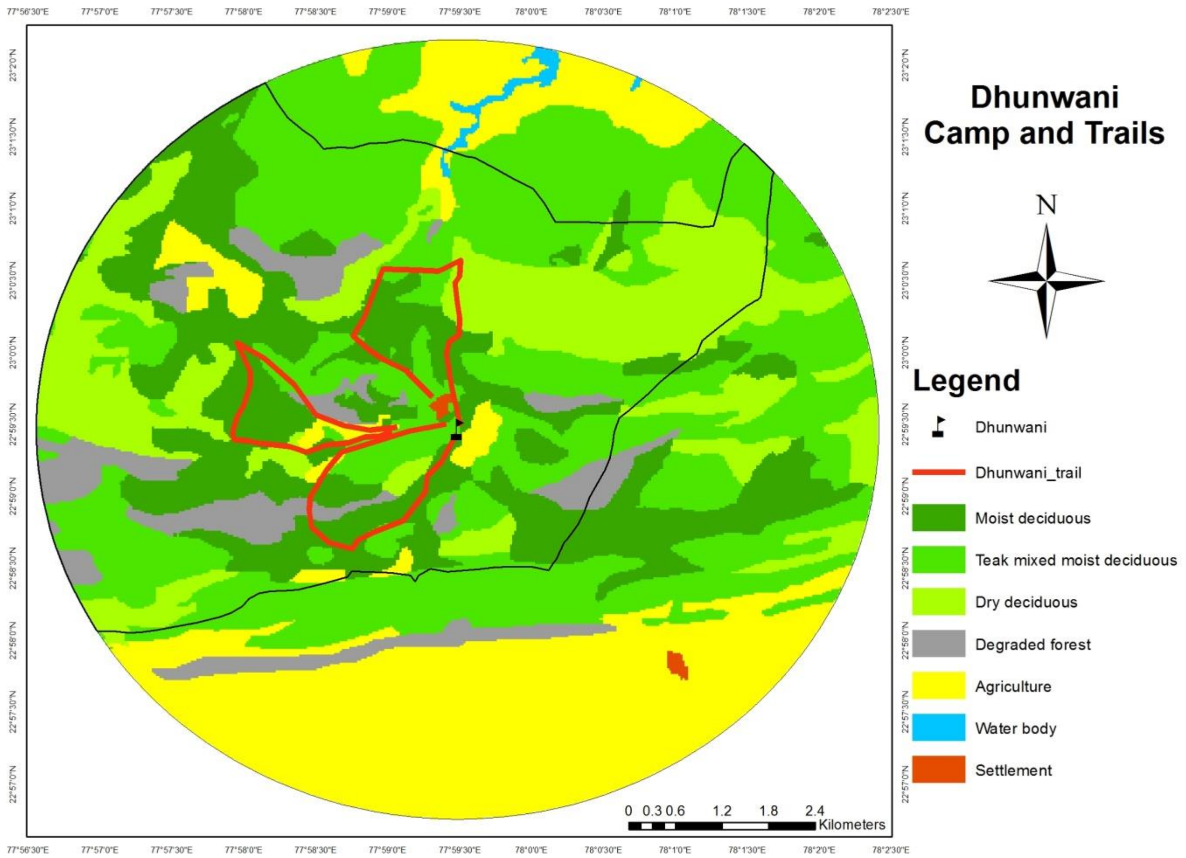

Bhoot Palasi
Camp and Trails
N
Legend
Bhoot Palasi
Bhoot Palasi_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Agriculture
Water body
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers

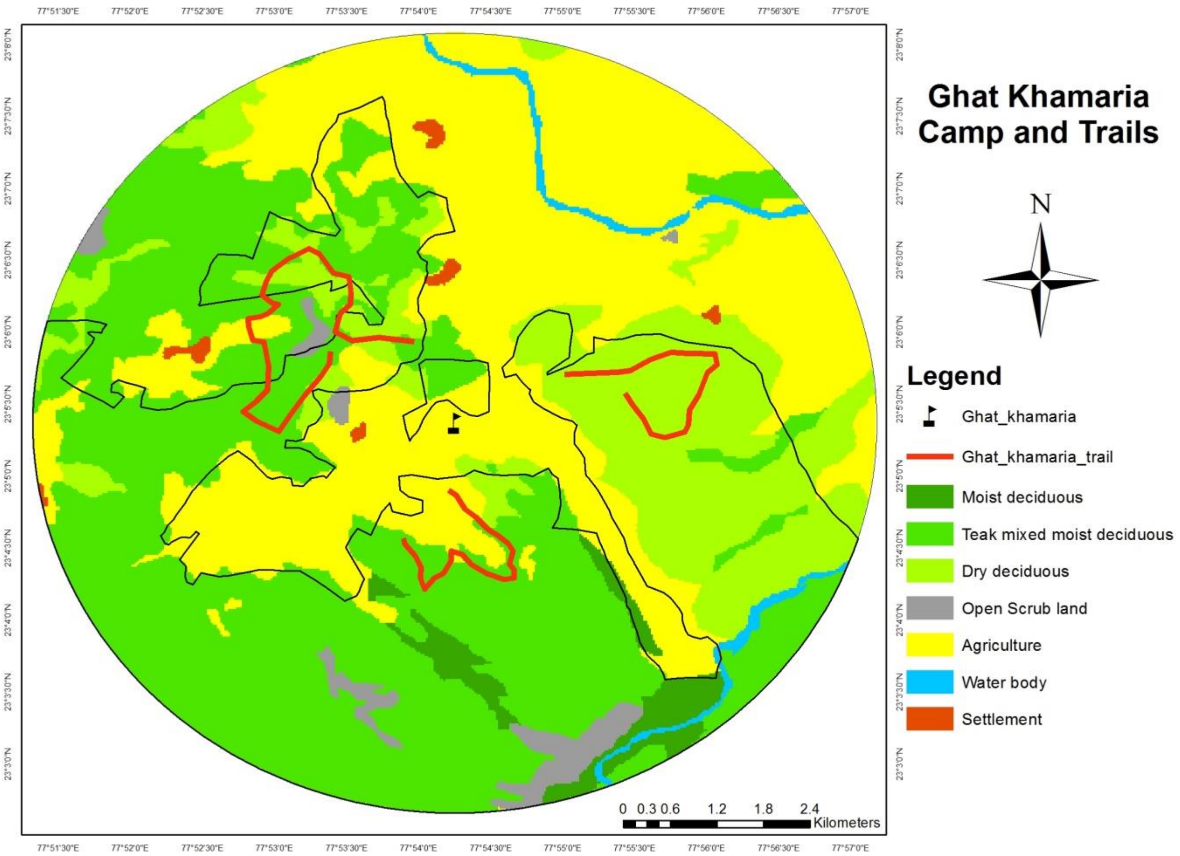

Bineka
Camp and Trails
N
Legend
Bineka
Bineka_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Scrub
Agriculture
Water body
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers

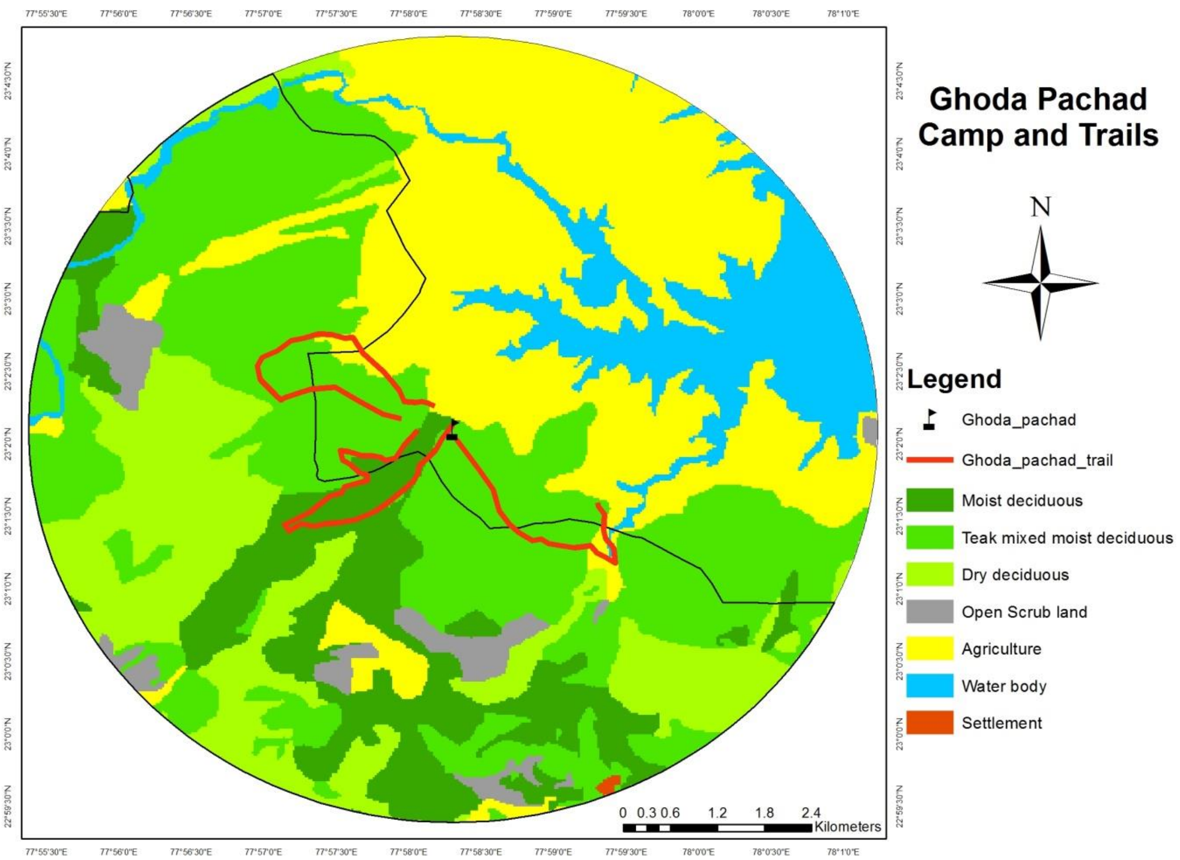

Bithori
Camp and Trails
N
Legend
Bithori
Bithori_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Agriculture
Water body
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers

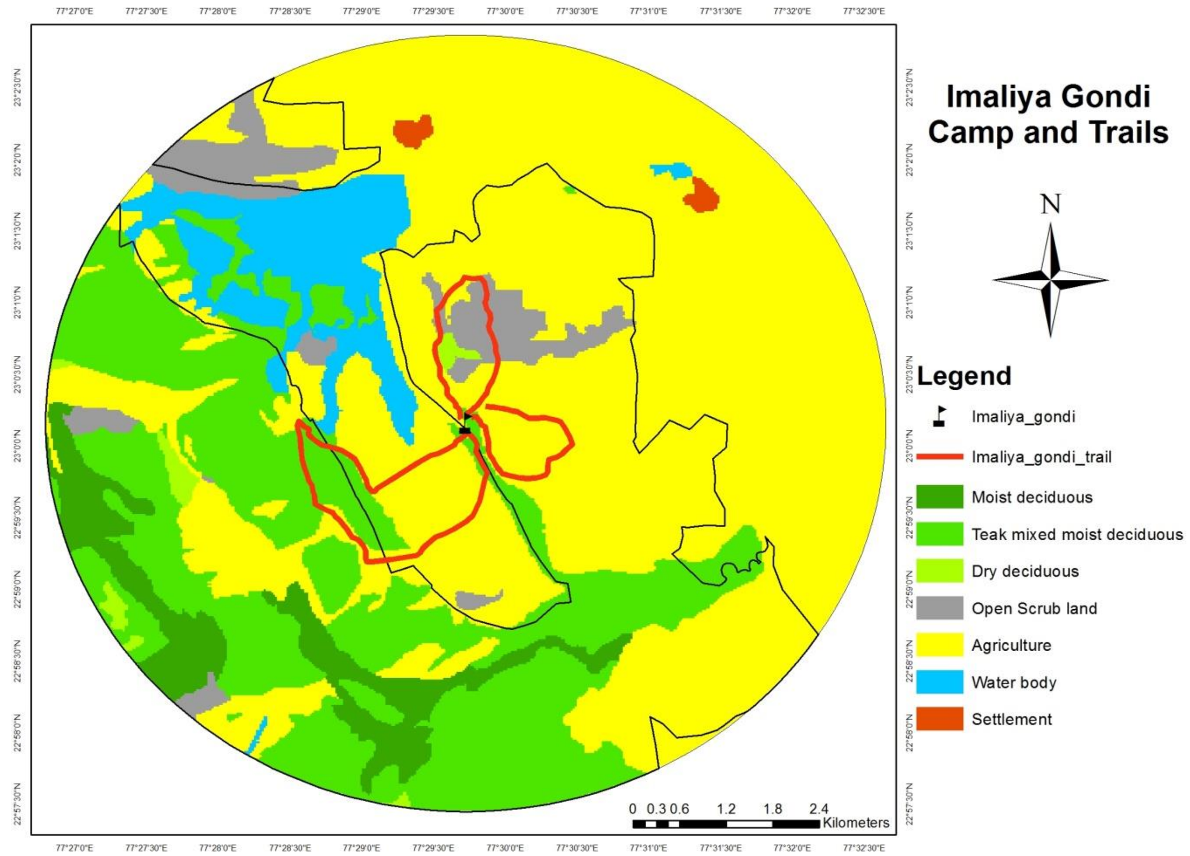

Delawadi Barrier
Camp and Trails
N
Legend
Delawadi Barrier
Delawadi Barrier_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Agriculture
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers


Delawadi
Camp and Trails
N
Legend
Delawadi
Delawadi_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Agriculture
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers


Dhunwani
Camp and Trails
N
Legend
Dhunwani
Dhunwani_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Degraded forest
Agriculture
Water body
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers


Ghat Khamaria
Camp and Trails
N
Legend
Ghat_khamaria
Ghat_khamaria_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Agriculture
Water body
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers
77°51'30"E
77°52'0"E
77°52'30"E
77°53'0"E
77°53'30"E
77°54'0"E
77°54'30"E
77°55'0"E
77°55'30"E
77°56'0"E
77°56'30"E
77°57'0"E


Ghoda Pachad
Camp and Trails
N
Legend
Ghoda_pachad
Ghoda_pachad_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Agriculture
Water body
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers
77°55'30"E
77°56'0"E
77°56'30"E
77°57'0"E
77°57'30"E
77°58'0"E
77°58'30"E
77°59'0"E
77°59'30"E
78°0'0"E
78°0'30"E
78°1'0"E


Imaliya Gondi
Camp and Trails
N
Legend
Imaliya_gondi
Imaliya_gondi_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Agriculture
Water body
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers
77°27'0"E
77°27'30"E
77°28'0"E
77°28'30"E
77°29'0"E
77°29'30"E
77°30'0"E
77°30'30"E
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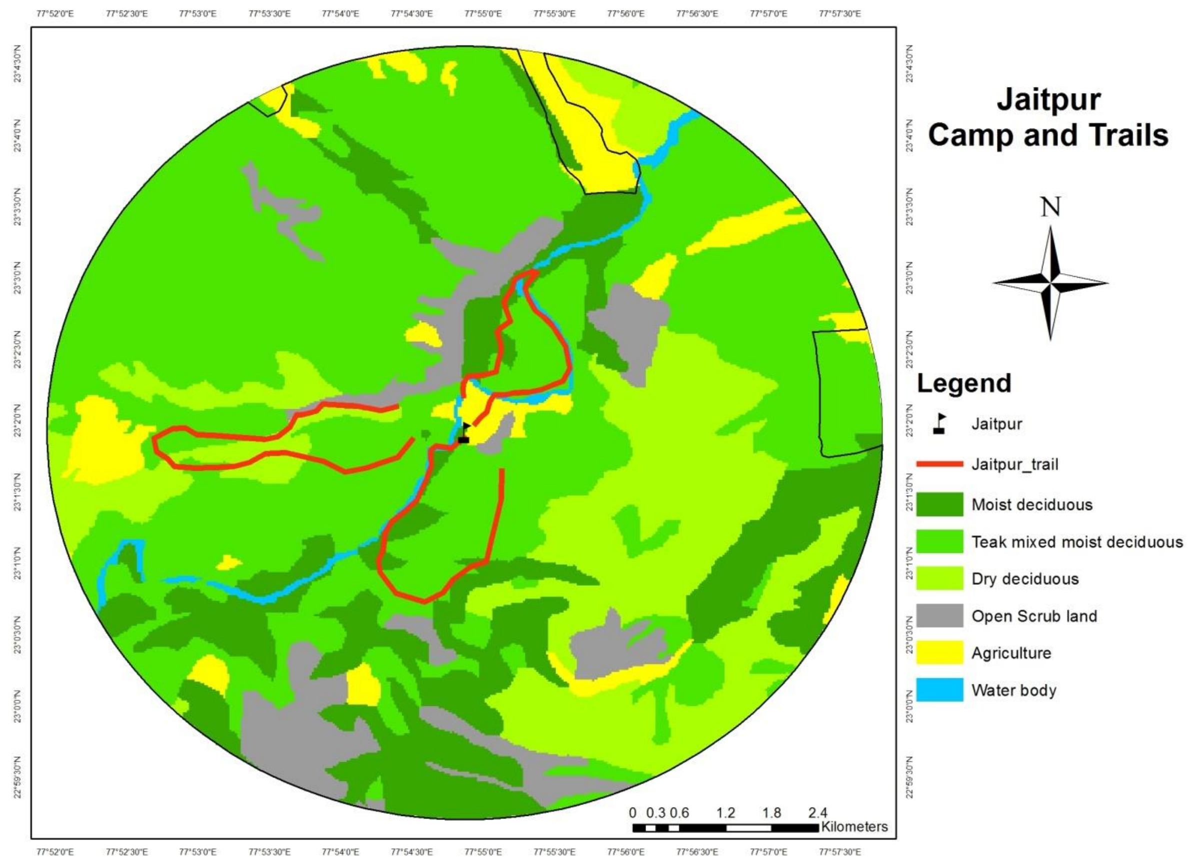
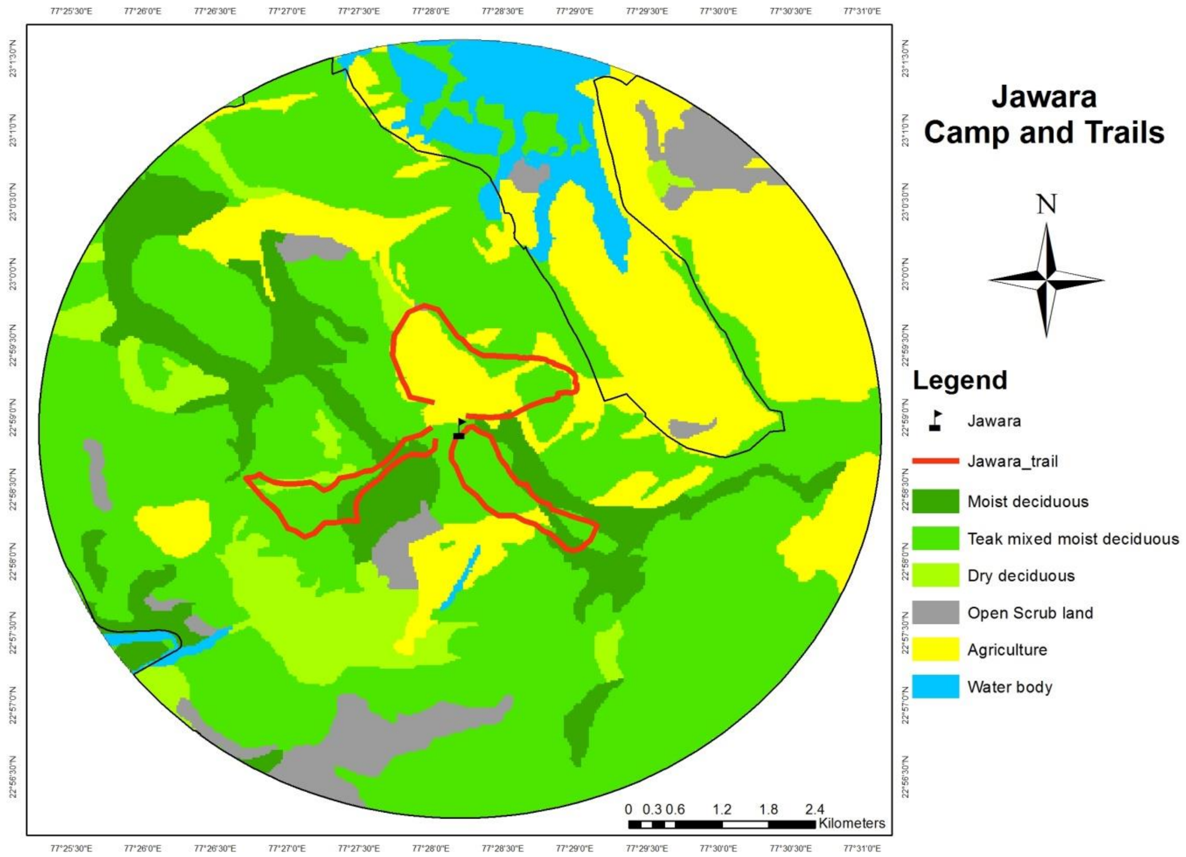
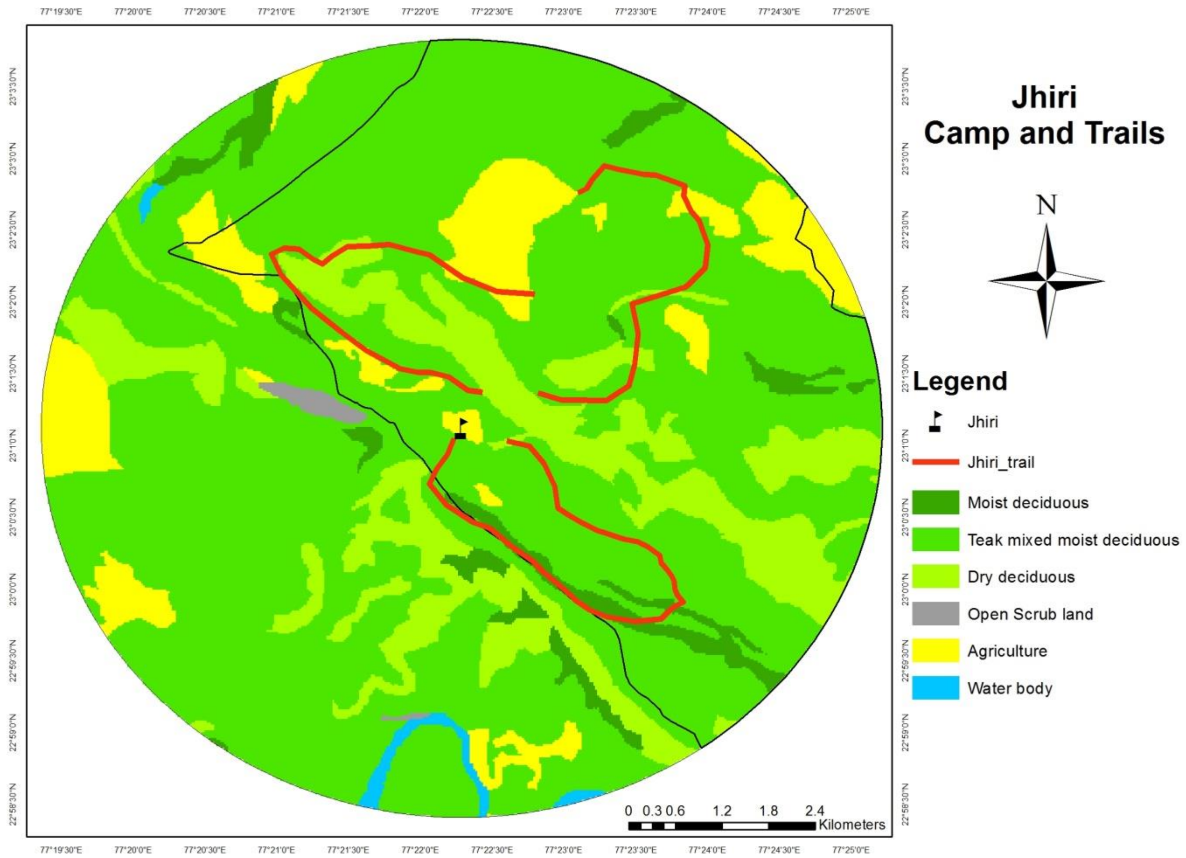
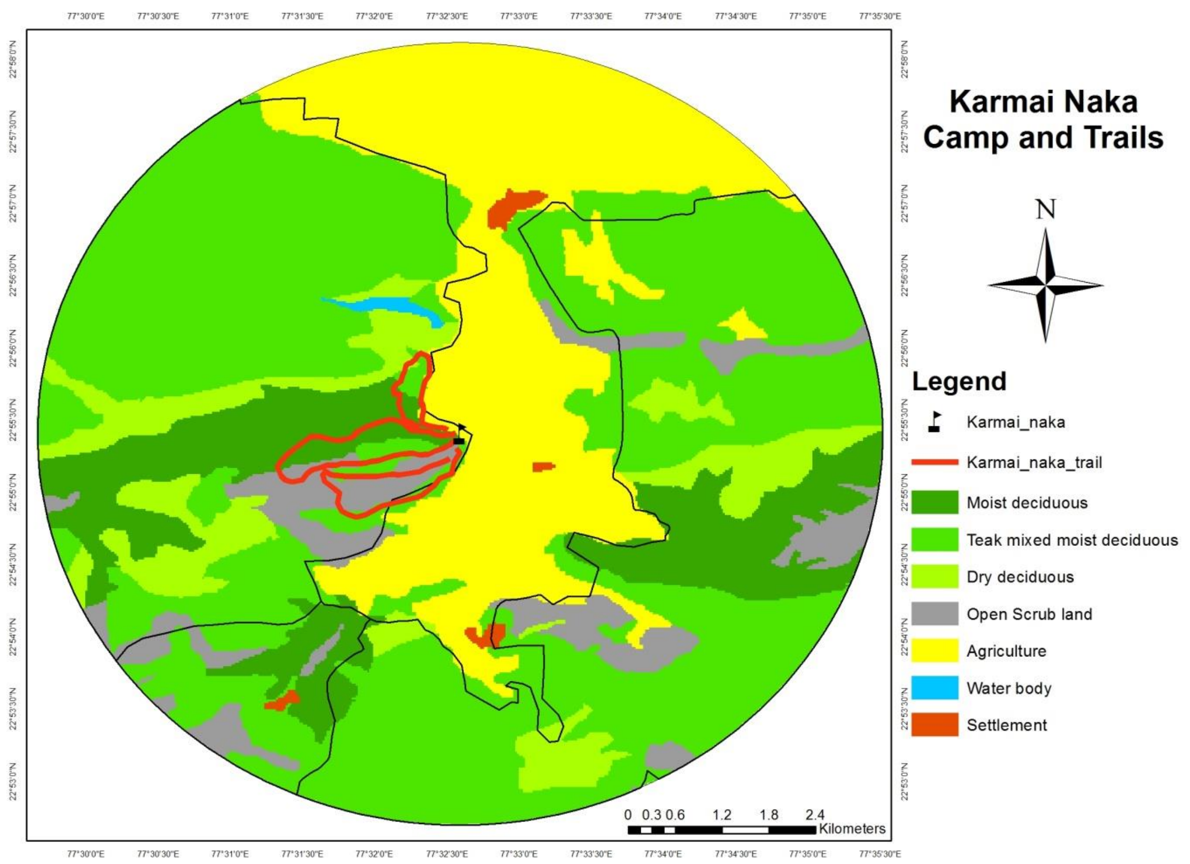
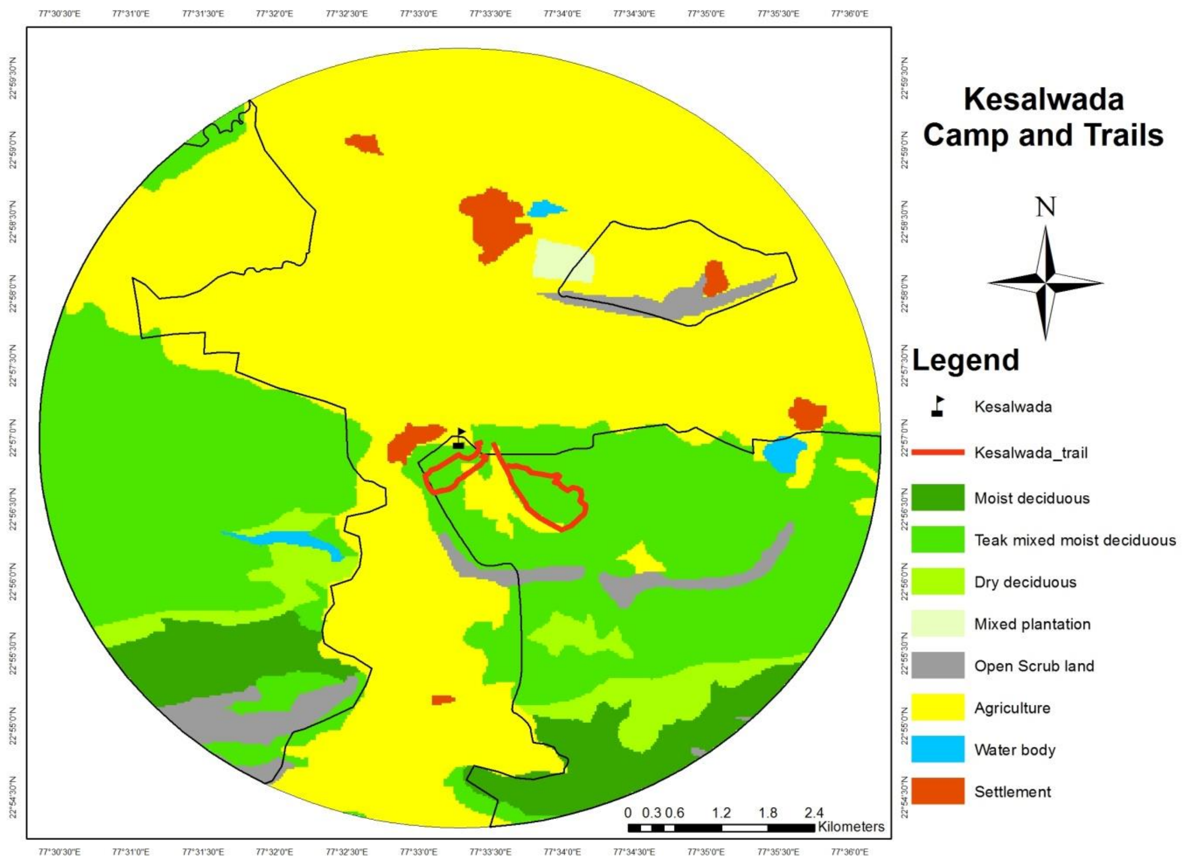
77°32'30"E

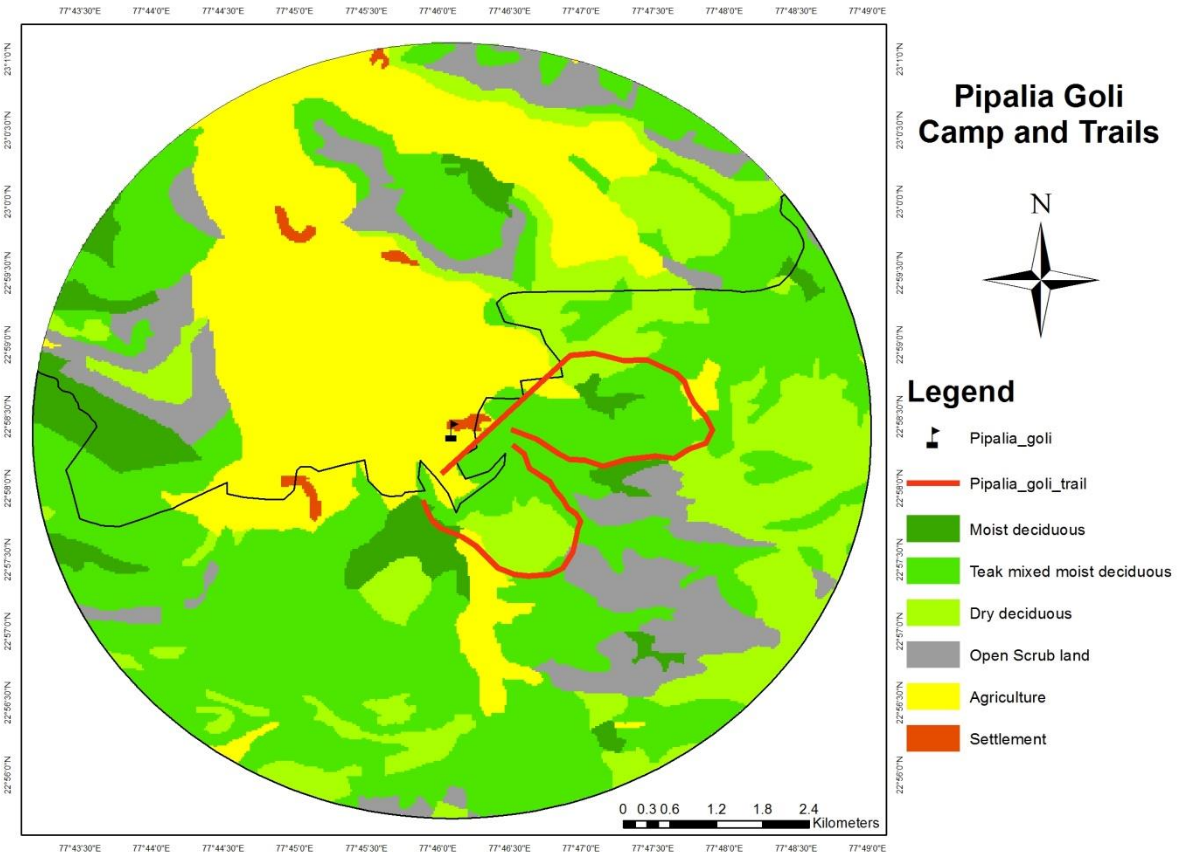

Jaitpur
Camp and Trails
N
Legend
Jaitpur
Jaitpur_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Agriculture
Water body
0 0.3 0.6 1.2 1.8 2.4
Kilometers
77°52'0"E
77°52'30"E
77°53'0"E
77°53'30"E
77°54'0"E
77°54'30"E
77°55'0"E
77°55'30"E
77°56'0"E
77°56'30"E
77°57'0"E
77°57'30"E

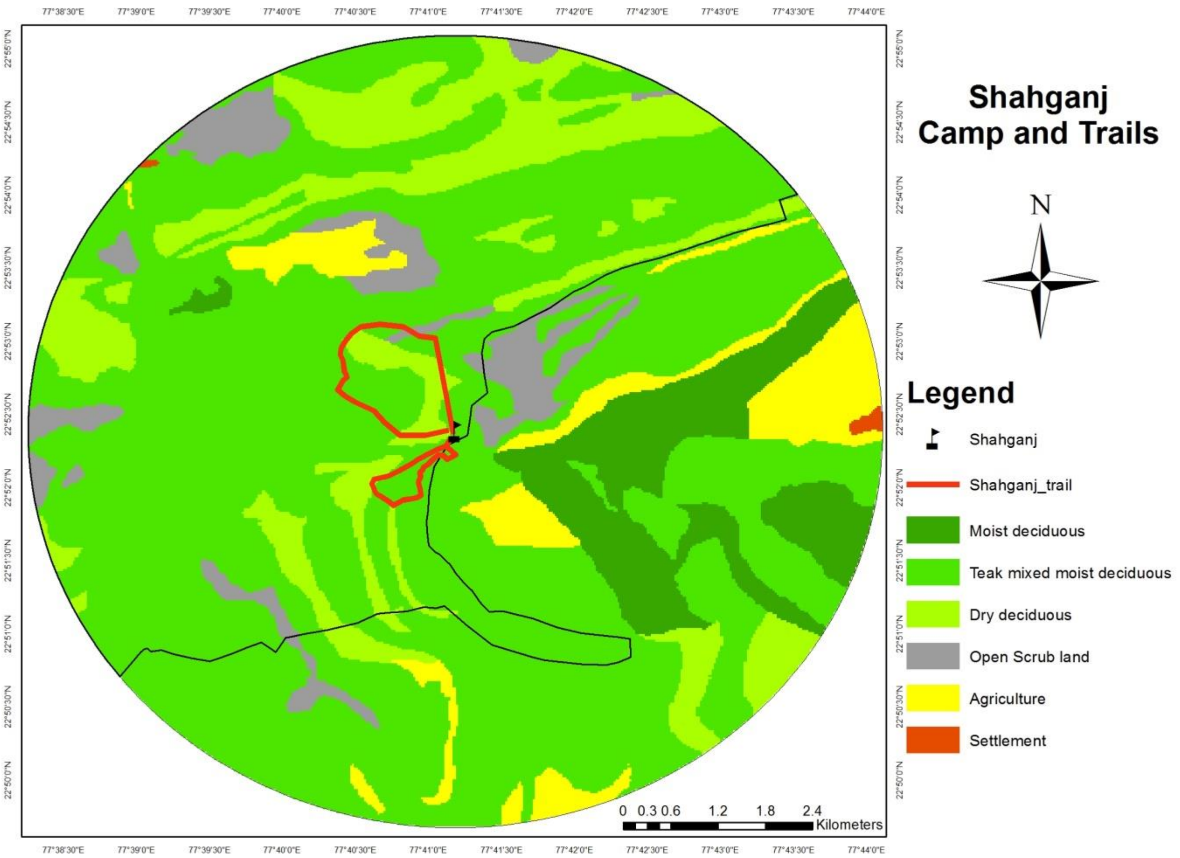

Jawara
Camp and Trails
N
Legend
Jawara
Jawara_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Agriculture
Water body
0 0.3 0.6 1.2 1.8 2.4
Kilometers

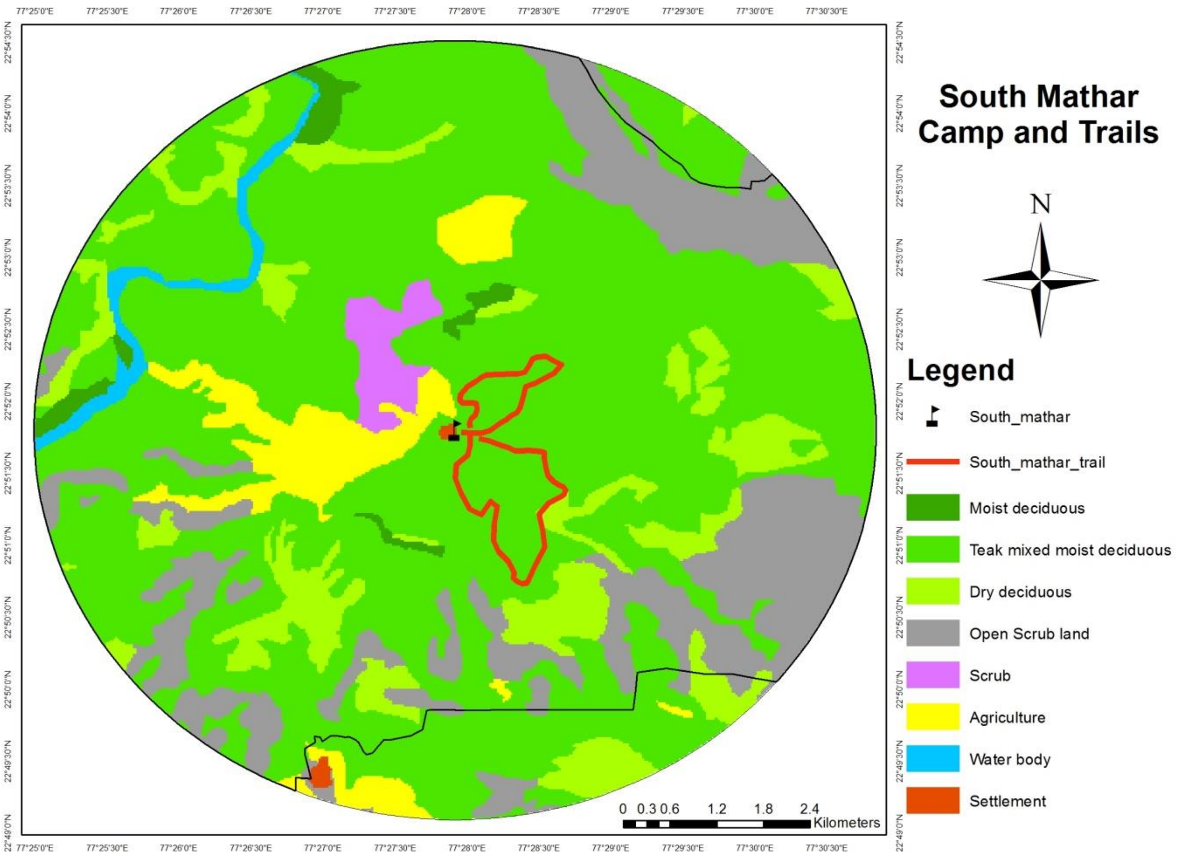

Jhiri
Camp and Trails
N
Legend
Jhiri
Jhiri_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Agriculture
Water body
0 0.3 0.6 1.2 1.8 2.4
Kilometers


Karmai Naka
Camp and Trails
N
Legend
Karmai_naka
Karmai_naka_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Agriculture
Water body
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers

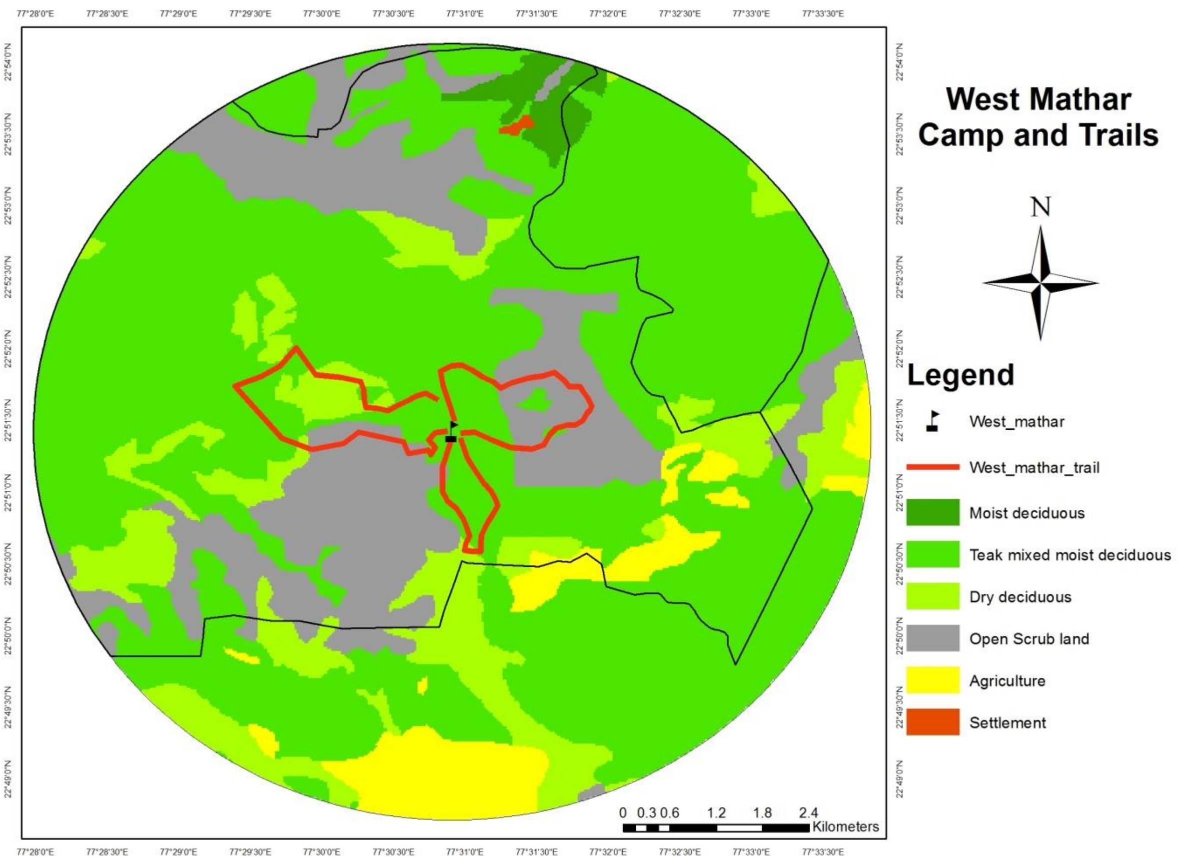

Kesalwada
Camp and Trails
N
Legend
Kesalwada
Kesalwada_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Mixed plantation
Open Scrub land
Agriculture
Water body
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers


Pipalia Goli
Camp and Trails
N
Legend
Pipalia_goli
Pipalia_goli_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Agriculture
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers


Shahganj
Camp and Trails
N
Legend
Shahganj
Shahganj_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Agriculture
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers



South Mathar
Camp and Trails
N
Legend
South_mathar
South_mathar_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Scrub
Agriculture
Water body
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers



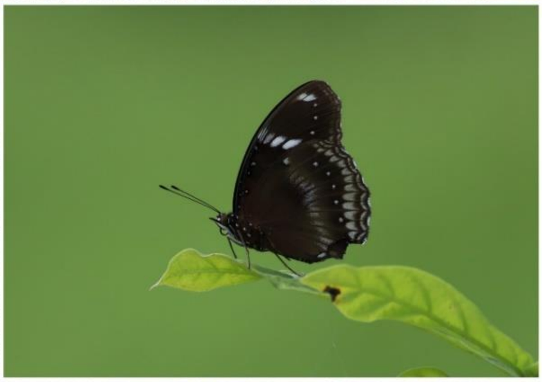
West Mathar
Camp and Trails
N
Legend
West_mathar
West_mathar_trail
Moist deciduous
Teak mixed moist deciduous
Dry deciduous
Open Scrub land
Agriculture
Settlement
0 0.3 0.6 1.2 1.8 2.4
Kilometers

APPENDIX VI: LIST OF PARTICIPANTS

S. No,	Name of Applicant	Father/Husband's Name	City	Profession
1	Aarohi Natu	Dipak Keshavrao Natu	Vadodara	Working as an intern at The Ecological Solutions, Pune
2	Abey Francis	Francis O. F.	Indore	Student (Life sciences)
3	Abhay Uzagare	Prassanna	Pune	Ex. Wildlife warden, Jalgaon
4	Abhigyan		Bhopal	Data Analyst
5	Abhishek Paliwal	ML paliwal	Indore	Education Officer, BNHS
6	Adarsha Mukherjee	Ashish Kumar Mukherjee	Baghmundi, Purulia	Student of B.Sc
7	Adil Khan	I H Khan	Sarni	Student
8	Aditya Singh Chauhan	Bhanwar Singh Chauhan	Delhi	NEO and Field Supervisor, CEMDE, University of Delhi
9	Ajay Gadikar	Vijay Gadikar	Indore	Business
10	Ajay kumar thakur	Mr. Malthu singh	Pachmarhi	Gaide
11	Akash Bharti	Vijay kumar Bharti	Baramkela	Student
12	Akash Hemant Mhadgut	Hemant	Mumbai	Biodiversity student, Freelancer Naturalist (In past worked with Sgnp & MNP)
13	Amit Kumar	Hardeep Singh	Delhi	Ecologist
14	Amod Gawarikar	Rajan Gawarikar	Indore	Wealth Management Professional
15	Ankit Madan Khoche	Madan Baburao Khoche	Kalyan	Currently Unemployed
16	Ankit Sinha	Shri. Dilip Kumar Sinha	Lucknow	PhD Scholar
17	Ankur Kumar	Aditya Kumar	Delhi	Quantitative Researcher
18	Anshuman Sharma	Dilip Sharma	Indore	Service
19	Anurag Chhajlani	Shri Rajendra Kumar	Ujjain	PROFESSIONAL
20	Aparna Rao	Balakrishnan S Rao	Navi Mumbai	Student (MSc in Biodiversity and Wildlife Conservation-Part 2)
21	Arjun Kumar	Kamala Kanta Kumar	Purulia	College Student
22	Ashish Bareth	Kanhaiya Lal Bareth	Bilaspur	Student Of Bsc Forestry, Wildlife And Environmental Science
23	Ashish Thoke	Atul Thoke	Mumbai	Education officer, Bombay Natural History Society, Mumbai
24	Chandrasen kori	Kaushal prasad kori	Bilaspur	Student
25	Deepa Mohan	K. Mohan	Bangalore	Wildlife Volunteer
26	Domendra Nishad	Rajkumar Nishad	Raipur	Student
27	DP Srivastava	Mr Rakesh Srivastava	Bhopal	PhD scholar
28	Dr Pallavi Vaze	Dr Ameya Vaze	Indore	Dentist
29	Dr Vijay Singh Yadav	Dr Suresh Kumar Yadav	Jabalpur	Doctor
30	Dr Vipul Keerti Sharma	DR Ashok Sharma	Indore	Professor in a Govt. College
31	Dr. Aamir Nasirabadi	Mr. Mushtaque Nasirabadi	Jabalpur	Doctor
32	Dr. Ritu Shekhar		Bhopal	Professor
33	Dr. Shekhar		Bhopal	Professor
34	Gaurav Nigam	Swatantra kumar Nigam	Indore	Government Service
35	Geeta Yadav	Mr. A.S Yadav	New Delhi	Nature Educator with BNHS
36	Ghanshyam jaiswal	Ramchandra jaiswal	Bilaspur	Student

37	Grishma Trivedi	Dr. Devendra Trivedi	Indore	Research scholar
38	Harvinder Singh DM		Rohtak	Tourism Manager
39	Heer Sanjaybhai Patel	Sanjaybhai bachubhai patel	Ahmedabad	Zoology final year student at st.xavier's college
40	Hemant Kataria	Sh. Gorumal	Chandrapur	Service (PSU) Retired now
41	Jayanti Khemchandani	Tahilram	Ahmedabad	Business
42	Jayesh Vishwakarma	Prahlad	Mumbai	Wildlife Biologist
43	Juhi Chaudhari	Popatbhai Chaudhari	Mehsana	forester
44	Lakshmikant Rajaram Neve	Rajaram Neve	Jalgaon	Service
45	Mahendra kalam	Mr Indal singh Thakur	Pachmarhi	Free lancer naturalist in satpura tiger reserve
46	Mehul singh tomar	P.S.Tomar	Bhopal	Wildlife researcher
47	Naman Chaturvedi	Rahul Chaturvedi	Indore	Student
48	Neel Gadikar	Ajay Gadikar	Indore	Student
49	Neeraj Bagwan	Mr. D.L. Bagwan	Indore	Engineer
50	Nitish Gupta	Shri Veerendra Gupta	chhatarpur	Student
51	Om prakash panchal	Mr dev singh panchal	Sehor	Farmer
52	P.S.Joshi	S.P.Joshi	Jalgaon	Service
53	Paras Kumar Sahu	Mr. Udhay bhanu sahu	Durg	Study
54	Pinal patel	Chintan patel	Mumbai	Wildlife biologist
55	Pitamber Lal Sahu	Ramdayal Sahu	Bilaspur	Students and forestry and wildlife science
56	Poornima K P	Chandrashekar K (Husband)	Bangalore	Landscape Architect (CEO SCALE architects)
57	Prashant Soni	Late Shri Radhe Shyam Soni	Vidisha	Development professional
58	Pratiksha Singh	Shivraj Bahadur Singh	Bhopal	Research Scholar
59	Preeti Gupta	Sushil Chandra Gupta	Lucknow	PhD Scholar
60	Priya Gupta	Kanhaiyalal Gupta	Mumbai	Student
61	Priyanka	Girirajsinh	Ahmedabad	Business
62	Purnima Singh	Ajay Kumar Singh	Ballia	Student
63	Radheshyam Baghel	Mr.Piladas Baghel	Bilaspur	Student in forestry and wildlife science
64	Rahul Chaudhary	Mr. Raghuveer Singh	Bhopal	Social Researcher;
65	Rakesh ahlawat	Bhagwan singh	Dighal	Wildlife researcher
66	Ramnish Geer		Bhopal	Joint Director, CBI
67	Ravi Sharma	Shri R K Sharma	Indore	pvt job
68	Ravindra G Phalak	Gendalal Shripad Phalak	Jalgaon	Business.
69	Rimasri Mandal	Satyajit Mandal	Purulia	Student
70	Ritesh Khabia	Mr. H. C. Khabia	Indore	Self Employed
71	Ritesh Kumar Shrivas	Omkesh Shrivas	Raipur	Student of B.Sc. Forestry, Wildlife and Enviromental Science
72	Rohit Kumar Baldodia	Laxmi Chand	New Delhi	Service
73	Sachin Matkar	Shiv Kumar matkar	Indore	Private service
74	Sameer Gautam	Badri prasad	Kapurthala	PhD scholar
75	Sarang Mhatre	Sham Mhatre	Raisen	Butterfly expert
76	Sarika Kaushal Gadikar	Ajay Gadikar	Indore	IT

77	Savita Bharti	Balram Mahadeo Bharti (Father)	Pune	Currently on a sabbatical from work
78	Shaileshkumar Gupta	Subhashchandra Gupta	Mumbai	HOD & Ass. Professor
79	Shakti kumar	Mr Manoj kumar	Bhopal	Wildlife Researcher
80	Shivam choudhary	Kishan lal choudhary	Pachmarhi	Yes
81	Shrikant Kalamkar	Shri. V. R. Kalamkar	Indore	Service
82	Shubham Kumar	DINESH CHANDRA	Varansi	Student
83	Shubham purohit	Mr. Mahendra Kumar purohit	Bhanpura (mandsaur)	Student
84	Shukal Dhavalkumar Keshavlal	Keshavlal C Shukal	Ahmedabad	Researcher
85	Shweta Dhiman	Father - Satish Kumar Dhiman	Roorkee	Senior Researcher
86	Shyam Ghate	Shreedhar	Thane	Retired
87	Sohail Madan	Dr. Shiban Madan	New Delhi	Centre Manager with BNHS
88	Soham	Sham	Dombivali	Biodiversity conservation in Devlopmental field
89	Sonu Dalal	Mahtab Singh	Bahadurgarh	Wildlife rescuer
90	Sumit Kumar Rajpurohit	Mr Anil Kumar Rajourohit	Bhopal	PhD Research Scholar
91	Supriya Samanta	Samir Samanta	Purulia	Student
92	Surendra Bagda	Ghan Shyam Sharma	Indore	Business
93	Suyash Jagat	S. K. Jagat	Bilaspur	Student (B.Sc. Forestry, Wildlife and Environmental sciences)
94	Swapnil Phanse	Shri Subhash Phanse	Indore	Service
95	Vasudha Mishra	Suryakant Mishra	Mumbai	Student
96	vinish kumar	Sh. G.L Kumawat	Jaipur	Health Care
97	Vipul saxena	S c saxena	Indore	Banker
98	Yash Nirmalkar	Dayalu Ram Nirmalkar	Panduka, Gariyaband	Student



When a butterfly flutters its wings in one part of the world,

it can eventually cause a hurricane in another.

-Edward Norton Lorenz