Insect Pollinators Visiting Invasive Plant of Northernpart of Kathmandu Valley, Nepal

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A dissertation submitted

in partial fulfillment of the requirements for the award of the degree

of Master of Science in Zoology with special paper Entomology

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August, 2025

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Declaration

I hereby declare that the work presented in this dissertation "**Insect Pollinators Visiting Invasive Plant of Northernpart of Kathmandu Valley, Nepal**" has been done by myself and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by rerefencing to the author(s) or institution (s).

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Letter of Approval

On the recommendation of supervisor "Dr. Daya Ram Bhusal" this dissertation submitted by Aakriti Karki entitled **"Insect Pollinators Visiting Invasive Plant of Northernpart of Kathmandu Valley, Nepal"** is approved for the examination in partial fulfilment of the requirements for Master's degree of Science in Zoology with special paper Entomology.

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Certificate of Acceptance

This dissertation work submitted by Aakriti Karki entitled **"Insect Pollinators Visiting Invasive Plant of Northernpart of Kathmandu Valley, Nepal"** has been accepted as a partial fulfilment for the requirements of Master's degree of Science in Zoology with special paper Entomology.

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Abstract

This study was conducted to investigate insect pollinator on invasive Plants of Northern part of Kathmandu valley. The research was purposively carried out in areas with a diverse presence of mixed flowers and insect populations. A total of 10 plots, each measuring 30/30 meters, were established at intervals of 100 meters along transect lines, with a movement of 1/1 meter within each plot. The study was carried out in both the summer and autumn seasons. Insects were collected using sweeping net method, and were observed for at least 30 minutes in each plot. A total of 228 insect individuals, belonging to 201 genera across 12 families and 3 orders, were recorded. Among the insect order, Hymenoptera was the most abundant, followed by Lepidoptera and Diptera in both seasons. *Apis cerana* and *Amegilla spp.* were the most common species that visited *Lantana camara* within the Hymenoptera group in both seasons. The common pollinators were *Apis cerana*, *Amegilla spp.*, *Episyrphus spp.*, *Parapolybia spp.*, *Episyrphus spp.*, and *Eupeodes spp.* were the least observed among the Diptera that visited *Bidens pilosa* followed by *Ipomoea carnea*, *Alternanthera philoxeroides* which were abundant in the autumn season. The baseline data collected could help government agencies, academic institutions, and stakeholders to enhance research efforts and inform decision making.

Keywords: Invasive plants, Insect Pollinators, seasonal variation, Northern Kathmandu valley; Nepal, Hymenoptera

शोधसार

यस अध्ययन काठमाडौँ उपत्यकाको उत्तरी भागमा पाइने मिचाहा वनस्पतिहरूमा पारागसेचकहरुको अध्ययन गर्नका लागि गरिएको थियो। यस अध्ययन Pruposive Sampling विधिबाट विभिन्न फूल र किराहरूको उपस्थिति भएको क्षेत्रहरूमा वर्षा र शरद दुवै मौसममा सम्पन्न गरिएको थियो। कुल १० वटा plot 30/30 मिटरको आकारमा १०० मिटरको अन्तरालमा स्थापना गरिएको थियो । प्रत्येक plot मा 9 वटा Transect line स्थापना गरि, प्रत्येक Transect line मा 1/1 मिटरको Subplot स्थापना गरिएको थियो । पारागसेचकहरु संकलन गर्न Sweeping net विधि प्रयोग गरि, प्रत्येक Plot मा ३० मिनेटको अवलोकन गरिएको थियो । अध्ययनबाट कुल २२८ वटा कीराको प्रजातिहरू अभिलेख गरिएका थिए, जुन १२ वटा परिवार, ३ वटा order र २०१ वटा genera maa विभाजित थिए। तिनीहरू मध्ये Hymenoptera समूहमा सबैभन्दा बढी संख्यामा भेटियो, त्यसपछिका क्रमशः Lepidoptera र Diptera । Hymenoptera समूहभित्र *Lantana camara* मा सबैभन्दा बढी देखिएका प्रजातिहरू *Apis cerana* र *Amegilla spp.* थिए, जुन दुवै मौसममा सामान्य रूपमा भेटिएका थिए। सामान्य रूपमा देखिने परागवाहकहरू *Apis cerana*, *Amegilla*, *Episyrphus*, र *Parapolybia* थिए। Diptera समूहभित्र *Episyrphus* र *Eupeodes* कम देखिएका परागवाहकहरू थिए, जसले *Bidens*, त्यसपछि *Ipomoea*, *Alternanthera* मा भ्रमण गरेका थिए, जुन प्रजातिहरू जाडो मौसममा बढी मात्रामा देखिएका थिए। सङ्कलित तथ्यांकहरूले सरकारी निकायहरू, शैक्षिक संस्थाहरू र सरोकारवालाहरूलाई अनुसन्धान अभिवृद्धि गर्न र निर्णयहरू लिन सघाउ पुर्‍याउन सक्छ।

मुख्यशब्दहरू: Pollinator; मिचाह वनस्पति, उत्तरी काठमाडौं उपत्यका; मौसमी विविधता; Hymenoptera

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1. Introduction

1.1 Background

Pollination represents a key example of ecological mutualism, where plants offer floral visitors rewards such as nectar, Pollinators assist in plant reproduction by transferring pollen between flowers of the same species (Mitchell et al., 2009). The reproduction of most flowering plants depends on this process. Approximately 87.5% of angiosperms relying on animals including insects and birds for effective pollen (Klein et al., 2007; Ollerton et al., 2011). Pollination happens when pollen is transferred from anther to its stigma, allowing fertilization to occur. (Albano et al., 2009; Halder et al., 2019; Stanley, 2013). Pollinators are attracted to flowers based on specific traits such as scent, shape, size, and color, which help them recognize and differentiate plant species (Araujo et al., 2018). Floral coloration often reflects the type of pollinator: bee-pollinated flowers are commonly blue or violet, while beetle-pollinated flowers tend to be white or cream-colored (Sircom et al., 2018).

In many regions, the primary and most widespread pollinators are insects, particularly those from the orders Hymenoptera, Lepidoptera, Coleoptera, Diptera, and Hemiptera (Ghetiya et al., 2020; Nalwaya & Saxena, 2023). Moths represent the most diverse group of Lepidoptera, comprising over 140,000 species (Wardhaugh, 2015). Major insect pollinators consist of honey bees, butterflies, wasps, solitary bees (such as *Xylocopa, Andrena, and Halictus*), bumblebees, stingless bees (including *Trigona and Melipona*), hoverflies (Syrphus), along with some beetle species. Honey bees are the main pollinators for most flowering plants, helping to pollinate about 66% of the world's 1,500 crop species, which contributes to 15–30% of global food production (Ollerton et al., 2012).

Many invasive species depends on pollinator, so that they can successfully establish in a new area (Aizen et al., 2008; Bartomeus et al., 2008; Memmott & Waser, 2002). Invasive plants that depend on insects for pollination are usually generalists, meaning their flowers are attractive and offer plenty of easy to reach rewards for many types of pollinators. This broad appeal helps them successfully grow and spread in new environments (Albrecht et al., 2014; Lopezaraiza-Mikel et al., 2007; Richardson et al., 2000). Plant invasions are recognized as one of the major threats to biodiversity, as they may modify different processes which are important for ecosystem functioning (Brooks et al., 2004; Sala et al., 2000).Pollinators are threatened by a number of different factors, causing declines in many pollinator species. Major threats to pollinators include the destruction and fragmentation of natural habitats, exposure to pesticides and agricultural chemicals. The spread of diseases, invasive species, and the impacts of climate change. (Brown & Paxton, 2009) & Paxton, 2009; Potts et al., 2010). Invasive species may outcompete native pollinators for essential resources or facilitate the spread of pathogens and diseases (Stout & Morales, 2009). Declines of some pollinator populations have been due to parasites or pathogens (Cameron et al., 2011).

Climate change can affect distribution and phenology of insects and plants (Memmott et al., 2007; Schweiger et al., 2010).An important but often under appreciated element of resource limitation is seasonality, defined as within year periodic variation in resource availability (White and Hastings, 2020). Insect pollinator activity depends on environmental factors like temperature, light, wind, and the time of day or season (Kevan and Baker, 1983). They are most active when it's bright (Lundberg, 1980; Willmer, 1983) but strong winds can reduce their movement (Brantjes, 1981). The number of pollinators like bees also depends on how many flowering plants are around, since these provide the pollen and nectar they need (Roulston and Goodell, 2011). These food sources change with the seasons, depending on when plants bloom (Baude et al., 2016; Hicks et al., 2016). For example, flower size tends to get larger at higher altitudes, and this matches the bigger body size of the pollinators found there. Some scientists suggest that this follows Bergmann’s rule, which says that animals tend to be larger in colder places, including insect pollinators (Malo and Baonza, 2002).

A broad variety of morphological and phenological characteristics are observed among invasive plant species. Numerous alien invasive plants are known for their showy blooms and rich floral rewards, which strongly appeal to pollinators. (Davis et al., 2018; Morales and Traveset, 2009). This can lead to competition with native plants for important resources like sunlight, water, nutrients, and space, often reducing native plant populations (Levine et al., 2003).The presence of invasive plants can influence pollinator behavior in different ways. They may increase pollinator visitation by enhancing floral abundance(Feldman et al., 2004; Ghazoul, 2006) or decrease visitation to native plants by diverting effective pollinators away (Mitchell et al., 2009; Morales and Traveset, 2009). These interactions can have positive, negative, or neutral effects on the pollination and seed output of native species (Albrecht et al., 2016; B. J. Brown et al., 2002).

The main aim of this study is to assess the number of pollinators visiting invasive plant species in the northern part of the Kathmandu Valley. By analyzing the interactions between these invasive plants and native pollinator communities, the research seeks to gain insights into how non-native species affect pollinator behavior, visitation patterns, and the overall dynamics of plant-pollinator relationships. The outcomes of this study are expected to clarify the ecological influence of invasive plants on pollination systems in the region, contributing valuable knowledge for biodiversity conservation, ecosystem health, and the effective management of invasive species.

1.2 Significance of the study

This study holds considerable ecological and conservation importance as it addresses the growing concern of how invasive plant species influence native pollinator communities in the northern part of the Kathmandu Valley. Insect-pollinated species visits up a significant portion of known invasive alien plants However, their ability to self-pollinate often supports their initial establishment and spread (Pyšek et al., 2011). As these species become more abundant, those that offer abundant nectar and pollen or have large, long-lasting floral displays can attract and recruit pollinators that are adapted to take advantage of these floral resources (Vanbergen et al., 2018). Many invasive species possess traits such as abundant flowers, long blooming periods, or nectar rich blooms, which can attract and support pollinators. (Feldman et al., 2004; Ghazoul, 2006).

By examining pollinator visitation to invasive plant species, this study enhances our understanding of how biological invasions affect mutualistic interactions within ecosystems. The findings will be instrumental in shaping biodiversity conservation strategies, improving invasive species management, and preserving ecological balance in the Kathmandu Valley. Additionally, the insights gained can support local and regional policymakers in formulating effective conservation measures to protect native pollinator populations and safeguard essential ecosystem services.

1.3 Objective

1.3.1 General objective

To assess the insect pollinator associated with invasive flowering plant in Northern part of Kathmandu valley.

1.3.2 Specific objective

i. To identify the species composition insect pollinators on invasive plants.
ii. To investigate the seasonal variation (summer and autumn) of insect pollinators with invasive plant species.

1.4 Research question

- Does pollinator abundance increase with plant density?
- Is there seasonal variation in insect pollinators visiting invasive plant species?

2. Literature review

2.1 Invasive plant

Shrestha,(2021) recorded 29 invasive plant in Nepal. Paudel et al., (2021) recorded 13 recorded IAPS, *Ageratum houstonianum, Bidens pilosa* and *Lantana camara* were three most frequent species in Kathmandu valley.

2.2 Diversity of pollinator on invasive plants

Mohan Ram and Mathur., (1984) investigated the pollination biology of *Lantana camara* in India. Their study found that thrips were consistent and regular pollinators, while butterfly visits were seasonal, occurring predominantly during two distinct periods of the year. Pollination patterns in three invasive Asteraceae species on *Bidens alba*, *Bidens pilosa*, and *B. subalternans* have been studied across various habitats and climates at Brazil. Hymenopterans and Lepidopterans consistently remained the most frequent floral visitors throughout all study areas Grombone-Guaratini et al., (2004). Araujo et al., (2018) investigated the reproductive success of *Ipomoea bahiensis* in India, emphasizing the importance of morphological and behavioral compatibility between flowers and their visitors. The study found that only medium-sized bees such as *Melitoma* spp., *Apis mellifera*, and *Pseudaugochlora pandora* acted as effective pollinators. Sharma & Sharma., (2013) conducted a study on butterfly nectar resources in Gujarat, India. A total of 50 butterfly species, both small and large, from four different families were identified. The most dominant group was Nymphalidae, followed by Pieridae, Lycaenidae, and Papilionidae. Among the nectar plants, *Lantana camara* supported the highest number of butterfly species (19), followed by *Asclepias syriaca*, *Tamarindus indica*, *Diospyros melanoxylon*, and *Ixora arborea*.

A study conducted in Thailand by Hassa et al., (2020) investigated floral color polymorphism in *Ipomoea aquatica*, morning glory species with two flower colors, white and purple. Bees and butterflies were identified as the primary pollinators. The study found no significant difference in the overall composition of insect visitors between the two morphs. Wolfe and Sowell., (2016) studied four *Ipomoea* species to determine if their floral traits influence pollinator attraction. The findings indicated that bumblebees were the main visitors to *Ipomoea hederacea* and *Ipomoea trichocarpa*, which bear blue and purple flowers.The results showed that *I. hederacea* and *I. trichocarpa*, with blue and purple, were primarily visited by bumblebees. In constrast, the red and tubular blooms of *I. quamoclit* and *I. hederifolia* attracted hummingbirds

Butterflies were also present but showed less preference, visiting both flower types with lower frequency. (Mallick et al., 2024) examined Insect pollinators of four common Asteraceae weeds, *Ageratum conyzoides*, *Bidens pilosa*, *Caesulia axillaris*, and *Tridax procumbens* in the Terai Arc Landscape of Uttarakhand, India. A total of 29 pollinator species from 10 families and three insect orders were recorded. *Apis mellifera* (honeybee) was observed on all four weeds, with *T. procumbens* and *C. axillaris* showing a particularly strong association with bee visitors. Goulson and Derwent., (2004) investigated the relationship between the introduced honeybee (*Apis mellifera*) and the invasive plant *Lantana camara* in Australia. Their research showed that *L. camara* relies on cross-pollination for fruit production, with honeybees serving as the primary and exclusive pollinators. Dutta and Mitra., (2017).Conducted a study to examine the association between butterflies with Lantana camara across the different time frame. Among, 24 species of butterfly belonging to four families have been documented. Among these, the family Nymphalidae was found to be the most dominant, followed by Pieridae, Papilionidae, and Lycaenidae. A study conducted by Ghetiya et al., (2020) documented a total of 63 insect pollinator species visiting flowering plants. Hymenoptera being the most dominant order, represented by four major families: Halictidae, Megachilidae, Apidae, and Xylocopidae. This was followed by Diptera, which included the Syrphidae and Calliphoridae families. The Lepidoptera was well represented, including six families (Pieridae, Nymphalidae, Lycaenidae, Papilionidae, Hesperiidae, and Erebidae), with a total of nine genera, nine distinct species recorded. Respectively, Six species of order Hymenoptera, six species of Diptera and three species of Lepidoptera visited on invasive *Taraxacum officinale* in the study conducted by Muñoz and Cavieres., (2008). (McIver et al., (2009) collected 10 species of order Hymenoptera, one species of Diptera, one species of both Coeloptera and Lepidotera from invasive *Centaurea solstitialis* in USA.

Bruner et al., (2008) explored butterfly preferences among various *Lantana camara* cultivars, including ‘New Gold’, ‘Radiation’, ‘White Doves’, ‘Firewagon’, ‘Confetti’, ‘Cherry’, ‘Carlos’, and *Lantana montevidensis* ‘Weeping Lavender’. The findings showed that butterflies spent more time on ‘New Gold’, ‘Radiation’, ‘Firewagon’, and ‘White Doves’, indicating these varieties were more attractive. In a related 2003 study using the same cultivars, it was found that ‘Carlos’ and ‘Confetti’ produced the highest nectar volumes, whereas ‘New Gold’, ‘White Doves’, and ‘Weeping Lavender’ had the lowest. Despite their lower nectar volume, these three cultivars had the highest ratios of sucrose to other sugars like fructose and glucose. The results suggest that both nectar quantity and sugar composition could influence butterfly visitation behavior.

2.3 Seasonal variation

A study by Baboo et al., (2019) documented on altitudinal difference in insect pollinators of *Lantana camara* at kerala, India. Lepidopterans and Hymenopterans are the most frequently observed floral visitors. Total of 29 insect species visiting *Lantana camara*. Diversity of insect visitors were dominant in monsoon and lowest during pre-monsoon. Similarly,Among the Dipteran visitors, the families Syrphidae and Bombyliidae showed the highest diversity. The Syrphidae, *Ornidia obesa* (L.) and *Palpada furcata* were the frequently observed floral visitors. The total number of Diptera individuals was significantly higher in the rainy season and a greater variety of Dipteran families was recorded during the dry season (Souza-Silva et al., 2001).

Pollinators from two major insect orders Diptera and Hymenoptera revealing clear seasonal activity patterns. Flies and bees remained active year-round, whereas wasp activity dropped sharply during the winter months. A total of 42 fly species from 10 families were identified. Bees showed greater diversity, comprising 68 species across five families, with *Apis dorsata*, *Apis florea*, and *Halictus sp* were the most dominant, showing peak abundance in spring and the highest species richness during summer. The wasp community, consisting of 57 species from nine families, was dominated by *Delta dimidiatipenne, Delta esuriens,* and *Vespa orientalis*, with peak activity in spring and autumn and complete absence during the winter Bashir.,(2015). Cézar et al., (2022) documented 15,749 flowers to evaluate fruit production in *Lantana camara.* Results showed that butterfly richness, abundance, and reproductive success were significantly higher in the dry season. Open pollination during this period resulted in a nine fold increase in fruit set compared to the rainy season. Conversely, hand cross-pollination produced three times more fruit than open pollination during the wet season. No significant difference was detected between treatments during the dry season.

3. Materials and Methods

3.1 Study area

The study area is the Kathmandu valley, which cover 899 square kilometer and include the district of Kathamndu, Bhaktapur and lalitpur located in Bagmati province, Nepal. Geographically, it lies between latitudes (27°32'13" to 27°49'10" N latitude and 85°11'31" to 85°31'38" E longitude). The valley is border by four by four major hills: Shivapuri Nagarjun to the northwest, Nagarkot to the northeast, Phulchoki to the southeast, and Chandragiri to the southwest (Dani and Tiwari, 2018).Kathmandu valley experience a range of climate, including subtropical, temperate and cool temperate .Annual temperature in the region typically range from a high of around 29°C on January (Dani and Tiwari, 2018). Data were collected from four specific sites based on feasibility: one site at Balaju, three sites at Budhanilkantha, five sites at Gokarna, and one site at Swayambhu. A total of 10 plots were observed during the summer season (June to July 2024) and the autumn season (November, 2024).

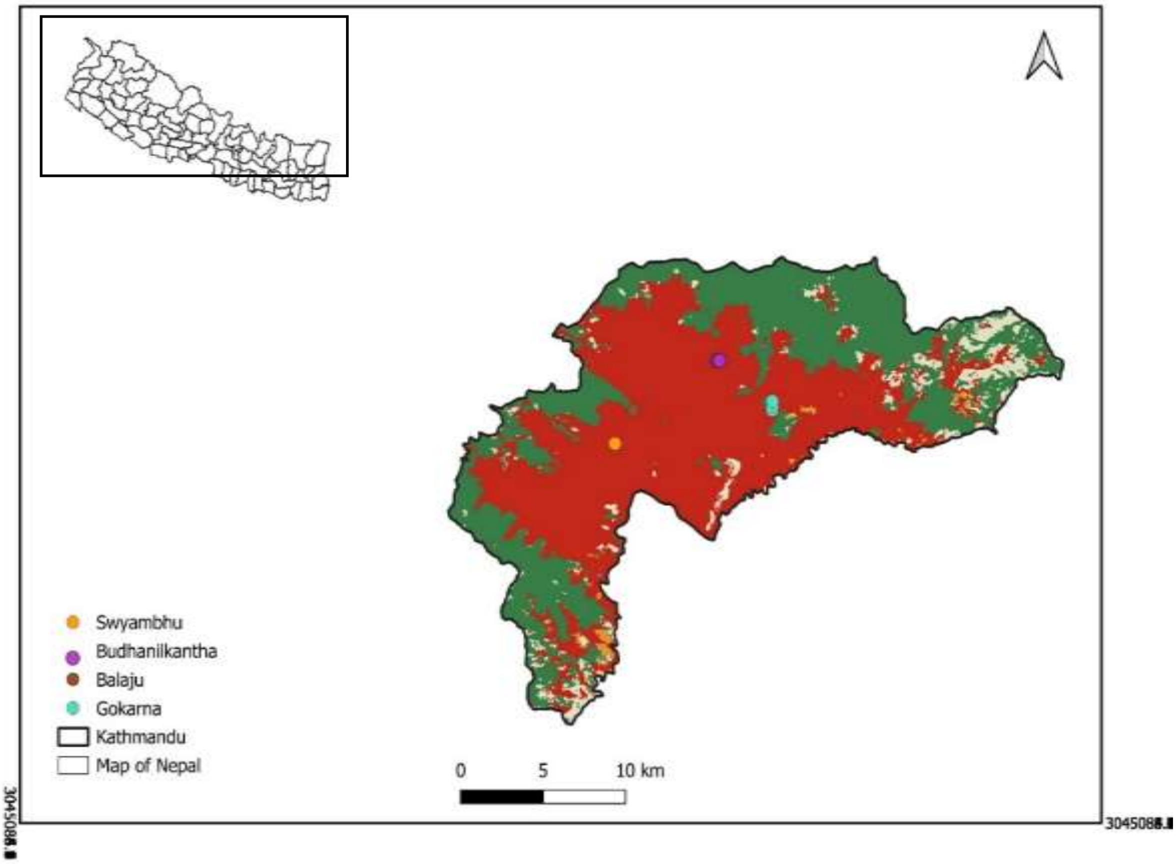

Figure 1: Map of study area

3.2 Materials required

Following materials were used during my thesis work.

a. Ethyl acetate and Ethyl Alcohol
b. GPS
c. Measuring Tape
d. Killing Jar
e. Insect Collection Vials
f. Forceps, Brush and Zip-lock Bags
g. Plastic boxes to carry samples
h. Stereo microscope
i. Sweeping net
j. Tracing paper, Pencil
k. Entomological pin
l. Entomological box

3.3 Methods

3.3.1 Field design

A purposive and extensive survey was first carried out in areas abundant with mixed flower. Once a suitable site was selected, three plots of 30 × 30 meters were established within that site, maintaining a minimum distance of 100 meters between each plot in one site. A total of 10 sites were selected, resulting in 30 plots overall. In each plot, three transects were established, resulting in a total of 90 transects across 10 sites. Within each plot, a 1 × 1 meter subplot was selected, with three subplots placed along each transect. This yielded 27 subplots per site, totaling 270 subplots across 10 sites. After plot selected, a detailed search for invasive plant species was carried out along the transect line by moving slowly from the first plot. The flowers of selected invasive plants were counted, treating each twig bearing flowers as a single floral unit. Pollinator observations were conducted for 30 minutes per plot**,** and all 10 sites were visited once per season. Data was collected in summer and autumn season. Pollinators were identified based on their location on specific plant parts, with insects that interacted with the reproductive parts of the flowers considered pollinators.

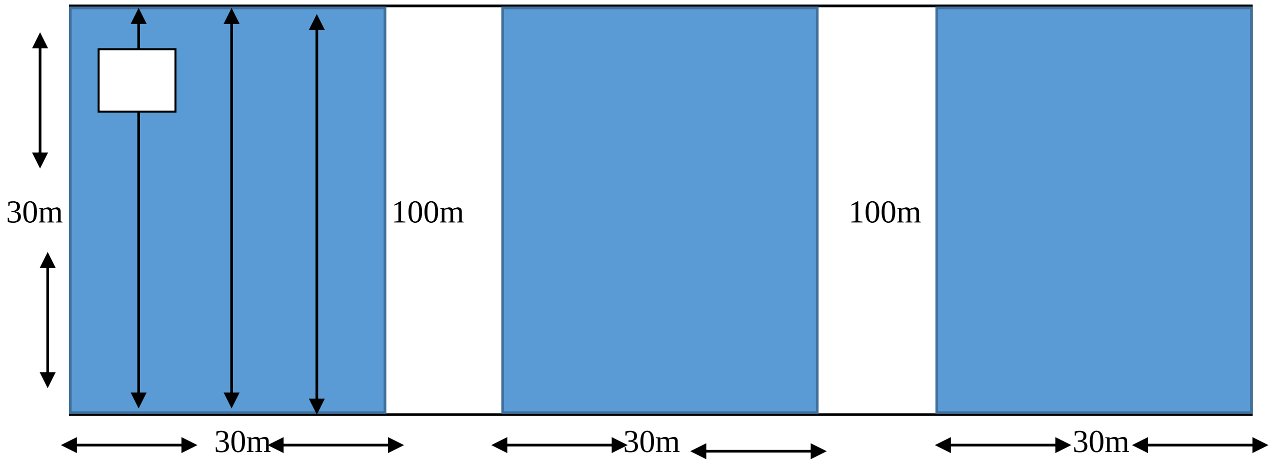

Figure 2: Field design

3.3.2 Insects Collection

Sweeping net

Sweeping nets come in all shapes and sizes, each designed for a particular insect group. Sweeping net consist of a 38-cm net ring, 91-cm handle, and white muslin bag. butterflies butterflies (Dewalt et al., 2015). Sweeping nets use to the purpose of capturing flying insects such as mayflies, dragonflies, butterflies, moths, true flies, bees, and wasps. Specifically designed to be lightweight, they feature long, slender handles, occasionally flexible hoops, and a soft bag with a large mesh size. This design makes them ideal for handling delicate specimens like mayflies or butterflies.(Gill and O'Neal, 2015)

The Insect pollinators were collected with the help of sweeping net method from June to December. In the field, pollinators were observed and collected during peak. The collection was done in two season autumn and summer season. The plant species on which pollinators were collected was recorded and photograph was taken for identification of plant species. The collected insect pollinators were placed in insect collection vials containing cotton soaked in ethyl acetate immediately after collection. Butterflies were carefully pressed at the thorax and stored in paper envelopes for dry preservation with preservative for further sorting and identification, based on their morphology features. The specimens were then labeled with relevant information, including the sample site name, sample plot name, date and time of collection, and the sample specimen code. The collected specimen were transported to the Entomology Laboratory at the Central Department of Zoology, Tribhuvan University, Kirtipur, Kathmandu, for further analysis.

3.4.3 Preservation and Identification of insects

The collected samples were brought to the Laboratory of Central Department of Zoology, Tribhuvan University, Kirtipur, Kathmandu. Insects were initially sorted based on morphological similarities. The specimen were stretched in stretching board and finally they were preserved in the entomological box by pinning with the entomological pins. The naphthalene balls were added as preservative. Each specimen was examined under a stereo microscope and photographed using a mobile phone. Identification was performed up to the family level using the family keys from (Triplehorn & Jhonson, 2005) with further identification were conducted using (Carpenter & Nguyen , 2003) (Rego et al., 2022) (Merryweather, 2020)(Tangi et al., 2016)(Augul et al., 2015). The identified specimens were carefully preserved in an entomological box, with labels containing detailed, including the species name, date of collection, collection site, and the name of the collector.

3.4.4 Species Deposition

The collected specimen during the field work was deposited in the museum at the central Department of Zoology, Tribhuvan University.

3.4.5 Data process and analysis

The data collected in this study was first organized and analyzed using Microsoft Excel 2013. Diversity indices, like Shannon-Wiener Diversity Index (H'), Simpson's index (D), richness within the same software was done to assess the diversity, dominance, and distribution patterns of pollinators across different invasive plant species. Regression analysis was done between the pollinator count and plant density. All relevant information was entered into Excel, which was also used to generate visual outputs like pie charts, bar graphs to effectively illustrate the findings.

The status of recorded Pollinators were categorized into four categories; 1-2 abundance- Very abundance, 3-10 abundance- Rare, 11-30 abundance- Fairly Common and 30<abundance- Common (Shrestha et al., 2018).

4. Results

4.1 Percentage of pollinator visits to invasive plant species in summer season

Out of 228 observed individuals, the highest number of pollinators visiting an invasive plant was recorded for *Lanatana camara*, primarily visited by *Polistes spp. followed by Amegilla spp.* (11.81%). Overall, the most frequently visited invasive plant was *Lantana camara*, followed by *Bidens pilosa.* (Table 1.)

Table 1: Percentage of Pollinator visiting invasive plant species in summer season.

Name of Pollinator	***Lantan camara***	***Ipomoea carnea***	***Bidens pilosa***	***Agaratum houstonianum***	***Alternanthera philoxeroides***	***Mesosphaerum suaveolens***	***Parthenium hysterophorus***
Apis cerana	3.93	1.57	3.36	-	-	-	-
Apis dorsata	0.78	-	0.78	-	-	-	-
Amegilla spp.	11.81	-	0.78	0.78	-	-	-
Bombus spp.	0.78	4.72		-	-	-	-
Parapolybia spp.	3.93	0.78	1.57	-	-	0.78	-
Vespa spp.	3.14	-	0.78	-	-	-	-
Nomioides spp.	0.78	-	1.57	-	-	-	-
Sceliphron spp.	2.36	-	2.36	-	-	-	
Polistes spp.	13.38	1.57	8.66	-	0.78	-	0.78
Episyrphus spp.	1.57	-	2.36	-	-	-	-
Eupeodes spp.	0.78	-	1.57	-	-	-	-
Syritta spp.	0.78	-	0.78	-	-	-	-
Syntomoides imaon	3.93	2.36	-	-	-	1.57	-
Colias erate	-	-	0.78	-	-	-	-

Jamides alecto			0.78	-	-	-	-
Parantica aglea	1.57	-	-	-	-	-	-
Danaus chrysippus	0.78		-		-	-	-
Ariadne ariadne	0.78	-	-	-	-	-	-
Pieris canidia	3.14	-	-	-	-	-	-
Potanthus mingo	0.78	-	-	-	-	-	-
Eurema hecabe	-		1.57	-	-	-	-
Aglais caschmirensis	0.78	-	-	-	0.78	-	
Papilio polytes	1.57	-	-	-	-	-	-
Samia canningi	0.78	-	-	-	-	-	-
Unidentified spp.	-		3.14	-	0.78	-	
Total	**58.13**	**9.43**	**29.05**	**3.14**	**4.7**	**0.78**	**2.35**

4.2 Percentege of pollinators visits to invasive plant species in autumn season

Table 2: Percentage of Pollinator visiting invasive plant species in autumn season.

Pollinator	***Lantana camara***	***Ipomoea carnea***	***Bidens pilosa***	***Agaratum houstonianum***
Apis cerana	1.98	-	81.18	-
Bombus spp.	-	0.99	-	-
Parapolybia spp.	0.99	-	-	-
Episyrphus spp.	-	-	4.95	-
Eristalis spp.	-	-	-	0.99
Danus chrysippus	-	-	0.99	0.99
Aglais cashmerensis	0.99	-	-	-
Jamides alecto	0.99	-	-	-
Pieis canidia	2.97	-	1.98	-

4.3 Diversity of pollinator visiting invasive plant species

The table highlights seasonal variations in pollinator diversity and abundance across invasive plant species. Pollinators were most abundant during the summer season, (n = 127) and followed by autumn (n = 101). In terms of diversity, *Lantana camara* hosted the most diverse pollinator community in summer (H' = 2.64) with (n=64), followed by *Bidens pilosa*, *Alternanthera philoxeroides*, *Ipomoea carnea*, *Ageratum houstonianum*, and *Parthenium hysterophorus*, with the lowest diversity observed in *Mesosphaerum* with only one individual. *Bidens pilosa* maintains high richness (n=90) in autum, though its diversity index drops. *Ageratum houstonianum* and *Ipomoea carnea* have low diversity and richness in both seasons. (Table 3.)

Table 3: Diversity Indices of pollinator visiting invasive plant species in two seasons

S.N	Name of invasive plants	Summer			Autumn		
		Shannon (H')	**Simpson(D)**	**Species Richness**	**Simpson(D)**	**Shannon (H')**	**Species Richness**
1.	*Lantan camara*	2.644	0.086	64	0.143	1.494	8
2.	*Bidens pilosa*	2.382	0.108	37	0.832	0.379	90
3.	*Agaratum houstonianum*	0.562	0.5	4	0	0.693	2
4.	*Alternanthera philoxeroides*	1.242	0.2	6	-	-	-
5.	*Parthenium hysterophorus*	0.636	0.33	3	-	-	-
6.	*Ipomoea carnea*	1.198	0.29	12	0	0 (only 1 individual)	1
7.	*Mesosphaerum suaveolens*	0 (only 1 individual)	0	1	-	-	-

4.4 List of Insect pollinator visiting invasive plant species in summer and autumn.

A total of 26 pollinator species were recorded visiting invasive plants in the northern Kathmandu Valley across summer and autumn seasons. These included bees, wasps, flies, butterflies, and moths. Eight species, such as *Apis cerana*, *Bombus spp.*, *Parapolybia spp.*, and *Danaus chrysippus*, were observed in both seasons, showing strong seasonal adaptability, while 18 species appeared only in summer. *Lantana camara* was the most visited plant, attracting 21 species, followed by *Bidens pilosa* with 20. Ageratum houstonianum and Ipomoea had lower species diversity. *Mesosphaerum suaveolens* had minimal visitation. *Eupeodes spp.*, and *Eristalis spp.*, were found only in autum, and one unidentified pollinator was recorded on *Bidens pilosa* and *Alternanthera philoxeroides*. (Table 4.)

Table 4: Insect pollinator visiting invasive plant species in summer and autumn season.

S.N	Name of pollinator	Summer	Autumn	Name of invasive plants
1.	*Apis cerana*	+	+	*Lantana camara ,Bidens pilosa, Agaratum houstonianum*
2.	*Apis dorsata*	+	-	*Lantana camara , Bidens pilosa*
3.	*Amegilla* spp.	+	-	*Lantana camara ,Bidens pilosa, Agaratum houstonianum*
4	*Bombus* spp.	+	+	*Lantana camara , Ipomoea carnea*
5	*Parapolybia* spp.	+	+	*Lantana camara , ,Bidens pilosa, Ipomoea carnea, Mesosphaerum suaveolens*
6	*Vespa* spp.	+	-	*Lantana camara , ,Bidens pilosa*
7.	*Nomioides* spp.	+	-	*Lantana camara , ,Bidens pilosa*
8.	*Sceliphron* spp.	+	-	*Lantana camara ,Bidens pilosa , Alternanthera*
9.	*Polistes* spp.	+	-	*Lantana camara , Ipomoea carnea, Parthenium, Alternanthera, ,Bidens pilosa*
10.	*Episyrphus* spp.	+	+	*Lantana camara*
11.	*Eupeodes* spp.	-	+	*Lantana camara ,Bidens pilosa*

12.	*Syritta* spp.	+	-	*Lantana camara ,Bidens pilosa*
13.	*Eristalis* spp.	+	+	*Agaratum houstonianum*
14.	*Syntomoides imaon*	+	-	*Lantana camara ,Parthenium, Ipomoea carnea*
15.	*Colias erate*	+	-	*Bidens pilosa*
16.	*Jamides alecto*	+	+	*Lantana camara ,Bidens pilosa*
17.	*Parantica aglea*	+	-	*Lantana camara*
18.	*Danaus chrysippus*	+	+	*Lantana camara ,Bidens pilosa , Agaratum houstonianum*
19.	*Ariadne ariadne*	+	-	*Lantana camara*
20.	*Pieris canidia*	+	+	*Lantana camara,,Bidens pilosa*
21.	*Potanthus mingo*	+	-	*Lantana camara,*
22.	*Eurema hecabe*	+	-	*Bidens pilosa*
23.	*Aglais caschmirensis*	+	+	*Alternanthera philoxeroides*
24.	*Papilio polytes*	+	-	*Lantana camara,*
25.	*Samia canningi*	+	-	*Lantana camara,*
26.	*Unidentified spp..*	+	-	*Bidens pilosa*

4.5 Percentage of pollinator family visiting invasive plant species.

Out of the total 228 individual observations, *Bidens pilosa* received the highest number of pollinator visits, with a notable dominance by the family Apidae (37.71%), particularly *Apis cerana*. However, in terms of overall diversity of visitors, *Lantana camara* attracted the highest diversity of pollinators among invasive plant species, with frequent visits from various families across the Hymenoptera, Diptera, and Lepidoptera orders. (Table 5)

Table 5: Percentage of pollinator family visiting invasive plant species.

Order	Family	Name of invasive plant	Percentage
Hymenoptera	Apidae	*Lantan camara*	10.52
		Bidens pilosa	37.71
		Ipomoea carnea	3.07
		Agaratum houstonianum	1.75
	Vespidae	*Lantan camara*	7.45
		Bidens pilosa	7.89
		Ipomoea carnea	1.31
		Parthenium hysterophorus	0.43
		Mesosphaerum suaveolens	0.43
		Alternanthera philoxeroides	0.43
	Halictidae	*Lantan camara*	0.43
		Bidens pilosa	0.87
		Alternanthera philoxeroides	1.31
	Sphecidae	*Lantan camara*	1.31
		Bidens pilosa	1.31
Diptera	Syrphidae	*Lantan camara*	1.75
		Bidens pilosa	4.82
		Agaratum houstonianum	0.43
Lepidoptera	Nymphalidae	*Lantan camara*	2.63
		Bidens pilosa	0.43
		Agaratum houstonianum	0.43
		Alternanthera philoxeroides	0.43
	Papilionidae	*Lantan camara*	0.87
	Hesperiidae	*Lantan camara*	0.43
	Lycaenidae	*Lantan camara*	0.43
		Bidens pilosa	0.43
	Erebidae	*Lantan camara*	2.19
		Ipomoea carnea	1.31
		Parthenium hysterophorus	0.87
	Saturniidae	*Lantan camara*	0.43

4.6 Categorization of Insect Pollinators of invasive plant Species

Table 6: Categorization of pollinator on invasive plant species.

S.N	Name of pollinator	Abundance	Status			
			Common	Fairly Common	Rare	Very rare
1.	*Apis cerana*	97	-			
2.	*Apis dorsata*	2				-
3.	*Amegilla* sp.	17		-		
4	*Bombus* sp.	8			-	
5	*Parapolybia* sp.	10			-	
6	*Vespa* sp.	5			-	
7.	*Nomioides* sp.	3			-	
8.	*Sceliphron* sp.	9			-	
9.	*Polistes* sp.	22		-		
10.	*Episyrphus* sp.	10			-	
11.	*Eupeodes* sp.	2				-
12.	*Syritta* sp.	2				-
13.	*Eristalis* sp.	1				-
14.	*Syntomoides imaon*	10			-	
15.	*Colias erate*	1				-
16.	*Jamides alecto*	1				-
17.	*Parantica aglea*	2				-
18.	*Danaus chrysippus*	3			-	
19.	*Ariadne ariadne*	1				-
20.	*Pieris canidia*	9			-	
21.	*Potanthus mingo*	1				-
22.	*Eurema hecabe*	2				-
23.	*Aglais caschmirensis*	2				-
24.	*Papilio polytes*	2				-
25.	*Samia canningi*	1				-
26.	*Unidentified sp.*	5			-	

4.7 Regression analysis

The plot and regression results show a strong moderate positive relationship between plant density and pollinator count. As plant density increases, pollinator counts also rise. However, the curve shows that the increase is not constant, the number of pollinators grows more slowly at higher plant densities.

Table 7: Regression analysis between Pollinator and Invasive plant abundance

	Coefficient	Standard Error	t- test	P- value
Intercept	0.186	0.069	2.670	0.008
X varaible	0.048	0.002	18.587	<0.001

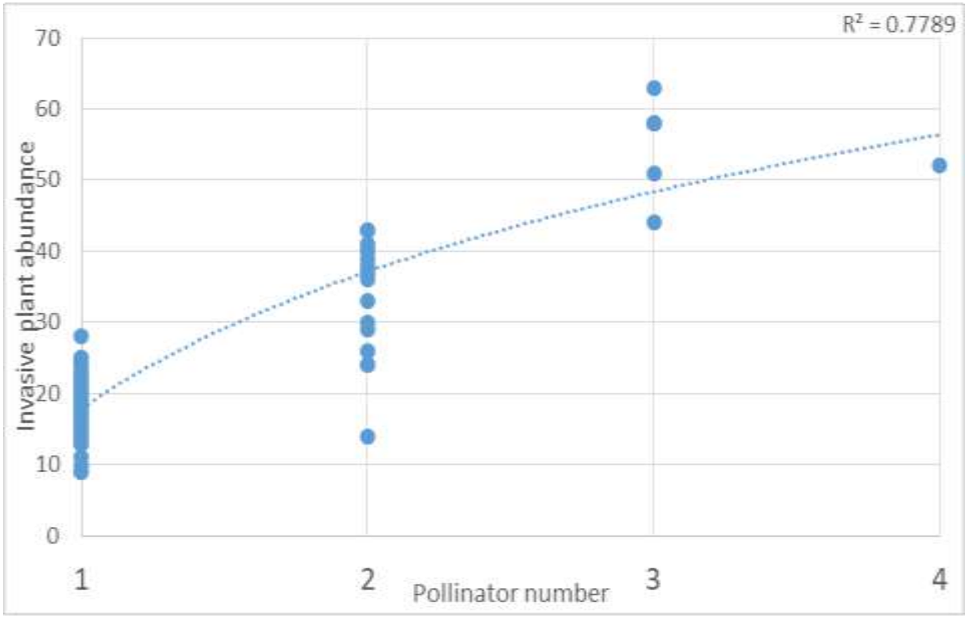

Figure 3: Relation between Pollinator and Invasive plant abundance

5. Discussion

5.1 Diversity of invasive plant species

This study explored the diversity of pollinator on invasive plant of Kathmandu valley across the two season; summer and autum. A total of 228 individuals belonging to three order mainly Hymenoptera, Diptera and Lepidoptera from twelve family were recorded. Among these, the family Apidae was the most abundant, followed by Vespidae**,** Syrphidae**,** Pieridae**,** Erebidae**,** Sphecidae**,** Halictidae**,** Papilionidae**,** Hesperiidae**,** Lycaenidae, and Saturniidae. These pollinators were observed visiting a range of invasive plant species, including (*Lantana camara*, *Bidens pilosa*, *Ageratum houstonianum*, *Alternanthera philoxeroides*, *Parthenium hysterophorus*, *Ipomoea carnea*, and *Mesosphaerum suaveolens).*

Out of 228 individual pollinator visits, the majority were from the Apidae family, with honey bees being the most abundant visitors to invasive plant species. This is likely due to their generalist foraging behavior, allowing them to exploit a wide range of floral. A study in southern California (Hung et al., 2019) showed that honey bees visit flowers more when there are many of them. As a result, honey bees may dominate flower-rich plants, which could push other pollinators to less attractive plants. Diptera was found to be second most abundant pollinator in the study followed by Lepidoptera.

Lantana camara were visited by most of the pollinators in the study area likely due to their high reward in the nectar quantity. A related study by Boff et al., (2021), conducted in the Brazilian Pantanal wetlands, investigated pollinator preferences for different flower color morphs of *Lantana* species. The study found that bees particularly *Apis* species (family Apidae) were the most frequent floral visitors, primarily attracted by the abundant nectar and rich floral resources offered by the plant. Similarly, Ravichandran et al., (2024) found that *Apis cerana* was the most consistently attracted bee species to the various flower color morphs of *Lantana camara*. and bidens pilosa similar study aligns with MG et al., (2023) reported that *Apis mellifera* (family Apidae) was the most abundant pollinator across Asteraceae weed species. (Ravichandran et al., 2024) also found that *Apis cerana* was the most consistent and broadly attracted bee species to the diverse flower color morphs of *Lantana camara*, being the only bee observed across all three color variants. Only *Apis cerana* and one butterfly species (*Danaus chrysippus*) demonstrated full-spectrum pollination across all morphs, indicating its wide attraction to the plant's floral traits.

Lepidoptera (Butterfly) were primarily observed visiting *Lantana camara*, with the family *Pieridae* being the most abundant, followed by *Nymphalidae and Erebidae*. A study by Dutta & Mitra., (2017) investigated the association between butterflies and *Lantana camara*, recording 24 butterfly species from four families. Among these, *Nymphalidae* was found to be the most dominant, followed by Pieridae**,** Papilionidae, and Lycaenidae**.** Similarly, Bruner et al., (2008) explored butterfly visitation patterns to *Lantana camara* and found that members of Hesperiidae and Nymphalidae constituted the majority of the visiting Lepidoptera. Bumblebees were more frequently observed on *Ipomoea* species, likely due to the attractive floral colors and abundant nectar. Wolfe & Sowell., (2016) conducted a study on various *Ipomoea* species to examine how floral traits influence pollinator attraction. Their results showed that *Ipomoea hederacea* and *Ipomoea trichocarpa*, which produce blue and purple flowers, were primarily visited by bumblebees, suggesting that both flower color and nectar availability play significant roles in attracting these pollinators.

Overall, the results highlight the significant role of pollinators, especially bees, in supporting the reproduction of invasive plants such as *Lantana camara* and *Bidens pilosa*, emphasizing the importance of pollinator-plant interactions.

5.2 Seasonal variation of pollinator diversity

The diversity of pollinator among the invasive plant were found to be higher in summer season than in winter season. Three insect order were recorded in summer season with 127 individual whereas in winter 101 individual is recorded.

Hymenoptera was abundant in summer season, Apidae mainly bee is most common show high species richness in summer. Similar results was obtained by Bashir., (2015) that with *Apis sp.* was the most abundant, peaking in abundance during spring and reaching maximum richness in summer.

Butterfly was found in both season, the diversity was higher in summer than in winter season. A study conducted by Cézar et al., (2022) also found butterfly richness, abundance, were significantly higher during the summer season

6. Conclusion and Recommendation

6.1 Conclusion

The study on pollinators visiting invasive plants in the northern part of Kathmandu Valley reveals that a diverse assemblage of insects particularly bees (Apidae), flies, and butterflies actively forage on invasive species, with *Lantana camara* and *Bidens pilosa* being the most frequently visited. Pollinator abundance was significantly higher during the summer season, likely driven by warmer temperatures and greater floral availability. These findings highlight the crucial role of generalist pollinators, especially honey bees, in supporting the reproduction and spread of invasive plants. While invasive plants can provide valuable nectar and pollen resources for pollinators, it remains essential to prioritize the conservation and promotion of native plant species. Native flora supports diverse and stable pollinator communities, helping maintain ecological balance and resilience. Therefore, integrated management strategies that control the spread of invasive plants while fostering native vegetation are vital for sustaining healthy ecosystems and pollinator populations.

Although this study represents an initial effort to document insect pollinators of invasive plants in Kathmandu, it offers important baseline data that can inform future research and conservation initiatives in the region.

6.2 Recommendations

Based on the results of this study following recommendations have been made:

- A comprehensive survey of all invasive plant species in the Kathmandu Valley is essential to assess pollinator diversity.
- As the present study was carried out only in two seasons (summer and autum). Therefore, future research should be conducted in all seasons to find the seasonal variation among all seasons.

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Appendices

Appendix I. List of Insect pollinator visiting invasive plant species during summer season

S.N	Scientific name of pollinator	Order	Family	Invasive plant family	Invasive plant
1.	*Apis cerana*	Hymenoptera	Apidae	Verbenaceae, Asteraceae	*Lantana*, *Bidens, Agaratum,*
2.	*Apis dorsata*	Hymenoptera	Apidae		*Lantana* , *Bidens*
3.	*Amegilla* sps.	Hymenoptera	Apidae	Verbenaceae, Asteraceae	*Lantana ,Bidens, Agaratum*
4	*Bombus* sps.	Hymenoptera	Apidae	Verbenaceae, Convolvulaceae	*Lantana* , *Ipomoea*
5	*Parapolybia* sps.	Hymenoptera	Vespidae	Verbenaceae, Convolvulaceae, Asteraceae, Lamiaceae	*Lantana ,Bidens, Ipomoea, Mesosphaerum*
6	*Vespa* sps.	Hymenoptera	Vespidae	Verbenaceae, Asteraceae	*Lantana ,Bidens*
7.	*Nomioides* sps.	Hymenoptera	Halictidae	Verbenaceae, Asteraceae	*Lantana ,Bidens*
8.	*Sceliphron* sps.	Hymenoptera	Sphecidae	Verbenaceae, Asteraceae, Amaranthaceae	*Lantana ,Bidens , Alternanthera*
9.	*Polistes* sps.	Hymenoptera	Vespidae	Verbenaceae, Convolvulaceae, Asteraceae, Amaranthaceae	*Lantana , Ipomoea, Parthenium, Alternanthera, Bidens*

10.	*Episyrphus* sps.	Diptera	Sypridae	Verbenaceae,	*Lantana*
11.	*Eupeodes* sps.	Diptera	Syrphidae	Verbenaceae, Asteraceae	*Lantana ,Bidens*
12.	*Syritta* sps.	Diptera	Syrphidae	Verbenaceae, Asteraceae	*Lantana ,Bidens*
13.	*Syntomoides imaon*	Lepidoptera	Erebidae	Verbenaceae, Asteraceae, Convolvulaceae	*Lantana ,Parthenium, Ipomoea*
14.	*Colias erate*	Lepidoptera	Pieridae	Asteraceae	*Bidens*
15.	*Jamides alecto*	Lepidoptera	Lycaenidae	Verbenaceae, Asteraceae	*Lantana ,Bidens*
16.	*Parantica aglea*	Lepidoptera	Nymphalidae	Verbenaceae,	*Lantana*
17.	*Danaus chrysippus*	Lepidoptera	Nymphalidae	Verbenaceae, Asteraceae	*Lantana ,Bidens , Agaratum*
18.	*Ariadne ariadne*	Lepidoptera	Nymphalidae	Verbenaceae,	*Lantana*
19.	*Pieris canidia*	Lepidoptera	Pieridae	Verbenaceae, Asteraceae	*Lantana ,Bidens*
20.	*Potanthus mingo*	Lepidoptera	Hesperiidae	Verbenaceae,	*Lantana*
21.	*Eurema hecabe*	Lepidoptera	Pieridae	Asteraceae	*Bidens*
22.	*Aglais caschmirensis*	Lepidoptera	Nymphalidae	Amaranthaceae	*Alternanthera*
23.	*Papilio polytes*	Lepidoptera	Papilionidae	Verbenaceae,	*Lantana*
24.	*Samia canningi*	Lepidoptera	Saturniidae	Verbenaceae,	*Lantana*
25.	*Unidentified* sps.	Hymenoptera	Vespidae	Asteraceae, Amaranthaceae	*Bidens, Alternanthera*

Appendix II. List of Insect pollinator visiting invasive plant species during autumn season

S.N	Scientific name of pollinator	Order	Family	Invasive plant family	Invasive plant
1.	*Apis cerana*	Hymenoptera	Apidae	Verbenaceae, Asteraceae	*Lantana*, *Bidens, Agaratum,*
2.	*Bumble bee*	Hymenoptera	Apidae	Verbenaceae, Convolvulaceae	*Lantana , Ipomoea*
3.	*Parapolybia*	Hymenoptera	Vespidae	Verbenaceae, Convolvulaceae, Asteraceae, Lamiaceae	*Lantana ,Bidens, Ipomoea, Mesosphaerum*
4.	*Episyrphus*	Diptera	Sypridae	Verbenaceae,	*Lantana*
5.	*Eristalis*	Diptera	Syrphidae	Asteraceae	Agaratum
6.	*Danus chrysippus*	Lepidoptera	Nymphalidae	Verbenaceae, Asteraceae	*Lantana ,Bidens , Agaratum*
7.	*Pieris canidia*	Lepidoptera	Pieridae	Verbenaceae, Asteraceae	*Lantana ,Bidens*
8.	*Agalis cashmirensis*	Lepidoptera	Nymphalidae	Amaranthaceae	*Alternanthera*

Appendix III. Pollinator visiting invasive plant in both seasons (Summer and autumn)

S.N	Pollinator	Summer	Winter
1.	*Apis cerana*	10.23% (13)	83.16% (84)
2.	*Apis dorsata*	1.57% (2)	-
3.	*Amegilla* sp.	13.38% (17)	-
4	*Bombus* sp.	5.51 (7)	0.99% (1)
5	*Parapolybia* sp.	7.08% (9)	0.99% (1)
6	*Vespa* sp.	3.93% (5)	-
7.	*Nomioides* sp.	2.36% (3)	-
8.	*Sceliphron* sp.	7.08% (9)	-
9.	*Polistes* sp.	17.32 (22)	-
10.	*Episyrphus* sp.	3.93% (5)	4.95% (5)
11.	*Eupeodes* sp.	1.57%(2)	-
12.	*Syritta* sp.	1.57%(2)	-
13.	*Eristalis* sp.	-	0.99% (1)
14.	*Syntomoides imaon*	7.87% (10)	-
15.	*Colias erate*	0.78% (1)	-
16.	*Jamides alecto*	0.78% (1)	-
17.	*Parantica aglea*	1.57%(2)	-
18.	*Danaus chrysippus*	0.78% (1)	1.98% (2)
19.	*Ariadne ariadne*	0.78% (1)	-
20.	*Pieris canidia*	3.14% (4)	4.95% (5)
21.	*Potanthus mingo*	0.78% (1)	-
22.	*Eurema hecabe*	1.57%(2)	-
23.	*Aglais caschmirensis*	0.78% (1)	0.99% (1)
24.	*Papilio polytes*	1.57%(2)	-

Samia canningi	0.78% (1)	-	
Unidentified sp.	3.93% (5)	-	
Total	**127**	**101**	

Appendix IV. Identified Insect Species with Diagnostic Character

S.N	Taxa	Diagnostic Character
1.	*Apis cerana*	Marginal cell long and narrow, Moderate body size**,** with four yellow abdominal stripes and legs of rusty colouration, Distal abscissa of vein M in hind wing present, Abdominal terga I-III partially or completely black
2.	*Apis dorsata*	Larger body size around 17–20 mm long, Distal abscissa of vein M in hind wing present, Forewings fuscous dark gray brown, with golden, blackand pale bands on the abdomen, Scutellum dark brown to black
3.	*Amegilla* sp.	Typically with mixture of light and dark pubescence, metasoma dark with strongly contrasting light white tergal hairbands, Lack of arolia between the tarsal claws, protuberant clypeus , first recurrent vein reaches the middle of the second submarginal cell
4	*Bombus* sp.	Medium-sized to very large species (10—35 mm), pollen-basket present, Gaster relatively densely long-haired, especially towards apex, never with rounded spots but often with complete bands of coloured hair either white, red, buff or yellow
5	*Parapolybia* sp.	Pronotal lobe separated from tegula by a distance equal to its length or less, Clypeus pointed, truncate or rounded, claws simple, hind- wing with jugal lobe, Pronotum with pretegular carina, mesepisternum with scrobal sulcus present
6	*Vespa* sp.	Pronotal lobe separated from tegula by a distance equal to its length or less, Clypeus pointed, truncate or rounded , claws simple, hindwing without jugal lobe, vertex long, distance between posterior ocelli and occiput greater than distance between posterior ocelli and eye,
7.	*Nomioides* sp.	Apex of marginal cell rounded or truncate, Metasoma with pale integument bands on base of terga, S8 of male with long apical process : yellow integument maculations on head, mesosoma and metasoma

8.	*Sceliphron* sp.	Propodeum with U-shaped dorsal enclosure defined tarsi with plantulae, body checkered by black and yellow colour
9.	*Polistes* sp.	Pronotal lobe separated from tegula by a distance equal to its length or less, Clypeus pointed, truncate or rounded, claws simple, hind- wing with jugal lobe, metasoma variable in shape, petiolate to subsessile, Metasomal segment I subsessile
10.	*Episyrphus* sp.	Face entirely yellow, scutellum always yellow clearly lighter than scutum, eye bare, Metasternum hairy, Abdomen more or less parallel-sided, as broad as scutum, Abdomen with double bands on t3 and t4
11.	*Eupeodes* sp.	Abdomen broad or oval, Abdomen with yellow spots on t3 and t4, t3-t4, sometimes connected to form bands, 2nd antennal segment more developed, approximately four times shorter than 3rd segment,
12.	*Syritta* sp.	Thoracic pleura heavily dusted, continuing on the frontal half of the lateral side of scutum, legs bicoloured, abdomen with yellow spots on the lateral sides of t2 and t3, t4 with dusted areas
13.	*Eristalis* sp.	Face dark or yellow with median dark stripe, sometimes obscured by dense pollinosity, scutellum never yellow, sometimes orange to brown, wing vein R4+5 with a strong dip in the cell below, often with a bee like appearance,Eyes concolorous, without stripes,
14.	*Syntomoides imaon*	The frons and collar are yellow with the metathorax having a yellow streak. The first and fifth abdominal segment has a yellow band, The tips of the antennae and proximal joints of the tarsi are white.
15.	*Colias erate*	With distinct spots underside and upper side of wings , Upper surface of hind and fore wing is cloudily yellow greenish with black spots, hind wings apex with black in colour and fore wing in underside having white spots
16.	*Jamides alecto*	Antenna are brownish black with white shafts. Greyish ground color with white banding, The upperside of the thorax , palpi and abdomen are white
17.	*Parantica aglea*	Background colour of both wings (upper and lower) is dark brownish black, Glassy white marking are present
18.	*Danaus chrysippus*	Forelegs are reduced, antennae tips are with large conspicuous knobs, Body colour is tawny, upper margin of forewing is black with white spots, hind wings have a thin black border enclosing a sequence of hemispherical white spots
19.	*Ariadne ariadne*	Underside is a more greyish brown, upper surfaces of both wings are rich

		chestnut and male bears a triangular black patch of scent scales
20.	*Pieris canidia*	With distinct spots underside and upper side of wings, Mostly creamy or white colour, antennae black with minute white specks, the long hairs on head and thorax greenish grey, abdomen black, beneath, head, thorax and abdomen white
21.	*Potanthus mingo*	About half the length of the forewings with a hooked apiculus, Golden yellow marking include a series on the forewings and hindwings.
22.	*Eurema hecabe*	With distinct spots underside and upper side of wings , Commonly yellow with expansive black apical and terminal area of forewings, forewings with black inner margin
23.	*Aglais caschmirensis*	Upperside of forewings bright orange with black patches and spots; Hindwings is orange with black in the marginal spots near the edges, underside of the wings are shinning with changeable colors and ash tipped wings
24.	*Papilio polytes*	Mainly with black or dark colors, Mainly with black or dark colours , Mainly black with conspicuous tails on hind wings, post-marginal area of hindwings are with distal band of elongated white spots
25.	*Samia canningi*	Hindwing uaually patterned,
26.	*Unidentified sp.*	Parategula (horizontal lobe projecting from poster- olateral corner of mesoscutum) usually present, claws usually bifid, posterior lingual plate longer than broad, solitary or subsocial.

Photo plates

Photo plates 1: Hymenoptera, Apidae A *Amegilla* sps., B *Apis cerana* , C *Bombus* sps., D *Apis dorsata*

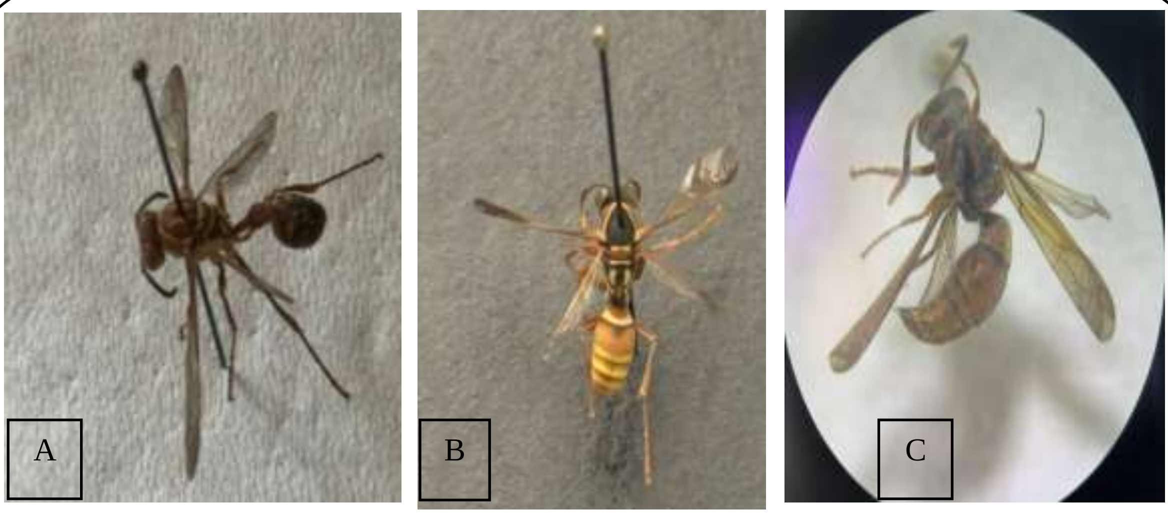

Photo plates 2: Hymenoptera, Vespidae, A *parapolybia* sps., B *Polistes* sps., C unidentified sps.

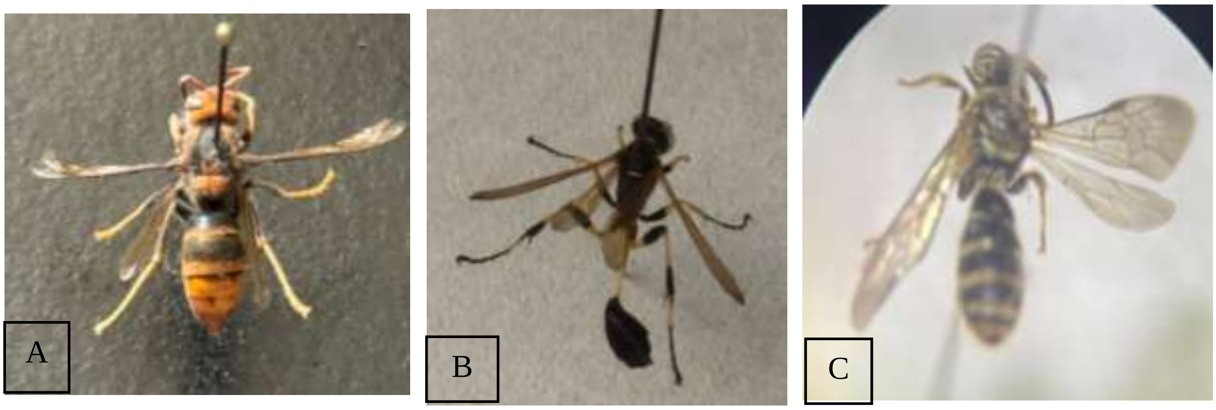

Photo plates 3: Hymenoptera Vespidae , A Vespa sps., Sphecidae B Sceliphron sps., Halictidae C Nomioides sps.

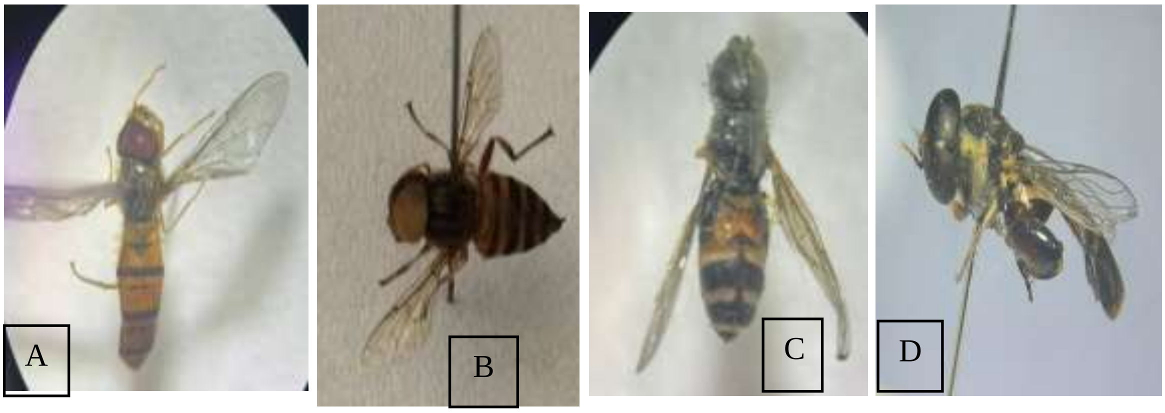

Figure 4. Diptera , Syrphidae, A Episyrphus sps., B Eristalis sps. C Eupeods sps. D Syritta sps.

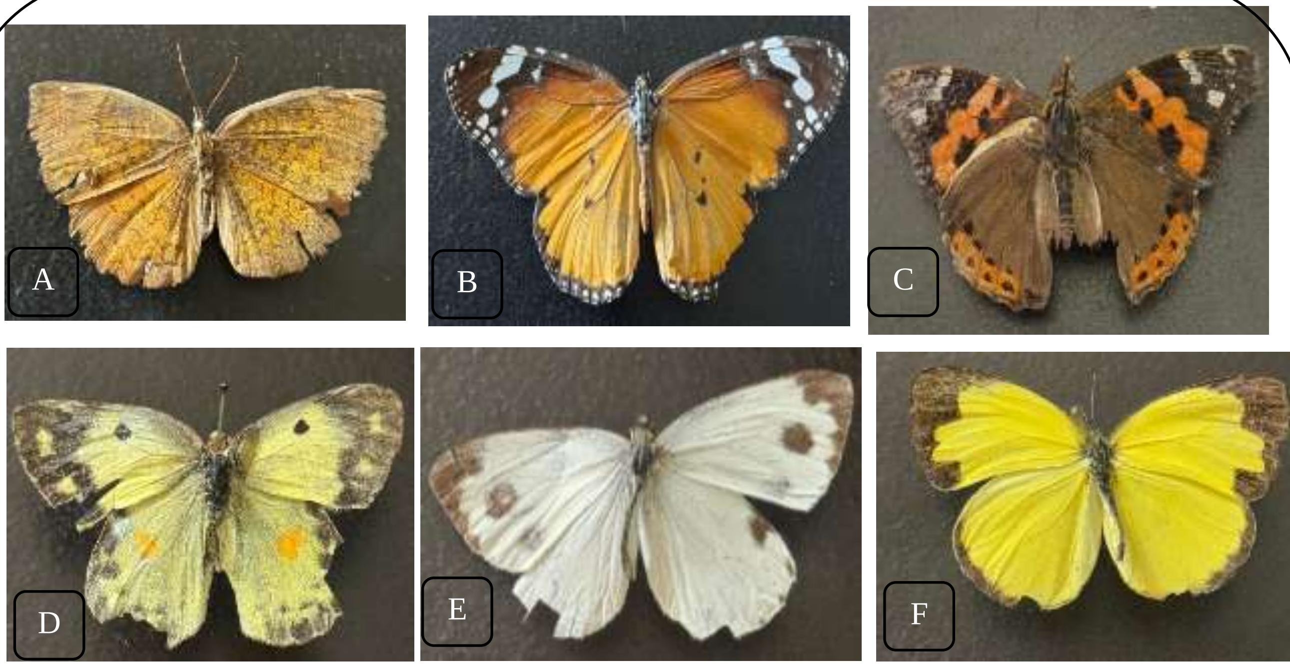

Photo plates 5: Lepidoptera, Nymphalidae, A *Ariadne ariadne*, B *Danus chrysippus*, C *Aglais cashmirensis*, Pieridae, D *Colis erate* ,E *Pieris canidia* , F *Eurema hecabe*

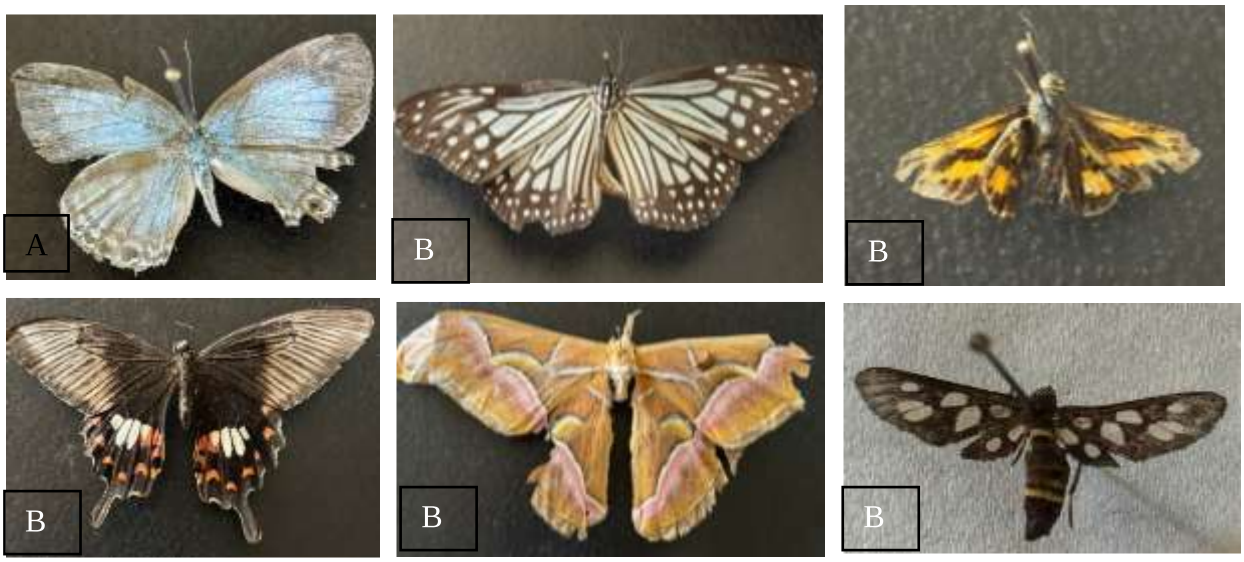

Figure 5. Lepidoptera, Lycaenidae G *Jamids alecto,* Nymphalidae, H *Parantica aglea*, Hesperiidae, I *Potanthus mingo,* Papilinoidae, J *Papilio polytes* , Saturniidae, K *Samia canningi*, Erebidae, L *Syntomoides imaon*

Figure 7. pollinator foraging on ***Bidens pilosa***

Figure 8. Pollinators foraging on *Bidens pilosa*

Figure 6. Pollinators foraging on *Bidens pilosa*

Figure 10. Pollinators foraging on *Bidens pilosa*

Figure 11. Pollinator foraging on *Parthenium hysterophorous*

Figure12. Pollinators foraging on *Ageratum houstoniaum*