Population Dynamics and Visit Timing of Insect Pollinator Families In Canola (*Brassica Napus* L.) Crops in Peshawar

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ABSTRACT

This study was carried out in the Newly Developmental Farm (NDF) of the University of Agriculture, Peshawar, during 2019-20. Its purpose was to determine the population dynamics, visit timing, and activity patterns of insect pollinators of canola crop. The order recorded such as Diptera, Hymenoptera, Lepidoptera, and Coleoptera. Diptera was the most abundant, with eight species in the family. The Syrphidae family had seven hoverfly species recorded. The Hymenoptera order had Apidae with four species of bees. The findings of the study indicated that the most active and consistent pollinators throughout the study period were European honeybees (Apis mellifera) and European hoverflies (Eristalis tenax), putting their very importance in the pollination of the canola crop. The information acquired on the temporal foraging patterns of these pollinators was quite rich in weekly observations during both morning hours, that is, 10:00 AM -12:00 PM, and in the evening hours for 03:00 PM-05:00 PM. Evening sessions were by Apis mellifera while a total of 241 Syrphid flies, who recorded the most prolific evening session with a total of 201. Other notable contributors included in the study were the Marmalade hoverfly, which appeared high in population during morning periods, and the Blue Butterfly (Zizina otis) showed a peak activity in the evening. Other species, for instance, include the Common hoverfly Ischiodon scutellaris and Giant honey bee (Ischiodan scutellaris), which were characterized by stable populations, giving weight to the fact that hoverflies and bees are key pollinators of canola.

The results suggest that an adequate abundance, as well as diversity of the pollinator community, are critical for high crop productivity. The work indicates that pollinators in canola fields have specific activity patterns and complex interactions, and therefore the study emphasizes the use of conservation strategies that would protect habitats for pollinators, support more sustainable agriculture practices, and increase biodiversity in canola fields.

Keywords:- insect pollinators, canola Brassica, Peshawar, Hymenoptera, Diptera, Lepidoptera

INTRODUCTION

Canola is a winter oilseed crop that is scientifically known as *Brassica napus* and belongs to the family Brassicaceae. Formerly it was known as Cruciferae originated from rapeseed breeding. Canola crops contain 23-35% protein and 40 - 44% oil content and are ranked 2nd after soybean in edible oil consumption (Kandil and Gad, 2012; USDA, 2016). Canola is used in Pakistan as a minor oil crop. For the preparation of medicines and traditional remedies canola can be grown on barren and marginal land as well as in those areas having low soil fertility and rainfall. Canola can tolerate salt and that's why it is also known to be drought-resistant (Flanders and Abdu, 1985; Shannon and Grieve 1999). Family Brassicaceae has 3000 species including 333 genera. (Warwick and Shehbaz, 2006). In our country, rapeseed and mustard are the important oil-producing crops. (Khan *et al* 2004).

Canola can be grown in different agroclimatic conditions and also tolerate both drought and stress conditions. In Europe, both *Brassica napus* and *Brassica compestris* are cultivated but in Canada, mostly spring season cultivation occurs. *Brassica napus* is mostly grown in China in the spring season while in India and sub-content *Brassica junica* is dominant and *Brassica carinata* is mostly grown in Ethiopia. (Prakash and, Hinata 1980). High amounts of protein and free amino acid have been responsible for susceptibility to canola aphid while the ascorbic acids and glucosinolates. Are harm the pest population. (Malik, 1981, labana *et al*, 1983). Insect pest infestation in Pakistan is almost up to 80 percent and severe infestation can lead to total destruction of the crop and due to their high attack, the crop becomes not viable for further germination. (Rustamani *et al.,* 1988).

In Pakistan, the total area under Canola cultivation was 243.000 hector with a total production of 231,000 tons while in Khyber Pakhtunkhwa the total area under canola cultivation was 17000 hectares with a production of 8000 tons and the average yield was 493kg/h (Anon 2013-2014). In ancient times rapeseed was a lubricating agent because of its high amount of Gluco sinolates and Erusic acid (Charlton et al., 1975). The consumption of canola was recorded in 2000 BC and has been grown in Europe since the 13th century and was used as an oil crop for Lamps. Family Brassicaceae is classified into four species, i.e., *B. napus B. carinata B. junicea*, and *B. compestris.* The annual production of canola 24.61 million metric tons has been recorded from 14 million hectares of growing areas. Which fulfills 12% of the world-wide edible consumption. (Colton and Sykes 1992 Canola crop mostly attack and are affected by major and minor's insect pests i.e., Flea beetles, head caterpillars, butterflies, and diamondback moths, and as also affected by sucking insects like thrips, jassids, whitefly, and aphids. By the infestation of the above insect pests the yield of the crop is highly affected and can lead to yield losses. For the control and bitter market values, formers used different high toxicant pesticides against insect pests which are harmful to man animals, and the environment. (AVRCD, 2011).

Coccinellidae family species are a well-known group of insect predators and 75 species have been recorded from Pakistan (Rafi *et al*., 2005). Most ladybird beetles are predaceous, as larvae and adults, feed on aphids. They are frequently quite common, particularly in vegetation where aphids are numerous (Mohyuddin, 1981). *Chrysoperla carnea* the green lacewing is a predator of exposed eggs and small larvae of all the lepidopterous pests, aphids, jassids, and mealy bugs. It has an advantage over egg parasitoids in that it can feed on both egg and larvae stages of pests and also its host range is much broader (Khan *et al*., 2005). According to Kannan (1999), natural enemies encountered preying on aphids were chrysopids, coccinellids, and syrphids, the first of these being the most important and dominant predators. Messina and Sorenson (2001) reported that lacewings reduced the aphid population on some plants and their effectiveness was 84%. The most dominant species of parasitoids are *Aphidious colemani*, *Aphidius ervi*, *Diaertilla rapae*, and *Aphidius morticaiae*.

MATERIALS AND METHODS

Study Site

The study was conducted at The University of Agriculture, Peshawar during the year during 2019-20. The major goal of the experiment was the assessment of chemical and botanical formulations utilized for managing canola aphids, which have been reported as one of the significant pests of economic importance causing reduction in crop yield. The site provided a controlled environment that allowed for the examination of interactions between pest management options and the populations of insects associated with crops of canola.

Insect Collection

Insect collection was primarily carried out through the hand net technique. The hand netting by the sweeping method was used extensively in the site covered with dense herbs and shrubs where small insects were likely to be encountered. This method, as noted by Donald et al. (1981), was particularly appropriate for collecting small-sized insects that are quite awkward to collect. It was done with much caution so that the most diversity of insects could be available for further study.

Pinning, Spreading, and Mounting

Larger specimens were pinned vertically through the body, using pins of an appropriate size in order not to damage any critical features such as legs and wings. In some instances, pinning was performed slightly off-center on the right side of the midline so that key morphological features would be fully visible for study purposes. Card points were used as a mounting base for smaller specimens. Glue was applied to the card tip, securing the insect in place. Every specimen was tagged with necessary information such as locality and data collection, the name of the collector, and the host plant. All the specimens were identified and once done, a label that stated the taxonomic order of the insect was attached for correct classification.

Conservation

All collected specimens were stored in wooden collection boxes with naphthalene balls to discourage infestation by pests as well as the growth of mold. The type of conservation was necessary for preserving the integrity of this collection, since it adhered to the recommendation posed by Donald et al. (1981) for long-term research.

Identification
For the identification of specimens collected, detailed taxonomic keys and literature by Donald et al. (1981) were utilized. The Grad Nikon Trinocular microscope from Nikon Corporation (2023) has been used to make observations at magnification powers up to 400X. Identification keys themselves were specifically designed and developed to classify orders of Class Hexapoda, thereby ensuring specimens that would be classified would be highly precise and reliable.

Repository
All the specimens collected and identified were deposited in the insect museum of the Department of Entomology, University of Agriculture, Peshawar.

Data Collection
The two-time intervals covered are from 10:00 AM to 12:00 PM and 3:00 PM to 5:00 PM, starting from flower initiation up to the crop mature stage. Five-minute observation was carried out for each of several pollinator species to document the latter's behavior and relative abundance. The relative abundance, RA, for every species was computed with the formula:

$$\textbf{Relative Abundance (RA)} = \frac{\textbf{Number of individuals visiting flowers}}{\textbf{Total number of pollinators}} \times 100$$

Data Analysis
The data collected from sowing to harvest were systematically analyzed using **STATISTICA-8** software to identify trends, population dynamics, and the impact of pest management strategies on pollinator activity. This analysis provided valuable insights into the interactions between pest control measures and pollinator populations, helping to inform sustainable pest management practices.

RESULTS

Table 1: Taxonomic Classification of Pollinator Species Observed by Family at the Newly Developmental Farm (NDF) of the University of Agriculture, Peshawar, spanning the period from 2019 to 2020.

Family	Order	Common Name	Scientific Name
Syrphidae	Diptera	Common Banded Hoverfly	Syrphus rebels
	Diptera	European Hoverfly	Eupeodes bucculatus
	Diptera	Paied Hover Fly	Scaeva pyrastri
	Diptera	European Hoverfly	Eristalis tenax
	Diptera	Marmalade Hover Fly	Episyrphus balteatus
	Diptera	Long Hoverfly	Sphaerophora scripta
	Diptera	Common Hoverfly	Ischiodan scutellaris
	Diptera	Syrphid Fly	Eupeodes bucculatus
Apidae	Hymenoptera	Giant Honey Bee	Ischiodan scutellaris
	Hymenoptera	Dwarf Honey Bee	Apis florea
	Hymenoptera	Eastern Honey Bee	Apis cerana
Lycaenidae	Lepidoptera	Blue Butterfly	Zizina otis
Pieridae	Lepidoptera	Cabbage Butterfly	Pieris brassica
Calliphoridae	Diptera	Blue Bottle Fly	Calliphora vomitoria
Coccinellidae	Coleoptera	Ladybird Beetle	Coccinella septempunctata

The pollinator families recorded in the canola fields were varied, ranging from species found in Syrphidae, Apidae, Lycaenidae, Pieridae, Calliphoridae, and Coccinellidae families. The family Syrphidae is an order of Diptera in which one can find various species of hoverflies such as Syrphus rebels or Common Banded Hoverfly, Eupeodes bucculatus or European Hoverfly, Scaeva pyrastri or Paied Hover Fly, and Episyrphus balteatus or Marmalade Hover Fly. The family Apidae, in the order Hymenoptera, consisted of Ischiodan scutellaris, popularly known as the Giant Honey Bee, Apis florea as the Dwarf Honey Bee, and Apis cerana as the Eastern Honey Bee. The Lycaenidae family of Lepidoptera order included Zizina otis or the Blue Butterfly and the Pieridae family of order Lepidoptera includes Pieris brassica or Cabbage Butterfly. In addition, the sub-order Diptera has hosted the Calliphoridae family, which was represented by Calliphora vomitoria (Blue Bottle Fly). Another example is Coccinellidae under Coleoptera, which was represented by Coccinella septempunctata (Ladybird Beetle). These are two of the most important insect families about pollination and largely contribute to the whole health of the ecosystem and agricultural productivity.

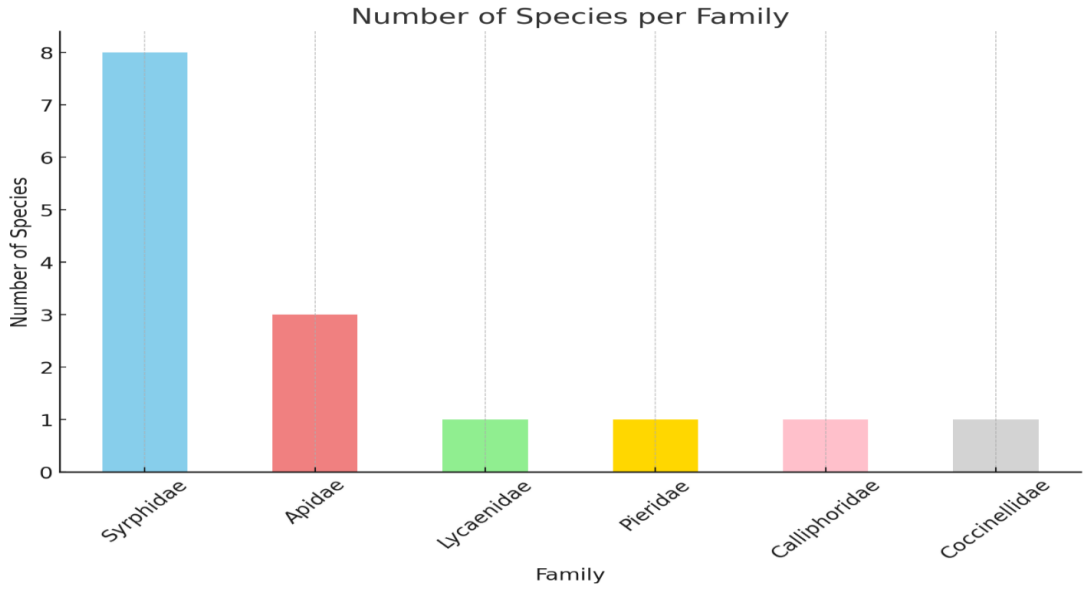

Fig 1: Number of pollinator species Number Per Family of Insect ARI during 2019-20

Fig 2: Number of pollinator species Number Per Order at during 2019-20

Table 2: Weekly Population Count of Various Pollinator Species Observed Across Four Weeks of Evening Observations (03:00 PM - 05:00 PM) **at the Newly Developmental Farm (NDF) of the University of Agriculture, Peshawar, spanning the period from** during 2019-20

Common Name	Scientific Name	W1	W2	W3	W4	Total
Common banded hoverfly	Syrphus reibessi	16	15	12	18	61
Blue Butterfly	Zizina otis	33	45	47	62	187
European hoverfly	Eupeodes bucculatus	15	12	13	14	54
Paied hoverfly	Scaeva pyrastri	25	34	26	42	127
Cabbage butterfly	Pieris brassica	16	23	22	26	87
European hoverfly	Eristalis tenax	17	16	23	22	78
Giant honey bee	Ischiodan scutellaris	15	12	17	22	66
Dwarfs honey bee	Apis florea	13	11	18	15	57
Blue bottle fly	Calliphora vomitoria	10	10	14	17	51
Ladybird beetle	Coccinella septempunctata	25	22	34	31	112
Marmalade hover fly	Episyrphus balteatus	10	12	11	14	47
Long hoverfly	Sphaerophora Scripta	14	16	13	17	60
Common hoverfly	Ischiodan scutellaris	11	19	15	15	60
Syrphid fly	Eupeodes bucculatus	41	48	55	57	201
Eastern honey bee	Apis cerana	21	21	18	15	75

The table 2 presents the population data of various pollinator species observed during four different weeks. The highest count is recorded for the European bee (*Apis mellifera*), with a total of 241 individuals. This species showed a gradual increase across the weeks, highlighting its significant presence and active role as a pollinator in the crop ecosystem. Similarly, the Marmalade hoverfly (*Episyrphus balteatus*) also had a notable population, reaching a total of 166, with a peak in the third week, indicating its dominance in certain periods. The Giant honey bee (*Apis dorseta*) recorded a moderate total of 102, showing a consistent presence but not as abundant as the European bee. Among the butterflies, the Cabbage butterfly (*Pieris brassicae*) and blue butterfly (*Zizina otis*) showed lower totals of 66 and 58 respectively, suggesting that their activity was relatively limited compared to other pollinators. The hoverfly species, including the European hoverfly (*Eristalis tenax*) and long hoverfly (*Sphaerophora scripta*), recorded totals of 151 and 92 respectively, highlighting the importance of hoverflies in the pollination process. Other notable hoverflies include the Commonly banded hoverfly (*Syrphus ribessi*) with 75 individuals and the Syrphid fly (*Eupeodus bucculatus*) with 98 individuals, both of which play crucial roles in pollination. The presence of the Ladybird beetle (*Coccinella septempunctata*) with a total of 57, along with the blue bottle fly (*Calliphora vomitoria*), which recorded a total of 54, emphasizes the diversity of insect pollinators. Lesser-known species, such as the Paied hoverfly (*Scaeva pyrastri*) and the Dwarfs honey bee (*Apis florea*), with totals of 64 and 88 respectively, further contribute to the overall pollinator community.

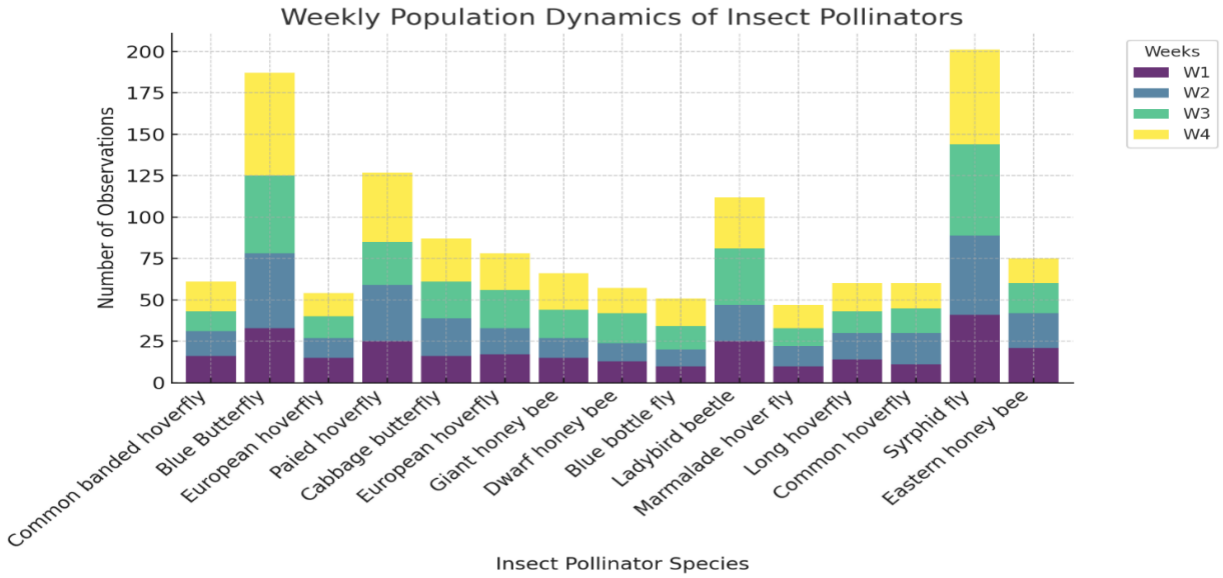

Fig 3 : Weekly Population Count of Various Pollinator Species Observed Across Four Weeks of Evening Observations (03:00 PM - 05:00 PM) **at the Newly Developmental Farm (NDF) of the University of Agriculture, Peshawar, spanning the period from 2019 to 2020.**

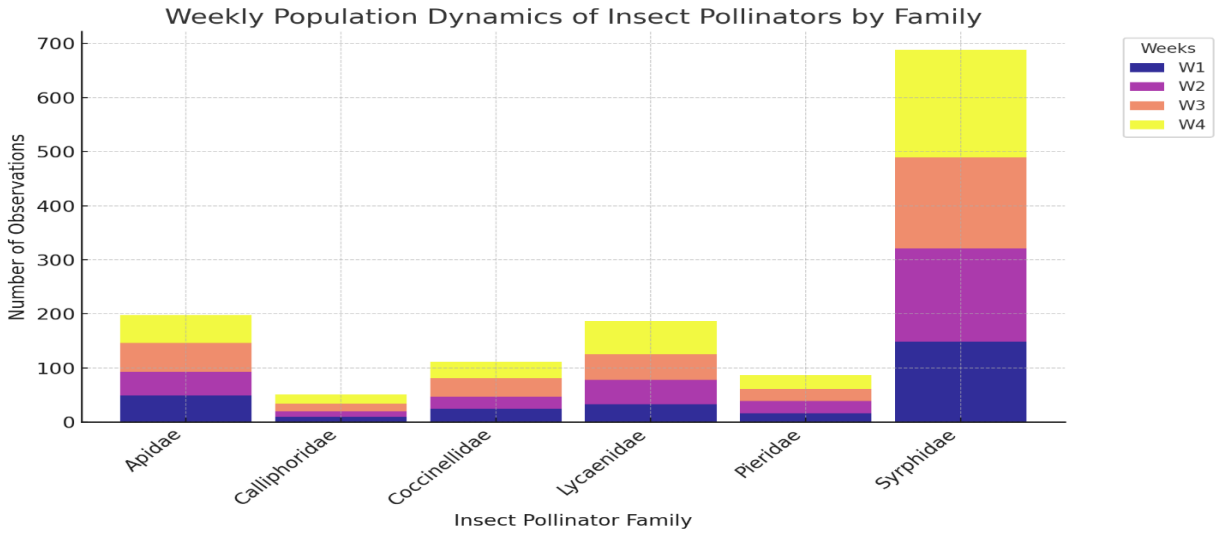

Fig 4 : Weekly Population Count of Various Pollinator Species by Families Observed Across Four Weeks of Evening Observations (03:00 PM - 05:00 PM) **at the Newly Developmental Farm (NDF) of the University of Agriculture, Peshawar, spanning the period from 2019 to 2020.**

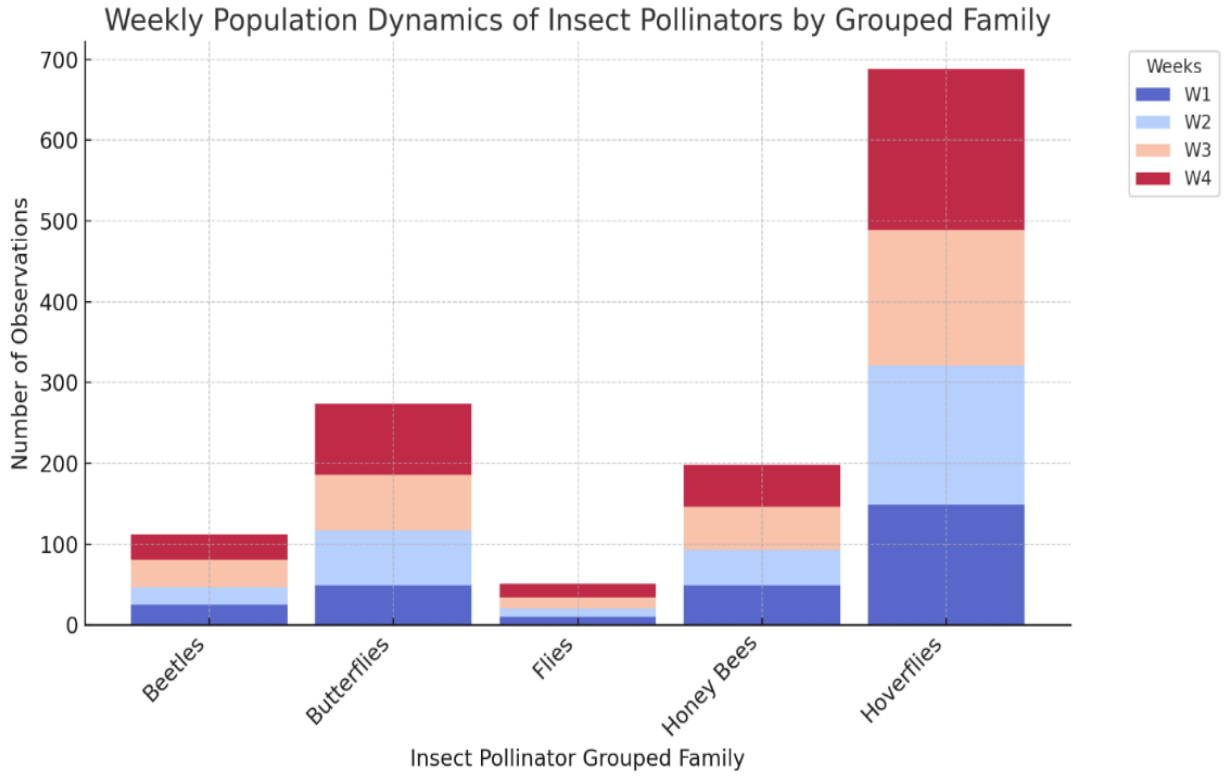

Fig 5 : Weekly Population Count of Various Pollinator Species by pollinator Groups Observed Across Four Weeks of Evening Observations (03:00 PM - 05:00 PM) **at the Newly Developmental Farm (NDF) of the University of Agriculture, Peshawar, spanning the period from 2019 to 2020.**

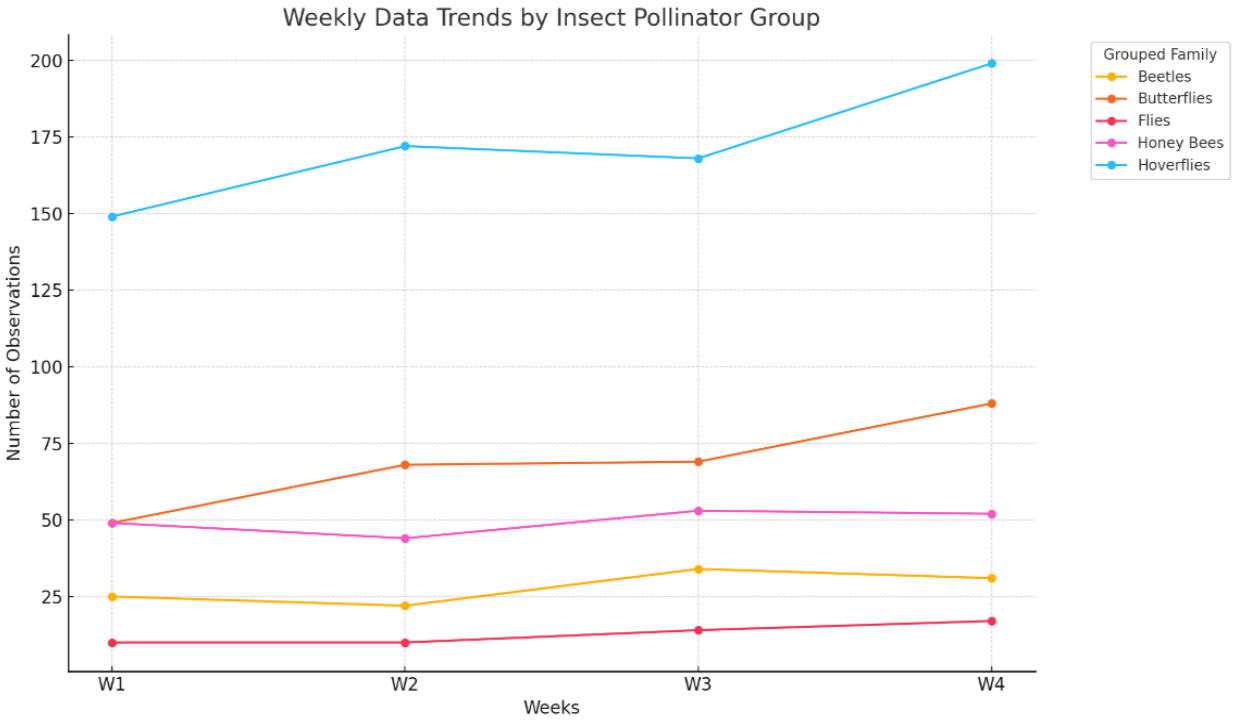

Fig 6 : Weekly Data Trends by Insect Pollinator Group **Observed Across Four Weeks of** Evening Observations (03:00 PM - 05:00 PM) **at the Newly Developmental Farm (NDF) of the University of Agriculture, Peshawar, spanning the period from 2019 to 2020.**

Table 3: Weekly Population Distribution of Pollinator Species Observed During Morning Period (W1 - W4) Morning Observations (10:00 AM - 12:00 PM) **at the Newly Developmental Farm (NDF) of the University of Agriculture, Peshawar, spanning the period from 2019 to 2020.**

Common Name	Scientific Name	W1	W2	W3	W4	Total
Giant honey bee	*Apis dorseta*	23	27	21	31	102
European bee	*Apis mellifera*	48	56	67	70	241
Cabbage butterfly	*Pieris brassicae*	19	15	18	14	66
European hoverfly	*Eristalis tenax*	29	40	34	48	151
Common hoverfly	*Ischiodan scutellaris*	14	25	19	23	81
Long hoverfly	*Sphaerophora Scripta*	21	16	25	30	92
Syrphid fly	*Eupeodus bucculatus*	21	23	29	25	98
Paid hoverfly	*Scaeva pyrastri*	15	18	14	17	64
Blue bottle fly	*Calliphora vomitoria*	10	16	15	13	54
Dwarfs honey bee	*Apis florea*	13	20	23	32	88
Blue Butterfly	*Zizina otis*	12	16	11	19	58
Ladybird beetle	*Coccinella septempunctata*	13	15	12	17	57
Common banded hoverfly	*Syrphus ribessi*	15	19	21	20	75
Marmalade hover fly	*Episyrphus balteatus*	30	39	51	46	166
Eastern honey bee	*Apis cerana*	13	20	27	25	85

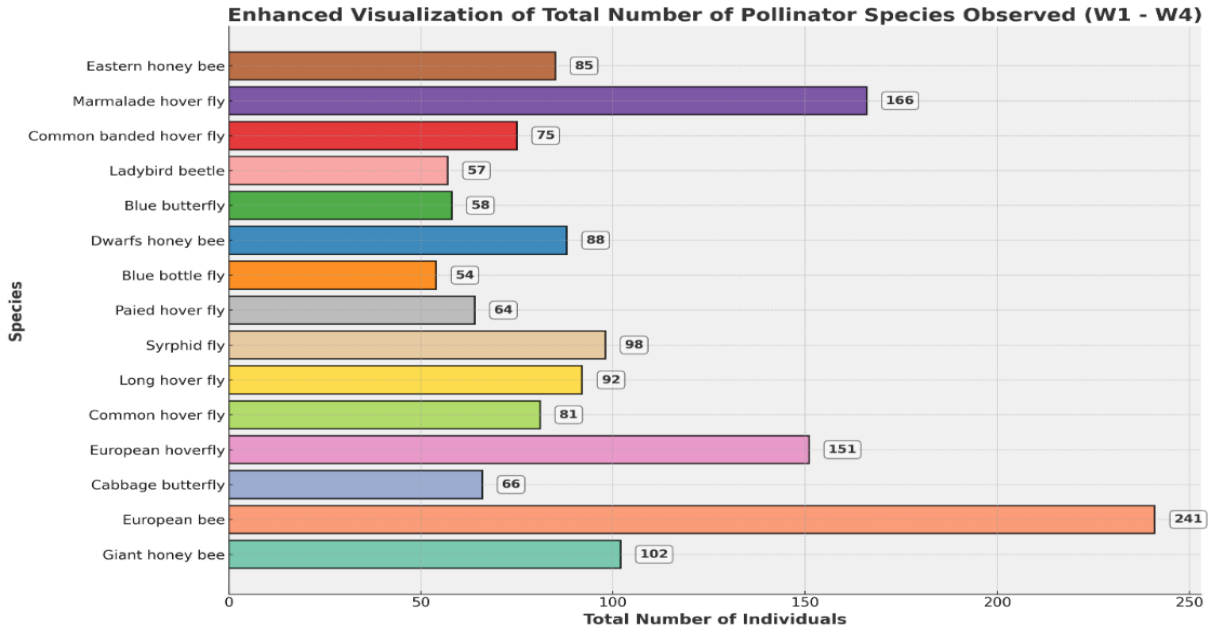

Fig7: Weekly Population Distribution of Pollinator Species Observed During Morning Period (W1 - W4) Morning Observations (10:00 AM - 12:00 PM) **at the Newly Developmental Farm (NDF) of the University of Agriculture, Peshawar, spanning the period from 2019 to 2020.**

The table 3 presents the weekly population data of various pollinator species observed over four weeks, reflecting the diversity and distribution of these species in the study area. The most abundant species recorded was the Syrphid fly (*Eupeodes bucculatus*) with a total count of 201 individuals. This species displayed a consistent increase over the four weeks, suggesting favorable conditions for its proliferation and an essential role in pollination. The Blue butterfly (*Zizina otis*) also showed a high population, reaching 187 individuals, with its numbers peaking in the final week. This indicates that this species is highly active during the later part of the observation period, possibly due to the increased availability of flowering resources. The Paied hoverfly (*Scaeva pyrastri*) and Ladybird beetle (*Coccinella septempunctata*) followed in abundance, with totals of 127 and 112 respectively, reflecting their robust presence in the ecosystem. Among the honey bee species, the Eastern honey bee (*Apis cerana*) and the Giant honey bee (*Ischiodan scutellaris*) had moderate populations of 75 and 66 respectively. Their distribution was relatively stable across the four weeks, highlighting their consistent foraging activity. In contrast, the Dwarfs honey bee (*Apis florea*) had a lower total of 57 individuals, with its highest count observed in the third week, suggesting fluctuating activity patterns. The European hoverfly (*Eristalis tenax*) and Cabbage butterfly (*Pieris brassica*) also exhibited moderate numbers, recording 78 and 87 individuals respectively. Their

populations peaked in the fourth week, indicating their preference for late-season floral resources. Other species such as the Common banded hoverfly (*Syrphus reibessi*) and long hoverfly (*Sphaerophora scripta*) showed relatively lower totals of 61 and 60, respectively, but maintained steady numbers throughout the period. Interestingly, the blue bottle fly (*Calliphora vomitoria*) and Marmalade hoverfly (*Episyrphus balteatus*) were among the least abundant species, with totals of 51 and 47, respectively. This lower abundance could indicate that these species are less prevalent or that their foraging preferences do not align with the flowering patterns observed during the study period.

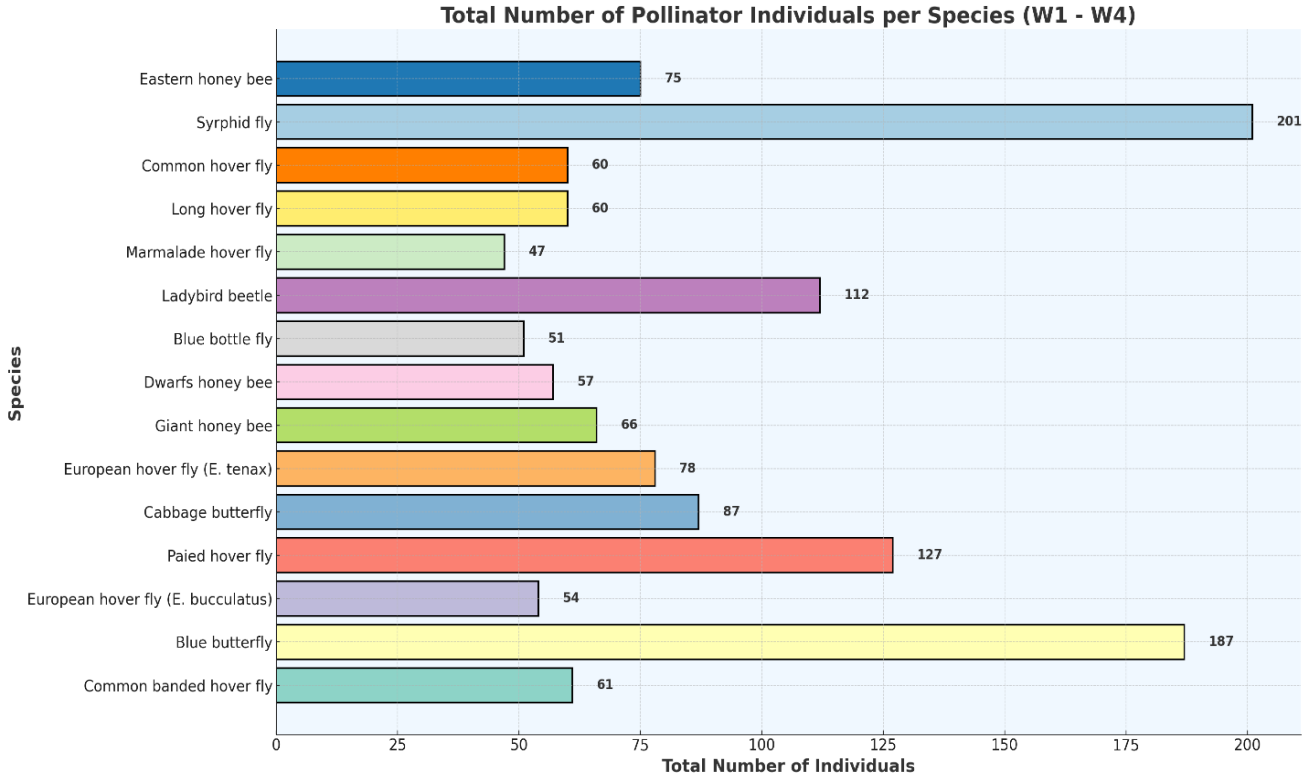

Figure 8 : Total Number of Pollinator Individuals per Species Observed Across Four Weeks during 2019-20

DISCUSSIONS

Several studies by different researchers have focused on the importance of insect pollinators in agriculture as one of the key factors that determine crop yield and quality under various crop systems. Naeem et al. (2016) identified 12 species of insect pollinators involved in pea crop pollination, signifying a diverse range of pollinators. According to Karanja et al., 2013, the significance of bees in coffee and berry crops was highlighted; it was shown that bees affected the crop quality and mass production. Douka and Fohou 2013 observed honey bees to be primary foragers and good pollinators during the flowering season, whereas Bodlah and Waqar indicated the role of hymenopterous and dipterous insects in vegetable pollination. Aumkin and Velkova (2013) evaluated the pollination-related diversity of insects on the crop of mustard plants, whereas Mukherjee et al. (2013) worked with different groups comprising butterflies, honeybees, and ladybugs, and these insects contribute largely to the pollination of crops. Pole et al. (2012) took Apis mellifera (Apis mellifera), and it may be seen that the activity of bees is parallel to the crops produced. Abrorol (2012) worked with the involvement of bees as agents in an ecosystem that brings biodiversity and stability to the ecosystem. Breez et al. (2011) mentioned that honey bees play a significant role in enhancing the productivity of agriculture, and Mudassar et al. (2011) asserted the role of Apis dorsata, Apis florea, and Halictus species in the improvement of canola production, while Ahmad et al. (2003) reported that the regular visitation of the pollinator that drastically reduced the seed yield assures that the uniform pollination is significant.

The present investigation focused on the activity levels of the vital pollinator insects that occur in the canola fields. The results displayed different trends in their daily counts. The Giant Honey Bee showed moderate levels with 102 morning and 61 evening counts, and it can surely participate in uniform pollination at every time of the day. The European Bee scored high activity with 241 morning and 187 evening counts, and its significant function is that of canola pollination. The Cabbage Butterfly showed poorer activity with 66 morning and 54 evening counts, but it still proves that this species contributes to pollination. The European Hoverfly presented high activity (151 morning and 127 evening counts), which supports the notion that this is a strong pollinator in the canola fields. Common Hover Fly's steady activity performed in 81 observations in the morning to 87 in the evening. Long Hover Fly executed its moderate level performance within 92 observations of the morning to 78 of the evening. The levels were moderate for Syrphid Fly, with records made of 98 observations in the morning and 66 in the evening. This might indicate that the Syrphid was a nectar and pollen forager. The Paied Hoverfly and the Blue Bottle Fly appeared with low activity, at 64 and 54 morning observations, respectively. The Dwarf Honey Bee showed moderate activity, with 88 morning and 112 evening observations, thus displaying a

preference for the evening. The Blue Butterfly and Ladybird Beetle showed weak yet consistent activity at 58 and 57 morning observations, respectively. The Common Banded Hoverfly recorded moderate activity, with 75 morning and 60 evening observations. The Marmalade Hoverfly recorded the highest evening activity that showed dominant species presence with 166 morning and 201 evening observations, respectively. Finally, the Eastern Honey Bee recorded moderate activity with 85 morning and 75 evening observations, indicating that the species spread out fairly at the different times of the day.

Conclusion:

The data reveals fluctuations in the activity levels of various pollinator species during morning and evening periods, emphasizing the importance of understanding their behavior for effective canola pollination. Bees, including the Giant honey bee and European bee, demonstrated significant activity throughout the day, underscoring their crucial role as pollinators. Hoverflies, such as the European hoverfly and Marmalade hoverfly, also displayed substantial activity, indicating their importance in canola fields. The presence of other pollinator species like the Cabbage butterfly and blue butterfly, although less abundant, suggests their potential contribution to canola pollination. Ladybird beetles and common banded hoverflies showed moderate activity levels, indicating their involvement in pollination processes as well.

Recommendation:

Further research is needed to comprehensively understand the behavior and preferences of different pollinator species in canola fields, especially concerning their foraging patterns and flower visitation rates. Conservation efforts should be implemented to protect and enhance habitats for pollinators, including maintaining diverse floral resources and minimizing the use of pesticides harmful to these beneficial insects. Integrated pest management strategies should be employed to balance pest control measures with the preservation of pollinator populations, ensuring sustainable agricultural practices. Farmers and agricultural stakeholders should be educated about the importance of pollinators in crop production and encouraged to adopt practices that promote pollinator health and abundance. By implementing these recommendations, we can support healthy pollinator populations and enhance the productivity and sustainability of canola cultivation.

Author Contributions

F. Khan assisted in the development of the idea for the study, as well as in the design and data collection. This author assisted in drafting the manuscript. **S. Yasmin** assisted with the analysis of data, interpretation, and critical review of the manuscript. **B. Uddin** assisted in fieldwork, aiding in identifying insect pollinator species. **S. Bibi** was assigned the tasks of laboratory analysis, data management, and drafting the manuscript. **S. Hayat** conducted the statistical as well as graphical representations of data. **S. Nazeef** worked on the literature review; he formatted the manuscript as well. **S. Faryal** supervised the overall study. She ensured that the dataset was quite homogenized. **M. Usman** assisted in technical work and manuscript proofing, and **M. Tayab** assisted in field experiments and helped with the management of resources during the course of the study.

Conflict of Interest

All authors declare that there are no conflicts of interest regarding the publication of this paper. The authors have no financial, professional, or personal affiliations that might influence or bias the content presented in this study. Furthermore, no funding sources or institutions have had any role in the design, execution, or presentation of the research findings.

How to Cite:

K. Fawad, S. Yasmin, B. Uddin, S. Bibi, M. Tayab, S. Hayat, S. Nazeef, M. Usman, and S. Faryal. (2024). *Population dynamics and visit timing of insect pollinator families in canola (Brassica napus L.) crops of Peshawar*. **Journal of Survey in Fisheries Sciences**, 10(2), 123-135. ISSN 2368-7487

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