**A study on diversity of insect pests and natural enemies inhabiting the chickpea (*Cicer* *arietinum* Linnaeus) agro-ecosystem in the Kanpur region of Uttar Pradesh, India, using Simpson’s Index**

**ABSTRACT**

In 2023–2024 and 2024–2025, an experiment was carried out at Chandra Shekhar Azad University of Agriculture and Technology’s Students’ Instructional Farm (SIF) in Kanpur, Uttar Pradesh, India. We identified seven insect pest and natural enemy species from the chickpea agroecosystem in the Kanpur area of Uttar Pradesh, India. These include two Lepidopteran species, two Hymenopteran species, and one each of Hemipteran, Odonata, and Dictyopteran species. According to their economic significance, three species were classified as insect pests, three as predators, and one as a parasitoid. Of the seven species, *Helicoverpa* *armigera* and *Agrotis* *ipsilon* were found often, and the gram pod borer was identified as a major pest. Gram cutworm, on the other hand, was found to be a minor insect pest of chickpea crop and had a very low population density. Despite its occasional occurrence, we classified *Aphis* *craccivora*, the cowpea aphid, as a minor pest. The four natural enemy species—the praying mantis, common yellow wasp, dragonfly, and ichneumonid wasp—occurred occasionally and had a minor status. *Aphis* *craccivora* had the highest relative abundance in both the 2023–2024 and 2024–2025 years, followed by *H. armigera*, *Crocothemis* *servilia*, *Vespa* *orientalis*, *Agrotis* *ipsilon*, *Mantis* *religiosa*, and *Campoletis* *chloridae*. For 2023–2024 and 2024–2025, the Simpson’s Index was 0.47 and 0.51, respectively. The Simpson's Index of Diversity was 0.53 in 2023–2024 and 0.49 in 2024–2025.

**Keywords:** Natural enemies; Agroecosystem; Parasitoid; Predators; Simpson’s Index; Simpson’s Index of Diversity.

**1. INTRODUCTION**

40% of India's total pulse production comes from the chickpea (*Cicer* *arietinum*), making it one of the most extensively grown pulse crops in the nation. Chickpeas are grown on 15 million hectares worldwide, yielding more than 18.1 million tonnes in 2022–2023. With 13.75 million tonnes produced from 10.91 million hectares of land and a yield of 10.12 quintals per hectare, India is the world's greatest producer of chickpeas. Despite being the biggest producer, India's output of 1012 kg per acre puts it in eighth place. Almost half of India's pulse production comes from chickpeas. Madhya Pradesh (2.346 million hectares), Rajasthan (1.938 million hectares), Uttar Pradesh (0.682 million hectares), Karnataka (0.962 million hectares), Maharashtra (2.631 million hectares), and Gujarat (0.631 million hectares) are the major producing states. Chickpeas are produced on 0.62 million hectares of land in Uttar Pradesh, with a productivity of 1250 kg/ha and a yield of 0.77 million tonnes in 2023–2024. With nearly 23.82 percent of the nation's total production, Maharashtra is by far the largest producer; Madhya Pradesh, Rajasthan, and Uttar Pradesh contribute roughly 22.05 percent, 19.28 percent, and 5.59 percent, respectively. According to the government's third advance estimate, the nation will produce 115.76 lakh tonnes of chickpeas nationwide in 2023–2024 **(ANGRAU 2023-24)**.

Because it contains 21.5% protein, 64.5% carbohydrates, and 4.5% fat—all of which are relatively lacking in grains and oilseeds—it is a rich source of nutritional benefits in the Indian diet. People use its green leaves and pods as green vegetables and germinated grains for breakfast and other delectable meals every day **(Parmar *et al.,* 2015)**.

As a significant source of protein, chickpeas are essential to a vegetarian diet. People use it to prepare desserts and a variety of other delicious dishes, including green vegetables, *dal*, *chhole*, and sprouted breakfast foods. People eat the leaves both raw and cooked to benefit from the therapeutic qualities of malic acid, citric acid, mineral content, and fibre. The major chickpea-producing states—Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Gujarat, Andhra Pradesh, and Karnataka—share more than 95% of their total area under cultivation. Weeds, diseases, insect pests, and a weak genetic background are some of the causes of chickpeas' low productivity and yield. *Helicoverpa* *armigera*, *Agrotis* *ipsilon*, *Autographa* *nigrisigna*, *Aphis* *craccivora*, and *Clavigralla* *gibbosa* are the major insect pests of chickpeas **(Sithanantham *et al.,* 1984)***.*

More than 25 kinds of insect pests damage chickpea crop, with *Helicoverpa* *armigera* and *Agrotis* *ipsilon* being significant pests across the country, while six other insects—*Aphis* *cracciovora*, *Autographa* *nigrisigna*, *Spodoptera* *litura*, *Riptortus* *pedestris*, and *Eucosma* *critica*—are major pests **(Sharma *et al.,* 2020).**

So, studying the diversity of insect pests and natural enemies in the chickpea agro-ecosystems will be helpful in developing sustainable pest management strategies. The study will help in understanding the specific pests and insects present in the locality. It will also allow for targeted and effective control measures. Consequently, it will reduce reliance on broad-spectrum pesticides and foster ecological equilibrium.

**2. MATERIALS AND METHODS**

**2.1 Qualitative diversity:**

The experiments on different aspects were conducted under field conditions at the Students’ Instructional Farm (SIF) of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India.

The appearance of insect-pests and their natural enemies including predators and parasitoids inhabiting chickpea agroecosystem were observed at weekly intervals from the seedling stage of chickpea to the maturity of the crop. The chickpea variety KGD-1168 was sown in the plot size of 10 × 10 m by adopting 30 cm row-to-row and 10 cm plant-to-plant spacing during the winter season of 2023-24 and 2024-25. Throughout the cropping season, we visually observed the incidence of insect pests and their natural enemies at weekly intervals. The qualitative diversity of insect pests and their natural enemies was categorised into different groups based on their occurrences. The insect pests and natural enemies that infested the crop continuously after their first appearance in considerable numbers were designated as major, and those that occurred intermittently and never had a high population were categorised as minor, while the species whose occurrence was scarce and had a very low population was designated as stray **(Namdev *et* *al*., 2021)**.

**2.2 Relative Abundance:**

We routinely monitored observations at weekly intervals to record the various insects. The number of insects was recorded on ten randomly selected plants from the 10 × 10 m plot by following the mode of observations as follows:

*H. armigera* and *A. ipsilon* (number of larvae on 10 randomly selected plants). *Aphis* *craccivora* (number of aphids per 10 cm on ten randomly selected plants). The population of natural enemies was recorded on ten randomly selected plants by visual count and sweep net. For the sweep net method, about 5 strokes of sweeping were made. We counted the predators caught in the net after each stroke. The total number of individuals of each species observed throughout the cropping season was used to calculate the relative abundance and Simpson’s Index of Diversity **(Singh *et* *al.,* 2018).**

The following formula calculated the relative abundance of insect pests and natural enemies:

**Relative abundance (%) =**

**2.3 Simpson’s Index (D):**

Species, or alpha diversity of the site, was quantified by using Simpson’s Index (D), **(Simpson, 1949)**. Simpson’s Index (D) is a measure of diversity that considers the number of species present as well as the relative abundance of each species. We calculated Simpson's Index (D) using the following formula:

**D =**

Where,

N is the total number of individuals of all species, including insect pests and natural enemies.

n = Total no. of individuals of a particular species.

**2.4 Simpson’s Index of Diversity (SID):**

Subtracting the value of Simpson’s Index (D) from 1 resulted in Simpson’s Index of Diversity (SID). The value of SID ranges from 0 to 1. The greater SID value will represent greater sample diversity.

**Simpson’s Index of Diversity = 1 – D**

Where,

D = Simpson’s Index

Researchers also recorded the infestation of insect pests, or the succession of insect pests, at different crop growth stages (crop phenology), from the seedling stage to the crop maturity stage.

**3. RESULTS AND DISCUSSION**

Table 1 presents a list of various insect pests and their natural enemies inhabiting the chickpea agroecosystem during the winter of the 2023-24 and 2024-25 cropping seasons. We observed seven different species of insect pests and their natural enemies from the chickpea agro-ecosystem during both cropping seasons. We categorized the diversity of insect pests and natural enemies into different groups - pest, predator, and parasitoid - based on their feeding behavior. Based on occurrence, those insect pests and natural enemies that occurred on the crop continuously after their first appearance in considerable numbers were designated as regular occurrence, while those insect pests and natural enemies whose population occurred intermittently or otherwise disappeared before harvest were categorized as occasional occurrence.

The perusal of the qualitative diversity of insect pests and natural enemies inhabiting chickpea agroecosystems (Table 1) revealed that seven species belonging to five orders and six families were recorded throughout the cropping period of chickpea crop during 2023–24 and 2024–25. Based on the total number of species, order Lepidoptera (two species), order Hymenoptera (2 species), order Hemiptera (1 species), order Odonata (1 species), and order Dictyoptera (1 species) were observed. Looking at their economic importance, we found different types of insects in the chickpea cropping system: 3 species of pests, 3 species of insect predators, and 1 species of insect parasitoids.

Among the three species of insect pests, two were designated as regular in occurrence, i.e., *Helicoverpa* *armigera* (Lepidoptera: Noctuidae) and *Agrotis* *ipsilon* (Lepidoptera: Noctuidae), and one species was designated to occur occasionally, i.e., *Aphis* *craccivora* (Hemiptera: Aphididae). Among the two regular pests, *Helicoverpa* *armigera* was identified as a major pest of chickpea, affecting both vegetative and reproductive growth stages, while *Agrotis* *ipsilon* was found regularly during the vegetative stage but in smaller numbers, making it a minor pest. Among occasional pests, *Aphis* *craccivora, which* also occurred in low population density, was also considered a minor pest.

The variety of natural enemies (predators and parasitoids) found in the chickpea agro-ecosystem showed that four species of natural enemies (three predators and one parasitoid) were seen in the chickpea crop from time to time, but in small numbers, and were considered minor. The highest number of species of natural enemies belonged to the order Hymenoptera, which included one predator and one parasitoid, specifically *Vespa* *orientalis* (Hymenoptera: Vespidae) and *Campoletis* *chloridae* (Hymenoptera: Ichneumonidae). The maximum number of natural enemies was of the order Hymenoptera (one species of predator and one species of parasitoid), i.e., *Vespa* *orientalis* (Hymenoptera: Vespidae) and *Campoletis* *chloridae* (Hymenoptera: Ichneumonidae). Among natural enemies, there was one species from the order Odonata, identified as *Crocothemis* *servilia*, and one species from the order Dictyoptera, identified as *Mantis* *religiosa*, which appeared occasionally and were minor in status.

**Relative Abundance and Diversity Index**

Table 2 presents a list of various species and their relative abundance in the chickpea agro-ecosystem during the winter 2023-24 and 2024-25 cropping seasons.

During the cropping season 2023–24, the highest number of individuals recorded was *Aphis* *craccivora* (325 individuals), followed by *Helicoverpa* *armigera* (105 individuals), *Crocothemis* *servilia* (26 individuals), *Vespa* *orientalis* (17 individuals), *Agrotis* *ipsilon* (12 individuals), and *Mantis* *religiosa* (6 individuals). The lowest number of individuals recorded was *Campoletis chloridae* (5 individuals) throughout the cropping season. The most abundant species was *Aphis* *craccivora*, making up 65.52% of all individuals, followed by *Helicoverpa* *armigera* at 21.16%, *Crocothemis* *servilia* at 5.24%, *Vespa* *orientalis* at 3.42%, *Agrotis* *ipsilon* at 2.41%, and *Mantis* *religiosa* at 1.20%, while *Campoletis* *chloridae* had the lowest at 1.00% for the entire cropping season. Simpson’s Index (D) was 0.47, and Simpson’s Index of Diversity (SID) was 0.53 during the cropping season 2023-24.

During the cropping season 2024-25, the highest number of individuals recorded was *Aphis craccivora* (418 individuals), followed by *Helicoverpa armigera* (122 individuals), *Crocothemis servilia* (22 individuals), *Vespa orientalis* (19 individuals), *Agrotis* *ipsilon* (15 individuals), and *Mantis religiosa* (8 individuals). *Campoletis* *chloridae* recorded the lowest number of individuals (7 individuals) throughout the cropping season. The relative abundance among all the species was found to be highest for *Aphis craccivora* (68.41%), followed by *Helicoverpa armigera* (19.96%), *Crocothemis servilia* (3.60%), *Vespa orientalis* (3.10%), *Agrotis* *ipsilon* (2.45%), and *Mantis religiosa* (1.30%), and the lowest relative abundance was recorded for *Campoletis chloridae* (1.14%) for the whole cropping season. Simpson’s Index (D) was 0.51 and Simpson’s Index of Diversity (SID) was 0.49 during the cropping season 2024–25.

The results are in accordance with the findings of **Tripathi *et al.* (2024),** who reported seven species of insects belonging to five orders and six families were recorded from chickpea agro-ecosystems. Among which two species were from Lepidoptera, two species from Hymenoptera, and one species from Odonata, Hemiptera, and Dictyoptera were identified. The results are also in accordance with **Rehman *et al.* (2021),** who reported that chickpea is infested by twenty-five species of insects, among which three (i.e., gram pod borer, *Helicoverpa* *armigera* (Hub.); cutworm, *Agrotis* *ipsilon* (Huf.); and termite, *Odontotermes* *obesus* (Ramb.) are insect pests of major importance of national significance, and six insect pests (i.e., bean aphid, *Aphis* *craccivora* (Koch); semilooper, *Autographa* *nigrisigna* (Walker); tobacco caterpillar, *Spodoptera* *exigua* (Hub.); pod bug, *Riptortus* *pedestris;* and leaf webber, *Eucosma* *critica* are major pests of regional significance. The ecological factors are known to affect the occurrence and severity of insect pests. The maintenance of biodiversity and variability of insect fauna within agricultural environments is widely recognized as being essential for their agronomic sustainability **Mari *et* *al.* (2013)** found that the chickpea pod borer, *Helicoverpa* *armigera*, and the gram cutworm, *Agrotis* *ipsilon*, are significant pests affecting chickpea crop*,* are major pests of chickpea in Uttar Pradesh and Madhya Pradesh, respectively. The earlier report made by **Meena *et al.* (2023)** reported that Lepidoptera was the largest order of insect pests infesting chickpea at Jabalpur, Madhya Pradesh, India. Among the insect pests, five species were seen from time to time: armyworm, *Mythimna* *seperata* (Walker); tobacco caterpillar, *Spodoptera* *litura* (Fab.); cowpea aphid, *Aphis* *craccivora* (Koch); termite, *Odontotermes* *obesus* (Rambur); and black flea beetle, *Altica* species, which are considered minor pests of chickpea crop. The results match what **Tomar *et al.* (2023)** found, which was that *Campoletis* *chloridae* (Uchida) was most important parasitoid in chickpea growing areas in the Kanpur region of Uttar Pradesh, India.

**Table 1 Qualitative diversity of insect pests and natural enemies in the chickpea agro-ecosystem duringwinter, 2023-24 and 2024-25**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Common Name** | **Scientific Name** | **Order:**  **Family** | **Occurrence** | | **Status** | | **Crop Stage** | **Nature** |
| **2023-24** | **2024-25** | **2023-24** | **2024-25** |
| 1 | Gram pod borer | *Helicoverpa armigera* (Hub.) | Lepidoptera:  Noctuidae | Regular | Regular | Major | Major | Vegetative & reproductive stage | Pest |
| 2 | Gram cutworm | *Agrotis ipsilon*  (Hufnagel) | Lepidoptera:  Noctuidae | Regular | Regular | Minor | Minor | Vegetative stage | Pest |
| 3 | Cowpea aphid | *Aphis craccivora* (Koch) | Hemiptera:  Aphididae | Occasional | Occasional | Minor | Minor | Vegetative & reproductive stage | Pest |
| 4 | Dragonfly | *Crocothemis servilia* (Drury) | Odonata:  Libellulidae | Occasional | Occasional | Minor | Minor | Vegetative & reproductive stage | Predator |
| 5 | Common yellow wasp | *Vespa orientalis* (L.) | Hymenoptera:  Vespidae | Occasional | Occasional | Minor | Minor | Flowering stage | Predator |
| 6 | Ichneumonid wasp | *Campoletis chloridae* (Uchida) | Hymenoptera:  Ichneumonidae | Occasional | Occasional | Minor | Minor | Flowering stage | Parasitoid |
| 7 | Praying mantis | *Mantis religiosa* (L.) | Dictyoptera:  Mantidae | Occasional | Occasional | Minor | Minor | Vegetative & reproductive stage | Predator |

**Table 2 Relative abundance and Diversity Index of insect pests and natural enemies during winter, 2023-24 and 2024-25**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **S. No.** | **Insect pests and natural enemies** | **2023-24** | | **2024-25** | |
| **Total no. of insect pests and natural enemies** | **Relative abundance (%)** | **Total no. of insect pests and natural enemies** | **Relative abundance (%)** |
| 1 | *Helicoverpa armigera* (Hub.) | 105 | 21.16 | 122 | 19.96 |
| 2 | *Agrotis ipsilon* (Hufnagel) | 12 | 2.41 | 15 | 2.45 |
| 3 | *Aphis craccivora* (Koch) | 325 | 65.52 | 418 | 68.41 |
| 4 | *Crocothemis servilia* (Drury) | 26 | 5.24 | 22 | 3.60 |
| 5 | *Vespa orientalis* (L.) | 17 | 3.42 | 19 | 3.10 |
| 6 | *Campoletis chloridae* (Uchida) | 5 | 1.00 | 7 | 1.14 |
| 7 | *Mantis religiosa* (L.) | 6 | 1.20 | 8 | 1.30 |
| **Simpson’s Index (D)** | | **0.47** | | **0.51** | |
| **Simpson’s Index of Diversity (SID)** | | **0.53** | | **0.49** | |

**Figure 1 Relative abundance of insect pests and natural enemies duringwinter, 2023-24**

**Figure 2 Relative abundance of insect pests and natural enemies during winter, 2024-25**

**4. CONCLUSION**

In the Kanpur region of Uttar Pradesh, India, seven species of insect pests and natural enemies belonging to five orders and six families were recorded from chickpea agro-ecosystem. The researchers identified seven species, including two from Lepidoptera, two from Hymenoptera, and one each from Hemiptera, Odonata, and Dictyoptera were identified. Based on economic importance, three species were insect pests, three species were predators, and one species was a parasitoid. Among the three insect pest species, the chickpea pod borer, *Helicoverpa* *armigera* (Hubner), and the gram cutworm, *Agrotis* *ipsilon* (Hufnagel), were regularly found, with the chickpea pod borer being identified as the major pest of chickpea crop in the Kanpur area of Uttar Pradesh, India. Meanwhile, the gram cutworm, *Agrotis* *ipsilon* (Hufnagel), affected the plants during their vegetative growth stage but was present in very small numbers, making it a minor pest of chickpea crop. Also, one species of insect pest occurred occasionally, i.e., thecowpea aphid, *Aphis craccivora* (Koch), and was considered a minor pest of chickpea in the Kanpur region of Uttar Pradesh, India.

The qualitative diversity of natural enemies (predators and parasitoids) inhabiting chickpea agro-ecosystems observed that four species of insects, among which three species of predators and one species of parasitoid, were observed in chickpea crop occasionally in very low population density. The maximum number of natural enemies was of the order Hymenoptera, one species of predator and one species of parasitoid, i.e., the common yellow wasp, *Vespa* *orientalis* (L.), and the ichneumonid wasp, *Campoletis* *chloridae* (Uchida), followed by the order Odonata, i.e., the dragonfly, *Crocothemis* *servilia* (Drury), and the order Dictyoptera, i.e., the praying mantis, *Mantis* *religiosa* (L.). All the natural enemies occurred occasionally, and their status was minor during both the cropping seasons.

Relative abundance of insect pests and their natural enemies during winter, 2023-24 and 2024-25, revealed that maximum relative abundance was recorded in *Aphis* *craccivora* (Koch), followed by *Helicoverpa* *armigera* (Hubner), *Crocothemis* *servilia* (Drury), *Vespa* *orientalis* (L.), *Agrotis* *ipsilon* (Hufnagel), and *Mantis* *religiosa* (L.), and minimum relative abundance was observed for *Campoletis* *chloridae* (Uchida).

Simpson’s Index (D) during winter, 2023-24 and 2024-25, was 0.47 and 0.51, respectively. Simpson’s Index of Diversity (SID) during winter, 2023-24 and 2024-25 was 0.53 and 0.49, respectively.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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