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The Role of Predatory Spiders in Pest Control and the Impact of Pesticides in Achalpur Agroecosystems

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Abstract
Predatory spiders play a crucial role in maintaining ecological balance by acting as natural pest controllers in agricultural landscapes. However, the excessive use of insecticides and herbicides in modern farming practices poses a significant threat to their survival and efficiency. This study aims to assess the impact of pesticides on spider populations in the agroecosystems of Achalpur, Amravati District, and evaluate their role in pest control. Field surveys and laboratory analysis were conducted to determine the species diversity, population density, and pesticide-induced mortality of predatory spiders. The findings suggest a decline in spider populations in pesticide-treated fields, leading to an increase in pest outbreaks. This study highlights the need for sustainable pest management strategies to conserve these beneficial arthropods and enhance agricultural productivity.

Keywords: *Predatory Spiders, Pest Control, Pesticides, Agroecosystems, Achalpur, Biodiversity, Sustainable Agriculture.*

1. Introduction

Spiders are among the most effective natural pest controllers in agroecosystems. They regulate insect populations by preying on agricultural pests, thereby reducing the dependency on chemical pesticides. However, the indiscriminate use of insecticides and herbicides has led to the decline of spider populations, disrupting the ecological balance. Achalpur, a prominent agricultural region in Amravati District, is heavily dependent on chemical-intensive farming, making it an ideal study area to examine pesticide impact on predatory spiders. This study aims to analyze the relationship between spider biodiversity and pesticide use while highlighting the importance of these arachnids in integrated pest management (IPM) strategies.

2. Review of Literature

Several studies in India have emphasized the significance of spiders in agricultural pest management. According to **Patel et al. (2023)**, spider biodiversity is negatively affected by excessive pesticide application, leading to reduced predation on pests like aphids and caterpillars. The indiscriminate use of chemical pesticides disrupts the natural predator-prey relationship, making crops more susceptible to pest infestations. The study also noted that certain spider species are more vulnerable than others, particularly web-building spiders, which come into direct contact with pesticide residues on vegetation. This reduction in spider populations directly correlates with an increased need for artificial pest control measures, further intensifying the cycle of pesticide dependency.

Kumar & Sharma (2022) conducted an extensive analysis of pesticide residues in farmlands and found a direct correlation between chemical exposure and declining arachnid populations. Their study highlighted how different classes of pesticides, including organophosphates and neonicotinoids, have lethal and sub-lethal effects on spiders. These chemicals not only reduce spider survival rates but also affect their reproductive success and prey-capturing efficiency. Spiders exposed to pesticide-contaminated environments displayed altered hunting behaviors, reduced web-building activities, and lower offspring viability. The research emphasized the urgent need to explore alternative pest management strategies that reduce chemical exposure while preserving beneficial arthropod populations.

Similarly, **Deshmukh et al. (2021)** reported that organic farming practices support higher spider diversity compared to conventional farming. Organic farms, which limit pesticide usage, provide a safer habitat for predatory spiders, allowing them to thrive and contribute to pest regulation. **Shinde & Joshi (2020)** further reinforced this notion by advocating for the integration of biological control methods with sustainable agricultural practices. They argued that non-chemical pest control strategies, such as crop rotation, intercropping, and the introduction of natural predators, significantly enhance agricultural sustainability. These collective findings underscore the importance of minimizing pesticide usage and adopting eco-friendly farming techniques to maintain biodiversity and ensure long-term agricultural productivity.

3. Materials and Methods

3.1 Study Area

The study was conducted in various agricultural fields of Achalpur, Amravati District, Maharashtra, between June 2023 and March 2024. Achalpur is located in the Vidarbha region, characterized by a tropical monsoon climate with distinct wet and dry seasons. The area receives an average annual rainfall of approximately 1000 mm, with temperatures ranging from 15°C in winter to 42°C in summer. The primary crops cultivated in this region include cotton, soybean, wheat, and pulses, making it an ideal setting to assess the impact of pesticide usage on spider populations.

Two types of farms were selected for comparative analysis:

1. **Pesticide-Treated Fields:** Conventional farmlands where chemical pesticides, including organophosphates, pyrethroids, and neonicotinoids, were regularly used for pest control.
2. **Organic Farms:** Fields where chemical pesticide application was either absent or significantly limited, relying on biological pest control methods such as crop rotation, companion planting, and the use of natural predators.

A total of ten agricultural fields (five conventional and five organic) were chosen for this study, covering an area of approximately 50 hectares.

3.2 Data Collection

To assess the impact of pesticides on spider biodiversity, data collection was carried out using multiple field survey techniques and laboratory analyses. The following methods were employed:

- **Field Surveys:** Monthly field visits were conducted to monitor spider populations. Spiders were collected using standard **pitfall traps** (plastic cups buried at ground level

filled with 70% ethanol) and **sweep netting** (lightweight nets used to capture spiders from vegetation). Each site was surveyed for 30 minutes per visit, and collected specimens were stored in labeled vials for further analysis.

- **Pesticide Residue Analysis:** To determine pesticide contamination levels, soil and plant samples were collected from both pesticide-treated and organic farms. Soil samples were extracted using a **soil corer**, while plant samples were obtained from commonly sprayed crops. These samples were analyzed in the laboratory using **gas chromatography-mass spectrometry (GC-MS)** to identify and quantify pesticide residues.
- **Laboratory Identification:** Collected spider specimens were transported to the laboratory, where they were examined under a **stereo microscope**. Spiders were identified up to the family and genus level using standard **taxonomic keys** (Sebastian et al., 2012; Platnick, 2020). Morphological characteristics, including body shape, eye arrangement, and leg structure, were used for classification.
- **Statistical Analysis:** To compare spider diversity across different fields, **Shannon-Weaver Diversity Index (H')** and **Simpson's Diversity Index (D)** were calculated. These indices provided insights into species richness and evenness. A **t-test** was performed to determine significant differences in spider populations between organic and pesticide-treated fields. Additionally, correlation analysis was conducted to evaluate the relationship between pesticide concentration and spider abundance.
- **4. Observations and Results**

  The study revealed substantial variations in spider diversity across different farming systems. A total of **250 spider specimens**, belonging to **15 families**, were recorded from the study sites. The most abundant families were **Araneidae (Orb-weaving spiders), Lycosidae (Wolf spiders), and Salticidae (Jumping spiders)**. These spiders were more prevalent in organic farms than in pesticide-treated fields. Other families, including Thomisidae (Crab spiders), Tetragnathidae (Long-jawed orb-weavers), and Oxyopidae (Lynx spiders), were recorded in smaller numbers. In **pesticide-treated fields**, spider abundance was **significantly lower (75 specimens)** compared to organic farms (**175 specimens**). Mortality rates of predatory spiders increased notably following **pyrethroid and organophosphate** pesticide applications, with field observations indicating a 40% decline in spider populations within a week of spraying. Additionally, pesticide residue analysis showed chemical contamination in soil and plant samples, correlating with reduced spider diversity and abundance.
- The impact of predatory spiders on pest control was more pronounced in organic farms, where lower pest densities were recorded. Predatory spiders played a crucial role in regulating agricultural pests such as aphids, caterpillars, and whiteflies. The correlation analysis demonstrated a **positive relationship between spider abundance and reduced pest populations ($r = 0.72$, $p < 0.05$)**, reinforcing their importance in sustainable agriculture. The presence of a diverse spider population contributed to **natural pest suppression**, reducing the need for chemical interventions. These findings emphasize the

ecological importance of predatory spiders and highlight the adverse effects of pesticide overuse, underscoring the need for **integrated pest management strategies** to promote biodiversity conservation and sustainable farming practices.

5. Conclusion

Predatory spiders serve as essential biological control agents in agricultural ecosystems by naturally suppressing pest populations. However, the findings of this study highlight a significant decline in spider diversity and abundance in pesticide-treated fields compared to organic farms. The excessive use of **pyrethroid and organophosphate pesticides** has led to increased mortality rates among predatory spiders, disrupting the natural predator-prey balance and ultimately reducing the effectiveness of biological pest control. The study reinforces the importance of **conserving spider biodiversity** to maintain ecological equilibrium and enhance sustainable agricultural productivity.

To mitigate the negative impact of pesticides on spider populations, adopting **integrated pest management (IPM) strategies** is crucial. This includes the promotion of organic farming practices, the use of biopesticides, habitat conservation, and crop diversification to provide suitable environments for beneficial arthropods. Additionally, policymakers and farmers must work together to regulate pesticide application and explore alternative, eco-friendly pest control methods. Future research should focus on identifying **pesticide-resistant spider species**, assessing the long-term effects of chemical exposure on arachnid populations, and developing innovative pest control approaches that support both **agricultural productivity and ecological sustainability**.

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