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# Spiders as Potential Biocontrol Agents in Insect Pest Management

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**ABSTRACT:** Most spiders pose no threat and play a crucial role in managing insect numbers. As versatile predators, spiders can adapt to various environmental roles, allowing them to capture and consume a broad spectrum of insects. This trait is particularly advantageous in farming environments, where it can greatly aid in pest regulation. This article highlights the advantages, classification, conservation, feeding potential, and mass production of spiders.

**KEY WORDS:** Advantages, classification, conservation, feeding potential, and mass production

## I. INTRODUCTION

For a considerable time, pesticides have been the primary method for regulating pests in agriculture. Yet, the extensive use of various pesticides has led to numerous adverse effects, such as the eradication of certain species, the rise of secondary pest issues, the development of resistance to insecticides, persistent toxic residues, the resurgence of pest populations, and the pollution of ecosystems. In light of these challenges, numerous initiatives have been taken in recent years to incorporate various non-chemical approaches alongside insecticides within the framework of Integrated Pest Management (IPM) systems. Spiders are members of the order Araneae, and class Arachnida. Owing to their varied hunting tactics, habitat preferences, and activity schedules, a diversified set of spiders may be useful in biological control[3]. Spiders react to prey density in both a functional and numerical way[4]. Spider populations in agroecosystems are stable as a result of these density-dependent responses and polyphagy. Their role as biological control agents has been recognized for centuries, with early observations highlighting their potential to suppress insect pest outbreaks in agricultural settings [10]. They demonstrate varying tolerance to pesticides. For instance, the wolf spider *Pardosa pseudoannulata* is highly tolerant of botanical insecticides like Neem-based chemicals. Additionally, spiders generally handle organophosphates and carbamates better than pyrethroids, organochlorines, and acaricides. Genetic resistance, developed over continuous exposure, likely contributes to their ability to withstand certain pesticides [6].

**Global scenario :** The updated checklist of spiders from the World Spider Catalog (WSC-Version 25.5) includes 52,262 species from 4,394 genera and 134 families. Among the 134 families, six represent more than 2,000 species: Salticidae (685 genera and 6,704 species), Linyphiidae (634 genera and 4,858 species), Araneidae (191 genera and 3,128 species), Lycosidae (134 genera and 2,473 species), Gnaphosidae (153 genera and 2,476 species), and Theridiidae (129 genera and 2,579 species)[1].

**Status of spider in India:** The updated spider checklist of spiders from India given by Caleb and Sankaran (2024) shows 1953 species from 503 genera and 62 families. Among the 62 families, 5 families represented more than 100 species and they are: Salticidae (110 genera and 326 species), Thomisidae (42 genera and 173 species), Araneidae (34 genera and 188 species), Gnaphosidae (28 genera and 140 species) and Lycosidae (20 genera and 120 species). This represents approximately 3.7% of the world's spider population, as compared to the global status[1].

## II. SPIDERS ARE MORE ADAPTIVE AMONG GENERAL PREDATORS

Different spider species contribute uniquely to pest management, with web weavers typically targeting phytophagous pests and non-web weavers foraging for foliage-dwelling pests. Maintaining a diversity of spider species is considered beneficial for effective pest control within specific areas, as each species may target different pests at various life stages [14]. Prior to experimental trials, spiders were subjected to a 10-day starvation to ensure uniform levels of hunger. Abundant research, including studies on wolf spiders, indicates that such periods of food scarcity are a common occurrence for spiders in the wild. For instance, wolf spiders collected from the field showed no significant differences in their physical condition compared to those in the lab that had been without food for three months. Moreover, a separate field investigation found that two spider species typically went without food for periods ranging from 4 to 8 days [8]. A recent study found that as many as 400 to 800 million tons of insect prey are being killed by spiders annually, which also includes agricultural pests [9]. A considerable number of spiders show a strong preference for staying in one place, where they often construct a web, burrow, or shelter that remains fixed in position [5].

### Spiders offer several advantages as biocontrol agents in managing insect pests, which include:

1. **Wide Prey Range:** Spiders have a broad diet and can prey on various pests, including mites, aphids, thrips, and termites, which are common in agricultural settings.
2. **Prey Searching Ability:** They possess an excellent ability to search for prey, making them effective at locating and controlling pest populations.
3. **Polyphagous Nature:** Being polyphagous predators, spiders can feed on a variety of prey items, allowing them to manage different pests found in agricultural areas.
4. **Ease of Multiplication:** Spiders can reproduce quickly under favorable conditions, which helps maintain their population and effectiveness as biocontrol agents.
5. **Minimal Risk to Crops:** Unlike some other predators, spiders do not cause damage to vegetation or crops, making them safe for use in pest management.
6. **Diverse Foraging Modes:** They display different foraging modes and hunting tactics, such as weaving webs for trapping prey, ambushing, or actively hunting, which contributes to their versatility as predators.
7. **Long Life Cycle:** Spiders have a long life cycle, with some species living from 9 months to 25 years. They are predaceous throughout their developmental stages, ensuring continuous pest control.
8. **Environmental Adaptability:** They can occupy many microhabitats and niches within an ecosystem, which allows them to be effective in various environmental conditions.
9. **Contribution to Biodiversity:** By maintaining spider populations, agricultural ecosystems benefit from increased biodiversity, which can lead to healthier and more resilient environments.
10. **Sustainable Pest Management:** Utilizing spiders as biocontrol agents aligns with sustainable agriculture practices, reducing the reliance on chemical pesticides and promoting ecological balance.

These advantages highlight the potential of spiders to be integrated into pest management strategies, offering an eco-friendly and sustainable approach to protecting crops from various insect pests [7],[11],[14].

### Mass production of hunting spider:

To mass-produce hunting spiders, their egg sacs are placed in closed, beehive-like breeding boxes. The inner structure of these boxes is lined with a removable material that offers a large surface area in a compact space, reducing cannibalism among the spiders. One side of the box has holes connected to tubes containing fruit fly (*Drosophila melanogaster*) cultures. The inner walls of the box are coated with Teflon or a similar material to prevent spiders from climbing into the tubes. The spiders feed on fruit flies from hatching until they lay eggs. Flour beetle larvae (*Tenebrio molitor*) at the bottom of the box clean up dead fruit flies, preventing mildew. Regular maintenance involves replacing old culture tubes with fresh ones. Spiders that hatch simultaneously mature and reproduce at the same time, attaching their egg sacs to the inner structure of the box. These egg sacs are then removed and stored at low temperatures to delay hatching until needed. When applied in greenhouses, each egg sac releases 50-70 spiderlings, which spread evenly across the plants and control small arthropod populations. Since hunting spiders do not spin webs to catch prey, they do not leave detectable amounts of silk on the plants [12].

### Mass production of ground dwelling spiders:

Rearing ground-dwelling spiders, such as *Micryphantids* and *Linyphiids*, is relatively straightforward. A wide-mouthed jar covered with a net, secured with rubber bands or a lid with air holes, is typically used. A one to two-inch layer of soil or sand at the bottom provides a suitable substrate. Adding a broken flower pot or piece of bark creates a favorable

microclimate for the spiders, which use these materials for shelter. Egg cocoons are collected from the bottom, and the sand layer is replaced using a removable paper towel. Water is supplied in small plastic cups, which should contain small rocks if the spiders are tiny to prevent drowning. Ground-dwelling spiders are delicate and should not be handled with fingers, as they may lose legs or their abdomen may burst if dropped. Chilling them in a refrigerator before handling can help. Young spiders should be given space to establish burrows, as they exhibit cannibalistic behavior if kept together [12].

#### **Mass production of rice spider:**

Barrior and Litsinger reported on the mass multiplication of common rice spiders. Adult male and female spiders were collected from rice fields, border habitats, and fallows, and placed in cylindrical plastic containers (15.4 cm x 36 cm) or Mylar film, with a 35-45 day-old rice plant as a substrate. Additional substrates like twigs or small bamboo sticks were also included. Egg masses and cocoons were cut from the foliage and kept separately by species in 1 cm x 6 cm glass vials with moist cotton at the bottom and dry cotton on top. Egg cocoons laid inside the Mylar films were collected and placed individually in glass vials or 1.5 mm x 9 mm plastic Petri dishes to prevent drying and desiccation.

Emerging spiderlings were isolated using a camel hair brush and placed in 7.6 cm x 12.8 cm plastic vials with freshly cut rice stems or leaves, partly dried straw, or small twigs, and a nylon mesh window on top, secured with tape or rubber bands. The vegetation served as a substrate for clinging and walking. After the first molt, when almost all stored food (yolk) was utilized, the spiderlings were fed a variety of diets, including first-instar nymphs of Cicadellids and Delphacids, Collembola, Drosophila flies, Hydrrellia adults, and Chironomids. The food, except Collembola, was partially crushed to aid feeding. Drinking water was provided via an inverted film tube filled with water, with a pin-pricked lid to allow slow water release and wet the cotton layer on the floor.

After two or three molts, immature Tetragnathid spiders (*Tetragnatha* spp.) were transferred to larger cylindrical cages (12 in x 15 in) with two mesh windows and a top vent. Longer branches or sticks were placed inside each chamber along with a hanging cotton ball wet with water. An additional plastic vial with water was placed on the floor of the rearing cell for drinking and cooling. The larger cage provided more space for *Tetragnatha* to construct webs. Similar rearing methods were used for *Argiope*, *Araneus*, and *Neoscona* spiders. Other spiders, such as lycosids and oxyopids, were reared in smaller cells or tubes (2 in x 5 in). The bottom end of each rearing cell, plugged with a cotton ball, rested on a pan lined with a wet paper towel. Cut rice stems or leaves and some dry straws were placed inside the tube as additional substrates. As the spiders grew, more food was added, and a diverse diet was continuously provided to ensure successful molting and development to the adult stage [12].

#### **Mass rearing of predatory spiders for biological control have several obstacles:**

- A. **Diet and Nutrition:** Ensuring a consistent and appropriate diet is essential for successful rearing. Although some spiders can be raised on artificial diets, these often lead to lower reproductive rates and longer development times compared to natural prey.
- B. **Cannibalism:** Spiders are inherently cannibalistic, which can cause significant losses in mass rearing environments. Controlling this behavior necessitates careful monitoring and the separation of individuals at certain life stages.
- C. **Environmental Conditions:** Optimal environmental conditions (temperature, humidity, light) are crucial for spider health and reproduction. Any deviations can adversely affect their growth and survival.
- D. **Disease and Parasites:** High-density rearing conditions make spiders more vulnerable to diseases and parasites, which can spread quickly and devastate populations.
- E. **Behavioural Issues:** Spiders display complex behaviours that can be challenging to manage in captivity. For instance, web-building species need specific structures for web construction, and hunting spiders require space to exhibit natural hunting behaviours.
- F. **Economic Viability:** The cost of mass rearing spiders, including labour, facilities, and diet, can be substantial. Ensuring that the benefits of using spiders for pest control outweigh these costs is a significant consideration.

Overcoming these challenges requires continuous research and innovation in rearing techniques, diet formulation, and environmental management.

### III. CLASSIFICATION OF SPIDERS ON THE BASIS OF FORAGING GUILD STRUCTURE [15]

Sr. No.	Guild	Families
1.	Sensing Web weavers	Hersillidae, Idiopidae, Liphistidae, Oecobidae
2.	Sheet Web weavers	Linyphiidae, Pisauridae
3.	Orb Web weavers	Araenidae, Tetragnathidae, Ulboridae
4.	Space Web weavers	Pholcidae, Theridiidae
5.	Specialists/ Stalkers	Oxyopidae, Salticidae
6.	Ground hunters	Corinnidae, Dysderidae, Gnaphosidae, Lycosidae
7.	Ambush hunters	Philodromidae Thomisidae, Sicariidae
8.	Foliage runner	Cheiracanthiidae, Clubionidae, Sparassidae,
9.	Primitive hunters	Scytodidae
10.	Tarantula	Theraphosidae

### IV. FUNCTIONAL RESPONSE OF PREDATORY SPIDERS

#### A. Types of Functional Responses:

- a. **Type I:** Linear increase in prey consumption with prey density until satiation.
- b. **Type II:** Prey consumption rate increases at a decelerating rate, forming a hyperbolic curve, due to handling time.
- c. **Type III:** Sigmoid (S-shaped) response where predation rate is low at low prey densities, increases rapidly at intermediate densities, and then levels off.

B. **Laboratory Studies:** Experiments often show that spiders exhibit a Type II functional response. For example, the spider *Hyllus semicupreus* showed a Type II response when preying on aphids, with a high predation rate at moderate prey densities.

C. **Field Observations:** In natural settings, spiders' functional responses can be influenced by factors like prey availability, habitat complexity, and presence of other predators. These factors can modify the predation efficiency and overall impact on pest populations.

D. **Implications for Pest Control:** Understanding the functional response helps in predicting the effectiveness of spiders in biological control programs. Spiders with a Type II response can be particularly effective at controlling pest populations at moderate densities [2].

#### Predatory spiders play a significant role in regulating pest populations due to their feeding habits and adaptability.

A. **Diverse Diet:** Predatory spiders consume a wide range of prey, including insects, larvae, and other arthropods. This diversity helps them adapt to various environments and prey availability.

B. **Laboratory Studies:** Research often involves laboratory feeding trials to determine the predatory potential of spiders. These studies show that spiders can effectively reduce pest populations, although their performance can vary based on prey type and environmental conditions.

C. **Field Observations:** Direct observations in the field provide valuable data on the dietary range and predation rates of spiders. For example, studies on hunting spiders in rice ecosystems have shown that they consume significant numbers of rice pests, helping to control these populations.

D. **Nutritional Balance:** Spiders balance their intake of macronutrients like protein and lipids, which can influence their feeding behavior and efficiency. This balance is crucial for their survival and reproductive success.

E. **Impact on Pest Control:** Field experiments have demonstrated that spiders can effectively reduce pest populations and the damage they cause to crops. Their presence in agricultural habitats is beneficial for integrated pest management (IPM) programs.

#### Conservation OF predatory spiders:

##### A. Mulching in Vegetable Gardens:

B. Mulch helps retain moisture in the soil by slowing evaporation and reducing water loss from the soil surface. Consider using coconut husk mulch (coir mulch) or pine straw mulch for your vegetable garden:

- C. **Coconut Husk Mulch:** Made from coconut shells, it's organic, eco-friendly, and keeps weeds out. It offers humidity as well as protection.
- D. **Pine Straw Mulch:** Made from dried pine needles, it allows good water infiltration, maintains soil humidity, and suppresses weeds. It offers humidity and protection.
- E. **Creating Spider-Friendly Habitats:**
- F. Provide attachment points for spider webs, such as boxes, tall plants, or bundles of hay. These structures encourage spiders to settle, aiding in pest control.
- G. Leave plant stems or tilled areas as overwintering habitats for spiders. They'll find shelter during colder months.
- H. **Attracting Prey and Enhancing Spider Activity:**
  - a. Plant flowers that attract prey insects. These will serve as a food source for spiders.
  - b. Use pesticides with minimal impact on spiders. If you must apply pesticides, do so when spiders are less active.
- I. **Apple Orchards and Spider Activity:**
  - a. In apple orchards, an increase in spider hunting activity is linked to growing foliage and plant complexity. Spiders thrive in diverse environments.
- J. **Crop Diversification:**
  - a. Diversifying crops provides alternate prey for spiders, supporting their population and pest control efforts [13].

## V. CONCLUSION

Spiders, as versatile predators in agroecosystems, play a crucial role in pest management by reducing the need for pesticides. Their overwintering behaviour allows them to establish early-season presence, enabling more effective pest control compared to other natural enemies. Nowadays, the growing interest in pesticide-free products and environmental stability, spiders are increasingly recognized as valuable contributors to natural pest control. Moreover, environmental stability is also improved.

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