Diversity and Functional Roles of Beneficial Insects in Sustainable Agroecosystems

Pooja Shekhawat[1], Sridhar Ketha[2], Ashutosh Gairola[3] and Jitesh Singh Bisht[3]*

[1]*Department of Entomology, College of Agriculture, Acharya Narendra Deva University of Agriculture and Technology, Ayodhya, Uttar Pradesh.*
[2]*College of Agriculture Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh*
[3]*Department of Entomology, College of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand.*

Corresponding Author
Jitesh Singh Bisht
Email: jiteshento@gmail.com

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ABSTRACT

Insects perform diverse ecological functions, with beneficial groups playing a pivotal role in sustaining agroecosystems and enhancing crop productivity. This article elucidates the diversity of beneficial insects, encompassing pollinators, natural enemies and decomposers and examines their functional roles in pollination, biological pest regulation and nutrient cycling. Natural enemies, including predators and parasitoids, regulate pest populations below economic thresholds, forming the foundation of biological control in integrated pest management (IPM). Pollinators contribute significantly to improved fruit set, seed quality and yield, while decomposers enhance soil fertility and structure. Additionally, insects such as honey bees, silkworms and lac insects provide economically valuable products, thus supporting rural livelihoods. The article highlights the importance of beneficial insects for ecological stability and long-term agricultural sustainability.

INTRODUCTION

Insects are organisms belonging to the phylum Arthropoda, characterized by a segmented body divided into head, thorax and abdomen. They constitute nearly two-thirds of the total Arthropod population (Giribet and Edgecombe, 2019). The head bears compound eyes, antennae and mouthparts, while the thorax, divided into prothorax, mesothorax and metathorax, carries three pairs of legs and usually two pairs of wings, hence termed Hexapoda.

Within Insecta, some species are harmful while others are beneficial. Phytophagous insects feed on plants and cause economic losses, thus classified as pests. Some are monophagous, restricted to a single host, while others are polyphagous, feeding on multiple hosts, enhancing their adaptability. Their oviposition behaviour and stage-specific feeding contribute to varied crop damage (Torto *et al.,* 2024).

Conversely, many insects contribute significantly in agroecosystems, like beneficial insects, including pollinators, predators and parasitoids, enhance crop productivity and regulate pest populations naturally. They form the foundation of biological control and sustainable agriculture. Additionally, insects like honey bees, silkworms, and lac insects provide valuable products, supporting farmers' livelihoods (Bashir *et al.,* 2022). Therefore, the article provides an overview of beneficial insects, their roles and importance in sustainable pest management.

1. Beneficial Insects

1.1 Pollinators

Pollinators are insects that visit flowers to obtain nectar and pollen. During foraging, they facilitate the transfer of pollen grains from the anthers to the stigma, enabling fertilization. This process promotes cross-pollination, particularly in self-incompatible and cross-pollinated crop species, allowing fertilization and the production of seeds, fruits and eventually new plants. Approximately two-thirds of flowering plant species depend on insect-mediated pollination for successful reproduction.

They significantly enhance fruit set and overall crop yield. Major groups include bees (most efficient), butterflies, moths, flies (syrphids) and beetles. Their activity is influenced by environmental factors such as temperature, light and floral characteristics, making them vital components of sustainable agroecosystems.

Table. 01 List of crops and the insects that pollinate them

	Insect	Family	Order	Crops Pollinated
A	**Honey bee**	Apidae	Hymenoptera	Sunflower, Cotton, Tobacco, Alfalfa, clover
B	**Weevils**	Curculionidae	Coleoptera	Oil palm
C	**Hoverflies/ Syrphid flies**	Syrphidae	Diptera	Carrot, Okra and pulses
D	**Fig wasps**	Agaonidae	Hymenoptera	Fig

A. **B.** **C.** **D.**

Fig. 01 Major Insect Pollinators

1.2 Natural enemies

Natural enemies act as secondary consumers, regulating herbivorous pests below economic thresholds. Predators, parasitoids and pathogens suppress pests through predation, parasitism or infection, maintaining ecological balance.

1.2.1 Predators

Predators are free-living organisms that actively capture, kill and consume insect pests for their nutrition, thereby contributing to effective pest suppression. In agroecosystems, predators play a crucial role in maintaining ecological balance by regulating pest populations, supporting biodiversity and stabilizing food webs. Their activity enhances species coexistence and ultimately contributes to increased crop productivity. These are generally polyphagous, highly mobile and consume multiple prey individuals throughout their lifetime. They may attack different life stages of pests, including eggs, larvae, nymphs and adults.

Table. 02 Major insect predators.

Predator	Family	Target Pest
Coccinella septumpunctata	Coccinellidae	Aphids
Cryptolaemus montrouzieri		Grapevine mealybug
Rodolia cardinalis		Cotton cushion scale
Menochilus sexmaculata		Mealybugs and scales
Cyrtorhinus lividipennis	Miridae	Rice brown planthopper
Eocanthecona furcellata	Pentatomidae	Red hairy caterpillar
Green lace wings (Aphid lions)	Chrysopidae	Aphids, scales and mealybugs
Damselflies	Coenagrionidae	Caterpillars
Mantids	Mantidae	Caterpillars
Robber flies	Asilidae	Small insects
Hover flies	Syrphidae	Small insects

1.2.2 Parasitoids

A parasitoid is an insect that lays its eggs on or within a host organism, usually another arthropod, where the developing immature stages feed on the host tissues and ultimately kill it. They are parasitic only during their immature stages, while the adults are free-living. In biological control, parasitoids are classified based on the host stage they attack. Egg parasitoids develop within host eggs, preventing pest emergence at an early stage. Egg-larval parasitoids begin development in the egg but complete it during the larval stage. Larval parasitoids attack actively feeding larvae and develop either internally or externally. Larval-pupal parasitoids parasitize larvae but complete development in the pupal stage. Nymphal or adult parasitoids attack later stages such as nymphs or adults. Additionally, parasitoids are categorized as endoparasites or ectoparasites depending on whether they develop inside or outside the host body and as solitary or gregarious based on the number of individuals developing per host (Kumar and Viji, 2021).

Table. 03 Major insect parasitoids

Category	Example	Target
Egg	*Trichogramma chilonis*	Cotton bollworm, sugarcane borer
	Trichogramma japonicum	Yellow Stem Borer
	Telenomus remus	Tobacco caterpillar
	Evania appendigaster	Cockroach ootheca
Egg Larval	*Chelonus blackburni*	Spotted bollworm
	Copidosoma koehleri	Potato tuber moth
	Campoletis chloridae	Gram pod borer
	Bracon hebetor/brevicornis	Black headed caterpillar
	Cotesia plutellae	Diamond back moth
	Goniozus nephantidis	Black headed caterpillar
	Platygaster oryzae	Rice gall midge
Larval pupal	*Isotima javensis*	Sugarcane top borer
	Xanthopimpla punctata	Black headed caterpillar

	Brachymeria nephantidis	Black headed caterpillar
Nymphal /Adult	*Encarsia formosa*	Cotton whitefly
	Encarsia perniciosi	Sanjose scale
	Aphelinus mali	Apple wooly aphid
	Epiricania melanoleuca	Pyrilla perpusilla

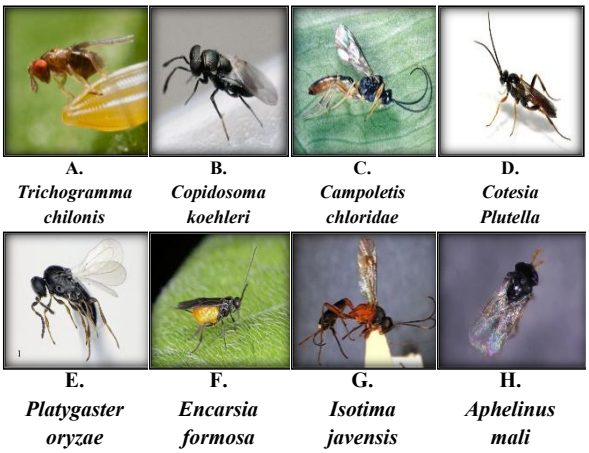

Fig. 02 Major Insect Parasitoids

1.3 Decomposers and Soil-Dwelling Insects

Decomposers are soil-dwelling beneficial insects that break down organic matter, recycle nutrients and improve soil structure and fertility. They enhance aeration, water retention and reduce soil pests. Examples include termites, springtails and dung beetles.

2. Insects as a food and as producers

Insects are used as a food in different parts of the world directly or indirectly. Insects provide high protein content. Many insects are involved in the production of various products like honey, wax, lac and silk. These products help in the additional income generation for the farmers, stakeholders and mitigates the risk of economic losses by diversified farm produce (Takov *et al.,* 2021).

2.1 Honey bees

Honey bees are among the most important beneficial insects, widely recognized for their role in honey production and pollination. The European honey bee (*Apis mellifera* L.) is the most widely managed species due to its high honey yield and adaptability. Other species such as *Apis cerana*, *A. dorsata* and *A. florea* also contribute to honey production in different regions. Honey bees collect nectar from flowers and convert it into honey through enzymatic activity and evaporation, storing it in honeycombs as a food reserve. This honey is harvested for human consumption and has significant nutritional and economic value. In addition to honey, bees also produce beeswax, which is used in various industries. Thus, honey bees have a crucial role in supporting agricultural productivity and rural livelihoods.

Fig. 03 Honey bee and honeycomb

2.2 Silkworm

Sericulture refers to the rearing of silkworms for silk production. Silkworms complete their life cycle through egg, larva, pupa (cocoon) and adult stages, with larvae feeding on host plant leaves. The pupa develops inside the cocoon, which yields silk fibre. Cocoons are treated in hot water to facilitate silk reeling. The mulberry silkworm (*Bombyx mori*) is the most important species, producing high-quality silk and supporting the silk industry and farmers' income.

2.3 Lac Insects

Laculture refers to the rearing of lac insects (*Kerria lacca*) for resin production. These

insects secrete lac on host plants such as palas, ber and kusum. The life cycle includes egg, nymph and adult stages, with nymphs feeding on sap and producing resin. The encrustation is harvested as stick lac and processed into products like shellac and dyes. Lac cultivation provides significant livelihood support to rural communities and contributes to economic and export value (David and Ramamurthy, 2016).

A. **B.** **C.**

Fig. 04 A. Silkworm **B.** Silkworm Adult **C.** Lac Insect

CONCLUSION

Beneficial insects play a crucial role in maintaining ecological balance and enhancing agricultural productivity through pollination, natural pest control and nutrient recycling. They not only reduce our dependence on chemical pesticides but also support sustainable farming. In addition, insects such as honey bees, silkworms and lac insects contribute significantly to farmers' income. Therefore, conservation and effective management of beneficial insects are essential for achieving environmentally sound agriculture, improved crop yield and long-term national food security.

REFERENCES

Bashir, N. H., Chen, H., Munir, S., Wang, W., Chen, H., Sima, Y. K. and An, J., 2022. Unraveling the role of lac insects in providing natural industrial products. *Insects* 13(12): 1117.

David, B. V. and Ramamurthy, V. V., 2016. Elements of economic entomology (8th ed.). Brillion Publishing.

Giribet, G. and Edgecombe, G. D., 2019. The phylogeny and evolutionary history of arthropods. *Current Biology* 29(12): R592-R602.

Kumar, K. P. and Viji, C. P., 2021. Entomology refresher (2nd ed.). Kalyani Publishers.

Takov, D. I., Zubrik, M. and Contarini, M., 2021. Insects as a food source–potential and perspectives. *Polish Journal of Entomology* 90(2): 48-62.

Torto, S. J., Sundufu, A. J., Samura, A. E., Fomba, S. N., Musa, D. P., Kanu, S. A. and Norman, P. E., 2024. Oviposition site preference and its effects on subsequent development of variegated grasshopper (*Zonocerus variegatus* L.) under laboratory conditions. *Advances in Entomology* 12: 143-154.