Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(3): 301-306

Received: 01-03-2020
Accepted: 03-04-2020

Liaqat Ali
Division of Entomology, Faculty of Horticulture, SKUAST-K,, Jammu and Kashmir, India

Ahmad Ali
Division of Agricultural Engineering, Faculty of Horticulture, SKUAST-K, Jammu and Kashmir, India

Chigurupati Sai Prasanth
Division of Vegetable Science, Faculty of Horticulture, SKUAST-K, Jammu and Kashmir, India

Mohd Abass
Division of Floriculture, Faculty of Horticulture, SKUAST-K, Jammu and Kashmir, India

Corresponding Author:
Liaqat Ali
Division of Entomology, Faculty of Horticulture, SKUAST-K, Jammu and Kashmir, India

Natural enemies as biological control tools for highly infesting apricot pests of Ladakh region

Liaqat Ali, Ahmad Ali, Chigurupati Sai Prasanth and Mohd Abass

Abstract
With the extensive use of pesticide-based pest management, which has affected our ecosystem, environment, and health of living beings. Insect pests gained resistance toward that chemical at that specific dose. Ladakh is the cold arid desert where the production of Apricot is pretty enough but due to the infestation of pests like Codling moth, Brown tail Moth, Gypsy Moth, Brown Scale, etc. leads to a high reduction in production. Chemical control is not sustainable management. Bio-control is one of the options and it's easily incorporated with integrated pest management (IPM). Ladakh where there is a social taboo of not to kill an insect by chemical, physical and mechanical means, bio-control is one of the viable options to control these noxious pests and it's also eco-friendly method. This review helps us to know the basics of natural enemies, types of natural enemies, the record of success, major noxious pests of apricot in Ladakh (India) and their natural enemies.

Keywords: Codling moth, parasitoids, predators, apricot pests

Introduction

In a natural ecosystem, plants, their pests, and the natural enemies of these pests have evolved natural interactions to influence the population levels of any one or all of them. However, once it comes to managed agriculture, these naturally evolved mechanisms are ignored while developing plant protection strategies. This has led to the extensive use of pesticide-based pest management, which has affected our ecosystem and environment. It is, therefore, necessary that, in the current millennium, pest management studies should be bio-intensive. One of the methods in recent years that has gained increased attention is the use of predators and parasitoids having a key advantage in their capacity both to kill and to reproduce at the expense of the pest. The equilibrium population size and dynamic behavior of many phytophagous insects are largely determined by their natural enemies and any reduction of these results in insect outbreaks. Therefore, in a strict ecological sense, applied biological control can be considered as a strategy to restore functional biodiversity in agroecosystems by adding, through classical and augmentative biotechniques, or by enhancing naturally occurring predators and parasitoids through conservation and habitat management.

Hyperparasitism is another aspect, which is a highly evolved behavior in insects involving the development of a secondary parasitoid at the expense of a primary parasitoid. This represents a highly evolved fourth trophic level. Although hyperparasitoids have traditionally been considered harmful to the beneficial primary parasitoids of insect pests, obligate hyperparasitoids should be distinguished from facultative, and exotic from indigenous [1, 2]. If the influence is positive and the extreme oscillations of primary parasitoids are dampened, then some insect hyperparasitoids might even be considered beneficial as the emerging patterns suggest that hyperparasitoid community structure seems to follow the same organizational patterns as that of primary parasitoid communities [3].

As per Animal and Plant Health Inspection Service Plant Protection and Quarantine (September 2014), Biological control (biocontrol) is the reduction of pest populations through the use of natural enemies such as parasitoids (stingless wasps), predators, pathogens, antagonists (to control plant diseases), or competitors. It is a practical option to suppress pest populations and an environmentally sound method of pest control.

Biological control is the beneficial action of parasites, pathogens, and predators in managing pests and their damage. Bio-control provided by these living organisms, collectively called "natural enemies," is especially important for reducing the numbers of pest insects and mites (Figure: 1) [4, 5]. Plant pathogens, nematodes, and vertebrates also have many natural enemies, but this biological control is often harder to recognize, less well understood, and or more difficult to manage [6].

Fig 1: Adult convergent ladybeetle feeding on aphids.

Types of Natural Enemies
Parasites, pathogens, and predators are the primary groups used in biological control of insects and mites. Most parasites and pathogens, and many predators, are highly specialized and attack a limited number of closely related pest species [7].

Parasites
A parasite is an organism that lives and feeds in or on a host (Figure 2). Insect parasites can develop on the inside or outside of the host's body. Often only the immature stage of the parasite feeds on the host. However, adult females of certain parasites (such as many wasps that attack scales and whiteflies) feed on and kill their hosts, providing an easily overlooked but important source of biological control in addition to the host mortality caused by parasitism. Although the term "parasite" is used here, true parasites (e.g., fleas and ticks) do not typically kill their hosts. Species useful in biological control, and discussed here, kill their hosts; they are more precisely called "parasitoids" [8]. Most parasitic insects are either flies (Order Diptera) or wasps (Order Hymenoptera). Parasitic wasps occur in over three dozen Hymenoptera families. For example, Aphidiinae (a subfamily of Braconidae) attack aphids (Figure 3). Trichogrammatidae parasitizes insect eggs. Aphelinidae, Encyrtidae, Eulophidae, and Ichneumonidae are other groups that parasitize insect pests. It's important to note that these tiny to medium-sized wasps are incapable of stinging people. The most common parasitic flies are the typically hairy Tachinidae. Adult tachinids often resemble house flies. Their larvae are maggots that feed inside the host [9, 10].

Fig 2: Parasitic larvae visible through the surface of their scale.

Fig 3: Aphid mummies and a parasitic wasp

Hyperparasitoids
Hyperparsitoids are secondary insect parasitoids that develop at the expense of a primary parasitoid, thereby representing a highly evolved fourth trophic level. The primary parasitoid attacks an insect host that is usually phytophagous but which could also be a predator or a scavenger. Hence, an insect hyperparasitoid attacks another insect that is or was developing in or on another insect host, and this sometimes impacts on biological control of a pest insect [11].

Pathogens
Natural enemy pathogens are microorganisms including certain bacteria, fungi, nematodes, protozoa, and viruses that can infect and kill the host (Figure 4). Populations of some aphids, caterpillars, mites, and other invertebrates high humidity or dense pest populations. In addition to a naturally occurring disease outbreak (epizootic), some beneficial pathogens are commercially available as biological or microbial pesticides. These include *Bacillus thuringiensis* or BT, entomopathogenic nematodes, and granulosis viruses. Additionally, some microorganism's by-products, such as avermectins and spinosyns are used in certain insecticides; but applying these products is not considered to be biological control.

Fig 4: Entomopathogenic nematodes emerging from a root weevil larva they killed.

The insects that prey on other insects and mites occur in many insect orders, the most prominent being Coleoptera, Neuroptera, Hymenoptera, Diptera, Hemiptera, and Odonata.

Besides, there are several species of mites and spiders feeding on a wide range of insects and mites. Some predators use biting or chewing mouthparts to devour their prey (e.g., praying mantids, dragonflies, and beetles), whereas others use piercing and sucking mouthparts to feed upon the body fluids of their prey (e.g., assassin bugs, lacewing larvae, and hoverfly larvae). The sucking type of feeders often injects a powerful toxin that quickly immobilizes their prey. Predatory insects feed on all host stages, i.e., egg, larval (or nymphal), pupal, and adult stages. Many species are predaceous in both larval and adult stages, although not necessarily on the same kinds of prey. Others are predaceous only as larvae, whereas the adults may feed on nectar, honeydew, etc., and among these, it is often the nonpredaceous adult female that seeks the prey for her larvae by depositing eggs among the prey. This is because their larvae are sometimes incapable of finding the prey on their own [9, 12, 13]. Predatory beetles, flies, lacewings, true bugs (Order: Hemiptera), and wasps feed on various pest insects or mites (Figures 5 and 6). Most spiders feed entirely on insects. Predatory mites that feed primarily on pest spider mites include Amblyseius spp., Neoseiulus spp., and the western predatory mite, *Galendromus occidentalis.*

Fig 5: An adult assassin bug eating a lygus bug.

Fig 6: An alligatorlike green lacewing larva eating an aphid

Past perspective

The Chinese used nests of Pharaoh's ant, *Monomorium pharaonis* (Linnaeus) to combat stored grain pests, while *Oecophylla smaragdina* (Fabricius) has been used to control foliage feeding caterpillars and large boring beetles in citrus trees since ancient times. [14] The Mynah bird from India was imported in 1762 for the control of red locust, *Patanga septemfasciata* (Serville) in Mauritius. By 1770 it brought about the successful control of the locust (van Emden, 1989). The recent outstanding example is the control of cassava mealybug, *Phenacoccus manihoti* Matile-Ferrero, by a tiny wasp, *Epidinocarsis lopezi* (De Santis) in Africa. [15, 9, 16] *E. lopezi* used as bioagent against *Phenacoccus manihoti* and was established over a total area of more than 750,000 km^2 in 16 African countries by the end of 1986. Over the next 7 years, the cassava mealybug problem was effectively eliminated from 30 countries [17-19].

There are several successful examples on record showing the number and extent of successes obtained from biological control importation projects against insect pests at a global level. The computerized data of IOBC (International Organization of Biological Control) shows that out of 4221 importations, 1251 natural enemies were established, 2038 failed, and the fate of another 932 was unknown. This implies a success rate of about 38 percent. Mass production of parasitoids and predators is a highly technical job beset with numerous problems. It needs years of experience and knowledge to tackle these problems to ensure the continuous production of various colonies. The area of work that needs urgent attention includes quantification of natural enemy biodiversity and standardization of conservation methods, the perfection of augmentation, refinement, and automation in mass production technology, and enhancement of efficiency of natural enemies [20-22].

Biological control strategies

1. Introduction/importation.
2. Augmentation.
3. Conservation.

Major Noxious pests of Apricot in Ladakh Region:

1. Codling moth: *Cydia pomonella*, (Lepidoptera: Tortricidae)
2. Brown tail moth: *Euproctis chrysorrhoea*, (Lepidoptera: Noctuoidea
3. Gypsy moth: *Lymantria dispar*, (Lepidoptera: Noctuoidea)
4. Flat-headed borers: *Chrysobothris mali* Horn (Coleoptera: Buprestide) & *Capnodis tenebrionis* Linne (Coleoptera: Buprestidae)
5. Hairy caterpillar: *Lymantria obfuscata* Walker (Lepidoptera: Lymantriidae)
6. Defoliating beetles: *Adoretos* sp. & *Brahmina* sp
7. Leaf curl plum aphid: *Anuraphid helichyrysi* Kaltenbach (Hemiptera: Aphididae)
8. Brown apricot scale: *Lecanium corni* (Bouché) (Hemiptera: Coccidae)
9. San Jose-scale: *Quadraspidiotus perniciosus* Comstock (Hemiptera: Diaspididae)

Sources: [23, 24].

Natural enemies of noxious pests of Apricot:

1. Parasitoids

1.1 Egg parasitoids.
1.2 Egg-larval parasitoids.
1.3 Larval parasitoids.
1.4 Pupal parasitoid.
1.5 Nymphal/larval and adult parasitoids.

Predators

Trichogramma spp.

Chelonus spp.

Ichneumon spp.

Lacewing

Black drongo

Mirid bug

Natural enemies of noxious pests of Apricot

Natural Enemies	Example(s)	Reference(s)
1.Parasitoids		Wang *et al.*, 2011
1.1 Egg parasitoids.	*Trichogramma* spp. *Tetrastichus* spp. *Telenomus* spp.	Cossenline and Jensen, 2000. Makee, 2004. Walton, 2013. Querino *et al.*, 2016. Horrocks *et al.*, 2020.
1.2 Egg-larval parasitoid.	*Chelonus* spp.	Driesche *et al.*, 1996. Makee, 2004. Ahmad and Ghramh, 2018
1.3 Larval parasitoids.	*Bracon* spp. *Ichneumon* spp. *Carcelia* spp. *Campoletis* spp. *Apanteles* sp. *Hyposoter exiquae* *Lespesia* sp. *Microgaster* sp.	Juan *et al., 2003* Duan - 2011 Legault *et al.*, 2012 Ahmad and Ghramh, 2018 El-Wakeil & Gaafar, 2020
1.4 Pupal parasitoid.	*Brachymeria euploeae*	Walton, 2013. Querino *et al.*, 2016.
1.5 Nymphal/larval and adult parasitoids.	*Chrysocharis* sp *Aphidius* *Dighyphus isaea* *Gronotoma micromorpha*	Walton, 2013. Querino *et al.*, 2016.
2. Predators.	Lacewing Ladybird beetle Reduviid bug Spider Robber fly Fire ant Black drongo Common Mynah Big eyed bug Ear wig Groung beetle Pentatomid bug	Duan - 2011 Legault *et al.*, 2012 Ahmad and Ghramh, 2018 Wang *et al.*, 2011 El-Wakeil & Gaafar, 2020

	Preying mantid Geocoris spp Predatory thrips *Oligota* spp. *Orius* spp. Hover fly Mirid bug	

Relative toxicity of insecticides to natural enemies [25].

	Toxicity to Parasites and Predators (*)
Insecticide	Direct
Microbial (*Bacillus thuringiensis*)	no
Botanicals (pyrethrins)	yes/no (**)
Oil (horticultural), soap (potash soap)	yes
Microbial (spinosad)	yes/no (**)
Neonicotinoids (imidacloprid)	yes/no (**)
Carbamates (carbaryl), Organophosphates (malathion), Pyrethroids (bifenthrin)	yes

(*)Direct contact toxicity is killing within several hours from spraying the beneficial or its habitat. Residual toxicity is killing or sublethal effects (such as reduced reproduction or ability to locate and kill pests) due to residues that persist.
(**)Toxicity depends on the specific material and how it is applied and the species and life stage of the natural enemy.

Conclusion
A great benefit of biological control is its relative safety for human health and the environment, compared to the widespread use of broad-spectrum pesticides. Predators and parasitoids can provide long-term regulation of pest species provided proper management practices are followed to make the environment conducive to furthering their abundance and efficiency in target agroecosystems. Biological control can potentially become a self-perpetuating strategy, providing economic control with the least environmental hazards. However, much work needs to be done to optimize the utilization of predators and parasitoids in integrated pest management (IPM). There is an urgent need to establish a network of large-scale multiplication units so that the natural enemies are made available to the farmers. Heat- and cold-tolerant strains have to be selected/developed in the cases of some natural enemies. Spread awareness among farmers via Regional Research Station, State Agriculture Universities and Central Government.

References

1. Roy G Van Driesche, Thomas S, Bellows Jr. Introduction of New Natural Enemies: Principles. Journal Biological Control, 1996, 128-157.
2. Ann E Hajek. Natural Enemies: An Introduction to Biological Control. Cambridge University Press, 2004.
3. Colmenarez YC, Corniani N, Jahnke SM, Sampaio MV, Vásquez C. Use of parasitoids as a biocontrol agent in the neotropical region: challenges and potential. Horticultural crops [recurso electronica]. London: Intech Open, 2020. Chapter, 2020; 9:171-193.
4. Dreistadt SH, Flint ML, Clark JK. Pests of Landscape Trees and Shrubs: An Integrated Pest Management Guide. 2nd ed. Oakland: California Agricultural, Natural and Human Resources Publication 3359, 2004.
5. Flint ML, Dreistadt SH. Natural Enemies Handbook: The Illustrated Guide to Biological Pest Control. Oakland: California Agricultural, Natural and Human Resources Publication 3386, 1998.
6. Rust MK, Choe DH. Pest Notes: Ants. Oakland: California Agricultural, Natural and Human Resources Publication 7411, 2012. Available online at www.ipm.ucanr.edu/PMG/ PESTNOTES/pn7411.html.
7. DuPont ST, John Strohm C. Integrated pest management programmes increase natural enemies of pear psylla in Central Washington pear orchards. Journal of Applied Entomology, 2020; 144(1, 2):109-122.
8. Headrick DH, Quezada H, Semet P, Finch S, Madrid LL, Stewart JR. Foreign exploration for citrus peelminer and its natural enemies in Sonora, Mexico, 1998.
9. DeBach P, Rosen D. Biological control by natural enemies. CUP Archive, 1991.
10. Altieri MA, Nicholls CI. Biological control in agroecosystems through management of entomophagous insects. Critical Issues in Insect Pest Management, Commonwealth Publishers, New Delhi, 1998, 67-86.
11. Sullivan DJ, Völkl W. Hyperparasitism: multitrophic ecology and behavior. Annual Review of Entomology, 1999; 44(1):291-315.
12. Beckage, Nancy E, Michael R, Kanost. "Effects of parasitism by the braconid wasp *Cotesia congregata* on host hemolymph proteins of the tobacco hornworm, Manduca sexta." Insect Biochemistry and Molecular Biology, 1993; 23(5):643-653.
13. Vázquez LL. Interactions of Entomopathogenic Fungus with Entomophagous Insects in Agroecosystems. In Natural Enemies of Insect Pests in Neotropical Agroecosystems Springer, Cham. 2019, 161-171.
14. Coulson JC, Duncan N, Thomas C. Changes in the breeding biology of the herring gull (*Larus argentatus*) induced by a reduction in the size and density of the colony. The Journal of Animal Ecology, 1982, 739-756.
15. Mohamad BM, Van Emden HF. Host plant modification to insecticide susceptibility in *Myzus persicae* (Sulz.). International Journal of Tropical Insect Science, 1989; 10(5):699-703.
16. Hoy MA. Parasitoids and predators in management of arthropod pests. Introduction to Insect Pest Management, 1994; 4:129-198.
17. Herren HR, Neuenschwander P. Biological control of cassava pests in Africa. Annual Review of Entomology, 1991; 36(1):257-283.
18. Herren HR, Neuenschwander P. Biological control of cassava pests in Africa. Annual Review of Entomology, 1996.
19. Bellotti AC, Smith L, Lapointe SL. Recent advances in cassava pest management. Annual Review of Entomology. 1999; 44(1):343-370.
20. Koul O, Dhaliwal GS, Marwaha SS, Arora JK. Future perspectives in biopesticides. Biopesticides and Pest Management, 2003; 1:386-388.
21. Pandey AK, Namgyal D, Mir MS, Ahmed SB. Major insect pest associated with forest plantations in cold arid region, Ladakh of Jammu and Kashmir. Journal of Entomological Research, 2007; 31(2):155-162.

http://www.kvkkargil.ac.in/

22. Dreistadt SH. Biological control and natural enemies of invertebrates: Integrated pest management for home gardeners and landscape professionals. University of California, Davis, Agriculture and Natural Resources, 2014.