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(5): 2251-2255

Received: 13-06-2020
Accepted: 16-08-2020

Akhtar Ali Khan
Professor, Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology-Kashmir, Shalimar, Srinagar, J&K, India

Azaz Ahmad Kundoo
Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology-Kashmir, Shalimar, Srinagar, J&K, India

Zakir Hussain Khan
Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology-Kashmir, Shalimar, Srinagar, J&K, India

Khurseed Hussain
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology-Kashmir, Shalimar, Srinagar, J&K, India

Corresponding Author:
Akhtar Ali Khan
Professor, Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology-Kashmir, Shalimar, Srinagar, J&K, India

Identification of potential and suitable natural enemies of arthropod pests for conservation biological control in vegetable ecosystem of Kashmir

Akhtar Ali Khan, Azaz Ahmad Kundoo, Zakir Hussain Khan and Khurseed Hussain

Abstract
The studies on Identification of potential and suitable natural enemies of arthropod pests for conservation biological control were carried out in vegetable ecosystem of Kashmir during 2016 and 2017. The surveys were made for the exploration of natural enemies of vegetable ecosystem of cabbage, tomato and brinjal in three districts of Kashmir. Viz., Srinagar, Budgam and Ganderbal. The different kinds of natural enemies that were collected with the stage of insect pest attacked in cabbage, brinjal and tomato including Coccinellids, Chrysoperla, Syrphid flies, spiders, ground beetles, Dragon flies, damsel flies and parasitoids viz., Braconid wasps, Chalcid wasps and Ichneumon wasps. The important insect pests of Solanaceous and Cruciferous plants along with the stage of insect attacked by beneficials also documented.

Keywords: Arthropod pests, natural enemies, conservation biological control, Vegetable ecosystem.

Introduction
Currently farmers rely on chemical pesticides for controlling the insect pests of various crops. These pesticides have negative effects on environment, biodiversity, human and animal health. To mitigate these problems alternative approach is needed [1, 2]. Conventional farming practices contributed to increase yields during the 20th century, but at the cost of environment, human health and imbalance of ecosystems [3, 4]. Unfortunately, more than 40% of all world food production is being lost to insect pests, plant pathogens and weeds, despite the application of more than 3 billion kilograms of pesticides to crops. Insect pests destroy an estimated 15%, plant pathogens 13% and weeds 12% [5]. These estimated losses vary based on the 'cosmetic' standards that exist in each nation. For example, many fruits and vegetables sold on the Guatemalan or Indian markets would not be saleable in the USA or Australia. Large quantities of pesticides are applied in the USA, Australia and other developed nations to achieve the 'perfect-looking' apple or cabbage. An excessive amount of pesticide is being recommended to replace the sound habitat manipulations previously employed in crop production. For example, since 1945 the amount of insecticide applied to US crops has increased more than 10-fold, yet crop losses to insects nearly doubled from 7% in 1945 to about 13% today [6, 7]. The reasons for the doubling of crop losses to insects, despite the 10-fold increase in insecticide use, include the reduction of crop rotations, the planting of some crop varieties that are more susceptible to insects, the destruction of natural enemies, the elimination of hedgerow and shelterbelts, an increase in monocultures, reduced crop diversity, reduction in sanitation, the practice of leaving crop residues on the surface of the land and the use of herbicides that increase crop susceptibility to insect attack [4]. No one can appose to the judicious use of pesticides; the concern is the neglect of various environmentally sound pest controls. The wide array of habitat manipulations currently includes agro-forestry, biological control, crop rotations, crop diversity, flower strips, natural enemy refuges, trap crops and other technologies. Each of these technologies, and combinations of these pest suppression technologies, offers opportunities to reduce crop losses to pests while at the same time reducing the use of pesticides [8, 9].
Conservation biological control involves manipulation of the environment to enhance the

survival, fecundity, longevity, and behavior of natural enemies to increase their effectiveness. Such conservation efforts may be directed at mitigating harmful conditions or enhancing favorable ones [10-12]. Conservation practices can be further categorized as those that focus on reducing mortality, providing supplementary resources, controlling secondary enemies, or manipulating host plant attributes to the benefit of natural enemies. Because of its importance in enhancing natural enemy performance, conservation biological control should be a keystone of all biological control efforts [10].

A focus of many past conservation efforts has been to seek more selective pesticides, or to time the use of pesticides to minimize their negative impacts on natural enemies. Recently, increasing attention has been paid to conservation practices that seek to alter the quality of the natural enemies' habitat [13-17]. In addition, identification, characterization and economic evaluation of conservation practices in a cropping system mode, and addressing the critical areas such as formulation of specific policies for promotion of conservation bio-control, coordination of government policy on pesticides and other agricultural matters affecting biological control, developing strong leadership for conservation programmes with adequate resources and quality control, and effective execution, monitoring and evaluation are the need of the hour [18-20]. The realm of conservation biological control needs immediate attention in pest management programme. Promoting functional biodiversity, which supports ecological processes, may allow agricultural systems to benefit from various ecosystem services, including nutrient cycling, soil structuration and pest control [3, 21].

Materials and Methods

The study area included the temperate regions of Kashmir, located in the Indian union territory of Jammu and Kashmir. The natural enemies for the key pests of Cabbage, Brinjal and Tomato were collected from Solanaceous and Cruciferous ecosystem of Kashmir during 2016-2017. The natural enemies for the present study were collected from three districts of Kashmir viz, Srinagar, Ganderbal and Budgam, mostly in the month of April through October as majority of Coccinellids are active during this period. The specimens were collected by hand picking, beating the bushes and shaking the trees. Each locality was visited weekly or fortnightly depending upon the accessibility to the area and active period of the natural enemies. The collected specimens were killed in a jar poisoned with ethyl acetate or potassium cyanide and provided with piece of paper to absorb the killing fluid and sweetening of insect. The specimens were pinned and then oven dried at 60 °C for 72 hours in order to preserve them and then set into wooden boxes and labelled according to their systematic position. The specimens were then kept in wooden insect boxes for permanent storage. Proper curation of the stored insects was made regularly.

The collected specimens were identified upto family level with the help of taxonomic keys published in pertinent literature, by comparison with already species in reference collections and in case of difficulty help was taken from internal and external experts.

Result and Discussion

Potential and suitable natural enemies of arthropod pests for conservation biological control in vegetable ecosystem

The three districts (Srinagar, Badgam and Ganderbal) were selected from Solanaceous and Cruciferous ecosystem with five different localities from each district. Survey was carried out and resulted in capture of potential natural enemies with respect to the key pests of Cruciferous and Solanaceous vegetables during 2016-2017. The aphids (*Brevicornye brassicae*), Diamond back moth *(Plutella xyostella*), Cabbage butterfly (*Pieris brassicae*), Cabbage semi lopper (*Trichoplusia ni*) and Cutworm (*Agrotis ipsilan)* were key pests of Cabbage; in case of tomato, Aphid (*Myzus persicae*), Fruit borer (*Helicoverpa armigera*) semi lopper (*Trichoplusia* sp) and Cutworm (*Agrotis ipsilan)* were recorded as key pests and in case of brinjal, it were Aphid (*Aphis gossypii*), Flea beetles (several species), Cutworm (*Agrotis ipsilan*) and Brinjal fruit and shoot borer (*Leucinodes orbonalis*). The different predators that were collected with the stage of insect attacked including Coccinellids, Crysoperla, Syrphid flies, spiders, ground beetles, Dragon flies, damsel flies and parasitoids viz., Braconid wasps, Chalcid wasps and Ichneumon wasps as shown in Table 1, 2, 3.

Potential and suitable natural enemies of cabbage insect pests

In case of Cabbage, potential and beneficial natural enemies of aphids (*Brevicornye brassicae*) were lady bird beetle, lacewing, syrphid fly larvae, spiders and braconid wasps; natural enemies of Dimond back moth (*Ptutella xyostella*) were Chalcid wasps (especially Trichogrammatidae), syrphid fly larvae and spiders; natural enemies of Cabbage butterfly (*Pieris brassicae*) were lacewing, spiders and syrphid fly larvae; natural enemies of Cabbage semi lopper (*Trichoplusia ni*) were Tachinidae fly and Chalcid wasps (especially Trichogrammatidae) and natural enemies of Cutworm (*Agrotis ipsilan*) were Tachinidae fly, Chalcid wasps (especially Trichogrammatidae), ground beetles, spiders and braconid wasps (Table 1). Similar report was cited by different workers from different part of the world [22-25].

Potential and suitable natural enemies of Tomato insect pests

In case of Tomato, potential and beneficial natural enemies of aphids(*Myzus persicae*) were lady bird beetle, lacewing, syrphid fly larvae, spiders and braconid wasps; natural enemies of Cutworm (*Agrotis ipsilan*) were Tachinidae fly, Chalcid wasps (especially Trichogrammatidae), ground beetles, spiders and braconid wasps; natural enemies of Fruit borer (*Helicoverpa armigera*) were Tachinidae fly, Chalcid wasps (especially Trichogrammatidae), ground beetles and spiders and natural enemies of white fly were lady bird beetle, lacewing, syrphid fly larvae, spiders and braconid wasps (Table 2). Similar report was cited by different workers from different part of the world [26-29].

Potential and suitable natural enemies of Brinjal insect pests

In case of Brinjal, potential and suitable natural enemies of aphids (*A. gossypii* and *Myzus persicae*) were lady bird beetle, lacewing, syrphid fly larvae, spiders and braconid wasps; natural enemies of Cutworm (*Agrotis ipsilan*) were Tachinidae fly, Chalcid wasps (especially Trichogrammatidae), ground beetles, spiders and braconid wasps; natural enemies of flea beetle were spiders and braconid wasps and for Brinjal fruit and shoot borer (*Leucinodes orbonalis*), Tachinidae fly, Chalcid wasps (especially Trichogrammatidae) as the important natural were recorded (Table 3).

Table 1: Natural enemies of key pests of Cabbage in Kashmir during 2016-2017

Insect Pests	Beneficial that attack it			Stage of insect Attacked
	Natural enemies	Order	Family	
Aphid (*Brevicornye brassicae*)	Ladybird beetle	Coleoptera	Coccinellidae	All stages
	Lacewing.	Neuroptera	Chrysopidae	All stages
	Syrphid fly larvae	Diptera	Syrphidae	All stages
	Spiders	Araneae	- -	All stages
	Braconid wasp	Hymenoptera	Bracnidae	All stages
Dimond back moth *(Ptuella xyostella*)	Chalcid wasps (especially Trichogrammatidae)	Hymenoptera	Trichogrammatidae	Egg/larvae
	Syrphid fly larvae	Diptera	Syrphidae	Early instar larvae
	Spiders	Araneae	-	All stages
Cabbage butterfly (*Pieris brassicae*)	Lacewing	Neuroptera	Chrysopidae	Early instars larvae
	Syrphid fly larvae	Diptera	Syrphidae	Early instar larvae
	Chalcid wasps	Hymenoptera	Trichogrammatidae	Egg/larvae
Cabbage semi lopper (*Trichoplusiani*)	Tachinidae fly	Diptera	Tachinidae	Larvae
	Chalcid wasps (especially Trichogrammatidae)	Hymenoptera	Trichogrammatida	Egg
Cutworm (*Agrotisipsilan*)	Tachinidae fly	Diptera	Tachinidae	Larave
	Anthocorid bug	Hemiptera	Anthocoridae	Eggs
	Ground beetles		Carabidae	Larave
	Braconid wasp	Hymenoptera	Bracnidae	Larave
	Spiders	Araneae	-	All stages

Table 2: Natural enemies of key pests of tomato in Kashmir during 2016-2017

Insect Pests	Beneficial that attack it			Stage of insect Attacked
	Natural enemies	**Order**	**Family**	
Aphid (*Myzus persicae*)	Ladybird beetle	Coleoptera	Coccinellidae	All stages
	Lacewing	Neuroptera	Chrysopidae	All stages
	Syrphid fly larvae	Diptera	Syrphidae	All stages
	Spider	Araneae	-	All stages
	Braconid wasp	Hymenoptera	Bracnidae	nymphs
Cutworm (*Agrotis ipsilan*)	Tachinidae fly	Diptera	Tachinidae	Larvae
	Anthocorid bug	Hemiptera	Anthocoridae	Eggs
	Ground beetles	Coleoptera	Carabidae	larvae
	Braconid wasp	Hymenoptera	Bracnidae	larvae
Fruit borer *(Helicovera armigera*)	Chalcid wasps (especially Trichogrammatidae	Hymenoptera	Trichogrammatidae	Egg/larvae
	Spider	Araneae	-	All stages
	Ground beetles	Coleoptera	Carabidae	larvae
White fly (*Bemisia tabaci*)	Ladybird beetle	Coleoptera	Coccinellidae	All stages
	Lacewing	Neuroptera	Chrysopidae	All stages
	Syrphid fly larvae	Diptera	Syrphidae	All stages
	Spider	Araneae	-	All stages

Table 3: Natural enemies of key pests of brinjal in Kashmir during 2016-2017

Insect Pests	Beneficial that attack it			Stage of insect Attacked
	Natural enemies	**Order**	**Family**	
Aphid (*Aphis gossypii) Myzus persicae*	Ladybird beetle	Coleoptera	Coccinellidae	All stages
	Lacewing	Neuroptera	Chrysopidae	All stages
	Syrphid fly larvae	Diptera	Syrphidae	All stages
	Spider	Araneae	-	All stages
	Braconid wasp	Hymenoptera	Bracnidae	Nymphs
Flea beetles (several species)	Braconid wasp	Hymenoptera	Bracnidae	Larvae
	Spider	Araneae	-	All stages
Brinjal fruit and shoot borer (*Leucinodes orbonalis*)	Chalcid wasps (especially Trichogrammatidae)	Hymenoptera	Trichogrammatidae	Egg/larvae
	Tachinidae fly	Diptera	Tachinidae	Larvae
Cutworm (*Agrotis ipsilan)*	Tachinidae fly	Diptera	Tachinidae	Larvae
	Anthocorid bug	Hemiptera	Anthocoridae	Early instar stage
	Ground beetles	Coleoptera	Carabidae	Larvae
	Braconid wasp	Hymenoptera	Bracnidae	Larvae

Conclusion

Potential and beneficial natural enemies of cabbage insects like aphids (*Brevicornye brassicae*) were lady bird beetle, lacewing, syrphid fly larvae, spiders and braconid wasps; natural enemies of Dimond back moth (*Ptutella xyostella*) were Chalcid wasps (especially Trichogrammatidae), syrphid fly larvae and spiders; natural enemies of Cabbage butterfly (*Pieris brassicae*) were lacewing, spiders and syrphid fly

larvae; natural enemies of Cabbage semi lopper (*Trichoplusia ni*) were Tachinidae fly and Chalcid wasps (especially Trichogrammatidae) and natural enemies of Cutworm (*Agrotis ipsilan*) were Tachinidae fly, Chalcid wasps (especially Trichogrammatidae), ground beetles, spiders and braconid wasps. Natural enemies of tomato aphids (*Myzus persicae*) were lady bird beetle, lacewing, syrphid fly larvae, spiders and braconid wasps; natural enemies of Cutworm (*Agrotis ipsilan*) were Tachinidae fly, Chalcid wasps (especially Trichogrammatidae), ground beetles, spiders and braconid wasps; natural enemies of Fruit borer (*Helicoverpa armigera*) were Tachinidae fly, Chalcid wasps (especially Trichogrammatidae), ground beetles and spiders and natural enemies of white fly were lady bird beetle, lacewing, syrphid fly larvae, spiders and braconid wasps. In case of Brinjal, potential and suitable natural enemies of aphids (*A. gossypii* and *Myzus persicae*) were lady bird beetle, lacewing, syrphid fly larvae, spiders and braconid wasps; natural enemies of Cutworm (*Agrotis ipsilan*) were Tachinidae fly, Chalcid wasps (especially Trichogrammatidae), ground beetles, spiders and braconid wasps; natural enemies of flea beetle were spiders and braconid wasps and for Brinjal fruit and shoot borer (*Leucinodes orbonalis*), Tachinidae fly, Chalcid wasps (especially Trichogrammatidae) as the important natural were recorded.

Acknowledgements
This research has been funded by Department of Science and Technology (DST), Ministry of Science; New Delhi, India entitled "Ecological Engineering for Conservation Biological Control of Insect Pests in Vegetable Ecosystem of Kashmir". The authors are highly thankful to DST for the financial assistance.

References

1. Lopes T, Hatt S, Xu Q, Chen J, Liu Y, Francis F. Wheat (*Triticum aestivum* L.) Based Intercropping Systems for Biological Pest Control. Pest Management Science, 2016;72:2193-2202. https://doi.org/10.1002/ps.4332.
2. Khan AA. Relative toxicity of pesticides for safety of predatory coccinellids. Annals of Plant Protection Sciences. 2009;17(2):307-311.
3. Altieri MA. Agroecology and the Conversion of Large-Scale Conventional Systems to Sustainable Management. International Journal of Environmental Studies 1991;50:165-185.
4. Landis DA, Menalled FD. Ecological considerations in the conservation of effective parasitoid communities in agricultural systems. 1998;12:101-21.
5. Chalak A, Bailey A, Balcombe K, Fraser I. Pesticide, preference heterogeneity and non-market values: a latent class model, 2006.
6. Liu YQ, Shi ZH, Zalucki MP, Liu SS. Conservation biological control and IPM practices in Brassica vegetable crops in China. Biological Control. 2014;68:37-46.
7. Riccardo B, Freddy M, Helena B, Christer B. Insecticides Suppress Natural Enemies and Increase Pest Damage in Cabbage. Journal of Economic Entomology, 2011; 104(3):782-791.
8. Hooks CRR, Johnson MW. Impact of Agricultural Diversification on the Insect Community of Cruciferous Crops. Crop Protection. 2003;22:223-238.
9. Khan AA. Effect of insecticides on distribution, relative abundance, species diversity and richness of syrphid flies in vegetable ecosystem of Kashmir. Journal of Entomology and Zoology Studies. 2017;5:808-817.
10. Gurr GM, Wratten SD, Luna JM, Multi-function agricultural biodiversity: pest management and other benefits. Basic and Applied Ecology 2003;4:107-116.
11. Labou B, Brévault T, Sylla S, Diatte M, Bordat D, Diarra K. Spatial and temporal incidence of insect pests in farmers' cabbage fields in Senegal. International Journal of Tropical Insect Science.2017;37:225-233.
12. Khan AA. Functional Response of Four Syrphid Predators Associated with Mealy Cabbage Aphid, *Brevicoryne brassicae* L. on Cruciferous Vegetables**.** International Journal of Current Microbiology and Applied Sciences. 201;6:2806-2816.
13. Parker JE, Rodriguez-Saona C, Hamilton GC, Snyder WE. Companion Planting and Insect Pest Control. INTECH Open Access Publisher, 2013.
14. Rizk AM. Effect of Strip-Management on the Population of the Aphid, *Aphis craccivora* Koch and its Associated Predators by Intercropping Faba bean, Vicia faba L. with Coriander, Coriandrum sativum L. Egyptian Journal of Biological Pest Control. 2011; 21:81-87.
15. Sarker PK, Rahman MM, Das BC. Effect of Intercropping of Mustard with Onion and Garlic on Aphid Population and Yield. Journal of Biological Science 2007;15:35- 40.
16. Wszelaki A. Trap Crops, Intercropping and Companion Planting: The University of Tennessee. Institute of Agriculture. Department of Plant Sciences Extension 2014;W235-F.4
17. Hasheela EBS, Nderitu JH, Olubayo FM, Kasina M. Evaluation of border crops against infestation and damage of cabbage by diamondback moth (Plutella xylostella). Tunisian Journal of Plant Protection. 2010;5:99-105.
18. Snyder WE, Ives AR. Interactions between specialist and generalist natural enemies: parasitoids, predators, and pea aphid biocontrol. Ecology. 2003;84:91-107.
19. Flint ML, Dreistadt SH, Clark JK. Natural Enemies Handbook: The Illustrated Guide to Biological Pest Control; University of California Press: Berkeley, CA, USA, 1998.
20. Nelson M, Revocatus SM, Kelvin MM, Patrick AN. Insect Pests of Economic Importance to Brassica oleracea, Their Control Strategies and the Potential Threat to Environmental Pollution in Africa. *Sustainability* 2020;12(9)3824; https://doi.org/10.3390/su12093824.
21. Nissar M, Khan AA, Khan ZH, Masoodi KZ, Ali A, Wani WM *et al*. Population dynamics of whitefly (Bemisia tabaci, Gennadius) on tomato (*Solanum esculentum*, Mill.) crop under protected conditions in Kashmir. Journal of Entomology and Zoology Studies. 2019;7(4):804-807.
22. Krishnamoorthy A. Biological control of diamondback moth, *Plutella xylostella* (L.), an Indian scenario with reference to past and future strategies. In Proceedings of the International Symposium, Montpellier, France,21–24 October 2002; Kirk, A.A., Bordat, D., Eds.; CIRAD: Montpellier, France, 2004.
23. Labou B, Brévault T, Bordat D, Diarra K. Determinants of parasitoid assemblages of the diamond back moth, *Plutella xylostella*, in cabbage farmer fields in Senegal.

Crop. Protection.2016;89:6-11.
24. Li Z, Zalucki M, Yonow T, Kriticos D, Bao H, Chen H, *et al*. Population dynamics and management of diamondback moth (*Plutella xylostella*) in China: The relative contributions of climate, natural enemies and cropping patterns. Bulletin of Entomological Research.2016;106:197-214.
25. Khan AA, Shah MA. Records of aphids and their natural enemies in agro-ecosystem with special reference to horticultural ecosystem of Kashmir. Journal of Entomology and Zoology Studies. 2017;5:189-203.
26. Cordero J, Cave RD. Natural enemies of *Plutella xylostella* (Lep, Plutellidae) on crucifers in Honduras. Entomophaga. 1992;37:397-407.
27. Kundoo AA, Khan AA. Coccinellids as biological control agents of soft bodied insects: A review. Journal of Entomology and Zoology Studies. 2017;5:1362-1373.
28. Khan AA, Reyaz S, Kunndoo AA. Evaluation of efficacy of predators against green apple aphid (*Aphis pomi*) in apple orchards and cabbage aphid (*Brevicoryne brassicae*) in cabbage field of Kashmir. Journal of Entomology and Zoology Studies. 2017;5:112-116.
29. Miranda FH, Bylund L, Grönberg L, Björkman C. Population density and killing capacity by predators of eggs and larvae of the diamondback moth in Nicaragua. Environmental Entomology. 2011;40:333-341.