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Biodiversity of lepidopteron pests (Insecta) and their Natural Bio-Control agents associated with vegetable crops in J&K

Deen Mohd. Bhat

Abstract
Lepidoptera is an order of insects that includes butterflies and moths. The larvae of many lepidopteron species are serious pests of agriculturally important crops. The vegetable crops in Jammu and Kashmir (J&K) are also infested by a number of lepidopteron pests causing significant loss to the crop yield. This paper gives a consolidated account of lepidopteron pests and their natural bio-control agents associated with vegetable crops in J&K region. The present work, which was based on literature survey and extensive field studies, reveals that as many as 28 species of lepidopteron pests damage vegetable crops in Jammu and Kashmir. It has also been established through this work that 40 natural bio-control agents (parasitoids, predators and pathogens) work against the major lepidopteron pests to suppress their population in vegetable crop fields. This study will be useful in future studies for understanding of lepidopteron pests of this region. It will also be helpful for the studies which aim at planning and devising of Integrated Control of lepidopteron pests in this region.

Keywords: Bio-control, J & K, lepidoptera, pest, parasitoid, vegetables

1. Introduction

The agro-climatic diversity of the J&K and Ladakh vary from sub-tropical in Jammu, temperate in Kashmir and cold arid in Ladakh, which makes it ideal for varied cultivation including that of vegetables (http://www.jkapd.nic.in). Vegetables make up a major portion of the diet of humans in many parts of the world, especially as sources of vitamins, minerals, dietary fiber and dietary minerals [31, 65]. The cultivation of vegetables is an important source of income generation for the farming communities of J&K [55]. However, across the world there are various constraints to the production of vegetables crops, among which insect infestation is prominent ones [47]. Over the years, the crop losses to the tune of 30-40% have been reported, due insect pests in the country [52]. Many of the lepidopteron larvae are serious pests in most of our cultural crops, including vegetables. Butani & Jotwani [25] and Sharma *et al.* [56, 57] have given detailed account of lepidopteron insect pests of vegetable crops in India. The cabbage butterflies - *Pieris brassicae* (Linn.), *P. canidia* (Sparm) and *P. rapae* (Linn) – American boll worm, *Helicoverpa armigera* (Hubner) and diamond back moth, *Plutella xylostella* (Linn.) have been found to be major pests of vegetable crops in different parts of India [23, 25, 42, 52]. In the erstwhile State of J&K, the first attempt to study lepidopterous insect pests on vegetables crops was made by Simmonds & Rao [59] who reported *P. xylostella* (=*P. maculipennis*) (Linn.) on cabbage. Rishi [53] has also studied three important lepidopteron pests on vegetable crops *viz.*, *Agrotis ypsilon* (=*ipsilon*) (Hufnagel), *Pieris rapae* (Linn.) and *Plusia signata* Fabricius. However, a detailed general survey of insect pests damaging vegetable crops, highlighting some lepidopterous pest species, in Kashmir region was carried out by Bhat *et al.* [17], while as, in Ladakh region similar kind of work was done by Pandey *et al.* [49]. A number of other key research papers, published from time to time, pertaining to lepidopteron pests on vegetable crops in J&K, have been given by Anonymous [1], Bhat [9], Bhat *et al.* [20], Bhat & Ahanger [10], Kumar *et al.* [41], Malik *et al.* [43] and Pujabi *et al.* [50].

In different parts of the world, different natural bio-control agents of lepidoptera are known to occur which keep their population in check (at least in un-managed ecosystems). These natural bio-control agents show great promise for the management of the lepidopteron pests under Integrated Control [33]. Therefore, it is important to study and gather comprehensive information about the lepidopteron pests and their natural bio-control agents in this region also. Such studies will be helpful for devising integrated control methods against them.

Pertinently, the present work is a part of that endeavor which aimed to provide updated information of lepidopteron pests and their natural bio-control agents in this region. Based on the literature study, it is established that the major earlier works to study natural bio-control agents (parasitoids, predators and pathogens) of lepidopterous insect pests of vegetable crops from J&K region have been done by Bhat [6, 8]; Bhat & Bhagat [11, 12, 13]; Bhat *et al.* [14, 15,16,18,19, 21]; Bhagat [4]; Shankar *et al.* [55]; Simmonds & Rao [59].

Since these research papers remained scattered in different journals, therefore, there was a dire need to document all such previous works and to present a consolidated account. So, in this paper, all the information is pertaining to lepidopteron insect pests and their natural bio-control agents prevailing in vegetable crops in J&K region, which has been consolidated. The database given in this paper will serve as ready reference and can be helpful in future studies and understanding of lepidopteron pests of this region. It will also be useful in the studies which aim at planning and devising of Integrated Control of lepidopteron pests in this region, particularly through standardization and utilization of natural bio-control agents.

2. Materials and Methods

2.1 Literature survey and preparation of compendium/ checklist of lepidopteron pests

A comprehensive literature survey of all the available published works/ research papers etc., published from time to time pertaining to lepidopteron insects and their natural bio-control agents (parasites and predators) in J&K regions, was done in order to collect the information. Besides consulting previous published papers, the other vital e-resources and abstracting services, particularly, CABI, NISCAIR, AGRI, Biological abstracts, Inflib net, etc., were also consulted for obtaining the required information. After examining said literature, the necessary data, pertaining to lepidopteron pests and their natural bio-control agents was compiled, documented and presented in this paper in the form of a checklist. The lepidopteron pests in this checklist are documented family-wise, with information given on their host-plant range, nature & extent of damage, period of activity, local distribution, natural bio-control agents and authors reporting said pest species and natural bio-control agents.

2.2 Field and Laboratory studies

The data presented in this paper is also based on extensive field surveys of lepidopteron insect pests and their natural bio-control agents (parasites and predators) conducted by the present author over the years from 2007-2018, appended as under:-

2.2.1 Study Area

Regular fortnightly random and extensive field surveys were conducted at 7study sites across the length and breadth of Kashmir Valley viz. Danderkhah in District Srinagar (34.0687° N, 74.7783° E), Zazuna in District Ganderbal (34.2301° N, 74.6854° E), Bugam in District Budgam (33.6911° N, 75.0231° E), Bangidar in District Anantnag (33.7265° N, 75.1443° E), Chaklu in District Baramulla (34.2004° N, 74.3969° E), Sumlar in District Bandipora (34.4111° N, 74.7235° E) and Murran in District Pulwama (33.8664° N, 74.8639° E).

2.2.2 Sampling Method and rearing of pest

The vegetable farms/ vegetable gardens/ kitchen gardens in above cited study areas were surveyed. Three fields at every site were selected randomly and sampling procedure was based on standardized sampling techniques. The field data regarding lepidopteron pests, their host-plant, nature and extent of damage, predators (natural enemy) preying on such pest larvae etc. was recorded in field diary. The immature stages (larvae/ caterpillars/ pupae) of lepidopteron pest were taken to laboratory for rearing in glass / plastic jars for the development of their adults and for the recovery of their parasitoids, if any. The adults emerged were identified and preserved.

3. Results

3.1 Checklist of Lepidopteron insect pests and their natural bio-control agents on vegetable crops in J&K and Ladakh

The lepidopteron pests and their natural bio-control agents, shown in the following checklist, are also highlighted through photographs (Fig. 1-51) in the coming pages. References of authors reporting the pest or its natural enemy have been shown in the square brackets. The Symbols used in the checklist are:- An= Anantnag, Bd.= Badgam, Br.= Baramulla, Bn.= Bandipora, Gn.= Ganderbal, Sr.= Srinagar, Jm.= Jammu, Lad= Ladakh, Kmr.= Kashmir, Nr.= New record, Ref.=References]

I. Family: Crambidae

1. *Evergestis forficalis* (Linnaeus) [Ref.= 10, 17]

Host vegetable plant/s: cabbage, kale, turnip, knol khol
Nature and extent of damage: larvae riddle holes in the leaves
period of activity; pest status; local distribution: June to August; major pest; Bd., Br., Gn., Sr.

2. *Crocidolomia binotalis* Zeller [Ref.=9]

Host vegetable plant/s: kale, cauliflower, cabbage, knol khol, turnip
Nature and extent of damage: larvae feed on leaves and cause leaf webbing
period of activity; pest status; local distribution: August to October; major pest; An., Bd., Bn., Br., Gn., Pl., Sr.

3. *Hellula undalis* (Fabricius) [Ref.= 10, 55]

Host vegetable plant/s: cauliflower, cabbage
Nature and extent of damage: larvae bore into cabbage and cauliflower heads
Period of activity; pest status; local distribution: June-August; major pest; Jm.
Natural bio-control agents / references from J&K:
Parasitoid: (Hymenoptera: Braconidae): *Bracon* sp. [55].

4. *Leucinodes orbonalis* Guenee [Ref.= 10,17]

Host vegetable plant/s: brinjal / egg plant
Nature and extent of damage: caterpillars bore into the shoots and fruits and feed inside them.
period of activity; pest status; local distribution: August and September; moderate pest; Bd., Sr.

5. *Diaphania nitidalis* (Stoll) [Ref.=6]

Host vegetable plant/s: bottle gourd
Nature and extent of damage: larva burrows into bottle gourd fruit and eat it away from inside

period of activity; pest status; local distribution: August – September, minor pest; Gn.

II. Family: Hesperiidae

6. *Parnara guttatus* Bremer & Gray [Ref.=5, 10, 25, 38,56]

Host vegetable plant/s: beans
Nature and extent of damage: caterpillars feed on leaves
period of activity; pest status; local distribution: not known; major pest; Jm., Sr.
Natural bio-control agents: *Apanteles* sp., *Brachymeria* sp. on rice [37].

7. *Pelopidas methias* (Fabricius) [Ref.=2,5,10,51]

Host vegetable plant/s: *Brassica* spp., radish
Nature and extent of damage: larvae feed on leaves
period of activity; pest status; local distribution: not known; major pest; Kmr.

III. Family: Lycaenidae

8. *Lycaena phlaeas* Linnaeus [ref.=7,10]

Host vegetable plant/s: rumex
Nature and extent of damage: larvae feed and bite holes in the leaves.
period of activity; pest status; local distribution: May to September; minor to moderate; Bd.,Gn., Sr.

IV. Family: Lymantridae

9. *Euproctis fraternal* (Moore) [Nr.]

Host vegetable plant/s: brassica plants, kale, turnip, brinjal, potato
Nature and extent of damage: larvae feed and bite holes in the foliage.
period of activity; pest status; local distribution: June-October; minor to moderate; Gn., Sr.

10. *Euproctis* sp. [Ref.=10, 17]

Host vegetable plant/s in J&K: turnip, brinjal, brassica vegetable plants
Nature and extent of damage: larvae feed and bite holes in the foliage.
period of activity; pest status; local distribution: July to September; minor; Bd., Gn.

V. Family: Noctuidae

11. *Agrotis ipsilon* (Hufnagel) [Ref.=1, 10, 17, 22, 28, 39, 46, 53, 64]

Host vegetable plant/s: onion, kale, cauliflower, cabbage, knol khol, capsicum, cucurbits, turnip, potato
Nature and extent of damage pest: larvae cutoff the infested growing plants at the soil surface and also bore into cabbage and cauliflower heads
period of activity; pest status; local distribution: June to August; major polyphagous pest, Kmr.

12. *Plusia signata* Fabricius (=*Argyrogramma signata*) [Ref.=10,17,28,53]

Host vegetable plant/s: mustard, cauliflower, cabbage, knol khol, turnip, pea, tomato, potato, spinach
Nature and extent of damage: polyphagous pest, larvae riddle holes in leaves causing defoliation and also bore into heads of cabbage and cauliflower
period of activity; pest status; local distrib.: May to July; moderate to major; Br., Gn., Sr.; Bd.,

13. *Thysanoplusia orichalcea (=Plusia orichalcea)* (Fabricius) [Ref.=6, 7,10,15, 17, 22,28, 46]

Host vegetable plant/s: onion, kale, cauliflower, cabbage, knol khol, turnip, carrot, mint, beans, pea, rumex, spinach, potato, fenugreek, mallow.
Nature and extent of damage: highly polyphagous pest, larvae riddle holes in leaves causing defoliation and also bore into the heads of cabbage and cauliflower
period of activity; pest status; local distribution: April to August; major pest; entire J&K
Natural bio-control agents / references from J&K:

i) Parasitoids (Hymenoptera: Ichneumonidae) = *Campoletis chlorideae*, *Scambus* sp. and unidentified Ichneumonid [15]
ii) Parasitoids (Hymenoptera: Braconidae) = *Cotesia ruficrus* [15]
iii) Parasitoids (Hymenoptera: Eulophidae) = *Euplectrus ceylonensis* [15]
iv) Predators (Hymenoptera: Vespidae) = *Polistes rothynei*, *Polistes stigma* [6]
v) Predatory birds= Myna [6]

14. *Trichoplusia ni* (Hübner) [8, 10,55]

Host vegetable plant/s: cabbage, knol khol, pea
Nature and extent of damage: larvae riddle holes in leaves and bore into the heads of cabbage and cauliflower
period of activity; pest status; local distribution: May to August; major pest; Bd., Jm., Sr.
Natural bio-control agents / References from J&K:

i) Parasitoids (Hymenoptera: Ichneumonidae) = *Campoletis sp.* [6, 8]
ii) Parasitoids (Diptera: Tachinidae) = *Voria ruralis* [8, 21, 55], *Drino* sp. [6, 21]
iii) Predators (Hymenoptera: Vespidae) = *Polistes rothynei*, *Polistes stigma* [6]
iv) Predatory birds= Myna [new record]

15. *Helicoverpa armigera* (Hubner) (=*Heliothis zea*) [6, 8, 10, 14, 17, 28, 39, 55]

Host vegetable plant/s: mountain spinach, kale, cauliflower, knol khol, cucurbits (bottle gourd, red pumpkin, bitter gourd, squash, cucumber, pepo), tomato, mint, pea, potato, mallow, spinach.
Nature and extent of damage: polyphagous destructive pest, larvae feed on the tender foliage, flower buds (squash) and bore into the heads (cauliflower, cabbage) and fruits (tomato) to eat away the inner contents.
period of activity; pest status; local distribution: May to August; major pest; entire J&K
Natural bio-control agents / references from J&K:

i) Parasitoids (Hymenoptera: Ichneumonidae) = *Charops bicolor*, *Campoletis chlorideae*, *Eriborus* sp., *Diadegma fenestralis* [14]; *Diadegma semiclausum* [8]
ii) Parasitoids (Hymenoptera: Braconidae) = *Cotesia* sp., *Microplitis* sp. [14]; *Bracon* sp. [55]; *Bracon hebator* [21]
iii) Parasitoids (Hymenoptera: Eulophidae) = *Euplectrus euplexae* [14]
iv) Parasitoids (Hymenoptera: Trichogrammatidae) = *Trichograma* sp. [14]
v) Parasitoids (Diptera: Tachinidae) = *Voria ruralis* [8, 55]; *Exorista* sp. [14, 21]
vi) Predators (Hymenoptera: Vespidae) = *Polistes rothynei*, *Polistes stigma* [6]
vii) Predators (Neuroptera : Chrysoperlidae)= *Chrysopa*

carnea [14]
viii) Predator (Hemiptera: Nebidae) = *Nebis* sp. [14]
ix) Predatory birds= Myna

16. *Spodoptera litura* (Fabricius) [Ref.=8, 10, 13, 18, 55]
Host vegetable plant/s: onion, kale, cauliflower, cabbage, knol khol, pea
Nature and extent of damage: defoliation of plants and in onion they feed from inside the shoot.
period of activity; pest status; local distribution: June to August; major; Bd., Br., Gn., Jm., Sr.
Natural bio-control agents / references from J&K:
i) Parasitoids (Hymenoptera: Braconidae) = *Zele chloraphthalama* [13, 18, 21]

17. *Spodoptera exigua* Hubner [Ref.=8,10,55]
Host vegetable plant/s in J&K: brassica crops, onion, garlic
Nature and extent of damage: larvae cause defoliation of plants and in onion they bore into shoots.
period of activity; pest status; local distribution: June to August; major; Bd., Br., Gn., Jm., Sr.

18. *Mamestra brassicae* (Linn.) [Ref.=8, 10, 20]
Host vegetable plant/s: kale, knoll khol
Nature and extent of damage: larvae cause defoliation of plants and in onion they bore into shoots.
period of activity; pest status; local distribution: June to Oct.; moderate to major; Bd., Bn., Gn., Sr.

VI. Family: Nymphalidae

19. *Vanessa cardui* (Linnaeus) (=*Cynthia cardui*) [Ref.=69]
Host vegetable plant/s: *Brassica* sp.
Nature and extent of damage: larvae cause defoliation of plant
period of activity; pest status; local distribution: not known; minor; Sr.

VII. Family: Pieridae

20. *Pieris brassicae* (Linnaeus) [Ref.=5, 8,5, 10, 15, 17, 19, 21, 27, 28, 34, 45,49, 53, 55]
Host vegetable plant/s: mustard, cabbage, cauliflower, kale, knoll khol, turnip, radish and other brassica crops
Nature and extent of damage: younger larvae scrap the leaf surface while as older ones riddle the leaves causing skeletonizaton and death of plant in severe infestation
period of activity; pest status; local distribution: April to October; major pest; entire J&K
Natural bio-control agents / References from J&K:
i) Parasitoids (Hymenoptera: Ichneumonidae) = *Hyposoter ebininus* [8, 12, 21, 16]; *Pimpla* sp. [16, 21]
ii) Parasitoids (Hymenoptera: Braconidae) = *Cotesia glomerata* [8, 16, 21, 55]
iii) Parasitoids (Hymenoptera: Chalcididae) = *Brachymeria* sp. [16, 21]
iv) Parasitoids (Hymenoptera: Pteromelidae) = *Pteromelus puparum* [16, 8, 21]
v) Parasitoids (Diptera: Tachinidae) = *Compsilura concinnata* [8, 19, 21]; *Exorista larvarum* [8, 21, 19]; *Phryxe vulgaris* [8, 55]
vi) Predators (Hymenoptera: Vespidae) = *Polistes rothynei* [6, 16], *Polistes stigma* [6, 16]
vii) Predators (Hymenoptera: Formicidae): *Myrmica* sp. [6, 16]
viii) Predatory birds= Myna [new record]
ix) Pathogen= Granulosis virus [40]

21. *Pieris brassicae kashmirensis* Rishi [Ref.=5, 10, 53]
Host vegetable plant/s: *Brassicas* spp., *Brassica juncea*
Nature and extent of damage: younger larvae scrap the leaf surface while as older ones riddle the leaves causing skeltonizaton and death of plant in severe infestation
Period of activity; pest status; local distribution: April to October; major pest; Kmr.

22. *Pieris canidia* (Sparm) [Ref.=3, 5, 10, 22, 24, 51]
Host vegetable plant/s: cauliflower, cabage, knol khol, radish
Nature and extent of damage: larvae cause defoliation and skeltonization of leaves
Period of activity; pest status; local distribution: April to September; minor to moderate; Kmr.

23. *Pieris rapae* (Linnaeus) [Ref.=5, 8, 10,12, 17, 21, 22, 28, 48, 49, 55, 62]
Host vegetable plant/s in J&K: kale, cabbage, knol khol, turnip and mustard
Nature and extent of damage: larvae feed next to veins or the midrib on the underside of the leaves and chew out irregular holes in them
period of activity; pest status; local distribution: April to November; moderate; entire J&K
Natural bio-control agents / References from J&K:
i) Parasitoids (Hymenoptera: Ichneumonidae) = *Hyposoter ebininus* [8, 6, 21]
ii) Parasitoids (Hymenoptera: Braconidae) = *Cotesia glomerata* [8, 6, 21]
iii) Parasitoids (Hymenoptera: Chalcididae) = *Brachymeria femorata* [8, 6, 21]
iv) Parasitoids (Diptera: Tachinidae) = *Phryxe vulgaris* [55]

24. *Pontia daplidice* (Linnaeus) [Ref.=5, 8, 10, 12, 17, 24, 28, 44, 51, 62, 63]
Host vegetable plant/s: kale, cauliflower, knol khol, mustard, turnip, radish, sugar beet
Nature and extent of damage: larvae bite holes into the leaves and are more damaging to young plans
period of activity; pest status; local distribution: May to October; minor to moderate; Kmr.
Natural bio-control agents:
i) Parasitoid (Hymenoptera: Ichneumonidae) = *Hyposoter ebininus* [8, 16, 21]

25. *Pontia glouconome* (Klug) [Ref.=8, 22, 10]
Host vegetable plant/s: cabbage, cauliflower
Nature and extent of damage: larvae cause defoliation and skeltonization of plant
period of activity; pest status; local distribution: April to September; minor to moderate; Kmr.

VIII. Family : Plutellidae

26. *Plutella xylostella* (Linnaeus) [Ref.=8, 10, 11, 17, 22, 55, 59]
Host vegetable plant/s: kale, cauliflower, mustard, cabbage, knoll khol, turnip, radish
Nature and extent of damage: larvae feed by scrapping the epidermal leaf tissues and creating holes, and also damage the buds.
period of activity; pest status; local distribution: April to August; major pest; entire J&K
Natural bio-control agents / References from J&K:

i) Parasitoids (Hymenoptera: Ichneumonidae) = *Diadegma fenestrale* [11, 21]; *D. semiclausum* [8]; *Horogenes* sp. [59]; *Itoplectis* nr. *himalayanensis* [11, 21]; *Itoplectis* sp. [8].
ii) Parasitoids (Hymenoptera: Braconidae) = *Cotesia plutellae* [8, 11, 21, 55]; *Apanteles* sp. [8, 11, 21].
iii) Parasitoids (Hymenoptera: Eulophidae) = *Tertrastichus sokolowskii* [8, 11, 21]
iv) Parasitoids (Diptera: Tachinidae) = *Voria ruralis* (Tachinidae: Diptera) [6, 21, 59]

IX. Family : Pyralidae

27. *Etiella zinckenella* (Treitschke) [10, 49]

Host vegetable plant/s: vegetable crops, *P. sativum*, *P. vulgaris*
Nature and extent of damage: pod borer
period of activity; pest status; local distribution: not known; major; Lad.

28. *Euzophera perticella* Zeller [10, 22, 60]

Host vegetable plant/s: brinjal, tomato, potato
Nature and extent of damage: shoot borer
period of activity; pest status; local distribution: April-August; moderate to major; Jm., Kmr.

3.2 Types of host Vegetable host- plants of Lepidopteran Insect pests of J&K (as shown in checklist)

As per the above checklist, as many as 30 species of vegetable host plants, belonging to 10 plant families are infested by Insect pests in J&K. The family wise botanical names of these vegetable plant species are encapsulated as under, with respective common name given in small brackets:-
Family 1, Alliaceae: *Allium cepa* L. (onion); *Allium sativum* L. (garlic) Family 2, Apiaceae: *Raphanus sativus* L. (radish) Family 3, Brassicacea: *Brassica campestris* L. (mustard); *Brassica juncea* L. (brown Mustard); *Brassica napus* L. (rape); *Brassica* spp./ cole crops; *Brassica oleracea* L. and its varieties, *viz.* B. *o. var. acephala* (Kale); *B. o. var. botyrtis* (Cauliflower); *B. o. var. capitata* (Cabbage); *B. o. var. gongylodes* (knol-khol); *B. o. var. kashmiriana*; *Brassica rapa* L. (turnip); Family 4, Chenopodiacea: *Atriplex hortensis* L. (mountain spinach); *Spinacea oleracea* L. (spinach); Family 5, Cucurbitacea: Cucurbits, *Cucurbita maxima* Duchesne (Red gourd/ Red pumpkin); *Cucurbita moschata* Duchesne. (Squash); *Cucurbita pepo*; *Cucumis sativus* L. (cucumber), *Cucumis* sp. (gourds); *Lagenaria siceraria* (Mol.) Standl (bottle gourd); *Momordica charantia* Linn. (Bitter gourd); Family 6, Fabaceae: *Pisum sativum* (garden pea); *Phaseolus vulgaris* (French beans), *Trigonella foenum-graecum* L. (Fenugreek); Family 7, Lamiaceae: *Mentha arvensis* Linn. (Field mint); Family 8, Malvaceae: *Malva sylvestris* L. (mallow); Family 9, Polygonaceae: *Rumex acetosa* Linn. (Common Garden Sorrel); *Rumex nepalensis* Spreng (Rumex); Family 10, Solanaceae: *Lycopersicon esculentum* Mill (Tomato); *Solanum melongena* Linn. (brinjal/ egg plant); *Solanum tuberosum* Linn. (potato)

3.3 Family wise-common names of Lepidopteran Insect pests of Vegetable crops reported in J&K (as shown in checklist)

The family-wise scientific and common names of lepidopteran insect pests documented in the above checklist are given as under:- Family 1. Crambidae: *Crocidolomia binotalis* Zeller (Leaf webber), *Evergestis forficalis* (Linnaeus) (Garden Pebble Moth), *Leucinodes orbonalis* Guenée (brinjal fruit and shoot borer), *Hellula undalis* (Fabricius) cabbage Borer/ Oriental cabbage webworm; Family 2. Hesperiidae: *Parnara guttatus* Bremer & Gray (Common Straight Swift); *Pelopidas methias* (Fabricius) (Variable Swift); Family 3. Lycaenidae: *Lycaena phlaeas* Linnaeus (Common Copper); Family 4: Lymantridae: *Euproctis* sp., *Euproctis fraternal* (Moore); Family 5. Noctuidae: *Agrotis ipsilon* (Hufnagel); *Argyrogramma signata* Fabricius (=*Plusia signata*); *Thysanoplusia orichalcea* (=*Plusia orichalcea*) (Fabricius) slender burnished brass (P73); *Helicoverpa armigera* (Hubner) (=*Heliothis zea*) cotton bollworm, corn earworm; *Spodoptera litura* (Fabricius) tobacco cutworm or cotton leaf worm; *Spodoptera exigua*; *Mamestra brassicae* (Linn.) Cabbage Moth; *Trichoplusia ni* (Looper); Family 6: Pieridae (Cabbage butterflies): *Pieris brassicae* (Linnaeus) (Large cabbage butterfly); *Pieris brassicae kashmirensis* Rishi (Large cabbage butterfly); *Pieris canidia* (Linnaeus) (Indian Cabbage White); *Pieris rapae* (Linnaeus) (Small white butterfly/ cabbage leaf web worm); *Pontia daplidice* (Linnaeus) (Bath White) (P83); *Pontia glouconome* (Klug) desert (Bath) white; Family 7: Plutellidae: *Plutella xylostella* (Linnaeus) diamondback moth; Family 8: Pyralidae: *Etiella zinckenella* (Treitschke) (Pod borer); *Euzophera perticella* Zeller (shoot borer).

3.4

Table 1: Number of families, genera and species of Lepidopteron pests of vegetable crops in J&K

S. No.	Name of Lepidopteron Family	No. of genera	No. of species
1	Crambidae	5	5
2	Hesperiidae	2	2
3	Lycaenidae	1	1
4	Lymantridae	1	2
5	Noctuidae	7	8
6	Nymphalidae	1	1
7	Pieridae	2	6
8	Plutellidae	1	1
9	Pyralidae	2	2
Total		22	28

3.5 Pictoral key to Lepidopteran pests and their bio-control agents in vegetable crops in J&K



Fig. 1 **Fig. 2** **Fig.3**



Fig. 4 **Fig. 5** **Fig. 6**



Fig. 7 **Fig. 8** **Fig. 9**



Fig. 10 **Fig. 11** **Fig .12**



Fig. 13 **Fig. 14** **Fig. 15**



Fig. 16 **Fig. 17** **Fig. 18**

Fig. 19

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Fig. 33

Fig.40 Fig. 41

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Fig. 40

Fig. 41

Fig. 42

Fig. 43

Fig. 44

Fig. 45

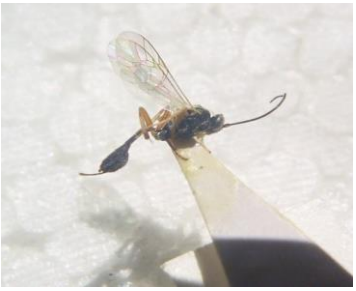

Fig. 46

Fig. 47

Fig. 48

Fig. 49

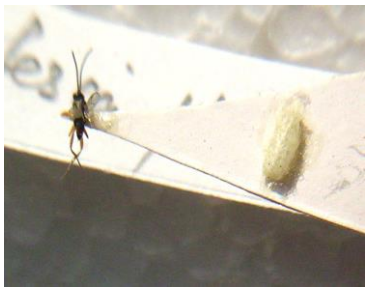

Fig. 50

Fig. 51

Legends of Figures

Fig 1: *Thysanoplusia orichalcea* feeding on knol khol
Fig 2, 4, 21, 37, 38: *Helicoverpa armigera* larval infestation on vegetable plants
Fig 3: Parasitoid pupa with *H. armigera* larva
Fig 5, 6: Infestation of *Agrotis ipsilon* larva on cabbage
Fig 6: *Agrotis ipsilon* larva feeding inside cabbage head
Fig 7: *Spodoptera exigua* larva feeding on brassica vegetable plant
Fig 8: *Diaphania nitidalis* larva feeding inside bottle gourd
Fig 9: *Leucinodes orbonalis* larva feeding inside brinjal
Fig 10: *Pieris gluconome* feeding on sugar beet plant
Fig 11, 25, 28, 29, 34: *Crocidolomia binotalis* larva feeding on brassica vegetable plant
Fig 12: *Euproctis* sp. feeding on knoll khol
Fig 13, 19, 36: *Pieris brassicae* larval infestation on brassica vegetables
Fig 14, 15, 22, and 27: *M. brassicae* larval infestation on brassica plant
Fig 16: Unidentified lepidopteron larva on cucurbits
Fig 17: Pupa of parasitoid *Campoletis chlorideae* recovered on cauliflower field from fields
Fig 18: *Plutella xylostella* larva feeding on brassica plant
Fig 20, 30: *Pieris rapae* larva feeding on turnip plant
Fig 23, 24: Larvae of *Lycaena phlaeas* on *Rumex*
Fig 26: Knol khol plant completely damaged by *Mamestra brassicae*
Fig 31: Infestation of *Spodoptera litura* on onion
Fig 32: unidentified larva feeding on brassica vegetable plant
Fig 33: Larva of *Pontia daplidice* feeding on kale plant
Fig 35: larva with parasitoid pupa attached
Fig 39: unidentified lepidopteron larva feeding on knol khol
Fig 40: Thysanaplusia orichalcea larvae recovered from fields
Fig 41: predator, *Chrysoperla* larva feeding on larva of *H. armigera* on potato plant
Fig 42: Predatory wasp, *Polistes* preying on *P. brassicae* larva on knolkhol
Fig 43: Pupa and Adult of parasitoid, *Zele chloraphthalama* recovered from *Spodoptera* larva
Fig 44: Pupa adult of parasitoid, *Hyposoter ebininus* recovered from *Pieris brassicae* and *P. rapae*
Fig 45: *Brachymeria femorata* adult parasitoid recovered from pupa of *P. rapae*
Fig 46: Adult of parasitoid, *Campoletis chlorideae*
Fig 47, 48: Parasitoid, *Euplectrus ceylonensis* recovered from *Thysanaplusia orchalcea*
Fig 49: Pupae and adult of parasitoid *Cotesia glomerata* recovered from *Pieris rapae*
Fig 50: Pupa & adult of parasitoid, *Cotesia plutellae* recovered from *P. xylostella*
Fig 51: Adult parasitoid, *Scambus* sp. recovered from *T. orichalcea*
(Photograph Credit: - Bhat Deen Mohd, 2007-2018)

4. Discussion

As highlighted in the introductory section insect pests are the major biotic constraints to vegetables production and lepidopteron insects cause serious damage to the vegetable crops of this region. The above given checklist reveals that as many as 28 species of lepidoptera damage vegetable crops in J&K region. These species belong to 9 families and 22 genera of order lepidoptera. A total of 40 natural bio-control agents including 33 parasitoids, 3 predators and 1 pathogen of these pest species have also been documented in this compendium. The parasitoid species covered in the present study belong to 11 species of family ichneumonidae, 9 species of braconidae, 2 species of chalcididae, 3 species of eulophidae and 1 species each of pteromelidae and trichogrammatidae under the order hymenoptera and 6 species of family tachinidae under the order diptera. Moreover, 5 insect predatory species have also been documented that include 3 species of order hymenoptera, 1 species each of orders hemiptera and neuroptera. Apart from this, 1 predatory bird species, and 1 virus have also been documented among natural bio-control agents of the lepidopteron pests on vegetable crops in the present compendium. The above checklist also reveals that, *Pieris brassicae, Thysanaplusia orichalcea, Helicoverpa armigera, Plutella xylostella* and *Agrotis ipsilon* are the most destructive pests in this region. Firake *et al*. [32] have also observed *P. brassicae* and *P. xylostella* as the major pest in North East (India). Devi & Raj [30] during their study in Himachal Pradesh have witnessed the diamondback moth (DBM), *P. xylostella* as an important pest of cruciferous crops, particularly on cabbage and cauliflower. The cabbage

butterflies, *P. brassicae, P. canidia* and *P. rapae* have also been reported as major pests of cabbage and cauliflower in other Indian states (Bhatia & Verma [23], Butani & Jotwani [25]). Further, Capinara [26] in his treatise has also reported afore said lepidopteron species as serious pests of vegetable crops. Hoffmann *et al*. [33] in their study have also revealed similar results and have reported above mentioned lepidopteron species as common pests of vegetable crops in Australia. It has also been established through above cited checklist that there are some natural bio-control agents occurring against some destructive pests in J&K region. Many of the natural bio-control agents of lepidoptera documented in this paper also occur in different parts of the world as reported by Razmi *et al.* [66], Shepard & Barrion [67] and Patriche *et al.* [68]. The present study is in line with the studies done by afore-mentioned authors in other parts of the world.

5. Conclusion

It is concluded that there are a number of destructive lepidopteron pest species which cause economic loss to the vegetable growers in J&K region. Therefore, it is important to gain sufficient knowledge about these pests and their natural bio-control agents, so as to plan their effective control through integrated pest control methods. The current study has provided an insight of the type of lepidopteron pest species prevailing in the vegetable ecosystems of this region. Further, valuable information regarding the type of natural bio-control agents of said pests, in J&K region has also been updated. Since, a complete knowledge of insect pests is crucial for formulating proper management strategies and the present study in this connection will be helpful in the long run for understanding insect pest problems and for devising pest management strategies against them, especially in vegetable ecosystems of this region. The data provided in this study would also be helpful in further understanding of the biodiversity of arthropod fauna associated with vegetable ecosystems in this region. This study will be helpful for vegetable growers and agriculturists in general and for agricultural entomologists in particular.

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