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Lepidopteron insect pests and their natural enemies in vegetable ecosystems of Jammu, Kashmir and Ladakh, India- A review

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Article published on April 30, 2020

Key words: J & K, Lepidoptera, Parasitoid, Pest, Vegetables

Abstract

The present Compendium provides a review and updated account of 26 Lepidopteron insect pests associated with various vegetable crops in the Union Territories of Jammu & Kashmir (J&K) and Ladakh, India. The compendium is based on both literature survey and field surveys conducted by present author during the years 2007-2018. The pest species recorded in this compendium belong to 8 families and 20 genera of Order Lepidoptera. A total of 40 natural enemies including 33 parasitoids, 3 predators and 1 pathogen of these lepidopteron species have also been documented in this compendium. Apart from this, a comprehensive account of host-plant range, nature & extent of damage, seasonal occurrence and local distribution of afore-mentioned lepidopteron pests has been given in this work. The compendium will act as a ready reference, for future studies of these lepidopteron pests and their management under integrated pest control in this region.

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Introduction

Vegetables make up a major portion of the diet of humans in many parts of the world, especially as sources of vitamins (C, A, B1, B6, B9, E, A, K), minerals, dietary fiber, dietary minerals and carbohydrates (Zim & Cottam, 1987; Dias, 2012). 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>). The cultivation of vegetables is an important source of income generation for the farming communities of J&K (Shankar *et al.*, 2016). However, despite the importance of these crops, there are various constraints to their production which include high cost of inputs, transportation, accessibility to market, insect infestation and disease problems (Olaniran *et al.*, 2014). Insect pests not only inflict direct damage to host crops, but also many of them act as vectors for several viral diseases and it has been established that they reduce the quality and/or quantity of yield (Olaniran *et al.*, 2014; Imam *et al.*, 2010). Over the years, the crop losses to the tune of 30-40% have been reported, due insect pest in the country (Rai *et al.*, 2014). Many of the Lepidopteron larvae are considered serious pests in most of our cultural crops, including vegetables, due to their polyphagous feeding behavior. A comprehensive account of lepidopteron insect pests of vegetable crops in India has been given by Butani & Jotwani (1984) and Sharma *et al.* (2008). Under the order Lepidoptera, various insects have been reported as serious pests of vegetable crops in India. The cabbage butterflies, *Pieris brassicae* (Linn.), *P. canidia* (Sparm) and *P. rapae* (Linn) have been found to be major pests of cabbage and cauliflower (Batia & Verma, 1993; Butani & Jotwani, 1984; Firake *et al.*, 2012; Lal, 1975). *Plutella xylostella* (Linn.) is considered an important pest of cruciferous crops, particularly cabbage and cauliflower (Devi & Raj, 1995). *Helicoverpa armigera* (Hubner) is also highly prevalent and polyphagous pest of crops in the entire country (Rai *et al.*, 2014).

In the State of J&K, the first major attempt to study Lepidopteron insect pests on vegetable crops was made by Simmonds & Rao (1960) who reported *P. xylostella* (= *maculipennis*) (Linn.) on cabbage. Rishi (1967) studied some important lepidopteron pests on vegetable crops *viz.*, greasy cut worm, *Agrotis ypsilon* (= *ippsilon*) (Hufnagel), cabbage butterfly, *Pieris rapae* (Linn.) and cabbage semilooper, *Plusia signata* Fabricius. A detailed general survey of insect pests damaging vegetable crops, highlighting some lepidopteron pests, in Kashmir region was carried out by Bhat *et al.* (2011), while as in Ladakh region similar kind of work was done by Pandey *et al.* (2006). A number of other key research papers published in this regard, pertaining to J&K State are : Pujabi *et al.* (1970), Malik *et al.* 1972, Anonymous (1975), Kumar *et al.*, (2006), Bhat (2008a), Bhat & Bhagat (2016) and Bhat & Ahanger (2018).

Various natural enemies lepidopteron pests have been reported across the world that are considered to keep their host population in check, at least, in un managed, vegetable ecosystems, and they show great promise as biological control agents for the management of these pests under Integrated Control (Hopman *et al.*, 2004). Therefore, it was important to study and gather enough information about the lepidopteron pests and their natural enemies in this region too in order to devise such integrated control measures against them. The first reported natural enemy of lepidopteron pest of vegetable from this region has been given by Simmonds & Rao (1960). Bhagat (2008) has also documented some parasites (natural enemies) of *P. xylostella* Linn. on cabbage in his treatise. Some other attempts made to study natural enemies (parasitoids, predators and pathogens) of Lepidopteron insect pests of vegetable crops from J&K region have been made by Bhat (2008), Bhat & Bhagat (2008), Bhat & Bhagat (2009 and 2009a), Bhat *et al.* (2009); Bhat *et al.* (2010 and 2010a), Bhat *et al.* (2011), Bhat *et al.* (2013), Bhat *et al.* (2017), Shankar *et al.* (2016) and Bhat (2018).

Since these research papers, and other literature carrying relevant information pertaining to

Lepidopteron insect pests and their natural enemies, remained scattered in different journals, therefore, there was a dire need to document all such previous works and to present a consolidated compendium/checklist of Lepidopteron insect pests (covering their host-vegetable plant range, seasonal occurrence, nature and extent of damage, local distribution) and their natural enemies in respect of vegetable crops from J&K and Ladakh region. This compendium summarized previously published information and present original data of lepidopteron pests and their natural enemies in vegetable ecosystems of J&K and Ladakh. The database provided in this paper will serve as ready references and can be helpful in future studies of lepidopteron insect pests and their natural enemies. The data provided here will be helpful in future studies for devising the pest management strategies, especially through utilization of natural enemies as bio-control agents, to facilitate any integrated control program in vegetable eco-systems in this region.

Materials and methods

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 enemies (parasites and predators) in J&K and Ladakh regions, was done in order to obtain valuable 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 enemies, was compiled and a data base was generated. Accordingly all such collected data was documented and presented in this paper in the form of a compendium/checklist. The lepidopteron pests in this compendium are documented family-wise & systematically, covering various aspects like their host-plant range, nature & extent of damage, period of activity, local distribution, natural enemies and authors reporting said pest species and natural enemies.

Field and Laboratory studies

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

Study Area

Regular fortnightly random and extensive field surveys were conducted at 7 study 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).

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.

Results

The Compendium (based on literature survey and field study by present author) provides a review and updated checklist/compendium of Lepidopteron insect pests and their natural enemies from the Union Territories of J&K and Ladakh.

The present study deals with 26 species of Lepidoptera reported as pests on various vegetable crops from these areas. These pest species belong to 8 families and 20 genera of Order Lepidoptera (Table 1.). A total of 40 natural enemies 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 Pteromalidae 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 enemies of the lepidopteron pests on vegetable crops in the present compendium. A detailed checklist of above mentioned 26 pest species of Lepidoptera in J&K, along with the information about their taxonomic position under families, host-vegetable plant range, nature and extent of damage, seasonal occurrence (period of activity), local distribution, natural enemies and authors reporting (both the pest and its natural enemies), is given as below. The authors reporting the pest or its natural enemy have been shown in the parentheses and square brackets respectively.

Table 1. Number of families, genera and species of lepidopteron pests of vegetable crops in Kashmir.

SN	Name of Lepidopteron Family	No. of genera	No. of species
1	Crambidae	4	4
2	Hesperiidae	2	2
3	Lycaenidae	1	1
4	Lymantridae	1	2
5	Noctuidae	7	8
6	Pieridae	2	6
7	Plutellidae	1	1
8	Pyralidae	2	2
Total		20	26

Checklist/Compendium

I. Family: Crambidae

1. *Evergestis forficalis* (Linnaeus)

Host vegetable plant/s: *Brassica oleracea*, *Brassica oleracea* var. *acephala*, *B. o.* var. *capitata*, *B. o.* var. *gongyloides*, *Brassica rapa*.

Nature & Extent of Damage: It is a leaf feeder. The caterpillars feed on all tender plant parts but prefer terminal buds and leaves. Young leaves and buds are often riddled with holes

Period of activity: June to August

Pest status: Major

Local Distribution: Baramulla, Badgam, Ganderbal, Srinagar

Authors reporting the pest from J&K: Bhat *et al.*, 2011; Bhat, 2018a; Bhat & Ahanger, 2018

Natural enemies: Not known

2. *Crociodolomia binotalis* Zeller

Host vegetable plant/s: *B. o.* var. *acephala*, *B. o.* var. *botrytis*, *B. o.* var. *capitata*, *B. o.* var. *gongyloides*, *B. rapa*.

Nature & Extent of Damage: it is a leaf webber. The caterpillars were observed webbing the foliage and feeding on the leaves of the host crops.

Period of activity: The peak period of pest activity recorded during the months from August to October

Pest status: Major

Local Distribution: Anantnag, Badgam, Bandipora, Baramulla, Ganderbal, Pulwama and Srinagar

Authors reporting the pest from J&K: Bhat, 2018b

Natural enemies: Not Known

3. *Hellula undalis* (Fabricius)

Host vegetable plant/s: *B. o.* var. *botrytis*, *B. o.* var. *capitata*,

Nature & Extent of Damage: cabbage head borer

Period of activity: June- August

Pest status: Major

Local Distribution: Srinagar, Jammu

Authors reporting the pest from J&K: Shankar *et al.*, 2016; Bhat, 2018a

Natural enemies/Biological Control & Authors reporting:

Parasitoid : *Bracon* sp. (Hymenoptera: Braconidae) [Shankar *et al.*, 2016]

4. *Leucinodes orbonalis* Guenee

Host vegetable plant/s: *Solanum melongena*

Nature & Extent of Damage: The caterpillars bore into the shoots and fruits, form narrow tunnels and feed inside them causing serious damage. Boring holes visible externally in fruits

Period of activity: Peak period of activity in August & September

Pest status: Moderate

Local Distribution: Badgam, Srinagar

Authors reporting the pest from J&K: Bhat *et al.*, 2011; Bhat & Ahanger, 2018

Natural enemies in J&K: Not Known

II. Family: Hesperidae

1. *Parnara guttatus* Bremer & Gray

Host vegetable plant/s: *Phaseolus vulgaris*

Nature & Extent of Damage: Leaf feeding caterpillars

Period of activity: Not known

Pest status: Major

Local Distribution: Srinagar, Jammu, Srinagar

Authors reporting the pest from J&K: Butani & Jotwani, 1984; Kaul & Kesar, 2003; Sharma & Ramamurthy, 2009; Bhagat, 2017; Bhat & Ahanger 2018

Natural enemies: *Apanteles* sp., *Brachymeria* sp. on rice [Jamal & Zaki, 2008]

2. *Pelopidas methias* (Fabricius)

Host vegetable plant/s: *Brassica* spp., *Raphanus sativus*

Nature & Extent of Damage: leaf feeder

Period of activity: Not known

Pest status: Major

Local Distribution: Kashmir

Authors reporting the pest from J&K: Atwal & Dhaliwal, 1999; Qureshi *et al.*, 2013; Bhagat, 2017; Bhat & Ahanger 2018

Natural enemies: Not known

III. Family: Lycaenidae

3. *Lycaena phlaeas* Linnaeus

Host vegetable plant/s: *Rumex acetosa*

Nature & Extent of Damage: Larvae leaf feeder, biting holes in leaves

Period of activity: May to September

Pest status in J&K: Minor to moderate

Local Distribution in J&K: Ganderbal, Srinagar and Budgam

Authors reporting the pest from J&K: Bhat, 2017; Bhat & Ahanger 2018

Natural enemies: Not known

IV. Family: Lymantridae

4. *Euproctis fraternal* (Moore)

Host vegetable plant/s in J&K: *B. o. var. acephala*, *B. rapa*, *Solanum melongena*, *S. tuberosum*

Nature & Extent of Damage: Larvae feed on the foliage biting holes

Period of activity in J&K: June- October

Pest status in J&K: Minor to moderate

Local Distribution in J&K: Ganderbal, Srinagar

Authors reporting the pest from J&K: New record from Kashmir

Natural enemies: Not known

5. *Euproctis* sp.

Host vegetable plant/s in J&K: *Brassica rapa* , *Solanum melongena*

Nature & Extent of Damage: Larvae feed on the foliage biting holes

Period of activity in J&K: July to September

Pest status in J&K: Minor

Local Distribution in J&K: Ganderbal, Badgam

Authors reporting the pest from J&K: Bhat *et al.*, 2011, Bhat & Ahanger 2018

Natural enemies in J&K: Not known

IV. Family: Noctuidae

6. *Agrotis ipsilon* (Hufnagel)

Host vegetable plant/s in J&K: Allium cepa , B. o. var. acephala, B. o. var. botryrtis, B. o. var. capitata, B.o. var. gongylodes, Capsicum annum, Cucurbita maxima, C. pepo, Brassica rapa, Solanum tuberosum

Nature & Extent of Damage: The growing plants are cut off at the soil surface. The larvae also feed on the leaves and enter into the cabbage and cauliflower heads during day time and feed inside them

Period of activity in J&K: June to August

Pest status in J&K: Polyphagous Major Pest

Local Distribution in J&K: Badgam, Srinagar, Ganderbal

Authors reporting the pest from J&K: Rishi, 1967; Anonymous, 1975; Zaki & Masoodi, 1990; Dar *et al.*, 2002; Bhat *et al.*, 2011, Kriti *et al.*, 2014; Munib *et al.*, 2016; Bhat, 2018a; Bhat & Ahanger, 2018

Natural enemies: Not known

7. *Plusia signata* Fabricius (= *Argyrogramma signata*)

Host vegetable plant/s: B. compestris, B. o. var. botryrtis , B. o. var. capitata , B. o. var. gongylodes , Brassica rapa , Pisum sativum , Lycopersicon esculentum , S. tuberosum , Spinacea oleracea

Nature & Extent of Damage: Polyphagous pest of vegetable crops. It feeds on foliage, and cause defoliation in severe infestation. Leaves are riddled with large holes. They also bore into the heads of cabbage and cauliflower

Period of activity: May to July Abundant in May & June

Pest status: Polyphagous Moderate to major pest

Local Distribution in J&K: Baramulla, Badgam, Srinagar, Ganderbal

Authors reporting the pest from J&K: Rishi, 1967; Dar *et al.*, 2002; Bhat *et al.*, 2011, Bhat & Ahanger 2018

Natural enemies: Not known

10. *Thysanoplusia orichalcea* (= *Plusia orichalcea*) (Fabricius)

Host vegetable plant/s: Allium cepa , B. o. var. acephala, B. o. var. botyrtis, B. o. var. capitata, B. o. var. gongylodes, Brassica rapa, Daucus carota,

Mentha arvensis, Phaseolus vulgaris, Pisum sativum, Rumex acetosa, R. nepalensis , Spinacea oleracea, S. tuberosum, T. foenum-graecum, Malva sylvestris

Nature & Extent of Damage: Polyphagous pest of vegetable crops. It feeds on foliage, and cause defoliation in severe infestation. Leaves are riddled with large holes. They also bore into the heads of cabbage and cauliflower

Period of activity: April to August

Pest status: Polyphagous Major pest

Local Distribution in J&K: Throughout J&K

Authors reporting the pest from J&K: Dar *et al.*, 2002; Bhat, 2008; Bhat *et al.*, 2010; Bhat *et al.*, 2011; Munib *et al.*, 2016; Bhat, 2017; Bhat, 2018a; Bhat & Ahanger, 2018

Natural enemies/Biological Control & Authors reporting:

(i). Parasitoids (Hymenoptera: Ichneumonidae) = *Campoletis chlorideae, Scambus* sp. and unidentified Ichneumonid [Bhat *et al.*, 2010]

(ii). Parasitoids (Hymenoptera: Braconidae) = *Cotesia ruficrus* [Bhat *et al.*, 2010]

(iii) Parasitoids (Hymenoptera: Eulophidae)= *Euplectrus ceylonensis* [Bhat *et al.* , 2010]

(iv). Predators (Hymenoptera :Vespidae) = *Polistes rothyni, Polistes stigma* [Bhat, 2008]

(v). Predatory birds= Myna [New record]

11. *Trichoplusia ni* (Hübner)

Host vegetable plant/s: B. o. var. capitata , B. o. var. gongylodes , P. sativum

Nature & Extent of Damage: larvae riddle holes in leaves. They also bore into the heads of cabbage and cauliflower

Period of activity in J&K: May to August

Pest status in J&K: Major pest

Local Distribution in J&K: Jammu, Srinagar, Budgam

Authors reporting the pest from J&K: Shankar *et al.* 2016; Bhat, 2018, Bhat & Ahanger, 2018

Natural enemies/Biological Control & Authors reporting:

(i). Parasitoids (Hymenoptera: Ichneumonidae) = *Campoletis* sp. [Bhat, 2008; Bhat 2018]

(ii). Parasitoids (Diptera: Tachinidae) = *Voria ruralis* [Shankar et al., 2016; Bhat et al., 2017; Bhat, 2018]; *Drino* sp. [Bhat et al., 2017]

(iii). Predators (Hymenoptera: Vespidae)= *Polistes rothyni*, *Polistes stigma* [Bhat, 2008]

(iv). Predatory birds= Myna [new record]

12. *Helicoverpa armigera* (Hubner) (= *Heliothis zea*)

Host vegetable plant/s: *Atriplex hortensis*, *B. o. var. acephala*, *B. o. var. botyrtis*, *B. o. var. gongylodes*, *Cucurbita moschata*, *C. maxima*, *C. pepo*, *Cucumis sativus*, *Lagenaria siceraria*, *Lycopersicon esculentum*, *Mentha arvensis*, *Pisum sativum*, *S. tuberosum*, *Malva sylvestris*, *Momordica charantia*, *Spinacea oleracea*

Nature & Extent of Damage: Polyphagous destructive pest. The early instars feed on the tender foliage, flower buds (squash), bore into the heads (cauliflower, cabbage) and fruits (tomato) and eat away the inner contents.

Period of activity: May to August

Pest status: Major pest

Local Distribution in J&K: Throughout J&K

Authors reporting the pest from J&K: Dar et al., 2002; Bhat, 2008; Bhat et al., 2009; Bhat et al., 2011; Kriti et al., 2014; Shanker et al., 2016; Bhat, 2018; Bhat & Ahanger, 2018

Natural enemies/Biological Control & Authors reporting:

(i). Parasitoids (Hymenoptera: Ichneumonidae) = *Charops bicolor*, *Campoletis chloridae*, *Eriborus* sp., *Diadegma fenestralis* [Bhat et al., 2009]; *Diadegma semiclausum* [Bhat, 2018]

(ii). Parasitoids (Hymenoptera: Braconidae) = *Cotesia* sp., *Microplitis* sp. [Bhat et al., 2009], *Bracon* sp., [Shankar et al., 2016]; *Bracon hebetor* [Bhat et al., 2017]

(iii) Parasitoids (Hymenoptera: Eulophidae) = *Euplectrus euplexae* [Bhat et al., 2009]

(iv). Parasitoids (Hymenoptera: Trichogrammatidae) = *Trichogramma* sp., [Bhat et al., 2009]

(v). Parasitoids (Diptera: Tachinidae) = *Voria ruralis* [Shankar et al., 2016; Bhat, 2018], *Exorista* sp. [Bhat et al., 2009; Bhat et al., 2017]

(vi). Predators (Hymenoptera: Vespidae)= *Polistes rothyni*, *Polistes stigma* [Bhat, 2008] ; (vii).

Predators (Neuroptera : Chrysoperlidae)=*Chrysopa carnea* [Bhat et al., 2009]

(Viii). Predator (Hemiptera: Nebidae)= *Nebis* sp. [Bhat et al., 2009]

(iv). Predatory birds= Myna

13. *Spodoptera litura* (Fabricius)

Host vegetable plant/s: *Allium cepa*, *B. o. var. acephala*, *B. o. var. botyrtis*, *B. o. var. capitata*, *B. o. var. gongylodes*

Nature & Extent of Damage: The young larvae scrape the leaves, later instars cause defoliation. In onion they feed from inside the shoot.

Period of activity: June to August

Pest status: Moderate to major

Local Distribution in J&K: Jammu, Budgam, Srinagar, Baramulla, Ganderbal

Authors reporting the pest from J&K: [Bhat & Bhagat, 2009a ; Bhat et al., 2011a; Shankar et al., 2016; Bhat, 2018; Bhat & Ahanger, 2018]

Natural enemies/Biological Control & Authors reporting:

(i). Parasitoids (Hymenoptera: Braconidae)= *Zelex chloraphthalama* [Bhat & Bhagat, 2009a ; Bhat et al. 2011a; Bhat et al., 2017]

14. *Spodoptera exigua* Hubner

Host vegetable plant/s in J&K: Cole crops, *Allium cepa*, *Allium sativum*

Nature & Extent of Damage: The young larvae scrape the leaves, later instars cause defoliation.. In onion they feed from inside the shoot

Period of activity in J&K: June to August

Pest status in J&K: Moderate to major

Authors reporting the pest from J&K: Shankar et al., 2016; Bhat, 2018; Bhat & Ahanger, 2018

Local Distribution in J&K: Jammu, Budgam, Srinagar, Baramulla, Ganderbal

Natural enemies in J&K: Not known

15. *Mamestra brassicae* (Linn.)

Host vegetable plant/s: *B. o. var. acephala*, *B. o. var. gongylodes*

Nature & Extent of Damage: The young larvae scrape the leaves, later instars cause defoliation. In onion they feed from inside the shoot

Period of activity: June to October

Pest status in J&K: Moderate to major

Local Distribution in J&K: Anantnag, Badgam, Bandipora, Baramulla, Ganderbal, Pulwama and Srinagar

Authors reporting the pest from J&K: Bhat *et al.*, 2016, Bhat, 2018, Bhat & Ahanger, 2018

Natural enemies: Not known

IV. Family: Pieridae

16. *Pieris brassicae* (Linnaeus)

Host vegetable plant/s: *Brassica campestris*, *Brassica oleracea* var. *acephala*, *B. o. var. botrytis*, *B. o. var. capitata*, *B. o. var. gongylodes*, *B. napus*, *Brassica rapa*, *Raphanus sativus*

Nature and extent of damage: younger larvae scrap the leaf surface while as older ones riddle the leaves with large irregularly shaped holes. When the infestation is high, leaves are completely skeltonized, causing the death of the plant.

Period of activity: April to October

Pest Status: Major pest

Local Distribution in J&K: Throughout J&K

Authors reporting the pest from J&K: Rishi, 1967; Bhat, 2002; Dar *et al.*, 2002; Mathew, 2005; Pandey *et al.*, 2006; Chandra, 2009; Bhat *et al.*, 2010; Bhat *et al.*, 2011; Bhat *et al.*, 2013; Shankar *et al.*, 2016; Bhagat, 2017; Bhat *et al.*, 2017; Bhat, 2018; Bhat & Ahanger, 2018; Hussain *et al.*, 2018

Natural enemies/Biological Control & Authors reporting:

(i). Parasitoids (Hymenoptera: Ichneumonidae) = *Hyposoter ebinius* [Bhat *et al.*, 2010; Bhat *et al.*, 2017; Bhat, 2018]; *Pimpla* sp. [Bhat *et al.*, 2010; Bhat *et al.*, 2017]

(ii). Parasitoids (Hymenoptera: Braconidae) = *Cotesia glomerata* [Bhat *et al.*, 2010; Sankae *et al.*, 2016; Bhat *et al.*, 2017; Bhat, 2018];

(iii). Parasitoids (Hymenoptera: Chalcididae) = *Brachymeria* sp. [Bhat *et al.*, 2010; Bhat *et al.*, 2017]

(iv). Parasitoids (Hymenoptera: Pteromalidae) = *Pteromelus puparum* [Bhat *et al.*, 2010; Bhat *et al.*, 2017; Bhat, 2018]

(v). Parasitoids (Diptera: Tachinidae) = *Compsilura concinnata* [Bhat *et al.*, 2013; Bhat *et al.*, 2017; Bhat, 2018], *Exorista larvarum* [Bhat *et al.*, 2013; Bhat *et al.*, 2017; Bhat, 2018], *Phryxe vulgaris* [Bhat, 2018; Shankar *et al.*, 2016]

(vi). Predators (Hymenoptera: Vespidae) = *Polistes rothynei* [Bhat *et al.*, 2010], *Polistes stigma* [Bhat *et al.*, 2010];

(vii). Predators (Hymenoptera: Formicidae) : *Myrmica* sp. [Bhat *et al.*, 2010]

(viii). Predatory birds= Myna [new record]

(Viii). Pathogen= Granulosis virus [Kour *et al.*, 2018]

17. *Pieris brassicae kashmirensis* Rishi

Host vegetable plant/s: *Brassicac* spp., *Brassica juncea*

Nature and extent of damage: younger larvae scrap the leaf surface while as older ones riddle the leaves with large irregularly shaped holes. When the infestation is high, leaves are completely skeltonized, causing the death of the plant.

Period of activity: April to October

Pest Status: Major

Local Distribution in J&K: Kashmir

Authors reporting the pest from J&K: Rishi, 1967;

Bhagat, 2017; Bhat & Ahanger, 2018

Natural enemies: Not known

18. *Pieris canidia* (Sparm)

Host vegetable plant/s: *B. o. var. botrytis*, *B. o. var. capitata*, *B. o. var. gongylodes*, *R. sativus*

Nature and extent of damage: Defoliation and skeltonisation

Period of activity: April to September

Pest Status: Minor to moderate

Local Distribution in J&K: Kashmir

Authors reporting the pest from J&K: Bhingam, 1907; Bhat, 2008b; Qureshi *et al.*, 2013; Bala *et al.*, 2014; Bhagat, 2017; Bhat & Ahanger, 2018

Natural enemies: Not known

19. *Pieris rapae* (Linnaeus)

Host vegetable plant/s in J&K: *B. o. var. acephala*, *B. o. var. capitata*, *B. o. var. gongyloides*, *B. napus*, *B. rapa*

Nature and extent of damage: The larvae feed next to veins or the midrib on the underside of the leaves and chew out irregular holes in the leaves.

Period of activity: April to November

Pest Status: Moderate

Local Distribution in J&K: Throughout J&K

Authors reporting the pest from J&K: Vashney, 1993; Dar *et al.*, 2002; Pandaey & Dawedi, 2005; Pandey *et al.*, 2006; Bhat, 2008b; Bhat & Bhagat, 2009; Bhat *et al.*, 2011; Shankar *et al.*, 2016; Bhagat, 2017; Bhat *et al.*, 2017; Bhat, 2018, Bhat & Ahanger, 2018

Natural enemies/Biological Control & Authors reporting:

(i). Parasitoids (Hymenoptera: Ichneumonidae)= *Hyposoter ebininus* [Bhat *et al.*, 2010; Bhat *et al.*, 2017; Bhat, 2018]

(ii). Parasitoids (Hymenoptera: Braconidae)= *Cotesia glomerata* [Bhat *et al.*, 2010; Bhat *et al.*, 2017; Bhat, 2018];

(iii). Parasitoids (Hymenoptera: Chalcididae) = *Brachymeria femorata* [Bhat *et al.*, 2010; Bhat *et al.*, 2017]

(v). Parasitoids (Diptera: Tachinidae) = *Phryxe vulgaris* [Shankar *et al.*, 2016]

20. *Pontia daplidice* (Linnaeus)

Host vegetable plant/s: *B. o. var. acephala*, *B. o. var. botrytis*, *B. o. gongyloides*, *B. napus*, *B. rapa*, *R. sativus*

Nature and extent of damage: The larvae bite holes into the leaves. Large larvae are more damaging to young plant

Period of activity: May to October

Pest Status: Minor to moderate

Local Distribution in J&K: Kashmir

Authors reporting the pest from J&K: Bhingam, 1907; Wynter Blyth, 1957; Mani, 1962; Vashney, 1993; Dar *et al.*, 2002; Bhat & Bhagat, 2009; Qureshi *et al.*, 2013; Bhat *et al.*, 2011; Bhagat, 2017; Bhat *et al.*, 2017; Bhat, 2018; Bhat & Ahanger, 2018

Natural enemies: (i). Parasitoid (Hymenoptera:

Ichneumonidae)= *Hyposoter ebininus* [Bhat *et al.*, 2010; Bhat *et al.*, 2017; Bhat, 2018]

21. *Pontia glouconome* (Klug)

Host vegetable plant/s: *B. o. var. botrytis*, *B. o. var. capitata*

Nature and extent of damage: Defoliation and skeletonisation of plant

Period of activity: April to September

Pest Status: Minor to moderate

Local Distribution: Kashmir

Authors reporting the pest from J&K: Bhat, 2008 b; Bhat, 2018; Bhat & Ahanger, 2018

Natural enemies: Not known

IV. Family: Plutellidae

22. *Plutella xylostella* (Linnaeus)

Host vegetable plant/s: *B. o. var. acephala*, *B. o. var. botrytis*, *B. o. var. capitata*, *B. o. var. gongyloides*, *B. rapa*, *B. napus*, *R. sativus*

Nature and extent of damage: The young larvae feed by scrapping the epidermal leaf tissues and mine between the upper and lower leaf surfaces. The older larvae feed on all plant parts, but prefer to feed around the buds and leaves. They create irregular shot holes and disFig. the bud t so that the cabbage head will not develop properly.

Period of activity: April to August. Highest prevalence in April & May

Pest Status: Major

Local Distribution: Throughout J&K

Authors reporting the pest from J&K: Simmonds & Rao, 1960; Bhat, 1987; Bhat, 2008 b; Bhat & Bhagat, 2008; Bhat *et al.*, 2011; Shankar *et al.*, 2016; Bhat, 2018; Bhat & Ahanger, 2018

Natural enemies/Biological Control & Authors reporting:

(i). Parastoids (Hymenoptera: Ichneumonidae)= *Diadegma fenestrata* [Bhat & Bhagat, 2008; Bhat *et al.*, 2017] ; *Diadegma semiclausum* [Bhat, 2018]; *Horogenes* sp. [Simmonds & Rao, 1960]; *Itopectis* nr. *himalayanensis* [Bhat & Bhagat, 2008; Bhat *et al.*, 2017]; *Itopectis* sp. [Bhat, 2018]

- (ii). Parasitoids (Hymenoptera: Braconidae) = *Cotesia plutellae* [Bhat & Bhagat, 2008; Shankar *et al.*, 2016; Bhat *et al.*, 2017; Bhat, 2018]; *Apanteles* sp. [Bhat & Bhagat, 2008; Bhat *et al.*, 2017; Bhat, 2018]
- (iii). Parasitoids (Hymenoptera: Eulophidae)= *Tertrastichus sokolowskii* [Bhat & Bhagat, 2008; Bhat *et al.*, 2017, Bhat, 2018]
- (iv). Parasitoids (Diptera: Tachinidae) = *Voria ruralis* (Tachinidae: Diptera) [Simmonds & Rao, 1960; Bhat 2008; Bhat *et al.*, 2017]

IV. Family : Pyralidae

23. *Etiella zinckenella* (Treitschke)

Host vegetable plant/s: Vegetable crops, *P. sativum*, *P. vulgaris*

Nature and extent of damage: Pod borer

Period of activity: Not known

Pest Status: Major

Local Distribution: Ladakh

Authors reporting the pest from J&K: Pandey *et al.*, 2006; Bhat & Ahanger, 2018

Natural enemies: Not known

24. *Euzophera perticella* Zeller

Host vegetable plant/s: *S. melongena*, *L. esculentum*, *S. tuberosum*

Nature and extent of damage: Shoot borer

Period of activity: April- August

Pest Status: Moderate to Major

Local Distribution: Jammu, Kashmir

Authors reporting the pest from J&K: Singh & Abrol, 2001; Bhat & Ahanger, 2018, Bhat 2008b

Natural enemies: Not known

Types of host Vegetable host- plants of Lepidopteran Insect pests of J&K

Upon literature survey, it was found that as many as 30 species of vegetable host plants, belonging to 10 plant families, were reported by various authors to be infested by Insect pests in the State of 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, Brassicaceae: *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. botrytis* (Cauliflower); *B. o. var. capitata* (Cabbage); *B. o. var. gongylodes* (knol-khol); *B. o. var. kashmiriana* ; *Brassica rapa* L. (turnip); Family 4, Chenopodiaceae: *Atriplex hortensis* L. (mountain spinach) ; *Spinacea oleracea* L. (spinach); Family 5, Cucurbitaceae: 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/eggplant) ; *Solanum tuberosum* Linn. (potato).

Family wise- common names of Lepidopteron Insect pests of Vegetable crops reported in J&K:

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. Hesperidae: *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).

Discussion

In the State of J&K, the vegetables are grown over an area of 63.1 thousand ha with annual production of 1385.5 thousand MT (Samnotra *et al.* 2016). However, as mentioned in introductory portion above, insect pests are the major biotic constraints to vegetables production, given that, they not only inflict direct damage to host crops, but also many of them act as vectors for several viral diseases as highlighted by Rai *et al.* (2014). As highlighted in the results, many Lepidopteron insects cause serious damage to the vegetable crops of this region. The perusal of the present compendium reveals that there as many as 26 reported species of Lepidopteron pests which damage various types of vegetable crops in different areas and localities of the Union territory of J&K. The highest number of pest species among them family Noctuidae represented by 9 species, followed by family Pieridae represented by 8 species. The present compendium also reveals that, among all the lepidopteron pests, enlisted and reported from this region, *P. brassicae*, *T. orichalcea*, *H. armigera*, *P. xylostella* and *A. ipsilon* are the most destructive ones.

It is also observed that there is good number of natural enemies available which suppresses the population of many of these pests in the field. Firake *et al.* (2012) have also observed *Pieris brassicae* and *P. xylostella* as the major pest in North East (India). Shankar *et al.* (2016) in their study have reported *P. brassicae* and *P. rapae*, *Plutella xylostella*, *Spodoptera litura* and *Trichoplusia ni* as major pests in vegetable ecosystems in Jammu region. Devi & Raj (1995) during their study in Himachal Pradesh has witnessed the diamondback moth (DBM), *Plutella xylostella* as an important pest of cruciferous crops, particularly cabbage and cauliflower. The cabbage butterflies, *Pieris brassicae*, *P. canidia* and *P. rapae* have also been reported as major pests of cabbage and cauliflower in other Indian states (Bhatia & Verma, 1993; Butani & Jotwani, 1984). Cpinara (2001) in his treatise has also mentioned afore mentioned lepidopteron species as serious pests of vegetable crops. Hoffmann *et al.*, 2004 have revealed similar results and reported above mentioned Lepidoptera as common pests of vegetable crops in Australia. The present study, in agreement with the previous studies carried by afore-mentioned authors, also suggest that that these pests need immediate attention for Control measures, particularly by adopting IPM strategies.

The current study can be helpful in future studies of lepidopteron insect pests and for devising their pest management strategies, especially through utilization of natural enemies to facilitate any integrated control program in vegetable eco-systems in this region. The overall database provided in this study will be useful for future studies of Insect pests other crops too, given that some of the pests covered in this study, being polyphgous in nature. Since, the complete knowledge of Insect pests is crucial for formulating proper management techniques and the present study in this connection will be helpful in the long run for understanding insect pest problems and devising pest management strategies against them, especially in vegetable ecosystems of this region. The data generated from the study would also be helpful in further understanding of the biodiversity of arthropod fauna. It would also be of immense help for vegetable growers, agriculturists and entomologists.

Acknowledgement

The author is highly thankful to Head, Department of Zoology, University of Kashmir; Chief Librarian, Sheri Kashmir Agriculture University of Science and Technology, Kashmir (SKAUST-K) and Chief Central Librarian, IARI, Pusa, New Delhi, for providing access to library journals and e-resources. The author also extends thanks to head of the Department of Zoology, University of Kashmir, Srinagar, Govt. Degree College, Ganderbal and Women's College Srinagar, J&K providing necessary laboratory and library facilities to the author during his study.

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