Diversity of Aphid Pests (Homoptera: Aphididae) and their Natural Bio-Control Agents in Vegetable Crop Ecosystems of Jammu & Kashmir, India

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ABSTRACT

The aphids (Homoptera: Aphididae) are one of major pests of agriculturally important crops, including vegetables, across the world. They suck plant sap, cause leaf curling, yellowing and stunted growth of the host plants. They also act as vectors of many viral diseases in plants. In order to explore aphid pests and their naturally occurring bio-control agents (parasitoids and predators), an extensive field survey was conducted in different vegetable ecosystems of the Kashmir valley during the years from 2014-2019. Moreover, a through literature survey pertaining to aphids, reported from Jammu and Kashmir, was also done. Accordingly, based on these studies, it was concluded that as many as 18 species of aphids belonging to 12 genera infest as many as 26 species and 30 varieties of vegetable crops in Jammu and Kashmir (J&K). It was also concluded that at least 29 species of insect predators and 17 species of parasitoids occur naturally to suppress these aphid pest species in vegetable ecosystems in J&K. In sum, through this study, a comprehensive account of aphids and their natural enemies with reference to vegetable crops in J&K is presented. This work will be useful for the studies concerning the devising of strategies for Integrated Control Program of aphids, especially through utilization of natural bio-control agents.

Keywords

Aphidiinae, Aphids, Coccinellidae, Jammu & Kashmir, Parasitoids, Predators

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Introduction

Aphids or ‘plant lice’ are minute pear-shaped, soft-bodied organisms. They belong to Class Insecta, order Homoptera and family Aphididae. They may be winged (alate) or wingless (apterous). Their life cycle is completed through egg, nymphaal and adult stages. Apart from sexual reproduction, they can also reproduce through a process of parthenogenesis (Dixon, 1987 and 1998). Aphids are an important group of plant insect pests having a high biotic potential as reflected by their parthenogenicity, viviparity
and fast development. They are found to inflict direct (sucking) and indirect (transmission of viruses and honeydew secretion) damage to different types of vegetation and are considered the most potent and worldwide enemies of many crops (Blackmon and Eastop, 2007).

Aphids are an extremely successful group which occurs throughout the world, with the greatest number of species in the temperate regions (Blackmon and Eastop, 2007). Out of 4702 aphid species so far known world over (Remaudiere and Remaudiere, 1997), about 1015 species occur in Oriental region (Agarwala and Gosh, 1984), among which, about 750 species belonging to 208 genera represent Indian Aphididae (Gosh and Gosh, 2006).

In Jammu and Kashmir region (India), more than 31 species of aphids have been reported on wide range of host-crop species of agricultural, horticultural and forest ecosystems, with varying degree of host specificity (Bhagat, 2012). Among these aphids, some species had earlier been reported on vegetable crops and the significant studies in this regard have been conducted by Ahmad and Bhat (1986); Bhagat (1986, 2012); Zaz (2001); Pandey et al., (2006); Bhat (2008, 2017); Khan et al., (2009, 2017); Bhat et al., (2011); Bhat and Bhagat (2017) and Bhat and Ahanger (2018).

Some natural enemies (parasitoids/predators) had earlier been reported on aphid pests on some vegetable crops in J&K region and the important studies in this connection were done by Ahmad and Bhat (1986); Bhagat and Lone (1984); Bhagat & Masoodi (1986); Bali (1987); Bhagat & Matta (2002); Bhat (2008a); Khan et al., (2009, 2017); Shah and Khan (2013); Bhat (2017) and Bhat & Bhagat (2017). Similarly, some parasitoid species were earlier recorded to suppress the aphid population in vegetable ecosystems in J&K region and the key researchs in this regard were conducted by Rao et al., (1969); Shujauddin (1973); Stary and Bhagat (1978); Takada & Rishi (1980); Bhagat (1982 a, 1982b, 1986, 2008); Bhagat & Ahmad (1991); Bhat (2008a), Khan et al., (2017) and Bhat et al., (2017).

However, all the aforementioned studies pertaining to aphids and their natural enemies in J&K were scattered in different journals and, hitherto, there was no consolidated checklist available concerning aphids and their natural enemies on vegetable crops in J&K. Therefore, in sum, this paper by way of adding new information and consolidating the previous works pertaining to aphids and their natural enemies, gives a clearer picture regarding this subject area. Accordingly, a comprehensive account of the systematic position, host-crop range and natural bio-control agents of 18 species of aphids along with their 45 species of natural enemies (parasitoids and predators) in J&K is provided through this work. This study will be helpful in future for understanding of biodiversity of aphis and their natural enemies, particularly from this region. Moreover it would also be useful for the studies concerning the devising of strategies of integrated control program for aphids, especially through utilization of natural enemies (as bio-control agents).

**Materials and Methods**

**Literature survey and preparation of compendium/checklist of aphid pests**

A comprehensive literature survey of all the available published works/ research papers etc., published from time to time pertaining to aphid pest 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, CAB, NISCAIR, AGRI, Biological abstracts, etc., were also consulted for obtaining the required information.

Field and laboratory studies

The data presented in this paper is also based on extensive field surveys of aphids and their natural bio-control agents (parasites and predators), in different vegetable farms, floating gardens, kitchen gardens etc in different localities of J&K region, conducted by the present authors over the years from 2007-2019, appended as under:

Study area (Fig. 62)

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

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 aphid pests, their host-plant, predators (natural enemy) was recorded in field diary. The immature stages (nymphs) of aphids were taken to laboratory, along with predatory larvae, if any and were reared on the host plant in glass / plastic jars for the development of their adults and for the recovery of their parasitoids. The adults of aphids, their parasitoids and predators which emerged after rearing were identified and preserved.

Presentation of data in the form of checklist

The necessary data, pertaining to aphid is documented and presented in this paper in the form of checklist. The aphid species are listed sub family-wise & systematically, with details given on their host-plant range (followed by references), insect predators (family wise and followed by references) and parasitoids (followed by references).

Results and Discussion

The results obtained during this work are highlighted through a below mentioned checklist, well supported by field photography (Fig. 1-61) and table 1. The checklist reveals that as many as 18 species of aphids (See Section b) belonging to 12 genera under 2 subfamilies (Aphidiinae and Lachinae) of family Aphididae (Order: Homoptera) infest at least 26 species and 30 varieties of vegetable crops (See Section a) in J&K.

The checklist also reveals that at least 29 species of insect predators (natural enemies) (See Section c), belonging to 25 genera under 5 families (Anthocoridae, Coccinellidae, Ceccidomyiidae, Syrphidae, Chrysoperlidae) under 4 Insect orders (Coleoptera, Hemiptera, Diptera, Neuroptera) commonly occur and feed on afore-mentioned aphid species. Apart from this, 17 species of parasitoids (Hymenoptera: Braconidae: aphidiinae) (See Section d), belonging to 7 genera which parasitize these aphids on vegetable crops, have been documented in this checklist.
Summary of vegetable plant host-range of aphid pests in J&K

As highlighted above, 26 species and 30 varieties of vegetable crops (both cultivated and wild) have been found infested by Aphid pests. These vegetable plants are: *Brassica napus* (Linn.) (= *Brassica campestris* L.), *Brassica juncea* Linn., *Brassica napus* (Linn.), *Brassica oleracea* (Linn.) - *Brassica oleracea* var. acephella (kale), *Brassica o. var. botrytis* (Cauliflower), *B. oleracea* var. capitata (cabbage), *B. o. var. kashmiriana*, *B. o. var. gongylodes* (knolkhol), *Brassica rapa* L. (turnip), *Capcicum annuum* L. (capsicum), *Coriandrum sativum* L. (Corriander), *Cucumis sativus* (Linn.) (Cucumber), *Cucurbita maxima* Duchensec (large pumpkin), *Cucurbita pepo* L. (Marrow), *Daucus carota* L. (carrot), *Dolichos lablab* L. (Lablab bean), *Helianthus tuberosus* L. (artichoke), *Hibiscus esculentus* L. (Okra), *Lagenaria siceraria* (Molina) (bottle gourd), *Lycopersicon esculentum* Mill (tomato), *Phaseolus coccineus* (Linn.) (runner bean), *Phaseolus vulgaris* (common bean/French beans), *Pisum sativum* L. (pea), *Raphanus sativus* L. (radish), *Rumex acetosa* (Liin.), *Rumex nepalensis* Spreng, *Rumex* sp. (rumex), *Solanum tuberosum* L. (potato), *Solanum melongena* L., *Taraxacum officinale* (L.).

Summary of aphid pest species of vegetable crops in J&K

The 18 species of Aphids (Family Aphididae) belonging to 12 genera, which have been reported to infest vegetable crops in J&K are: *Aphis craccivora* Koch, *Aphis fabae* solanella Theobald, *Aphis gossypii* Glover, *Aphis rumicis* Linnaeus, *Aphis spiraecola* (Patch), *Acyrthosiphon pisum* Harris, *Aulacorthum solani* (Kaltenbach), *Brachycaudus helichrysi* (Kaltenbach), *Brachycaudus rumexicolens* (Patch), *Brevicoryne brassicae* (Linnaeus), *Cavariella aegopodii* Scopoli, *Hyadaphis coriantri* (Das), *Lipaphis* (Lip.) *erysimi* (Kaltenbach), *Lipaphis pseudobrassicae* (Davis), *Myzus persicae* (Sulzer), * Macrosiphum euphorbiae* (Thomas), *Semiaphis heraclei* (Takahashi), *Protrama penecaeia* Stryon

Summary of insect predator species (natural bio-control agents) of aphid pests on vegetable crops in J&K

The 29 species of insect predators distributed over 25 genera, which have been reported on aphid pests in vegetable ecosystems in J&K, include 12 species of Coccinellidae (Coleoptera), 10 species of Syrphidae (Diptera), 2 species of Cecidomyiidae (Diptera), 3 Species of Chrysoperilidae (Neuroptera) and 2 species of Anthocoridae (Hemiptera) and are highlighted as under:-

Order-coeloptera (family coccinellidae)

*Adalia tetraspilota* (Hope), *Calvia punctata* (Mul.), *Coccinella septempunctata* L., *Coccinella undecempunctata* Linnaeus, *Cheilomenes sexmaculatus* Fabricius, *Hippodamia variegata* (Goe.), *Harmonia dimidiata* (Fabricius), *Oenopia conglobata* (Goe.), *Platynaspis saundersi* (Crotch) (= *Platynaspis saundersi*), *Priscibrumus uropygialis* (=*Exochomus uropygialis*) (Mulsant), *Propylea luteopustulata* (Mulsant), *Scymnus sp.*

Order-diptera (family syrphidae)

*Betasyrphus serarius* (Wiedemann), *Episyrphus balteatus* DeGeer, *Eupeodes (Macroserphus) confirater* (Wiedemann), *Ischiodon scutellaris* (Fabricius), *Melanostoma univitatum* (Wiedemann), *Metasyrphus corolla* (Fabr.), *Paragus tibialis* (Fallén, 1817), *Sphaerophoria scripta* (Linnaeus), *Syrophus confractor* Weid,
Order- diptera (family cecidomyiidae)

Aphidoletes aphidimyza (Rondani), Leucopis sp.

Order- Hemiptera (Anthocoridae): Anthocoris sp., Orius sp.

Order-neuroptera (family chrysopidae)

Chrysoperla zastrowi Sillemi (Esben-Petersen), Chrysoperla (=Chrysopa) carnea Stephens, Chrysoperla (=Chrysopa) orestes Banks

Summary of parasitoid species (natural bio-control agents) of aphid pests on vegetable crops in J&K region

The 17 species of aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) belonging to 7 genera reported on aphid pests of vegetable crops in J&K are: Aphidius colemani Viereck, Aphidius eglanteriae Haliday, Aphidius matricariae Haliday, Aphidius smithi Sharma and Subbarao, Aphidius sp., Diaeretiella rapae (McIntosh), Ephedrus persicae Froggatt, Ephedrus plagiator (Nees), Lysaphidus erysimi Stray, Lysiphlebus(Phelbus) fabarum (Marshall), Toxares zakai Shujauddin, Trioxys kahmirensis (Takada), Trioxys (Binodoxys) jaii, Bhagat, Trioxys (Binodoxys) indicus, Trioxys rubicola Shujauddin, Trioxys (Trioxys) complanatus Quilis

Check list of family aphididae on vegetable crops in J&K

The 18 species of Aphids (Family Aphididae), which have been reported on vegetable crops in J&K are appended in the following checklist. The Aphid species in this checklist are documented subfamily-wise, & systematically, with details given on their host-plant range (followed by references), insect predators (family wise and followed by references) and parasitoids (followed by references).

Sub-family: aphidinae

Tribe-aphidini Latreille, 1802

Aphis craccivora koch, 1854

Aphis craccivora is commonly known as cow pea aphid.

Host vegetable plants in J&K/ references

Cucumis sativus, Dolichos lablab, Lycopersicum esculentum, Phaseolus vulgaris, Rumex acetosa, Rumex nepalensis, Solanum melongena, Solanum tuberosum / (Bhagat, 2012; Bhat, 2017; Bhat and Bhagat, 2017; Khan et al., 2017; Bhat and Ahanger, 2018)

Predatory natural enemies in J&K/ references

Coleoptera (Coccinellidae)

Adalia tetraspilota, Cheilomenes sexmaculata, Hippodamia variegata, Platynaspis saundersi (= Platynaspis saundersi), Scymnus sp., Oenopia conglobata, Propylea luteopustulata;

Diptera (Syrphidae)

Euepodes (Macroxyrhus) confrater, Ischiodon scutellaris, Melanostoma univitatum, Sphaerophoria scripta, Paragus tibialis / (Bhat, 2017; Khan et al., 2017; Bhat and Bhagat, 2017)
Parasitoid natural enemies in J&K/ references

(Hymenoptera: Braconidae: Aphidiinae): Diaeretiella rapae / (Bhagat & Ahmad, 1991; Bhagat, 2008); Trioxys (Binoxydos) indicus / (Bhagat, 2008), Ephedrus persicae Froggatt, Trioxys jaii Bhagat/ (Stary and Bhagat, 1978; Bhagat, 1982 a, 1982b; Khan et al., 2017)

*Aphis fabae solanella* Theobald, 1914

It is commonly known as Black bean aphid.

Host vegetable plants in J&K/ references

*Phaseolus* sp. (French beans), *Rumex acetosella, Rumex nepalensis* / (Bhat & Lone, 1984; Bhat, 2017; Khan et al., 2017; Bhat and Ahanger, 2018)

Predatory natural enemies in J&K/ references

**Coleoptera (Coccinellidae)**

*Adalia tetraspilota, Coccinella septempunctata, Chrysoperla z. sillemi, Hippodamia dimidiate, Hippodamia variegata, Oenopia conglobata* (Goe.); Diptera: (Chamaemyiidae): *Aphodoletes aphidomyzae, Leucopis* sp. / (Bhagat and Lone, 1984; Bhagat and Matta, 2002; Bhat, 2017; Khan et al., 2017); Hemiptera (Anthocoridae): *Anthocoris* sp., *Orius* sp.

Parasitoid natural enemies in J&K/ references

(Hymenoptera: Braconidae: Aphidiinae): *Aphidius matricariae* Haliday (Bhagat and Ahmad, 1991; Bhat et al., 2017); *Lysiphelebus* (Phelbus) fabrum, *Trioxys (Binoxydos) indicus* (Bhagat. 2008)

*Aphis gossypii* Glover, 1802

*Aphis gossypii* is commonly known as cotton aphid.

Host vegetable plants in J&K/ references

*Capsicum annum, Cucumis sativus, Cucurbita maxima, Cucurbita pepo, Lagenaria sicerraria, Rumex sp., Solanum melongena, S. tuberosum, Taraxacum officinale* (Bhagat and Masoodi, 1986; Bhat et al., 2011; Khan et al., 2017; Bhat, 2017; Bhat and Bhagat, 2017; Bhat & Ahanger, 2018).

Predatory natural enemies in J&K/ references

**Coeloptera (Coccinellidae)**

*Adalia tetraspilota* (Hope), *Coccinella septempunctata* L., *Cheilomenes sexmaculatus, Hippodamia variegata* (Goe.), *Symnus* sp., *Priscibrumus urophygialis* (=*Exochomus urophygialis*), *Propylea luteopustulata* (Mulsant); Neuroptera (Chrysopidae): *Chrysoperla sillemi* (Esben-Petersen), *Chrysopa arestes*; Diptera (Syrphidae): *Episyrphus balteatus* DeGeer (Ahmad and Bhat, 1986; Bhat, 2017; Bhat and Bhagat, 2017; Khan et el., 2017); Hemiptera (Anthocoridae): *Anthocoris* sp., *Orius* sp. (new records)

Parasitoid natural enemies in J&K/ references

(Hymenoptera: Braconidae: Aphidiinae): *Ephedrus plagiator* (Nees), *Trioxy srubicola* Shujauddin (Rishi, 1976; Shujaudh, 1973; Khan et al., 2017)

4. *Aphis rumicis* Linnaeus, 1758

Host vegetable plants in J&K/ references

*Rumix* sp. (Khan et al., 2017)

Natural enemies and authors reporting

Predatory natural enemies in J&K/ references

**Coeloptera (Coccinellidae)**

*Adalia tetraspilota* (Hope), *Hippodamia variegata* (Goe.), *Propylea luteopustulata* (Mulsant) (Khan et al., 2017).
Parasitoid natural enemies in J&K/ references: not known

*Aphis spireaeola* (Patch, 1914)

*Aphis spireaeola* is commonly known as spirea aphid.

Host vegetable plants in J&K/ references

*Cucumis sativus* (Khan *et al.*, 2017)

Natural enemies and authors reporting

Predatory natural enemies in J&K/ references

**Coeloptera (Coccinellidae)**

Adalia tetraspilota, *Coccinella septempunctata*, *H. dimidiata*, *Hippodamia variegata* (Goe.); Neuroptera (Chrysopidae): *Chrysoperla z. sillemi* (Khan *et al.*, 2017)

Parasitoid natural enemies in J&K/ references

(Hymenoptera: Braconidae: Aphidiinae): *Aphidius matricariae* Haliday (Stary and Bhagat, 1978; Khan *et al.*, 2017)

Tribe-Macrosiphini Wilson, 1910

**Acyrthosiphon pisum** Harris, 1776

Host vegetable plants in J&K/ references

*Phaseolus* sp., *Pisum sativum* Linn (Ahmad and Bhat, 1986; Bhagat, 1986, 2012; Bhat *et al.*, 2011; Khan *et al.*, 2017; Bhat and Ahanger, 2018)

Predatory natural enemies in J&K/ references

**Coeloptera (Coccinellidae)**

Adalia tetraspilota (Hope), *Hippodamia variegata* (Goe.); Diptera (Syrphidae):

Parasitoid natural enemies in J&K/ references

*Episyrphus balteatus*, *Melanostoma univitatum* (Ahmad and Bhat, 1986; Bhat *et al.*, 2011; Bhat and Bhagat, 2017)

(Host vegetable plants in J&K/ references)

*Aulacorthum solani* (Kaltenbach, 1843)

Predatory natural enemies in J&K/ references

**Coeloptera (Coccinellidae)**

Adalia tetraspilota (Hope), *Coccinella septempunctata*, *Hippodamia variegata* (Goe.) (khan *et al.*, 2017).

Parasitoid natural enemies in J&K/ references

(Hymenoptera: Braconidae: Aphidiinae): *Aphidius eglanteriae* (Bhagat, 2008); *Aphidius smithi* Sharma and Subbarao (Takada and Rishi, 1980); *Trioxys Trioxys complanatus* Quilis (Bhagat, 2008).

**Brachycaudus helichrysi** (Kaltenbach, 1843)

Brachycaudus helichrysi is commonly known as green peach aphid.

Host vegetable plants in J&K/ references

**Brassica oleracea** (Khan *et al.*, 2017)

Predatory natural enemies in J&K/ references

**Coeloptera (Coccinellidae)**

Adalia tetraspilota (Hope), *Coccinella septempunctata*, *Hippodamia variegata* (Goe.); Diptera (Syrphidae):
septempunctata L., Hippodamia variegata (Goe.), Propylea luteopustulata; Neuroptera (Chrysopidae): Chrysoperla sillemi E. & P. (Khan et al., 2017)

**Parasitoid natural enemies in J&K/ references**

(Hymenoptera: Braconidae: Aphidiinae): Aphidius matricariae Haliday (Khan et al., 2017)

**Brachycaudus rumexicolens (Patch, 1917)**

**Host vegetable plants in J&K/ references**

*Rumex* sp. (Khan et al., 2017)

**Predatory natural enemies in J&K/ references**

Coeloptera (Coccinellidae)

Adalia tetraspilota (Hope), Cheilomenes sexmaculata, Coccinella septempunctata, Hippodamia variegata (Goe.), Propylea luteopustulata (Mul.); Diptera (Syrphidae): Episyphus balteatus, Sphaerophoria scripta (Bhagat and Lone, 1984; Ahmad and Bhat, 1986; Khan et al., 2009, 2017; Bhat, 2017; Bhat and Bhagat, 2017; Khan et al., 2017)

**Parasitoid natural enemies in J&K/ references**

(Hymenoptera: Braconidae: Aphidiinae): Aphidius matricariae Haliday, Diaeretiella rapae (M’Int) (Rao et al., 1969; Bhagat and Amad, 1991; Stary & Bhagat, 1978; Bhagat, 1986; Bhat, 2008; Bhat et al., 2017; Bhagat and Ahmad, 1991)

*Cavariella aegopodii* Scopoli 1763

**Host vegetable plants in J&K/ references**

*Daucus carota* (Bhat, 2017; Bhat and Ahanger, 2018)

**Predatory natural enemies in J&K/ references**

Diptera (Syrphidae): Episyphus balteatus (Bhat and Bhagat, 2017)

Parasitoid natural enemies in J&K/ references: Not known

*Hyadaphis coriandri* (Das, 1918)

**Host vegetable plants in J&K/ references**

*Coriandrum sativum* (Coriander) (Khan et al., 2017)
Predatory natural enemies in J&K/ references

Coeloptera (Coccinellidae)

*Adalia tetraspilota* (Hope), *Calvia punctata* (Mul.), *Coccinella septempunctata* L., *Hippodamia variegata* (Goe.); Neuroptera (Chrysopidae): *Chrysoperla z. sillemi* E. & P. (Khan et al., 2017)

Parasitoid natural enemies in J&K/ references

(Hymenoptera: Braconidae: Aphidiinae): *Diaertiella rapae* (Rao et al., 1969; Rishi, 1976; Bhagat, 1986; Bhagat and Ahmad, 199; Bhat et al., 2017)

*Lipaphis pseudobrassicae* (Davis, 1914)

Host vegetable plants in J&K/ references

*Brassica oleracea* *Brassica juncea* *Brassica napus* (Linn.) (= *Brassica campestris*), *Brassica napus* (Bhagat, 1986; Bhat et al., 2011; Bhat, 2012; Bhat and Ahanger, 2018)

Predatory natural enemies in J&K/ references: Coeloptera (Coccinellidae)

*Adalia tetraspilota* (Hope), *Calvia punctata*, *Cheilomenes sexmaculata*, *Coccinella septempunctata* L., *Coccinella undecempunctata*, *Hippodamia variegata* (Goe.), *Oenopia congoblata*; Diptera (Syrphidae): *Sphaerophoria scripta*, *Melanostoma univittatum*, *Ischiodon scutellaris*, *Metasyrphuscorolae*, *Metasyrphus confractor*, *Paragus seratus*, *Betasyrphus serarius*, *Syrphus sp.* (Bhagat and Lone, 1984; Ahmad and Bhat, 1986; Bali, 1987; Bhagat and Matta, 2002; Khan et al., 2009; Bhat, 2017; Bhat and Bhagat, 2017)

Parasitoid natural enemies in J&K/ references

(Hymenoptera: Braconidae: Aphidiinae): *Lysaphidus erysimi* Stray (Khan et al., 2017)

Myzus persicae (Sulzer, 1762)

*Myzus persicae* is commonly known as green peach aphid.

Host vegetable plants in J&K/ references

*Capsicum annuum*, *Cucurbita maxima* *Lycopersicon esculentum* *Solanum melongena*, *Solanum tuberosum* (Bhat, et al., 2011; Bhat, 2012; Khan et al., 2017; Bhat and Ahanger, 2018)
Predatory natural enemies in J&K/ references

Coeleoptera (Coccinellidae)

Adalia tetraspilota (Hope), Cheilomenes sexmaculata, Coccinella septempunctata, Hippodamia variegata (Goe.), Propylea luteopustulata (Mul.), Scymnus sp.; Diptera (Syrphidae): Episyphus balteatus (Bhat, 2017; Bhat and Bhagat, 2017; Khan et al., 2017); Hemiptera (Anthocoridae): Anthocoris sp., Orius sp. (new record); Neuroptera (Chrysopidae): Chrysopa (Chrysoperla carnea) Stephens (Bhat, 2008a)

Parasitoid natural enemies in J&K/ references

(Hymenoptera: Braconidae: Aphidiinae): Trioxys kahmirensis (Takada) (Takada and Rishi, 1980; Khan et al., 2017)

Semiaphis heraclei (Takahashi, 1921)

Host vegetable plants in J&K/ references

Daucus carota (Bhagat, 1986, 2012; Bhat and Ahanger, 2018)

Predatory natural enemies in J&K/ references: Not known

Parasitoid natural enemies in J&K/ references

(Hymenoptera: Braconidae: Aphidiinae): Aphidius salicis (Bhagat, 1986; Bhagat, 2008)

Sub-family-Lachinae Herrich-Schaeffer, 1854

The tribe- Tramini

Protrama penecaea Stryon 1998

Host vegetable plants in J&K/ references

Helianthus tuberosus (Artichoke) (Khan et al., 2017)

Predatory natural enemies in J&K/ references

Coeleoptera (Coccinellidae): Adalia tetraspilota (Hope), Calvia punctata (Mul.), Hippodamia variegata (Goe.); Neuroptera (Chrysopidae): Chrysoperla z. Sillemi E. & P. (Khan et al., 2017). Parasitoids / references: Not known.
Table 1: Species richness of Aphids and their natural enemies on vegetable crops in J&K

| Aphids                                                                 | Predators                                      | Parasitoids                               |
|-----------------------------------------------------------------------|-----------------------------------------------|-------------------------------------------|
| No. of Aphid sub-families (Aphidiine, Lachiniae)                       | No. of Insect predator Orders (Coleoptera, Dipera, Hemiptera Neoploera) | No. of Insect parasitoid orders (Hymenoptera) |
| No. of Aphid Genera (see sec. b in text)                              | No. of Insect predator families (Anthocoridae, Cecidomyiidae, Chrysoperilidae, Coccinellidae, Syrphidae, etc.) | No. of insect parasitoid families (Braconidae: Aphidiinae) |
| No. of Aphid species (see sec. b in the text)                         | No. of Insect predator species (see Sec. c in the text) | No. of insect parasitoid Genera (see sec. d in the text) |
| 2                                                                     | 10                                            | 1                                         |
|                                                                       | 18                                            | 1                                         |
|                                                                       | 4                                             | 17                                        |
|                                                                       | 5                                             | 7                                         |

Legends to Figures (Photo credit Deen Mohd.)

1.

2.

3.

4.

5.

6.
Fig. 1-5, 11, 12, 14, 18, 34, 40, 48, 50 Aphid infestations on different vegetable plants in Kashmir

Fig. 6, 7, 9, 10, 16, 21, 22, 28, 31, 33, 38, 43, 45, 47, 49, 51 Larvae of coccinellid beetles (predators) feeding on aphid pests on different vegetable plants in Kashmir

Fig. 13, 17, 19, 20, 23, 24, 26, 30, 35, 37 larvae of syrphid flies (predators) feeding on aphid pests on different vegetable plants in Kashmir

Fig. 8, 15, 27, 29, 32, 36, 39, 42 adult coccinellid beetles (predators) feeding on aphid pests on different vegetable plants in Kashmir

Fig. 51 larva of *Chrysoperla* feeding on aphids in vegetable fields in Kashmir

Fig. 52 Predatory bug *Anthocoris* sp. recovered from vegetable fields while feeding on aphids in Kashmir

Fig. 53 Parasitoid *Trioxys* sp. recovered from aphids in Kashmir

Fig. 54-55 Parasitoid *D. rapae* recovered from aphid *B. brassicae* in Kashmir

Fig. 57 Adult syrphid fly *Metasyrphus* sp. (Syrphidae), predator of aphids, collected after rearing of its larvae in Kashmir

Fig. 58 Adult *Chrysoperla* recovered after rearing of its larvae on aphids in Kashmir
Since, the complete knowledge of aphids is crucial for understanding their pest nature and for formulating a proper control and management strategy in order to mitigate their damage on vegetable crop ecosystems, So, the present work, based on field and literature survey provided a base line data pertaining aphid pests and their natural bio-control agents in vegetable ecosystems in J&K. Based on this work, it is understood that there are large number of aphid species (at least 18) which attack various types of vegetable crops in this region.

However there are even more diverse kinds of natural bio-control agents of these aphid pests represented by 17 species of parasitoids and 29 species of predators, which mitigate the damage caused by aphids in vegetable ecosystems of this region.
Thus, it is concluded that it is important to preserve and conserve the existing diversity of such natural enemies so that efforts of integrated control program, if planned for vegetable crop ecosystems in this region, can materialize and be successful.

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