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An inventory of the predatory Coccinellidae of Himachal Pradesh, India

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Abstract

Surveys were conducted periodically from 2014 to 2017 in all the four agro-climatic zones of Himachal Pradesh to study the diversity of the predatory beetles. Coccinellid fauna reported by earlier workers from the state have also been compiled to prepare a complete inventory of the predatory coccinellid beetles of the state. In total 65 predatory coccinellids have been found to be associated with different sucking pests of agricultural crops and wild flora. Beetle diversity varied with the agro-climatic conditions and zone II (sub-temperate) was the most diverse having 35 species followed by zone I (sub-tropical) (25 species). Zone IV (dry temperate zone) and zone III (wet temperate zone) were comparatively less diverse with 13 and 16 coccinellid species, respectively. Beetles namely *Coccinella septempunctata* Linnaeus, *Hippodamia variegata* (Goeze) and *Cheilomenes sexmaculata* (Fabricius) were the most common and widely distributed in all the agro-climatic zones of the state.

Keywords: Agro-climatic zones, coccinellids, diversity, Himalayan region, Ladybird beetles

1. Introduction

Coccinellids are well known predators of several soft bodied insect-pests of economically important agricultural and horticultural crops [1-3]. Both larvae and adults are predaceous and contribute significantly in natural bio-control of many insect pests. They are important not only because of their significance as bio-control agents, but, also due to their diversity and adaptations to a large number of habitats. The degree of their adaptation and efficiency as predator varies with the prey species and the environmental conditions. These beetles vary in their feeding habits as many of them are the generalists, while, some are specialists possessing all desirable attributes of an effective bio-control agent [4]. Coccinellids provide excellent ecosystem service by maintaining ecological balance by keeping the pest densities low and thereby reducing the farmers' dependence on chemical pesticides. They also act as bio-indicators and provide the general information about the health of the ecosystem in which they occur [5, 6]. Indeed, coccinellids are extremely diverse in their habits and live in almost all the terrestrial habitats. There are more than 6000 species of coccinellids in the world [7], of which more than 400 occur in the Indian sub-region [8]. Keeping in view the economic importance in biological control of crop pests, many workers have tried to explore the coccinellid fauna of India [2, 3, 8, 9-17].

Himachal Pradesh, situated in the western Himalayas is a mountainous state of India and is known for the commercial cultivation of temperate fruits especially apple, off-season vegetables, ornamental flowers and mushroom cultivation. Due to variable agro-climatic conditions, the state varies greatly in diversity with respect to flora and fauna. There are many reports on the coccinellid beetles present in different parts of India [2, 3, 8, 9-17], however, the reports from Himachal Pradesh are scanty. Though, there are few reports on the coccinellid fauna of the state [3, 8, 18-20], only Sharma *et al.* [3] surveyed a wider area of the state. Authors, therefore, surveyed different agroclimatic zones of the state to study the diversity of coccinellid beetles in the state and also compiled the information documented by the earlier workers to present a complete inventory of the Coccinellidae of Himachal Pradesh.

2. Material and methods

2.1 Study area

Himachal Pradesh is a hilly state of India situated in the western Himalayas. The state occupies an area of 55673 km between 30° 22' 40'' to 33° 12' 40'' N latitude and 75° 45' 55'' to 79° 04' 20'' E longitude. The elevation of this mountainous state varies from 350 to 7000 m amsl, as a

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result, the agro-climatic conditions vary from hot humid sub-tropical to cold, alpine-glacial. Annual rain fall is also highly variable across the state and ranges from as high as 3400 mm at Dharamshala and surroundings to almost nil in old deserts of Lahul and Spiti. Based on the agro-climatic conditions, Himachal Pradesh is divided into four zones (zone I - zone IV). Zone-I is sub-tropical low hills and valley areas up to an elevation of 914 m amsl. Zone-II is sub-temperate sub-humid mid hills with an altitude ranging from 915 to 1523 m amsl. This region receives moderate to heavy monsoon rains. In contrast, zone III is a wet temperate zone between 1524 and 2472 m amsl. Zone-IV is dry temperate mountainous area beyond 2472 m amsl. This zone is almost rainfall and experiences heavy snow fall during winter.

2.2 Collection of beetles

Surveys were conducted periodically from 2014 to 2017 in all the four agro-climatic zones of the state to collect the beetles. For the collection of beetles, fruit orchards, vegetable fields, agricultural fields, forest trees and shrubs, ground flora of the orchards and forests, weeds, etc. were covered thoroughly to ensure maximum collection of the beetles from the area. The beetles were collected as per method used by Sharma *et al.* [3] which included hand picking, sweet nets, insect collection tubes and jars depending upon the habitat and species. Beetles collected at different locations were brought to the laboratory, processed and preserved in insect collection cabinets after proper labelling in the Biological Control Research Laboratory of the Department of Entomology, YS P University of Horticulture and Forestry, Solan (HP) India.

2.3 Identification of specimens

The beetles were examined under stereo microscope (SZ2, Olympus make, Japan) carefully for all morphological details and identification was made on the bases of available literature and reference collection maintained in the laboratory. Help of Dr J Poorani, Principal Scientist, Indian Council of Agricultural Research, National Research Centre for Banana, Tiruchirappalli, Tamil Nadu, India was also taken to identify or to confirm the identity of the specimens.

Coccinellid fauna of the state collected in the present survey and reported by earlier workers have been compiled to prepare a complete inventory of the predatory coccinellid beetles of Himachal Pradesh, India

3. Results and discussion

During the survey, 42 species of Coccinellidae namely *Adalia* sp., *Adalia tetraspilota* (Hope), *Alloneda dodecaspilota* (Hope), *Calvia punctata* (Mulsant), *Calvia* sp., *Cheilomenes sexmaculata* (Fabricius), *Chilocorus circumdatus* (Gyllenhal), *Chilocorus infernalis* Mulsant, *Chilocorus nigrita* (Fabricius), *Coccinella luteopicta* (Mulsant), *Coccinella septempunctata* Linnaeus, *Coelophora bissellata* Mulsant, *Coelophora saucia* (Mulsant), *Cryptogonus* sp. nr. *orbiculus* Gyllenhal, *Halyzia sanscrita* Mulsant, *Harmonia dimidiata* (Fabricius), *Harmonia eucharis* (Mulsant), *Hippodamia variegata* (Goeze), *Illeis* sp. nr. *cincta* (Fabricius), *Illeis* sp. nr. *confusa* Timberlake, *Illeis* sp. nr. *indica* Timberlake, *Megalocaria dilatata* (Fabricius), *Oenopia billieti* (Mulsant), *Oenopia conglobata* (Linnaeus), *Oenopia kirbyi* Mulsant, *Oenopia sexareata* (Mulsant), *Oenopia souzeti* Mulsant, *Ortalia* sp., *Ortalia* sp. nr. *vietnamica* Hoang, *Ortalia vietnamica* Hoang, *Pharoscyrmus flexibilis* Mulsant, *Phrynocaria unicolor* (Fabricius), *Platynaspis saundersii* Crotch., *Priscibrum uropygialis* (Mulsant), *Propylea dissecta* (Mulsant), *Propylea*

luteopustulata (Mulsant), *Rodolia octoguttata* Weise, *Scymnus nubilus* Mulsant, *Scymnus posticalis* Sicard, *Scymnus* sp., *Stethorus aptus* Kapur and unidentified scymninae were collected from different agro-climatic zones of the state (Table 1). Out of these, 12 species viz. *Adalia* sp., *Alloneda dodecaspilota* (Hope), *Calvia punctata* (Mulsant), *Calvia* sp., *Halyzia sanscrita* Mulsant, *Illeis* sp. nr. *confusa* Timberlake, *Illeis* sp. nr. *indica* Timberlake, *Ortalia* sp. nr. *vietnamica* Hoang, *Phrynocaria unicolor* (Fabricius), *Scymnus* sp., *Stethorus aptus* Kapur and unidentified scymninae were recorded for the first time from the state, whereas, others were reported from the state earlier also [3, 8, 18-20]. Sharma *et al.* [3] reported 36 coccinellids from different agroclimatic zones of Himachal Pradesh of which 27 were collected in the present survey, while, the other 9 could not be retrieved in the present survey. Similarly, species namely *Leis 10-maculatus*, *Harmonia13-guttata* and *Ortalia malklini* reported earlier by Sharma [18] could not be collected during the present survey. The collective list of present survey and Sharma *et al.* [3] takes the number of coccinellid species to 51. In addition, Khajuria [21] reported *Stethorus punctum* Le Conte preying on apple mites and Poorani [8] listed 13 species from Himachal Pradesh increasing the total number of species from the state to 65 (Table 1).

Beetle diversity varied with the agroclimatic conditions and zone II was the most diverse having 35 species followed by zone I (25 species). Zone IV and zone III were comparatively less diverse with 13 and 16 coccinellid species, respectively (Table 1). Beetles namely *Coccinella septempunctata*, *Hippodamia variegata* and *Cheilomenes sexmaculata* were the most common and widely distributed in all the agroclimatic zones of the state, whereas, the beetles such as *Ortalia vietnamica*, *Ortalia* sp., *Phrynocaria perroteti*, *Pharoscyrmus horni*, *Scymnus* sp., *Sumnius vestita* and unidentified scymninae were restricted to zone I, *Adalia bipunctata*, *Calvia punctata*, *Calvia* sp., *Coccinella transversalis*, *Cryptogonus* sp. nr. *orbiculus*, *Cryptogonus trioblitus*, *Illeis* sp. nr. *cincta*, *Illeis* sp. nr. *indica*, *Magalocaria delatata*, *Ortalia* sp. nr. *vietnamica*, *Psyllobora bisoetnotata*, *Phrynocaria unicolor*, *Rodolia octoguttata*, *Stethorus aptus* and *Stethorus punctum* to zone II, *Adalia* sp. nr. *simondsi* and *Alloneda dodecaspilota* to zone III and *Stethorus* sp., *Oenopia conglobata*, *Oenopia billieti*, *Halyzia sanscrita* and *Coccinella lutiopicta* to zone IV (Table 1). Extreme cold climate, desert landscape and more application of pesticides due to apple cultivation contributes to the low diversity of beetle in zone III and IV. Previous studies also reported *C. septempunctata*, *H. variegata* and *C. sexmaculata* to be the most common and abundant in Himachal Pradesh and Uttarakhand [1, 3, 17]. Among the collected species, *C. infernalis*, *P. uropygialis*, *C. luteopicta*, *H. eucharis*, *Illeis* sp. nr. *confusa*, *P. lutiopustulata*, *Adalia* sp. nr. *simondsi*, *A. dodecaspilota*, *Stethorus* sp., *O. conglobata*, *O. billieti*, *H. sanscrita*, *C. lutiopicta*, *C. septempunctata*, *H. variegata* and *C. sexmaculata* have been adapted well to the dry temperate conditions of the state (Table 1). Some of these beetles have also been reported earlier from temperate areas of Srinagar district of Jammu and Kashmir feeding on scale and aphid pests of apple [22]. Earlier reports reveal that most of the recorded beetles were effective predators of a large number of sucking pests of crops like cabbage, cauliflower, peach, eggplant, cucumber, apple, nectarine, Unimus, citrus, chrysanthemum, wheat, barley, crucifers, maize, capsicum duranta, radish, fig, forest trees, bushes and ground flora of different orchards and forests [3, 8, 18-20]. In India, many

workers have studied the biodiversity of predatory coccinellids and according to them, 36 species have been found in North India and Nepal [12, 23], 53 in Mysore [9], 17 in Goa [10], 30 in Chandigarh [11,24], 17 in Lucknow [14, 25], 21 in Maharashtra [15], 9 in Madurai, Tamil Nadu [16, 26], 31 in Haridwar region, Uttarakhand [17], 15 in Srinagar district of Jammu and Kashmir [13, 22], 25 in Dehradun region, Uttarakhand [1], 35 in Arunachal Pradesh [27], 23 in Nainital region, Uttarakhand [28], 13 in Gudalur (Nilgiris) area of Tamil Nadu [29], 24 in Tripura [30], 16 in Jharkhand [2], 9 in Mizoram [31], 12 in Assam [32], 16 in Nasik [33] and 13 in Karnataka [34] preying on different sucking pests of agriculturally important crops. Besides, Poorani [8] documented more than 400 species of predatory coccinellids from the Indian sub-region. Present study reports that *C. septempunctata*, *H. variegata* and *C. sexmaculata* are the most common and abundant coccinellid species present associated with different sucking pests of many crops in all the four agro-climatic zones of the state. These beetles along with *C. transversalis* have also been reported to be the dominant species in many cropping systems (35 Goswami *et al.*, 2016; 32 Ramya and Thangjam, 2016; 36 Hayat and Khan 2013 and 37 Hayat *et al.*, 2017). *C.*

septempunctata and *H. variegata* have also been found to be the most prone to sudden change in prey population and respond very quickly to the increase or decrease to the prey population by increasing or decreasing their density (38 Jafari 2011; 39 Swaminathan *et al.*, 2015). Present study further reveals that Himachal Pradesh harbours about 16 per cent of the predatory coccinellids reported from India which is higher than many other parts of the country. Climatically, Himachal Pradesh is unique and occupies a wide range of agro-climatic conditions ranging from hot humid sub-tropical to cold, alpine-glacials and very high (3400 mm) to almost nil rainfall zones. These agro-climatic variations are, perhaps, responsible for the higher diversity of the beetles in the state than other parts of the country. Himachal Pradesh is rich in coccinellid fauna which play an important role in the natural control of various pests of many important crops in a density dependent manner. Further, these beetles can follow their prey and are capable of migrating from one place to another depending on the availability of prey [40]. It is, therefore, important to conserve the diversity of these important predators in the state by being careful in insecticide application for pest management.

Table 1: Coccinellidae of Himachal Pradesh, India

SN	Coccinellid species	Prey insect/host plant	Zone	Reference
1	<i>Adalia bipunctata</i> (Linnaeus)	Peach leaf curl aphid	II	[3,18]
2	<i>Adalia simonlsi</i> Kapur & Suha Rao	-	-	[8]
3	<i>Adalia</i> sp nr <i>simonlsi</i> Kapur & Suha Rao	Ground flora of deodar forest	III	[Present survey]
4	<i>Adalia tetraspilota</i> (Hope)	Wheat field, Peach leaf curl aphid	I, II, III	[Present survey,] [3, 8, 18]
5	<i>Alloneda dodecaspilota</i> (Hope)	Apple tree	III	[Present survey]
6	<i>Brumoides suturalis</i> (Fabricius)	Unknown weed plant	I, II	[3]
7	<i>Callicaria superba</i> (Mulsant)	-	-	[8]
8	<i>Calvia breiti</i> Mader	-	-	[8]
9	<i>Calvia punctata</i> (Mulsant)	Peach orchard	II	[Present survey]
10	<i>Calvia</i> sp	Peach orchard	II	[Present survey]
11	<i>Cheilomenes sexmaculata</i> (Fabricius)	All most all the cropping systems	I, II, III, IV	[Present survey,] [3,18,19]
12	<i>Chilocorus circumdatus</i> (Gyllenhal)	Citrus and peach orchards	I, II	[Present survey,] [18]
13	<i>Chilocorus infernalis</i> Mulsant	Sanjose scale in apple	III, IV	[Present survey,] [3,8,18]
14	<i>Chilocorus nigrita</i> (Fabricius)	Scale on citrus	I, II	[Present survey,] [3]
15	<i>Coccinella luteopicta</i> (Mulsant)	Apple and radish	IV	[Present survey,] [3]
16	<i>Coccinella septempunctata</i> Linnaeus	All the cropping systems	I, II, III, IV	[Present survey,] [3,18-20]
17	<i>Coccinella transversalis</i> Fabricius	Aphid on capsicum	II	[3,18]
18	<i>Coelophora bissellata</i> Mulsant	Sorghum, unidentified bushes	I, II	[Present survey,] [3]
19	<i>Coelophora saucia</i> (Mulsant)	Pomegranate tree, weeds	I, II	[Present survey,] [3]
20	<i>Cryptogonus</i> sp nr. <i>orbiculus</i> Gyllenhal	Tomato and cucumber	II	[Present survey,] [3]
21	<i>Cryptogonus trioblittus</i> (Gorham)	Unidentified bush	II	[3]
22	<i>Halyzia sanscrita</i> Mulsant	Collected in a light trap	IV	[Present survey]
23	<i>Halyzia straminea</i> (Hope)	-	-	[8]
24	<i>Halyzia tschitscherini</i> Semenow	-	-	[8]
25	<i>Harmonia dimidiata</i> (Fabricius)	All the cropping systems	I, II, III	[Present survey,] [3,8,18-20]
26	<i>Harmonia eucharis</i> (Mulsant)	Peaches, apple, conifers	II, III, IV	[Present survey,] [3,8]
27	<i>Harmonia expalida</i> (Weise)	-	-	[8]
28	<i>Hippodamia tredecimpunctata</i> (Linnaeus)	-	-	[8]
29	<i>Hippodamia variegata</i> (Goeze)	All the cropping systems	I, II, III, IV	[Present survey,] [3,8,18-20]
30	<i>Illeis</i> sp nr <i>cincta</i> (Fabricius)	Cucumber, rose	II	[Present survey,] [3,18]
31	<i>Illeis</i> sp nr <i>confusa</i> Timberlake	Peaches, light trap	II, IV	[Present survey]
32	<i>Illeis</i> sp nr <i>indica</i> Timberlake	Unknown	II	[Present survey]
33	<i>Megalocaria dilatata</i> (Fabricius)	Bamboo aphid	II	[Present survey,] [3,8]
34	<i>Oenopia billieti</i> (Mulsant)	Light trap	IV	[Present survey,] [8]
35	<i>Oenopia conglobata</i> (Linnaeus)	Almond orchard, light trap	IV	[Present survey,] [8]
36	<i>Oenopia kirbyi</i> Mulsant	Peach, cucumber, almond	I, II, III	[Present survey,] [3, 8]
37	<i>Oenopia mimica</i> Weise	-	-	[8]
38	<i>Oenopia sexareata</i> (Mulsant)	Many crops	I, II, III	[Present survey,] [3,18]
39	<i>Oenopia souzeti</i> Mulsant	Many crops	I, II, III	[Present survey,] [3,8,18]
40	<i>Ortalia</i> sp	Fig, citrus, paper mulberry	I	[Present survey,] [3]
41	<i>Ortalia</i> sp nr <i>vietnamica</i> Hoang	Peach	II	[Present survey]
42	<i>Ortalia vietnamica</i> Hoang	Fig, citrus, paper mulberry	I	[Present survey,] [3]

43	<i>Palaeoneda auriculata</i> (Mulsant)	-	-	[8]
44	<i>Pharoscyrnus flexibilis</i> Mulsant	Apple, nectarine, citrus, Unymus	I, II, III	[Present survey,] [3]
45	<i>Pharoscyrnus horni</i> Weise	Nectarine	I	[3]
46	<i>Phrynocaria unicolor</i> (Fabricius)	Peaches	II	[Present survey]
47	<i>Phrynocaria perrotteti</i> (Mulsant)	Citrus	I	[3]
48	<i>Platynaspis saundersii</i> Crotch.	Apple, <i>Solanum nigrum</i> , unidentified bush	I, II, III	[Present survey,] [3,8]
49	<i>Priscibrumus lituratus</i> (Gorham)	-	-	[8]
50	<i>Priscibrumus uropygialis</i> (Mulsant)	Apple, radish, unidentified bush	III, IV	[Present survey,] [3,8]
51	<i>Propylea dissecta</i> (Mulsant)	Sorghum, peach, unidentified bush	I, II	[Present survey,] [3]
52	<i>Propylea luteopustulata</i> (Mulsant)	Apple, pomegranate, radish, peach, brinjal	II, III, IV	[Present survey,] [3,8]
53	<i>Psyllobora bisoctonotata</i> (Mulsant)	Duranta	II	[3]
54	<i>Rodolia fumida</i> Mulsant	-	-	[8]
55	<i>Rodolia octoguttata</i> Weise	Peaches	II	[Present survey,] [3]
56	<i>Scymnus nubilus</i> Mulsant	Maize, cucumber, colocasia, sorghum	I, II	[Present survey,] [3]
57	<i>Scymnus posticalis</i> Sicard	Maize, cucumber, colocasia, sorghum, citrus	I, II	[Present survey,] [3,8]
58	<i>Scymnus</i> sp	Mango	I	[Present survey]
59	<i>Stethorus aptus</i> Kapur	Mite on unidentified host	II	[Present survey]
60	<i>Stethorus gilvifrons</i> (Mulsant)	-	-	[8]
61	<i>Stethorus punctum</i> Le Conte	Mite on apple	II	[21]
62	<i>Stethorus</i> sp	Mite on apple	IV	[3]
63	<i>Sticholotis marginalis</i> Kapur	-	-	[8]
64	<i>Sumnius vestita</i> (Mulsant)	Unknown	I	[3]
65	unidentified scymninae	Nectarine	I	[Present survey]

4. Conclusion

The study presents an inventory of the predatory coccinellids of Himachal Pradesh and reveals that the state is very rich in coccinellid fauna associated with different crop pests. The study presents useful information for future workers to develop bio-intensive management strategies for temperate crop pests which will reduce the farmers' sole dependence on harmful chemical pesticides. The study will also be useful to select an appropriate species for further bio-ecological studies. However there is a need to conserve these important beetles by avoiding indiscriminate use of chemical pesticides.

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