Biocontrol potential of insects associated with invasive weed Canada thistle *Cirsium arvense* (L) Scop. (Asteraceae) in Jammu (J&K), India

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Abstract

The present work, on the study of insects associated with invasive weed Canada thistle (*Cirsium arvense*), was conducted in the Jammu division of J&K state, India. The study aimed at enumerating the potential biocontrol agents that can be used to control the expanding population of Canada thistle (*Cirsium arvense*), which was introduced accidentally in the region. A total of 13 insects belonging to 4 orders, i.e. Coleoptera, Hemiptera, Lepidoptera and Diptera were recorded for the first time on this weed. Order Coleoptera (53.85%) dominated the table followed by Hemiptera (30.77%) while least abundant were Diptera and Lepidoptera (7.69%) each. Of all the insects studied, four insects, namely, *Vanessa cardui*, *Orellia ruficauda*, *Cleonis piger* and *Lixus sp.*, have been observed to cause significant damage to *Cirsium arvense* in Jammu division. Various life cycle stages of these insects feed on the weed thereby creating a possibility for biocontrol. Despite enumerating the potential biocontrol agents from the study area, still more work needs to be done with regard to the spread of this weed in the state and in the country as well. Firstly, the efficacy and biocontrol potential of these pests needs to be evaluated, secondly, more natural enemies should be sought for managing this invasive species.

Key words: *Cirsium arvense*, Canada thistle, Alien species, weeds.

Introduction

Alien species that become invasive are considered a main driver of biodiversity loss across the globe. In addition, alien species have been estimated to cost our economies hundreds of billions of dollars each year. Invasive alien species have invaded and affected native biota in almost every ecosystem type on Earth, and have affected all major taxonomic groups (IUCN, 2000)· The Millennium Ecosystem Assessment concluded that the relative impact of invasive alien species on biodiversity has varied across biomes, and that for all biomes, the impact is either steady or increasing (MEA, 2005).Safeguarding the earth's biodiversity is the best way to maintain our life support system. Communities all over the world are taking useful initiatives, which contribute to one better management practices and a reduced incidence of biological invasions.

Canada thistle (*Cirsium arvense*), (Fig.1, 2) native to Europe is one of the top ten worst invasive species in world. It is an herbaceous perennial with erect stems, prickly leaves and an extensive creeping rootstock. It belongs to family Asteraceae. In India, it is widely spread in northern region and introduced accidentally (Zouhar, 2001). Severe to medium infestation of this weed can be observed in many parts of the country, including the state of Jammu and Kashmir (Fig.3). Canada thistle has become one of the most serious weed pests in agricultural, rangeland and wet land environmental (Nuzzo, 1997). The invasive nature of Canada thistle is mainly due to extensive vegetative reproduction and large amount of seed production involving development of new shoots from a spreading, ramifying root system. Canada thistle forms dense patches, with up to 39 stems per m^2 (Bakker, 1960) and spreads by lateral expansion of root system.

Cirsium arvense is very tenacious and difficult to control. (Nuzzo, 1997) reports that it should be removed from high quality natural areas when it is first observed. By using chemicals, mechanical removal, fire etc. it can be controlled to some extent. However, in many situations these methods are not feasible because of the large areas involved, its capability to resurge and high

operational and chemical cost etc. All these factors limit the usefulness of herbicides in its control. As this weed cover extensive areas, the mechanical and chemical control become expensive especially for developing countries like India. In addition, increasing concern about financial costs and undesirable environmental hazards associated with chemical control measure and their limited effectiveness had led to growing interests in the use of biological control especially using insect as natural biocontrol agents.

Due to lack of any effective management practices being adopted in Jammu region and the problem posed by this alien invasive weed, it becomes very important to undertake research and devise effective management program for this invasive species in the region. A long-term objective is the biological control program which eventually removes the need for conventional (often chemicals) method of control for a weed species that is growing prolifically in the absence of its natural enemies.

Materials and Methods

Study Area: The State of Jammu and Kashmir is the northern most state of India covering an area of 2,22,236 sq. Km. The state lies between $32^{o}17^{'}$ to $36^{o}58^{'}$ North latitude and $73^{o}26^{'}$ to $80^{o}30^{'}$ East latitude (Fig.3). It has four geographical zones of Sub-mountain and semi-mountain plain known as Kandi or dry belt, the Shivalik ranges, the high mountain zone constituting the Kashmir Valley, Pir Panchal range and its off-shoots including Doda, Poonch and Rajouri districts and part of Kathua and Udhampur districts and the middle run of the Indus river comprising Leh and Kargil. The state is divided into three divisions: Jammu, Kashmir and Ladakh. The state shares international boundaries with Pakistan in the west, China in the north and Tibet in the west. The climate varies from tropical in Jammu plains to semi-arctic cold in Ladakh with Kashmir and Jammu mountainous tracts having temperate climatic conditions. The annual rainfall also varies from region to region with 92.6 mm in Leh, 650.5 mm in Srinagar and 1115.9 mm in Jammu. A large part of the State forms part of the Himalayan Mountains. The state is geologically constituted of rocks varying from the oldest period of the earth's history to the youngest present day river and lake deposits. The present work was carried out in Jammu Division of the state.

Jammu Division is situated at the northwest of India and is bordered by Punjab and Himachal Pradesh in the east and Pakistan in the west and south while Pir Panjal range of mountains separates it from Kashmir division in the north. It is situated between the longitude 74^{o} 9' East and 32^{o} 67' North. Altitude varies from nearly 1000 ft. to 1200 ft. above sea level. Due to extreme variations within a limited distance, there is a marked difference in climate. Jammu is divided into 10 districts i.e., Jammu, Kathua, Udhampur, Samba, Reasi, Ramban, Doda, Kishtwar, Rajouri, Poonch.

Methods: The present work is based on the studies conducted by the author both in the field as well as in the laboratory conditions. The field studies for recording the spread of the weed, *Cirsium arvense* and the survey of various insect enemies associated with it was conducted in all the ten districts of Jammu, Kathua, Samba, Udhampur, Reasi, Rajouri, Poonch, Doda, Ramban, and Kishtwar. The insects along with their immature stages were collected initially from the fields using traditional entomological techniques. After collection, the insects were killed using ethyl acetate in killing bottle. After killing, the insects were pinned and then oven dried for some time and were stored in collection boxes for subsequent morphological studies and for determining their taxonomic status. Agencies like Indian Agricultural Research Institute (IARI), New Delhi and ZSI Kolkata were approached for the identification of the insects.

Observations and Discussion

Extensive survey of phytophagous insects associated with *Cirsium arvense* was carried out in Jammu division of J&K state. The survey yielded 13 species of insects from four orders i.e. Coleoptera (53.85%), Lepidoptera (7.69%), Hemiptera (30.77%) and Diptera (7.69%) Table: 1, Fig.4.

Among these, Coleoptera and Hemiptera were predominant. All these species recorded have been reported for the first time on *Cirsium arvense* from Jammu. The Coleoptera includes *Cleonis piger* and *Lixus* species (Curculionidae), *Hoplosoma maculata*, *Cryptocephalus senarius*, *Lema* species and *Cassida* species (Chrysomelidae) and *Mylabris phalerata* (Meloidae). The lepidopteran insects include *Vanessa cardui* (Nymphalidae). The Hemipteran includes *Dolycoris baccarum*, *Nezara viridula* (Pentatomidae), *Lygaeus militaris* (Lygaeidae) and *Cosmoscarta* species (Cercopidae). Dipteran includes *Orellia ruficauda* (Tephritidae). This fly is being used as a potential biocontrol agent of *Cirsium arvense* in many countries of the world. Of all these insects, four insects namely *Vanessa cardui*, *Orellia ruficauda*, *Cleonis piger* and *Lixus* species have been observed to cause significant damage to C*irsium arvense* in Jammu division. The details of the insects collected are given below:

***Vanessa cardui* (L.) Nymphalidae**

Vanessa cardui (Fig.5) commonly called as 'The Painted Lady Butterfly or thistle butterfly has been recorded on *Cirsium arvense* for the first time from Jammu region. It is very common and widespread throughout the world, except South America, The Arctic and Australia. This species has attracted much attention because of its peculiar external morphology and its impact on *C. arvense*. Publication to this date have dealt with the biology and life history of the species (Opler and paul, 1992; Shields, 1987 and Harris, 1999).Only the larval stage of *Vanessa cardui* feeds voraciously and cause significant damage to this weed. Defoliation of *C. arvense* by larvae reduce the number of leaves, plant height, plant density and reduction in number of flowers.

Vanessa cardui can be efficient biocontrol agent that can have significant negative impact on the growth and reproduction of *C. arvense*. It can play an important role in reducing the density of weed in Jammu region and encourage the growth of vegetation formerly suppressed by this weed. Besides, the climatic conditions are quite conducive for its growth and development. Effectiveness is more serious when damage is initiated at the early stage of plant growth and sustained for longer duration. In Jammu region, this butterfly has been recorded to feed only on this plant.

According to Detmers (1972) and Rees (1991), the larvae of *Vanessa cardui* can defoliate and kill individual plants and thus can be very effective biocontrol agents.

Vanessa cardui has the potential to become a good biocontrol agent of Canada thistle in Jammu region as it causes considerable damage to *C. arvense* during its activity period. Detailed studies on the biocontrol potential of this butterfly in Jammu region is further being carried out.

***Orellia ruficauda* (Fab.) Tephritidae**

Orellia ruficauda (Fig.6) also known as seed head predator, is a small fly that deposits its eggs in the flower heads of *Cirsium arvense*. It is recorded for the first time on *Cirsium arvense* in Jammu region. *Orellia ruficauda* is adventive to North America where it is found in a wide variety of Canada thistle habitats. In Canada, it has been found in British Columbia, Manitoba, Ontario and New Foundland. Its geographical range is all Palaearctic except the south. Its distribution in United States is similar, stretching from coast to coast. This fly has already been used as biocontrol agent in North America (Forsyth and Watson, 1985a).

The larval stages of the fly have huge potential in causing damage to *C. arvense*. Adult do not cause any damage. The damage occurs when developing larvae eat the seed from May-August, thus reducing the seed production, seed dispersal and reproduction of *Cirsium arvense*.

Orellia ruficauda is one of the most potential biocontrol agents. In one study, 20-85% of seed heads were attacked and 20-80% of seeds within each other attacked seed head were damaged (Forsyth and Watson, 1985b; Detmers, 1927). *Orellia ruficauda* occurred in up to 70% flowers heads and destroyed 22% of seeds/head. The biocontrol potential of this fly in Jammu region is very high and if this fly is cultured and released in field, it will play significant role in decreasing the growth of *Cirsium arvense*.

***Cleonis piger* (Scop.) Curculionidae**

Cleonis piger (Fig.7) is also known as "The root feeding weevil". It occurs in New york, Pennysylvania, Michigan, Indiana, Ontario and Quebec. *Cleonis piger* occurrence on *Cirsium arvense* is very common. The species is very important because of its impact on *Cirsium arvense*. *C. piger* is however recorded for the first time on *C. arvense* from Jammu region. O'Brien and Wibmer, 1982; Anderson, 1987, studied the distribution, biology and Life history of *Cleonis piger*.

Both the adult and the larval stages are potential in causing damage to *Cirsium arvense.* The adults of *Cleonis piger* feed on leaves of host plant and cause severe defoliation. Adult feed on both fresh as well as on older leaves thereby reducing the power to produce flower and seeds. The larval stages are more potential natural enemies. The larvae feed in the lower portion on the stem tissue and feed on roots and leaves near the soil.

Cleonis piger can be one of the good biocontrol agents that can cause great negative impact on the growth and reproduction of this weed. This weevil can reduce the density of this weed in Jammu region and prevent its further spread. Beside the climatic conditions are quite conducive for its growth and development of *Cleonis piger*. *Cleonis piger* has earlier been reported to cause extensive damage to *C. arvense* in Europe (LaFerla, 1939 and Zwolfer, 1965). Since this weevil has been recorded for the first time, its efficacy and biocontrol potential is yet to be ascertained. In this direction, detailed studies on its relative abundance, host specificity and biology are further being carried out.

***Lixus* species (Fab.) Curculionidae**

Lixus species (Fig.8), the stem mining weevil; it occurs in Canada and United States with concentrations in Southern Canadian provinces, and Northern United States. *Lixus* species occurs on Canada thistle. This is very important weevil for its impact on *Cirsium arvense* (Anderson, 1987). Earlier, *Lixus cardui* has been reported to reduce plant vigour and size in thistles (Woodburn and Briese, 1996).

Both larval and adult stages feed on the plant. The larval stages feed on soft tissues of stem. The larval mine down the stem and make plant dry. Adults feed on the leaves of plant and thus have a great potential for the control of Canada thistle. Like *C. piger*, this weevil species also cause extensive damage to *C. arvense* in Jammu region. Further study to ascertain the biocontrol potential of this weevil is being carried out.

***Lygaeus militaris (*Fab.) Lygaedeae**

This is commonly known as milkweed bug, soldier bug, seed bug, lygarid bug (Fig.9). It is found in Canady Island, Spain, Tunisia, Kenya, Australia, South Africa, Southern Europe, China, India and Mediterranean countries. In India, it is found in Rajasthan, Darjeeling, Haora and Nadia (Debagram).

Lygaeus militaris is a phytophagous species feeding on many different plants like *Asclepias fructicosa* (L.); *Asclepias curassavical* (L.), *Emilia sochifolia* (L.), *UrenalLobata* (L.), *Gossypium sp.* etc. (Sudan, 2008).

The adults were found feeding on leaves and near flowering peduncles of *Cirsium arvense* causing appreciable damage. The bugs feed together with their sucking mouthparts inserted into the buds, leaves, flowers etc. Damaged leaves and flowers eventually become dry.

***Nezara viridula* (L.) Pentatomidae.**

It is commonly known as Southern stinkbug, Southern Green shield Bug and Green Vegetable bug (Fig.10). It is widely disturbed in Ethiopia, Europe, Asia, Africa, Australia (Panizzi *et al.* 2000), North America (Hoffmann *et al.* 1991), South America and New

Zealand (Waterhouse and Norris, 1987). In India, it is found in Maharashtra, Himachal Pradesh, Assam, West Bengal, Medinipur, Murshidabad etc.

Nezara viridula is a highly phytophagous feeder, attacking many important food plants comprising a very wide range of fruits and ornamental and wild plants, field crops, vegetable and weeds. E.g., Cabbage, Citrus, Crucifers, Castor bean, Peppers potatoes soybeans, amaranth, cotton, peaches, tomatoes and *Jatropha curcas* (Sudan, 2008; Raina, 2009).

Nezara viridula was found feeding on *Cirsium arvense*. The bugs feed by piercing plant tissue with needle like stylets. Adult and all nymphal stages suck plant sap from leaves and flowers.

***Dolycoris baccarum* (L.) Pentatomidae**

This bug is commonly known as Brown Shield bug, berry bug, sloe bug and hairy shield bug (Fig.11). In world, it is found in China, Japan, Turkey, Britain, Germany, Bulgaria, Spain, Sweden, Denmark, Former USSR, France, Italy, Norway etc. In India it is found in Kolkata, Tamil Nadu, Bhavanisagar, Darjiling, Jalpaiguri, Maldah, Koch Bihar, Medinipur

It is a polyphagous pest of perennials, especially in hedgerow shrubs and berries, feeding on growing shoots and fruits. E.g. Raspberry, Hawthorn, Strawberry, rice, cherry, potatoes, *Jatropha curcas* etc. (Sudan, 2008; Raina, 2009).

These bugs have been found feeding on *Cirsium arvense*. Both adults and nymphs feed severely on *Cirsium arvense*. They suck the plant sap from leaves, flowers and flower buds leading to the necrosis, especially of young parts of the plant. They usually feed on the plants near flowering peduncles often turning them dry.

The above-mentioned Hemipteran insects are polyphagous and are pests of many economically important crops and as have a very limited role in the biocontrol programme for *C. arvense.*

OTHER INSECTS

Five beetles include *Cassida sp.* (Fig.16), *Mylabris phalerata* (Fig.12), *Hoplosoma maculata* (Fig.13), *Cryptocephalus senarius* (Fig.14) and *Lema species* (Fig.15) have been recorded on *Cirsium arvense*.

Of these, *Mylabris phalerata* feeds extensively on the flowers of *Cirsium arvense*. Inspite of *Mylabris phalerata* causing extensive damage to *Cirsium arvense*, it is a serious pest of many Malvaceous plants and thus, has a limited role in the ecological management of *Cirsium arvense*.

Tortoise beetle (*Cassida* species) (Fig.16). Adult beetle feed on stems and foliage of Canada and musk thistle. This hardy and effective beetle defoliates plant. Observation shows that *Cassida* species can be a promising biocontrol agent on *Cirsium arvense.*

Hoplosoma maculata (Fig.13), the adult beetle is found to feed on leaves and sometime on stem also. *Cryptocephalus senarius* (Fig.14) feed on leaves and *Lema* species (Fig.15) feed on flowers of *Cirsium arvense. Cosmoscarta* species (Fig.17) adult feeds on the young apical portion of the plant and sucks sap from the young tissues thus damaging the plant.

Conclusion

A comprehensive strategic plan needs to be prepared in response to growing community concern regarding the spread of *Cirsium arvense* within the state of Jammu and Kashmir and rest of India and the impact of it in production areas, on environment and on the human affairs. Nationally the emphasis must be on establishing, detection, monitoring and stopping the spread of this invasive species. Further work on the biological control of *Cirsium arvense* is needed in Jammu region. First, available species need to be fully evaluated specially the efficacy and biocontrol potential of *Vanessa cardui*, *Orellia ruficauda*, *Cleonis piger* and *Lixus* species. Second additional natural enemies from the native range of *C. arvense* should be sought and augmentation of the existing ones especially the *Orellia ruficauda* which has huge potential in managing this invasive species.

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Table: 1: Potential Bio-control agents recorded from Jammu Division during the study period.

S.No.	Name	Order	Family	Remarks
1.	*Vanessa cardui*	Lepidoptera	Nymphalidae	Larvae feed on leaves
2.	*Orellia ruficauda*	Diptera	Tephritidae	Larvae feed on flower head
3.	*Cleonis piger*	Coleoptera	Curculionidae	Feed on leaves and stem
4.	*Lixus* species	Coleoptera	Curculionidae	Feed on leaves and stem
5.	*Mylabris phalerata*	Coleoptera	Meloidae	Feed on flowers
6.	*Hoplosoma maculata*	Coleoptera	Chrysomelidae	Feed on leaves and stem
7.	*Cryptocephalus senarius*	Coleoptera	Chrysomelidae	Feed on leaves and flowers
8.	*Lema* species	Coleoptera	Chrysomelidae	Feed on leaves and flowers
9.	*Cassida* species	Coleoptera	Chrysomelidae	Feed on flowers
10.	*Lygaeus militaris*	Hemiptera	Lygaeidae	Leaf sap sucker
11.	*Nezara viridula*	Hemiptera	Pentatomidae	Leaf sap sucker
12.	*Dolycoris baccarum*	Hemiptera	Pentatomidae	Leaf sap sucker
13.	*Cosmoscarta* species	Hemiptera	Cercropidae	Stem sap sucker

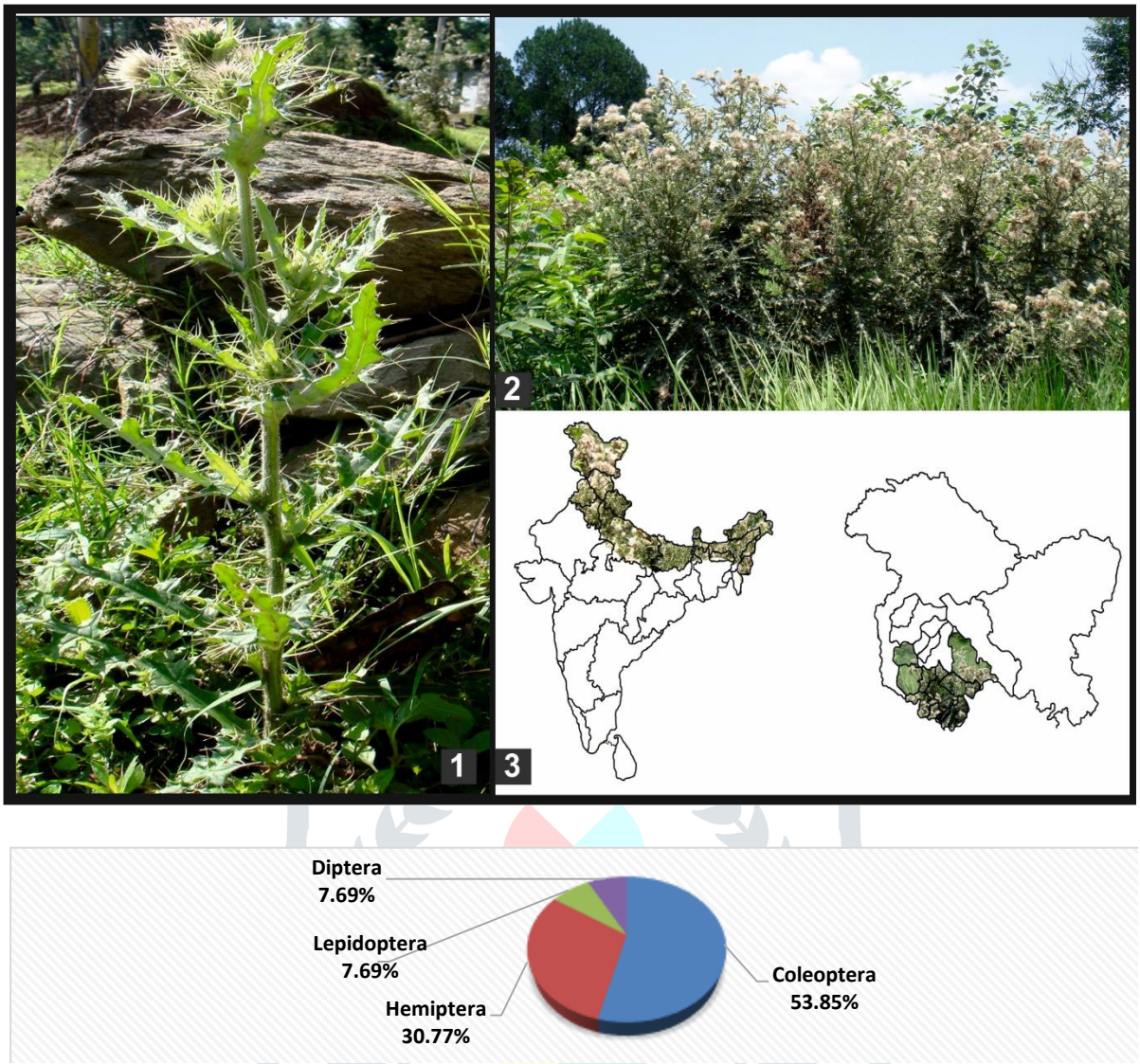
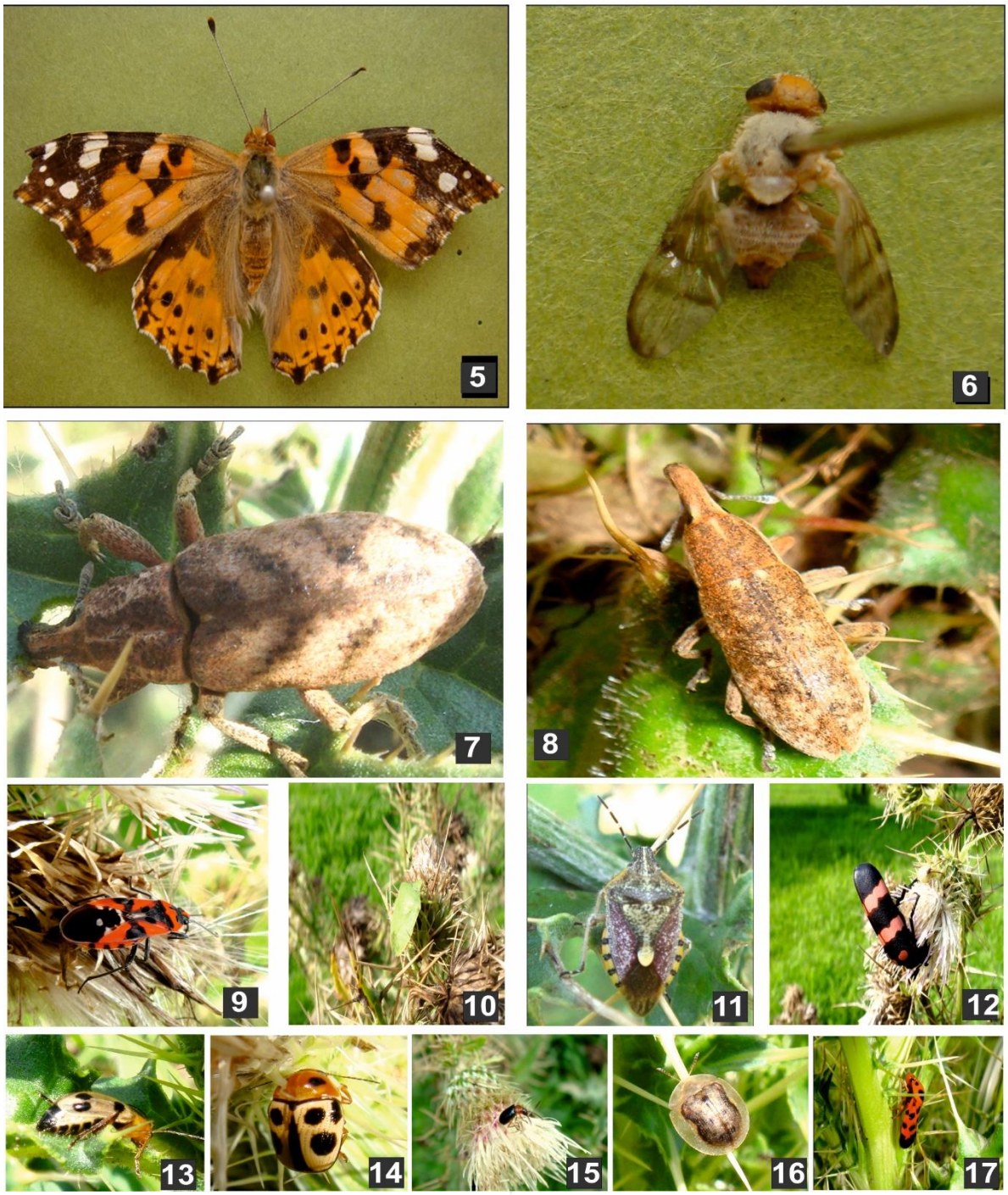


Fig. 4: Relative Abundance of insects on *Cirsium arvense* in Jammu.



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