ENTOMOLOGY

First report of Coccinellid beetles (Coleoptera: Coccinellidae) from Gharana Wetland Conservation Reserve and connected agricultural fields in Jammu

Anosh Ali,[1] Mohd Yousuf,[1] Akhtar Ali Khan[2]

[1]Department of Zoology, School of Life Sciences, Central University of Kashmir, Nunar, Ganderbal, Jammu and Kashmir; [2]Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar Campus, Srinagar, Jammu and Kashmir, India

Abstract

The present study reveals that Predatory ladybird beetles are being utilized for the application of biological control in many agricultural and horticultural fields globally. A comprehensive survey was carried out for the collection of ladybird beetles by different methods like handpicking, sweeping net, and beat tray method in the month of May and June 2023 in Gharana wetland conservation reserve and connected agricultural fields along the international border in the outskirts of Jammu. A total number of 12 species were collected. The collected specimens were identified up to the species level as *Coccinella septumpunctata* (Linnaeus), *Hippodamia variegata* (Goeze), *Propylea dissecta* (Mulsant), *Henosepilachna vigintioctopunctata* (Fabricius), *Menochilus sexmaculatus* (Fabricius), *Brumoides suturalis* (Fabricius), *Oenopia sauzeti* (Mulsant), *Anegleis cardoni* (Weise), *Oenopia conglobata* (Mulsant), *Micraspis allardi* (Mulsant), *Platynaspidius saundersi* (crotch), *Harmonia eucharis* (Mulsant). This study also shows the dominance of the two species *i.e.*, *Coccinella septumpunctata* and *Oenopia sauzeti* occurring along the agricultural fields in the vicinity of this wetland.

Correspondence: Anosh Ali, Department of Zoology, School of Life Sciences, Central University of Kashmir, Nunar, Ganderbal, Jammu and Kashmir, 191201, India.
E-mail: anoshali508@gmail.com

Key words: Gharana wetland; agricultural; biological control; Coccinellidae; predatory beetles.

Acknowledgments: the authors are highly thankful to Central University of Kashmir, Ganderbal and SKUAST-K, Shalimar for providing needful research facilities.

Contributions: the authors contributed equally.

Conflict of interest: the authors declare no potential conflict of interest.

Funding: none.

Availability of data and material: data and materials are available by the authors.

Received: 3 January 2024.
Accepted: 10 January 2024.

Licensee PAGEPress, Italy
Journal of Entomological and Acarological Research 2023; 55:12255
doi:10.4081/jear.2023.12255

Introduction

Ladybirds, often known as ladybirds or ladybird beetles, are classified under the family Coccinellidae. The family comprises 360 genera and around 6000 species globally (Vandenberg, 2002). India has documented over 400 species of ladybird beetles (Poorani 2002; Kapur, 1954). These beetles belong to the order Coleoptera, which is a group of winged insects with hard exoskeletons. Specifically, they are part of the superfamily Cucujoidea and the suborder Polyphaga. This information is supported by Kovar (1996) and Hunt *et al.* (2007). The effectiveness of *Chilocorus infernalis* (Mulsant) in controlling sanjose scale in apple orchards was investigated in five locations of Kashmir. The release of predators at four different rates resulted in a considerable reduction in Sanjose scale infestation across all locations in Kashmir (Khan and Zaki, 2007). Coccinellids are predatory insects commonly used as efficient biological control agents to manage insect pests in different crops (Obrycki and Kring, 1998). However, certain phytophagous species, such *Epilachna* spp., are known to cause damage to crops and are considered pests (Omkar and Pervez, 2016). These phytophagous species consume the plants belonging to the Solanaceae family (Mishra and Yousuf, 2019). The majority of ladybird species, including both adults and larvae, are predators that feed on insects (entomophagous). They consume microscopic insects such as aphids, whiteflies, scale insects, mealybugs, and mites (Moreton, 1969; Hawkeswood,

1987; Majerus, 1994; Salehi *et al.,* 2011). In addition to the large group of species that feed on other animals, ladybird beetles also include species that feed on fungi, some of which are harmful to economically significant crops (Giorgi, *et al*. 2009). India is actively involved in the large-scale breeding of Coccinellids, specifically *Coccinella septempunctata* and *Harmonia axyridis*. These insects are utilized for pest control in various agricultural crops. This practice has been documented by Bianchi and Van der Werf (2003), as well as Koch *et al.* (2005). Ladybird beetles have also been examined as effective models for addressing many issues related to ecology and evolution (Omkar and Parvez, 2016).

Study area

Collection of the ladybird beetles was carried out during May and June 2023 in the Gharana Wetland Conservation Reserve, located at 10km away from Ranbir Singh Pora and 35km approximately far from Jammu city. The wetland is situated just 500m from the international border of India-Pakistan with a total area of about 1600 kanals providing home for many migratory birds. Despite this, it has been declared an Important Bird Area by international organizations. This wetland also harbors roofs for many insect species. The ladybird beetles were also collected in agricultural fields surrounding this wetland, favoring shady environments for them.

Geographical location

The Gharana wetland is situated at a zero-line international border between India and Pakistan in the southwest part of District Jammu in the union territory of Jammu and Kashmir, bears a latitude of 32.54°N and a longitude of 74.69°E with an altitude level of 273m (Figure 1).

Materials and Methods

These ladybird beetles were collected by applying the following methods: i) hand-picking method: big-sized coccinellid beetles were picked directly by hand and preserved in 70% alcohol; ii) sweeping net (Gadakar *et al.,* 1990) method: approximately 500 sweeps were taken from the green vegetations of a spot and complete material has been preserved in 70% alcohol, from which sorting was carried out under microscope and coccinellids were sorted out to preserve in 70% alcohol; iii) beating tray method: taking the tray under a bush,

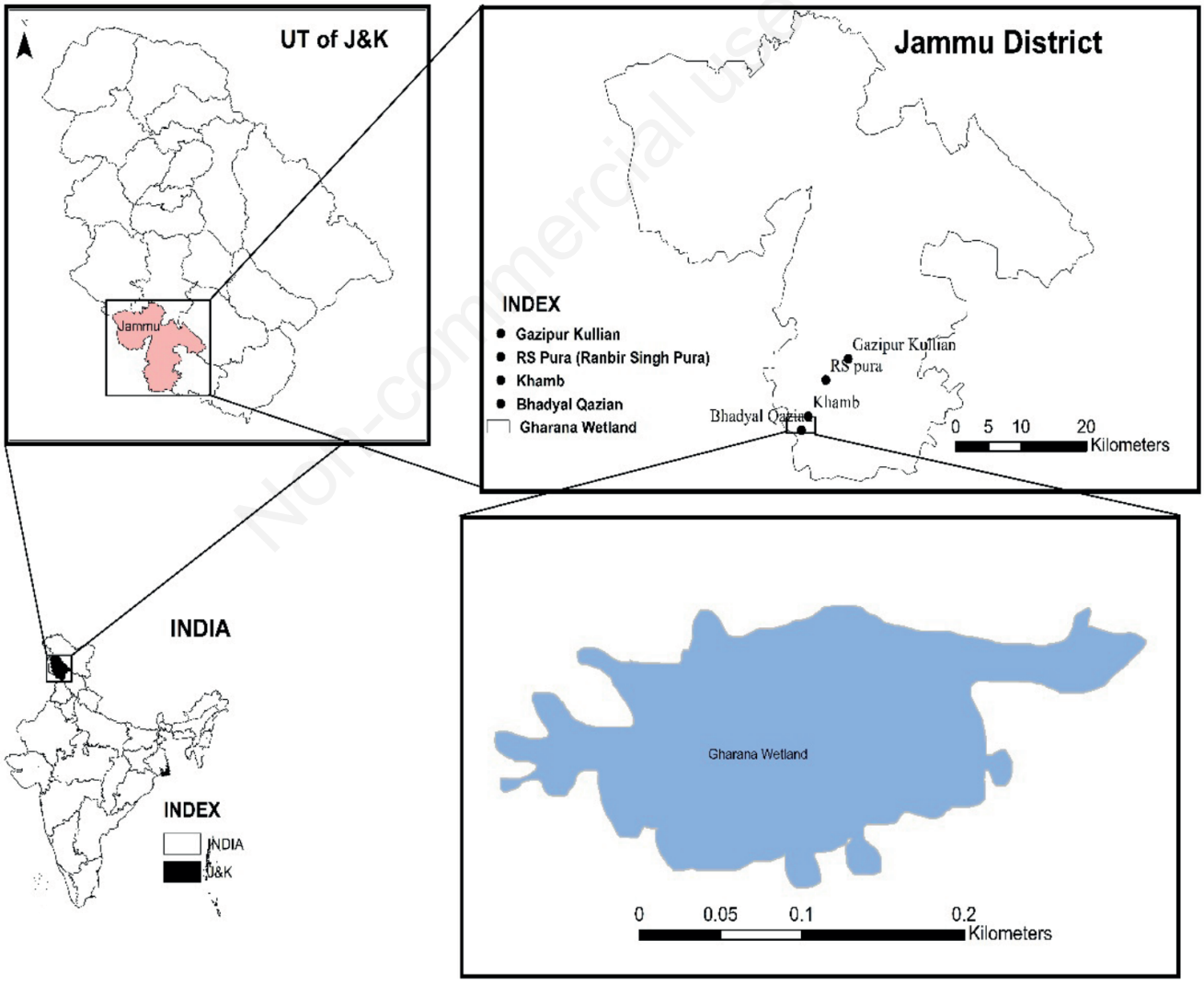


Figure 1. Map of Gharana Wetland Conservation Reserve along with their location sites.

beating was followed for collection of adult beetles and pupae. Adults were preserved in 70% alcohol and pupae were kept at laboratory temperature, till the adults emerged; iv) killing and preservation: beetles were put in a jar containing some cotton balls with ethyl acetate fumes. After killing, some specimens were transferred in 5ml plastic vials containing 70% alcohol for dissection and some were kept in 90% alcohol for molecular screening. The rest of the specimens were kept in plastic containers for drying purposes; v) labeling: specimens collected were labeled with their collection date, name of the locality, host plant and the collector; vi) sorting: these preserved beetles were sorted and examined under Olympus microscope for identification based on their morphological characters; vii) dissection: to study the genitalic characters of these collected specimens dissection (Afroze and Shafee, 1991) was carried out; viii) identification: for the identification of these ladybird beetles descriptions by many taxonomist was taken into consideration. (Kapur, 1955, 1973, Poorani, 2002).

Results

The present study reports the identification of 12 species *Coccinella septumpunctata* (Linnaeus), *Hippodamia variegata* (Goeze), *Propylea dissecta* (Mulsant), *Henosepilachna vigintioctopunctata* (Fabricius), *Menochilus sexmaculatus* (Fabricius), *Brumoides suturalis* (Fabricius), *Oenopia sauzeti* (Mulsant), *Anegleis cardoni* (Weise), *Oenopia conglobata* (Mulsant), *Micraspis allardi* (Mulsant), *Platynaspidius saundersi* (crotch), *Harmonia eucharis* (Mulsant). All these 12 species are being reported for the first time from Gharana Wetland Conservation Reserve along with the agricultural fields in its vicinity. Details of the collected species are described below along with subfamily (see Table 1; Poorani, 2002 and Tomaszewska and Szawaryn, 2016).

1) *Coccinella septumpunctata* (Linnaeus)

Diagnosis: it is most commonly found ladybird beetle in India and in other parts of the world (Kapur, 1973). The body length of the beetle is about 6.0mm with 5.0mm in width. The body of the beetle is dome shaped and oval. The elytral colour is brown or red with a pattern of seven black spots and one sutural spot in the middle. The pronotum of the beetle is black having two spots on each side. The head is black with brown eyes and mouth parts and antennae dark brown in color (Figure 2).

Remarks: habit with associated host plant: it is a mealy bug destroyer, feeds on aphids, white flies. It was collected from *Rosa rubiginosa*.

Table 1. Coccinellids of Gharana Wetland with host plants and distribution.

S.N.	Ladybird beetle Species	Host plants	Distribution
A.	**Subfamily Coccinellinae**		
Tribe Coccinellini			
1.	*Coccinella septumpunctata* (Linnaeus)	*Rosa rubiginosa*	India, Pakistan, Sri Lanka, Palaearctic, North America (Poorani, 2002)
2.	*Hippodamia variegata* (Goeze)	*Ammi majus*	India, Pakistan, Afghanistan, Tibet (Poorani, 2002)
3.	*Harmonia eucharis* (Mulsant)	*Ficus carica*	India, Pakistan, Myanmar, Himalayas, Southern China (Poorani, 2002)
4.	*Oenopia conglobata* (Mulsant)	*Mentha piperta, Bacopa monnieri* and *Pyrus communis*	India, Pakistan, China, Mongolia, Europe, North Africa, North America(Poorani, 2002)
5.	*Menocheilus sexmaculatus* (Fabricius)	*Solanum nigrum* and *Phragmites australis*	India, Bangladesh, Pakistan, Sri Lanka, Bhutan, Myanmar, Malaysia, Indonesia. The Philippines, Vietnam, China, Japan, Oriental Australia (Poorani, 2002)
6.	*Anegleis cardoni* (Weise)	*Hygroryza aristata* and *Ficus benghalensis*	India, Pakistan, Sri Lanka (Poorani, 2002)
7.	*Micraspis allardi* (Mulsant)	*Ficus carica, Catharanthus roseus, Lagenaria siceraria*	India, Pakistan, Myanmar, Indonesia (Poorani, 2002)
8.	*Propylea dissecta* (Mulsant)	*Solanum nigrum, Mentha arvensis* and *Amarenthus deflexus*	India, Nepal, Bangladesh (Poorani, 2002)
9.	*Oenopia sauzeti* (Mulsant)	*Stellaria media* and *Morus alba*	India, Bhutan, Himalayas, Pakistan, Nepal, Myanmar, Thailand, China (Poorani, 2002)
B.	**Sub family Epilachninae**		
Tribe Epilachnini			
1.	*Henosepilachna vigintioctopunctata* (Fabricius)	*Solanum nigrum*	India, Himalayas, New Guinea, Madagascar Wioletta (Tomaszewska and Szawaryn, 2016)
C.	**Sub family Chilocorinae**		
Tribe Chilocorini			
1.	*Brumoides saturalis* (Fabricius)	*Trichodesma indicum, Leucaena leucocephala* and *Triticum aestivum*	India, Pakistan, Bangladesh, Sri Lanka, Himalayas, Bhutan, Nepal (Poorani, 2002)
Tribe Platynaspidini			
1.	*Platynaspidius saundersi* (Crotch)	*Artium lappa, Amaranthus deflexus* and *Bacopa monnieri*	India, Nepal, Afghanistan (Poorani, 2002)

2) *Hippodamia variegata* (Goeze)

Diagnosis: the body of the beetle is elongated, measuring about 4.0-4.5mm in length with 2.5-3.0mm in width. The pronotum is black with white outline having two white spots on it. The color of the elytra is red to orange. Elytral markings varies with more or less 12 black spots (Figure 3).

Remarks: habit with associated host plant: the variegated Lady-bird beetle preys on Aphis *pomi* and *Brevicoryne brassicae* (Shah and Khan, 2014). It was collected from the flower of *Ammi majus.*

3) *Propylea dissecta* (Mulsant)

Diagnosis: the adult beetle body is oval, bulged with an average length of 4.8-5.2mm and 4.2-4.4mm width. Pronotum black with white outline. The color of the elytra is orange-red with two white oval spots on the anterior side of black sutural line in the middle. Elytral markings vary as adults show Polymorphism. (Figure 4).

Remarks: habit with associated host plant: it is aphidophagous and its key food is *Aphis gossypii* (Parvez 2002; Parvez and Omkar 2004). It was found on many host plants like *Solanum nigrum, Mentha arvensis,* and *Amarenthus deflexus.*

4) *Henosepilachna vigintioctopunctata* (Fabricius)

Diagnosis: it is also known as hadda beetle. The body of the beetle is somewhat hairy, copper to light orange in color. Pronotum is light yellowish and elytra have 28 black spots. The adult beetle size is about 5.5-6.5mm in length and 4.0-5.0mm width (Figure 5).

Remarks: habit with associated host plant: it is Phytophagous and is considered as crop pest feeding on family Solanaceae (Mishra and Yousuf, 2019). It was noticed skeletonizing the foliage of *Solanum nigrum.*

5) *Menochilus sexmaculatus* (Fabricius)

Diagnosis: body of the beetle is light yellow in color having an average length of about 4.5mm long and 3.5mm wide. Eyes are black with a pronotum which is creamish in color having a boat-shaped black line. The elytra have a black zig-zag pattern with a medial dark black sutural line and two tiny black spots at both the ends of elytra. This beetle has many morphs with varying elytral pattern (Figure 6).

Remarks: habit with associated host plant: it is most widely distributed species throughout the globe. Its presence in Kashmir was noticed in fruit orchards feeding on *Aphis pomi* and *Lipaphis erysimi* (Khan *et al.,* 2009). It was found on the host plants namely *Solanum nigrum* and *Phragmites australis* in this wetland.

6) *Brumoides suturalis* (Fabricius)

Diagnosis: also known by the name three-striped ladybird beetle, is oval, bears length of about 4.0 mm and width of 2.6 mm. The head is light brown with protruding jet-black eyes and slightly brownish transparent pronotum. The elytra have a banded pattern of black and cream from anterior to the posterior end of the body (Figure 7).

Remarks: habit with associated host plant: this ladybird beetle is predatory on many species of insects like aphids, scale insects, mealy bugs. It was collected from three host plants *i.e.*, *Trichodesma indicum, Leucaena leucocephala* and *Triticum aestivum.*

7) *Oenopia sauzeti* (Mulsant)

Diagnosis: the body of the beetle is small, oval measuring length of about 4.0 mm and 3.2 mm in width. The pronotum has an inverted U type black marking, elytra are yellow in color covering black spots over it with a thick black sutural line in the middle of black spot (Figure 8).

Remarks: habit with associated host plant: it feeds on aphids. It was collected from the host plants namely *Stellaria media* and *Morus alba.*

8) *Anegleis cardoni* (Weise)

Diagnosis: it is round in shape with body size 3.50-3.75mm in length and 3.25-3.50 mm width. The pronotum bears two black spots with a pair of prominent eyes. The color of the body is light yellow with a tint of median black line joining the elytra. The elytra possess a pattern of black strips with two black posteriorly (Figure 9).

Remarks: habit with associated host plant: this ladybird beetle feeds on aphids like *Lipaphis erysimi* (Omkar *et al.,* 2009). It was collected from the inner side of the leaves of *Hygroryza aristata and Ficus benghalensis.*

9) *Oenopia conglobata* (Mulsant)

Diagnosis: the body of the beetle is oblong, slightly creamish in color. The pronotum is small having seven black spots on it. The elytra have circular black spots connected to each other with a median black sutural line passing from scutellum to the posterior part of the body. The size of the body measures up to 3.5-5.0 mm in length (Figure 10).

Remarks: habit with associated host plant: this species was recorded from Kashmir feeding on *Aphis pomi* and *Aphis fabae* (Khan *et al.,* 2009). The species was collected from the host plant namely *Mentha piperta, Bacopa monnieri and Pyrus communis.*

10) *Micraspis allardi* (Mulsant)

Diagnosis: body of the beetle is oval, slightly pinkish in color. The pronotum is transparent with two small circular black dots. Elytra have a type of four triangular spots with a black sutural line in the middle. Body size measures up to 4.0-5.0mm in length with a width of about 3.5-4.0 mm (Figure 11).

Remarks: habit with associated host plant: it feeds on small insects and aphids. This beetle was collected from *Ficus carica, Catharanthus roseus, lagenaria siceraria.*

11) *Platynaspidius saundersi* (Crotch)

Diagnosis: body of the beetle is dome-shaped bearing black pronotum. The elytra are brown in color and bear small rounded black spots with white hairs scattered all over the body (Figure 12).

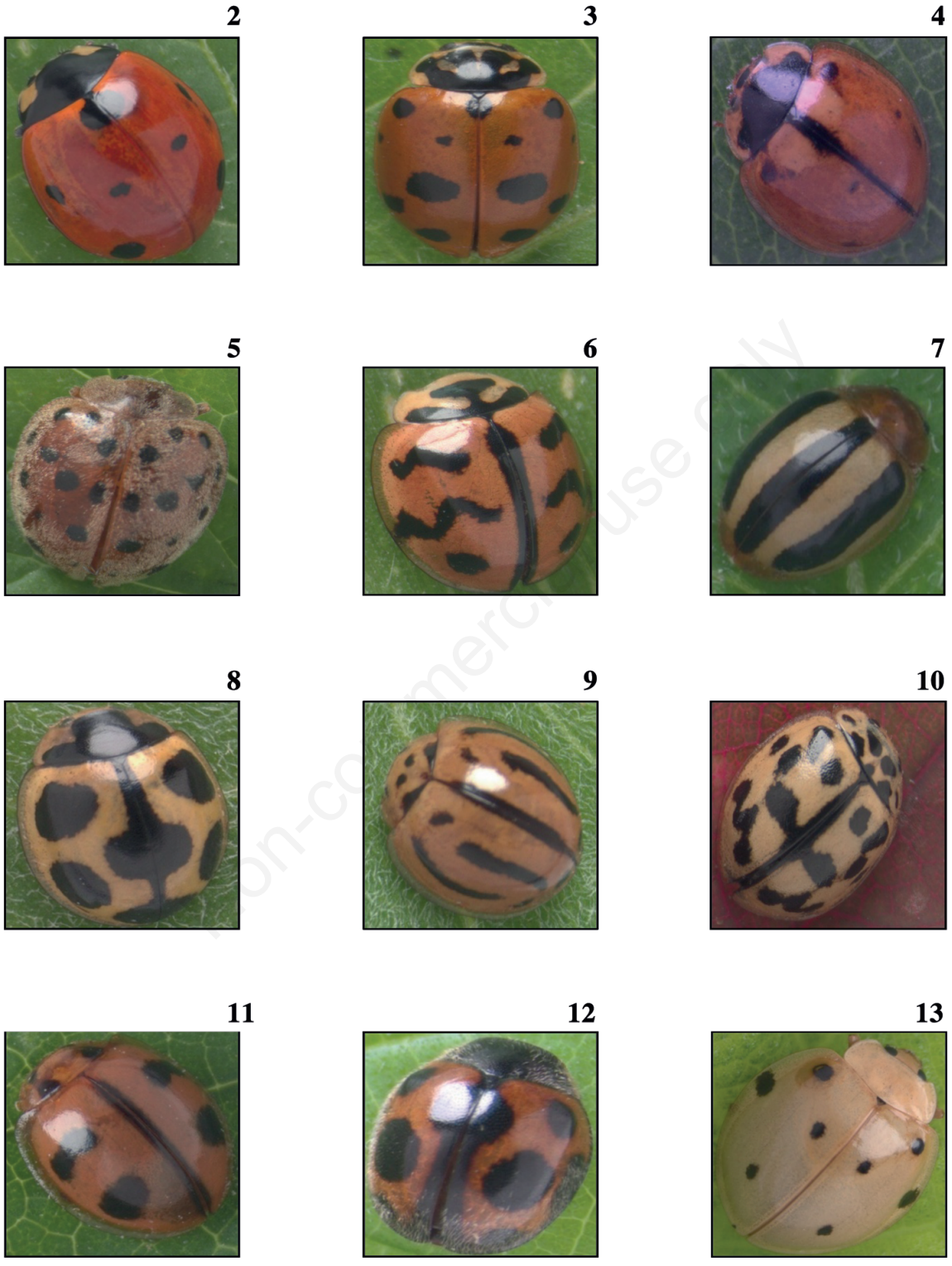
Remarks: habit with associated host plant: Agarwala and Ghosh (1988) reported this species as an accidental predator of some unclassified aphids. It has been also reported predatory on aphids and small insects in agro-forestry areas (Mishra and Yousuf, 2019). This beetle was collected from the plants namely *Artium lappa, Amaranthus deflexus and Bacopa monnieri.*

12) *Harmonia eucharis* (Mulsant)

Diagnosis: adult beetle is oblong, creamish in color. Eyes are black and clearly visible. The pronotum is clear with no spots. The elytra have eight spots, four on each and its pattern varies with the

temperature. The measuring size of the body is about 4.0-8.0mm long (Figure 13).

Remarks: habit and associated host plant: being predatory the fourth instar larva of this beetle has been proven as the efficient predator for the bio-control of green apple aphid *Aphis pomi* (Khan, 2010). The pupa of this beetle was collected from the agricultural field surrounding the wetland with the host plant namely *Ficus carica.*



Figures 2-13. 2) *Coccinella septumpunctata* (Linnaeus); 3) *Hippodamia variegata* (Goeze); 4) *Propylea dissecta* (Mulsant); 5) *Henosepilachna vigintioctopunctata* (Fabricius); 6) *Menochilus sexmaculatus* (Fabricius); 7) *Brumoides suturalis* (Fabricius); 8) *Oenopia sauzeti* (Mulsant); 9) *Anegleis cardoni* (Weise); 10) *Oenopia conglobata* (Fabricius); 11) *Micraspis allardi* (Mulsant); 12) *Platynaspidius saundersi* (Crotch); 13) *Harmonia eucharis* (Mulsant).

Discussion

The present study involves the collection and identification of Ladybird beetles from Gharana wetland, Jammu. The family Coccinellidae shows a high level of variation in elytral pattern and pronotum. All of these Coccinellid beetles have been identified as valuable to the agricultural crops surrounding the wetland except *Henosepilachna vigintioctopunctata* which is phytophagous. All predatory Coccinellids collected during the study are natural biological control agents, coccids, and pseudococcids on agricultural crops. Being eco-friendly, these ladybird beetles serve as fruitful natural enemies against many insect pests damaging agricultural and forest ecosystems. These Coccinellid beetles have been regarded as potential bio-control agents worldwide. The application of Coccinellid predators in biological control of insect pests is eco-friendly and free from chemicals and health hazards.

Conclusions

Exploration and identification of these ladybird beetles were done from the Gharana wetland of Jammu and their associated fields of agriculture. Furthermore, the dominance of two species *i.e.*, *Coccinella septumpunctata* and *Oenopioa sauzeti* was also observed during the survey of this wetland. The diversity of ladybirds in this wetland is rich and these can be further used as natural enemies in biological control of many insect pests.

References

AFROZE S., SHAFEE S.A., 1991a – Spermatheca in some Indian species of Coccinellidae (Coleoptera). – Indian J Syst Entomol. 8: 49-52.

AFROZE S., SHAFEE S.A., 1991b – Significance of male genitalia in the classification of Indian Coccinellidae (Coleoptera). – Indian J. Syst. Entomol. 8: 41-48.

AGARWALA B.K., GHOSH A.K., 1988 – Prey records of aphidophagous Coccinellida in India. A review and bibliography. – Trop. Pest. Manag. 34: 1-14

BIANCHI F.J., VAN DER WERF W., 2003 – The effect of the area and configuration of hibernation sites in the control of aphids by *Coccinella septumpunctata* (Coleoptera: Coccinellidae) in agricultural landscapes: a simulation study. – Environ. Entomol. 32: 1290-1304.

GADAGKAR R., CHANDRASHAEKARA K., NAIR P., 1990 – Insect species diversity in the Tropics: sampling method and case study. – J. Bombay Nat. Hist. Soc. 87: 328-353.

GIORGI J.A., VANDENBERG N.J., MCHUGH J.V., FORRESTER J.A., SLIPINSKI S.A., MILLER K.B., SHAPIRO L.R, WHITING M.F. 2009 – The evolution of food preferences in Coccinellidae. – Biol. Control. 51: 215–231.

HAWKESWOOD T., 1987 – Beetles of Australia. – Angus and Robertson, Sydney, Australia.

HUNT T., BERGSTEN J., LEVKANICOVA Z., PAPADOPOULOU A., JOHN O.S., WILD R., HAMMOND P.M., AHRENS D., BALKE M., CATERINO M.S., 2007 – A Comprehensive phylogeny of Beetles reveals the evolutionary origins of a Super radiation. – Science. 318: 1913-1916.

KAPUR A.P., 1954 – Contribution to knowledge of the fauna of Manipur State, Assam. – Records of the Indian Museum.

KAPUR A.P., 1955 – Coccinellidae of Nepal. – Rec. Indian Mus. 53: 338.

KAPUR A.P., 1973 – The Coccinellidae (Coleoptera) of the Italian Expeditions to the Karakoram and Hindukush. – Rec. Zool. Surv. India. 67:373-378.

KHAN A.A., ZAKI F.A., 2007 – Predation rates of *Coccinella septumpunctata* (Linnaeus) and *Chilocorus infernalis* Mulsant on aphids. – Asian J. Biosci. 2:53-55.

KHAN A.A., ZAKI F.A., KHAN Z.H., MIR R.A., 2009 – Biodiversity of Predacious ladybird beetles (Coleoptera: Coccinellidae) in Kashmir. – J. Biol. Control. 23: 43-47.

KHAN A.A., 2010 – Stage-specific functional response of predaceous Ladybird beetle *Harmonia eucharis* (Mulsant) (Coleoptera: Coccinellidae) to green apple aphid, *Aphis pomi* DE Geer (Hemiptera: Aphididae). – J. Biol. Control. 24: 222-26.

KOCH R.L., VENETTE R.C., HUTCHINSON W.D., 2005 – Influence of alternate prey on predation of monarch butterfly (Lepidoptera: Nymphalidae) larvae by the multicolored Asian lady beetle (Coleoptera: Coccinellidae). – Environ Ecol. 34: 410-416.

KOVAR I., 1996 – Phylogeny. – In: Hodek, I., Honk, A. Editors. Ecology of Coccinellidae. Dordrecht: luwer Academic Publishers: 19-31 pp.

MAJERUS M.E.N., 1994 – Ladybirds. – Harper Collins London: 359 pp.

MISHRA A.K., YOUSUF M., 2019 – Notes on coccinellid beetles (Coleoptera: Coccinellidae) from forest ecosystem of Uttarakhand, India. – J. Biol. Control. 33: 1-6.

MORETON B.D. 1969 – Ladybirds and spider mites – In: Beneficial insects and mites. Her Majesty, Stationary Office London. Ministry of Agriculture, Fisheries and Food. Bulletin, 20: 15-20.

OBRYCKI J.J., KRING T.J., 1998 – Predaceous Coccinellidae in biological Control. – Annu. Rev. Entomol. 43: 295-321.

OMKAR, KUMAR G., SAHU J., 2009 – Performance of a predatory ladybird beetle, *Anegleis cardoni* (Coleoptera: Coccinellidae) on three aphid species. – Eur. J. Entomol. 106: 565-572.

OMKAR, PARVEZ A., 2016 – Chapter 9 – ladybird beetles. Dlm. (pnyt.) – In: Ecofriendly pest management for food security. Academic Press, San Diego: 281-310 pp.

PERVEZ A., 2002 – Contribution on Prey-Predator Relationship and Reproductive Biology of a Colour Morph of *Propylea dissecta* (Mulsant) (Coccinellidae: Coleoptera). – Ph.D. Thesis, University of Lucknow, Lucknow: 197 pp.

PERVEZ, A., OMKAR, 2004 – Prey dependent life attributes of an Aphidophagous ladybird beetle, *Propylea dissecta* (Mulsant). – Biocontrol Sci. Technol. 385-396 pp.

POORANI J., 2002 – An annoted checklist of the Coccinellidae (Coleoptera) (excluding Epilachninae) of the Indian subregion. – Orient Insects 36: 307-383.

SALEHI T., PASHAEI R.S.H., MEHRNEJAD M.R., SHOKRI M.R., 2011 – Ladybirds associated with Pistachio trees in part of Kerman Province, Iran (Coleoptera: Coccinellidae). – Iran. J. Anim. Biosyst. 7: 157-169.

SHAH M.A., KHAN A.A., 2014 – Assessment of coccinellid biodiversity under pesticide pressure in Horticulture ecosystems. – Indian J. Entomol. 76:107-116.

TOMASZEWSKA W., SZAWARYN K., 2016 – Epilachnini (Coleoptera: Coccinellidae) A. Revision of the World Genera. – J. Insect Sci. 16.

VANDERBERG N.J., 2002 – Coccinellidae Latreille, 371-389. – In: R.H. Arnett and M.C. Thomas, (eds). American Beetles. Polyphaga: Scarababaeoidea through Curculionoid Boca Raton, CRCPress, 2: 861.