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POLYMORPHISM IN A PREDACEOUS LADYBIRD, *HARMONIA EUCHARIS* (MULSANT)

Ahmad Pervez and Pooja Bhatt
Biocontrol Laboratory, Department of Zoology, Pt. Lalit Mohan Sharma Campus, Sri Dev Suman Uttarakhand University, Rishikesh – 249201, Dehradun, Uttarakhand, India.
Email: ahmadpervez@yahoo.com

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ABSTRACT

We studied polymorphism in Coccinellidae by sampling and collecting various morphs of a predaceous ladybird, *Harmonia eucharis* (Mulsant) from the different geographical zones of India. Literature on its ecology, distribution, prey-predator interaction, biocontrol potential and intraguild predation was reviewed and gaps highlighted. We highlighted its important in the zoogeographical habitats, significance of polymorphism ignored importance despite of its immense biocontrol potential and invasive approach, and recommended more research on its ecology, evolution and ethological aspects.

Keywords: Ladybird, Aphids, Predator, Prey, Intraguild Predation

INTRODUCTION

Polymorphism is well documented in Coccinellidae, which comprises of beneficial insects popularly known as ladybirds or ladybird beetles and exhibit immense biocontrol potential (Omkar and Pervez 2002; Zare et al. 2012a, b; Singh et al. 2016, Pervez et al. 2020). Amongst them, Genus *Harmonia* constitutes some important species recognized both for their biocontrol potential and polymorphism (Monalisa et al. 2020). In *Harmonia axyridis* (Pallas) temperature influences polymorphism with darker morphs prevail more in cooler areas (Pervez and Omkar 2006; Honek et al. 2020). This diversity improves the species' ability to adapt and contribute to its effectiveness as an invasive species (Chen et al. 2019). *Harmonia yedoensis* (Takizawa) and *H. axyridis* display differing dominant colour morphs, where *H. yedoensis* demonstrates a rise in non-melanic forms as one moves southward, while the melanic forms of *H. axyridis* decrease as one heads northward (Norkiyuki and Osawa 2015).

The ladybird beetle *Harmonia eucharis* (Mulsant), commonly found in north eastern and north western India demonstrates this with notable differences in the number of elytral spots (ranging from 0 to 20) and in coloration from pale yellowish-brown to bright shades (Chaudhary and Singh 2012; Pervez et al. 2020a; Poorani 2019). Various colour morphs of *H. eucharis* interbreed freely, suggesting they belong to the same species and emphasizing the evolutionary significance of this diversity (Ghani 1962; Ren et al. 2009; Yu 2010). The diverse traits, influenced by a combination of genetic and environmental elements (Chen et al. 2019; Noriyuki and Osawa 2015), highlight the adaptability of species in various environments such as fruit orchards, Euonymus hedges, and the forests of the Western Himalayas (Noriyuki and Osawa 2015). This variation not only affects its life cycle and biological development but also plays a significant role in its ecological functions (Chen et al. 2019). The life cycle of *H. eucharis* includes egg, larval, pupal, and adult stages, exhibiting developmental plasticity (Poorani 2023), where polymorphic characteristics may influence growth rates and survival in different environments. Nevertheless, its involvement in intraguild predation, which involves competition with other predators, highlights the complexity of its ecological relationships (Khan 2012). These characteristics rank *H. eucharis* as a significant component in integrated pest management, as its polymorphic diversity could improve its effectiveness as a biocontrol agent (Khan 2010). It plays a significant role in controlling the population of the cotton aphid, *A. gossypii* (Pervez et al. 2020b). In this research, we examine the variations in spot number and colour in *H. eucharis*, concentrating on their significance for ecological fitness and biocontrol effectiveness, while also considering how these

characteristics influence its life cycle, predation patterns, and function in IPM. By clarifying these connections, we aim to advance understanding how polymorphism influences *H. eucharis* evolutionary and ecological success, as well as its impact on sustainable pest management.

MATERIALS AND METHODS

Extensive surveys were made covering distal parts of India, and visiting the geographical habitats of Uttarakhand, West Bengal, Tripura, Mizoram, Manipur, Arunachal Pradesh, Andaman and Nicobar island. Coccinellid biodiversity was sampled from these areas. In this paper we will only discuss about the polymorphs of *H. eucharis*. However, other species and polymorphs will be dealt separately in other publications. The primary objective was to distinguish different morphs by examining characteristics such as elytral patterns and colour variations. Various morphs of *H. eucharis* were studied and photographed using Spectroscopic Trinocular (*Lyzer*) with image card attached to a personal computer *(hp-Pavillion)* at 40X magnification.

RESULTS AND DISCUSSION

The documented prey species is presented in Table-1. The morphs of *H. eucharis* were oval shaped with a size ranging from about 6.50 to 10.50 mm (8.50 ± 0.25 mm, n=20) in length and 5.70 to 7.70 mm in width (6.75 ± 0.12 mm, n=20). It has a smooth upper surface and data agrees with the previous reports of its morphometrics (Nagarkatti and Ghani 1972; Pervez et al. 2020b; Siddique et al. 2023). The adults of *H. eucharis* were also elongated form with pale coloration, featuring prominent black eyes and their pronota were smooth with no markings or spots (Ali et al. 2023). This ladybird possesses antennae consisting of 11 segments, which are somewhat shorter than the head; the final three segments are wider and create a small club shape at the end (Siddique et al. 2023). This species is particularly remarkable due to its significant degree of polymorphism, which is evident in the diverse colours and patterns observed on its elytra (Chaudhary and Singh 2012). The elytra are generally a light yellowish-brown in colour (Ghani 1962). However, this species shows significant polymorphism in elytral colouration (Ren et al. 2009). The different forms include unmarked yellow versions, individuals with 4-5 black spots, light brown elytra featuring creamy yellow patterns, and reddish-brown variants with dark side margins (Yu, 2010). *Harmonia eucharis* is thoroughly detailed by Poorani (2023), focusing on the morphology of adults, which includes dorsal coloration, abdominal post coxal lines, and the genitalia of both males and females. This variation is not only significant from a taxonomic perspective but may also contribute to strategies for avoiding predators, mimicry, and adapting to different environments. The species displays significant variation in coloration, showcasing various forms. All life stages—egg, larva, pupa, and adult—are captured in detailed images (Poorani, 2023).

Table-1: Documented Prey of *Harmonia eucharis*.

Prey species	Reference
Aphis craccivora (Koch), *Myzus persicae* (Sulzer), *Brevicoryne brassicae* L.	Agarwala and Ghosh (1988)
Aphis gossypii (Glover), *Lipaphis erysimi* (Kaltenbach), *Aphis fabae* Scopoli, *Aphis spiraecola* Patch, *Aphis nerii* Boy., *Aphis medicaginis* Koch, *Aphis rumicis* L., *Macrosiphoniella pseudoartemisiae* Shinji	Chakrabarti et al. (1995)
A. gossypii, A. craccivora, A. nerii, A. fabae	Chaudhary and Singh (2012)
Aphis pomi de Geer	Khan (2010)
A. pomi, Tetranychus urticae (Koch), *M. persicae, B. brassicae, A. fabae, A. craccivora*	Kundoo and Khan (2017)
Eulecanium tiliae (L.), *Adelges* sp.	Nagarkatti and Ghani (1972)
A. craccivora, A. gossypii	Phaloura and Singh (1993)
Dreyfusia knucheli (Stebbing), *Eriosoma lanigerum* (Hausmann), *Hyalopterus pruni* (Geoffroy), *Cervaphis quercus* (Takahashi), *Cervaphis rappardi indica* Basu, *Phorodon cannabis* (Passerini), *Rhopalosiphum nymphaeae* (L.)	Poorani (2023)

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1: *H. eucharis* (Morph 1) 2: *H. eucharis* (Morph 2) 3: *H. eucharis* (Morph 3)

4: *H. eucharis* (Morph 4) 5: *H. eucharis* (Morph 5) 6: *H. eucharis* (Morph 6)

7: *H. eucharis* (Morph 7) 8: *H. eucharis* (Morph 8) 9: *H. eucharis* (Morph 9)

Figures 1-9: Different mophs of *Harmonia eucharis* (Mulsant)

Morph identification: Polymorphism were identified based on elytral spot patterns, base colour and spot colour. Nine polymorphic variations of *Harmonia eucharis* were recognized based on external morphological traits, including coloration patterns, elytral markings, and differences in size. These variations were spread out over various geographic areas, indicating diversity within the species. All nine polymorphs are characterised in following given table with photographs (Table-2; Figures 1-9):

Table-2: Details of the nine morphs of *H. eucharis*.

Morphs	Base colour of elytra	colour of spot/patches/ Lines	No. Of spot/ Patches/lines
Morph 1	Glossy reddish-brown.	Absent	Spot less
Morph 2	Reddish-brown	Absent	Spot less
Morph 3	Bright yellowish-orange	Black spots	18-20
Morph 4	Glossy light brown	Light brown wavy lines	5-6
Morph 5	Glossy light brown	Faint light brown spots	18-19
Morph 6	Bright yellowish-brown	Black spots	18-19
Morph 7	Glossy yellowish-brown	Black patches	Irregular
Morph 8	Light brown	Yellowish-white spot	15-18
Morph 9	Light yellowish-orange	Dark brown spots	16-18

The polymorphic forms of *H. eucharis* demonstrate significant versatility in various environments and altitudes. This species thrives at elevations ranging from 1200 to 3100 meters above sea level and it prefers moderate climates where temperatures are warm but not extreme (Siddique et al. 2023). In India, records indicate its presence in various states, including Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Manipur, Sikkim, Uttarakhand, and Uttar Pradesh (Sharma et al. 2017). It is commonly located on fruit trees, Euonymus hedges, and forest vegetation, showcasing its ecological flexibility and durability across different environments (Kundoo and Khan 2017). This adaptability is highlighted by their occurrence on Euonymus hedges, woodland plants, and farm crops. Although comprehensive information on the distribution of geographic morphs is scarce, regional insights indicate possible links between environmental factors and the occurrence of specific morphs, which calls for additional research.

The developmental cycle of *H. eucharis* is closely synchronized with the life cycle of the aphids it preys upon (Phaloura and Singh 1993). Its life stages occur in alignment with the seasonal fluctuations of aphid populations (Chakrabarti et al. 1995). The reproductive behavior and feeding habits of *H. eucharis* are closely associated with periods when aphids are most abundant (Phaloura and Singh 1993; Chakrabarti et al. 1995). Although existing research does not specifically associate morph types with developmental timing or their success, upcoming studies might investigate whether various morphs offer benefits in particular environmental settings or areas with abundant prey. As a generalist predator, *H. eucharis* has demonstrated a type II functional response exists in the prey-predator relationship between *Harmonia eucharis* and *Aphis pomi* de Geer, with the highest predation efficiency observed during the 4th instar and adult phases of the predator (Khan, 2010). It feeds on a wide range of aphid species such as *Aphis citricola* van der Goot, *Brachycaudus helichrysi* (Kaltenbach), *Eriosoma lanigerum* (Hausmann), and *Rhopalosiphum nymphaeae* (L.) (Agarwala and Ghosh 1988), which demonstrates its versatility and ability to feed on a wide range of prey. Both larval and adult stages are effective predators of aphids, with the peak predation rates observed during the fourth instar and adult stages. Intraguild predation (IGP) by *H. eucharis*, especially in the fourth larval instar, where it frequently preys upon the eggs and larvae of other coccinellids such as *Adalia tetraspilota* (Hope) (Khan 2012). This predatory superiority highlights its competitive advantage but also calls for caution when it is incorporated into multi-predator environments.

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