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Life History Traits and Biocontrol Potential of *Harmonia eucharis* (Coleoptera: Coccinellidae) Himachal Pradesh

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ABSTRACT: This study reveals the biology and developmental history of *Harmonia eucharis* (Mulsant), (Coleoptera: Coccinellidae), a native ladybug species with significant potential in aphid control. Studies conducted under controlled laboratory conditions (24±1°C, 65±2% RH with 16:8 L:D photoperiod) and observed that the beetle completes its life cycle from egg to adult in about 28-29 days. Incubation period lasted for 5.2±0.83 days, followed by four larval instars, a pre-pupal stage, and a pupal phase lasting 6.4±0.89 days. The total development time reflects rapid predatory adaptation. Adult males and females lived for 16.8±2.94 and 18±3.08 days, respectively. Results indicate a high predatory potential and reproductive efficiency, making *H. eucharis* a promising candidate for inclusion in integrated pest management strategies. Observations also highlight its compatibility with Indian agro-ecosystems, particularly in high-altitude regions. This study reinforces the importance of utilising native biological agents for sustainable pest control and reducing dependency on exotic or chemical alternatives. Maintaining consistent prey density and environmental conditions posed challenges, slightly affecting developmental uniformity. the study establishes vital baseline insights into the biology, adaptability, and predatory potential of *Harmonia eucharis*, reinforcing its promise as a native, eco-friendly biocontrol agent for sustainable pest management in Indian agro-ecosystems.

Keywords: *Harmonia eucharis*, coccinellids, biological control, aphid IPM.

INTRODUCTION

Coccinellids, commonly known as ladybird beetles or ladybugs (Coleoptera: Coccinellidae), represent one of the most ecologically and economically important families of predatory insects. With more than 6,000 described species globally, coccinellids are particularly valued for their role in regulating populations of soft-bodied insect pests such as aphids, scale insects, and mealybugs both in natural ecosystems and agricultural landscapes (Poorani, 2019). Their vibrant colouration, dome-shaped bodies and diverse feeding behaviours have made them central subjects in studies of insect ecology, predator-prey interactions and integrated pest management. Coccinellids exhibit holometabolous development, comprising egg, larval, pupal and adult stages. The larvae are often elongated and spiny, actively foraging and consuming aphids in large numbers, while adults, more conspicuous in colouration, continue feeding and reproduce with great biotic potential. Both developmental and reproductive parameters of coccinellids are influenced prey by availability, ambient temperature and photoperiod (Lanzoni *et al.,* 2004). Studies have shown that coccinellid predators such as *Adalia bipunctata*, *Hippodamia variegata* and *Harmonia axyridis* have short generation times, high fecundity and prey-specific responses, traits that underpin their efficacy as biological control agents (Lanzoni *et al.*, 2004). Among them, *Harmonia axyridis*, the harlequin ladybird, has become a global model species for studies in insect ecology, predator-prey dynamics and invasive biology (Koch, 2003). Originally native to eastern Asia, this species has been extensively introduced across Europe and North America as a biocontrol agent, yet its introduction has led to complex ecological consequences, including competitive displacement of native coccinellid species.

Harmonia eucharis (Mulsant) (Coleoptera: Coccinelidae) is a prominent aphidophagous predator widely distributed in the Western Himalayas and adjoining agroecosystems, where it plays a pivotal role in natural pest regulation. This species is well known for its voracious predatory habits, particularly against soft-bodied pests such as aphids, whiteflies and scale insects, which are major agricultural nuisances.

(Chakrabarti *et al.*, 1995). The success of *H. eucharis* in diverse environments is attributed to its broad ecological plasticity, high reproductive potential and effective prey utilisation strategies. Comparative studies have shown that *H. eucharis* generally outperforms native or previously established species such as *Hippodamia variegata* and *Adalia bipunctata* in terms of development rate, fecundity and survivorship under similar conditions (Lanzoni *et al.*,2004). Its life table parameters reflect an adaptive edge, reinforcing its potential as both a boon and a challenge in integrated pest management systems. The biology of *H. axyridis* has been explored across various developmental and environmental contexts, including its behavioural adaptations during winter aggregations (Nalepa *et al.*, 1996). These physiological and ecological traits make it an ideal species for meta-analytical reviews of coccinellid life histories on a global scale (Raak-van den Berg *et al.*, 2017). Yet, while *H. axyridis* dominates much of the academic discourse; other native and regionally significant coccinellid species warrant equal attention for their contributions to aphid regulation in agroecosystems. In the Indian subcontinent, species such as *H. eucharis* and *A. bipunctata* have shown considerable potential in aphid suppression. *H. eucharis*, in particular, has demonstrated a robust stage-specific functional response to the green apple aphid (*Aphis pomi*), highlighting its ecological value in fruit-based cropping systems (Khan, 2010). Observations on the bioecology of *H. eucharis* in the Western Himalayas further support its role as a resilient and adaptable aphid predator in high-altitude agroecosystems (Chakrabarti *et al.*, 1995); (Phaloura & Singh 1993). These native species, unlike *H. axyridis*, are better integrated into the local ecological fabric and may offer sustainable alternatives in pest regulation without the ecological risks posed by exotic introductions. Understanding the biological diversity, predator efficiency and habitat adaptability of coccinellid species is therefore crucial for the development of ecologically sound pest management strategies. The taxonomic richness of Coccinellidae in the Indian subcontinent, as outlined by Poorani (2019), provides a valuable resource for researchers aiming to harness the natural potential of these beetles in sustainable agriculture. *H. eucharis* demonstrates high prey consumption rates, especially during the larval stages, when feeding intensity is maximum. Laboratory and field trials have shown that prey density significantly influences larval growth, survival, and fecundity. Moreover, competition with conspecifics and heterospecifics has a measurable impact on its developmental rate and reproductive potential (Sharmila *et al.*, 2011). The predatory potential of *H. eucharis* is further enhanced by its ability to exploit multiple prey species, ensuring persistence even when primary prey populations decline. Its functional response to prey density suggests a capacity for rapid population buildup under favourable conditions, enabling suppression of pest outbreaks before they reach damaging thresholds. Additionally, the beetle's reproductive strategy, characterised by high egg production and relatively short generation time, strengthens its role as a sustainable biocontrol agent.

While considerable work has been done globally on the biology and biocontrol potential of ladybird beetles, detailed studies on *Harmonia eucharis* are still scarce in India. Most available information is based on older or laboratory-focused observations, with limited understanding of how this species performs under varying ecological and climatic conditions. In recent years, researchers have highlighted the need to link life-history traits with environmental factors such as temperature, prey density and habitat diversity to better assess field efficiency. However, such integrative studies remain largely unexplored for *H. eucharis*, particularly in high-altitude and temperate farming systems. This gap underlines the need for comprehensive investigations to evaluate its adaptability, predatory capacity and role as a sustainable native biocontrol agent in Indian agro-ecosystems. The present study focused on understanding the biology and biocontrol potential of *Harmonia eucharis* (Mulsant), emphasising its developmental stages, survival and predatory efficiency against aphids under controlled conditions. The findings provide baseline information to support its utilisation as a native, eco-friendly biocontrol agent in sustainable pest management programs.

MATERIAL AND METHODS

Study area: The study area comprises Himachal Pradesh, a hilly state of India situated in the western Himalayas. The state occupies an area of 55673 km between 30º 22' 40" to 33º 12' 40" N latitude and 75º 45' 55" to 79º 04' 20" E longitude.

Collections of specimens: Collection of beetles has been carried out from fruit orchards, vegetable ields, agricultural fields, and the entire vegetation of forests including herbs, shrubs and trees, the Methods for collecting beetles were as, hand picking, directly in the insect collection tubes, containers, forceps, beating sheets and jars, depending upon the habitat and species available in that area. The data has been recorded on different parameters like time, date, location, weather conditions, and characteristics of each collection site.

Identification: The morphological features, such as antennae, pronotum and spots on elytra, were used to identify the specimen. All identifications were made using checklists and keys developed by (Poorani, 2002).

Biology: The traits, development and morphology of coccinellids vary with their food. Biology of *H. eucharis* was carried out under controlled studies in laboratory conditions in the Department of Biosciences, Himachal Pradesh University, Shimla, at 24±1ºC temperature, 65±2% R.H., and 16:8 L: D photoperiod, by providing nymphs of *Rhophalosiphum padi* (Linneaus) as food as per the laboratory protocol developed by (Deho, 2009). Adults of *H. eucharis* collected from various field crops were cultured on wheat aphids. For mass rearing, the collected adults were kept in paired Petri plates measuring 75 mm in diameter. Every day, the eggs laid on the leaves or surrounding the Petri plate by the female coccinellids were collected and stored in separate Petri plates after being gently brushed with a soft camel hair brush. Freshly hatched grubs were cultured separately in Petri plates. The nymphs were placed in these Petri dishes and monitored daily. The duration of the incubation period of egg hatching was also noted. Each newly hatched grub was given 15-20 aphid nymphs, but as the grubs matured, nymph number increased. Exuviae released by the grubs were used to calculate each life stage's number of instars and the pupae developed in Petri dishes were maintained apart and undisturbed until they emerged as adults. The statistical parameters were derived by computing the length of time for each instar and the total life span. Laboratory-reared adults were segregated as male and female based on their body size and other sexual dimorphic characters. Longevity of males and females was studied separately. For this purpose, ten pairs of *H. eucharis* were kept individually and data were recorded. The time after the emergence of adults from the pupa and the start of oviposition was considered the pre-oviposition period (Gurung *et al.*, 2018)**.**

Predatory potential

Laboratory culture: Adults of, *Harmonia eucharis* was collected from diverse agroforestry ecosystems and reared on *Brassica rapa* (cabbage) to ensure a consistent food source before experimentation. To evaluate the larval feeding potential of *H. eucharis* on *Myzus persicae* (green peach aphid), five neonate larvae were individually reared in Petri plates (75 mm) with three replications from hatching until pupation. Each larval instar was supplied with a specific, counted number of aphids (nymphs and adults). The number of aphids provided was adjusted according to the larval stages, increased with each subsequent instar. The aphid consumption rate was recorded over 24 hours by counting the remaining aphids and subtracting this number from the total initially provided.

RESULTS

The life cycle of *H. eucharis* follows a process of complete metamorphosis, consisting of four stages: egg, larva, pupa and adult. The life cycle begins when a female lays small, yellowish, oval eggs in clusters on the underside of leaves, usually near aphid colonies. The biology of *H. eucharis* was carried out under laboratory conditions and results were obtained during the investigation. The eggs hatch after approximately 5.2±0.83 days, giving rise to tiny, elongated larvae that immediately begin feeding. The larval stage consists of four instars, each marked by growth and increased predatory activity. The first instar lasts around 3.6±0.54 days, followed by the second instar at 3.4±0.54 days, the third instar at 4.2±0.83 days, and the fourth instar, lasted 4.4±1.34 days. After completing the larval phase, the beetle enters a pre-pupal stage for about 2.6±0.54 days, during which it attaches itself to a surface before transforming into a pupa. The pupal stage lasts approximately 6.4±0.89 days, during which metamorphosis occurs and the adult beetle develops. Upon emergence, the soft-bodied adult gradually hardens and attains its characteristic red colouration with seven black spots.

Table 1: Developmental duration of various stages of *H. eucharis*, under laboratory conditions to evaluate (Values are means ±SD).

Developmental stages	Duration (in days)
Incubation period	5.2±0.83
1st instar	3.6±0.54
2nd instar	3.4±0.54
3rd instar	4.2±0.83
4th instar	4.4±1.34
Pre-pupa	2.6±0.54
Pupa	6.4±0.89
Adult male	16.8±2.94
Adult female	18.±3.08

Adult males typically live for 16.8±2.94 days, while females, which have a slightly longer lifespan, survive for about 18±3.08 days. This rapid life cycle enables *H. eucharis* to reproduce efficiently, making it an essential predator in controlling aphid populations and contributing to natural pest management in agricultural ecosystems.

Predatory potential

In this study, observations were made to assess the aphid consumption capacity of the adult beetles under controlled conditions. This evaluates species' feeding rate, survival and behavioural responses. Adult coccinellids maintained their significant predatory capacity throughout their lifespan. Newly emerged adults started feeding immediately and as they matured, their consumption rates often increased, especially among females who need additional energy for reproduction. Adult beetles' average aphid consumption rate was about 78.2±1.77. Adults also played a vital role in dispersal, enabling biological control agents to cover larger crop areas and sustain aphid suppression over extended periods.

Fig. 1. Detailed observation of the life cycle and developmental stages of *Harmonia eucharis* from egg to adult emergence, under controlled laboratory conditions to understand stage-specific durations, morphological transitions and overall developmental duration.

DISCUSSION

This reproductive strategy is highly advantageous, as it ensures that the newly hatched larvae have immediate access to a food source, facilitating rapid growth and survival (Khan, 2010; Chakrabarti *et al.*, 1995). Eggs of *H. eucharis* hatched after an average of 5.2 ± 0.83 days, which aligns with the findings on aphid species Rauf *et al.*, (2013) documented similar egg incubation periods and larval duration for *H. eucharis* in controlled settings. Upon hatching, the larvae emerge as small, elongated individuals, which immediately begin to feed on aphids. The larval stage consists of four instars, each marked by significant growth and an increase in predatory activity. The first instar lasts 3.6 ± 0.54 days, the second instar 3.4 ± 0.54 days, the third instar 4.2 ± 0.83 days and the fourth instar, which is the longest, lasts 4.4 ± 1.34 days. This progression of development is consistent with the observations of Rauf *et al.*, (2013) who also noted an increase in predatory behaviour as the larvae progressed through different instars. The extended duration of the fourth instar is consistent with findings from Khan (2010), where a longer larval phase allows for more intense predation, ensuring the larvae effectively reduce aphid populations during this critical period. After completing the larval stage, *H. eucharis* enters a pre-pupal phase, lasting approximately 2.6 ± 0.54 days, during which it attaches itself to a surface in preparation for pupation. The pupal stage lasts around 6.4 ± 0.89 days, during which significant metamorphosis occurs, transforming the soft-bodied larva into the hardened adult beetle. The transformation observed in this study is in line with the findings of Rauf *et al.* (2013), who documented similar durations for the pupal stage and the changes occurring during this critical phase of development. Adult males of *H. eucharis* have an average lifespan of 16.8 ± 2.94 days, while females live slightly longer, at about 18 ± 3.08 days.

The present study revealed that adult coccinellids exhibit a sustained and substantial predatory potential throughout their lifespan under controlled laboratory conditions. The observed average aphid consumption rate of 78.2 ± 1.77 aphids per day underscores the crucial role of adults in aphid population regulation. These findings align with earlier studies that demonstrate the adult stage of coccinellids represents the most efficient and persistent phase of predation, due to their extended longevity and higher energy requirements (Pervez and Omkar, 2006; Hodek and Michaud, 2008). Newly emerged adults commenced feeding almost immediately after eclosion, suggesting strong innate predatory instincts and rapid physiological readiness for aphid consumption. Similar behavioural trends were noted by Dixon (2000).

CONCLUSIONS

The present study establishes that *H. eucharis* completes its life cycle through rapid metamorphosis, enabling multiple generations within a season. Each developmental stage, particularly the larval and adult phases, exhibits strong predatory potential. Adults consumed an average of 78.2 ± 1.77 aphids daily and maintained high survival rates. Their active dispersal and sustained feeding behaviour highlight *H. eucharis* as an efficient, ecologically valuable biocontrol agent against aphid infestations.

FUTURE SCOPE

The present study offers a foundational understanding of the developmental biology and predatory potential of *Harmonia eucharis*. Future investigations should emphasize field-based evaluations across varying agro-climatic zones to examine its adaptability, prey preference, and interactions with other natural enemies. Integrating environmental factors such as temperature, prey density, and habitat diversity will enhance predictions of its performance under real-world conditions. Molecular and ecological studies may further elucidate its genetic variation and suitability for mass rearing, contributing to sustainable and region-specific IPM strategies.

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Conflict of Interest. The authors declare no conflict of interest.

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