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A Study on The Polymorphism of *Adalia Bipunctata* Ladybird In Maymana City, Faryab Province, Afghanistan

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ABSTRACT
This research was conducted in the year 1400 (2021) in Maymana city, the center of Faryab province in northern Afghanistan. The sampling area was located within the geographic coordinates of 35° 53' 25.8″ to 35° 54' 46.3″ N latitude and 64° 44' 11.6″ to 64° 49' 15.7″ E longitude. Lady beetles (Col.: Coccinellidae), with more than six thousand described species worldwide, are considered important natural enemies of agricultural pests and play a significant role in the biological control of pests such as aphids, whiteflies, scale insects, and plant mites. Despite the considerable climatic and botanical diversity in Afghanistan, available information about the lady beetle fauna of the country is limited. Faryab province, with Maymana as its center, is one of Afghanistan's important agricultural regions. Considering the ecological importance of lady beetles in biological pest control, this study aimed to investigate the polymorphism of the species Adalia bipunctata in this area. The study was carried out during spring and summer of 1400 (2021), with sampling conducted on cultivated hosts such as peach, pear, and rose, as well as on non-cultivated plants and weeds. Three collection methods were used: insect netting, manual collection, and shaking the host plant onto a white plastic tray. Collected adult insects were preserved either in 70% ethanol or by killing and drying. Identification of specimens was performed using morphological features and examination of the male external genitalia. Different morphs of Adalia bipunctata were distinguished based on morphological traits such as the number, size, and pattern of elytral spots, as well as the color of the elytra and pronotum. Overall, two major morphs and several minor morphs of this species were identified and classified into seven categories.

Keywords: *Adalia bipunctata*; Afghanistan; biological control; Maymana; polymorphism

1. INTRODUCION

Lady beetles (Coccinellidae: Coleoptera) are among the most important predatory insect groups, playing a vital role in the biological control of agricultural pests. More than 6,000 species of this family have been identified worldwide, over 90% of which exhibit predatory behavior [1]–[3]. These beetles have proven effective in suppressing populations of damaging pests such as aphids, thrips, scale insects, and certain mites across various regions of the world [4], [5].

Among their biological traits, the external variability in color and elytral pattern makes this group an ideal model for studying color polymorphism [6]. Polymorphism, the occurrence of different forms within a species, is common in many insect orders such as Diptera, Lepidoptera, Hymenoptera, and Coleoptera [7]. These differences

can appear not only within a single population but also among different sexes and geographically separated populations [8], [9].

Variations in color and spot patterns on different body parts—especially the elytra and pronotum—are key factors in identifying different morphs of lady beetles [10]– [12]. Among these, *Adalia bipunctata* has been extensively studied as a notable polymorphic species. This beetle, measuring 3.5 to 5.5 mm in length, typically has orange to reddish-orange elytra with distinct black spots. However, the diversity of its elytral patterns is high. With a wide host range, it is considered an effective natural enemy of aphids [4].

Research on polymorphism provides an opportunity to assess functional traits such as predation rate, lifespan, and fecundity in different morphs. If significant functional differences exist among morphs, certain dominant or more active forms can be selected for use in biological control programs. This knowledge is crucial for mass rearing and targeted use of beneficial predators [13].

Various studies have revealed that species of *Adalia* and *Oenopia* exhibit notable morphological polymorphism across different parts of Iran, including Sarakhs, Shahrood, Bastam, and western Mazandaran province [14]–[16]. In faunistic studies and identifying dominant species, external polymorphism—especially in color and spot patterns—has been regarded as a major diagnostic feature [17], [18].

Additionally, environmental factors such as temperature have been shown to affect the development and reproduction of *Adalia bipunctata*, potentially leading to greater morphological variation [19]. Polymorphism in this species has also been observed on various host plants and in different regions, such as pistachio orchards in Kerman Province, highlighting its ecological and biological significance [20].

Zare et al. reported substantial morphological diversity in *Adalia bipunctata* populations in central Iran, suggesting that polymorphism may play an adaptive role under varying environmental conditions [7].

Furthermore, the study by Bayram et al. provided the first record of *Allothrombium triticium* larval parasitism on *Adalia bipunctata* in Turkey, contributing to a better understanding of the species' ecological interactions [21].

Afghanistan, located within the Palearctic biogeographical region between 30° to 38° north latitude, possesses notable ecological and climatic diversity. Faryab province in the north, covering approximately 21,000 km^2 with a population of over 1.7 million, is one of the key areas for agricultural and horticultural production. Various crops including wheat, legumes, sesame, cotton, vegetables, and fruits such as grapes, apples, pomegranates, and almonds are cultivated here [22]. This plant diversity creates a favorable habitat for multiple lady beetle species, making polymorphism studies in such ecosystems highly valuable.

2. METHOD

Research Design

This study applied a qualitative-descriptive research design to document and identify species of ladybird beetles (Coccinellidae) in different agricultural and horticultural habitats. The research involved field sampling, specimen preservation, dissection, slide preparation, and taxonomic identification using morphological characteristics and valid identification keys.

Time and Place of Research

The research was conducted during spring and summer 2025 in various regions of Golestan Province, northern Iran. Sampling was performed only on sunny and calm days to increase the likelihood of encountering active adult beetles. All laboratory work, including dissection and identification, was carried out in the Entomology Laboratory of the Plant Protection Department at Gorgan University of Agricultural Sciences and Natural Resources.

Research Target/Subject

The research targeted adult ladybird beetles found on a variety of host plants, including fruit trees, alfalfa, wheat, and other vegetation. Sampling was conducted using a purposive method based on vegetation type and ecological conditions, with emphasis on areas likely to host high insect diversity. The host plant species, geographical coordinates, and elevation were recorded for each sampling point.

Research Procedure

Collection techniques were adapted to plant type. For trees, direct observation, hand collection, and aspirators were used. In agricultural fields with low-growing crops such as wheat and alfalfa, standard sweep nets were employed. For bushes and dense vegetation where netting was impractical, branches were shaken over white plastic trays and specimens were collected using aspirators or fine brushes. Specimens were killed using ethyl

acetate and preserved in two ways: in 75% ethanol or by pinning on entomological boards. Small specimens were mounted on triangular card points to prevent damage.

Instruments and Data Collection Techniques

Key instruments included sweep nets, aspirators, brushes, scalpels, dissecting needles, and microscopes. For genitalia dissection, terminal abdominal segments were removed and boiled in 10% potassium hydroxide (KOH) for 15–20 minutes to clear tissues. The cleared parts were rinsed, dehydrated in graded ethanol concentrations, and mounted in Canada balsam on permanent microscope slides. The slides were dried in an oven at 45°C for one week.

Data Analysis Technique

Species identification was performed using established taxonomic keys [1]–[5]. Diagnostic features and genitalia were compared with museum specimens and published images for confirmation.

3. RESULTS AND DISCUSSION

A total of 120 specimens of *Adalia bipunctata* were collected in the city of Maymana, and various morphs of this species were identified in this region for the first time. The body length of the ladybirds ranged from 3.5 to 5.5 millimeters. The elytra are usually orange or reddish-orange, with distinct black spots or sometimes spotless. Typically, there are two spots (one on each elytron), which gives the species its name. In some specimens, the number of spots may be more or fewer, and in some cases, the spots have merged. In all specimens, the spots on the elytra are clearly visible.

This ladybird is a polymorphic species with both dark and light morphs. In some specimens, black spots on the elytra may be completely absent, while in others, the spots may be so extensive that only a small portion of the elytra remains in the lighter color. The pronotum is small and brown or black; the pronotum color varies between yellow, cream, or orange, bearing five black or brown spots—three located at the base and two in the middle region. In some specimens, these spots are connected, covering a large area. The head is yellow or cream with a black base, and sometimes the black band extends to the middle of the head, connecting the eyes. The legs, antennae, and mouthparts are light brown, and the underside of the body is black. The postcoxal line on the first abdominal segment is incomplete, and the prosternum lacks a distinct carina. The antenna consists of 11 segments with a large terminal segment. The apex of the upper mandible is bifurcated, and the terminal segment of the lower maxillary palp is axe-shaped. The male genitalia are symmetrical; the basal lobe is slightly longer than the parameres, the siphonal tube is long and curved, and the capsule is large (Figure 1). The female genitalia have a curved spermatheca and a distinct infundibulum.

The patterns on the elytra and pronotum in the adult insects of this species are highly variable, and in this study, different morphs of this ladybird were observed among the specimens collected from Meymeh. Previous studies have also reported several morphs of this species from different regions worldwide [1]–[3].

Figure 1. Male genitalia of ***A. bipunctata***: a) siphon, b) tegmen.

Host Plants and Geographic Distribution

Information regarding the collection sites and host plants of this species are presented in Table 1. Peach and pear trees, as well as rose bushes infested with aphids, were the three host plants from which this species was collected.

This species is a predatory ladybird previously reported from Afghanistan (without specifying the collection area) [4]. Its geographic distribution is very wide and includes many regions worldwide, such as Iran—including provinces bordering Afghanistan [5], India [6], [7], Pakistan [8], the United States of America [9], and Russia [1].

1. **1a.** Elytra are red with distinct black spots in the center of each elytron. The pronotum is black in the center with creamy areas on the sides (Figures 2 and 3, images 1 and F).
2. **1b.** Similar to 1a, but the black spots in the center of the elytra are smaller. The pronotum is creamy with five black spots in the middle section (Figures 2 and 3, images a1 and B).
3. **1c.** Elytra are red with smaller black spots than 1a, and the pronotum is brown with creamy areas on the sides (Figures 2 and 3, images b1 and A).
4. **1d.** Similar to 1b, but the black spots on the pronotum are almost merged. A small dot is also visible in the center of the pronotum (Figures 2 and 3, images 1c and C).
5. **1e.** Elytra are pale red with black spots smaller than those of 1a. The pronotum is light brown with brown prominences in the center and sides, and creamy bands around and in the center (Figures 2 and 3, images 1d and D).
6. **2a.** Elytra are orange-red and spotless. The pronotum is creamy with five black spots in the center, one of which appears as a small dot in the middle section (Figures 2 and 3, images 2 and E).
7. **2b.** Elytra are uniformly orange-red without any spots. The pronotum is light brown with dentate prominences on the sides and creamy lateral areas (Figures 2 and 3, images a2 and A).

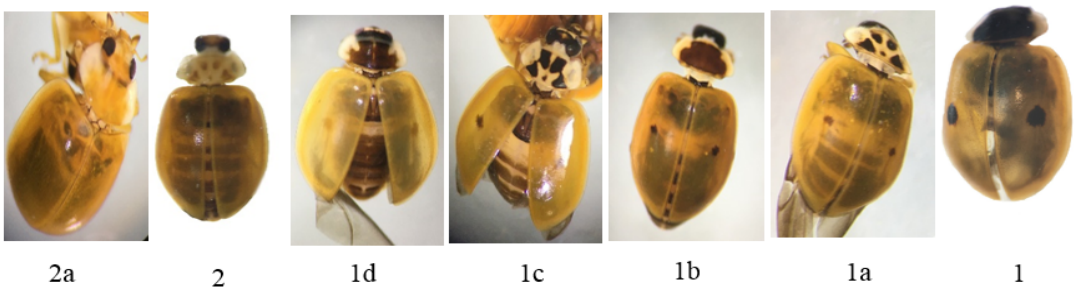

Figure 2. Dorsal view of various morphs of *A. bipunctata* in Meymeh County (1–2a).

Table 1. Collection data of *A. bipunctata* in Meymeh County, Faryab, Afghanistan

Collection Date	Collection Site	Host Plant	Geographic Coordinates	Altitude (m)
21 May 2021	Zargar Khaneh	Rose (*Rosa* sp.)	35° 55′ 02.8″ N, 64° 47′ 27.5″ E	879
18 May 2021	Zargar Khaneh	Peach (*Prunus persica*)	35° 55′ 02.8″ N, 64° 47′ 27.5″ E	879
3 May 2021	Zargar Khaneh	Peach (*Prunus persica*)	35° 55′ 02.8″ N, 64° 47′ 27.5″ E	879
6 May 2021	Zargar Kaneh	Peach (*Prunus persica*)	35° 55′ 02.8″ N, 64° 47′ 27.5″ E	879
8 May 2021	Faryab Univrsity Farm	Peach (*Prunus persica*)	35° 54′ 25.9″ N, 64° 47′ 20.8″ E	825
22 May 2021	Faryab University Farm	Peach (*Prunus persica*)	35° 54′ 25.9″ N, 64° 47′ 20.8″ E	825
30 May 2021	Faryab University Farm	Peach (*Prunus persica*)	35° 54′ 25.9″ N, 64° 47′ 20.8″ E	825
23 July 2021	Deh Seydan	Pear (*Pyrus communis*)	35° 54′ 27.8″ N, 64° 47′ 51.8″ E	902

Ladybird beetle specimens were collected from three different sites in 2021: Zargar Khaneh, Faryab University Farm, and Deh Seydan. At Zargar Khaneh (879 m), collections were made between 3 and 21 May from peach (*Prunus persica*) and rose (*Rosa* sp.). Faryab University Farm (825 m) was sampled on 8, 22, and 30 May, exclusively from peach trees. A single collection from Deh Seydan (902 m) was conducted on 23 July from pear

(*Pyrus communis*). Geographic coordinates for each site were recorded using GPS, providing precise location data for ecological and distributional analysis of the sampled beetles.

Figure 3. Pronotum patterns (A–F) in different morphs of *A. bipunctata* in Meymeh County.

Figure 3. Pronotum patterns (A–F) in different morphs of *Adalia bipunctata* collected from Meymeh County. The variation in pronotal markings among specimens indicates intraspecific polymorphism, which may be influenced by ecological factors such as microhabitat conditions, host plant type, or altitude. These morphological differences can aid in understanding population structure and local adaptation within the species.

4. DISCUSSION

The results obtained from studying the polymorphism of *Adalia bipunctata* in Meymeh region, Faryab province, indicate a significant morphological diversity within populations of this species in the studied area. The identification of two main morphs and several sub-morphs associated with different patterns of spot distribution and coloration on the elytra and pronotum suggests the presence of stable polymorphism in this species, which is consistent with previous findings from other regions [1], [2].

Polymorphism in *A. bipunctata*, which can result from genetic factors or complex gene-environment interactions, has been reported in various parts of Iran and other countries such as Turkey [3]. The results of this study also suggest that specific environmental factors in the Meymeh area, such as temperature, host plant species, and ecological conditions, may play a role in the expression and maintenance of this polymorphism. Ecologically, the presence of different morphs may provide adaptive advantages for *A. bipunctata* populations. For example, darker color morphs might confer thermal benefits in cooler regions by absorbing more sunlight, while lighter morphs may be better suited for warmer conditions [4], [5]. These differences, along with other behavioral and physiological traits, can contribute to the stable coexistence of multiple morphs within a single population. Furthermore, this phenotypic diversity could have important implications for selecting appropriate forms in biological control programs. Further investigation into the performance of different morphs regarding predation rate, reproduction, and host plant adaptation could assist in choosing the most effective forms for mass rearing in integrated pest management (IPM) programs.

Considering that Afghanistan, especially Faryab province, has high climatic and botanical diversity, it is recommended that similar studies be conducted in other parts of the country to create a comprehensive map of distribution, phenotypic diversity, and ecological performance of ladybird populations. Additionally, genetic studies could be valuable in clarifying the origin and stability of polymorphism in local populations.

5. CONCLUSION

The present study provides the first detailed investigation of the polymorphism of *Adalia bipunctata* in Maymana city, Faryab Province, Afghanistan. Through the collection and analysis of 120 specimens, significant morphological diversity was recorded, with two major morphs and several sub-morphs distinguished based on variations in coloration and spot patterns on the elytra and pronotum. These findings confirm that *A. bipunctata* populations in this region exhibit stable polymorphism, contributing to the broader understanding of phenotypic variability in natural populations of predatory ladybirds.

The observed differences in coloration and spot distribution among individuals may reflect the influence of environmental factors such as temperature, host plant availability, habitat structure, and other ecological pressures. The presence of both dark and light morphs within a single population suggests that these variants may serve distinct adaptive purposes, potentially aiding survival in varied microclimates and habitats across the region.

From an applied perspective, this polymorphism could have important implications for biological pest control. The ability of *A. bipunctata* to adapt to different environmental conditions through morphological variation may enhance its effectiveness as a biological control agent in diverse agroecosystems. This highlights the potential value of this species in integrated pest management programs across Afghanistan and neighboring regions.

Furthermore, the results of this study emphasize the need for additional research across other provinces of Afghanistan to map the full extent of ladybird diversity and their ecological roles. Expanding this research to include genetic studies would also provide insights into the hereditary basis of these polymorphic traits and their evolutionary significance.

Overall, this study establishes a foundational understanding of *A. bipunctata* polymorphism in northern Afghanistan and lays the groundwork for future ecological, genetic, and applied entomological studies focused on native beneficial insect populations.

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