Sapienza Università Editrice

E-ISSN 2284-4880
ISSN 0429-288X

Fragmenta entomologica, 57 (2): 205–212 (2025)

Research article
Submitted: June 26th, 2025 – *Accepted*: October 10th, 2025 – *Published*: October 31st, 2025
Doi: 10.13133/2284-4880/1805

Zoogeographic distribution and host plant relationships of Coccidae species in the Fergana valley, eastern Uzbekistan (Hemiptera: Coccomorpha)

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Abstract
This study investigates the zoogeographic distribution, ecological characteristics, and host plant associations of soft scale insects (family Coccidae) in the Fergana Valley, which includes the Andijan, Fergana, and Namangan regions of eastern Uzbekistan. Field surveys conducted during the vegetation season yielded a total of 12 species identified based on morphology and georeferenced sampling. Zoogeographic analysis revealed that 66.7% of the species are cosmopolitan, 25% are endemic to the Palearctic region, and 8.3% are distributed across multiple regions. In total, more than 25 host plants belonging to 13 plant families were recorded. These findings provide valuable insights for pest monitoring and integrated management strategies in Central Asia.

Keywords: Coccidae, host plant associations, zoogeographic distribution, Fergana Valley, Palearctic region

Introduction

Currently, 1241 species of the family Coccidae belonging to 180 genera are widespread in different zoogeographic regions in the world fauna, and their dynamics in the context of climate change and global trade deserve significant attention (García Morales et al. 2016; ScaleNet 2025). To maintain an up-to-date list of Coccidae species, effectively control them and timely detect new invasive species, it is important to study their zoogeographic and ecological characteristics in depth, and the role of local studies in this process is increasing (Bodenheimer 1935, 1947; Chen et al. 2022). Based on the studies conducted by F.S. Bodenheimer, 429 species of the common coccid family (Coccoidea) were recorded in the Palearctic zoogeographic region, of which 112 species occur in the territory what is now Israel and Palestine (Bodenheimer 1935). However, according to the latest ScaleNet data accessed 12 June 2025, the current number of Palearctic species belonging exclusively to the family Coccidae is 344, which indicates a significant change in the taxonomic classification of species compared to previous data (García Morales et al. 2016; ScaleNet 2025). Their regional distribution and association with food plants have been extensively studied by scientists such as Y. Ben-Dov, F. Kozár, E. M. Danzig, G. Pellizzari, E. Chadzidimitriou, P. Milonas, G. Stathas, S. Joshi, M. Moghaddam and G. Watson, and an international body of knowledge has been formed in this area (Kozár & Drozdjak 1986; Ben-Dov 1993; Danzig 1993; Kozár & Ben-Dov 1997; Pellizzari et al. 2015; Joshi 2019; Moghaddam & Watson 2024).

Since climate change and global trade processes are accelerating the spread of Coccidae species to new areas, increasing the risk of negative impacts on agroecosystems, there is a need to study their distribution in local ecosystems and develop strategies for managing them. For this purpose, this study was conducted to determine the distribution of Coccidae species in the Fergana valley (Andijan, Fergana and Namangan regions), assess their ecological characteristics, and study the degree of specialization in food plants. To achieve these objectives, we applied morphological identification and GIS-based mapping during the growing season.

Material and methods

The study was conducted in the Fergana Valley (Andijan, Fergana, and Namangan regions) in eastern Uzbekistan during 2024-2025 (Fig. 1). The study was carried out in the following stages:

Sample collection: the sample collection process was carried out during the active growing season, that is, from April to October 2024, using entomological traps and manual collection methods. The location coordinates of each sample were recorded using a GPS (Global Positioning System) device.

Insect identification: insects were identified based on morphological characteristics, and the diagnostic criteria were confirmed according to Danzig (1997), Hodgson (1994), and the updated ScaleNet database (García Morales et al. 2016; ScaleNet 2025).

Forage plant identification: host plants of each species were identified in the field, and the species–plant relationships were summarized based on the studies of Ben-Dov (1993), Pellizzari et al. (2015), Moghaddam & Watson (2024), Qaxhorova et al. (2025), and Sobirov et al. (2024).

Distribution maps: maps of species distributions were generated using QGIS 3.28. The coordinates of each species were mapped in shapefile format and visualized on the map of the Palearctic region (Hijmans et al. 2011). Distribution data were compared with previously published sources (Bodenheimer 1935; Kozár & Ben-Dov 1997; Joshi 2019; Qaxhorova 2024; Sobirov et al. 2025).

Zoogeographic classification: the subregions of the Palearctic zoogeographic region (Euro-Siberian, Mediterranean, Irano-Turanian, and Far Eastern) were distinguished based on the recommendations of Emeljanov (1974) and Lagowska (2001). Species were classified into Palearctic, Holarctic, subcosmopolitan, or cosmopolitan groups according to the criteria defined by Gertsson (2011, 2023).

Statistical analysis: the relationships and distribution of host plants were analyzed and plotted using Microsoft Excel and RStudio (version 4.4.1, ggplot2 package). The frequency distribution and degree of correlation were assessed by correlation analysis (Wickham 2016).

Results

Global distribution: according to recent records from international databases such as ScaleNet (2025; [https://scalenet.info] (https://scalenet.info), accessed 12 June 2025), IPM Images, and the ITP Node, members of the family Coccidae are distributed across all zoogeographic regions of the world. The number of recorded species per region is as follows: Neotropical (309), Afrotropical (277), Australian (214), Oriental (208), Palearctic (344), and Nearctic

Table 1 – List of Coccidae species from the Fergana valley and their known geographic distribution.

Species	**Zoogeographic regions and main geographic subdivisions**						
	Pal. (subregions)	**Aus.**	**Afr.**	**Nea.**	**Neo.**	**Ori.**	**NZ & P**
Anapulvinaria pistaciae **(Bodenheimer, 1926)**	**Pal. (IT, M, ES)**						
Coccus hesperidum **Linnaeus, 1758**	**Pal. (ES, M, IT, FE)**	*	*	*	*	*	*
Eulecanium rugulosum **(Archangelskaya, 1937)**	**Pal. (IT)**						
Parthenolecanium corni **(Bouché, 1844)**	**Pal. (ES, M, IT, FE)**	*	*	*	*	*	*
Pulvinaria salicicola **Borchsenius, 1953**	**Pal. (IT, ES, FE)**						
Pulvinaria vitis **(Linnaeus, 1758)**	**Pal. (ES, IT, FE)**	*		*	*		*
Pulvinaria hydrangeae **Steinweden 1946**	**Pal. (ES, IT, FE)**	*		*	*	*	
Pulvinaria floccifera **(Westwood, 1870)**	**Pal. (ES, M, IT, FE)**	*		*		*	
Rhodococcus turanicus **(Archangelskaya, 1937)**	**Pal. (IT, FE)**						
Sphaerolecanium prunastri **(Boyer de Fonscolombe, 1834)**	**Pal. (ES, M, IT, FE)**			*			
Saissetia oleae **(Olivier, 1791)**	**Pal. (ES, IT)**	*	*	*	*	*	
Parasaissetia nigra **(Nietner, 1861)**	**Pal. (ES, IT)**			*	*	*	

Note: Zoogeographic regions and main geographic subdivisions (alphabetical order): Afr. – Afrotropical; Aus. – Australia; ES – Europe and W Siberia; M – Mediterranean areas; IT – Irano-Turanian areas; FE – Palearctic Far East; Nea. – Nearctic; Neo. – Neotropical; NZ & P – New Zealand and Polynesia; Ori. – Oriental; Pal. – Palearctic.

(170). Among these, the Palearctic region hosts the highest number of Coccidae species.

Number and distribution of species in the Fergana Valley: a total of 12 Coccidae species were identified to date in the studied areas of the Fergana Valley (Table 1). These were classified into the following zoogeographic groups:

Species endemic to the Palearctic region: 3 species (25.0%)

Species occurring in 2–3 regions: 1 species (8.3%)

Cosmopolitan or subcosmopolitan species: 8 species (66.7%)

The identified species showed the following distribution within the Palearctic subregions: Euro-Siberian (9 species, 75.0%), Mediterranean (5 species, 41.7%), Irano-Turanian (12 species, 100.0%), and Far Eastern (7 species, 58.3%) (Table 1).

Associations with host plants in total, more than 25 host plant species belonging to 13 plant families were recorded in association with Coccidae species in the Fergana Valley. Notably, strong host associations were found within the family Rosaceae, particularly with the genera *Prunus, Malus, Pyrus,* and *Rosa*. Among these, *Parthenolecanium corni* was the most frequently recorded species (see Fig. 2; Qaxhorova et al. 2024; Sobirov et al. 2024).

Species of the genus *Pulvinaria* showed close relationships with members of the families Salicaceae (*Salix, Populus*), Vitaceae (*Vitis vinifera*), and Moraceae (*Ficus benjamina*). The species *Coccus hesperidum* was found on a wide variety of host plants, indicating high polyphagy and ecological plasticity.

Host-plant relationships here (Table 2)

Table 2. List of host plant species (**bold**) associated with each studied Coccidae species (*italic*) in the Fergana Valley, grouped according to plant family.

ANACARDIACEAE

Pistacia vera
Anapulvinaria pistaciae

ROSACEAE

Prunus persica
Parthenolecanium corni

Malus domestica
Parthenolecanium corni

Pyrus communis
Parthenolecanium corni

***Crataegus* sp.**
Parthenolecanium corni

***Rosa* sp.**
Parthenolecanium corni

Pyrus L.
Pulvinaria vitis

Prunus domestica
Sphaerolecanium prunastri
Parthenolecanium corni

Prunus armeniaca
Sphaerolecanium prunastri
Parthenolecanium corni
Eulecanium rugulosum

SALICACEAE

Salix alba
Pulvinaria salicicola

Populus alba
Pulvinaria salicicola

VITACEAE

Vitis vinifera
Pulvinaria vitis

RUTACEAE

Citrus limon
Coccus hesperidum

FABACEA

Gleditsia triacanthos
Parthenolecanium corni

ASTERACEAE

Artemisia absinthium
Coccus hesperidum

Helianthus annuus
Rhodococcus turanicus

PLATANACEAE

Platanus orientalis
Rhodococcus turanicus

JUGLANDACEAE

Juglans regia
Rhodococcus turanicus

BETULACEAE

Alnus glutinosa
Pulvinaria vitis

Corylus avellana
Eulecanium rugulosum

SAPINDACEAE

Acer palmatum
Pulvinaria floccifera

LAMIACEAE

Salvia rosmarinus
(= Rosmarinus officinalis)
Saissetia oleae

MORACEAE

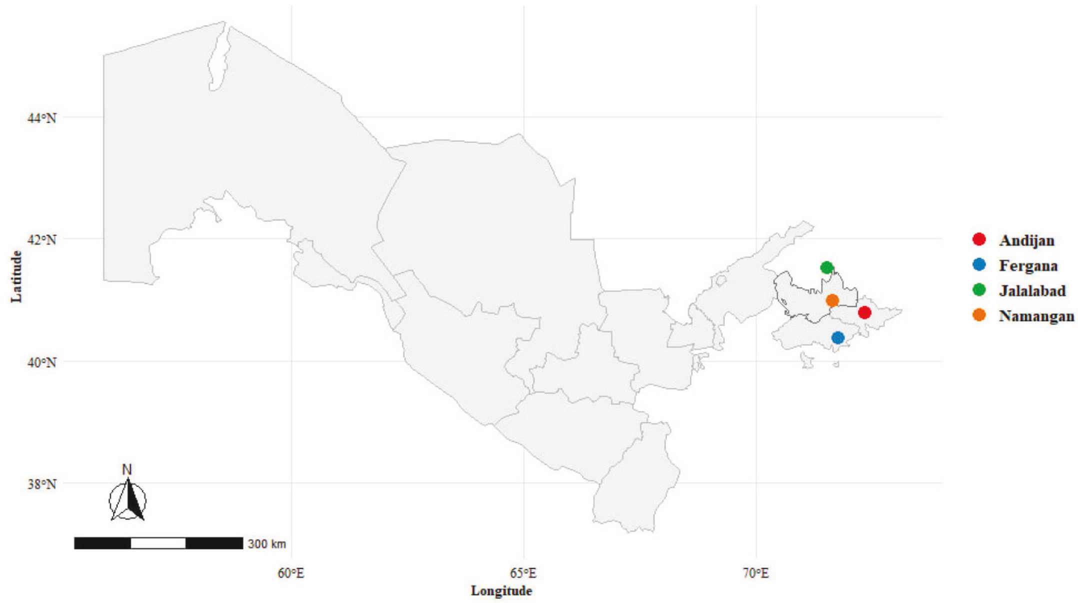
Ficus benjamina
Pulvinaria hydrangeae
Parasaissetia nigra

Ficus carica
Coccus hesperidum

Discussion

The results of the study show that Coccidae species found in the Fergana valley are ecologically adapted to different plant families (including Rosaceae, Vitaceae and Salicaceae), have a wide geographical distribution and show a high degree of specialization only in some cases. The Irano-Turonian subregion of the Palearctic region stands out as an important area for the diversity of Coccidae species, which is consistent with the classification proposed by Emeljanov (1974) and Lagowska (2001), and with more recent biogeographic analyses (Holt et al. 2013). This confirms the influence of regional ecological conditions on the distribution of species. Climate change, especially increasing temperatures, may facilitate the occupation of new territories by alien insects, leading to economic and ecological consequences (Kozar 2009; Kozar et al. 2013; Gertsson 2023). Members of the Coccidae family are distributed worldwide except for the polar regions, and a number of species have become cosmopolitan pests, causing significant economic losses to agriculture, horticulture, and forestry (Malumphy et al. 2012; Garonna et al. 2018; Dilley et al. 2020).

Cosmopolitan species, such as *Coccus hesperidum*, *Pulvinaria floccifera* and *Saissetia oleae*, are widely distributed in greenhouses and have adapted to environments affected by human activities. The widespread distribution of *Coccus hesperidum* in greenhouses and houseplants is an important factor in its penetration into new areas through global trade, and its polyphagous nature and high reproductive capacity lead to the isolation of aphids (Villanueva et al. 2020; Wu et al. 2021). This aphid promotes the development of black mold fungus and causes crop damage (Chen et al. 2022), therefore, biological control measures, such as the use of parasitoids, are important to limit its spread (Jones & Smith 2023). *Pulvinaria floccifera* has been shown to be persistently abundant in ornamental shrubs, especially in greenhouses, and its ecological plasticity and phenological characteristics have increased its harmfulness, and monitoring its distribution and population dynamics is essential for agriculture (López et al. 2021; Tanaka & Kamitani 2022; Kumar et al. 2023). *Saissetia oleae* is



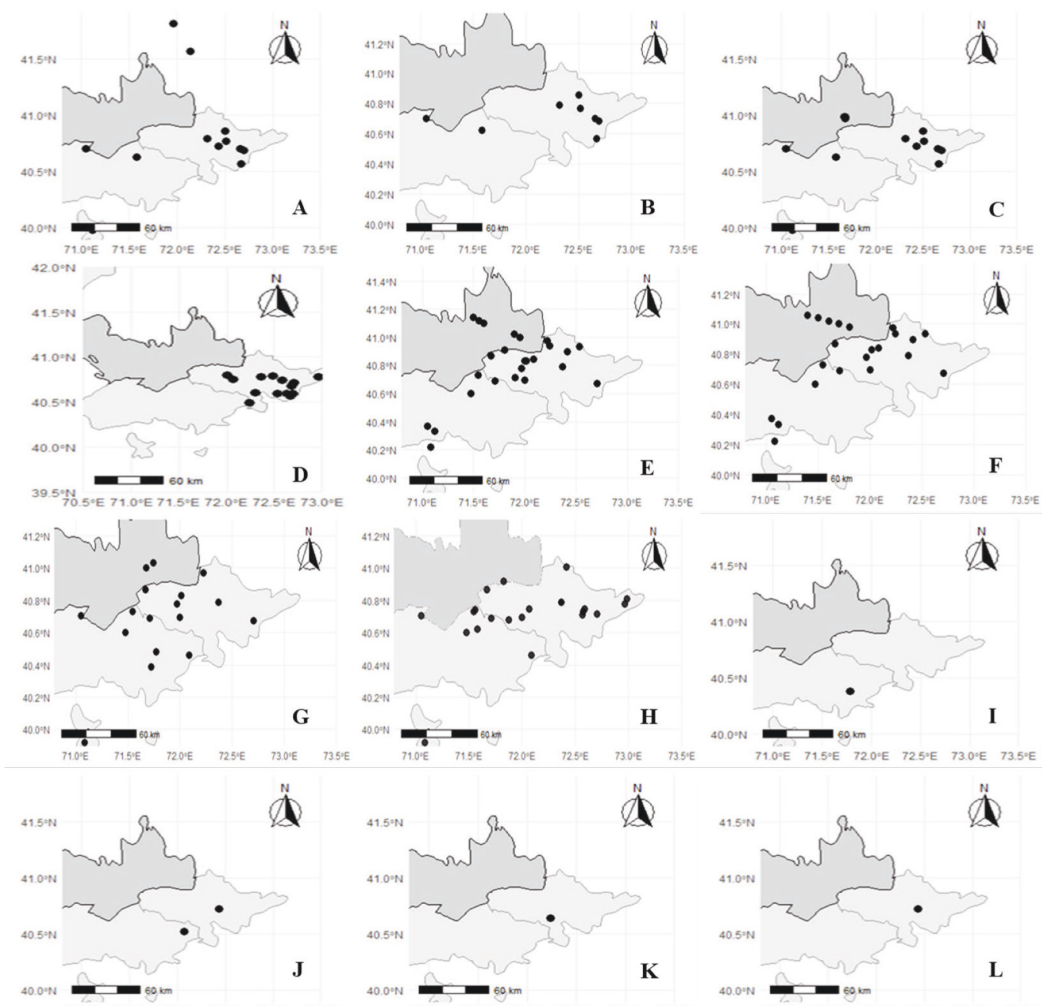


Fig 1 – Maps of local distribution in eastern Uzbekistan provinces of each listed Coccidae species. **A**, *Anapulvinaria pistaciae,* **B**, *Pulvinaria vitis,* **C**, *Pulvinaria salicicola,* **D**, *Rhodococcus turanicus,* **E**, *Coccus hesperidum,* **F**, *Parthenolecanium corni,* **G**, *Spharelecanium prunastri,* **H**, *Eulecanium rugulosum*, **I**, *Saissetia oleae,* **J**, *Pulvinaria hydrangeae* **K**, *Pulvinaria floccifera,* **L**, *Parasaissetia nigra.*

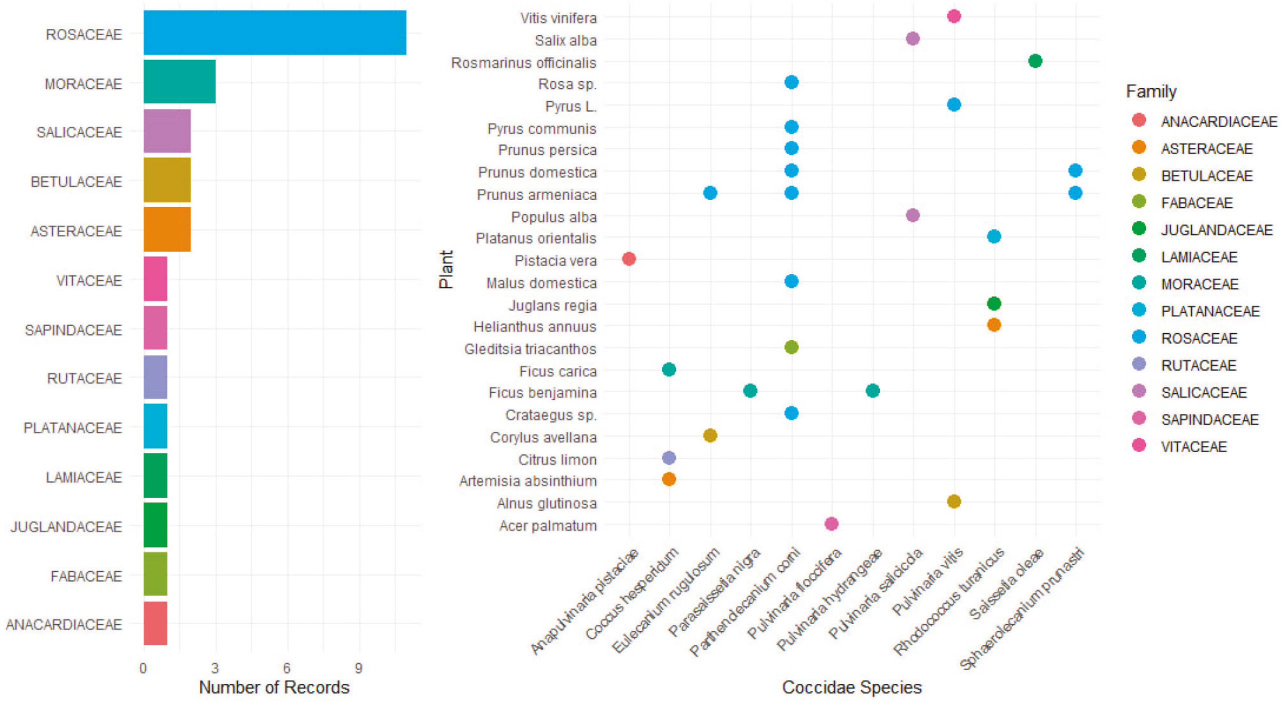


Fig 2 - Relationships of Coccidae species occurring in the Fergana Valley, eastern Uzbekistan, with their major host plant families and species.

found on olive, citrus and other fruit trees and is expanding its distribution due to climate change and anthropogenic factors Ilias & Hammadi (2017). Its damage by sucking plant sap and the development of mold fungi as a result of the sap causes economic losses (Dos Santos et al. 2022), and the dependence of its population on climatic conditions is an important factor in the development of control strategies (Gonzalez et al. 2023).

Factors such as global trade, urbanization, and climate change are accelerating the spread of Coccidae species to new geographic areas, making them a global threat as invasive pests (Wu et al. 2021). Recent studies, including Wang et al. (2024) and Kim & López (2025), suggest that climate warming is increasing the overwintering of some species in new areas and their adaptation to agroecosystems. For example, *Saissetia oleae*, originally thought to be endemic to Mediterranean climates, is now widespread in greenhouses and has been confirmed to be established in open gardens by Fernández et al. (2024). This situation also suggests a potential threat to other autochthonous Coccidae species.

Relationships with food plants also play an important role. The close association of *Parthenolecanium corni* with the Rosaceae family and the specialization of *Sphaerolecanium prunastri* with *Prunus spp*. are of economic importance in orchards in the Fergana valley (Qaxhorova et al. 2025). The association of these species with plants, especially the high diversity observed in the Rosaceae, Vitaceae and Salicaceae families, increases the risk of damage to agricultural products. Rising temperatures and changes in precipitation may extend the growing season of *P. corni* and expand its distribution area, which will further aggravate ecological problems.

Data obtained in the Fergana valley, including distribution maps (Fig. 1), pest population monitoring, andit will be useful in predicting the risk of cosmopolitan species spreading through climate models. This map will provide a basis for identifying unexplored areas and for further research, for example, the occupation of all areas of the valley by species such as *Parthenolecanium corni*, *Sphaerolecanium prunastriva Eulecanium rugulosum* indicates that other species may also have a wide range of distribution. From the perspective of biodiversity conservation, the 12 species of Coccidae and their associations with more than 25 plant species belonging to 13 plant families indicate the complexity of the ecosystems in the Fergana valley. This data will serve as a basis for studying similar ecosystems in other regions.

In terms of integrated pest management (IPM) strategies, this study makes an important contribution to reducing the dependence on chemical pesticides in agriculture. For example, the use of biological control using parasitoid insects (e.g., from the Encyrtidae family) in orchards of the Rosaceae family for *Parthenolecanium corni* can help prevent economic losses (Chen et al. 2022). The specialization of *Sphaerolecanium prunastri* on *Prunus domestica* can be used to optimize agronomic practices in orchards, such as pruning or water management (Chen et al. 2022). This IPM approach can help to increase the sustainability of global agriculture and minimize environmental damage. At the same time, monitoring global trade and transport systems is important to prevent the spread of invasive species, especially cosmopolitan Coccidae species, to new areas (Wu et al. 2021).

Most of the 12 species identified during the study were Palearctic or cosmopolitan in nature, with their distribution zones and specialization in host plants being determined. The highest host plant biodiversity was observed in the families Rosaceae, Vitaceae, and Salicaceae, where species such as *Parthenolecanium corni* and *Coccus hesperidum* were widely distributed in association with various plant species and are considered to be major pests in agroecosystems.

The results obtained indicate the ecological adaptation and geographical distribution of Coccidae species in the Fergana valley, which is important for developing effective monitoring and integrated management strategies against agricultural pests. These data can be used to predict the spread of pests under climate change, preserve biodiversity and ensure agricultural sustainability on a global scale. In particular, the risk of the spread of invasive cosmopolitan species to new territories and their expansion under the influence of human activities (trade, urbanization) poses a significant threat to global agriculture and ecological sustainability. The results of the study will serve as a basis for work on identifying areas, studying similar ecosystems in other regions and developing IPM strategies.

Conclusions

The study provides new insights into the zoogeographic distribution and host plant relationships of Coccidae (Hemiptera: Coccomorpha) species in the Fergana Valley, an ecologically significant but underexplored region of Central Asia. The recorded species showed distinct patterns of distribution across various altitudinal and climatic zones, with some species exhibiting clear preferences for specific host plants and habitats. Environmental factors such as temperature, humidity, and vegetation type appeared to influence both the abundance and spatial distribution of scale insects. Among the studied species, *Anapulvinaria pistaciae* and *Pulvinaria vitis* were dominant in orchard habitats, while *Sphaerolecanium prunastri* and *Parthenolecanium corni* showed stronger associations with natural riparian vegetation.

These findings contribute to the broader understanding of scale insect biogeography in Middle Asia ecosystems and establish a foundation for future ecological and molecular investigations of Coccomorpha in the region. The data presented in this study may also support pest management strategies and conservation efforts targeting vulnerable habitats of high ecological and biogeographical concern, affected by anthropogenic pressures and climate change.

The results highlight that the faunistic exploration of soft scale insects in Uzbekistan is still in progress, and additional comprehensive studies are required to achieve a more complete understanding of their actual diversity and distribution.

Acknowledgments – We thank the staff of the Zoology and Biochemistry Department at Andijan State University for logistical support during field sampling. Special thanks to Dr. Ozodbek Tojimatovich Sobirov for assistance in specimen identification and data interpretation. We are also grateful to local landowners and park rangers who facilitated access to study sites across the Fergana Valley. The authors acknowledge the reviewers for their constructive feedback, which improved the clarity and quality of the manuscript.

Authors' contributions: Kholida Rakhimjon qizi Kakhkhorova: Conceptualization, fieldwork, specimen preparation, data analysis, writing – original draft. Ozodbek Tojimatovich Sobirov: Supervision, methodology, writing – review & editing.

Competing interests: The authors declare that they have no competing interests.

Availability of data and materials: All data generated or analyzed during this study are available from the corresponding author upon reasonable request.

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