

ON THE OCCURRENCE OF LADYBIRDS ON
BROADLEAVED TREES IN THE URBAN HABITATS
OF BULGARIA

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Abstract

In July 2024 we sampled ladybirds on broadleaved trees in urban plantings of Sofia and Koprivshitsa (Bulgaria). During our research, a total of 812 adults and larvae belonging to 16 species were collected. While in Sofia invasive *Harmonia axyridis* (71.5%) and *Oenopia conglobata* (13.9%) were eudominant ladybirds, in Koprivshitsa *Adalia decempunctata* (33.9%), *Harmonia axyridis* (30.7%) and *Stethorus pusillus* (25.1%) were eudominant. Ladybird community in Sofia was dominated by the invasive and synanthropic *Harmonia axyridis*, however, in a rural-like town Koprivshitsa, native ladybirds were more abundant than this non-native ladybird. We documented the occurrence of four colour morphs of the invasive species *Harmonia axyridis*: *succinea*, *spectabilis*, *conspicua*, and *equicolor* with a morph *succinea* being the most abundant. Our research shows, that in Bulgaria, broadleaved trees in urban habitats are significant hosts of ladybird communities.

Key words: Coccinellidae, harlequin ladybird, urban plantings, *Tilia*, *Acer*

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Introduction. Ladybirds (Coleoptera: Coccinellidae) are common representatives of insect communities found in urban plantings [1, 2]. Their presence in the urban environments is beneficial, since they contribute to the reduction of populations of sap-sucking pests, such as aphids and coccids, thereby serving a biocontrol function [3].

Current research on the ecology and distribution of arboricolous ladybirds in Europe primarily focuses on those associated with broadleaved trees [1, 2, 4], with comparatively less emphasis on coniferous species [5]. Among the woody plants found in the urban environments, ladybirds are most commonly associated with lime trees (*Tilia* spp.) and maples (*Acer* spp.) [1].

The communities of native ladybirds have been significantly affected by the introduction and fast spread of the invasive harlequin ladybird (*Harmonia axyridis* (Pallas, 1773)) [4]. This species is frequently documented as the most prevalent ladybird inhabiting broadleaved trees in the urban environments across various European countries [1, 2, 6].

Ladybirds in the Balkans have been the subject of investigation by several authors [2, 7, 8]. In Bulgaria, studies on ladybirds are rare, primarily focusing on their role as beneficial biocontrol agents in fruit trees, ornamental flowers and agricultural crops [9–11]. Recent research has particularly concentrated on the invasive species *H. axyridis* [12]. However, data regarding ladybird communities inhabiting trees in the urban plantings in Bulgaria remain absent. The aim of this study is to enhance the understanding of ladybird species diversity on broadleaved trees at two urban locations in Bulgaria.

Material and methods. Ladybirds were sampled at three urban parks in Sofia – Knyazhevska Gradina (N 42°41.41310', E 23°20.02797'; 543 m a.s.l.), Borisova Gradina (N 42°41.12532', E 23°20.49870'; 550 m a.s.l. N 42°41.41310', E 23°20.02797'; 543 m a.s.l.), and Yuzhen Park (N 42°40.73205', E 23°18.96970'; 560 m a.s.l.) on July 3rd and 4th, 2024. Additionally, sampling occurred in the town of Koprivshtitsa (N 42°38.33625', E 24°21.50315'; 1014 m a.s.l.) on July 5th, 2024. Ladybirds were collected from the branches of various broadleaved tree species present in the urban plantings, predominantly *Tilia* spp., *Acer* spp., and *Betula* spp. The beetles were dislodged from the branches using a wooden stick and collected in a square beating tray measuring 100 × 100 cm. The collection process lasted for four hours at each location. The collected ladybirds, including both adults and larvae, were preserved in 70% ethyl alcohol and subsequently identified in a laboratory following the methodologies outlined by NEDVĚD [13].

The species diversity of ladybird communities was evaluated using Shannon's diversity index, which was computed using the PAST software [14]. The accumulation of species richness in relation to increasing sample size at the study localities was analyzed through rarefaction curves, incorporating a 95% confidence interval, using the R software [15].

Results. Ladybird communities on broadleaved trees in Bulgaria.

A total of 812 ladybirds, encompassing both adults and larvae, representing 16 species, were documented at two urban locations in Bulgaria. Specifically, 597 ladybirds (14 species) were observed in Sofia, while 215 ladybirds (8 species) were recorded in Koprivshtitsa. Five of the identified species were also present in their larval stage: *Harmonia axyridis*, *Oenopia conglobata*, *Adalia decempunctata*, *A. bipunctata*, and *Coccinella septempunctata* (Table 1).

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A list of ladybird species documented on broadleaved trees in the urban plantings of Sofia and Koprivshtitsa

Species	Sofia			Koprivshtitsa		
	N	D %	Degree of dominance	N	D %	Degree of dominance
<i>Harmonia axyridis</i> (Pallas, 1773) *	427	71.52	EU	66	30.70	EU
<i>Oenopia conglobata</i> (Linnaeus, 1758) *	83	13.90	EU	0	0.00	
<i>Stethorus pusillus</i> (Herbst, 1797)	31	5.19	DO	54	25.12	EU
<i>Exochomus quadripustulatus</i> (Linnaeus, 1758)	23	3.85	SD	0	0.00	
<i>Coccinella septempunctata</i> Linnaeus, 1758 *	8	1.34	RE	5	2.33	SD
<i>Aphidecta oblitterata</i> (Linnaeus, 1758)	8	1.34	RE	0	0.00	
<i>Vibidia duodecimguttata</i> (Poda, 1761)	6	1.01	RE	0	0.00	
<i>Adalia decempunctata</i> (Linnaeus, 1758) *	4	0.67	SR	73	33.95	EU
<i>Adalia bipunctata</i> (Linnaeus, 1758) *	2	0.34	SR	13	6.05	DO
<i>Propylea quatuordecimpunctata</i> (Linnaeus, 1758)	1	0.17	SR	0	0.00	
<i>Coccinula quatuordecimpustulata</i> (Linnaeus, 1758)	1	0.17	SR	1	0.47	SR
<i>Scymnus frontalis</i> (Fabricius, 1787)	1	0.17	SR	0	0.00	
<i>Scymnus subvillosus</i> (Goeze, 1777)	1	0.17	SR	0	0.00	
<i>Scymnus rubromaculatus</i> (Goeze, 1777)	1	0.17	SR	0	0.00	
<i>Harmonia quadripunctata</i> (Pontoppidan, 1763)	0	0.00		2	0.93	SR
<i>Scymnus flagellisiphonatus</i> (Fürsch, 1970)	0	0.00		1	0.47	SR
Σ	597	100		215	100	

*the species was present also in a larval stage. Degrees of dominance according to TISCHLER [16]: EU – eudominant (> 10%), DO – dominant (5–10%), SD – subdominant (2–5%), RE – recedent (1–2%), SR – subrecedent (< 1%)

The eudominant species within the ladybird communities in Sofia were identified as *Harmonia axyridis*, comprising 71.5% of the population, and *Oenopia conglobata*, which accounted for 13.9%. In contrast, the predominant species in Koprivshtitsa included *Adalia decempunctata* (33.9%), followed by *Harmonia axyridis* (30.7%), and *Stethorus pusillus* (25.1%). Other ladybird species were found to be considerably less abundant (Table 1). In Sofia, *H. axyridis* exhibited a marked predominance over native ladybird species, whereas in

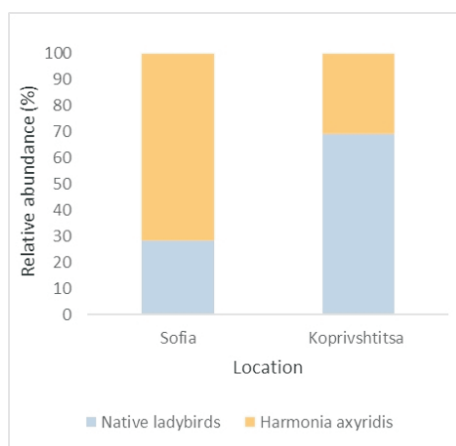


Fig. 1. Relative abundance of native ladybirds and invasive *Harmonia axyridis* at studied locations

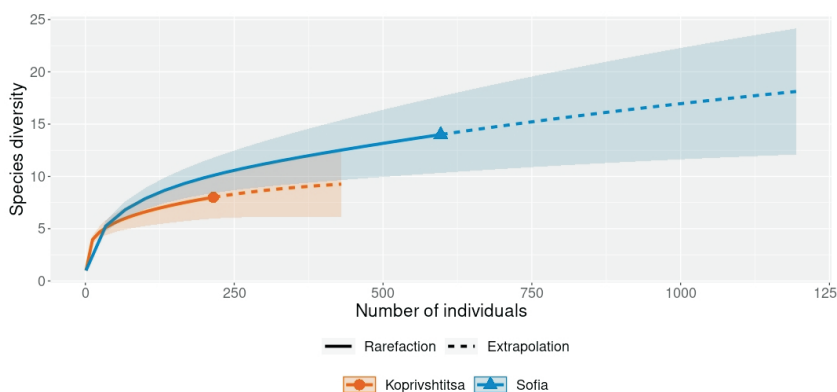


Fig. 2. The accumulation of species richness in relation to an increasing number of individuals was examined at two locations in Bulgaria, utilizing rarefaction curves with a 95% confidence interval. In Sofia, ladybirds were collected from three distinct parks, while in Koprivshtitsa, sampling occurred at a single location

Koprivshtitsa, *H. axyridis* was less abundant than the native ladybird species (Fig. 1).

According to rarefaction curves, the ladybird community in Sofia exhibited greater species richness compared to that in Koprivshtitsa (Fig. 2). However, the Shannon index of diversity was higher in Koprivshtitsa ($H' = 1.443$) than in Sofia ($H' = 1.072$).

Polymorphism of *Harmonia axyridis* at studied localities. During our research, we documented the occurrence of four colour morphs of the invasive species *H. axyridis*. Among these, three were identified as common morphs:

succinea (92% of all specimens), *spectabilis* (7%), and *conspicua* (1%), with *succinea* being the most abundant. Additionally, a single specimen of the rare colour morph *equicolor* was discovered in Yuzhen Park (Sofia) on July 4th, 2024.

Discussion. Ladybird communities on broadleaved trees in Bulgaria. In July 2024, we sampled ladybirds on broadleaved trees within the urban environments of Sofia and Koprivshitsa (Bulgaria). Generally, ladybird communities on broadleaved trees in the urban plantings exhibit high species richness [1, 4]. Our findings indicate a lower overall species richness than that reported by HONEK et al. [4], who recorded 22 species on broadleaved trees in Prague. Additionally, VIGLÁŠOVÁ et al. [1] documented a total of 28 ladybird species from broadleaved trees and nettle (*Urtica dioica*) across three European countries (Czechia – 21 species, Slovakia – 15 species, Great Britain – 12 species). In Serbia, particularly in parks in Belgrade, the species richness of ladybird communities was comparable, with 13 species identified [2], aligning closely with the findings in Bulgaria. It is important to note, however, that the data regarding ladybirds in the aforementioned studies were collected using different methodologies and sampling efforts from those employed in our study.

All ladybird species observed in Bulgaria were native, with the exception of *H. axyridis*, an invasive species originally from Asia [6]. This species was first documented in Bulgaria in July 2008 [12]. The proportion of *H. axyridis* within ladybird communities exhibited significant variation between Koprivshitsa, a small rural town, and Sofia, a large urban centre. In Koprivshitsa, native ladybird species predominated over the non-native *H. axyridis*. Conversely, in Sofia, *H. axyridis* was the most abundant species, being approximately 2.5 times more abundant than native ladybirds. These findings align with those of FARROW et al. [17], who reported that ladybird communities in rural areas did not exhibit dominance by *H. axyridis* on trees. It is well-documented that this non-native ladybird favours urban environments over semi-natural and natural landscapes [6, 12]. Additionally, the relatively high altitude of Koprivshitsa (1014 m above sea level) may contribute to the lower abundance of *H. axyridis* in this area. Although populations of this ladybird have been reported at altitudes around 1000 m above sea level in Serbia [8], it is generally more abundant at lower elevations [6]. In Sofia, the eudominant species *H. axyridis* and *O. conglobata* markedly predominated the ladybird communities, accounting for a total of 85.4%. Similarly, in Koprivshitsa, three eudominant species – *A. decempunctata*, *H. axyridis*, and *S. pusillus* – comprised a total of 89.8% of all individuals observed. This is in line with HONEK [18], who found that ladybird communities typically consist of a limited number of dominant species that may present up to 90% of the total individuals, alongside other species that are less abundant. The eudominant ladybirds identified in our study are well-documented as common species inhabiting broadleaved trees [1, 2, 13].

Notes on the occurrence of selected ladybird species. *Harmonia axyridis* was the most prevalent ladybird species in this study. This species exhibits a strong preference for broadleaved trees [1,6]. Shortly after its invasion, it became the most abundant ladybird on broadleaved trees within urban environments, with dominance levels potentially reaching up to 90% [1,2].

Oenopia conglobata was identified as the second most abundant species in Sofia; however, it was completely absent in Koprivshtitsa. The reasons for its absence in Koprivshtitsa remain unclear. This ladybird is among the most common ladybird species found on broadleaved trees [1,13]. In ladybird communities in the urban habitats in Slovakia and Serbia, it was the most abundant ladybird species following *H. axyridis* [1,2]. Conversely, in broadleaved trees in Prague (Czechia), *O. conglobata* was observed to be relatively less abundant [4].

Stethorus pusillus was identified as the third most abundant species within the communities at both study localities. According to KOCH [19] and Nedvěď [13], this ladybird is commonly found on broadleaved trees, particularly on lime trees. However, it has been noted that this species is absent from broadleaved trees in urban environments across Czechia, Slovakia, Great Britain and Serbia [1, 2, 4]. *Stethorus pusillus* can achieve high population densities, which are typically associated with the presence of its prey – spider mites on various trees in diverse habitats [13,19]. Nevertheless, due to its diminutive size, measuring 1.1–1.5 mm [13], this species may be easily overlooked in field observations.

Adalia decempunctata was the most abundant ladybird species in Koprivshtitsa; however, it was unexpectedly infrequent in Sofia. This ladybird is recognized as a typical and abundant species associated with broadleaved trees [13,19]. In Prague (Czechia), it was documented as the most abundant native ladybird species on broadleaved trees [4]. Similarly, in urban plantings in Belgrade (Serbia), this species was frequently observed [2].

We documented several individuals of *Harmonia quadripunctata* and *Aphidecta oblitterata*, which are ladybirds typically associated with coniferous trees [13,19]. However, these species may also inhabit broadleaved trees [1,4]. The frequent presence of coniferous trees at the studied sites may have facilitated the occurrence of these ladybirds on broadleaved trees as well.

Polymorphism of *Harmonia axyridis* at studied localities. Harlequin ladybird (*H. axyridis*) is characterized by significant polymorphism [6]. In Bulgaria, we documented the presence of four colour morphs of this species: *succinea*, *spectabilis*, *conspicua*, and *equicolor*. In a prior investigation of *H. axyridis* populations, TOMOV et al. [12] did not identify the *equicolor* morph in Bulgaria. To the best of our knowledge, this study represents the first report of the morph *equicolor* in Bulgaria. Across Europe, this particular colour morph is exceedingly rare, with occurrences previously documented in Slovakia, Hungary, Czechia, the Netherlands, and Great Britain [20].

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