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BIRD'S CONSORTIUM TIES WITH *Parthenocissus inserta* (A. Kern.) Fritsch., 1922 ON THE EXAMPLE OF FOREST PARKS AND CITY PHYTOCENOSES IN KYIV CITY (UKRAINE)

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Abstract

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Parthenocissus inserta (A. Kern.) Fritsch. adapts to living in the forests of Ukraine. The influence of *P. inserta* on native species and its consortial ties with representatives of the secondary ranges biota, in particular birds, has not been studied. The purpose of this study is to make an inventory of the consorts' ornithocomplexes of *P. inserta*, to give a comparative analysis of topic and trophic consorts as a result of an introduced species' participation in the transformation of habitat's conditions. The material was collected from 2019 to 2022 in forest parks and urban green spaces of the Kyiv city. The bird distribution was determined by the standard method of counting birds at points. Exactly 12.2 ha of *P. inserta* plantations were surveyed. Trophic consortium relationships of *P. inserta* with 32 bird species and topic ones with six bird species were revealed. The species composition of consorts was higher in forest fragments than in urban plantations (26 and 21 species, respectively). In the ornithocomplexes of *P. inserta* consorts in forest biotopes, there was a smaller pressure of dominant species and a more evenly ranked distribution of species by abundance than in urbanized ones. The similarity of the consort's species composition in urbanized and natural biotopes according to the Sorensen index was 0.64, in consorts 1 and 2 of the consortium concentres was 0.32, and in topic and trophic consorts was 0.27. According to the status of stay in the region, trophic consorts of P. *inserta* were mainly resident birds – 20 species (62.50%), wintering birds – six species (18.75%), and birds migrating through the region – six species of birds (18.75%). Among the topic consorts, there were four species of sedentary species and two species arriving for nesting. Principal component analysis revealed the largest positive relationship between *P. inserta* planting area and the number of consort bird species nesting (0.999) and feeding (0.889) on girlish vine plants. We predict that in the future, *P. inserta* will be more strongly woven into the matter cycle of the secondary range ecosystems. The study of consortial relationships between invasive plants and birds, taking into account the knowledge of the ecological characteristics of consort birds, will make it possible to more effectively prevent the spread of plants into natural biotopes.

Key words: alien species, *Parthenocissus inserta* (A. Kern.) Fritsch., 1922; Ukraine, bird's consortium; α-diversity indices.

Introduction

Every year, the relevance of the alien biota species studies about the influence on the communities into which they were introduced increases. This impact is complex, and it works simultaneously at several levels of the ecosystem. Despite the fact that sometimes diversity of cultural phytocenoses, for example, park ecosystems, increases due to alien species (Miroshnyk et al., 2021), the problem of negative impact of non-native species on the environment due to disruption of structural and functional relationships in ecosystems does not fade away. Invasive plants often result in reduced biodiversity (Wilcove et al., 1998; Ayup et al., 2014; Dragomir et al., 2017), reduced ecosystem resilience, and degradation (Pyšek, Richardson, 2010; Kumagai et al., 2015). Alien species destroying the natural environment, degrading its quality, can also lead to a negative impact on the social well-being of society (Brice et al., 2014).

Controlling the spread of alien species requires an understanding of the factors that promote them to enter new areas (Davis et al., 2000; Medley, 2010; Westcott, Fletcher, 2011). It is important to know the native capabilities of adventitious species, such as settlement ability (Guisan, Thuiller, 2005; Soberon, 2007; Blackburn et al., 2009), reproduction intensity (Lockwood et al., 2009), physiological and genetic characteristics (Theoharides, Dukes, 2007; Crawford, Whitney, 2010), and environmental influences on them. There is an opinion that the absence of natural enemies is necessary for the favorable anchorage of invasive species (Keane, Crawley, 2002). The ability of invasive species to function in close proximity to humans is separately emphasized (Brice et al., 2014; Møller et al., 2015), which contributes to the resettlement of many invaders (Moffatt et al., 2004; Cohen et al., 2019).

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Alien plants have become an integral component of the cultural landscape in urbanized conditions, since their use in landscaping brings esthetic diversity and cultivation is quite simple (Yang et al., 2010; Khuzhakhmetova et al., 2020). It has already been established that the distribution of invasive species is positively correlated with socioeconomic factors, population, and building density (Jang et al., 2020; Soltani et al., 2020). Introduced lianas have become an important element of residential areas, the most common among which in Ukraine are representatives of the genus *Parthenocissus* Planch (family *Vitaceae* Juss.). In Ukraine, these are introduced species, for example, *Parthenocissus inserta* of North American origin (The International Plant Names Index and World Checklist of Vascular Plants, 2023). *P. inserta* is widely distributed in many biotopes in the conditions of the forest-steppe of Ukraine, often forming monodominant stands, becoming a sub-edificator of the grass layer, displacing typical forest species, forming large stable sinuses (Blinkova et al., 2023). Its introduction into mixed forest communities leads to a restructuring of the cenoflora composition and unsatisfactory restoration of tree and shrub species and reduces the α- and β-diversity (Panasenko, Anishchenko, 2018). In European countries, it is classified as an invasive weed (Bean, 1976; Axmacher, Sang, 2013).

P. inserta are perennial deciduous vines, widely demanded in landscaping settlements. They grow in parks, courtyards of individual and apartment buildings, and green hedges of streets. Recently, residents of high floors have started to plant girlish grapes (*Parthenocissus*) on the balconies and windowsills of their apartments in pots. Plants are characterized by a dense leaf cover, which turns bright red in autumn, and tenacious stems that can rise up to six or seven floors. Lianas have an important esthetic and sanitary value in residential areas, especially in the southern regions. The use of vines in vertical gardening improves the microclimate near the house, lowering the temperature by 3–4 °C in summer and increasing air humidity up to 55–60% (Khuzhakhmetova et al., 2020). Fruits of *Parthenocissus* Planch. contain a lot of fat (Smith et al., 2007) and anthocyanins (Suthers et al., 2000; Bolser et al., 2013; Liang et al., 2018; Khan et al., 2018). Plants attract birds, which optimize the psychological state of the population of the technogenic environment. All this significantly improves the design of the city and the mood of its inhabitants, increasing the relevance of liana in the cultural landscape. At the same time, the issues of the influence of populations of species of the genus *Parthenocissus* Planch. on native species of communities of secondary ranges and their consortial relationships with representatives of various taxa of the biota still remain insufficiently studied.

The influence of the aboriginal population of animals of the secondary ranges on *P. inserta* has not been studied either. For successful introduction into the ecosystems of the secondary range, not only the characteristics of the plant itself (reproduction intensity, ability to spread, its eurytopicity to environmental conditions), but also a set of factors that form the scope of opportunities that the new habitat provides to the alien species are important (Gutiérrez et al., 2014). An important element of this environment is the animals that inhabit it and use plants as one resource or another. For example, in Western France, studying the distribution of forest plants by seeds in hedges revealed the positive impact of animal participation in the number and diversity of viable seeds (Mony et al., 2022). In Brazil, a study found that the abundance of birds determines the distribution of seeds (Vitorino et al., 2022), and for tropical forests, their floristic diversity is predicted to be preserved in the future precisely because of zoochory and, in particular, ornithochory (de la Pena-Domene, 2014). Calls for research into how birds and plants interact have been around for a long time (Snow, Snow, 1988). We believe that to elucidate the possibilities of distribution and potential ranges, it is necessary to identify as many relationships as possible between an alien plant and other biotic representatives of secondary ranges. Among these relationships, there can be both positive ones, for example, promoting fertilization, fruit germination, or their spread, and negative ones (e.g., destruction of the whole plant or its fruits by phytophages, growth inhibition). Knowledge of the positive and negative relationships of an alien plant with other organisms of the secondary range will improve the quality of forecasting and prevent the future dispersal of each plant species. These influences of organisms on each other are manifested in the process of consortium formation.

The concept "consortium" was proposed in 1951 by Beklemishev (1951), and it is defined as a set of individuals of various species that are trophically or topically associated with one autotrophic or heterotrophic organism – the core (edificator) of the consortium. Individual consortia (the core of a consortium is a separate organism) (Korchagin, 1976) are combined into higher ranks (population, species, generic, biomorphic). In supra-individual consortia, it is proposed to distinguish concentres: individuals of the first concentre are directly connected with the edificator, those of the second are indirectly connected through members of the first concentre, etc. The most typical links of the edificator are with the members of the first concentre (Mazing, 1966). In turn, we believe that the diversity indicators of the first concentre can be a good criterion for the adaptation of an adventitious plant to the conditions of the secondary range.

Any organism is functionally related to other organisms in the natural community; between the organism and the environment, there is a continuous exchange of matter, energy, and information. Due to this, consortative relationships are always found in the habitat of consorts, and consortium should be interpreted as an elementary ecological system that has its own spatial and functional parameters (Golubets, Chernobay, 1983).

In Ukraine, the problem of consortium relations has been studied quite actively, and significant material has already been accumulated on many issues (Tsarik et al., 1983; Ponomarenko, 2000; Chaplygina, 2015; Chaplygina et al., 2015, 2016). However, knowledge of the relationships between invasive plants and representatives of other biota groups is not so broad (Koshelev, 2015; Shupova, 2022).

We settled on the study of consortative relations of birds with the edificator species *P. inserta* in a population consortium, that is, in the aggregate of related populations of *P. inserta* in the territory of the Kyiv city. Birds are one of the most influential faunal components of communities (Fischer et al., 2007; Robledano et al., 2010; Adler, Jedicke, 2022), which are sensitive to any changes in the environment (Blair, Johnson, 2008) which affect their species composition, abundance, and spatial distribution (Blinkova, Shupova, 2017, 2018). Analysis of the ornithocomplex of pine–oak plantations showed differences in the group of important consorts of tree plantations in ecosystems with the introduced population of *Quercus rubra* L. in comparison to natural pine–oak forests with *Q. robur* L. (Gaychenko et al., 2021). The pur-

pose of this work is to make an inventory of the ornithocomplex of *Partenocissus inserta* consorts, to give a comparative analysis of the topic and trophic consorts because of the participation of an introduced species in the transformation of its secondary range.

Material and methods

The material was collected from the territory of the Kyiv city. Kyiv is located on the border of the forest and forest-steppe zones and the border of two geobotanical regions: the European broad-leaved forest region (represented by the sub-province of coniferous–deciduous forests of Polissya) and the Eurasian steppe region (represented by the Ukrainian forest-steppe subprovince of oak forests, steppe meadows, and meadow steppes). City center coordinates are 50°27′03″ N, 30°31′21″ E. The area of the city is 835.6 km², of which 313 km² is covered by forests. The vegetation period (> 5 °C) is 204 days long and starts on April 10. The climate type is hemicontinental (Biluk, 1977). The average annual air temperature for the period 1961–2016 was 8.9 °C. Latest research has noted a warming trend in the region over the past 150 years (Netsvetov et al., 2018).

P. inserta is adapted to living in Kyiv natural biotopes and its environs; therefore, we conducted the study of consortative relationships of this species with birds. The species identification of *P. inserta* was carried out during the period of their active flowering (end of May–June). The defining features of the species are: young twigs are green in spring, antennae with two to five branches, wavy, without or with very weakly developed suckers; leaves palmately compound with five, rarely three leaflets; leaflets are elliptical, 5–12 cm below, brilliant green, with a pointed apex; loose inflorescences, on a stem 3–7 cm long (wfo-0000476975, 2023; Kohno et al., 2005).

In 2019, nests of blackbird *Turdus merula* and common wood pigeon *Columba palumbus* were accidentally discovered in a vine of grapes. This prompted targeted research on the consortative relationships of *Parthenocissus* Planch. with birds. The material was collected from September 2020 to December 2022. The bird distribution was determined by the standard method of counting birds at points (Bibby et al., 2000). Observations were made in the morning (7.00–11.00 hours) and in the evening (16.00–20.00 hours). Birds were identified visually. All birds that fed on the model plants were recorded. The observation time at each point was 10 min. Two hundred and eighteen counts were carried out in parks and plantations of residential areas and 99 in forest plantations. Ninety-eight cases of birds feeding on *P. inserta* were taken into account: 79 during the period of full ripeness of berries and 19 during the summer growing season. Also, 885 individuals of trophic consorts and nine pairs nesting consorts, and 32 species and three orders of birds were recorded. The abundance (individuals/ha) of each species and their density in forest parks (2.8 ha) and urban phytocenoses (9.4 ha) were calculated. The scientific names of the species are given in accordance with the International Code of Zoological Nomenclature (2017).

We analyzed the species composition of ornithocomplexes and their abundance (individuals/ha) and calculated the α-diversity indices (Magurran, 1992) as follows: diversity indices: Menchinick $DMn = S/\sqrt{N}$, Marhalef $DMg = (S-1)/lnN$, Shannon $H' = -\Sigma(P_i \times lnP_i)$, McIntosh $U = \sqrt{\Sigma N_i^2}$; dominance indices: Berger–Parker $Dbp = N_{imax}/N$, McIntosh $Dm = (N-\sqrt{\Sigma N_i})/(N-\sqrt{N})$; evenness indices: Pielou $Ep = H'/LnS$; and species richness $Rs = S/N$, where S is the number of species, N_i is the abundance of each species (individuals/ha), N is the total abundance of birds, N_{max} is the abundance of the most numerous species, and $P_i = N_i/N$ is the ratio of species in ornithocomplexes.

Similarity of species composition in two ornithocomplexes was calculated by the formula of Sorensen index: $Cs = 2j/(a+b)$, where a is the number of ornithocomplex species present in the first list, b is the number of ornithocomplex species present in the second list, and j is the number of species common to both lists.

Intensive phenological monitoring was used for *P. inserta* to synchronize the phenodates of the circadian rhythm of birds and plants (Raspe et al., 2020). Particular attention was paid to the dates of ripening of *P. inserta* fruits. Observations were carried out during the growing season on separate model fragments of *P. inserta* stands: healthy plants were selected and numbered ($n = 5$). They described the biotope, orientation to the cardinal points, height, diameter, and crown condition. The phenophase stage was recorded for each plant once a week at the beginning of the growing season and twice during flowering and fruit ripening.

The birds of four residence statuses in the region were noted as consorts of *P. inserta*. Residents are the species living in Kyiv all year round; nesting means arriving in the region during the reproductive period and then flying away for the winter; wintering means spending the winter period in the region; and migratory birds are those whose migration routes pass through the territory of Kyiv and its environs and which stop here for feeding and rest. Some species in different periods of the year are represented by different populations, replacing each other and differing in the status of stay. For example, the fieldfare *Turdus pilaris* in Kyiv is characterized by a nesting population migrating to more southern regions and arriving for the winter. The lesser whitethroat *Curruca curruca* as a breeding consort is represented by a breeding population and as a trophic one by a migratory one.

In consortia, many links are formed between their constituent elements. To clarify the most significant of them for the consortia "*Parthenocissus inserta*–birds" was carried out by principal component analysis (PCA). The analysis used the value of the average area of a fragment of *P. inserta* stands; the number of bird species feeding and nesting in the vine; and the values of the Shannon, Pielou, Berger–Parker indices of the consorts' ornithocomplexes. According to PCA, variables in one quadrant are directly proportional and those in the opposite quadrant are inversely proportional. The length of the line indicates the strength of the link relative to other links.

Results

From the parks, individuals of *P. inserta* penetrate beyond the limits of the place allotted to them, braiding the trees growing nearby, and enter natural biotopes. At the same time, the vine enters the crown of trees to a height of 4–13 m. The average vine length is 646.56 ± 34.01 cm ($n = 90$). The number of berries in one brush at the beginning of September 2021 was 10–106 (aver-

age 40.6 ± 4.65, *n* = 11), and on November 22, 2021, after the foliage had fallen, we counted 2612 berries in the crown of one tree.

We have identified trophic consortative relationships between *P. inserta* and 32 bird species; in addition, four of these species nested in the vine and six used it as a shelter, forming topic consortial ties (Table 1).

Based on the obtained phenodata of *P. inserta*, we found that the relationships of the first concentre of trophic consortia "*P. inserta*–birds" are formed in early September, as soon as the first ripe berries appear. As a result of phenological observations, it was also noted that in the region of research, budding and flowering of *P. inserta* are extended until the end of the growing season. Until 10.10.2022, new buds appeared on all plants, and on some individuals, they appeared until 10.30.22. Consequently, the ripening of fruits is also extended in time.

The species composition of bird consorts differs significantly in natural and urban biotopes, although the number of species is close (26 and 21 species, respectively).

The similarity of the species composition of consort birds between urbanized and natural biotopes according to the Sorensen index is 0.64 and between topic and trophic consorts is 0.27.

According to the stay status in the region, trophic consorts of *P. inserta* are mainly sedentary birds – 20 species or 62.50% (see Table 1). The berries of girlish grapes are eaten by birds that have arrived for wintering (six species – 18.75%), as well as by those stopping for rest during the migration period (six species – 18.75%). Among the topic consorts, there are four species of sedentary birds (common wood pigeon *Columba palumbus,* blackbird *Turdus merula,* house sparrow *Passer domesticus,* Eurasian tree sparrow *P. montanus*) and two species arriving for

Table 1. Ornithocomplex of consorts *P. inserta* in Kyiv forest parks and city phytocenoses.

Species	Residence status in the region	Consortium type	The abundance of birds (individuals/ha)	
			city phytocenoses	forest parks
Columba palumbus L.1758	r	nc, fc	0.32	1.79
Columba livia Gmelin, 1789 *	r	fc	12.10	-
Dendrocopos major (L.1758) *	r	fc	-	0.71
Leiopicus medius (L.1758) *	r	fc	-	0.71
Dendrocopos syriacus (Hemprich et Ehrenberg, 1833) *	r	fc	0.11	-
Motacilla alba L.1758 *	n, m	nc, fc	0.11	-
Sturnus vulgaris L.1758	n, m	fc	3.62	2.50
Garrulus glandarius (L.1758)	r	fc	0.32	0.71
Pica pica (L.1758)	r	fc	0.43	0.71
Corvus frugilegus L.1758	r	fc	2.13	-
Corvus cornix L.1758	r	fc	1.70	-
Bombycilla garrulus (L.1758) *	w	fc	1.70	7.14
Curruca curruca (L.1758) *	n, m	nc, fc	0.53	0.71
Regulus regulus (L.1758) *	w	fc	-	2.50
Phoenicurus ochruros (S.G. Gmelin, 1774) **	n, m	fc	0.53	1.07
Erithacus rubecula (L.1758) **	n, m	fc	-	0.36
Turdus pilaris L.1758**	n, m, w	fc	16.0	3.57
Turdus merula L.1758**	r, n	nc, fc	1.06	0.71
Turdus viscivorus L.1758**	w	fc	-	0.36
Aegithalos caudatus (L.1758) *	r	fc	-	5.36
Lophophanes cristatus L.1758 *	r	fc	-	0.36
Periparus ater L.1758 *	r	fc	0.21	0.36
Cyanistes caeruleus L.1758 *	r	fc	0.32	0.36
Parus major L. 1758 *	r	fc	6.38	11.80
Sitta europaea L.1758 *	r	fc	-	2.14
Passer domesticus (L.1758)	r	nc, fc	2.45	-
Passer montanus (L.1758) *	r	nc, fc	6.38	8.57
Fringilla coelebs L.1758 *	n, m	fc	-	0.36
Carduelis carduelis (L.1758) *	r	fc	-	0.07
Acanthis flammea (L.1758) *	w	fc	-	8.93
Pyrrhula pyrrhula (L.1758) *	w	fc	0.21	0.71
Coccothraustes coccothraustes (L.1758) *	r	fc	0.32	0.71

Notes: * – protected by the Berne Convention; ** – protected by the Berne and Bonn conventions; - – the species is absent in consortia with *P. inserta* in this group of biotopes; r – resident (sedentary species); n – nesting; w – wintering; m – migratory; nc – topic consortium; fc – trophic consortium.

nesting (white wagtail *Motacilla alba,* lesser whitethroat *Curruca curruca*).

Common wood pigeon, blackbird, lesser whitethroat, and house sparrow nest in vine thickets and hide there from predators. The frequency of bird nests averages 1.34 ± 0.27 nesting pairs per 1 ha of *Parthenocissus inserta* stands. White wagtail and Eurasian tree sparrow use *P. inserta* as a shelter during the day and for roosting.

Species that arrive in the region to nest are represented by different populations: in summer, as consorts of the second concentre of trophic consortia, lesser whitethroat, black redstart *Phoenicurus ochruros*, Eurasian blue tit *Cyanistes caeruleus*, great tit *Parus major*, nesting in Kyiv; in autumn, consorts are representatives of other populations of these species, which migrate through the territory of Kyiv from nesting sites to wintering grounds; in winter, populations of great tit and Eurasian blue tit winter in the study area. In this case, birds form consortia of two concentres of topic consortia: they feed on berries and invertebrates hiding in *Parthenocissus inserta* thickets.

Table 2. α-diversity of ornithocomplexes of *Parthenocissus inserta* consorts in Kyiv forest parks and city phytocenoses.

Indices		Index data	
		topic	trophic (first concentre)
Diversity indices	Marhalef	3.52	7.54
	Menchinick	2.83	4.21
	Shannon	1.22	2.54
	McIntosh	1.88	19.98
Dominance indices	Berger–Parker	0.53	0.23
	McIntosh	0.91	0.75
Evenness index	Pielou	0.76	0.73

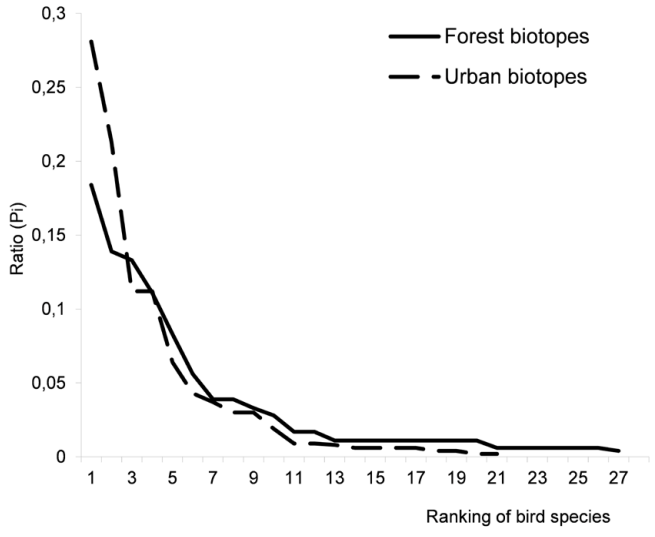


Fig. 1. Ranked curves of the relative abundance of species in ornithocomplexes of *Parthenocissus inserta* consorts in Kyiv forest parks and city phytocenoses:

- the ranked curve for the ornithocomplex of *P. inserta* consorts in the Kyiv forest biotopes has a slight bend in the first third of its length, indicates three dominant species and three subdominants, and further along the curve, its line approaches the abscissa scale, reaching the number of species – 26;
- the ranked curve for the ornithocomplex of *P. inserta* consorts in the Kyiv urban biotopes is lower than the previous curve, the relative abundance of birds in the ornithocomplex per two dominant species is 0.494, and the total number of species of the ornithocomplex is 21.

It is necessary to dwell on a group of birds whose main food is invertebrates. Most of the species (long-tailed tit *Aegithalos caudatus*, European crested tit *Lophophanes cristatus*, Eurasian blue tit, great tit, coal tit *Periparus ater*, Eurasian nuthatch *Sitta europaea*) are sedentary, and during the cold season, in conditions of deficiency, invertebrates eat berries and plant seeds; three species (common starling *Sturnus vulgaris* L., lesser whitethroat, black redstart) feed on berries of *Parthenocissus inserta* during the migration period. At the end of 2019, in the Kyiv residential areas, we observed migrating flocks of common starling numbering 20–50 individuals feeding on *P. inserta*. By the end of September, in plantations of *P. inserta* growing in cosy quiet yards, almost all the berries were eaten by common starling.

In addition to the berries, long-tailed tit, European crested tit, coal tit, Eurasian blue tit, and great tit collect insects on the grape vine. We also noted flocks of goldcrest *Regulus regulus* feeding on *Parthenocissus inserta* vine in winter. Birds did not eat berries, but collected invertebrates on the stems of *P. inserta*. These species are members of the second concentre, in which the links with the plant are mediated through invertebrates hiding in the vine for wintering. In autumn and summer, the group of the second concentre is supplemented by white wagtail, lesser whitethroat, black redstart, and European robin *Erithacus rubecula*. Thus, 10 species of birds form the second concentre of trophic cosortative relationships, and six of them are simultaneously included in both concentres. The similarity of the species composition of birds from the first and second concentres according to the Sorensen index is 0.32.

Species richness is significantly higher for topic consorts (0.14) than for trophic consorts (0.05). Synchronism in the data of birds' α-diversity indices of *Parthenocissus inserta* consort is not observed. For example, the data of the Marhalef, Menchinick, and Shannon species diversity indices for trophic consorts of *P. inserta* are higher than for topic one, while the McIntosh index is significantly higher. Dominance and evenness index data are higher for topic consorts (Table 2).

In general, the ornithocomplex of consorts of *P. inserta* in the forest biotopes of Kyiv city is characterized by a larger species composition, a smaller pressure of dominant species, and a more evenly ranked distribution. In the urban biotopes of Kyiv, the main part of the ornithocomplex is represented by the two most numerous species: rock pigeon *Columba livia и* fieldfare (Fig. 1). In forests in the ornithocomplex of consorts of *Parthenocissus inserta* dominated great tit, Eurasian tree sparrow, Grote Barmsijs *Acanthis flammea.*

PCA revealed that the planted area of *P. inserta* has a large positive relationship with the number of bird species nesting (0.999) and foraging (0.889) on vineyards. The relationship of the planted area of *P. inserta* with the value of the Shannon index of the ornithocomplex significantly less (0.297). There is a slight negative relationship between the planting areas of *P. inserta* and the value of Pielou's indices (-0.413) (Fig. 2). In the consortia "*P. inserta*–birds," the number of species of feeding and nesting birds has a strong positive

relationship with each other (0.891). The values of the Shannon and Pielou indices are positive (0.747) and the Berger–Parker indices are negative with the values of the Shannon and Pielou (-0.954) and Pielou (-0.912) indices.

Discussion

Birds adapt to changes in their habitat by creating consortative bonds, including with alien plants due to their wide ecological valence (Shupova, 2021). Fruit and berry introducers used in landscaping settlements provide birds of the urbanized landscape with plant food. The species composition of birds that add plant foods to their diet and to the diet of chicks is quite wide (Snow, Snow, 1988; Howe, 2016; Pesotskaya et al., 2020). The berries of girlish grapes, ripening in autumn, are eaten by sedentary birds or those that have flown in during winter. In autumn and winter, the resource of invertebrates is limited by weather conditions, and therefore, the presence of berry plants is of particular importance. There is a hypothesis that birds choose fruits and berries rich in anthocyanins for food (Bolser et al., 2013), especially during the migration period (Suthers et al., 2000). This strategy prevents the destructive effects of stress caused by a long flight. Birds eat the berries of girlish grapes, which contain many polyphenolic compounds (Bolser et al., 2013). Moreover, in most plants, the proportion of carbohydrates reaches 41.3–91.2% of dry mass, while the proportions of protein and fat are not high: 2.6–8.6% and 0.9–3.7%, respectively. The berries of the *Parthenocissus* Planch species, unlike most other species, contain more fat (e.g., *P. quinquefolia* – 23.6%) and are more high-calorie foods (Smith et al., 2007).

Berries ripening of *Parthenocissus* Planch species in the forest-steppe zone of Ukraine begins in early September and coincides with the period of migration of migratory birds. Sedentary birds supplement their diet with berries as soon as they ripen. Already in autumn (October 22, 2020; October 29, 2021; September 16, 2022), on some *P. inserta* plants, the berries were completely eaten. In plantations of girlish grapes, located in less-comfortable places, the berries remain until the arrival of flocks of wintering birds, primarily fieldfare. *P. inserta* berries stay on the vine even in frost. Frost resistance of *Parthenocissus* Planch species is estimated for *P. quinquefolia* at –16.63 °C, and for *P. tricuspidata* at –10.78 °C (Yang et al., 2010). The grass seeds are inaccessible to birds during snowfalls in winter, and the only food resource is the fruits of woody plants, which are at a sufficient height. In addition, the location of the berries high in the canopy creates safe places for birds to feed. Berries of *Parthenocissus* Planch species optimize the conditions for the birds' existence in winter. In the cultural city phytocenoses, the role of girlish grapes especially increases after exhaustion of the berry resources of natural biotopes. During this period, birds feeding outside the city fly in search of food to settlements.

For eating *P. inserta* berries, birds peck them from the branches or collect them on the ground. Observing the flocks of rock pigeon feeding on *P. inserta* hedges, we noted how some of the individuals, clutching the vine with their paws, pecked the berries in flight while hovering in place. At the same time, many berries, knocked down by the wings of birds, fell to the ground. The rest of the individuals of the flock collected berries on the ground. Fieldfare feeds in flocks, perching on a vine; single birds pick berries on the ground. Great spotted woodpecker *Dendrocopos major*, middle spotted woodpecker *Leiopicus medius*, mistle thrush *Turdus viscivorus*, Eurasian magpie *Pica pica,* Eurasian nuthatch *Sitta europaea*, Eurasian bullfinch *Pyrrhula pyrrhula*, and hawfinch *Coccothraustes coccothraustes* were observed feeding where *Parthenocissus inserta* penetrated high (8–12 m) into tree crowns. These birds feed on grapes berries in the crown of a tree.

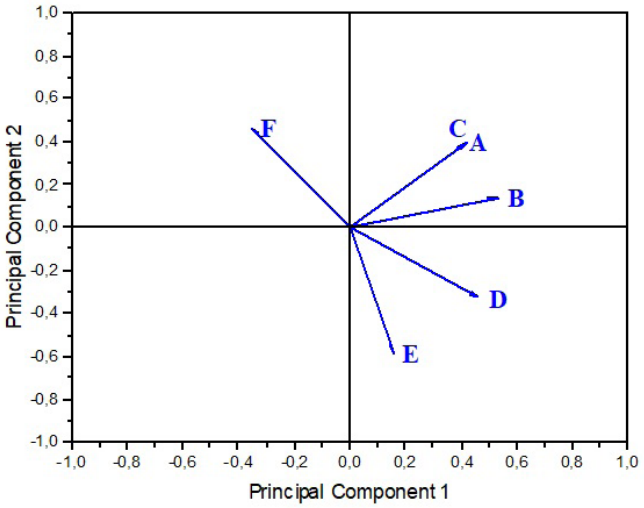


Fig. 2. Ties in consortia "*Parthenocissus inserta*–birds."
Notes: A – the value of the average area of a *P. inserta* stand fragment; B – the number of species of feeding birds; C – feeding nesting birds; D – the value of the Shannon index, E – Pielou index, F – the Berger–Parker index of consorts' ornithocomplexes.

We found that the relationships of the first concentre of trophic consortia "*P. inserta*–birds" are formed in early September, as soon as the first ripe berries appear. The extended flowering and ripening of *P. inserta* fruits, along with the frost resistance of berries, enables birds to feed on its fruits from early September to late February, and even longer in the case of a large harvest. Thus, the bonds of the first concentre of trophic consortia last half a year (all autumn and winter). In summer, birds collect invertebrates on *P. inserta* plants and are representatives of the second concentre. During the period of berry maturity, *P. inserta* forms bonds of both concentres with birds: the majority eat berries, some gather invertebrates on the plant, some of them simultaneously consume both berries and invertebrates. Therefore, saints of the second concentre of trophic consortia "*P. inserta*–birds" last all year round.

For the trophic consortia of *P. inserta* in the cultural phytocenoses of Kyiv, a large indicator of the dispersion of the number of birds of the first concentre of the consortium was previously revealed (Shupova, 2022). It is due to the fact that birds gathering in flocks often feed on berries and, at other times, birds lead a solitary lifestyle: 1–24 birds were fed on one plant during one observation, on average 5.90 ± 0.95 (n =41) (Shupova, 2022). In the forests, we did not observe large concentrations of birds in one locality of plantings – at the same time, one to five individuals of one or two species were noted on average 2.23 ± 0.27 (n = 22). The ranged curves of the relative abundance of species in the ornithocomplexes of *P. inserta* consorts obtained by us in this work also indicate that feeding birds are more evenly distributed in natural biotopes than in urban ones.

In birds with mixed types of nutrition, food of plant origin occupies a fairly large part of the diet not only in winter. Many mi-

gratory birds must eat both fruits and insects to meet their energy requirements (Suthers et al., 2000; Smith et al., 2007). Langlois and McWilliams (2010) found a decrease in protein requirements in birds during migration, and Orlowski et al. (2011) described a trend toward a significant increase in the proportion of berries in the diet of black redstart from July to October. This can be seen as an adaptation of birds to survive in invertebrate scarcity by increasing the consumption of plant berries and fruits. At the same time, birds choose berries with a large amount of anthocyanins and phenolic compounds (Bolser et al., 2003). For example, black redstart is described feeding on berries of *Parthenocissus* sp. (Crocq, 2002) from October to February during the wintering season in southeastern France. American robin *Turdus migratorius* L. feeding on berries of *Parthenocissus* sp. during autumn migration (Suthers et al., 2000). Long-tailed tit eats mulberry berries (*Morus nígra* L., 1753) during the cold season (Crocq, 2003).

As noted by Suthers et al. (2000), when birds use habitats during their migration period, the relative abundance of fruit-bearing plant species may be a more important factor than habitat structure, although thickets of lianas provide good habitat. Habitat transformation often leads to a reduction in bird species diversity (Graham et al., 2014). The introduction of alien plants plays a rather large role in this process. Thus, in Argentina, in forests dominated by invasive *Ligustrum lucidum*, the stability of the composition of the bird community in time and space is disturbed in comparison to natural forests (Ayup et al., 2014*)*. Dragomir et al. (2017) showed that the species richness, species diversity of bird communities, and their species composition are higher in natural forests with native plant species compared to plantations of introduced trees in Romania. At the same time, on test plots with the same density of birds, more species were observed (average 5.79) in the forest with native species than in stands of non-native species (average 3.07). One of our studies (Gaychenko et al., 2021) showed a decrease in species diversity of the forest ornithocomplex, a violation of the uniform distribution of species and dominant relationships of birds as a result of introduction of an alien species *Quercus rubra* into the ecosystem. García, (2016) studying "bird–plant" networks, came to the conclusion that they are sensitive to anthropogenic impacts, especially habitat degradation, biodiversity reduction, and biological invasions. Conversely, zoochory can promote the germination of invasive organisms (de Freitas et al., 2020). In food webs, it is also important to coincide the phenodates of the birds' presence during the period of certain plants' fruit ripening and the anatomical correspondence of the bird's pharynx to the size of the fruit of a plant. Suthers et al. (2000) indicated in their study that the birds ate all the available fruits in the sequence in which they ripened. Late ripening of *Parthenocissus inserta* berries determines the fact that the birds flying away from the forest-steppe zone of Ukraine in August do not form trophic consortial relationships with the plant. The proportion of birds that spent winter in the region – settled and wintered – was 81.25% of all consorts. It was also described that native birds preferred to feed on native trees, while alien birds preferred to feed on alien trees (Paker et al., 2014), but in our study, out of 32 species of *P. inserta* trophic consorts, only two, black redstart and Syrian woodpecker *Dendrocopos syriacus* were alien. The large number of intact seeds of several shrub species in the analyzed feces, including non-native plant species, indicates that birds, in particular, black redstart, are potential dispersers of woody plants (Orlowski et al., 2011). *Parthenocissus inserta* in the conditions of the Kyiv metropolis is actively used by birds for feeding, but weakly for nesting. Only four species of birds were noted that built nests in the vine (common wood pigeon, lesser whitethroat, blackbird, house sparrow), and their occurrence was not high.

P. inserta often go beyond the limits of the place allotted to them, braiding trees growing nearby, and in this way penetrate into natural biotopes. But we found individual young plants in the forests outside the city, remote from any cultivated plantings. This indicates that the species did not enter the forest on its own, but due to a certain vector. A consequence of the trophic consortative plant–bird relationships of the first concentre is the avivector of plant dispersal (Howe, 1986; de la Pena-Domene et al., 2014). The trophic relationships of the first concentre should be studied from the point of view of the transfer of *P. inserta* berries or seeds to new territories by birds, and as a result, the formation of new plant populations and expansion of the species range. The routes of transfer of mulberry by birds have already been shown (Koshelev, Matruhan, 2010). We also observed the growth of solitary mulberry trees in the forests of the study region, remote from the plantations of adult plants, and we consider this a consequence of their fruits transferred by birds. Ornithochory is essential for the distribution of adventitious plants in natural biotopes. The positive relationship between the planting area of *P. inserta* and the species composition of birds' consorts, revealed by PCA, suggests that with an increase in the area occupied by the plant, the number of bird species that feed and nest on it will increase. Therefore, *P. inserta* in the future will be more strongly woven into the cycle of matter in the ecosystems of the secondary range. The study of consortial relationships between invasive plants and birds, taking into account the knowledge of the ecological characteristics of consort birds, will make it possible to more effectively prevent the spread of plants into natural biotopes.

Conclusion

Parthenocissus inserta supports the food resource of 32 bird species, including those that feed mainly on invertebrates, maintaining a high level of bird species diversity in the autumn–winter period. Birds poorly use *P. inserta* for nesting because the list of nested consorts consists of four species with an average occurrence of 1.34 ± 0.27 pairs/ha. Species diversity indices are significantly higher for the ornithocomplex of *P. inserta* trophic consorts. The bird complex of *P. inserta* consorts in forest biotopes is characterized by a larger number of species, a smaller pressure of dominant species, and a more uniform ranged distribution of species by abundance compared to the bird complexes of phytocenoses consorts of urban biotopes. The similarity of the species composition of the consortia "*P. inserta*–birds" in urbanized and natural biotopes according to the Sorensen index is 0.64. The similarity of the species composition of the consorts first and second of the consortium concentres – 0.32, and similarity of the species composition of the topic and trophic consorts – 0.27. We predict that with an increase in the territories occupied by *P. inserta*, the number of bird species associated with the plant will increase, and in the future, *P. inserta* will be more strongly woven into the cycle of substances of the ecosystems of the secondary range. The study of consortial relationships between invasive plants and birds, taking into account the knowledge of the ecological characteristics of birds' consort, will make it possible to more effectively prevent the spread of plants into natural biotopes.

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References

Adler, K. & Jedicke E. (2022). Landscape metrics as indicators of avian community structures – A state of the art review. *Ecological Indicators*, 145, 109575. DOI: 10.1016/j.ecolind.2022.109575.

Axmacher, J.C. & Sang W.G. (2013). Plant invasions in China – challenges and chances. *PLoS ONE*, 8(5), e64173. DOI: 10.1371/journal.pone.0064173.

Ayup, M.M., Montti, L., Aragón, R. & Grau H.R. (2014). Invasion of *Ligustrum lucidum* (Oleaceae) in the southern Yungas: Changes in habitat properties and decline in bird diversity. *Acta Oecol.*, 54, 72–81. DOI: 10.1016/j.actao.2013.03.006.

Bean, W.J. (1976). *Trees and Shrubs Hardy in the British Isles (Volume III: N-Rh)*. UK, London: Martin's Press.

Beklemishev, V.N. (1951). On the classification of biocenological (symphysiological relationships) (in Russian). *Biulleten MOIP,* 56, 3–30.

Bibby, C., Burgess, N., Hill, D. & Mustoe S. (2000). *Bird census techniques*. London: Academic Press.

Biluk, G. (1977). *Geobotanical zoning of Ukraine (in Ukrainian)*. Kyiv: Naukova Dumka.

Blackburn, T.M., Cassey, P. & Lockwood J.L. (2009). The role of species traits in the establishment success of exotic birds. *Global Change Biology*, 15, 2852–2860. DOI: 10.1111/j.1365-2486.2008.01841.x.

Blair, R.B. & Johnson E.M. (2008). Suburban habitats and their role for birds in the urban-rural habitat network: Points of local invasion and extinction? *Landsc. Ecol.*, 23, 1157–1169. DOI: 10.1007/s10980-008-9267-y.

Blinkova, O., Makarenko, N., Raichuk, L., Havrylıuk, Y., Grabovska, T. & Roubík H. (2023). Invasion of *Parthenocissus quinquefolia* (L.) Planch in the forest-steppe of Ukraine. *Ecological Questions,* 34, 1. DOI: 10.12775/EQ.2023.011.

Blinkova, O. & Shupova T. (2017). Bird communities and vegetation composition in the urban forest ecosystem: correlations and comparisons of diversity indices. *Ekológia (Bratislava)*, 36, 366–387. DOI: 10.1515/eko-2017-0029.

Blinkova, O. & Shupova T. (2018). Bird communities and vegetation composition in natural and semi-natural forests of megalopolis: correlations and comparisons of diversity indices (Kyiv city, Ukraine). *Ekológia (Bratislava)*, 37, 259–288. DOI: 10.2478/eko-2018-0021.

Bolser, J.A., Alan, R.R., Smith, A.D., Li L., Seeram, N.P. & McWilliams S.R. (2013). Birds Select Fruits with More Anthocyanins and Phenolic Compounds During Autumn Migration. *The Wilson Journal of Ornithology*, 125(1), 97–108. DOI: 10.1676/12-057.

Brice, M-H., Bergeron, A. & Pellerin S. (2014). Liana distribution in response to urbanization in temperate forests. *Ecoscience*, 21, 104–113. DOI: 10.2980/21-2-3692.

Chaplygina, A.B. (2015). Ecofaunistic analysis and breeding successful of dendrophilous birds on the transformed territories of North-Eastern Ukraine. *Studia Biologica*, 9(2), 133–146. DOI: 10.30970/sbi.0902.410.

Chaplygina, A.B., Gramma, V.M., Bondarets, D.I. & Savynskay N.O. (2015). Arthropods in trophic-cenosis structure of collared flycatcher consortium in conditions of forest ecosystems of North-Eastern Ukraine. *Vìsnik Dnìpropetrovskogo Unìversitetu, Seria Bìologie, Ekologia*, 23(1), 74–85. DOI: 10.15421/011511.

Chaplygina, A.B., Yuzyk, D.I. & Savynskay N.O. (2016). The robin, erithacus rubecula (Passeriformes, Turdidae), as a component of autotrophic consortia of forest cenoses, northeast Ukraine. *Vestn. Zool.*, 50(4), 369–378.

Cohen, T.M., McKinney, M., Kark, S. & Dor R. (2019). Global invasion in progress: modeling the past, current and potential global distribution of the common myna. *Biol. Invasions,* 21, 1295–1309. DOI: 10.1007/s10530-018-1900-3.

Crawford, K.M. & Whitney K.D. (2010). Population genetic diversity influences colonization success. *Mol. Ecol.*, 19, 1253–1263. DOI: 10.1111/j.1365-294X.2010.04550.x.

Crocq, C. (2002). Frugivory in overwintering Black Redstarts *Phoenicurus ochruros* in south-eastern France. *Alauda,* 70, 351–361.

Crocq, C. (2003). Notes sur la frugivoree choz la Mésange à longue quene *Aegithalos caudatus*. Camparaison avec la frugivorus ches divers Paridé (in French). *Alauda*, 71, 357–361.

Davis, M.A., Grime, J.P. & Thompson K. (2000). Fluctuating resources in plant communities: a general theory of invasibility. *J. Ecol.*, 88, 528–534. DOI: 10.1046/j.1365-2745.2000.00473.x.

de Freitas, Th.C., de Souza Gomes Guarino, E., Gomes, G.C., Molina, A.R., da Luz Real, I.M. & Beltrame R. (2020). The effect of seed ingestion by a native, generalist bird on the germination of worldwide potentially invasive trees species *Pittosporum undulatum* and *Schinus terebinthifolia. Acta Oecol.*, 108, 103639. DOI: 10.1016/j.actao.2020.103639.

de la Pena-Domene, M., Martınez-Garza, C., Palmas-Pe´rez, S., Rivas-Alonso, E. & Howe H.F. (2014). Roles of Birds and Bats in Early Tropical-Forest Restoration. *PLoS ONE* , 9(8), e104656. DOI: 10.1371/journal.pone.0104656.

Dragomir, M.-I., Dragomir, A. & Murariu D. (2017). Aspects of Habitat Use by Birds during Spring in Natural Forests and Non-Native Plantation Forests in the Lower Siret Meadow (Eastern Romania). *Trav. Mus. Natl. Hist. Nat. "Grigore Antipa"*, 60, 401–412. DOI: 10.1515/travmu-2017-0002.

Fischer, J., Lindenmayer, D.B., Blomberg, S.P., Montague-Drake, R., Felton, A. & Stein J.A. (2007). Functional richness and relative resilience of bird communities in regions with different land use intensities. *Ecosystems,* 10, 964–974. DOI: 10.1007/s10021-007-9071-6.

García, D. (2016). Birds in Ecological Networks: Insights from Bird-Plant Mutualistic Interactions. *Ardeola*, 63, 151–180. DOI: 10.13157/arla.63.1.2016.rp7.

Gaychenko, V., Shupova, T. & Illienko V. (2021). Ornithocomplex changes of the pine-oak forest due to the participation of the introduced population of *Quercus rubra* L. *Baltic Coastal Zone*, 25, 9–18.

Golubets, M.A. & Chernobay U.M. (1983). Consortium as an elementary ecological system (in Ukrainian). *Ukr. Bot. Zh.,* 40, 78–85.

Graham, C., Wilson, M., Gittings, T., Kelly, T., Irwin, S., Sweeney, O. & O'Halloran J. (2014). Factors affecting the bird diversity of planted and semi-natural oak forests in Ireland. *Bird Study*, 61, 309–320. DOI: 10.1080/00063657.2014.927415.

Guisan, A. & Thuiller W. (2005). Predicting species distribution: offering more than simple habitat models. *Ecol. Lett.*, 8, 993–1009. DOI: 10.1111/j.1461-0248.2005.00792.x.

Gutiérrez, J.L., Jones, C.G & Sousa R. (2014). Toward an integrated ecosystem perspective of invasive species impacts. *Acta Oecol.,* 54, 131–138. DOI: 10.1016/j.actao.2013.10.003 .

Howe, H.F. (1986). Seed Dispersal by Fruit-Eating Birds and Mammals. In D.R. Murray (Ed.), *Seed dispersal* (pp.123–189). London: Academic Press. DOI: 10.1016/B978-0-12-511900-9.50009-7.

Howe, H.F. (2016), Making dispersal syndromes and networks useful in tropical conservation and restoration. *Global Ecology and Conservation*, 6, 152–178 DOI: 10.1016/j.gecco.2016.03.002.

International Code of Zoological Nomenclature adopted by the International Union of Biological Sciences (Internet) (2017). London: International Trust for Zoological Nomenclature. http://www.nhm.ac.uk/hosted-sites/iczn/code/.

Jang, W., Eskelson, B.N.I., Murray, T., Crosby, K.B., Wagner, Sh., Gorby, E. & Aven N.W. (2020). Relationships between invasive plant species occurrence and socio-economic variables in urban green spaces of southwestern British Columbia, Canada. *Urban Forestry and Urban Greening*, 47, 126527. DOI: 10.1016/j.ufug.2019.126527.

Keane, R.M. & Crawley M.J. (2002). Exotic plant invasions and the enemy release hypothesis. *Trends Ecol. Evol.*, 17, 164–170. DOI: 10.1016/S0169-5347(02)02499-0.

Khan, Z-U-D., Faisal, S., Perveen, A., Andleev, S.A. & Siddiqui S.Z. (2018). Phytochemical properties and antioxidant activities of leaves and fruits extracts of *Parthenocissus quinquefolia* (L.) Planch. *Bangladesh J. Bot*., 47(1), 33–38.

Khuzhakhmetova, A., Lazarev, S. & Semenyutina V. (2020). Ecological and biological assessment of climbing shrubs for landscaping residential areas. *World Ecology Journal*, 10, 88–109 DOI: 10.25726/worldjournals.pro/WEJ.2020.2.5.

Kohno, M.A., Trofymenko, N.M., Parkhomenko, L.I. et al. (Eds.) (2005). *Dendroflora of Ukraine: wild and cultivated trees and shrubs*. Angiosperms, Part II. Handbook. Kyiv: Fitosociotsentr.

Korchagin, A.A. (1976). *Structure of plant communities (in Russian)*. Vol. 5. Field geobotany. Leningrad: Nauka.

Koshelev, V.A. (2015). Consortive relations of birds and mulberry in the South of Ukraine (in Russian). *Biodiversity and Role of Animals in Ecosystems*, 8, 249–252.

Koshelev, V.A. & Matruhan T.I. (2010). Location and structure bird complex in agricaltural landscapes south Zaporizhia region (in Ukrainian). *Bulletin of Zaporizhzhia National University. Biological Sciences*, 1, 39–52.

Kumagai, Y., Gibson, R.B. & Filion P. (2015). Evaluating long-term urban resilience through an examination of the history of green spaces in Tokyo. *Local Environment,* 20, 1018–1039. DOI: 10.1080/13549839.2014.887060.

Langlois, L.A. & McWilliams S.R. (2010). Protein Requirements of an Omnivorous and a Granivorous Songbird Decrease During Migration. *The Auk*, 127, 850–862. DOI: 10.1525/auk.2010.10068.

Liang, X., Gao, Y., Fei, W., Zou, Y., He, M., Yin, L., Yuan, Z., Yin, Z. & Zhang W. (2018). Chemical characterization and antioxidant activities of polysaccharides isolated from the stems of *Parthenocissus tricuspidata. Int. J. Biol. Macromol.*, 119, 70–78. DOI: 10.1016/j.ijbiomac.2018.07.131.

Lockwood, J.L., Cassey, P. & Blackburn T.M. (2009). The more you introduce the more you get: the role of colonization pressure and propagule pressure in invasion ecology. *Divers. Distrib.*, 15, 904–910. DOI: 10.1111/j.1472-4642.2009.00594.x.

Magurran, É. (1992). *Ecological diversity and its measurement (in Russian)*. Moscow: Myr.

Mazing, V.V. (1966). Consortia as elements of the functional structure of biogeocenosis (in Russian). *Trudi MOIP: Natural Forage Grounds of the USSR*, 27, 52–64.

Medley, K.A. (2010). Niche shifts during the global invasion of the Asian tiger mosquito, *Aedes albopictus* Skuse (Culicidae), revealed by reciprocal distribution models. *Glob. Ecol. Biogeogr.*, 19, 122–133. DOI: 10.1111/j.1466-8238.2009.00497.x.

Miroshnyk, N.V., Likhanov, A.F., Grabovska, T.O., Teslenko, I.K. & Roubík H. (2021). Green infrastructure and relationship with urbanization – Importance and necessity of integrated governance. *Land Use Policy*, 114, 105941. DOI: 10.1016/j.landusepol.2021.105941.

Moffatt, S., McLachlan, S. & Kenkel N. (2004). Impacts of land use on riparian forest along an urban – rural gradient in southern Manitoba. *Plant Ecol.*, 174, 119–135. DOI: 10.1023/B:VEGE.0000046055.27285.fd.

Møller, A.P., Díaz, M., Flensted-Jensen, E., Grim, T., Ibáñez-Álamo, J.D., Jokimäki, J., Mänd, R., Markó, G. & Tryjanowski P. (2015). Urbanized birds have superior establishment success in novel environments. *Oecologia*, 178, 943–950. DOI: 10.1007/s00442-015-3268-8.

Mony, C., Landais, Q., Georges, R., Butet, A., Burel, F., Jambon, O., Gouesbet, V. & Ernoult A. (2022). Effects of connectivity on seed dispersal patterns in hedgerows. *J. Veg. Sci.*, 33(1), e13113. DOI: 10.1111/jvs.13113.

Netsvetov, M., Prokopuk, Y., Didukh, Y. & Romenskyy M. (2018). Climatic sensitivity of *Quercus robur* L. in floodplain near Kyiv under river regulation. *Dendrobiology*, 79, 20–33. DOI: 10.12657/denbio.079.003.

Orlowski, G., Karg, J. & Czarnecka J. (2011). Frugivory and size variation of animal prey in Black Redstart Phoenicurus ochruros during summer and autumn in south-western Poland/Hedelmaravinto ja elainravinnon kokovaihtelu mustaleppalinnun ravinnossa kesalla ja syksylla Lounais-Puolassa. *Ornis Fenn.*, 88(3), 161-171. link.gale.com/apps/doc/A270373415/AONE?u=googlescholar&sid=bookmark-AONE&xid=9c385825.

Paker, Y., Yom-Tov, Y., Alon-Mozes, T. & Barnea A. (2014). The effect of plant richness and urban garden structure on bird species richness, diversity and community structure. *Landsc. Urban Plann.*, 122, 186–195. DOI: 10.1016/j.landurbplan.2013.10.005.

Panasenko. N.N. & Anishchenko L.N. (2018). Influence of Invasive Plants *Parthenocissus vitacea* and *Vinca minor* on Biodiversity Indices of Forest Communities. *Contemporary Problems of Ecology,* 11(6), 614–623. DOI: 10.1134/S1995425518060070.

Pesotskaya, V.V., Chaplygina, A.B., Shupova, T.V. & Kratenko R.I. (2020). Fruit and berry plants of forest belts as a factor of species diversity of ornithofauna during the breeding season and autumn migration period. *Biosystems Diversity*, 28, 290–297. DOI: 10.15421/012038.

Ponomarenko, A. L. (2000). Spatial distribution of the birds in oak (*Quercus robur*) consortium in line-ashen oak-forests of the steppe Dnieper region in the nesting period (in Russian). *Vestnik Zool.*, 14, 107–113.

Pyšek, P. & Richardson D.M. (2010). Invasive species, environmental change and management, and health. *Annual Review of Environment and Resources*, 35, 25–55. DOI: 10.1146/annurev-environ-033009-095548.

Raspe, S., Fleck, S., Beuker, E., Bastrup-Birk, A. & Preuhsler T. (2020). *Manual on methods 1018 and criteria for harmonized sampling, assessment, monitoring and analysis of the effects 1019 of air pollution on forests*. Eberswald: Thünen Institute of Forest Ecosystems. http://www.icp-forests.org/Manual.htm.

Robledano, F., Esteve, M.A., Farinós, P., Carreño, M.F. & Martinez-Fernandez J. (2010). Terrestrial birds as indicators of agricultural-induced changes and associated loss in conservation value of Mediterranean wetlands. *Ecological Indicators*, 10, 4–286. DOI: 10.1016/j.ecolind.2009.05.006.

Shupova, T.V. (2021). Connections of alien birds species with alien plants of parks and botanical gardens (in Ukrainian). *Studia Biologica*, 15, 79–92. DOI: 10.30970/sbi.1501.648.

Shupova, T.V. (2022). Trophic consortive relations of grape woodbine (*Parthenocissus inserta*) with birds in cultural phytocoenosis of Kyiv (in Ukrainian). *Acta Biologica Ukrainica*, 1, 23–31. DOI: 10.26661/2410-0943-2022-1-03 .

Smith, S.B., McPherson, J.M., Backer, B.J., Pierce, B.J., Podlesak, D.W. & McWilliams S.R. (2007). Fruit quality and consumption by songbirds during autumn migration. *The Wilson Journal of Ornithology*, 119(3), 419–428. DOI: 10.1676/06-073.1.

Snow, B. & Snow D. (1988). *Birds and Berries*. London: T. & AD Poyser.

Soberón, J. (2007). Grinnellian and Eltonian niches and geographic distributions of species. *Ecol. Lett.,* 10, 1115–1123. DOI: 10.1111/j.1461-0248.2007.01107.x.

Soltani, G.A. & Shilnikov D.S. (2020). Transformation of historical landscapes as a result of biological invasions (in Russian). *Plant Biology and Horticulture: Theory, Innovation*, 156, 37–43. DOI: 10.36305/2712-7788-2020-3-156-37-43 .

Suthers, H.B., Bickal J.M. & Rodewald P.G. (2000). Use of successional habitat and fruit resources by songbirds during autumn migration in Central New Jersey. *The Wilson Bulletin*, 112, 249–260. DOI: 10.1676/0043-5643(2000)112[0249:UOSHAF]2.0.CO;2.

The International Plant Names Index and World Checklist of Vascular Plants (2023). Published on the Internet at http://www.ipni.org and https://powo.science.kew.org/ *Parthenocissus quinquefolia* (L.) Planch. First published in A.L.P.P.de Candolle & A.C.P.de Candolle (Eds.), Monogr. Phan., 5, 448(1887). https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:184091-2.

Theoharides, K.A. & Dukes J.S. (2007). Plant invasion across space and time: factors affecting nonindigenous species success during four stages of invasion. *New Phytol.*, 176, 256–273. DOI: 10.1111/j.1469-8137.2007.02207.x.

Tsarik, I.V., Zhilyaev, G.G. & Morfenina O.E. (1983). The role of consorts in the pollination of plants in the Carpathian highlands (in Russian). *Russian Journal of Ecology*, 3, 19–24.

Vitorino, B.D., Frota, A.V.B.D., Nunes, J.R.D.S., Carniello, M.A., Castrillon, S.K.I. & Maruyama P.K. (2022). Abundance determines core–periphery roles of birds in a Neotropical seed dispersal network. *Ibis*, 164, 1132-1144. DOI: 10.1111/ibi.13075.

Westcott, D.A. & Fletcher C.S. (2011). Biological invasions and the study of vertebrate dispersal of plants: Opportunities and integration. *Acta Oecol.*, 37(6), 650–656. DOI: 10.1016/j.actao.2011.04.007.

wfo-0000476975 (2023). *Parthenocissus inserta* (A. Kern.) Fritsch. http://www.worldfloraonline.org/taxon/wfo-0000476975.

Wilcove, D.S., Rothstein, D., Dubow, J., Phillips, A. & Losos E. (1998). Quantifying Threats to Imperiled Species in the United States: Assessing the relative importance of habitat destruction, alien species, pollution, overexploitation, and disease. *BioScience*, 48, 607–615. DOI: 10.2307/1313420.

Yang, X.J., Sun, Z.Y., Han, L., Ju, G.S. & Peng Z.H. (2010). Study on semi-lethal low temperatures and physiological index for cold resistance of four *Parthenocissus* species (in China). *For. Res.*, 23(1), 147–150.