Introduction

Each year, billions of seasonal migrants connect the continents, transporting different substances, energy and pathogens between remote communities and ecosystems. Migratory animals change ecology and ecosystems by transporting energy, nutrients and living organisms, as well as by extracting food and becoming prey (Bauer & Hoye, 2014; Zaifman et al., 2017). Consequently, migratory species profoundly alter the dynamics of trophic connections, bioenergetics processes and ecosystem functioning as a unique and highly influential component of local biodiversity. The bird migrations that have been most studied (Doreen & Horton, 2018; Schmaljohann, 2018) are those which have been common since the last ice age (Sornville et al., 2020). Bird migration behaviour has taken shape at different times and along different biogeographical routes, some of which are adaptations to new environmental opportunities that have allowed a return to sedentary lifestyle (Dufour et al., 2019).

Today, about 20% of bird species are migratory and their seasonal movements influence the redistribution of species diversity, which radically changes the composition of the ornithofauna of certain areas. Given their significant movements, migratory birds, in principle, have a wide range of possible breeding and wintering locations, but each species migrates within the limits of its range (Sornville et al., 2019). The feasibility of different routes for birds depends on latitude, migration direction, migration season and geographical location (Muheim et al., 2018). It is already known that annual migration periods vary much less for repeat flights of the same individual than for repeat flights between different individuals, while there have been significant differences in routes for repeat flights of the same individual (Vardanis et al., 2011). Three main bird migration routes to wintering areas in sub-Saharan Africa are known. Overwintering areas and migration routes of different breeding populations can overlap, which is best described as a “weak (diffuse) connection”. Migration characteristics, i.e. time, duration, distance and rate of migration, can be surprisingly similar for the three routes despite differences in habitat characteristics (Trierweiler et al., 2014). Global models of the geographical distribution of birds in the world point to the strong spatial diversity of migratory birds, which may explain why they migrate (Somvillier et al., 2015; Sornville, 2016). Contemporary migrants are uniquely able to respond to temperature conditions throughout the year, avoid local competition, and reach areas with the best access to food resources by minimizing the distance travelled according to the species’ geographical location (Chevallier et al., 2010; Sornville et al., 2019). The peculiarities of bird movements are discussed considering different parameters: meteorological conditions – fog with low clouds, wind direction (Helm et al., 2019; Nilsson et al., 2019; Panuccio et al., 2019; Aurbach et al., 2020); global climate change (Zaifman et al., 2017; Curley et al., 2020). The tendency towards warmer winters in northwestern Europe is leading to a reduction in the distance between suitable wintering areas and breeding sites for many bird species, which has a positive impact on the conservation of chicks from late broods (Vissers et al., 2009; Rotics et al., 2017).

On a continental scale, a system for predicting the movement of birds from environmental conditions is important for reducing collisions with buildings, aircraft, wind turbines and other structures (Doreen & Horton, 2018; Gasteren et al., 2018). Bird responses to powerful ground-based artificial light sources at night in urban areas have been studied (Doreen et al., 2017; Sorteel et al., 2017; Smallwood & Bell, 2020). Urbanization increases the likelihood of feed-provided birds reducing their migration activity (Bonnet-Lebrun et al., 2020). The main biological mechanism regulating seasonal variation in migration rate is the seasonal difference in the duration of migration stops. In autumn, birds stay longer in search of
food, thus taking longer to move to wintering grounds than to move to breeding grounds during spring migration (Schmuljohn, 2018).

During migration, the availability of food that affects the success, nature and timing of bird movements is critical for many species (Drent et al., 2006; Newton, 2006; Vilkov, 2013; Wolfe et al., 2014). Of great importance is the relationship between migration routes and fruit production along the tree-shrub route (Karpov, 2017), including fruit and berries (Tattioni et al., 2019). The availability of quality and accessible food determines where migratory birds stop (McWilliams et al., 2004). Catching migratory birds in the autumn has revealed higher daily body weight gain in areas where fruit was available, compared with individuals taken in areas where fruit and berry plants were not (Thomas, 1979; Bairlein, 2002). The experimental removal of available fruits resulted in a decrease in local autumn migration in these areas (Parrish, 2000). Early ripening mulberries are very popular among birds (Kornarow & Kornarowa, 2001; Gubin, 2018; Lyakh, 2018). The influence of wood-shrub plantations on the composition of ornithological fauna in the urban landscape was also proven (Karpov, 2017). The abundance of seasonal fruits is a significant food resource for migratory birds (Petrovich, 2014; Kuzmenko, 2018). By eating fruits, birds can carry the seeds of plants, sometimes for considerable distances. Some papers show their role in plant distribution (Koshelev & Matrakul, 2010).

In studies of global biodiversity, many bird migration issues remain subject to debate. Many of the factors governing migration flows and migration routes have not been sufficiently explored (Bairlein, 2003). Most birds use different types of plantation for migration. Woodland areas with an appropriate stand structure, undergrowth and scrub layers are very favourable for this purpose, both for camouflage and for supplementary feeding on fruit-bearing plants and feeding in adjacent agroecosystems. The birds’ diet is also interesting from the point of view of studying geographical variability in feeding. Consequently, the provision of forest belts with fruit-berry plants and the preservation of the environment along the bird flight path influences their condition and successful migration, which may be crucial for the survival of the population as a whole (Parrish, 1997; Smith et al., 2007; Trierweiler et al., 2014; Ogachi et al., 2017).

The presence of fruit-berry plants, and general climate warming affect bird migration and sedentary population formation (Chaplygina, 2016). Single or group wintering is becoming more and more common amongst such traditional migratory birds as Phoenicurus ochruros (Girinelt, 1774) (Shupova, 2014), Motacilla alba (Linnaeus, 1758) (Chaplygina, 2018), S. vulgaris (Brezgunova, 2013), some species of Fringillidae (Chaplygina, 2018). In anthropogenic landscapes, the proportion of overwintering Corvus frugilegus (Linnaeus, 1758), Turdus pilaris (Linnaeus, 1758) which reduce their nomadic distances is increasing (Chaplygina, 2009; Visser et al., 2009; Shupova, 2014).

Consequently, taking into account the relevance of such studies, we have set an objective: to find out the species diversity of birds feeding in forest belts of different structure, to compare the use of forest belts for feeding on different fruit-berry plants and to evaluate their role in the period of bird migration to places of wintering.

The most widespread berry bearing shrub in the north of the Ukrainian steppe is blackthorn Prunus spinosa Linnaeus, 1753, of the family Rosaceae, which grows mainly in clumps of bushes, often on the edges of the forest, filled areas, usually as dense thickets. Fruits are coarse monostones, similar to plums, with blue waxy patches, 12 mm in diameter. Fruits contain sugar (levulose and sucrose), malic acid, pectin and tannins, vitamin C, red dye agent.

Hawthorn (Crataegus laevigata Poir, 1825), in the investigated region grows in the underbrush of broad-leaved and mixed forests, on the banks of rivers and ravines, in valleys and on the edges. Fruits of C. laevigata contain sugars, flavonoids, saponins, phytoestrogens, carotene, choline, glycosides, tannins, organic acids - malic acid, citric acid, erucatic acid, wine acid, ascorbic acid, etc. Amigdalen and ester oils were found in the seeds.

Elderberry (Sambucus nigra Linnaeus, 1753) has a wide growing area. It is also a species present in the undergrowth of tree plantations. Fruits contain vitamins C and E, carotene/provitamin A, glucose and fructose (sugar), malic acid and citric acid, ester oil, ester resin, macro elements (Mg, K, Ca, Fe), trace elements (Mn, Cr, Cu, Zn, Co, Al, Se, Ni, Sr, Pb, Br, I, Mo), sambucine, amino acids, dyes, free acids, tyrosine.

Rose eglantine (Rosa canina Linnaeus, 1753) is distributed in the region of study in edge ecotopes, river and ravine banks. Rose eglantine fruits have different shapes: from round to spindle-like. Less than 1 cm long and more than 3 cm in diameter, they have a shiny surface covered with wrinkles. Rose eglantine fruits contain large amounts of vitamins, especially vitamin C (at least 0.2%) and vitamins P and K, flavonoids, carotenoids, tannins, pectin, pectic substances.

The distribution of bird cherry (Prunus padus Linnaeus, 1753) is associated with both tree plantations and open-space biotopes. Fruits are black monostones in the form of a ball, about 8–10 mm across, taste sweet, somewhat tart and astringent. The smooth berries are of greenish colour, heart-shaped and dense, with time they acquire red and then black colour. They begin to ripen in the middle of June. P. padus fruits contain carbohydrates (fructose, glucose, sucrose), nitrogen-containing substances, vitamins C, E and P, carotene, flavonoids and phenolic carboxylic acids.

Mountain ash (Sorbus aucuparia Linnaeus, 1753) is distributed in the investigated region both in mountain forest belts and in undergrowth plantations. Fruits contain vitamin C and carotene, sugar, apple, citric, tartaric and succinic acids, tannins and pectins, sorbitol and sorbose, amino acids, essential oils, salt, calcium, magnesium and sodium, as well as carotenoids, ascorbic acid, flavonoids, triterpene compounds, bitter substances, sorbic acid.

Purging buckthorn (Rhamnus cathartica Linnaeus, 1753) grows on the slopes of hills and river valleys, as well as in the steppe. The fruits contain anthracylosides, chrosohyric acid, and alkaloids –0.17%, sugar.

Representatives of the genus mulberry (Morus) in Ukraine are naturalised in the steppe and forest-steppe zones. Two species are widely spread: Morus alba Linnaeus and M. nigra Linnaeus. The motherland of M. nigra is in South-West Asia, while that of M. alba in East China. It grows on roadsides, field and water protection forests, in artificial forests, on special plantations, on estates, in parks, along streets in cities and villages. The mulberry has been grown as a fruit tree and a forage plant for silkworms for over 4000 years. The tree bears abundant fruit annually, 30–50, up to 200 kg of fruit are harvested from one tree. M. nigra is unpretentious to conditions of growth on the territory of Ukraine, to drought and winter frosts, quickly restores crowns after freezing of branches. The life expectancy of M. nigra is up to 200, less often 300–500 years. Fruits ripen in late May – August, the period is 2.5–3.0 months. The fruits, or rather the stems, are 2–3 cm long. They are sweet, contain up to 9–11% sugar, a lot of vitamins, various acids, pectins, trace elements and dyes, as well as resveratrol, which is a strong plant antioxidant. In terms of potassium content, they rank first among berries; healthy and caloric foods not only for humans, but also for wild animals. The seeds of M. nigra are very small, 1000 seeds weighing only 1–2 g. Leaves, especially M. alba, are the main feed of Bombyx mori (Linnaeus, 1758), larvae of Oauraetzys sambucaria (Linnaeus, 1758), Minas tiliae (Linnaeus, 1758) and Acrornica aceris (Linnaeus, 1758) also eat them. Many insect species feed on ripe fruits, where they are picked up by birds.

Materials and methods

The research was carried out in compliance with bioethical standards in accordance with the provisions of the “European Convention for the Protection of Vertebrate Animals used for Experimental and Other Scientific Purposes” (Strasbourg, 1986), and also did not violate the requirements of the “Convention on the Protection of Wild Flora and Fauna and Natural Habitats in Europe” (Berne Convention), the Law of Ukraine “On Animal World”, the Law of Ukraine “On Environmental Protection”.

This research used bird counts conducted in summer and autumn in forest belts which included fruit and berry bearing plants. In each forest belt 13 counties were made during the period of the greatest ripening of fruit and berry plants (the third decade of May – the third decade of October). The research covered the territory of Kharkov (Kupyansk, Dvurechansky, Borovsk and Shevechenko districts) and Lugansk (Svatovsky district) regions. Routine bird surveys were conducted using generally accepted methods (Ravkin & Chelintsev, 1990). Multiple mapping was used to record the number of birds feeding on fruits, which allowed for the elimi-
nation of that part of their population which could be accidentally located near fruit and berry plants. Birds were identified by both voice and visual registration of individuals. All individuals feeding on trees and shrub vegetation and nearby were recorded on the route. Due to the small width of the forest belts it was possible to register all birds. The number of individuals per kilometer of the survey line is expressed as bird numbers. Bird visits to fruit and berry plants were recorded in the morning and evening hours, during the route with a detailed analysis of trees growing in the forest plantations during the ripening of fruits. The route length of 6–7 km was determined in each type of field. An average of 7.5 hours forest belts (FB2) were recorded in oak-maple-linden forest plantations during the ripening of fruits. The route length of 6–7 km hours, during the route with a detailed analysis of trees growing in the forest belts it was possible to register all birds. The number of individuals per kilometer of the survey line is expressed as bird numbers. Bird visits to fruit and berry plants were recorded in the morning and evening visits to fruit and berry plants were recorded in the morning and evening hours.

For average bird abundance, standard deviation and variance were calculated. Some generally accepted diversity indices of biocenoses that express the relationships between the number of species and their density were calculated. To compare the diversity of bird biocenoses for each research plot the Shannon’s, Berger–Parker and Pielou indices were applied (Maguran, 1985).

The investigated forest belts are small in width, most with 3–4 rows (20 m, occasionally 30 m), less often 1–2 rows (5–10 m). They are mostly old (30–50 years) with different density of plantation: dense (with well-developed understory), latticed (with medium-developed understory) and wind-blowed (without understory, or with poorly developed understory) and differ in floral composition: Maple-ash wind-blow forest belts (FB1), maple-linden latticed forest belts (FB2), oak- maple-poplar wind-blow forest belts (FB3), oak-maple-linden dense forest belts (FB4). The tiering of the forest bands is weak, but there is a characteristic shrub-berry tiering for all types. Undergrowth forms in the dense and latticed forest belts (Table 1). In the investigated forest belts the level of crown closure was determined, in the wind-blow maple-ash and latticed maple-linden forest belts, the index was 0.3–0.4 or 30–40%, in the wind-blow oak-maple-poplar forest belts – 0.4 (40%). For dense oak-maple-linden forest belts, the crown closure index was 0.5–0.6 or 50–60%.

A comparison of the similarities among the bird biocenoses was performed using cluster analysis with Origin Pro software (One Roundhouse Plaza Origin Lab Corporation Northampton, MA01060, USA, 2015, 64 bit Beta 3 69.2.196).

**Results**

In the forest belt of the investigated region, birds feed on the fruits of at least 15 plant species. We have identified the nine main fruit-berry plant species which are the most common feeders of birds during summer movements and migrations. Most of the fruit-berry plants grow in the forest belt in the indigenous tree formations of the region, where they are native species, though some of which are introduced. Some have been planted in the forest belts with major species of trees and shrubs, but many have penetrated through seed zoochory. A total of 6,064 observations of individual birds of 43 species feeding on fruit and berry plants were registered on the route. Due to the small width of the forest belts, the crown closure index was 0.5–0.6 or (50–60%)..

A comparison of the similarities among the bird biocenoses was performed using cluster analysis with Origin Pro software (One Roundhouse Plaza Origin Lab Corporation Northampton, MA01060, USA, 2015, 64 bit Beta 3 69.2.196).

| Types of forest belts | I tier | II tier | Undergrowth | Shrub layer |
|-----------------------|-------|--------|--------------|-------------|
| Maple-ash wind-blow forest belts (FB1) | F. excelsior, Linnæus, 1753 – 60% | Acer platanoides Linnæus, 1753 – 20% | No underbrush | Prunus spinosa Linnæus, 1753 – 5% |
| Maple-linden latticed forest belts (FB2) | A. platanoides Linnæus, 1753 – 30%, Tilia cordata Mill, 1768 – 20% | Without the II tier | A. platanoides Linnæus, 1753 – 20%, Morus nigra Linnæus, 1753 – 10%, Populus alba Linnæus, 1753 – 10% | No underbrush |
| Oak-maple-poplar wind-blow forest belts (FB3) | Q. robur Linnæus, 1753 – 30% | Acer platanoides Linnæus, 1753 – 20%, Morus nigra Linnæus, 1753 – 10%, Populus alba Linnæus, 1753 – 10% | No underbrush | Prunus spinosa Linnæus, 1753 – 5%, S. nigra Linnæus, 1753 – 20% |
| Oak-maple-linden dense forest belts (FB4) | Q. robur Linnæus, 1753 – 30%, Acer negundo Linnæus, 1753 – 20%, A. platanoides Linnæus, 1753 – 10%, Tilia cordata Mill, 1768 – 10% | A. platanoides Linnæus, 1753 – 7%, U. laevis Pallas – 5%, Sorbus aucuparia Linnæus, 1753 – 10%, Morus nigra Linnæus – 4%, Prunus cerasus Linnæus – 2%, P. padus Linnæus, 1753 – 3% | No underbrush | C. vitis – 2%, Rhamnus cathartica Linnæus, 1753 – 1% |

**Table 1** Composition of different types of forest belts in plant species and tiers

Note: * – the ratio of plants in the species composition of the forest belt (%)
Table 2
Distribution of birds in different types of forest belts by numbers* (ind./km; n = 13; x ± SE)

| Order        | Species name          | Forest belts type                        |  |  |  |  |
|--------------|-----------------------|------------------------------------------|---|---|---|---|
|              |                       | maple-ash wind-blown forest belts (FB1)  | maple-linden lattice forest belts (FB2) | oak-maple-linden dense forest belts (FB3) | oak-maple-poplar wind-blown forest belts (FB4) |
| Columbiformes| *Columba palumbus* (Linnaeus, 1758) | 0.92 ± 0.57                            | 1.23 ± 0.71                            | 0.92 ± 0.09                            | 2.15 ± 0.65                            |
|              | *C. oenas* (Linnaeus, 1758)   | 0.31 ± 0.43                            | 0.77 ± 0.83                            | 0.54 ± 0.66                            | 1.15 ± 0.78                            |
|              | *Sturnus tyrannus* (Linnaeus, 1758) | 0.31 ± 0.43                            | 0.77 ± 0.95                            | 0.53 ± 0.42                            | 2.23 ± 0.66                            |
| Piciformes   | *Lyrapicus eremita* (Linnaeus, 1758) | 0.15 ± 0.26                            | 0.38 ± 0.53                            | 0.46 ± 0.64                            | 0.62 ± 0.66                            |
|              | *Jynx torquilla* (Linnaeus, 1758) | 0.15 ± 0.26                            | 0.38 ± 0.47                            | 0.53 ± 0.75                            | 1.23 ± 0.98                            |
|              | *Perdix canus* (Gmelin, 1758) | 0.53 ± 0.50                            | 0.77 ± 0.71                            | 0.23 ± 0.36                            | 0.46 ± 0.50                            |
|              | *Dendrocopos major* (Linnaeus, 1758) | 0.92 ± 0.43                            | 0.92 ± 0.42                            | 2.15 ± 0.96                            | 2.38 ± 0.78                            |
|              | *D. minor* (Linnaeus, 1758) | 0.38 ± 0.47                            | 1.00 ± 0.76                            | 0.15 ± 0.26                            | 0.31 ± 0.43                            |

Note: * – average absolute number of birds that feed on juicy fruits of plants growing in forest belts of different types in the northern steppe zone of Ukraine.

Fig. 1. a-Diversity of birds in forest belts of different types that have fruit-bearing berry plants Kharkiv and Lugansk regions (n = 13)

The smallest number of bird species was noted to feed on *P. spinosa*, *R. canina*, *S. aucuparia* fruit. Significant differences in the species composition of feeding birds on different fruit plants are associated with differences in the Shannon index data for trophic consortia of fruit trees (Fig. 3). Uniformity of birds’ distribution on all fruit trees is high. The differences between the Berger-Parker and Pielou index data for feeding bird assemblages on different fruit trees are not significant. In cluster analysis, the number of feeding bird species was a more influential factor in dividing assemblages into similarity groups than data from 6-diversity indices.

The consortium of *S. nigra* and *M. nigra* is divided in one flank of the dendrogram and the small numbered-species assemblages of *P. spinosa*, *R. saxatilis* and *S. aucuparia* – on the opposite flank (Fig. 4). The central block of the dendrogram occupies a block of two pairs of trophic consortia assemblages: *P. spinosa* – P. cerasus and R. cathartica – P. padus. The main one in bird nutrition is *S. aucuparia*. Representatives of 39 species of birds were observed to feed on its berries. The main consumers of its fruits are *Ch. chloris* (11.6% of the total number of birds observed to feed on this fruit; n = 947), *S. vulgaris* (11.2%), *F. coelebs* (10.0%),
S. atricapilla (8.2%), E. rubecula (7.7%), T. philomelos (5.1%) and others (0.3–4.5%). Since the ripening of M. nigra fruit (early June), they became the main supplement to the diet of 42 bird species adults and chicks (Fig. 5).

The fruit of R. cathartica attracted 32 bird species. The dominant species were Ch. chloris (10.6%) of the total number of birds observed to feed on this fruit; n = 548), F. coelebs (10.2%), T. philomelos (8.4%), S. vulgaris (6.4%), E. rubecula (5.8%), P. major (5.1%), and others (0.4–4.9). There were 30 bird species registered on P. padus fruit-bearing trees. Ch. chloris (11.8%) of the total number of birds observed to feed on this fruit; n = 629), F. coelebs (9.7%), S. atricapilla (8.6%), S. vulgaris (7.3%), T. philomelos (6.8%), L. collurio (6.7%), P. major (6.5%), T. merula (5.9%), S. nisoria (5.2%), and others (0.2–4.0%) were registered. Twenty-eight bird species were observed to feed on C. laevigata, of which the following were dominant: C. coccophila (14.3%) of the total number of birds observed to feed on this fruit; n = 554), F. coelebs (13.7%), Ch. chloris (12.5%), S. vulgaris (11.2%), L. collurio (6.9%), T. philomelos (6.1%), and others (0.2–4.5%). The participation of P. cerasus in forest belt formation is insignificant; it mainly enters this biotope from cultural plantations, due to ornithochory. Cherry fruit attracted 25 species of birds from the forest belt as well as adjacent biotopes. Its fruit was primarily the food of C. coccophila (20.7%) of the total number of birds observed to feed on this fruit; n = 752), Ch. chloris (12.5%), S. vulgaris (11.2%) and T. philomelos (11.0%), in lesser degree – of F. coelebs (6.5%), T. merula (5.6%), O. oriolus (5.1%), and others (0.1–4.0%). S. aucuparia berries served as the food of 14 species of birds, mainly T. pilaris (20.1%) of the total number of birds observed to feed on this fruit; n = 488), S. vulgaris (17.6%), Ch. chloris (15.8%), T. philomelos (11.5%), P. montanus (7.6%), F. coelebs (7.0%), T. merula (6.4%), C. coccophila (5.5%), and others (0.4–3.4%). P. spinosa berries were consumed by 13 species of birds, among which the most frequent were S. vulgaris (18.7%) of the total number of birds observed to feed on this fruit; n = 225), C. coccophila (17.3%) and T. merula (11.1%), as well as F. coelebs (9.7%), T. pilaris (8.9%), Ch. chloris (8.4%), D. major (8.0%), P. canus (5.3%) and T. philomelos (5.3%), others (0.9–3.1%). R. canina berries were consumed by 13 bird species in late autumn and winter. Ch. chloris (15.6%) of the total number of birds observed to feed on this fruit; n = 294), F. coelebs (12.5%), T. merula (12.2%), T. pilaris (11.6%), P. montanus (11.6%), T. philomelos (10.9%), S. vulgaris (8.8%), and others (1.0–3.4%) were registered.

Slightly more than half (51.2%) of the species composition of birds feeding on fruit and berry plants belongs to migratory birds, the share of sedentary birds is 27.9%, nomadic birds – 20.9% (n = 43). Therefore, about half of the species use forage resources of the forest belt in the northern steppe zone of Ukraine all year round. In the list of plants, P. spinosa, R. canina and S. aucuparia were most actively used by sedentary and nomadic species (Fig. 6). The use of these plants by migratory species was minimal (14.3–15.4%). In contrast, the proportion of migratory birds using R. cathartica and P. padus is significant, 59.4% and 60.0%, respectively. As

**Fig. 2.** The similarity of bird communities in forest belts of different types that have fruit-bearing berry plants Kharkiv and Lugansk regions

**Fig. 3. a-Diversity of birds on fruit trees (in decreasing order of frequency of occurrence of birds on fruit plants): 1 – Sambucus nigra, 2 – Morus nigra, 3 – Prunus spinosa, 4 – Crataegus laevigata, 5 – Rosa canina, 6 – Rhamnus cathartica, 7 – Sorbus aucuparia, 8 – Prunus padus, 9 – Prunus cerasus**

Its fructification season lasts for 3.0–3.5 months, which provides berries to most nesting and nomadic birds. M. nigra berries were most frequently consumed by S. vulgaris (24.5% of the total number of birds observed to feed on this fruit; n = 922), Ch. chloris (14.8%), F. coelebs (14.6%), C. coccophila (10.3%), T. philomelos (10.1%), T. merula (7.3%) and E. rubecula (7.3%), P. montanus (6.1%), S. atricapilla (5.7%), and others (0.2–4.1%).

(Biosyst. Divers., 2020, 28(3))

![Distance on Fruit trees](image)

**Fig. 4.** The similarity of bird assemblages on fruit trees (in decreasing order of frequency of occurrence of birds on fruit plants):

1 – Sambucus nigra, 2 – Morus nigra, 3 – Prunus spinosa, 4 – Crataegus laevigata, 5 – Rosa canina, 6 – Rhamnus cathartica, 7 – Sorbus aucuparia, 8 – Prunus padus, 9 – Prunus cerasus
we see, the distribution of ornithofauna of fruit-berry plants by these indicators corresponds to the two last blocks of the cluster analysis dendrogram. The role of other plants (S. nigra, M. nigra, C. laevigata, P. cerasus) can be considered equal for both sedentary and migratory bird species.

Scientists repeatedly point to the abundance of seasonal fruit as a significant food resource for migratory birds, which can improve fat reserves and immunity during stopovers (Petrovich, 2014; Kuzmenko, 2018). By eating fruit, birds spread plant seeds, sometimes over considerable distances. Some papers have shown the role of birds in plant distribution (Koshelev & Mat rushkin, 2010). Consequently, the role that succulent fruit play in the life of birds in forest belts should not be underestimated. We have registered 43 species of birds feeding on fruit and berry plants. This is 80% of the recorded species of birds in the forest belts (Psotska, 2018). No bird species has a predilection for a particular fruit. According to literature data, 16 bird species feed on S. racemosa (Prokofieva, 2005), the main ones being Turdus species, P. major, P. caeruleus, S. vulgaris, P. domestica, Ch. chloris and B. garrulae (Olney, 1966).

M. nigra is very popular among birds and its fruit are eaten by adults and fed to their chicks such as Streptopelia senegalensis (Linnaeus, 1766), Acridotheres tristis (Linnaeus, 1766) (Gubrin, 2018), T. merula (Kornarov, & Kornarova, 2001) and C. palumbus (Lyalid, 2018). During the summer fruiting season of M. nigra, birds are also actively involved in eating invertebrates on its fruit (M. striata, F. albicollis, M. alba, Sylvia species and others).

According to observations made by Koshelev (2015), 62 species of forest birds eat the fruit of M. nigra. Fruit of Prunus avium (Linnaeus, 1755) are eaten in large quantities by G. glandarius, various species of Turdus, F. coelebs and Pinicola enucleator (Linnaeus, 1758) (Turcek, 1968). S. aucuparia berries are used by 9 bird species in the Leningrad Region, among which Corvidae was the dominant bird family (Prokofieva, 2005). The eating of juicy fruit was registered for all Piciformes in the Leningrad Region (Bardin & Tansenko, 2018). Dryocopus martius (Linnaeus, 1758) picks berries of Sorbus aucuparia subsp. sibirica (Hedl), Keylov, 1953 (Berezovikov, & Iachenko, 2018), Malus baccata (Linnaeus), Borch, 1803 (Lyapunov et al., 2017; Feldman & Berezovikov, 2017) and C. laevigata (Viselkayava, 2018).

The famously stenophagous white-backed woodpecker Dendrocopos leucopterus (Bedschin, 1802), all year round extracts xylaphagous insects (Malcheyvsky & Pukinsky, 1983). However, in the Far East, individuals of the form of D. leucopterus siniticus (Baturin, 1907) have plant food as the staple of the diet during autumn and winter (fruit of Phellodendron amurense (Rupr, 1857), Kalopanax septemlobus (Thunb) (Koidz, 1925), and Auglaure mandshurica (Maxim, 1856) (Polivanov, 1981). Birds do not specialize in the extraction of fruit of a certain species, but feed on different ones. Thus, in the diet of S. vulgaris, T. philomelos, T. merula, Ch. chloris and F. coelebs we found the fruit of all 9 studied plant species. Prokofieva (2001a) observing 5 species of Turdus, noted that only T. philomelos fed on Vaccinium myrtillus berries (Linnaeus, 1758) composing 16.3% out of all its food objects. According to her data, S. europaea fed on V. myrtillus and Frangula vesca berries (Linnaeus, 1753) (Prokofieva, 2001b). G. glandarius used berries of S. nigra, S. aucuparia and Vaccinium subgen (Gray, 1848), Oxycoccus palustris (Gray, 1848). In August remains of Sambucus racemosa berries were found in droppings of Corvaceae flock birds composed of C. corvinus, C. frugilegus and Corvus monedula (Linnaeus, 1758). In September droppings of this flock contained stones of Cornus sanguinea (Linnaeus, 1753) (Prokofieva, 2001b, 2002, 2003). The fruit are also eaten by birds when there is a lack of typical food. Often in cold and windy weather insect eaters such as Ficedula, Muscicapa, Motacilla, Saxicola, Pardus, and others, especially actively feed on berries. Similar behaviour is also known for Aegithalos caudatus (Linnaeus, 1758) (Croq, 2003).

For feeding birds, the structure of the forest belt is also important. Pereina et al. (2014) have shown that insectivorous birds were more numerous in dense oak plantations with a wider undergrowth vegetation cover. Insectivores, partly due to the lack of suitable nest sites, may also face food shortages that limit their distribution (Pereina et al., 2014). Trunks foraging species and birds in agro-forest open habitats increased their abundance in cleared areas and remained less frequent in denser forests (Shirihai et al., 2001). However, the density of Piciformes and Passeriformes that feed on the trunks during wood thinning falls from 56.2 to 28.0 pairs/km. Nevertheless, if the woody vegetation is thick enough, the clearing of the vegetation may have little impact on birds. If thinning is accompanied by selective tree clearing, the combined effect of these two factors on the bird assemblage is more intense (Shirihai et al., 2001; Blinova & Shapova, 2018). This management practice reduces the number of undergrowth bird species, but thinning also
causes changes in the composition of birds of the tree canopy and benefits other species associated with open agroforestry habitats (Shinshi et al., 2001). For the north of the steppe zone of Ukraine, our analysis of α-diversity revealed that latticed forest belts were the most attractive for birds. The similarity of bird assemblages to each other was more influenced by the number of main tree species of the forest belt than by its structure.

Conclusion

The presence of fruit-berry plants in woodlands of various types enables birds to find additional food both in summer-autumn, and in winter. In the conditions of the north of the steppe zone of Ukraine 43 bird species of four orders, 81.4% of which are Passeriformes, were observed to feed on the fruits of plants of field-protective woodlands. Birds most actively visit dense oak-maple-linden forest belts, least actively wind-blown maple-ash forest belts. The best characteristics of α-diversity of ornithoflora are recorded for latticed maple-linden forest belts: Shannon (3.37) and Pielou (0.90) data are the highest, Berger-Parker (0.11) data are the lowest.

The similarity of bird assemblages of trophic consortia is influenced more by the number of main tree species of the forest belt than by its structure. In the summer-autumn diet juicy fruit were most important for S. vulgaris (11.8% of the total number of birds observed to feed on this food resource; n = 6004), Ch. chloris (11.3%), F. coelebs (9.3%), T. philomelos (7.3%), C. coccintheatraes (7.1%), T. merula (5.4%). For other birds, the share of fruit in the diet was less than 5.0%. Most actively, birds fed on the fruit of plants of field-protective woodlands. Birds most actively visit dense oak-maple-linden forest belts, least actively wind-blown maple-ash forest belts. The best characteristics of α-diversity of ornithoflora are recorded for latticed maple-linden forest belts: Shannon (3.37) and Pielou (0.90) data are the highest, Berger-Parker (0.11) data are the lowest.

The rest of the birds use forage resources in the forest belts of the northern steppe zone of Ukraine (7.1%), a special place is occupied by forest belts with a certain number of main tree species of the forest belt than by its structure.

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