ECOLOGIA BALKANICA

2024, Vol. 16, Issue 1 June 2024 pp. 174-184

Density and composition of breeding bird communities in lowland forests

Polina Hristova[1,2*], Georgi Popgeorgiev[2,3], Vladimir Dobrev[2], Dobromir Dobrev[2], Hristo Dimitrov[1], Dimitar Plachiyski[2,3]

[1]University of Plovdiv "Paisii Hilendarski", Faculty of Biology, Department of Zoology, 24 Tsar Asen Str., Plovdiv, 4000, BULGARIA
[2]Bulgarian Society for the Protection of Birds/BirdLife Bulgaria, Yavorov complex, bl. 71, entr. 4, app. 1, Sofia, 1111, BULGARIA
[3]National Museum of Natural History, Bulgarian Academy of Sciences, 1 Tsar Osvoboditel Blvd., Sofia, 1000, BULGARIA
*Corresponding author: polinadhr@gmail.com

Abstract. Bird communities were studied during three consecutive years (2020–2022) in forest fragments from the Western Upper Thracian lowland, Bulgaria. In total, 62 bird species with 4922 individuals were registered using point count methodology. Relative species abundance and frequency for all species was calculated. Density for the most abundant 19 species for the whole study area was estimated using DISTANCE software. Area-specific densities were estimated for nine species in nine of the studied forests. The results showed overall high species richness, which is consistent with other surveys in deciduous lowland forests. The most abundant species for the whole area made up to 61% of all registered species (*Luscinia megarhynchos, Fringilla coelebs, Streptopelia turtur, Turdus merula, Oriolus oriolus, Sylvia atricapilla*). The estimated densities were consistent with other studies in similar forest habitats. Species with the highest density was found to be Great tit D = 1.29 (1.14 – 1.46), followed by Hawfinch, European turtle dove, Common chaffinch, European robin and Blackbird, whereas specialist species (e.g. forest-interior) were less abundant. Eurasian hoopoe was found with lower densities for the whole territory D = 0.27 (0.23 – 0.31), while the Robin had the highest estimation for the forest of Begovo D = 2.28 (1.36 – 3.85).

Key words: avian density, forest bird species, bird composition, lowland forests.

Introduction

Bird communities are suitable subject for ecological studies and many recently are focused on their response to environmental changes. Habitat loss and fragmentation are the main threats for the biodiversity, and have complex and species-specific impacts (Lynch & Whigham, 1984). Most of the forests nowadays are transformed fulfilling the growing demand of the increasing human populations. Thus, forests are characterized by high level of heterogeneity, isolation and vegetation structure, that differs significantly from the natural one (Vieira de Matos et al., 2018). Heterogeneity has a positive effect on the biodiversity, in cases where forest area is kept sufficiently large in relation to the requirements of the individual bird species (Andrén, 1994) for breeding, foraging and shelter (Slattery & Fenner, 2021). The positive impact of the habitat diversity is well studied, and its contribution is explained by the species-area relationship, where larger areas consist of multiple habitat types and support greater species richness (Bellamy et al., 1996), including forest-interior species. Forest-interior species are generally sensitive to forest fragmentation (Fernández-Juricic, 2004), and have specific requirements (Kameniar et al., 2023). Important habitat features that benefit forest specialists include the presence of old trees, different forest stand age (Piechnik et al., 2022) and overall habitat heterogeneity with various microhabitats (Kameniar et al., 2023) that could encourage a diverse community of specialists (Onodi et al., 2021). Moreover, edge species are determined by the amount and quality of the forest edge (Bellamy et al., 1996), inhabit forest margins and open spaces within the forests (Berg & Part, 1994), resulting in increase of the overall bird richness.

The present study focuses on the density and composition of breeding bird communities in forests from the Western Thracian lowland. The results can be used to develop future management practices that favor the diversity and the composition of bird communities in similar fragmented forests.

Materials and Methods

Study area

The study was carried out in 15 plain forest patches across the Western Thracian lowland (Fig. 1). The landscape is predominated of arable lands and settlements with dense population and highly developed infrastructure. This is the most extensively managed plain in Bulgaria and the entire lowland falls into the area with transitional-continental climate. The annual temperature is between 11.5°C and 12.5°C, with low annual precipitations amount (500 – 550 mm) (Yordanov & Velev, 1956). The mean elevation of the study area is 165 m (133 – 331 m a.s.l.).

The surveyed forests fragments range in size from 69 ha to 577 ha and a total area of 3677 ha (Hristova et al., 2024, in press) (Table 1). The forest fragments represent three forest types - riparian forests, mesophilic forests and xerothermic oak forests (Ganchev, 1965; Bondev & Nikolov, 1983; FEA, 2021), and consist predominantly of different oak species (*Quercus robur, Quercus frainetto, Quercus cerris*), as well as Field elm (*Ulmus minor*), Narrow-leaved ash (*Fraxinus angustifolia*), and Black locust (*Robinia pseudoacacia*). The available undergrowth consists mainly of Common hawthorn (*Crataegus monogyna*), Common dogwood (*Cornus sanguinea*), Dog rose (*Rosa canina*) and European smoketree (*Cotinus coggygria*).

Five of the study forests are protected by the Natura 2000 ecological network under the Habitats and Birds Directives: Reka Pyasachnik (forest of Trud), Gora Shishmantsi, Trilistnik (forest of Chekeritsa), Reka Maritsa and Maritsa-Parvomay (forest of Vinitsa), Gradinska gora and Maritsa-Parvomay (forest of Gradina), and two of them (the forest of Chekeritsa and Gradina) are part of the State hunting enterprise "Trakia" with restricted access and different forest management practices.

Bird sampling

Bird sampling was carried out during three consecutive years, from 2020 to 2022, for a total of 98 days using point counts (Bibby et al., 1998).

The study forests were split into grid of 150 x 150 m plots (n = 1307 subsets) (QGIS, 2020), which is considered sufficient size for surveys in dense forests and inconspicuous birds (Bibby et al., 1998). The study plots were selected using random selection of ~ 5% (n = 69) of all plots, with recommended minimum of 50 point counts for describing a forest bird community (Bibby et al., 1998). During the field work, one plot was replaced due to inaccessibility, and another three were visited in addition, to cover all presented microhabitats in the largest study site (the forest of Padarsko). Thus, a total of 424 visits in 73 plots were made (Table 1).

All birds seen or vocally detected were counted for up to 10 min. (Bibby et al., 1998) in each plot during the breeding season (April–July). Species, flying over the observer were not recorded. Field work was carried out under good weather conditions (without strong wind, rain or fog). In each plot we accounted for the number of breeding pairs whenever one of the following conditions was met: 1) Adult bird observed in a habitat suitable for breeding; 2) Singing male; 3) Male and female birds located closely; 4) Flock of fledged young birds moving together with or without parents; 5) Occupied nest or hollow (Nikolov & Spasov, 2005). Bird data was recorded using the mobile application SmartBirds Pro (Popgeorgiev et al., 2015). Two counts per point transect were made each year with 10 – 40 day (average 21) interval between the visits. Every following visit at the point station was made in a reverse order, aiming in recording all species depending on their breeding periods (early or late breeders).

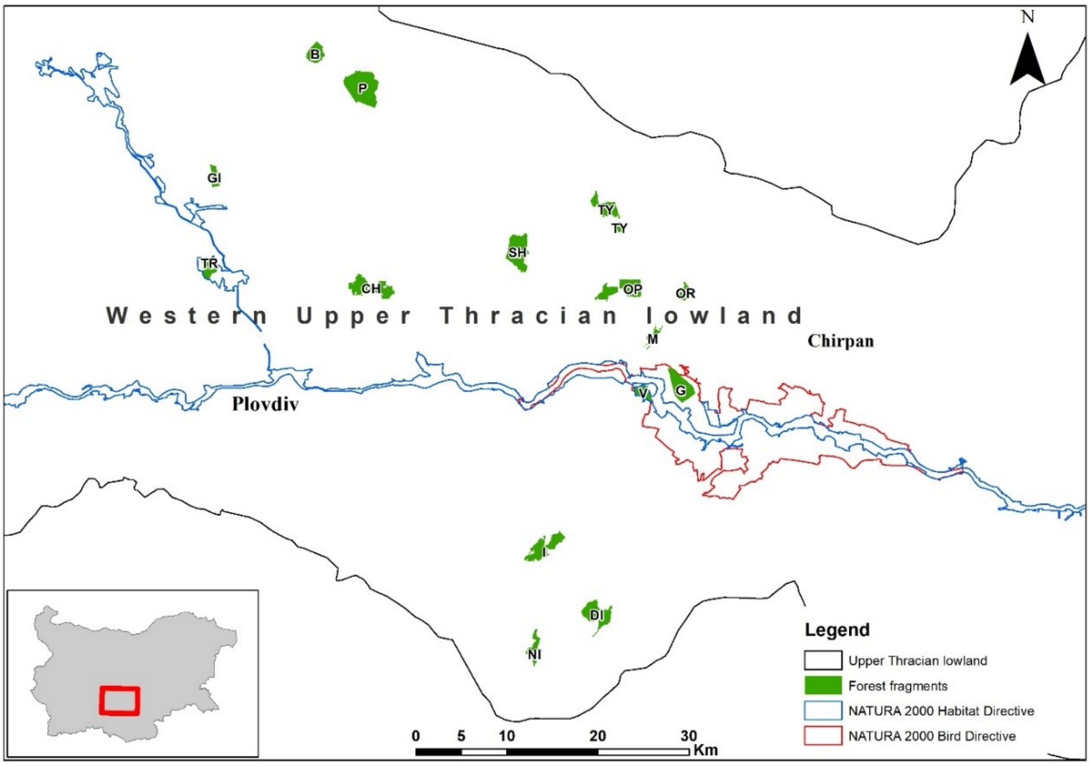

Fig. 1. Map of the study forest fragments (Begovo [B]; Vinitsa [V]; Gradina [G]; Graf Ignatievo [GI]; Dalbok Izvor [DI]; Izbeglii [I]; Mirovo [M]; Novi izvor [NI]; Opalchenets [OP]; Orizovo [OR]; Padarsko [P]; Trud [TR]; Tyurkmen [TY]; Chekeritsa [CH]; Shishmantsi [SH]) with coverage of protected areas within Natura 2000 ecological network.

Table 1. Study forests with the associated number of visited point plots and area in hectares.

Study forest	Numb. of plots	A [ha]
Begovo (B)	4	169
Vinitsa (V)	2	120
Gradina (G)	6	314
Graf Ignatievo (GI)	2	113
Dalbok izvor (DI)	5	319
Izbeglii (I)	5	311
Mirovo (M)	2	69
Novi izvor (NI)	2	158
Opalchenets (OP)	6	325
Orizovo (OR)	2	105
Padarsko (P)	14	577
Trud (TR)	4	148
Tyurkmen (TY)	5	234
Chekeritsa (CH)	7	324
Shishmantsi (SH)	7	391
Total	**73**	**3677**

Data analysis

For each species, the ratio between the number of individual species and the total number of registered species was calculated and presented as percentage. Hereafter, the estimation is referred as relative species abundance (RSA) (Preston, 1948).

The frequency is presented as

$$F_i = (m / n) * 100,$$

where: *m* is number of sample plots, where species was registered, and *n* – total number of sample plots. Species with frequency > 50% are considered dominant (Onodi et al., 2021).

The analysis on the bird density and numbers were performed using DISTANCE 7.3 Software, Release 2 (Thomas et al., 2005). To increase the precision of the detection function estimate and the reliability of the density estimates on subsets of species, the data was analyzed using Multiple covariate distance sampling (MCDS) (Marques & Thomas, 2007). Species with fewer observations were omitted from the analysis. Model selection was based on Akaike's information criterion (AIC) between half-normal and hazard-rate functions with cosine and simple polynomial adjustments. Models with lower AIC were consi-dered best models (Burnham & Anderson, 2002). Two approaches were applied: 1) for estimations for the whole study area, we modelled different detection functions for each species, based on species-specific stratification (Alldredge et al., 2007); and 2) for estimations of individual species by forest fragment, we used area-specific covariate and stratum-specific detection probabilities based on the covariate values of the birds observed in each stratum (Marques & Thomas, 2007). For the latter, forests with fewer than four replicate plots (n ≤ 4) were excluded from the analysis. Mean densities are presented with 95% confidential intervals.

Results

A total of 62 bird species with 4922 individuals were recorded. The most abundant bird species for the whole area (n = 6) made up to 61% of all registered species: Common nightingale (*Luscinia megarhynchos*), Chaffinch (*Fringilla coelebs*), European turtle dove (*Streptopelia turtur*), Blackbird (*Turdus merula*), Golden oriole (*Oriolus oriolus*) and Blackcap (*Sylvia atricapilla*) (Table 2). The most frequent species (presented in all study plots) were Nightingale and European Turtle-dove, followed by Blackbird, Chaffinch, Great tit (*Parus major*) and Blackcap. Species with the lowest frequency were exceptionally habitat specialists (e.g. forest-interior species, riparian, species of the open habitat, forest edge species, diurnal raptor species) (Table 2).

Table 2. List of registered bird species in descending order of relative species abundance, and the corresponding frequency.

Species	Frequency [%]	RSA [%]
Luscinia megarhynchos	100.00	11.36
Fringilla coelebs	95.95	10.55
Turdus merula	98.65	8.90
Streptopelia turtur	100.00	8.76
Oriolus oriolus	97.30	8.13
Sylvia atricapilla	93.24	7.17
Parus major	95.95	6.10
Turdus philomelos	79.73	4.45
Cuculus canorus	89.19	4.02
Erithacus rubecula	70.27	3.98
Columba palumbus	83.78	3.58
Garrulus glandarius	70.27	2.28
Upupa epops	58.11	2.17
Phasianus colchicus	55.41	1.71
Coccothraustes coccothraustes	60.81	1.59
Picus viridis	51.35	1.34

Species	Frequency [%]	RSA [%]
Lanius collurio	39.19	1.30
Phylloscopus collybita	41.89	1.22
Sturnus vulgaris	44.59	1.12
Dendrocopos major	41.89	1.04
Sitta europaea	39.19	0.98
Parus caeruleus	41.89	0.91
Emberiza hortulana	18.92	0.73
Emberiza calandra	18.92	0.71
Hippolais pallida	20.27	0.69
Aegithalos caudatus	22.97	0.51
Alauda arvensis	17.57	0.43
Carduelis chloris	16.22	0.37
Dryocopus martius	17.57	0.37
Muscicapa striata	20.27	0.37
Streptopelia decaocto	14.86	0.37
Buteo buteo	16.22	0.26
Curruca communis	9.46	0.26
Corvus corax	10.81	0.22
Corvus cornix	9.46	0.16
Dryobates minor	9.46	0.14
Accipiter nisus	8.11	0.12
Motacilla flava	2.70	0.12
Perdix perdix	6.76	0.12
Troglodytes troglodytes	8.11	0.12
Acrocephalus palustris	5.41	0.10
Carduelis carduelis	6.76	0.10
Pica pica	2.70	0.10
Coracias garrulus	5.41	0.08
Dendrocopos syriacus	5.41	0.08
Lanius nubicus	5.41	0.08
Lanius senator	5.41	0.08
Curruca curruca	5.41	0.08
Accipiter gentilis	4.05	0.06
Coturnix coturnix	2.70	0.06
Ficedula semitorquata	4.05	0.06
Passer montanus	2.70	0.06
Emberiza melanocephala	2.70	0.04
Galerida cristata	2.70	0.04
Passer hispaniolensis	2.70	0.04
Pernis apivorus	2.70	0.04
Remiz pendulinus	1.35	0.04
Curruca nisoria	2.70	0.04
Certhia brachydactyla	1.35	0.02
Falco tinnunculus	1.35	0.02
Lanius minor	1.35	0.02
Lullula arborea	1.35	0.02

The densities for 19 of the registered species were calculated for the whole study area. For the remaining 43 species data were insufficient (n = 39 of the total species) or unsuitable (*Cuculus canorus, Phasianus colchicus, Garrulus glandarius, Sturnus vulgarus*) for reliable estimations (Table 3). Species with density above 1 pair/ha were Great tit, Hawfinch, European Turtle-dove, Chaffinch, Robin (*Erithacus rubecula*) and Blackbird. Species with intermediate density (0.5 > 1 pair/ha) were nine, and species with low density (< 0.5 pairs/ha) – four (*Oriolus oriolus, Picus viridis, Emberiza hortulana, Upupa epops*).

Table 3. Densities for the 19 most abundant species (pairs per hectare) within the whole study area with coefficient of variation (CV) and 95% confidence intervals (95% CI).

Species	p/ha	CV	95% CI
Parus major	1.29	6.31	1.14–1.46
Coccothraustes coccothraustes	1.19	10.78	0.97–1.48
Streptopelia turtur	1.14	6.17	1.01–1.28
Fringilla coelebs	1.10	5.49	0.99–1.23
Erithacus rubecula	1.08	9.74	0.90–1.31
Turdus merula	1.04	5.49	0.93–1.16
Luscinia megarhynchos	0.99	4.51	0.91–1.08
Columba palumbus	0.91	8.99	0.82–1.16
Hippolais pallida	0.88	22.32	0.56–1.37
Lanius collurio	0.83	15.75	0.61–1.13
Sylvia atricapilla	0.75	5.84	0.67–0.84
Phylloscopus collybita	0.66	15.76	0.48–0.90
Turdus philomelos	0.65	7.05	0.56–0.74
Sitta europaea	0.62	15.84	0.45–0.85
Emberiza calandra	0.59	22.55	0.38–0.93
Oriolus oriolus	0.44	4.45	0.40–0.48
Picus viridis	0.39	11.57	0.31–0.50
Emberiza hortulana	0.32	11.05	0.26–0.40
Upupa epops	0.27	7.66	0.23–0.31

We calculated area-specific densities for nine species (*Turdus phillomelos, Turdus merula, Sylvia atricapilla, Streptopelia turtur, Parus major, Oriolus oriolus, Fringilla coelebs, Erithacus rubecula, Luscinia megarhynchos*) in nine of the forests (60% of all) (Table 4). Robin was found to be the species with the greatest density for the forest of Begovo D = 2.28 (1.36 – 3.85), followed by the European Turtle-dove with 1.8 pairs/ha. The Golden oriole had relatively low density for all forests (0.3 < 0.6 pairs/ha). All analyzed species were found to breed in lower densities in the forest of Dalbok Izvor (0.24 > 0.97 pairs/ha), compared with the rest of the study sites.

Discussion

Our data show overall high species richness (n = 62), which is consistent with other surveys in deciduous lowland forests (Wesolowski et al., 2022; Onodi et al., 2021; Machar, 2012). We confirmed that broadleaf forests hold higher species diversity and birds have greater densities, than in coniferous forests (Nikolov, 2007). Our results demonstrate that higher bird diversity can be reached even in strongly impacted habitats, whereas habitat heterogeneity is considered a key factor for structuring the bird assemblages (Heidrich et al., 2020; Sommer & Fichtner, 2023). The study forest patches are relatively large in size and consist of various microhabitats with different features, which is beneficial for a number of species from diverse ecological groups (e.g. diurnal raptors, forest edge species, hole nesters, etc.). Our result is consistent with the statement that the species richness is determined by forest size, where larger patches support higher species diversity (Opdam et al., 1985). Species typical of forest margins and forest openings increase in larger areas, due the high degree of forest fragmentation, which creates greater amount of forest edge and ecotone areas, suitable for non-forest species (Machar, 2012; Heidrich et al., 2020), such as Red-backed shrike (*Lanius collurio*), Corn bunting (*Emberiza calandra*), Ortolan bunting. Many of these open-habitat species are being more abundant in arable lands within the forests, or in sparse forests (Berg & Part, 1994).

Table 4. Area-specific densities [D] with coefficient of variation [CV] and 95% confidence intervals [95 %CI] of the most abundant species (n = 9), breeding in the forest fragments of the Western Upper Thracian lowland. The estimations were made for forests with more than four replicate plots (Begovo [B]; Chekeritsa [CH]; Dalbok Izvor [DI]; Opalchenets [OP]; Padarsko [P]; Shishmantsi [SH]; Gradina [GR]; Izbeglii [I]; Tyurkmen [TY]).

Species	B			CH			DI		
	D	CV	95 % CI	D	CV	95 % CI	D	CV	95 % CI
Turdus phillomelos	0.84	23.70	0.52–1.35	0.76	22.07	0.49–1.18	0.24	22.38	0.15–0.38
Turdus merula	0.81	25.13	0.49–1.35	0.55	9.52	0.45–0.66	0.41	13.92	0.31–0.54
Sylvia atricapilla	0.90	18.48	0.62–1.31	1.07	23.23	0.68–1.69	0.33	28.50	0.18–0.61
Streptopelia turtur	1.82	26.85	1.07–3.11	1.46	19.25	0.99–2.14	0.37	26.17	0.22–0.63
Parus major	0.50	20.43	0.33–0.76	1.46	16.68	1.05–2.04	–	–	–
Oriolus oriolus	–	–	–	0.64	18.20	0.44–0.92	0.32	13.11	0.24–0.41
Fringilla coelebs	–	–	–	1.56	14.32	1.18–2.08	0.84	12.58	0.65–1.07
Erithacus rubecula	2.29	25.73	1.36–3.85	1.54	25.37	0.92–2.57	0.72	16.58	0.51–0.99
Luscinia megarhynchos	1.07	26.29	0.63–1.82	0.94	13.52	0.71–1.22	0.53	17.76	0.37–0.77
	OP			**P**			**SH**		
	D	CV	95 % CI	D	CV	95 % CI	D	CV	95 % CI
Turdus phillomelos	0.41	15.27	0.30–0.56	1.15	25.04	0.69–1.92	0.58	30.34	0.31–1.07
Turdus merula	1.14	21.83	0.73–1.76	1.17	21.77	0.76–1.79	1.01	13.88	0.77–1.33
Sylvia atricapilla	1.03	25.07	0.62–1.70	0.76	14.71	0.57–1.01	0.97	17.44	0.68–1.37
Streptopelia turtur	1.16	16.38	0.83–1.61	1.09	15.49	0.80–1.48	1.58	12.48	1.23–2.02
Parus major	1.16	25.83	0.69–1.95	0.90	18.00	0.63–1.28	0.79	19.80	0.53–1.17
Oriolus oriolus	0.37	10.03	0.30–0.45	0.60	15.61	0.44–0.82	0.65	17.30	0.46–0.91
Fringilla coelebs	1.03	13.74	0.79–1.36	1.12	15.22	0.83–1.51	1.19	15.22	0.88–1.61
Erithacus rubecula	–	–	–	1.19	17.20	0.85–1.67	0.81	17.49	0.57–1.15
Luscinia megarhynchos	1.51	14.99	1.12–2.03	1.65	14.79	1.24–2.22	0.78	12.72	0.60–1.00
	GR			**I**			**TY**		
	D	CV	95 % CI	D	CV	95 % CI	D	CV	95 % CI
Turdus phillomelos	0.63	16.78	0.45–0.88	–	–	–	0.75	14.36	0.56–1.00
Turdus merula	1.06	19.97	0.72–1.58	0.80	20.55	0.53–1.21	1.21	28.88	0.68–2.16
Sylvia atricapilla	1.15	23.05	0.73–1.83	0.56	23.98	0.34–0.92	0.66	16.39	0.48–0.92
Streptopelia turtur	1.07	18.49	0.74–1.55	1.19	15.29	0.87–1.61	1.65	25.01	1.00–2.73
Parus major	1.28	22.63	0.81–2.01	–	–	–	1.20	19.33	0.81–1.78
Oriolus oriolus	0.41	10.79	0.33–0.51	0.47	15.19	0.35–0.63	0.49	16.54	0.36–0.69
Fringilla coelebs	1.25	12.48	0.98–1.60	1.03	25.17	0.61–1.716	1.09	19.25	0.74–1.60
Luscinia megarhynchos	1.43	20.95	0.94–2.18	1.60	15.10	1.19–2.16	1.73	18.33	1.20–2.49

When compared with other studies in deciduous forests, our results of the density and frequency for the dominant species were found to be similar, except of the Nightingale and European Turtle-dove. We found both species presented in all study plots, whereas contrariwise, similar studies found the species with lower frequency (Machar, 2012; Onodi et al., 2021). This is not unusual, given the fact that the study area is structurally highly heterogeneous, offering suitable breeding habitat for species inhabiting forest edges or the shrub layer. Blackcap, Great tit and Chaffinch were found to be dominant, consistently with results from unmanaged deciduous forests in Germany (Sommer & Fichtner, 2023), unmanaged forests in Poland (Wesolowski et al., 2022), floodplain forests (Machar, 2012) and deciduous forest remnants in Central Hungary (Onodi et al., 2021).

Species with certain habitat preferences were less frequent, such as the Short-toed treecreeper (*Certhia brachydactyla*), Semicollared flycatcher (*Ficedula semitorquata*), woodpeckers (e.g. *Dryobates minor, Dendrocopos syariacus*), Woodlark (*Lullula arborea*), Penduline tit (*Remiz pendulinos*), etc. Usually, habitat specialist species are less presented in fragmented landscapes (Blake & Karr, 1984). Forest specialists are particularly sensitive to fragmentation due to their high habitat specificity and are negatively affected by forest fragmentation (Opdam et al., 1985). The study remnants generally consist of small amount of true forest interior and larger edge area, and species associated with early successional habitats and forest edges usually benefit from harvesting and fragmentation (Leso et al., 2019).

Our results show that Great tit was the species with the highest density for the whole study area D = 1.29 (1.14 – 1.46). We find similar results in the work of Machar (2012) where species was found to breed with 10.6–14 pairs/10 ha in floodplain forests, and was most numerous in Black lockust plantations, managed oak forests and old oak forests in Hungary (Onodi et al., 2021).

European Turtle-dove had relatively high breeding densities for the whole study area, as well as for most of the study forests. The species is listed as Threatened with decreasing European population, mainly due to loss of habitat and hunting (BirdLife International, 2019). Nevertheless, the observed densities are similar with previous study in forests, dominated by Downy oak (Simeonov et al., 1990), where the species was found to be numerous. The species often inhabits forest edges, and it is best presented in forests with opening, preferably near croplands. Pairs were found to breed close in areas with limited nesting sites, but good and easily accessible feeding grounds (Cramp, 1977–1994).

Our results show that the study forests provide both, suitable breeding and foraging sites, and could serve as a baseline for further long-term studies of variations in the population. As pointed above, the protection status of some of the forests might benefit the species and limit the hunting pressure.

European robin was found to breed with relatively high density D = 1.08 (0.90 – 1.31), which is in contrast with the results of Onodi et al. (2021), where the species was found to be common for managed oak and old oak forests, as well as in floodplain forests (Machar, 2012), although with two-fold lower density (3.9 – 6.1 pairs/10 ha) than in our study. Generally, it is found with greater densities in coniferous and mixed forest belts in Bulgaria, but lower for the plain regions (Iankov, 2007). Although we report higher densities for the lowland region, the study sites comprise only woodland areas, where tree stands are with different stand age and structure, thus we consider our results relevant.

The Chaffinch was found with similar density, compared with other oak and mixed deciduous forests in Bulgaria (10 – 11 pairs/10 ha) (Simeonov et al., 1990), floodplain forests in Czech Republic (9.5/10ha or 6.5/10 ha) (Machar, 2012) and developing Pedunculate oak (*Quercus robur*) forests in France (Cramp, 1977–1994).

When compared with similar works, four species (Hawfinch, Blackbird, Nightingale and Wood pigeon) were found with higher or similar breeding densities. Hawfinch is considered generalist and edge species and its presence is also related with available foraging grounds as a granivore species (Cramp, 1977–1994). Similar breeding densities were reported for the unmanaged forests in Balowieza park (up to 13 – 15 pairs/10 ha) (Wesolowski et al., 2022), but lower for floodplain forests (up to 5 pairs/10 ha) (Machar, 2012).

Species with intermediate density (*Luscinia megarhynchos, Columba palumbus, Hippolais pallida, Lanius collurio, Sylvia atricapilla, Phylloscopus collybita, Turdus philomelos, Sitta europaea, Emberiza calandra*) were quite similar with other studies (Simeonov et al., 1990; Cramp, 1977–1994). Moreover, arable areas are sufficient foraging source for granivores, as well as attract-ting insectivores. Golden oriole was found with lower breeding density, slightly higher in contrast with other studies in deciduous (2 pairs/10 ha) and lower compared with xerothermic forests (11 pairs/10 ha) in Bulgaria (Simeonov et al., 1990). We consider the observed variations in the density are related with the different survey methodologies applied, as well as differences in the study sites. The Ortolan bunting was reported with lower density in oak dominated forests (2 pairs/10 ha) (Simeonov et al., 1990), than in the current study D = 0.32 (0.26 – 0.40). The species is attracted to trees, favoring dry regions and forest openings, especially in open cultivated lands (Cramp, 1977–1994).

Generally, the heterogeneous structure of the study forests with high amount of edge area and different stand aged trees with complex canopy structure can explain the observed high species richness. Thereby, these fragments are suitable for species from different ecological groups such as forest-edge species, or those related with open habitats.

Conclusions

In conclusion, the study suggests that the lowland forests of the Thracian plane hold a high species richness with significant number of few dominant species, low frequency and density of specialist species, including forest-interior species.

The current research could serve as a baseline for studying further changes in the bird communities of the forests and promote management practices, that could benefit species diversity and conservation.

Acknowledgements: We are grateful to Zdravka Taseva and Edita Difova for the support during the field work. Many thanks to Dr. Eric Rexstad for the valuable advises on the analysis of the bird densities.

References

Alldredge, M.W., Pollock, K.H., Simons, T.R., & Shriner, S.A. (2007). Multiple-species analysis of point count data: a more parsimonious modelling framework. *Journal of Applied Ecology*, 44 (2), 281-290. doi: 10.1111/j.1365-2664.2006.01271.x

Andren, H. (1994). Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. *Oikos*, 71, 355-366. doi: 10.2307/3545823

Bellamy, P., Hinsley, S. A., & Newton, I. (1996). Factors influencing bird species numbers in small woods England. *Journal of Applied Ecology*, 33, 249-262. doi: 10.2307/2404747

Berg, A., & Part, T. (1994). Abundance of breeding farmland birds on arable land set-aside fields at forest edges. *Ecography*, 17, 147-152.

Bibby, C., Jones, M., & Marsden, S. (1998). *Expedition Field Techniques. Bird Surveys*. Royal Geographical Society, London, 143 p.

BirdLife International. (2019). *Streptopelia turtur*. The IUCN Red List of Threatened Species: e.T22690419A154373407. doi: 10.2305/IUCN.UK.2019-3.RLTS.T22690419A154373407.en

Blake, G.J., & Karr, J.R. (1984). Species composition of bird communities and the conservation benefit of large versus small forests. *Biological Conservation*, 30, 173-187. doi: 10.1016/0006-3207(84)90065-X

Bondev, I., & Nikolov, N. (1983). The vegetation cover in the region of the scientific investigation station at the village of Patriarh Evtimovo, Plovdiv district. *Third National Conference on Botany, BAS, Sofia*, 367-375. (In Bulgarian).

Burnham, K.P., & Anderson, D.R. (2002). *Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach*. Springer-Verlag, New York, NY, 488 p. doi: 10.1007/b97636

Cramp, S., & Simmons, K.E.L. (Eds). *1977-1994. Handbook of the birds of Europe, the Middle East and Africa. The birds of the western Palearctic.* Oxford University Press, Oxford, 655 p. doi: 10.1038/272652a0

Fernández-Juricic, E. (2004). Spatial and temporal analysis of the distribution of forest specialists in an urban-fragmented landscape (Madrid, Spain). Implications for local and regional bird conservation. *Landscape and Urban Planning*, 69, 17-32. doi: 10.1016/j.landurbplan.2003.09.001

Forest Executive Agency (FEA). Version: 2021.01.04. Available online: https://maps.iag.bg/.

Ganchev, I. (1965). *Ostatachni gori v Starozagorsko pole i po perifernite mu halmove (formirane, sukcesii I floren analiz)*. BAS, Sofia, 5-71. (In Bulgarian).

Heidrich, L., Bae, S., Levick, S., Seibold, S., Weisser, W., Krzystek, P., Magdon, P., Nauss, T., Schall, P., Serebryanyk, A., Wöllauer, S., Ammer, C., Bässler, C., Doerfler, I., Fischer, M., Gossner, M.M., Heurich, M., Hothorn, T., Jung, K., Kreft, H., Schultze, E.D., Simons, N., Thorn, S., & Müller, J. (2020). Heterogeneity–diversity relationships differ between and within trophic levels in temperate forests. *Nature Ecology & Evolution*, 4, 1204–1212. doi: 10.1038/s41559-020-1245-z

Hristova, P., Popgeorgiev, G., Dobrev, V., Dimitrov, H., & Plachyiski, D. (2024). Birds composition in forest fragments across the Western Upper Thracian lowland. *Acta Zoologica Bulgarica*, In press.

Iankov, P. (2007). *Atlas of the breeding birds in Bulgaria*. Sofia, Bulgaria: BSPB. (In Bulgarian).

Kameniar, O., Balaz, M., Svitok, M., Mikolas, M., Ferencik, M., Frankovic, M., Ralhan, D., Gloor, R., & Svoboda, M. (2023). Spruce- and beech-dominated primary forests in the western Carpathians differ in terms of forest structure and bird assemblages, independently of disturbance regimes. *European Journal of Environmental Science*, 13 (1), 47-59. doi: 10.14712/23361964.2023.6

Leso, P., Kropil, R., & Kajtoch, L. (2019). Effects of forest management on bird assemblages in oak-dominated stands of the Western Carpathians – Refuges for rare species. *Forest Ecology and Management*, 453, 117620. doi: 10.1016/j.foreco.2019.117620

Lynch, J.F., & Whigham, F.D. (1984). Effects of Forest Fragmentation on Breeding Bird Communities in Maryland, USA. *Biological Conservation*, 28, 287-324.

Machar, I. (2012). The effect of floodplain forest fragmentation on the bird community. *Journal of Forest Science*, 58(5), 213-224. doi: 10.17221/123/2010-JFS

Marques, T.A., Thomas, L., Fancy, S.G., & Buckland, S.T. (2007). Improving estimates of bird density using multiple covariate distance sampling. *The Auk*, 127, 1229-1243. doi: 10.1093/auk/124.4.1229

Nikolov, S., & Spasov, S. (2005). Frequency, density and number of some breeding birds of south part of Kresna Gorge (SW Bulgaria). *Acrocephalus*, 26, 23-31.

Nikolov, S. (2007). Density and community structure of breeding birds in Macedonian pine *Pinus peuce* forests in Bulgaria. *Avocetta*, 31, 53-60.

Onodi, G., Botta-Dukat, Z., & Winkler, D. (2021). Endangered lowland oak forest steppe remnants keep unique bird species richness in Central Hungary. *Journal of Forestry*, 33, 343-355. doi: 10.1007/s11676-021-01317-9

Opdam, P., Rijsdijk, G., & Hustings, F. (1985). Bird communities in small woods in an agricultural landscape: Effects of area and isolation. *Biological Conservation*, 34, 333-352. doi: 10.1016/0006-3207(85)90039-4

Piechnik, L., Holeska, J., Ledwon, M., Kurek, P., Szarek-Lukaszewska, G., & Zywiec, M. (2022). Stand Composition, Tree-Related Microhabitats and Birds—A Network of Relationships in a Managed Forest. *Forests*, 13(1), 103. doi: 10.3390/f13010103

Popgeorgiev, G., Spasov, S., & Korniliev, Y.V. (2015). SmartBirds: Information system with biological information of the BSPB, pp. 3-226. Available at https://smartbirds.org.

Preston, F.W. (1948). The Commonness, and Rarity, of Species. *Ecology*, 29(3), 254-283.

QGIS.org. 2020. QGIS Geographic Information System. Open Source Geospatial Foundation Project. Available at http://qgis.org.

Simeonov, S., Michev, T., & Nankinov, D. (1990). *Fauna of Bulgaria. 20., Aves, 1*. BAS, Sofia, 349 p. (In Bulgarian).

Slattery, Z., & Fenner, R. (2021). Spatial Analysis of the Drivers, Characteristics, and Effects of Forest Fragmentation. *Sustainability*, 13, 3246. doi: 10.3390/su13063246

Sommer, R.S., & Fichtner, A. (2023). Effects of habitat heterogeneity on bird communities in forests of northeastern Germany. *Baltic Forestry*, 29 (2), id 699. doi: 10.46490/BF699

Thomas, L., Laake, J.L., Strindberg, S., Marques, F.F.C., Buckland, S.T., Borchers, D.L., Anderson, D.R., Burnham, K.P., Hedley, S.L., Pollard, J.H., Bishop, J.R.B., & Marques, T.A. (2005). Distance 5.0. Release BETA 3. Research Unit for Wildlife Population Assessment. University of St Andrews, St Andrews, UK. Available at http://www.ruwpa.st-and.ac.uk/distance/

Vieira de Matos, V.P., Vieira de Matos, T.P., Cetra, M., Carmargo e Timo, T.P., & Valente, R.A. (2018). Forest fragmentation and impacts on the bird community. *Revista Avrore*, 42 (3), e420309. doi: 10.1590/1806-90882018000300009

Wesolowski, T., Czeszczewik, D., Hebda, G., Maziarz, M., Mitrus, C., Rowinski, P., & Neubauer, G. (2022). Long-term changes in breeding bird community of a primeval temperate forest: 45 years of censuses in the Bialowieza National Park (Poland). *Acta Ornithologica*, 57(1), 71-100. doi: 10.3161/00016454AO2022.57.1.005

Yordanov, T., & Velev, V. (1956). *The Thracian Lowlands*. Sofia, Bulgaria: Nauka i izkustvo. (In Bulgarian).

Received: 24.01.2024
Accepted: 09.06.2024