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Study on the habitat selection by birds in mature and over-mature Macedonian Pine *Pinus peuce* forests in Pirin National Park (SW Bulgaria)

Ptice in njihov izbor habitata v optimalni in terminalni fazi odraslega gozda molike *Pinus peuce* v Narodnem parku Pirin (JZ Bolgarija)

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Habitat selection by birds in mature (60–100 years old) and over-mature (>120 years old) Macedonian Pine *Pinus peuce* forests was studied over 3 years (2004–2006) in Pirin National Park (SW Bulgaria). Overall, 185 study plots were randomly located and at each study plot habitat characteristics were described within a radius of 25 m. Birds were counted twice per year (June–July) within a radius of 50 m using the distance-sampling point-count technique. There was almost no difference in bird diversity between the studied forest age classes. Five species (Wren *Troglodytes troglodytes*, Chiffchaff *Phylloscopus collybita*, Coal Tit *Parus ater*, Nuthatch *Sitta europaea* and Treecreeper *Certhia familiaris*) showed preferences to over-mature Macedonian Pine forests and they had higher breeding densities in over-mature than in mature forests. Only one species (Mistle Thrush *Turdus viscivorus*) was found to prefer mature forests. The important criteria in habitat selection of these 6 species were analyzed, using a forward stepwise Multiple Regression Analysis. From the species that preferred over-mature forest, 2 species were trunk and bark-feeders and 4 species were hollow nesters. The paper stresses the importance of the amount of dead wood and decaying trees for forest bird communities and suggests that removal of dead wood from old forests, especially those in protected areas, should be minimized.

Key words: forest birds, habitat selection, distance sampling, point transects, Macedonian Pine, *Pinus peuce*, Pirin National Park
Ključne besede: gozdne ptice, izbor habitata, točkovni transekti, molika, *Pinus peuce*, Narodni park Pirin

1. Introduction

In the context of global reduction and degradation of natural habitats, many forests are undervalued and clear-cut. The protected areas have an essential role to play in countering this process. Historically, they were only concerned with protection, but now there is also a need to focus on conservation, sustainable use and ecological restoration (Bennett 2003). However, there is still a lack of knowledge on which forest characteristics have a greater influence on biological diversity, particularly in Mediterranean forests (Gil-Tena *et al.* 2007). Therefore, better understanding of relationships between forest birds and their habitat in protected areas is crucial to the implementation of sustainable, ecosystem based forest management (Kirk & Hobson 2001). It is well known that avian communities differ greatly in early succession forests and in older forest stands (Helle & Mönkkönen 1990, Conner & Dickson 1997, Kirk & Hobson

2001). While the early succession bird species, majority of which are field and shrub-nesting species, decline in abundance as a response to vegetation growth, bird species associated with older forests age classes begin to increase in number and abundance (Dickson *et al.* 1993). But still little is known on the differences between bird communities in mature and over-mature forest age classes (Davis *et al.* 1999, Pearce & Venier 2005). In this paper we present the results from a short-term study on habitat selection by birds on local scale in mature and over-mature Macedonian Pine *Pinus peuce* forests in Bulgaria.

2. Studied habitat and area

The Macedonian Pine is a tertiary relict belonging to primeval quasi-boreal mesophyte vegetation, distributed endemically in Serbia, Montenegro, Macedonia, Albania, Greece and Bulgaria (Tutin *et al.* 1993). In Bulgaria, it can be found mainly in Pirin and Rila mountains (covering totally 12,000 ha), where it normally grows between 1700 and 2000 m a.s.l. (exceptionally 1200–2200 m a.s.l.) on rocky acid soils of silicate grounds (Iordanov 1963, Bondev 1991). It comprises up to (approximately) 30 m of comparatively light forest stands (Velchev 2002).

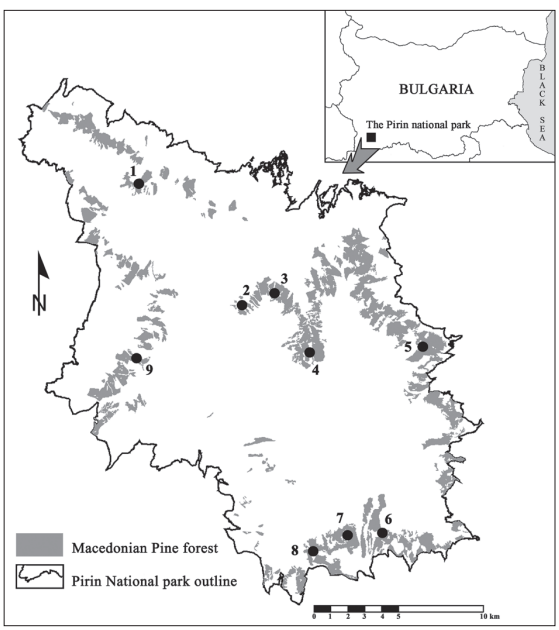

Figure 1: Location of Pirin National Park in Bulgaria and localities of studied areas within the park: (1) Bela Reka valley; (2) Bunderishka River valley; (3) area of Shiligarnika; (4) Demjanishka River valley; (5) Bezbojka River valley; (6) Demirkapyiska River valley; (7) Bashmandrevska River valley; (8) Kelyova River valley; and (9) Sinanishka River valley.

Slika 1: Lokacija narodnega parka Pirin v Bolgariji in lokacije raziskovanih območij znotraj parka: (1) dolina Bele reke; (2) dolina reke Bunderishka; (3) območje Shiligarnika; (4) dolina reke Demjanishka; (5) dolina reke Bezbojka; (6) dolina reke Demirkapyiska; (7) dolina reke Bashmandrevska; (8) dolina reke Kelyova; (9) dolina reke Sinanishka.

This study was carried out in 9 localities within Pirin National Park (Figure 1), south-western Bulgaria (41°40' N, 23°30' E), which is recognized as a UNESCO World Heritage Site, Important Bird Area (code EG055) and Natura 2000 site (code BG0002056). It holds a significant part (42%) of the Macedonian Pine forest in Bulgaria, representing 5,416 ha (23.4% of the forest cover in the park) – 95% of which is of native origin (Petrov 2003). The study area has a moderate continental climate and falls into a mountainous climatic sub region with average annual temperatures of 2–3°C and annual amplitude about 17°C. Summers are cool (mean temperature 3–5°C) and winters are cold (mean January temperatures from –2°C to –5°C) with snow cover (60–160 cm deep) presence for 120–160 days annually (Koleva 2003).

3. Methods

3.1. Bird sampling design

Field work was carried out in June and July for a total of 59 days, over three successive years (2004–2006). Overall, 185 study plots were located randomly using ArcMap 8.3 software (ESRI 2000) at 1,700–2,230 m elevation in two age classes of Macedonian Pine forests: mature, 60–100 years old (n = 95) and over-mature, >120 years old (n = 90). Minimal centre distance of adjacent study plots was 180 m (Bibby *et al.* 1998). The exact location of study plots was established in the field by means of Global Positioning System (GPS) Garmin 60CS.

Bird sampling was carried out using the distance-sampling point-count technique (Bibby *et al.* 1992, Buckland *et al.* 1993). At each study plot, birds seen and / or heard were counted within a radius of 50 m. A breeding pair was chosen for a counting unit, as described in Nikolov & Spasov (2005). Birds in flight were not counted. The counts were made between 6.00 h and 11.00 h local time. There was a setting down period of 2 min and the duration of a count was 5 min. Two counts per point transect were made each year, with a 10–40 day (on average 21) interval between the two successive visits. Most of the fundamental assumptions in distance-sampling methods (Bibby *et al.* 1992, Buckland *et al.* 1993) were met. All observations were carried out by the

same person (author of this paper), in the same day-time period, in similar weather conditions and within similar habitat types. This minimizes the interactions of detection probability with the observer, habitat, weather and day-time. Although the bird counts were carried out in mornings during the breeding season, when the vocal activity of birds is higher, we should take into consideration that in forested habitats some of the birds situated directly overhead the observer could be missed (Bächler & Liechti 2007). As the assumption g(0) = 1 cannot be guaranteed in all counts, only the relative bird density is discussed further in the paper.

The bird sampling method used in this study does not consider nocturnal birds (Owls and Nightjars) and was not applicable to species with very low abundance in the studied habitat (e.g. raptors, grouse, and some species of Woodpeckers).

3.2. Habitat sampling design

At each study plot, several physical characteristics of habitat and structural parameters of vegetation were measured. Elevation and exposition were measured using the GPS Garmin 60CS at the centre. Tree measurements were made for the closest 10 trees (with diameter at breast height >0.2 m) to the centre of the study plot. Tree diameter at breast height (DBH) and a distance of the 10th tree to the centre of study plot was measured by means of callipers and tape respectively. Foregoing measured parameters were used for the calculation of 2 derived parameters: density of trees (DT) and index of basal area of trees (IBAT). The rest of habitat parameters were estimated visually within a radius of 25 m from the centre of the plot: cover of rocks and piles of stones; vegetation layers; tree canopy; number of dead trees (with diameter at breast height >0.2 m) and stumps (higher than 0.5 m). The averages of the collected vegetation physiognomy data was used to represent a study plot in the statistical analysis. The studied forests were with up to 10% mixture of other than Macedonian Pine tree species: Norway Spruce *Picea abies* (L.) Karst., Scots *Pinus silvestris* L. and Bosnian Pines *Pinus heldreichii* Christ, Silver Fir *Abies alba* Mill., and Rowan *Sorbus aucuparia* L. Within these forests, 6 foliage profiles were distinguished: (1) Ground level (0.1–0.4 m high), composed of Bilberry *Vaccinium myrtillus* L., herbs and Wild Geranium *Geranium* spp.; (2) Low level (0.4–1 m high), composed of Hellebore *Veratrum* spp., thistles and ferns; (3) Small shrubs (0.4–1 m high), composed of Siberian Juniper *Juniperus sibirica* Burgsd., Balkan Broom *Chamaecytisus absinthioides* (Janka) Kuzm. and Raspberry *Rubus idaeus* L.; (4) Mid-level (1.6–4 m high), composed of Mountain Dwarf Pine *Pinus mugo* Turra., and saplings; (5) Sub-canopy level (4–7 m high), composed of short trees; (6) Canopy level, composed of tall trees (9–30 m high).

The habitat sampling method applied was based on estimation rather than actual measurement, but it is believed that such semi-quantitative methods have sufficient accuracy and efficiency for characterizing vegetation profiles (Braun-Blanquet 1932, Moore *et al.* 1970, Mueller-Dombois & Ellenberg 1974, Barbour *et al.* 1980) and are effective enough in analyzing avian-habitat relationships (Sabo 1980, Moskát & Waliczky 1992).

3.3. Data analysis

Species diversity was described using the reciprocal Simpson's index N_2 (Hill 1973), as species diversity calculated in this manner is highly dependent upon the most abundant species (Krebs 1999) who are the focus of this study. Habitat preferences of birds were tested using the G-test (Manly *et al.* 1993, Krebs 1999), which is an improved version of the Utilization-availability analysis (Neu *et al.* 1974). The technique comprises the calculation of the Selection Index (Cock 1978), which was used for estimating whether the species occurs more or less frequently than expected in each of the studied habitat categories. The significance of the Selection Index was analysed using the chi-square test (Krebs 1999) with the null hypothesis that species have no preferences to the studied habitat types. The Standardized Selection Index (Manly *et al.* 1993) was calculated for comparison between the habitat preferences of different species. Because of the constraint of Dixon & Massey (1969) that no more than 20% of all categories should contain less than 5 expected observations, only species with more than 10 observations were included in the analysis (n = 22 species). The sample sizes of all species used in the analysis were sufficiently large because the conservative rule of Hayes & Winkler (1970) that np and $n(1 - p) \geq 5$, where n is the number of observed birds and p is the proportion of observed birds in the studied habitat category, was respected.

The relative bird densities were computed using Distance 5.0 Release 2 software (Thomas *et al.* 2006). Conventional distance sampling analysis was applied, considering that the study was limited to only one habitat where the detection probability was similar, and consequently was solely a function of distance from the observation point. The model of uniform key function with simple polynomial series expansion

was selected on the basis of a minimum value selection of Akaike's Information Criterion (Akaike 1973).

The study plots were grouped in clusters taking into account the Central Limit Theorem, with the aim to achieve normal distribution of data (Fowler & Cohen 1992). A single cluster was composed by study plots in forests with similar age, pattern and exposition and it was represented by average values of study plots' measured/estimated parameters. Altogether, 48 clusters (24 in mature and 24 in over-mature forests) were made. Data were tested for normality using the Shapiro-Wilk's Test (Shapiro & Wilk 1965). Bird data were additionally square root transformed to achieve a normal distribution (Fowler & Cohen 1992). Habitat characteristics were compared by a z test (Fowler & Cohen 1992). Forward stepwise Multiple Regression Analysis (MRA) was performed for bird-habitat relationships (Jongman *et al.* 1997). Analyses were computed with Statistica 7.0 software (StatSoft 2004). Averages and their standard deviations are reported.

4. Results

There was almost no difference in bird diversity between the studied forest age classes (in over-mature N_2 = 10.09 and in mature forests N_2 = 10.45). Five species were found in only one of the studied habitat types. Four among them (Firecrest *Regulus ignicapillus*, Redstart *Phoenicurus phoenicurus*, Gray Wagtail *Motacilla cinerea* and Black Woodpecker *Dryocopus martius*) were with very low abundance in the studied habitat (n < 3 observations). Therefore the registration of these species in only one forest age class may be due to fortuity. The Greenfinch *Carduelis chloris* (n = 7 observations) was found in mature forests only and it is very probable that the species prefers this forest age class. According to the G-test, 6 species showed preferences to one of the studied age classes of Macedonian pine forests in Pirin National Park (Tables 1 & 2). Only one species (Mistle Thrush *Turdus viscivorus*) showed preference to mature Macedonian Pine forests, while the rest five species (Wren *Troglodytes troglodytes*, Chiffchaff *Phylloscopus collybita*, Coal Tit *Parus ater*, Nuthatch *Sitta europaea* and Treecreeper *Certhia familiaris*) preferred over-mature forests and therefore had higher breeding densities in this habitat type (Table 3). In the forementioned five species, the degrees of preference to over-mature forests were similar (Table 4). Chiffchaff was negatively correlated with the canopy cover and to a lesser extent with the tree height (Table 5). The canopy was closer in mature than in over-mature Macedonian Pine forests (z = 5.84, P < 0.001), but trees were higher in over-mature forests (z = 2.92, P < 0.01). Although the Coal Tit abundance was negatively correlated with the tree density and positively correlated with the IBAT (Table 5), the main factor related to the species preference to over-mature forests was DT. It was higher in mature forests (z = 4.48, P < 0.01), whereas the difference in IBAT was not significant between the studied forest age classes. According to the MRA, the important criteria in habitat selection for Wren, Nuthatch and Treecreeper was the amount of dead wood (Table 5). The number of stumps, dead and fallen trees was almost twice higher (z = 5.18, P < 0.001) in over-mature (mean = 5.78 ± 1.84) than in mature (mean = 3.14 ± 1.69) Macedonian pine forests. Additional factors for Nuthatch and Wren were the tree height and the rocks and stone piles cover respectively. The latter was present to a greater extent in over-mature forests (z = 1.90, P < 0.05). The abundance of Mistle Thrush was positively correlated with the cover of ground level vegetation profile and DT and negatively correlated with the canopy cover, but only the last two factors played a role in the habitat selection of species, since there was no significant difference in the cover of ground level vegetation profile between mature and over-mature Macedonian Pine forests (Table 5; z = 1.14, P > 0.05).

5. Discussion

The species found to prefer over-mature forest in Pirin National Park are more or less related to the old forest throughout their range in Palearctic (Cramp 1998). So far, we have had no quantitative studies on habitat selection of forest Passerines in Bulgaria, hence a comparison of the presented results with previous works at the national level is impossible.

Although the Wren inhabits different types of habitats in its Holarctic range, there are several factors that play an important role in habitat selection of species: the humidity, the presence of dense vegetation at the ground level and the vertical structures as stumps, stones and fallen branches (Hagemeijer & Blair 1997, Iankov *in press*). The results from the present study confirm the importance of the forementioned factors in habitat selection of Wren. Probably this relation is due to the availability of more sites for nesting and refuge (Cramp 1998). So far in Bulgaria, Wren has been found to prefer older forests in Scots Pine woodlands (Nankinov 1997). Higher density of Wren in old forests was registered also in Britain (Fuller 1995).

Table 1. Selection indices of birds in mature (60–100 years) and over-mature (above 120 years) Macedonian Pine *Pinus peuce* forests during the breeding seasons of 2004–2006 in Pirin National Park, Bulgaria. Abbreviations: *n* – number of breeding pairs observed; o_O & o_M – observed proportions of birds in over-mature and mature forests respectively; p_O & p_M – expected proportions of birds in over-mature and mature forests respectively; w_O & w_M – selection indices of birds in over-mature and mature forests respectively; *ns* – P > 0.05.

Tabela 1: Selekcijski indeksi ptic v optimalni (60–100 let) oz. terminalni fazi (nad 120 let) odraslih gozdov molike *Pinus peuce* v gnezditvenem obdobju 2004–2006 v bolgarskem Narodnem parku Pirin. Okrajšave: *n* – število opaženih gnezdečih parov; o_O & o_M – zabeleženi deleži ptic v terminalni oz. optimalni fazi; p_O & p_M – pričakovani deleži ptic v terminalni oz. optimalni fazi; w_O & w_M – selekcijski indeksi ptic v terminalni oz. optimalni fazi; *ns* – P > 0.05.

Species / Vrsta	*n*	Proportion / Delež		Selection index/ Selekcijski indeks		χ^2	P
		O_O ($p_O = 0.5$)	O_M ($p_M = 0.5$)	w_O	w_M		($df = 1$)
Dendrocopos major	48	0.53	0.47	1.06	0.94	0.18	*ns*
Anthus trivialis	16	0.50	0.50	1.00	1.00	0.00	*ns*
*Troglodytes troglodytes***	124	0.60	0.40	1.19	0.81	4.60	<0.05
Prunella modularis	85	0.53	0.47	1.06	0.94	0.29	*ns*
Erithacus rubecula	130	0.58	0.42	1.15	0.85	3.09	*ns*
Phoenicurus ochruros	30	0.61	0.39	1.23	0.77	1.59	*ns*
*Turdus viscivorus**	64	0.36	0.64	0.72	1.28	5.13	<0.05
T. torquatus	43	0.40	0.60	0.79	1.21	1.90	*ns*
Sylvia atricapilla	10	0.30	0.70	0.60	1.40	1.65	*ns*
*Phylloscopus collybita***	219	0.58	0.42	1.16	0.84	5.92	<0.05
Regulus regulus	186	0.48	0.52	0.97	1.03	0.19	*ns*
Parus montanus	57	0.42	0.58	0.85	1.15	1.38	*ns*
*P. ater***	363	0.55	0.45	1.11	0.89	4.38	<0.05
P. cristatus	26	0.42	0.58	0.85	1.15	0.62	*ns*
*Sitta europaea***	121	0.61	0.39	1.22	0.78	6.08	<0.05
*Certhia familiaris***	111	0.60	0.40	1.20	0.80	4.71	<0.05
Nucifraga caryocatactes	173	0.53	0.47	1.07	0.93	0.83	*ns*
Fringilla coelebs	512	0.53	0.47	1.07	0.93	2.51	*ns*
Serinus serinus	16	0.50	0.50	1.00	1.00	0.00	*ns*
Loxia curvirostra	83	0.57	0.43	1.13	0.87	1.46	*ns*
Pyrrhula pyrrhula	74	0.50	0.50	1.00	1.00	0.00	*ns*
Emberiza cia	10	0.50	0.50	1.00	1.00	0.00	*ns*

Remarks / Opombe:

* bird species preferring mature Macedonian Pine forests / vrste, ki so bolj naklonjene optimalni fazi odraslega gozda molike

** bird species preferring over-mature Macedonian Pine forests / vrste, ki so bolj naklonjene terminalni fazi odraslega gozda molike

The Chiffchaff has marked geographical variations in habitat requirements, but it is basically known as a bird of mature forests with not too dense canopy (Hagemeijer & Blair 1997). As observed in Macedonian Pine forests, in Central and Western Europe Chiffchaff prefers forests consisting of tall trees and providing an open canopy (Fuller 1995). In Fennoscandia, these habitat requirements are changed to a certain extent because of the competition with the Willow Warbler *Phylloscopus trochilus* (Tiainen *et al.* 1983). The results from the present study confirm the habitat requirements of Chiffchaff in Europe, but there is lack of strong correlation between species abundance and tree height of Macedonian Pines. This could be explained with the fact that in the present study the comparison was made between mature and over-mature forest communities, where the trees had reached their optimum height, while in Central and Western Europe the studies are based mainly on comparisons between young and mature forests.

The Coal Tit inhabits different types of coniferous forests throughout its range in Europe and is often

Table 2: Standard errors and confidence intervals of selection indices of breeding bird species with preference to mature or over-mature Macedonian Pine *Pinus Peuce* forests during the breeding seasons of 2004–2006 in Pirin National Park, Bulgaria. Abbreviations: SE – standard error (the standard errors of selection indices for mature and over-mature forests are equal); CI – confidence interval; w_o & w_M – selection indices of birds in over-mature and mature forests respectively.

Tabela 2: Standardne napake in intervali zaupanja selekcijskih indeksov vrst ptic gnezdivk, raje izbirale optimalno oz. terminalno fazo odraslega gozda molike *Pinus Peuce* v gnezditvenem obdobju 2004–2006 v bolgarskem Narodnem parku Pirin. Okrajšave: SE – standardna napaka (standardne napake selekcijskih indeksov za optimalno in terminalno fazo so enake); CI – interval zaupanja; w_o & w_M – selekcijski indeksi ptic v terminalni oz. optimalni fazi odraslih gozdovih.

Species / Vrsta	SE	95% CI	
		w_O	w_M
Troglodytes troglodytes	0.09	$1.019 \leq w_o \leq 1.362$	$0.638 \leq w_M \leq 0.981$
Turdus viscivorus	0.12	$0.484 \leq w_o \leq 0.954$	$1.046 \leq w_M \leq 1.516$
Phylloscopus collybita	0.07	$1.033 \leq w_o \leq 1.294$	$0.706 \leq w_M \leq 0.967$
Parus ater	0.05	$1.007 \leq w_o \leq 1.211$	$0.789 \leq w_M \leq 0.993$
Sitta europaea	0.09	$1.049 \leq w_o \leq 1.397$	$0.603 \leq w_M \leq 0.951$
Certhia familiaris	0.09	$1.023 \leq w_o \leq 1.384$	$0.616 \leq w_M \leq 0.977$

Table 3: Relative densities of breeding bird species showing preference to mature or over-mature Macedonian Pine *Pinus peuce* forests in Pirin National Park, Bulgaria. Densities with their coefficients of variation (CV) and confidence intervals (CI) were computed using Distance 5.0 Realize 2 (Thomas *et al.* 2006).

Tabela 3: Relativne gostote vrst ptic gnezdilk, raje izbirajo optimalno oz. terminalno fazo odraslega gozda molike *Pinus peuce* v bolgarskem Narodnem parku Pirin. Gostote s koeficienti variacije (CV) in intervali zaupanja (CI) so bile izračunane z uporabo programa Distance 5.0 Realize 2 (Thomas *et al.* 2006).

Species / Vrsta	Forest age (years)/ Starost gozda (let)	Density / Gostota		
		Breeding pairs / 10 ha Gnezdečih parov / 10 ha	CV (%)	95% CI
Troglodytes troglodytes	>120	1.5	11.0	1.24–1.90
	60–100	1.1	13.0	0.87–1.46
Turdus viscivorus	>120	0.9	37.1	0.41–1.75
	60–100	1.4	28.9	0.81–2.52
Phylloscopus collybita	>120	2.7	8.4	2.29–3.18
	60–100	2.0	10.8	1.59–2.43
Parus ater	>120	7.8	11.8	6.18–9.82
	60–100	5.8	13.9	4.40–7.60
Sitta europaea	>120	2.5	21.3	1.67–3.84
	60–100	1.0	13.6	0.82–1.39
Certhia familiaris	>120	2.7	20.6	1.78–3.99
	60–100	1.6	27.0	0.95–2.74

among the dominant species in these habitats (Hagemeijer & Blair 1997). All this makes it difficult to explain its preference to over-mature Macedonian Pine forests. Moreover, the species is not highly dependent on the availability of hollows, as it often breeds in holes in the ground, between roots and stones (Cramp 1998, Hagemeijer & Blair 1997). The Coal Tit is considered socially subordinate to the other *Parus* species, but it tends to dominate in the Macedonian Pine forests (Nikolov 2007) and there is little probability for the species preference to over-mature forests to be related to inter species competition. The correlation between the abundance of Coal Tit and the habitat characteristics DT and IBAT could be related to the food supply. Similar results are obtained from other areas in Europe, where the species was found to prefer old coniferous forests (Fuller 1995).

In Western Europe, Nuthatch is closely attached to over-mature, and even decaying deciduous trees (Cramp 1998). With the present study, the same relation was proved for coniferous forests.

Treecreeper was also predominantly found in old trees (Jansson & Andrén 2003, Ellermaa 2005) and it was proposed as indicator species for the status of forest communities (Jansson & Andrén 2003,

Table 4: Standardized selection indices of breeding bird species with preference to mature or over-mature Macedonian Pine *Pinus peuce* forests during the breeding seasons of 2004–2006 in Pirin National Park, Bulgaria. Abbreviations: B_O & B_M – standardized selection indices of birds in over-mature and mature forests respectively.

Tabela 4: Standardizirani selekcijski indeksi vrst ptic gnezdilk, ki so raje izbirale optimalno oz. terminalno fazo odraslih gozdov molike *Pinus peuce* v gnezditvenem obdobju 2004–2006 v bolgarskem Narodnem parku Pirin. Okrajšave: B_O & B_M – standardizirani selekcijski indeksi ptic v terminalni oz. optimalni fazi odraslih gozdov.

Species / Vrsta	Standardized selection index / Standardizirani selekcijski indeks	
	B_O	B_M
Troglodytes troglodytes	0.60	0.40
Turdus viscivorus	0.36	0.64
Phylloscopus collybita	0.58	0.42
Parus ater	0.55	0.45
Sitta europaea	0.61	0.39
Certhia familiaris	0.60	0.40

Suorsa *et al.* 2005). The preference of species to the old forests is because of its feeding strategy to look for small invertebrates in trees covered in loose bark providing many crevices (Cramp 1998). According to Gibb (1954), the Treecreeper feeds more often on live than dead trees, but the amount of the dead wood within the forest is crucial for the survival rate of the species during the winter. Both Nuthatch and Treecreeper, being secondary hollow nesters, benefit of higher amount of old trees in over-mature forests as well in their nest-site selection.

It is known that eight amongst the species inhabiting the Macedonian Pine forests prefer old forests, but this was not confirmed during the present study. Four of them (Capercaillie *Tetrao urogallus*, Tawny Owl *Strix aluco*, Tengmalm's Owl *Aegolius funereus* and Black Woodpecker) were not included in the analysis due to the small sample sizes. The other four species (Great Spotted Woodpecker *Dendrocopos major*, Mistle Thrush, Willow Tit *Parus montanus* and Crested Tit *Parus cristatus*) had sample sizes large enough to obtain reliable inferences. In Europe, the Great Spotted Woodpecker has higher density in older forests, but this is not a rule (Gorman 2004). The Mistle Thrush prefers open canopy and old forest communities, but this was proved only for deciduous forests (Hagemeijer & Blair 1997). A main factor in the habitat selection by Willow and Crested Tits is the amount of dead wood, where they dig their hollows (Baker 1991, Hagemeijer & Blair 1997) and that is why these species prefer old forests (Fuller 1995). The results from the present study did not show a preference of forementioned species to mature or over-mature Macedonian Pine forests, but this does not mean that they do not prefer the old forest communities. In most of the other studies, comparison was made between young and old forests, whereas mature and over-mature forest communities were compared in the present study. The lack of preference to any of the studied Macedonian Pine forest types probably means that both of the studied forest age classes satisfy the habitat requirements of these species.

Two of the species preferring over-mature forest in Pirin National Park were trunk and bark-feeders and four of them were hollow nesters. It is known that the density of hole-nesting and trunk and bark-feeding birds increases with forest maturation (Moss 1978, Helle & Mönkkönen 1990, Pearce & Venier 2005), in relation to the greater structural complexity of the bark and greater availability of holes and crevices in the old trees (Smith *et al.* 1985, Schieck *et al.* 1995). Apart from birds (Fuller 1995), the old and dead trees are home to many other animals and storage for moisture and nutrients. Therefore the retention of snags, limb, logs and decaying old trees is an essential component of any wildlife conservation or management plan (Ranius & Fahrig 2006). Nevertheless, the practice to consider snags and logs as signs of "unkempt" forests and as waste materials, which should be discarded, continue. For the 1993–2000 period, a total of 93,914 m^3 of wood was obtained in Pirin National Park. This amount of cut wood exceeds the permitted limit from the management plan with 6.5% and what is more, 80% of obtained wood consisted of dead and decaying trees (Petrov, *unpubl.*). Taking into consideration that the removal of dead wood from the managed forests is one of the main factors for the decrease of woodland birds (Hanski & Walsh 2004), we strongly suggest that more attention should be paid to minimizing the dead wood and decaying trees clearing from old forest and especially from the protected areas.

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Table 5: Results from the forward stepwise Multiple Regression Analysis (computed by STATISTICA 7.0), testing correlations between abundances of bird species preferring mature or over-mature Macedonian Pine *Pinus peuce* forests, and habitat parameters. Only significant betas are shown, * P < 0.05, ** P < 0.01, *** P < 0.001.

Tabela 5: Rezultati multiple regresijske analize, metoda forward stepwise (izračunani s programom STATISTICA 7.0) za testiranje korelacij med abundanco vrst ptic, ki so bolj naklonjene do optimalnih oz. terminalnih faz odraslih gozdov molike *Pinus peuce*, in habitatnimi parametri. Prikazani so samo statistično značilni faktorji β, * P < 0.05, ** P < 0.01, *** P < 0.001.

Dep. Var. / Odv. spr.	Ind. Var./ Neodv. spr.	β	R	R^2	F	df
T. troglodytes	ADW	0.45	0.42	0.18	3.11*	3, 43
	ROCK	0.33				
T. viscivorus	L1	0.56	0.57	0.33	4.07**	5, 42
	DT	0.61				
	CC	−0.39				
P. collybita	CC	−0.43	0.61	0.37	8.53***	3, 43
	TH	−0.37				
P. ater	DT	−0.64	0.48	0.23	4.31**	3, 43
	IBAT	0.32				
S. europaea	ADW	0.46	0.56	0.31	4.68**	4, 42
	TH	0.39				
C. familiaris	ADW	0.42	0.45	0.21	5.74**	2, 44

Remarks / Opombe:

* Dep. Var. – Dependent variables (abundances of species); Ind. Var. – Independent variables (habitat parameters): ADW – amount of dead wood, ROCK – cover of rocks and piles of stones, L1 – cover of the ground level foliage profile, DT – density of trees, CC – canopy cover, TH – tree height, IBAT – index of basal areas of trees.

** Odv. spr. – Odvisne spremenljivke (abundanca vrst); Neodv. spr. – Neodvisne spremenljivke (habitatni parametri): ADW – količina odmrlega lesa, ROCK – pokrovnost skal in kamnitih skladov, L1 – profil talnega listnega pokrova, DT – gostota drevja, CC – pokrovnost krošenj, TH – višina dreves, IBAT – indeks bazalnih predelov drevja.

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6. Povzetek

Avtor študije je v obdobju treh let (2004–2006) preučeval, kako si ptice izbirajo habitat v optimalni (60–100 let) in terminalni fazi (>120 let) odraslega gozda molike *Pinus peuce* v Narodnem parku Pirin (JZ Bolgarija). Na skupaj 185 naključno izbranih ploskvah s polmerom 25 m je preučeval in opisal značilnosti habitatov. Ptice je s točkovnim popisom (r = 50 m) štel dvakrat na leto (junija in julija) in ugotovil, da med preučevanimi starostnimi razredi gozdov skoraj ni razlik v številu ptičjih vrst. Pet vrst, in sicer stržek *Troglodytes troglodytes*, vrbji kovaček *Phylloscopus collybita*, meniščk *Parus ater*, brglez *Sitta europaea* in dolgoprsti plezalček *Certhia familiaris*, je bilo bolj naklonjenih terminalni fazi gozda molike (v kateri je bila zabeležena tudi višja gostota gnezdenja) kot optimalni. Slednji je bila bolj naklonjena le ena vrsta, in sicer carar *Turdus viscivorus*. Avtor je z uporabo multiple regresije razčlenil pomembne kriterije za izbor habitata, kar zadeva teh šest vrst. Pri dveh vrstah, ki so bile bolj naklonjene terminalni fazi, je šlo za ptice, ki se prehranjujejo na deblih in lubju, pri štirih pa za duplarje. Avtor poudarja pomen količine odmrlega lesa in trohnečega drevja za ptičje združbe in predlaga, da je treba minimizirati odstranitev odmrlega lesa iz vseh gozdov, posebno tistih v zaščitenih območjih.

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