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Habitat preferences of the sympatric barred warbler (*Sylvia nisoria*) and the red-backed shrike (*Lanius collurio*) breeding in central Poland

Marcin Polak

Department of Nature Conservation, Institute of Biology and Biochemistry, Maria Curie-Skłodowska University, Akademicka 19, PL-20-033 Lublin, Poland (e-mail: mpolak@hektor.umcs.lublin.pl)

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The phenomenon of creating a breeding association by the barred warbler (*Sylvia nisoria*) and the red-backed shrike (*Lanius collurio*) was documented relatively long ago by several researchers. Some of the authors suggest that this phenomenon is a result of similar habitat requirements rather than a product of active selection. The main goal of this study was a quantitative analysis of differences and similarities in selection of breeding habitats by both species in the area of their sympatric occurrence. Research was carried out in the years 2009–2011 in the study plot located in the Middle Vistula Valley (central Poland). The red-backed shrike preferred shrubs and open areas, however, it avoided woods and waters. The only habitat strongly preferred by the barred warbler was bushes, and this species avoided waters, woods and open areas. Neither species nested in places with a thick tree concentration. Because of differences in their feeding strategy, as opposed to barred warblers, red-backed shrikes preferred habitats with low vegetation and a low concentration of shrubs. In nest location selection, the red-backed shrike clearly preferred hawthorns, whereas the barred warbler nested also in other species of bushes. As compared with warblers, shrikes more often preferred to nest in high bushes. The knowledge of the red-backed shrike's and the barred warbler's optimal habitat requirements can provide useful guidelines for future conservation projects involving these vulnerable birds.

Introduction

The phenomenon of using the same ecological niches during the breeding period by the barred warbler (*Sylvia nisoria*) and the red-backed shrike (*Lanius collurio*) was described relatively long ago by many researchers (*see* e.g. Nankinov & Darakchiev 1979, Neuschulz 1981, Neuschulz 1988). Part of the authors suggest that this relationship is a result of similar habitat requirements rather than a product of active selection (similar habitat hypothesis, Gotzman 1965, Kuźniak *et al*. 2001, Quinn & Ueta 2008). The barred warbler — the largest sylviid warbler in this part of Europe — is not afraid to nest in the neighbourhood of the red-backed shrike, which can pose a threat to other species from the genus *Sylvia* (Kuźniak & Tryjanowski 2003).

Both species have similar habitat requirements and prefer open areas with extensive farming, great amount of bushes and low trees (Neuschulz 1981, Bocheński 1985, Hedenström & Åkesson 1991, Horvath *et al*. 2000).

The red-backed shrike and the barred warbler are typical of the ecotone between open habitats and forest edges (Neuschulz 1988, Kuźniak 1991, Waldenström *et al*. 2004, Goławski 2007a, Hollander *et al*. 2011). These are areas inhabited by numerous invertebrates, which comprise the main part of diet of both studied species (Cramp 1992, Goławski & Goławska 2008, Söderström & Karlsson 2011). Studies carried out so far show that the co-appearance of red-backed shrikes and barred warblers is a result of similar habitat requirements. These studies, however, had either a descriptive character (Gotzman 1965), or were solely concerned with comparing the nesting sites only (Kuźniak *et al*. 2001). Studies on variation in habitat parameters in the areas where these species occur sympatrically are lacking. Therefore, it would be interesting to know to what extent the habitat niches occupied by these species overlap.

Red-backed shrikes and barred warblers have recently attracted attention because of dramatic population declines throughout their ranges (Tucker & Heath 1994, Brambilla *et al*. 2007). In Europe, the main threat to the red-backed shrike and the barred warbler is progressive lessening and degradation of appropriate habitats in farmlands (Hagemeijer & Blair 1997, Brambilla *et al*. 2010). Both species are rare and threatened in Europe, hence they were included in Appendix I of the Bird Directive. Member states of the European Union are required to effectively protect the habitats of both species and, therefore, to set parameters describing the proper state of protecting breeding populations, and to select particular habitat criteria for assessing the favourable conservation status of the afore-mentioned species. In this context, studies can help to more effectively plan and manage works and projects whose goal is to protect environments where the barred warbler and red-backed shrike live during the breeding season.

The main goal of this work was to study the differences and similarities in the habitat requirements of both species in the area of their sympatric occurrence. It was assumed that due to their feeding strategies and nest-site preferences, both species should be associated with the mosaic of open territories and thickets. They should avoid greater woods and waters but prefer places with scattered low shrubs and trees. It was also assumed that both species, although settling in the same environments, will choose and use micro-habitats in a somewhat different ways reflecting their morphological and behavioural differences. The red-backed shrike hunts for insects mainly in air and on the ground hence, prefer open areas with low herbal vegetation; the barred warbler, however, catch insects primarily in thickets (Gotzman 1965).

Material and methods

Study area

Research on habitat requirements of the red-backed shrike and the barred warbler was carried out in the area located in the Stężyca region near Dęblin (Lublin County, central Poland, 51°34´N, 21°48´E) from 2009 to 2011. The study area was located on the north-eastern bank of the Vistula river. The study plot covered 76 ha, however, in 2010 its area was slightly larger, 84 ha. It was located on the partly used, sun-exposed pasture which, due to limited grazing in the last few years, was undergoing intense vegetation succession. Dry meadow with hawthorn (*Crataegus* sp.) thickets was dominant in the area. The pasture is the property of the countryside community of the Stężyca village, upon which horses, cows and sheep (about 100 individuals) feed annually. Small fragments were overgrown by the *Salici-populetum* (willow–poplar) moor.

General methods

The number of pairs of the studied species was determined using a modification of the mapping method (Tomiałojć 1980). Between May and July, the study plot was regularly checked at intervals of 4–10 days. Altogether, 9, 14 and 18 control counts were carried out in the entire area in 2009, 2010 and 2011, respectively. The nests were located by systematic search of all potential

breeding places in thickets growing on the studied plot. The location of every nest was marked on the orthophotomap, and the exact coordinates were recorded with a GPS receiver. All 74 active nests of shrikes and 32 nests of warblers were further visited at least once a week to gather data on habitat and breeding parameters. Height of bushes and nest height above ground were measured with a measuring tape. In all 91 transects, 906 bushes were measured for height and classified to species or genus. To check for potential vegetation that may be for building a nest, plant material was collected along transects in 2010.

Macro-habitat use

In 2010, proportions (%) of the four main habitat types (open habitats, bushes, woods and waters) in the study plot were evaluated using colour orthophotomaps and the Geoxa Viewer GIS program. The study plot consisted of 42.8% open areas, 29.4% bushes, 19.7% woods, and 8.1% waters. In addition to this, proportions of habitat types in each red-backed-shrike and barred-warbler breeding territories were calculated. The breeding territory was delimited by a circle whose centre contained either nests or, if these were not found, the sites where individuals were recorded of most frequently. This method of identifying breeding territories cannot guarantee that habitats not used by birds are excluded, but is appropriate for comparisons between species (Goławski & Dombrowski 2002). The radii of these circles corresponded to the average breeding-territory sizes of the studies species given in the literature (red-backed shrike: radius was 70 m (1.539 ha) Goławski & Meissner 2008; barred warbler: radius 50 m (0.785 ha) Waldenström *et al*. 2004). In total, proportions of habitat types in 38 red-backed-shrike and 20 barred-warbler territories occupied in 2010 were measured. Proportions (%) and not the raw data were used to test for interspecific differences.

Micro-habitat use

Research on micro-habitats used by both species was carried out in 2010. For this purpose, a total of 91, parallel north–south transects (each 100 m long) were situated in the entire research area. Along each transect, measurements of the following five habitat variables were taken: height of grass, height of bushes, bush density, height of trees and tree density (Table 1). Height of trees and higher bushes was measured with an altimeter. The majority of habitat measurements along the studied transects was done in May, i.e. during the period when the studied species choose nesting places. Based on the mapping, four types of areas were distinguished in the study plot: (i) CONTROL = not occupied by either species (43 transects), (ii) SHRIKE = occupied exclusively by the red-backed shrike (28 transects), (iii) SHRIKE-WARBLER = occupied by both species (10 transects), and (iv) WARBLER = occupied exclusively by the barred warbler (10 transects).

Data analysis

To analyse habitat preferences of the species, the Jacobs preference index (D) was used:

$$D = (r - p)/[r + p - (2rp)]$$

where r is the proportion of the habitat in the bird's territory, and p is the proportion of this same habitat in the study plot.

The Jacobs index can take values from –1.00 (complete avoidance) to +1.00 (full usage).

Distribution of the data was checked with the one-sample Kolmogorov-Smirnov test. If the data were not normally distributed, they were log-transformed to meet the assumption of normality. ANOVA was used to analyse the micro-habitat use by comparing the environmental parameters within the four habitat types. The variables were not strongly correlated with each other ($R < 0.6$). To test the bush selectivity, in which both studied species built nests, Student's t-test and a chi-square test were used. The calculations were performed with STATISTICA ver. 6.0 (Statsoft Inc.).

Results

During the study period, the number and density of the nesting barred-warbler pairs increased

from 17 to 24, and from 3.4 to 4.5 per 10 ha, respectively; while the number and density of the nesting red-backed-shrike pairs decreased from 33 to 26, and from 2.2 to 3.2 per 10 ha, respectively (Table 2).

Macro-habitat use

A red-backed-shrike breeding territory (n = 38) consisted of 44.1% open areas, 31.9% bushes, 16.4% woods, and 7.6% waters. According to the Jacobs (D) preference index, the shrike chose bushes (+0.06) and open areas (+0.03), and avoided woods (–0.11) and waters (–0.04). A barred-warbler breeding territory (n = 20) was comprised of 57.9% bushes, 29.4% open areas, 12.4% woods, and 0.3% waters. The Jacobs (D) habitat preference index revealed that bushes were the only habitat strongly preferred by this species (+0.54), whereas the other habitats — waters (–0.93), open areas (–0.29) and woods (–0.27) — were clearly avoided.

Micro-habitats use

When comparing habitats in the territories of both species in relation to all available habitats, it appeared that both the red-backed shrike and to a somewhat lesser degree the barred warbler avoided nesting in places with high-tree thickets (Table 3). In addition, both species chose areas with low shrubs and low trees, even though warblers chose somewhat taller trees and bushes than shrikes (Fig. 1). However, the red-backed shrike, as opposed to the barred warbler, preferred habitats with low herb vegetation and low bush thicket.

Shrub species

In total, 906 shrubs from 13 species/genera were located in the study plot (Table 4). The hawthorn was the most common (80.1%) species growing in the area. Altogether, species with thorns comprised 95.5% of all bushes. All the red-backed-shrike and barred-warbler nests were found in thorny shrubs. In selecting places for nesting, the shrikes preferred hawthorn over other bush species, as all their nests were found in this species. However, the barred warbler did not display similar preferences for hawthorns, since the percentage of nests in this plant (84.4%, n = 32) was close to its proportion in the study plot.

Nest-site selection

Barred warblers built their nests lower above the ground (mean ± SD = 88.7 ± 29.0 cm, range = 50–140 cm, n = 32) than red-backed shrikes (mean ± SD = 131.1 ± 47.4 cm, range = 60–400 cm, n = 74), and the difference was statistically significant (t-test: $t = -5.81$, $p < 0.0001$; Fig. 2). In both warblers and shrikes, the mean above-ground nest height was strongly correlated with

Table 1. The micro-habitat parameters obtained at transects on the study plot.

Micro-habitat variables	Description
Low vegetation height (cm)	The average height of herbaceous plants (with an accuracy of 1 cm) based on 10 measurements taken every 10 m along transect
Shrub height (m)	The mean height of shrubs (with an accuracy of 0.1 m) from 10 randomly selected shrubs (lower than 5 m) growing in an area with a length of 100 meters and a width of 1 m on both sides of the transect
Shrub density index	The length of the distance, in meters (with an accuracy of 1 m), overgrown by shrubs in an area with a length of 100 meters and a width of 0,5 m on both sides of the transect
Tree height (m)	The average height of trees (higher than 5 m), as measured by the altimeter, growing belt along the 100-m transect and a width of 40 m on both sides of the transect
Tree density index	The number of trees (higher than 5 m) growing in the belt along the 100-m transect and a width of 40 m on both sides of the transect

the bush height (Pearson's correlation: $r_p = 0.49$, $p < 0.01$, $n = 32$; and $r_p = 0.71$, $p < 0.001$, $n = 74$; respectively). Small bushes with a height of up to 1.5 m dominated in the study area (Fig. 3). They comprised 40% of all the bushes ($n = 906$). The proportion of bushes in the area decreased along with their increasing height. This shows a rapid and progressing bush succession in the study plot.

When choosing a nesting location, the barred warbler preferred low shrubs (chi-square test: $\chi^2 = 184.30$, $p < 0.0001$), since the majority (72%) of nests of this species were found in bushes with heights between 1.6 and 2.5 m (Fig. 3).

The red-backed shrike preferred bushes with a height of 2.6–3.5 m (chi-square test: $\chi^2 = 89.70$, $p < 0.0001$) where 50% of the nests of this species was found (Fig. 3).

The mean height of shrubs with barred-warbler nests was significantly lower than the mean height of shrubs with red-backed-shrike nests (mean ± SD: 232.7 ± 63.8 cm ($n = 32$), and 290.0 ± 81.5 cm ($n = 74$), respectively; range = 100–410 cm and 80–490 cm, respectively; *t*-test: $t = 3.54$, $p < 0.001$).

Discussion

This study confirms previous findings indicating, that both studied species have very similar habitat requirements (Gotzman 1965, Neuschulz 1981, Kuźniak 1991). In the area, I studied, the red-backed shrike and the barred warbler preferred the shrub zone, while clearly avoiding nesting in woods and in the vicinity of water. Moreover, the shrikes and warblers avoided breeding in areas with tall shrubs and trees. Open areas, in the early phase of vegetation succession, with low bushes (< 2 m) and trees (< 10 m) were most preferred. This agrees with previous studies showing that both species prefer forest edges over forests or woods (Kuźniak *et al.* 2001, Waldenström *et al.* 2004, Brambilla *et al.* 2009).

However, these studies indicated a small and subtle differences in habitat selection of both studied species, which allowed them to reduce the costs of coexistence and competition for nest sites. I showed that the red-backed shrike chose the mosaic of open areas and shrubs as its breeding place, whereas the barred warbler clearly

Table 2. The number of pairs and density of the barred warbler and the red-backed shrike on the study plot in the Middle Vistula Valley in central Poland.

Season	Study area (ha)	Number of pairs (territories)		Density (number of pairs/10 ha)	
		Barred warbler	Red-backed shrike	Barred warbler	Red-backed shrike
2009	76	17	33	2.2	4.5
2010	84	20	38	2.4	4.5
2011	76	24	26	3.2	3.4

Table 3. Micro-habitat parameters (mean ± SD) on the transects in the four types of areas distinguished in the study plot: (i) CONTROL = not occupied by either species, (ii) SHRIKE = occupied exclusively by the red-backed shrike, (iii) SHRIKE-WARBLER = occupied by both species, (iv) WARBLER = occupied exclusively by the barred warbler. The asterisks indicate significant ($p < 0.05$) difference as revealed by Tukey's post-hoc test.

Micro-habitat variables	CONTROL ($n = 43$)	SHRIKE ($n = 28$)	SHRIKE-WARBLER ($n = 10$)	WARBLER ($n = 10$)	ANOVA	
					$F_{3,87}$	p
Low vegetation height (cm)	21.8 ± 9.2	19.1 ± 6.8	19.1 ± 5.2	23.1 ± 4.7	1.13	ns
Shrub height (m)	2.3 ± 0.9	1.8 ± 0.5	2.0 ± 0.4	2.1 ± 0.6	2.66	ns
Shrub density index	49.5 ± 33.5	40.0 ± 30.8	56.7 ± 18.7	65.2 ± 21.5	2.00	ns
Tree height (m)	11.6 ± 7.6	8.8 ± 6.8	10.2 ± 5.9	13.3 ± 6.1	1.33	ns
Tree density index	26.2 ± 29.0*	10.6 ± 14.9*	7.8 ± 6.8	14.0 ± 19.5	3.62	$p < 0.05$

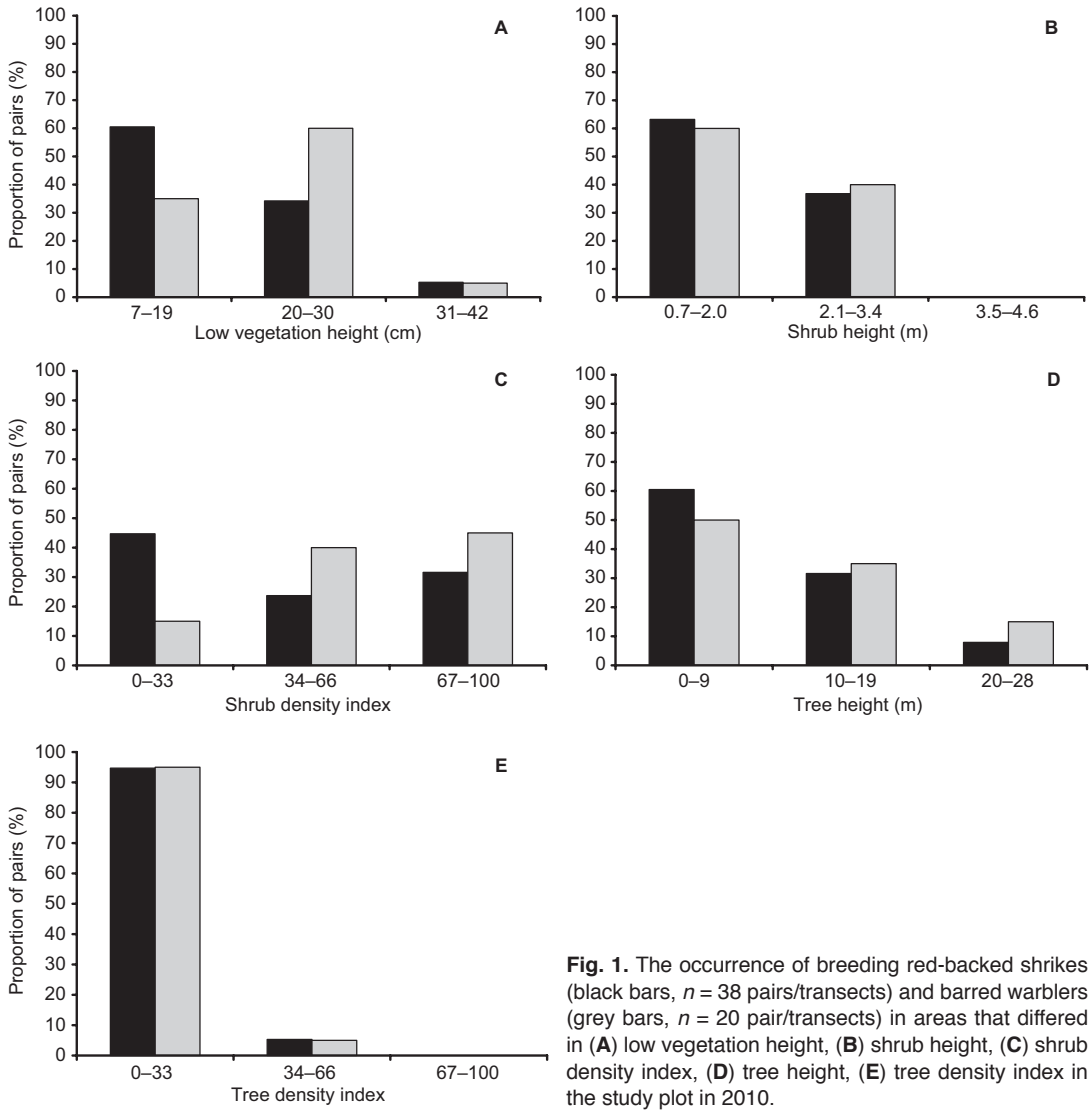

Fig. 1. The occurrence of breeding red-backed shrikes (black bars, $n = 38$ pairs/transects) and barred warblers (grey bars, $n = 20$ pair/transects) in areas that differed in (**A**) low vegetation height, (**B**) shrub height, (**C**) shrub density index, (**D**) tree height, (**E**) tree density index in the study plot in 2010.

Table 4. Species composition of shrubs and low trees with the barred-warbler and the red-backed-shrike nests ((n = 32 and 74, respectively).

Shrub/tree species	Barred warbler		Red-backed shrike		Available vegetation	
	n	%	*n*	%	*n*	%
Hawthorn (*Crataegus* sp.)	27	84.4	74	100	726	80.1
Wild rose (*Rosa* sp.)	4	12.5	0	0	69	7.6
Pear tree (*Pyrus communis*)	0	0	0	0	45	5.0
Blackthorn (*Prunus spinosa*)	0	0	0	0	23	2.5
Alder buckthorn (*Frangula alnus*)	0	0	0	0	18	2.0
Barberry (*Berberis vulgaris*)	1	3.1	0	0	7	0.8
Others	0	0	0	0	16	1.7
Total	32	100.0	74	100	906	100.0

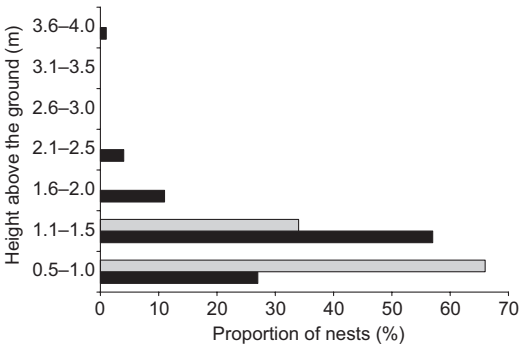

Fig. 2. Above-ground heights at which the red-backed shrike and barred warbler nests (black bars, n = 74; and grey bars, n = 32; respectively) were located.

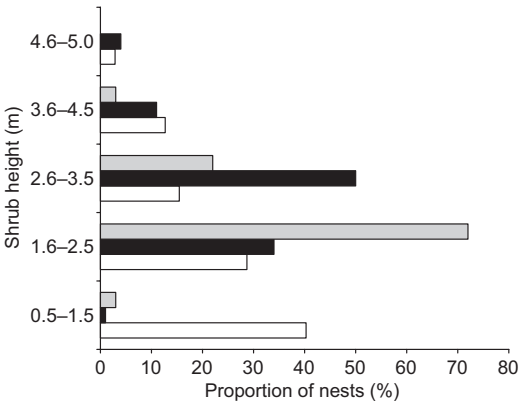

Fig. 3. Heights of shrubs in which the red-backed-shrike and barred-warbler (black bars, n = 74; and grey bars, n = 32; respectively) nests were located, compared with height distribution of all shrubs (white bars, n = 906).

avoided open areas. In addition, the shrikes, as opposed to the warblers, clearly preferred areas with the least possible height of ground vegetation (grass). Over 60% of the red-backed-shrike pairs nested in parts of the study meadows which were intensely grazed by cows and horses (Fig. 1) thus having low-growing grass (< 20 cm). At the same time, only 35% of the barred warblers nested in these areas, while the remaining 60% nested at sites with average vegetation height 20–30 cm. This difference most likely resulted from dissimilar hunting strategies of the studied species and varying preferences in choosing feeding areas (Gotzman 1965). The red-backed shrike often hunts for insects moving on the ground, thus needs low, mowed or grazed vegetation (Brambilla *et al*. 2009, Tsiakiris *et al*. 2009). For the barred warbler, this is less essential, since this species catches insects primarily in thickets (Hagemeijer & Blair 1997). Bush density was the trait related to nesting that differed between the studied species. The greatest number of shrike pairs (45%) nested in areas rarely overgrown by bushes, whereas number of nesting warblers increased with the increasing bush density.

The choice of shrub or tree species in which red-backed shrikes and barred warblers nested is strongly dependent on accessibility (Kuźniak & Tryjanowski 2003). In the study area, all nests of both species were found in thorny shrubs: the red-backed shrike clearly preferred hawthorns, whereas barred warblers also nested in other bush species. Some other authors also pointed to the red-backed shrike's preference for thorny or prickly species, such as hawthorn, plum tree (*Prunus* sp.) or blackberry (*Rubus* sp.) (Kuźniak 1991, Nikolov 2000). Goławski (2007b) found the preferences of this species for nesting in pear trees (*Pyrus communis*) and black elder (*Sambucus nigra*), which were relatively rare in his research area. However, Hedenström and Åkesson (1991) argue that barred warblers do not have set preferences for nesting-bush selection and choose plant species which are most available and common in a given area. Many researchers pointed to thorny bushes as preferred by barred warblers and red-backed shrikes (Neuschulz 1981, Hedenström & Åkesson 1991). Due to intensive predation in the study area (author's unpubl. data), choice of such bush type can be an adaptation, since it reduces the possibility of penetrating the inner bush by potential predators destroying broods. Studies carried out in other habitats showed that both studied species inhabit a broad spectrum of bushes and low tress (Bocheński 1985, Goławski 2007b). In northern Germany, highest numbers of barred warbler nests were found in wild rose *Rosa* sp. (29% of nests), blackberry (21%), blackthorn *Prunus spinosa* (19%) and hawthorn (10%) (Neuschulz 1981). On the island of Öland in Sweden, this species nested mainly in the juniper (*Juniperus communis*) (35% of nests), hawthorn (27%) and blackberry (19%) (Hedenström & Åkesson 1991). Of the 44 barred-warbler nests found by Bocheński (1985) in various regions of Poland,

11% were in the juniper, 9% in the willow (*Salix* sp.), 9% in birch *Betula* sp., and 9% in blackberry. In the Wielkopolska region (western Poland), red-backed shrike most frequently nest in wild rose, blackberry, pine (*Pinus sylvestris*), spruce (*Abies alba*), and black elder (Kuźniak 1991). However, in the Podlasie region (eastern Poland), 13% red-backed-shrike nests were found in willow, 12% in pear tree, and 9% in black elder (Goławski 2007b). In north-eastern Hungary, this species mostly nests in blackthorn (22%), common dogwood (*Cornus sanguinea*) (18%), willow (16%), black elder (11%) and wild rose (11%) (Horvath *et al*. 2000).

It is possible that differences between species in nest height above ground result from different hunting strategies and related benefits, aiming at minimizing the distance between the nest and suitable foraging areas (Wesołowski & Rowiński 2004). Making this as optimal as possible is particularly essential during the chick-feeding period. Birds feed chicks with a high frequency and even small changes in the location of a nest (height above ground and vegetation) may affect survival of chicks (Dunn *et al*. 2010). The barred warbler actively collects invertebrates by searching plants in thickets. However, the red-backed shrike's most common method of hunting is to catch invertebrates moving in the air or on the ground by launching attacks from a perch located on the top of a bush (Brambilla *et al*. 2007, Tsiakiris *et al*. 2009). In other populations studied in detail, the barred warbler placed nests significantly lower than found in this study. Barred-warbler pairs studied by Gotzman (1965) built nests on average 44 cm above ground (20–100 cm), and the average nesting bush height was 97 cm (50–200 cm). In northern Germany, barred warblers placed nests at a mean height of 65 cm above ground (15–161 cm), and a 60% of broods were between 35 and 70 cm above ground (Neuschulz 1981). In the current study, the plant height in which the birds build their nests was on average 268 cm. On the island of Öland in Sweden, this species nested ~78 cm above ground (Hedenström & Åkesson 1991). The 39 nests found in various parts of Poland were at the heights from 30 to 130 cm (mean = 74 cm) above ground, i.e. markedly lower than those found in the Middle Vistula Valley (Bocheński 1985). Elsewhere, red-backed shrikes placed their nests higher than found in the current study. Shrikes studied by Gotzman (1965) in northern and central Poland, built their nests on average 150 cm above ground (90–220 cm), and the mean nesting bush height was 221 cm (140–320 cm). The average above-ground elevation of the nests in eastern Poland's Podlasie (mean = 128, range = 8–535 cm, Goławski 2007b) was almost identical to that in the Middle Vistula Valley. In the Wielkopolska region, most nests (73%) were located at heights of 70–180 cm (mean = 140 cm) (Kuźniak 1991). Somewhat different barred-warbler and red-backed shrike nest heights in the Middle Vistula Valley as compared to those in the current study indicate ability to adapt to local conditions. In comparison with other populations, the studied population of the barred warbler built their nests at a higher level, whereas the red-backed shrike at a lower level. Most likely, this was caused by the preference of both species to inhabit bushes, mostly hawthorn, of optimal height and leaf density.

The current research indicated that the optimal habitat for the red-backed shrike is an open area with low vegetation and grasses shorter than 20 cm, and with scarcely growing, low, thorny bushes (here < 30%) and trees (< 2 m). The optimal habitat for the barred warbler is depleted of greater shrub islets with a high concentration of bushes (here < 67%), whose height does not exceed 2 m. In addition, the essential element for this species are individual high trees serving as locations for singing. This valuable information on habitat requirements of the studies species can be used while planning their protection and conservation.

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