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Source: Folia Zoologica, 66(1) : 29-36

Published By: Institute of Vertebrate Biology, Czech Academy of Sciences

URL: https://doi.org/10.25225/fozo.v66.i1.a5.2017

Folia Zool. – 66 (1): 29–36 (2017)

Comparative distribution of Syrian and great spotted woodpeckers in different landscapes of Poland

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Received 1 September 2016; Accepted 30 March 2017

Abstract. Species often express some differences in habitat choice which enable their co-occurrence in sympatry and this phenomenon is particularly noticeable for related taxa and during range shifts. Here, co-distribution of two sibling woodpeckers (Syrian woodpecker *Dendrocopos syriacus* and great spotted woodpecker *Dendrocopos major*) in different types of urban, rural and riparian landscapes of Poland is presented. The Syrian woodpecker reached high densities in urban (city) landscape, but it was less common in town, rural and riparian areas, and everywhere it mostly occupied orchards and poplar and willow hedges. In contrast, the great spotted woodpecker was the dominant species in most areas, except city and everywhere was associated with forests or larger wooded areas (like parks). The Syrian woodpecker was dependent on the presence of softwood trees (poplars, willows), but it needed generally less than 40 % of wooded area in its territories, whereas the second species needed more than 70 %. The data presented here, together with information available from other areas in Central Europe, suggest that protection of Syrian woodpecker (species annexed in the European Union Bird Directive) should not be restricted to only rural landscapes but also needs to include its urban populations. Protection of this species should be focused on preservation of softwood tree hedges and woodlots and traditional orchards.

Key words: *Dendrocopos syriacus*, *Dendrocopos major*, Picidae, habitat requirements, urban birds

Introduction

Sibling species often express some differences in habitat choice which enable their co-occurrence in sympatry (Pianka 1981, Schoener 1982). The situation could be more complicated if formerly allo- or parapatric species start to occupy the same area due to expansion or range shift (Swihart et al. 2003). In such cases, habitat occupied by the local taxon could be invaded by its congener and finally, both species must divide environment and resources to co-exist, unless one of the species retreats due to direct or indirect competition (e.g. Berger & Gese 2007). There are many examples of species which have experienced such events. In Central Europe, an excellent example of sibling species co-occurrence caused by expansion of one of the siblings are woodpeckers: widespread great spotted woodpecker *Dendrocopos major* (Linnaeus, 1758) (hereafter, GW) and expanding Syrian woodpecker *Dendrocopos syriacus* (Hemprich & Ehrenberg, 1833) (hereafter, SW). The first species is native to Europe and is the most abundant woodpecker inhabiting the continent from the Mediterranean to boreal regions (Flade 1997, BirdLife International 2004). The second woodpecker originally bred in the Middle East. By the end of the 19th century it had expanded to the Balkans and then, during the 20th century, it settled Central and Eastern Europe, reaching Austria to the west, Poland to the north and southern Russia to the east (Munteanu & Samwald 1997, Zavialov et al. 2008, Michalczuk 2014). There are many dissimilarities in biology and ecology of both species. GW is a generalist and breeds in various forests (both coniferous and deciduous), whereas SW is associated with forests only in its easternmost populations in Iran (Khanaposhtani et al. 2012). The latter species in majority of its range in the Middle East and the Balkans breeds in scattered woods and forest steppe, but in Central Europe it is mostly synanthropic breeding in man-made urban and rural woody vegetation (Szlivka 1957, Winkler 1972, Ciach & Fröhlich 2013, Michalczuk & Michalczuk 2016a). There is plenty of research describing the ecology of GW (Hansson 1992, Salvati et al. 2001, Mazgajski & Rejt 2006, Kosiński & Kempa 2007, Hebda 2009, Domokos & Cristea 2014), whereas similar studies for SW are scant and limited to only

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some types of landscapes and to only occurrence data (e.g. Szlivka 1957, Marisova & Butenko 1976, Bozsko & Juhász 1985, Mitjaj 1986, Mullerova-Franekova & Kocian 1995). There are almost no studies about this species' ecology and this deficiency of data has been highlighted in a review of European woodpeckers biology and ecology (Pasinelli 2006). Apart from some studies from the Middle East (Al-Safadi 2004, Aghanajafizadeh et al. 2011), there are exhaustive works from rural populations in eastern Poland (Michalczuk & Michalczuk 2016a, b) and rather preliminary works from urban populations in Slovakia (Mošanský & Mošanský 1999) and Poland (Ciach & Fröhlich 2013, Figarski 2014). It is known that SW also inhabits woody vegetation along river valleys, but knowledge about such populations is limited to only occurrence data (Kurek 1984, Grzybek & Kuziemko 2004, Michalczuk & Michalczuk 2011, Kajtoch 2012). Only some of these studies simultaneously presented data about both species, whereas such comparative studies are necessary as these woodpeckers hybridize in nature (Kroneisl-Rucner 1957, Gorman 1997, Dudzik & Polakowski 2011) and the level of this phenomenon is underestimated (Michalczuk et al. 2014). Therefore, interactions among particular pairs and whole local populations could be much more complex than expected which could have important implications for appropriate description of the niche of a species (see e.g. Morelli & Tryjanowski 2015). Moreover, woodpeckers have known value as indicators and keystone species for wooded areas (Mikusiński et al. 2001) and are proposed for monitoring of general biodiversity in forests (e.g. Drever et al. 2008). SW could be considered as appropriate species for such inventories and monitoring in urban and rural areas.

The first aim of this study was to complement knowledge about urban, rural and riparian populations of SW on example of southern Poland in respect to their densities and general habitat requirements. The second goal was to compare relative abundance and general habitat composition within the territories of SW and GW living in sympatry in different landscape types. The practical aim of this research was to verify whether rural landscapes are crucial for the protection of this species as it results from designation of Special Protection Areas for this species in Natura 2000 network.

Material and Methods

Data from field inventories on four designed study plots in S Poland were collected. These plots were selected arbitrarily in areas in which known populations of SW have been existing (Kajtoch 2012, 2017, Ciach & Fröhlich 2013). Each plot was situated in a different landscape (see details on landscape composition in Table 1). The first was localized in the southern part of the city of Krakow (hereafter Krakow; 12.5 km^2, center point 50.0205° N, 19.9963° E; inventoried in 2014) and covered all types of urban environments: tenement houses, housing estates, single-family houses and industrial areas, as well as different types of green urban areas with prevalent parks and cemeteries, avenues of trees along roads or railways and scattered orchards. The second encompassed the town of Wieliczka and its suburbs adjacent to Krakow (hereafter Wieliczka; 13 km^2, center point 49.9813° N, 20.0685° E; inventoried in 2015) which included all types of houses, but with a prevalence of single-family houses, and again all types of green urban areas with a prevalence of orchards, clusters of trees and avenues of trees along roads or railways. The third plot (rural) was localized seven kilometers south-east of Wieliczka on the Carpathian Foothills (hereafter Foothills; 24.5 km^2, center point 49.9481° N, 20.1223° E; inventoried in 2014). In that plot an agricultural landscape was prevalent, mainly villages with numerous orchards (about half of the plot area) and fields and meadows (about one third of the plot area). There were also several small deciduous and uneven-aged forests and woody vegetation areas of 10-50 ha area (in total 2.5 km^2) dominated by either European hornbeam *Carpinus betulus* or oak *Quercus* spp. with small share of Scots pine *Pinus sylvestris*. The fourth plot (riparian) covered the middle part of the River Raba eight km south-east of the Foothills plot (hereafter Raba; 26 km^2, marginal points: 49.8856° N, 20.0928° E and 49.9737° N, 20.3300° E; inventoried in 2007). This plot included only the immediate vicinity of the river within the second fluvial terrace, which apart from the river channel was covered by meadows and locally riparian forests and wood hedges (dominated by poplar *Populus* spp. and willow *Salix* spp., approximately 33 % of the study area) and a very little number of buildings (villages placed 0.5-1 km from river banks, outside the studied plot).

Woodpeckers were surveyed according to standard count methods with the use of play-back stimulation (Michalczuk & Michalczuk 2006a, b, Dorresteijn et al. 2013). Calls and drumming of SW were used for broadcasting according to the following protocol: 2 min of calls, 3 min of listening, 2 min of drumming, 3 min of listening in each point.

Three counts per year (in March, April and May) were executed, which is enough for detection of most territories of SW (Michalczuk et al. 2011). In the Krakow and Wieliczka plots, play-back points were distributed systematically in networks, where points were located in nodes separated by a distance of 500 m. Additionally, birds were stimulated in each wooded area localized between these nodes to reduce probability of underestimation the number of territories in the plot. In the Foothills plot, play-back points were distributed to cover all woody vegetation types: forests, woodlots, orchards, tree-hedges and green urban areas (parks, cemeteries). In forests points were placed every 500-1000 m depending on topography and wood cover. Designation of play-back points in open areas (treeless fields and meadows) was omitted. In the Raba plot, play-back points were distributed along river banks every 500-1000 m (depending on topography and wood cover), except treeless parts of the valley. One check of each study area lasted 3-5 days, and each day observations lasted 5-6 hours. All counts were executed in good weather conditions (rainless and windless) during morning or evening hours. Observers moved between points on bikes and only in the Raba valley on foot. Observed woodpeckers or their hole nests were GPS marked and territories were identified from repeated observations of birds exhibiting mating or breeding behaviour (where woodpeckers were detected at least twice or where hole nest excavation or feeding of young birds was observed).

Woodpecker territories were assigned to the following categories of woody vegetation types: i) pine forests, ii) hornbeam & oak forests (broadleaf forests), iii) riparian forests, iv) willow and/or poplar hedges, v) midfield strips of trees, vi) green urban areas (parks and cemeteries), vii) orchards, based on the dominance of one of these woody vegetation types near the point (within a 100 m radius). The collection of environmental variables for analyzes was executed around play-backed points with the presence of woodpeckers (within a 100 m radius). Moreover, the approximate share of areas covered by woody vegetation (of any type) and, separately, the approximate share of all built-up areas were counted with the use of the orthophotomap available on http://mapy.geoportal.gov.pl/imap/ GIS tool. Survey points with the presence of woodpeckers were also compared in respect to the prevalence of trees with soft/hardwood. In the first category were assigned all points where woody vegetation types iii, iv, v and vii were identified; the second category included types i, ii and vi.

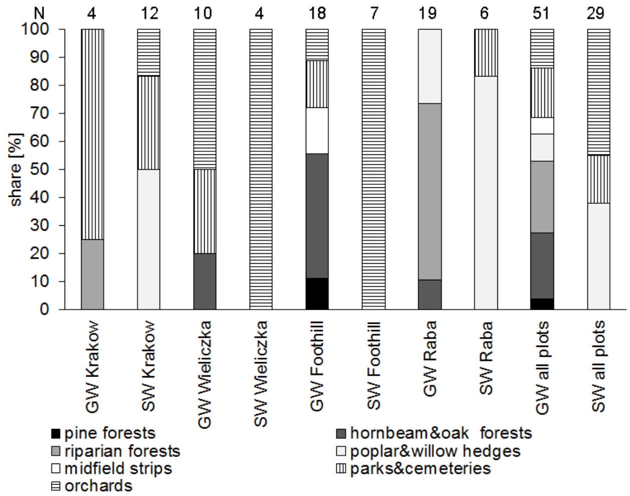

Fig. 1. Relative shares of woodpecker territories found in selected types of woods in four examined plots in southern Poland. GW – great spotted woodpecker, SW – Syrian woodpecker.

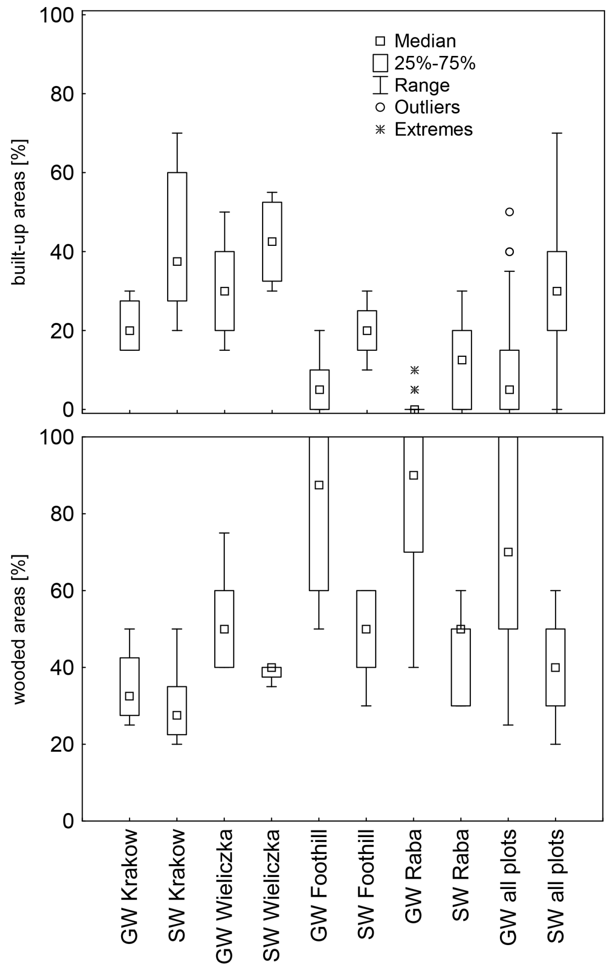

Fig. 2. Coverage by built-up areas and wooded areas in territories of great spotted (GW) and Syrian (SW) woodpeckers in four examined plots in southern Poland.

Frequencies of survey points with the presence of woodpeckers in the above-mentioned woody vegetation

Table 1. Shares of land cover types in four studied plots (data from CORINE land cover – http://clc.gios.gov.pl/, adjusted and aggregated to actual state of landscapes on the basis of orthophotomaps http://mapy.geoportal.gov.pl/imap/ and field observations).

CORINE code	Land cover type	Plot							
		Krakow		Wieliczka		Foothill		Raba	
		km^2	%	km^2	%	km^2	%	km^2	%
311, 313	Deciduous, mixed and riparian forests and woodlands	0.0	0.0	0.0	0.0	2.6	10.6	8.7	33.5
141, 222, 242	Orchards, gardens, parks, cemeteries and built-up areas (rural)	2.0	16.0	6.3	48.4	13.7	55.9	4.2	16.1
112	Built-up areas (urban)	7.7	61.6	5.3	40.8	0.0	0.0	0.0	0.0
121, 122	Industrial areas (factories, railways)	2.1	16.8	0.0	0.0	0.0	0.0	0.0	0.0
211, 231, 243	Fields, meadows, pastures	0.4	3.2	1.4	10.8	8.2	33.5	10.0	38.5
512	Water bodies	0.3	2.4	0.0	0.0	0.0	0.0	3.1	11.9
	∑	12.5	100.0	13.0	100.0	24.5	100.0	26.0	100.0

Table 2. Number of territories and densities of great spotted (GW) and Syrian woodpeckers (SW) in four examined plots in southern Poland.

Plot	Krakow	Wieliczka	Foothills	Raba
Year	2014	2015	2014	2007
Area (km^2)	12.5	13.0	24.5	26.0
	territories (N)			
GW	4	10	18	19
SW	12	4	7	6
	densities (territories/1km^2)			
GW	0.32	0.77	0.73	0.73
SW	0.96	0.31	0.29	0.23

Table 3. Generalized linear mixed model (GLM) outputs distinguish survey points where Syrian woodpecker was observed from these where great spotted woodpecker was noted in terms of the total shares of woody vegetation (woods) and total shares of built-up areas (built-up areas).

Model statistics	Woods	Built-up areas	Woods × built-up areas
Estimate	0.089	0.004	–0.001
Wald statistic	6.831	0.005	0.144
P	0.009	0.944	0.703

types were compared between species for the same plot and also for all plots jointly with use of the Mann-Whitney test, and between plots for the same species with the use of Friedman ANOVA. Next, the total shares of woody vegetation and total shares of built-up areas at survey points were compared separately between species for the same plot and for all plots jointly with the use of Mann-Whitney test (two compared groups), and between plots for the same species with the use of Kruskal-Wallis ANOVA (more than two compared groups). Furthermore, generalized linear mixed model (GLM) with Poisson distribution was tested in order to check whether the total shares of woody vegetation and total shares of built-up areas distinguish survey points where SW was observed from these where GW was noted. All statistical calculations were performed with Statistica 11.0 (Statsoft).

Results

GW was noted more often than SW in three out of the four examined plots and the ratio of GW/SW was 2.5 in Wieliczka, 2.6 in Foothills and 3.2 in Raba plots. Only in the Krakow plot was SW approximately three-times more often noted than GW. If woodpecker territories found in various types of forests were excluded (this concerned only GW), the GW/SW ratio would be lower in Foothills (1.4) and Raba (1.3). The densities of each species were similar in Wieliczka, Foothills and Raba plots. In the Krakow plot, the pattern was reversed. The exact numbers of territories and densities of both species are presented in Table 2. In general, GW bred in all types of woody vegetation, but it preferred hornbeam-oak and riparian forests (49.0 % of territories found in these types of woody vegetation) and parks/cemeteries (17.6 % territories), whereas SW preferred orchards (44.8 % territories), poplar/willow hedges (37.9 % territories) and also bred in parks/cemeteries (17.2 % territories) (Fig. 1). In the following types of landscapes (plots), both species occupied slightly different types of woody vegetation, but they settled interchangeably in woody vegetation of different types. In Krakow, both GW and SW preferred parks and cemeteries, but SW was most often noted in poplar-willow hedges or orchards. In Wieliczka, SW occupied only orchards, but GW was found in orchards, parks and cemeteries. In Foothills, SW again bred only in orchards, but GW was found mostly in forests. In Raba, SW occupied mostly poplar-willow hedges, whereas GW was most abundant in riparian forests (Fig. 1). These inter-specific differences in respect to wood choices were significant in Foothills, Raba and in joined data from all plots ($Z = -3.39$, $P \leq 0.001$; $Z = -2.83$, $P = 0.005$ and

Z = –4.00, $P < 0.001$; respectively) but insignificant for Krakow and Wieliczka (Z = 0.00, $P = 1.000$ and Z = –1.41, $P = 0.157$; respectively). On the other hand, when comparing woody vegetation choices for particular species between all four examined plots, the differences were insignificant (Chi^2 ANOVA = 1.50, $P = 0.68$ for GW and Chi^2 ANOVA = 1.73, $P = 0.63$ for SW).

As much as 54.9 % of GW territories were found in woody vegetation in which softwood trees dominated, whereas 45.1 % were in woody vegetation where hardwood trees prevailed. On the other hand, SW territories were most often (82.8 %) found in areas where trees with softwood prevailed and rarely (17.2 %) where hardwood trees were abundant. These differences between species were significant (Chi^2 = 6.3, $P = 0.01$).

Built-up area cover near play-backed points with the presence of woodpeckers was on average 3-fold higher for SW (average 30.5 %) than for GW (average 10.1 %) and in all plots the cover of built-up areas was higher for SW than for GW (Fig. 2). Conversely, wooded area cover was 2-fold lower for SW (average 38.6 %) than for GW (average = 72.2 %); and again, this pattern was consistent in all the examined types of landscapes (Fig. 2). General differences between species were significant both for built-up area cover (Z = −4.83, $P < 0.001$) and wooded area cover (Z = 5.59, $P < 0.001$). When considering only one landscape (plot), built-up area cover was significantly different between species for Krakow (Z = −2.14, $P = 0.032$) and Foothills (Z = −3.25, $P = 0.011$), but not for Wieliczka (Z = −1.44, $P = 0.151$) and Raba (Z = −1.82, $P = 0.069$). For wooded area cover there was no significant difference between species for Krakow (Z = 0.99, $P = 0.322$), but the difference was significant for Wieliczka (Z = 2.05, $P = 0.040$), Foothills (Z = 3.08, $P = 0.002$) and Raba (Z = 2.84, $P = 0.004$). When comparing covers between plots, the differences for GW were significant for built-up area cover (ANOVA H = 35.06, $P < 0.001$) and wooded area cover (ANOVA H = 22.10, $P < 0.001$) and for SW as well for built-up areas (ANOVA H = 16.67, $P < 0.001$) and wooded area cover (ANOVA H = 12.55, $P = 0.006$). According to the GLM, wooded area cover was the variable which clearly distinguished survey points with the presence of either SW or GW (Table 3).

Discussion

Woodpecker densities in mixed landscapes are difficult to compare due to high levels of differences in landscape composition between examined plots and between areas presented in other studies. Moreover, such comparisons are violated by the varying sizes of areas in which woodpeckers were inventoried – most such studies have been performed on relatively small areas, e.g. a single park in a city or orchards in some villages, whereas studies covering whole cities or large rural landscapes are scarce. Densities of SW in the typical urban landscape (this study) are relatively low compared to densities found in other Central European cities; however, densities in these Slovakian and Hungarian cities were counted from small areas within parts of these cities (Sasvári 1981, Bozsko & Juhász 1985, Mullerova-Franekova & Kocian 1995, Mošanský & Mošanský 1999), where SW reached densities in ranges from 1 to even 17 territories/10 km^2. On the other hand, the density from the urban landscape (this study) is higher than those found in other similar studies (Fröhlich & Ciach 2013, Figarski 2014). The densities in town landscape (this study) were three-times lower than in urban area, but were similar to those calculated for adjacent rural and riparian landscapes. As similar densities (0.2-0.7 territories/1 km^2) have also been found in other rural and rural/riparian landscapes of southern and eastern Poland (Grzybek & Kuziemko 2004, Michalczuk & Michalczuk 2011, 2016a, b), it could be assumed that in a mixed rural landscape one territory of SW corresponds to approximately 3 km^2 of rural landscape. Although the home range of a pair of SW covers a much smaller area if unsuitable habitats are excluded (e.g. open lands, continuous forests).

Estimated average coverage of wooded area in the plots where SW was observed was less than 40 % and this was smaller in the urban landscape of a large city (30 %) and higher in town, rural and riparian landscapes (38 %, 49 % and 45 %, respectively). SW is synanthropic, as it breeds in areas where built-up cover is approximately 1/3 of the area and in urban landscapes it can breed even if buildings cover more than 40 % of land, as in centers of cities and in multi-family housing estates. In such densely built-up areas, SW mostly breeds along tree hedges, in groups of softwood trees or locally in parks (Ciach & Fröhlich 2013, Figarski 2014). This study also confirms that SW is highly dependent on softwood trees such as poplars and willows in wood hedges or fruit trees in orchards, but it avoids areas where hardwood trees prevail (e.g. hornbeam and oak forests or parks where oaks and chestnuts dominate), unless such woody vegetation is used by woodpeckers in highly polluted areas like in large cities, where also hardwood trees are susceptible to decay (Ciach & Fröhlich 2013). This preference of SW for softwood trees has been highlighted in many earlier studies not only from Poland and other European countries (Ciach & Fröhlich 2013, Figarski 2014, Michalczuk & Michalczuk 2016a), but also from its native range in the Middle East (Al-Safadi 2004, Aghanajafizadeh et al. 2011).

Habitat preferences directed the expansion of SW across Europe, where it has settled almost exclusively anthropogenic habitats such as orchards and green urban areas. The affinity of SW to the urbanized areas follows general finding that birds could benefit from living in cities where they find food resources and could be active over longer periods (e.g. due to light pollution, Ciach & Fröhlich 2016). The other factor which restricted its expansion was the presence of a closely related congener – GW. It is assumed that expansion of SW forced GW to leave urban and rural green areas, but this species remained dominant in forests (Cramp 1985, Munteanu & Samwald 1997, Michalczuk & Michalczuk 2016a). Indeed, this study showed an interesting pattern that both species express reverse relative abundances in different types of landscapes. SW is dominant in the urban landscape of a large city, but GW is more abundant in town, rural and riparian landscapes if forests are present. Domination of GW in town is an interesting phenomenon. This could be due to the well-developed tall vegetation and the vicinity of forests which could be source areas for GW population. In the town, SW maintained its population on the peripheries with dispersed vegetation and orchards – areas not suitable for GW. That is why the SW population in the town is related to rural populations and forms a smooth connection with them. The predominance of GW over SW in the rural landscape is inconsistent with the co-occurrence of these woodpeckers in rural landscapes of eastern Poland (Michalczuk & Michalczuk 2016a, b); however, in the latter forests constituted only 4 % of the total area, whereas in the former forests covered 10.6 %. Despite these differences, in both areas GW mostly settled forests, whereas SW was restricted to orchards. It is interesting that also in riparian landscape GW is much more numerous than SW. It is noteworthy that in the riparian plot SW was absent from poplar forests where softwood is abundant. Apparently, SW avoids compact woody vegetation, regardless of which tree species is dominant, but it is also probable that the high density of GW in riparian forests prevents SW from breeding there. In the riparian landscape of the Raba plot, SW was mostly found in willow hedges on the verge of the valley. Some of these territories included orchards located close to, but above the valley. Also, in other river valleys of southern and eastern Poland, SW was found either in willow hedges or in orchards surrounding the valley (Kurek 1984, Grzybek & Kuziemko 2004, Michalczuk & Michalczuk 2011). It was shown that species richness and abundance of woodpeckers correlated positively to woodland patch area and negatively to increasing urbanization (Myczko et al. 2014) and apparently SW is the only species which break out of this pattern.

The results of this study show that protection of SW should not be only focused on its rural populations. In Poland, several Natura 2000 sites have been designed for the protection of SW, but all of them are localized in rural or rural-riparian landscapes. These sites almost exclusively protect populations breeding in orchards and only rarely in willow woods (Wilk et al. 2010, http://obszary.natura2000.pl/). No Special Protection Area has been defined for SW in any Polish city, while this study and previous articles (Luniak et al. 2001, Ciach & Fröhlich 2013, Figarski 2014) support the statement that urban populations of SW could be one of most numerous (with higher densities). In spite of that, these crucial urban populations of SW are not protected (except of species protection under Polish law). Protection of SW (and other woodpeckers) in cities would be much more difficult due to mixed land coverage, where woody vegetation is scarce and fragmented, and there is complex ownership. There should be implemented some regulations which prevent removal of trees in urban areas. In areas under municipal administration removal of trees (especially poplars and willows) should be restricted only to places where it is necessary due to public safety. In private lands, which concern mainly orchards, some regulations should be implemented to encourage owners (also financially) to maintain old fruit trees and plant new ones (see Kajtoch 2017). Regardless of these issues, protection of SW is of immediate importance as recent data suggest a substantial decrease in its number in rural populations (Michalczuk & Michalczuk 2015). Also, urban populations are in danger due to intensive works in green urban areas, during which especially softwood tress (poplars, willows, fruit trees) are cut out mainly to enable private investments or during meaningless care of green urban areas. Protection via the attribution of Natura 2000 site status for some SW urban populations could bring new tools for regulation of artificial vegetated areas management in cities. Finally, SW should be considered as keystone species for woody vegetation in urban and rural areas, as protection of its sites would lead to preserving of trees and associated biodiversity.

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