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Nesting Requirements of the Syrian Woodpecker *Dendrocopos syriacus* (Hemprich and Ehrenberg, 1833) (Aves: Picidae) in the Rural Landscape of SE Poland

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Abstract: This study assessed the nesting preferences of the Syrian woodpecker *Dendrocopos syriacus*. For this purpose, basic tree parameters (trunk diameter, health condition and species diversity of trees) of 22 nest tree stands were compared to the tree stands present in the territories of the Syrian woodpecker (n=22) and those outside breeding territories (n=22). The study was conducted in 2006 in the agricultural landscape of SE Poland. During the study, no significant differences were found between the tree stands situated in and outside the woodpeckers' breeding territories. This may be an indication of the high ecological flexibility of the Syrian woodpecker as well as the wide availability of suitable habitats for this species in the studied region. However, in order to protect the nesting habitats of the Syrian woodpecker in the agricultural landscape, the presence of older trees in poor health condition, which also often includes dead trees or trees with visible mycelia, is needed. Tree stands with higher species diversity and numbers of trees may also be important for these woodpeckers, as this may positively affect foraging conditions in nesting territories.

Key words: primary cavity nesters, habitat preferences, non-forest tree stands, agricultural landscape

Introduction

The presence of a diversity of tree stands is of key importance for the occurrence of many species of birds in the agricultural landscape (e.g. Berg 2002, Domokos & Domokos 2016, Dorresteijn et al. 2018). Although these are the nesting habitats for many widespread species (e.g. Hinsley et al. 1995), their presence may be especially significant for rare birds such as woodpeckers (Dorresteijn et al. 2013, Michalczuk & Michalczuk 2016a, 2016b, Kajtoch & Figarski 2017, Michalczuk et al. 2018). As shown by numerous studies, apart from the area of tree stands, their age may also be decisive for many of these species (Kosiński 2006, Robles & Ciudad 2012, Walczak et al. 2013, Wojton & Krasoń 2017, Gerdzhikov et al. 2018). For woodpeckers, the presence of older trees is of particular importance, as they are usually characterized by considerable dimensions and often are in poorer health condition (Melletti & Penteriani 2003, Kosiński 2006, Grüebler et al. 2013, Kumar et al. 2014). These are the trees that provide good foraging areas for these birds, as well as suitable nesting sites (e.g. Glue & Boswell 1994, Melletti & Penteriani 2003, Czeszczewik

2009, Grüebler et al. 2013). Many studies have shown that nest holes are often built by woodpeckers in dead trees or in places with dying or dead tree fragments (Wesołowski 1995, Kosiński et al. 2006, Kosiński & Kempa 2007, Damoc et al. 2014, but see also Hebda et al. 2017). Woodpeckers also favour trees with developed mycelia, which also weaken the condition of trees and increases their usefulness for excavating nest holes (e.g. Jackson & Jackson 2004, Jusino et al. 2015). Requirements for these types of trees are characteristic not only for such rare species as the middle spotted woodpecker *Dendrocopos medius* but also for the most common species – the great spotted woodpecker *Dendrocopos major* (see Pasinelli 2007), which also often occurs in non-forest tree stands (Glutz & Bauer 1980, Cramp 1985).

In these habitats, the greater spotted woodpecker is very often accompanied by the Syrian woodpecker *Dendrocopos syriacus* (Hemprich and Ehrenberg, 1833), a species for which non-forest tree stands are the basic habitat in Europe (Glutz & Bauer 1980, Crapm 1985, Michalczuk & Michalczuk 2011, 2016a, 2016b, Kajtoch & Figarski 2017, Figarski & Kajtoch 2018, Michalczuk et al. 2018). However, after its dynamic expansion in Europe (Zavialov et al. 2008, Michalczuk 2014), the Syrian woodpecker is currently decreasing in some regions (BirdLife International 2004, Hristov & Petkov 2013, EBCC 2019). The population of this species was also found to be declining in SE Poland (Michalczuk et al. 2011, Michalczuk & Michalczuk 2015), and the recorded situation may be related to the devastation of non-forest tree stands. In previous studies on Syrian woodpecker habitats, macro-habitat parameters, such as, for example, the share and type of tree stands within its territories were analysed (Ciach & Fröhlich 2013, Michalczuk & Michalczuk 2016a, Kajtoch & Figarski 2017, Figarski & Kajtoch 2018). Its nest preferences were assessed in only exceptional cases (Aghanajafizadeh et al. 2011, Michalczuk & Michalczuk 2016c). Understanding the ecological requirements of the Syrian woodpecker can thus provide the key knowledge needed to plan its protection.

The intention of this work was to determine the habitat preferences of the Syrian woodpecker in the agricultural landscape of SE Poland. To this end, nest sites were characterized and compared to the tree stands within and outside of the territory of breeding pairs, which may help to indicate recommendations for the protection of the nesting habitats of this species.

Materials and Methods

Study area

The study area consisting of 339 km^2 was located near Tomaszów Lubelski in south-eastern Poland (50º28'N, 23º40'E, Fig. 1). This area is an agricultural landscape and is part of the Sokal Plateau-Ridge, which is part of the Volhynian Upland (Kondracki 2000). Due to the presence of very fertile soils (Bański 2010), arable lands constitute about 75% of the area. Meadows cover about 15% and occur mainly in the valleys of small rivers, the largest of which is the Huczwa. Forests in the research area are heavily fragmented and occupy about 5% of the area (Michalczuk et al. 2018). Oak-hornbeam forests predominate in the eastern part of the study area, with a large share of hornbeam *Carpinus betulus* and oak *Quercus* sp., while forests with a distinct predominance of Scots pine *Pinus sylvestris* dominate in the west (FDB 2016). Non-forest plantings occupy about 3% of the study area. They are found mainly around human settlements, but also in arable fields and meadows. These are mainly orchards and gardens with fruit trees - mostly apple trees *Malus domestica*, cherry trees *Prunus cerasus*, plum trees *Prunus* sp. and walnut trees *Juglans regia*. Groups of trees dominated by willows *Salix* sp., poplars *Populus* sp. and ash *Fraxinus* sp. are also often present. Tree rows and trees along roadsides mostly consist of ash, maple *Acer* sp. and poplar, which are also present in the few parks and cemeteries. Shrubs with a dominant share of willows are also often found in the river valleys. Conifers, such as pine *Pinus* sp., larch *Larix* sp. or spruce *Picea* sp. are rarely found in non-forest tree plantings (Michalczuk & Michalczuk 2016a, Michalczuk et al. 2018).

Detection of breeding territories

The study was conducted in 2006. The Syrian woodpecker breeding territories were determined by using a territory searching method with voice stimulation (for details see Michalczuk & Michalczuk 2006a, 2006b, Michalczuk et al. 2011). The search was conducted mainly in the tree stands located in the villages and in woodlots placed in fields and meadows. Counts were carried out along roads, where a point was designated at every 200–400 m for stimulation and listening for responses. At these sites, a 5-min sequence of Syrian woodpecker calls and drumming was played. The sites of bird encounters were marked on a topographic map at a scale of 1:10,000. In order to determine the birds' territories, at least six controls of the entire study area were carried out each season from March to July. Territorial boundaries were determined by connecting the farthest external points in which the birds of a given breeding pair had been observed. A breeding territory was determined to be one in which the presence of birds had been confirmed at least three times, including at least one observation of a pair of birds or an alternating male and female (for details see Michalczuk & Michalczuk 2006a, 2006b). In 2006 a total of 51 Syrian woodpecker breeding territories were conducted (Michalczuk & Michalczuk 2015). In order to find a nest hole in bird territories, tree stands were searched: mainly males were observed, as they primarily excavate nest cavities, as well as defend them against competitors (Glutz von Blotzheim & Bauer 1980, Cramp 1985, Michalczuk & Michalczuk 2016d). Searching for nests was also facilitated by observing birds that gathered food and delivered it to nestlings (for details see Michalczuk & Michalczuk 2016c, 2016d). The study did not include nests which were abandoned by the woodpeckers before being completed or when they were not used for breeding. In 2006, a total of 22 active Syrian woodpecker nests were located.

Selection and description of tree stands

To characterize the trees in the closest vicinity to the nest tree (n=22), a circle with a radius of 20 m (area of 0.125 ha) was measured around it. Within these designated areas, trees with a diameter (diameter at breast height – DBH) equal to and larger than 16 cm were measured at 1.3 m above the ground surface. Syrian woodpeckers can excavate cavities in trees of such dimensions, which is why they are potentially suitable for nesting, and their presence may determine the nesting site choice of the bird (Michalczuk & Michalczuk 2016c). Tree stands inhabited by the Syrian woodpecker were evaluated in 22 territories with found nests, too. In order to do this, in so described territories circular control areas with a radius of 20 m were randomly selected. For this purpose, on the map (in 1:10 000 scale) with outline territories range we outlined a network of points. To do this, we have drawn vertical and horizontal lines in regular 0.5 cm distance. Crossings of these lines marked the points on the territory map. The lines were numbered to choose tree points to assess. Then we randomized numbers of horizontal and vertical lines using so called "golden numbers" (Zieliński 1972). The cross of these two random lines gives a random point which we were looking for in fields. Most of the sites had no trees, as they were located in fields or meadows which occupy over 80% of the study area. In these cases, new points were selected. When there was afforestation, this procedure was finished and we assessed the tree stand. If the control site had trees with a diameter of at least 16 cm, they were ranked as territory tree plot. If not, a new point was chosen by this iterative method. During the study, tree stands which could potentially inhabited by the Syrian woodpecker were also described. For this purpose, in the whole study area (305 km^2) outside territories' space, 22 circular control plots with a radius of 20 m were randomly selected. These plots were determined by method analogous as using for selection of the tree stands in territories (for details see description above and Michalczuk & Michalczuk 2016a, 2016c).

After study plot selection, the 12 measurements of tree stands were made. This evaluation was done after breeding season. In the first step, trees were defined by species - this data was used for the Shannon-Wiener biodiversity index evaluation (H', Krebs 2014). Afterwards, we measured the diameter of a tree trunk (DBH) at 1.3 meters from the ground using forestry calliper. Based on these measurements consecutive tree stands parameters were assessed: number of trees, number of trees in particular trunk diameter ranges: 16-40, 41-60 and greater than 60 cm, average tree diameter and cumulative basal area of tree trunks (m^2). The average condition of the tree was assessed according to a seven-point scale, wherein the health of the tree decreases with each seven successive rating (see Appendix 1, Michalczuk & Michalczuk in review). Additionally, number of trees in four health categories was specified: healthy (1 degree in scale), weakened (2 and 3 degree in scale), dying (4 and 5 degree in scale) and dead (6 and 7 degree in scale, Table 1). In addition, the presence of trees with visible mycelium and dead trees were also assessed in particular tree stands (Michalczuk & Michalczuk 2016c). All these assessments were used to compare the features of nest tree stands, tree stands in the woodpecker breeding territories as well as those occurring outside the birds' territories (Table 1).

Statistical analysis

The collected data were used to compare the parameters of nest, territory and non-territory tree stands. The Kruskal Wallis test with post hoc Dunn test were used to compare the evaluations of particular tree stands (Table 1). The chi square test with the Yates correction was used to assess the frequency of the use of tree stands with fungi (Fig. 1), as well as the frequency of the use of tree stands including dead trees (Fig. 2). Differences were assumed to be significant at the level of $p < 0.05$.

Results

No statistical differences were found during the study between the tree stands present in the Syrian woodpeckers' breeding territories and outside of them (Table 1, Fig. 1, Fig. 2). For nesting, however, the birds more frequently chose stands in which trees with fungi were noted (41%, n = 22, Fig. 1). Such stands were found to have nesting sites significantly more frequently in comparison to tree stands occurring within and outside the territories of breeding pairs, in which the share of stands with visible mycelia was only 9% (for both cases the Yates' corrected Chi-square test = 4.36, df = 1, p = 0.037). Half of the breeding sites were also located in stands with dead trees (50%, n = 22, Fig. 2). This was significantly more often (Yates' corrected Chi-square test = 9.28, df = 1, p = 0.002) compared to stands recorded within territories where dead trees constituted only 5% of the stand (n = 22). Similar differences were found in relation to tree stands recorded outside the territories of breeding pairs, in which the share of stands with dead trees was 9% (Yates' corrected Chi-square test = 6.99, df = 1, p = 0.008, Fig. 2). This was significantly more often (Yates' corrected Chi-square test = 9.28, df = 1, p = 0.002) compared to tree stands recorded within territories where dead trees constituted only 5% (n = 22). Similar differences were found in relation to tree stands recorded outside the territories of breeding pairs, in which the share of tree stands with dead trees was 9% (Yates' corrected Chi-square test = 6.99, df = 1, p = 0.008, Fig. 2). Despite the fact that the number of dead trees was five times greater in nesting sites compared to the tree stands present in and outside of nesting pairs' territories, these differences were not statistically significant (although they were close to statistical significance – see Table 1). However, the study found that nest site trees were characterized by relatively worse health condition compared to the trees located in the territories, as well as outside them (Table 1). This resulted mainly from the significantly more frequent presence of sick and dying trees in comparison to the trees recorded within and outside the birds' territories (Table 1).

Table 1. Parameters of nest site, territory and outside territory tree stands of the Syrian woodpecker in agricultural landscape of SE Poland. For all measurements the mean values are given ± SD.

Parameters	Tree stand location			Kruskal Wallis ANOVA test with post hoc Dunn test (df = 2)
	Nesting (n=22)	Inside territory (n=22)	Outside territory (n=22)	
Number of trees	12.0±9.13a,b	4.8±3.3a	5.5±4.4b	H =21.0; p = 0.0000 a – p= 0.0001 b – p= 0.0005
Number of trees DBH 16-40 cm	10.2±6.14a,b	3.4±2.66a	4.2±3.94b	H = 20.97; p = 0.0000 a – p= 0.0001 b – p= 0.0006
Number of trees DBH 41-60 cm	1.6±1.82	1.0±1.40	1.0±1.29	H = 1.94; p = 0.3798
Number of trees DBH >60 cm	0.4±1.05	0.4±0.66	0.3±1.29	H = 2.17; p = 0.3378
Average tree trunk diameter at breast height 1.3 m (cm)	31.3±7.18	33.1±11.66	34.4±14.26	H = 0.32; p = 0.8528
Cumulative basal area of tree trunks (m^2)	1.09±0.72a,b	0.35±0.45a	0.18±0.17b	H = 30.38; p = 0.0000 a – p = 0.0001 b – p = 0.0000
Number of healthy trees (1 degree in scale)	2.4±3.66	1.1±1.55	1.6±1.43	H = 2.45; p = 0.2941
Number of weakened trees (2 and 3 degree in scale)	6.3±3.26a,b	3.0±2.73a	3.2±2.56b	H = 14.56; p = 0.0007 a – p = 0.0020 b – p = 0.0055
Number of dying trees (4 and 5 degree in scale)	3.1±2.67a,b	0.55±0.67a	0.73±1.72b	H = 22.51; p = 0.0000 a – p = 0.0006 b – p = 0.0002
Number of dead trees (6 and 7 degree in scale)	0.5±0.86	0.1±0.43	0.1±0.29	H = 5.44; p = 0.0660
Average health condition of trees	4.3±6.3a	2.5±0.8	2.2±0.7a	H = 10.29; p = 0.0058 a – p = 0.0045
Shannon-Wiener tree diversity index (H')	1.6±0.68a	1.1±0.81	0.9±0.71a	H = 11.50; p = 0.0032 a – p = 0.0028

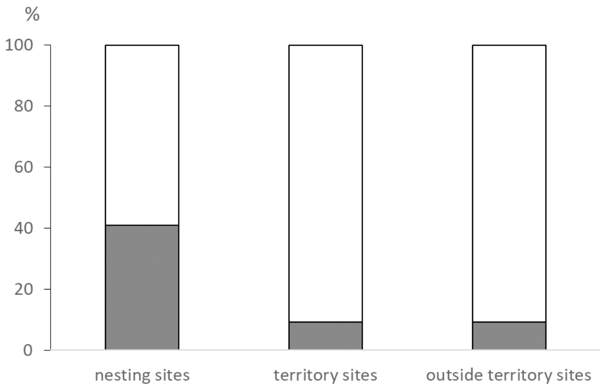

Fig. 1. Frequency of tree stands containing visible fungi noted in the nest vicinity, inside and outside of the Syrian Woodpeckers' territories. For all cases n=22. Grey – tree stands containing trees with visible fungi, white – tree stands without trees with visible fungi

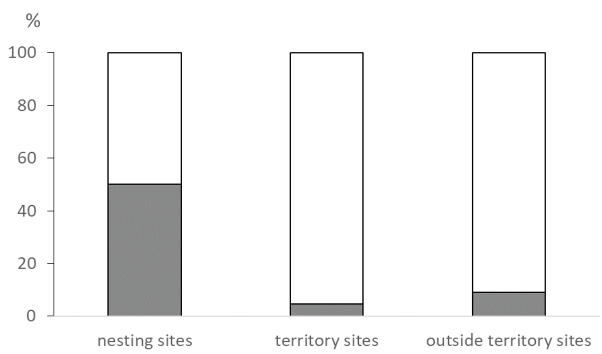

Fig. 2. Frequency of tree stands containing dead trees noted in the nest vicinity, inside and outside of the Syrian Woodpeckers' territories. For all cases n=22. Grey – tree stands with dead trees, white – tree stands without dead trees

stands had about a 3 times larger area, and compared to the trees located outside the woodpeckers' territories, even 5 times larger (Table 1). Nest tree stands were also characterized by greater species diversity compared to tree stands located within and outside the territories – in the latter case, the differences were statistically significant (Table 1).

Discussion

The Syrian woodpecker can be considered one of the most flexible species of European woodpeckers (Glutz von Blotzheim & Bauer 1980, Cramp 1985). It is able to inhabit a wide variety of trees stands in the agricultural and urban landscapes (Michalczuk & Michalczuk 2016a, 2016c, Kajtoch & Figarski 2017, Figarski & Kajtoch 2018). These are mainly orchards, gardens, and parks; these woodpeckers can even nest in single trees or wooden pillars (Szlivka 1957, 1962, Ruge 1969, Glutz von Blotzheim & Bauer 1980, Cramp 1985). It rarely inhabits the forests of Europe, which are its major habitats in SW Asia – the place of origin if this species (Glutz von Blotzheim & Bauer 1980, Cramp 1985). The similar parameters of the tree stands occurring in and outside the breeding territories of Syrian woodpeckers observed during the study confirms the high ecological plasticity of this species (Szlivka 1957, 1962, Cramp 1985, Michalczuk & Michalczuk 2016a, 2017). However, this species was found to prefer tree stands in the urban landscape (e.g. in Krakow) with greater numbers of trees (Ciach & Fröhlich 2013). Such dependence was not confirmed in other studies conducted in the urban landscape of central Poland, where this species preferred trees with larger trunk diameters, and at the same time, a greater cumulative basal area (Figarski & Kajtoch 2018). As suggested by the authors, the reported differences may derive from the different methods used in the studies or may result from differences in the existing environments of particular study sites (Ciach & Fröhlich 2013, Figarski & Kajtoch 2018). Such dependencies are also observed in areas of the original range of this species, e.g. from Iran, where nest trees also had larger tree trunks compared to the available trees in the environment (Aghanajafizadeh et al. 2011).

The lack of differences in the stands inhabited and not inhabited by Syrian woodpecker breeding pairs may also indicate the wide availability of suitable habitats for this species in the studied region. In the agricultural landscape, the Syrian woodpecker inhabits very diverse types of tree stands, such as orchards, gardens, parks and tree rows, which have very diverse resources and tree parameters (Michalczuk & Michalczuk 2016c). However, as research has shown, the species already has clear requirements for nest trees, as the breeding pairs chose nesting sites with greater tree species diversity. It can be assumed that such stands provided greater stability and variety of food resources, and this is just the diet required by the Syrian woodpecker, including what it needs to feed its chicks (Michalczuk & Michalczuk 2017). It can additionally be assumed that the larger number of trees as well as the total cumulative basal area also positively influenced the food resources of the nest trees. Other studies also mention the significant importance of sick, weakened and dying or dead trees, whose presence positively affects the food resources of trees used by woodpeckers (e.g. Czeszczewik 2009). These tree parameters probably positively affect the presence of many invertebrates, in particular beetle larvae, which are important in the diet, especially of rare and specialized woodpeckers such as the White-backed woodpecker (Hogstad & Stenberg 1997). As shown by the conducted research, such trees could also be significant even for the opportunistic Syrian woodpecker. The presence in the habitats of trees often occupied by beetles may be important especially in the first period of a nestling's life, when beetle larvae comprise a significant share of their diet – constituting half of the food items brought by the parents (Michalczuk & Michalczuk 2017).

The presence of trees of inferior health, the dying or dead trees confirmed during the study may also be important for Syrian woodpecker nesting (e.g. Michalczuk & Michalczuk 2016c). The results of many studies also confirm that the presence of such trees is one of the most important factors determining the occurrence of woodpeckers (Walankiewicz et al. 2002, Kosiński & Winiecki 2004, 2005, Czeszczewik & Walankiewicz 2006, Kosiński & Kempa 2007). The presence of such trees in habitats most likely affects the availability of sites with dried fragments, e.g. broken branches, which are often suitable places for excavating nest holes (e.g. Kosiński et al. 2006, Kosiński & Kempa 2007). Such sites may be especially important for species with weaker neck muscles, whose body structure limits the ability to excavate nest holes in hard wood. This was noted many times when comparing the nesting preferences of the great spotted woodpecker, which is stronger than the weaker woodpeckers – the middle spotted and little spotted woodpeckers (Hågvar et al. 1990, Kosiński et al. 2006, Kosiński & Kempa 2007). Probably for this reason, the presence of diseased, fungi-infested or even dead trees is probably one of the most important factors affecting the selection of nest sites by the Syrian woodpecker (Michalczuk & Michalczuk 2016c). Perhaps this is why the study did not show a significant influence of trunk diameter on woodpecker nesting, as shown by other studies of this species (Michalczuk & Michalczuk 2016c, Figarski & Kajtoch 2018) and others, such as the great spotted and middle spotted woodpeckers (e.g. Kosiński & Winiecki 2004). The lack of such dependencies in the conducted study may also result from the significant diversification of the tree stand features growing in particular study sites. As research has shown, the agricultural landscape can have a variety of areas with trees (from forests to individual trees, Michalczuk & Michalczuk 2016a), which are characterized by significant differences in tree dimensions, even within one study area (e.g. Michalczuk & Michalczuk 2016c).

Although the Syrian woodpecker exhibits large ecological plasticity, and the research area is characterized by widely accessible habitats appropriate for this species, the presence of tree stands in poorer health condition should be ensured in order to protect the Syrian woodpecker in the agricultural landscape. This applies especially to tree stands with dead trees and trees with visible mycelium, which are the preferred nesting sites for this species. Tree stands with higher numbers and species diversity of trees may also be important for the woodpeckers, as this may positively affect the feeding conditions in the vicinity of nesting sites. Preserving non-forest plantations with such features in the agricultural landscape should be the basic direction of activities undertaken to protect the habitats of this species, e.g. in Europe, where the Syrian woodpecker is protected, for example under the Birds Directive.

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Appendix 1. Level of the health condition of trees (according to Hågvar et al. 1990, modified).

Tree health scale	Percentage of tree damage	Tree damage/health condition of the tree	
		Trunk	**Crown**
1	≤ 10	Bark has no damage, very sporadic cracks found	All branches have live buds or leaves, no damaged bark
2	11 – 30	Bark is cracked to a small degree	Most branches are living, but there are signs of dying in the form of dry tops of branches and leaves
3	31 – 50	Bark is cracked over a significant share of its area, small areas lack bark	Single boughs or a large share of the thin branches are dry, there may be cracks on the bark of thicker branches and mycelium, some branches have been pruned
4	51 – 70	Significant areas of bark coming off the trunk, sporadic presence of mycelium	A large share of the thin branches are dry, thicker branches are dying and losing their bark, sometimes mycelium growth is observed, a large share of the boughs have been pruned
5	71 – 99	Large areas of the trunk lack bark, frequent presence of mold and mycelium	The vast majority of branches and thick boughs are dry, only a few branches are living, quite often patches of decay are encountered in the boughs and mycelium is present, a large share of the branches have been pruned
6	100	Dead hardwood tree, bark coming off the trunk, dry leaves, mycelium is often present	
7	100	Dead softwood and decaying tree, bark coming off the crown and trunk, developed mycelium	