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Comparison of nest holes between Syrian Woodpecker (*Dendrocopos syriacus*) and Middle Spotted Woodpecker (*Dendrocoptes medius*) around Yasouj city in Southwestern Iran

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In this study, the nest-cavity characteristics of Middle Spotted and Syrian Woodpeckers as well as tree characteristics (i.e. tree diameter at breast height and hole measurements) chosen by each species were analyzed. Our results show that vertical entrance diameter, chamber vertical depth, chamber horizontal depth, area of entrance and cavity volume were significantly different between Syrian Woodpecker and Middle Spotted Woodpecker ($P < 0.05$). The average tree diameter at breast height and nest height between the two species was not significantly different ($P > 0.05$). For both species, the tree diameter at breast height and nest height did not significantly correlate. The directions of nests' entrances were different in the two species, not showing a preferentially selected direction. These two species chose different habitats with different tree coverings, which can reduce the competition between the two species over selecting a tree for hole excavation.
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Key words: *competition, dimensions, nest-cavity, primary hole nesters.*

INTRODUCTION

Woodpeckers (Picidae) are considered as important excavator species by providing cavities and holes to many other hole-nesting species (Cockle *et al*., 2011). An important part of habitat selection in bird species is where to choose a suitable nest-site (Hilden, 1965; Stauffer & Best, 1982; Cody, 1985). The key roles of woodpeckers in the control of pests in their habitats are well known (Tao *et al*., 2008). The behavior of nest-site selection by woodpeckers is affected by numerous biotic factors such as tree species, substrate diameter and its viability, interspecific competition and predation (Short, 1979; Wesołowski & Tomiałojć, 1986; Hagvar *et al*., 1990; Stenberg, 1996; Bai *et al*., 2005; Kosiński *et al*., 2006). In general, Picidae shows a relationship between woodpecker size and substrate diameter at nest-height (e.g. Hagvar *et al*., 1990; Stenberg, 1996). Some studies have clearly shown that selection of smallest stems by the smallest species decreases the risk of usurpation and nest-enlarging by larger woodpecker species (Short, 1979). Moreover, the broods may gain more protection against environmental hazards, like predators, which is due to some characteristics of

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nest-cavity such as nest-hole depth and entrance size (Walankiewicz, 1991; Sandström, 1992; Wesołowski, 2002).

The Syrian Woodpecker (*Dendrocopus syriacus*) (22–23 cm; wingspan 34–40 cm, Mansoori, 2013) is approximately 10% larger than the Middle Spotted Woodpecker (*Dendrocoptes medius*) (20–22 cm; wingspan 33–34 cm, Pasinelli, 2003). This larger size in body necessitates a larger size for nest-holes excavated by the Syrian Woodpecker. Detailed nest-hole characteristics in woodpeckers have rarely been studied (e.g. Yamauchi *et al*., 1997; Kosenko & Kaygorodova, 2003; Remm, 2006, see also review in Michalek & Miettinen, 2003; Pasinelli, 2003; Kosiński & Ksit, 2007). To our knowledge, a detailed study comparing nest-cavity characteristics between the Syrian and Middle Spotted Woodpeckers in its original range, has not been documented so far.

This study aims to conduct a nest-cavity comparison and unveil the variation in nest-cavity characteristics, tree diameter at breast-height and at nest-height of the Syrian and Middle Spotted Woodpecker active nests. We suppose that due to the larger body size, the size of nest-cavity of the Syrian Woodpecker is larger than Middle Spotted Woodpecker.

MATERIAL AND METHODS

Covering an area of 600 hectares, the study region is a natural forested area with an elevation of 2200 m above sea level which is located around the city of Yasouj in Southwestern Iran (31° 48' N, 51° 42' E). The vegetation is represented by shrubs of the genera *Acantholimon, Amygdalus* and *Astragalus* as well as various species of trees including Oak (*Quercus brantii* var. *persica*), Honysuckle (*Lonicera nummularifolia*), Mount Atlas Mastic Tree (*Pistacia atlantica*), Wild Pears (*Pyrus glabra*), Dotted Hawthorn (*Crataegus puntica*) and Ash (*Fraxinus angustifolia*). In general, the area ground is densely vegetated by bushes, shrubs and annual Graminae vegetation. This area is characterized by cold climate, with average annual rainfall of 817 mm and an average annual temperature of 14º C. We began to search for active nests from late March to mid-May 2015-2017 (for Syrian Woodpecker) and in 2017 and 2018 (for Middle Spotted Woodpecker) in a survey on parallel lines by 2-4 people on foot (6 hours per day). To find the nest cavities, almost all of the susceptible trees in the area were investigated. The approximate territories were determined by watching the pairs at the beginning of breeding season. A more accurate look at this time led to the location of some of the nests. No play back was used to stimulate the Syrian Woodpecker. Active nests of the Woodpeckers were found using the sound of excavation, signs of scratching and tree excavating, woodpeckers' entering and leaving the nest or observation of the wood chips under-tree ground, and in the next steps, hearing the sound of chicks or observation of the eggs within the nests.

After this location phase, the following characteristics for each nest were measured and recorded: DNH (tree diameter at nest height), DBH (tree diameter at breast height) and distance of cavity entrance to ground level using a tape meter; chamber horizontal and vertical depths, vertical and horizontal diameter of the entrance using a digital caliper (to the nearest 0.01 mm); tree species; orientation of the nest and vertical slope of the nest site using iLevel software v. 2.0 (www.jrsoftworx.com) installed on the mobile phone; and condition of tree (alive, decay or dead).

The area of the entrance was calculated based on the formula:

$$A = \pi ab$$

where *a* and *b* are the horizontal and vertical radius of the entrance.

We calculated the nest chamber volume according to Remm *et al*. (2006) using cylindrical approximation:

$$V = \pi\,(c/2)^2 d$$

where c is the chamber horizontal diameter and d is the chamber height (vertical depth).

To prevent birds from leaving the nests, recording of the active hole-nests characteristics were done after the nestlings had fledged. As the hole-nest characteristics are influenced by such factors as rainfall, heat, coldness, and tree growth and subsequently change over time, only the characteristics of newly excavated holes were studied. A total of 69 active nests (18 for MSW and 51 for SW) were studied. All data were analyzed by SPSS package V.16. DNH and DBH were log-transformed for comparing the means. We used the t-test (for normally distributed characters) and Mann-Whitney U test (for non-normally distributed characters) to compare the means. A significance level of 0.05 was set for all statistical tests. All tests are two-tailed.

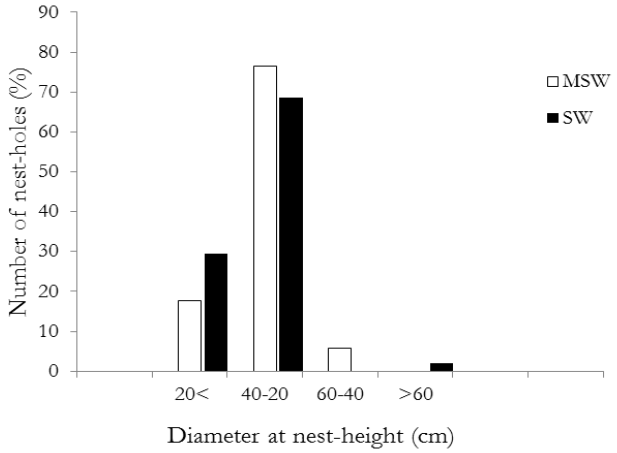

FIGURE 1. Distribution of the diameter at nest-height in Syrian (SW) and Middle Spotted Woodpeckers (MSW).

RESULTS

On the one hand, characteristics such as vertical entrance diameter, chamber horizontal depth, area of entrance and cavity volume had significantly greater values in SW, compared with those in MSW. On the other hand, chamber vertical depth had significantly greater values in MSW than that in SW (Fig. 1, Table 1). In Middle Spotted Woodpeckers, entrances were approximately circular, having the same values for vertical and horizontal diameters of the entrances (t-test for matched pairs, t = 0.84, $P = 0.4$). The vertical diameter of hole entrance was significantly greater than horizontal diameter in Syrian Woodpeckers (t test for matched pairs, t = 3.13, $P = 0.003$).

There was no significant difference in tree diameter at nest-height between Middle Spotted Woodpeckers (24.50 ± 5.65 cm) and Syrian Woodpeckers (23.35 ± 7.87 cm) (U = 337.5, $P = 0.17$, Table 1).

The area of the entrance for Syrian Woodpeckers (16.00 ± 1.90) was significantly larger than that in Middle Spotted Woodpeckers (14.87 ± 1.10) (t = -2.98, $P = 0.004$, Table 1).

In both woodpecker species, as the chamber horizontal depth increases, the volume cavity also increases ($r = 0.89$, $P = 0.0001$, n = 51 for SW and $r = 0.84$, $P = 0.0001$, n = 17 for MSW). The variation in nest height did not influence DNH either in Syrian Woodpeckers ($r = -0.06$, $P = 0.68$, n = 51) or in Middle Spotted Woodpeckers ($r = 0.032$, $P = 0.89$, n = 17).

The directions of nests' entrances were different in the two species, not showing a preferentially selected direction. The Syrian Woodpecker constructs its nest in Mount Atlas Mastic

(*Pistacia atlantica*) and Ash (*Fraxinus angustifolia*) trees while Middle Spotted Woodpecker construct its hole exclusively in Oak tree (*Quercus brantii* var. *persica*).

TABLE 1. Characteristics of nest-holes of Middle Spotted Woodpecker and Syrian Woodpecker. Mean ± standard deviation (SD), range (min-max), numbers of nest measured (N) and t/U-values and their probability are given.

Variable	Middle Spotted Woodpecker			Syrian Woodpecker			Test used	t/U	p
	Mean ± SD	Range	N	Mean ± SD	Range	N			
Vertical entrance diameter (mm)	43.99 ± 2.95	39.24-49.47	17	45.83 ± 3.28	35.52-52.86	51	t-test	-2.05	0.044
Horizontal entrance diameter (mm)	43.11 ± 2.42	39.12-47.52	17	44.37 ± 2.99	39.68-52.61	51	M-U test	326	0.13
Chamber vertical depth (cm)	27.83 ± 4.87	19.5-36	18	24.54 ± 4.18	16-35	51	t-test	2.75	0.008
Chamber horizontal depth (cm)	11.19 ± 1.94	7-14	18	14.00 ± 2.64	9-22	51	M-U test	171	0.0001
Height to ground (cm)	403.67 ± 191.88	106-515	18	253.65 ± 82.08	106-515	51	M-U test	237.5	0.002
DBH (cm)	37.99 ± 12.73	21.02-67.52	18	39.40 ± 15.37	18.15-88.22	51	M-U test	435	0.74
DNH (cm)	24.50 ± 5.65	18.79-42.99	17	23.35 ± 7.87	15.92-66.88	51	M-U test	337.5	0.17
Branch slope in the nest place	67.94 ± 19.51	35-105	18	69.19 ± 17.79	28-87	50	M-U test	439	0.88
Area of entrance (cm^2)	14.87 ± 1.10	12.95-16.73	17	16.00 ± 1.90	12.01-21.83	51	t-test	-2.98	0.004
Volume (l)	2.79 ± 0.96	1.12-4.31	18	3.87 ± 1.60	1.53-9.88	51	M-U test	255.5	0.005

DISCUSSION

Our research showed no preference in nest-hole entrance direction. In contrast to direction, entrances were almost uniformly inclined downwards. The same trend was found in some other woodpecker species (e.g. Conner, 1975; Hooge *et al.*, 1999; Ćiković *et al.*, 2014). A possible explanation for this is that downward-directed entrances refrain from precipitation or wind entering the nest (Conner, 1975; Tao *et al.*, 2008).

Exclusive use of Oak trees for nest-hole excavation by Middle Spotted Woodpecker is probably due to the prevalence of this tree in its habitat. Nest-hole height from the ground was higher in Middle Spotted than Syrian Woodpecker, which could be attributed to the greater height of Oak in comparison to Mount Atlas Mastic trees. It has been suggested in some studies that another reason for nest-hole excavating in geater heights is the use of softer parts of these trees, which is considered beneficial for Middle Spotted Woodpecker, because of its weaker excavating abilities, compared to other species (for example Syrian woodpecker) (Jenni 1981; Schepps *et al.*, 1999). Tree diameter at the nest-height should be large enough to provide space needed for the breeding of woodpecker nestlings (Pettersson, 1984; Günther, 1993; Kosenko & Kaygorodova, 2003).

The nest-cavity dimensions of both woodpecker species (especially Middle Spotted Woodpecker) in our study are congruent with other studies carried out on these species in other regions (e.g. Kosenko & Kaygorodova, 2003; Remm *et al.*, 2006; Pasinelli, 2003; Kosiński & Ksit, 2007; Aghanajafizadeh *et al.*, 2011). Kosiński and Ksit (2007). This suggests that differences between Great- and Middle Spotted Woodpeckers regarding vertical diameter of the entrance and the entrance area is probably due to the differences in body size between these two species. The same is true for our studied species with greater values for SW in comparison to MSW. An anti-predator adaptation might account for the small variations in the nest-cavity dimensions (Kawada, 1980; Yamauchi *et al.*, 1997; Kosenko & Kaygorodova, 2003; Kosiński & Ksit, 2007).

The only published data about nest volume of Syrian Woodpecker was reported by Ar *et al.* (2004) stating that the nest volume below entrance (nest volume was measured using a large polyethylene bag, which was inserted into the cavity and filled with water through an elastic tube up to the rim of the entrance opening) of Syrian Woodpecker is 2.2 ± 0.6l m^3 (n=19) which is less than the calculated nest-cavity volume in our study. This difference is due to different calculation methods used. In contrast, more studies have been conducted on the nest volume of the Great

Spotted Woodpecker (structurally similar to Syrian Woodpeckers) (Carlson *et al*., 1998; Remm *et al*., 2006; Kosiński & Ksit, 2007). Kosiński and Ksit (2007) reported 3.3 ± 1.6l m^3 of nest volume for Great Spotted Woodpeckers (having equal sizes with Syrian Woodpeckers).

Nest volume of the woodpeckers is probably overestimated because the nest-hole shape is not a real cylinder; rather it is cone frustum or a conical bifrustum (Z. Kosiński & P. Ksit unpubl. data). However, the nest volume of Middle Spotted Woodpecker in this study (2.79 ± 0.96 l, n=18) was almost equivalent to the volume reported by Kosiński and Ksit (2007) (2.8 ± 1.0 l, n=24).

The entrance diameter of holes is considered an anti-predator factor providing the meeting of some limitations. For example, the minimum entrance diameter for Pine Marten (*Martes martes*) to passes through is 44 and 50 mm as reported by Walankiewicz (2002) and Nyholm (1970), respectively. In this study, 23.53% of nest cavities of Syrian Woodpeckers (n = 12) and 52.94% of Middle Spotted Woodpeckers (n = 9) had diameter lower than 44 mm.

In this study some of nest-hole's dimensions of the two species (*D. syriacus* and *D. medius*) were similar. Why is that? As our results indicated, Middle Spotted Woodpeckers laid larger clutches and had more fledglings than Syrian Woodpeckers. The primary reason for this equivalency is that larger nest-hole volume provides enough space for smaller, but more chicks in MSW. This has also been confirmed in other studies (e.g. Hansell, 2000; Wesołowski, 2003; Wiebe & Swift, 2001; Kosiński & Ksit, 2007).

In our study area, Middle Spotted Woodpeckers and Syrian Woodpeckers chose different habitats with different trees, which can naturally; result in a reduced competition between the two species over selection of trees for nest-hole excavation. The same conclusion has also been reported for Middle Spotted and Great Spotted Woodpeckers in other studies (e.g. Short, 1979; Pasinelli, 2003; Kosiński & Ksit, 2007).

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