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Differences in Reproductive Investment between Male and Female Syrian Woodpeckers *Dendrocopos syriacus* (Hemprich and Ehrenberg, 1833) in a Newly-colonised Area

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Abstract: The reproductive investment of 14 pairs of Syrian woodpecker *Dendrocopos syriacus* was studied in the newly-colonised area of SE Poland in 2003-2006. The birds devoted av. 62.5% of their time to nest hole excavation, which varied between 44.7% of the time spent in April (before the egg laying) and 84.0% in May (during the breeding season). Nest construction was largely carried out by the male, with av.88.0% share of participation in this activity. In April, the share of male participation in nest construction averaged 96.8% and fell to 77.3% in May. Clutches were incubated 97.2% of the day time, shared equally by the pair members. The share of male and female participation in feeding was similar, too. In each successive fourth seven-day periods of nestling's life, one nestling received on average, respectively, 1.08, 1.86, 2.62, and 2.90 (average 2.12) food deliveries per hour. The involvement of both pair members in nest excavation during the breeding season and the participation of the female in this activity reduced the construction time of new nest holes, and simultaneously accelerated renesting. Additional costs of Syrian woodpecker reproduction at the northern limit of the species range may also result from an increased investment in egg incubation. This may be due to the greater thermal requirements of this southern species when breeding in the cooler climate of central Europe.

Key words: parental care, costs of reproduction, primary cavity nesters

Introduction

Parental effort among woodpeckers (family Picidae) varies between males and females and, in general, has partially reversed sex roles. In the case of the socially monogamous species, males invest more in parental care than females (Cramp 1985, Winkler *et al*. 1995, Winkler, Christie 2002). The male mainly excavates, guards and defends nest holes against intruders (Wiktander *et al*. 2000, Michalek, Winkler 2001, Woźniak, Mazgajski 2003, Fisher, Wiebe 2006). At night, primarily the male incubates the eggs and keeps the nestlings warm, while the share of male and female participation in these activities during the day is similar (Winkler *et al*. 1995, Wiebe 2014). Both parents clean the nests by removing nestlings' fecal sacs and feed their nestlings (Michalek, Winkler 2001, Woźniak, Mazgajski 2003, Rossmanith *et al*. 2009). However, participation of both sexes in these activities can vary in some species (Hogstad, Stenberg 1997, Hogstad 2009, Gow, Wiebe 2014a). Differences in the intensity of nest cleaning and food delivery between males and females may depend on the size of the brood and the age of nestlings (e.g. Woźniak, Mazgajski 2003, Rossmanith *et al*. 2009, Gow, Wiebe 2014b, Gow *et al*. 2015).

There are several reports of equal parental care roles in Syrian woodpeckers (Szlivka 1957, 1962, Ruge 1969, Marisova, Butenko 1976, Mersten-Katz *et al*. 2012). Nevertheless, more details are needed to examine the parental care roles of the sexes in various conditions. This study characterises the expenditure incurred by Syrian woodpeckers during various stages of reproduction: nest hole excavation, egg incubation and nestling feeding. The study also assessed the contribution of males and females in raising young depending on the age of the nestlings and the size of the brood.

Material and Methods

Study area and species

The 305 km^2 study area is located in SE Poland (50º28'N, 23º40'E). Approximately, 30–50 pairs of Syrian woodpeckers nested in this area in 2003-2006 (Michalczuk, Michalczuk 2006a, 2006b, 2015). The region was colonised by this species at the end of the 20th century (Michalczuk 2014). A native of Asia Minor, the Syrian woodpecker has been colonising Europe since the end of the 19th century, and its expansion is now occurring at a very fast rate in the Eastern part of the continent (Cramp 1985, Zavyalov *et al*. 2008, Michalczuk 2014). The landscape of the study area consists of gently rolling hills from 195 to 263 m a.s.l. and small river valleys (Kondracki 2000). Crop fields dominate, comprising more than 71% of the area. Meadows, found in the valleys, occupy 10% of the area, water bodies – 1%, and small forests – 4%. The western part of the area is dominated by pine forests, with a large proportion of *Pinus sylvestris*. Eastern areas are dominated by broad-leaved forests, with a large share of common hornbeam *Carpinus betulus* and oak *Quercus* spp. The trees in built-up areas preferred by the Syrian Woodpecker (Glutz von Blotzheim, Bauer 1980, Cramp 1985, Michalczuk, Michalczuk 2011, 2015, 2015b) comprise 14% of the area, made up mostly of clumps of trees, and less frequently avenues, tree rows, parks and cemeteries. The trees are mostly willow *Salix* spp., poplar *Populus* spp., *Fraxinus* spp. and maples *Acer* spp. Orchards with fruit trees, such as apple *Malus domestica*, cherry *Prunus cerasus*, plum *Prunus* spp., and walnut *Juglans regia* are equally often encountered. Coniferous species, such as spruce *Picea* spp., larch *Larix* sp. and pine *Pinus* sp. are rare (Michalczuk, Michalczuk 2015, 2015b).

Syrian Woodpecker is a monogamous species which breeds once per year (Cramp 1985). From the end of April up to middle June females lay from two up to seven eggs (average five eggs). After 9-13 days of egg incubation (most often after ten days) from one up to six nestlings are hatched. They remain in the hole for 24-30 days and fledge from the nest in June or in July (Michalczuk, Michalczuk 2016a).

Field observation methods and data treatment

The study was conducted in 2003-2006. We observed 14 pairs of birds directly from a hide near the tree hole or by recording videos, which were then analysed. We conducted observations from April to July, that is, from the period of hole excavation to the time the young fledged (Michalczuk, Michalczuk 2016a). During this time, we measured the time spent by the male and female excavating the nest hole and incubating the eggs. Time spent by an individual on specific activity was defined as "sequence". We also assessed the intensity with which nestlings were delivered food depending on their age and the size of the brood. Observations were made in the morning or in the evening, in good weather conditions.

Nest excavation

To assess the effort of the woodpeckers in nest construction, we conducted individual four-hour observations of birds excavating cavities. In each case, we calculated the excavating time and breaks taken by each partner. In order to compare the length of excavating sequences by the male and female, we used only full observations, consisting of the time a woodpecker arrived at the hole, began excavating it, and then flew away. The time when woodpeckers were not excavating the nest hole was recorded as a break. Observations obtained in April were made before egg laying, thus were defined as "before breeding season". Results we got in May were defined as "in breeding season" because they were made when a lot of woodpeckers' pairs have their eggs laid, incubated and fed broods (Michalczuk, Michalczuk 2016a). For 11 pairs, we assessed 33 sequences of males excavating, seven sequences of females and 56 breaks.

Clutch incubation

We assessed incubation during day time and only for pairs that had completed laying. We observed 14 breeding pairs over a four-hour period. Then, we calculated general time budgets of each sex during incubation, including time incubating, outside the nest hole and time away. To compare the length of time of each incubation sequence, we used only data from a full period, measured from the time a particular individual entered to the time it left the nest hole. For fourteen males and females, we obtained data on

Table 1. Intensity (mean ± SD) average proportion and intensity of food deliveries by the male and female in specific seven-day periods of life of Syrian woodpecker nestlings. The average percentage of participation of males and females together with minimum and maximum values are presented in parentheses, s.l.n. – seven-day period of life of the nestlings

Brood stage (s.l.n.)	Total	Males	Females	Mann-Whitney U test
early (1 – 7 days)	1.08±0.30[a,b]	0.52±0.16[a,c] (48.4, 36.4 – 60.0)	0.56±0.19[d,e] (51.6, 40.0 – 63.6)	U = -0.63 p = 0.530
middle (8 – 14 days)	1.86±0.28	0.96±0.28 (51.3, 33.3 – 63.0)	0.90±0.17 (48.7, 37.0 – 66.7)	U = -0.66 p = 0.510
late (15 – 21 days)	2.62±0.65[a]	1.29±0.28[a] (51.0, 33.3 – 64.8)	1.33±0.62[d] (49.0, 35.2 – 66.7)	U = -0.43 p = 0.669
near-fledgling (22 – 28 days)	2.90±1.46[b]	1.46±1.14[c] (47.7, 0.0 – 100.0)	1.44±0.78[e] (52.3, 0.0 – 100.0)	U = -0.36 p = 0.718
Kruskall-Wallis test	H_3 = 27.56 p = 0.0001	H_3 = 20.67 p = 0.0001	H_3 = 18.64 p = 0.0003	-

Dunn's post-hoc test: a – p = 0.0001, b – p = 0.0001, c – p = 0.0049, d – p = 0.0016, e – p = 0.0009

respectively 39 and 47 complete sequences of incubation, as well as 74 incubation breaks.

Food delivery

We observed the delivery of food to nestlings near the nest holes of two or three pairs in each season between 2003 and 2006. Then, using 10 x 50 binoculars and 30 x 50 telescopes or by recording videos (which were then analysed), we identified the sex of the bird bringing food to the nestlings. We observed nests from a hide, sometimes even only a few meters away from the nest and were able to observe food delivering by birds in their bills. To capture the variability in the intensity of food deliveries associated with nestling development, we divided the time spent by the young in the nest (approximately 26-28 days) (Holzer, Holzer 1982, Al-Safadi 2004, Mersten-Katz *et al*. 2012, Michalczuk, Michalczuk 2016a) into four seven-day periods. They were defined as: an early stage between 1-7 days since hatching: nestlings have grown up from c. 4 grams to 30 grams; middle stage between 8 and 14 days after hatching when nestlings have grown up to about 50 grams; late stage (15-21 days after hatching) when nestlings have attained about 60 grams, and near-fledging stage (22-28 days) when nestlings were about 60 grams, too (Al-Safadi 2004, Mersten-Katz *et al.* 2012). In the middle of each seven-day period, we performed two two-hour observations and used the results to calculate the relative feeding rate – average number of feedings per nestling in the brood per one hour. In order to determine the number of nestlings in the broods, we have checked study holes. We used the values obtained (number of trips/hour/nestling) to compare the intensity of nestling feedings by individual parents and the pair in successive seven-day periods of life of the nestlings. We obtained data on a total of 11 pairs, consisting of 1399 feedings, ranging from 75 to 193 feedings per brood with two – five nestlings in the nest.

Statistical analysis

In the analysis, we compared the share and average length of time spent by the male and female for specific activities, and length of incubation breaks, when the birds were not present at the nest. For this purpose, we calculated the average values for each pair and for each individual of the pair. We performed the statistical analysis with Excel 2007 and StatisticaSoft 7.1. We determined the differences to be statistically significant when the associated probability was less than 0.05. We used the U Mann-Whitney test or Student's t-test when comparing two groups of single variables. We used the Kruskall-Wallis test with Dunn's post-hoc test when analysing multiple levels for a single variable. We also used Spearman's rank correlation coefficient. Mean values are given ± SD.

Results

Nest hole excavation

Syrian woodpeckers *Dendrocopos syriacus* devoted approximately 62.5% (± 29.5, n = 11) of the time to excavate a nest cavity. The share of time spent on nest construction by specific pairs ranged from 9% to 96% and depended on the date of excavation. In April, before the breeding season, birds devoted about 44.7% of time (± 28.4, n = 6, range from 9% to 89%) to nest building, while in May, this figure was 84.0% (± 10.6, n = 5, range 67-96%). These differences were statistically significant (Mann-Whitney U test, U = 2.00, p = 0.040).

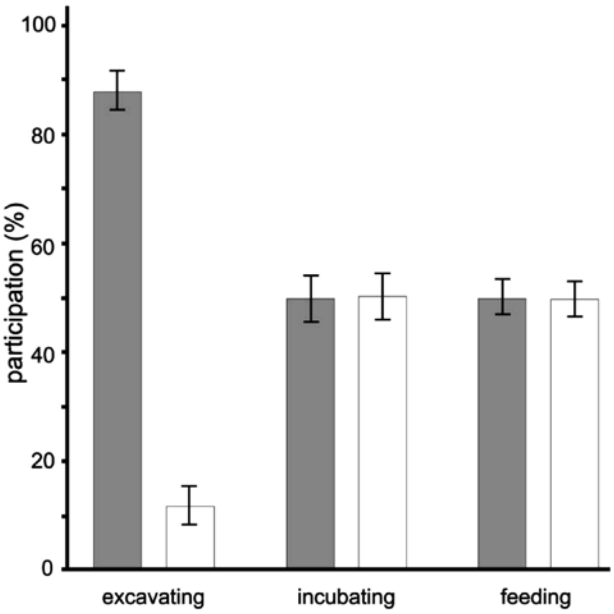

Fig. 1. The proportion of participation of Syrian woodpecker males (gray bars) and females (white bars) in nest hole excavation (n = 11), egg incubation (n = 14) and feeding the nestlings (n = 11; vertical lines – standard errors)

The nest hole was mostly excavated by the male, with an 88.0% (± 11.8, n = 11, range 69.2-100.0%; Fig. 1) average share of participation in this activity. The share of a female participation in excavation was significantly lower (Mann-Whitney U test, U = -3.87, p = 0.001), only 12.0% (± 11.8, range 0.0-30.8%, n = 11). As the season progressed, the male's participation in excavation decreased and the female's share increased (Mann-Whitney U test, U = 2.56, p = 0.010). In April, the proportion of male participation in nest hole excavation averaged 96.8% (± 5.8, n = 6), and in May, 77.3% (± 7.1, n = 5).

Average time spent by males on excavation in four-hour study period was 126.40 min (± 56.12, n = 11) and was similar in April (102.08 min ± 64.36, n = 6) and May (155.48 min ± 27.04, n = 5; Mann-Whitney U test, U = -1.46, p = 0.144). Females excavated statistically less holes than males (Mann-Whitney U test, U = 3.51, p = 0.0004) by average 23.03 min (± 23.58, n = 11). They spent more time on this activity in May (45.22 min ± 15.00, n = 5) than in April (4.12 min ± 6.42, n = 6; Mann-Whitney U test, U = -2.74, p = 0.006). Breaks in hole excavation lasted about 90.17 min (± 70.42, n = 11) and were longer in April (133.31 min ± 67.29, n = 6) than in May (38.25 min ± 10.10, n = 5; Mann-Whitney U test, U = 2.00, p = 0.044).

The average length of a single sequence of nest hole excavation by the male and female was the same (Mann-Whitney U test, U = -0.37, p = 0.708). This was 22.36 min for the male (± 24.3, n = 33), with a range of from 0.12 to 95.6, min whereas the average sequence length for the female was 22.36 min (± 18.0, n = 7) with a range of from 1.30 to 57.18 min. Breaks in excavating lasted on average 15.26 min (± 21.0, n = 56) and ranged from 0.01 to 222.14 min.

Incubation

During the day, the pair members incubated their eggs to a comparable degree. The clutches were incubated a mean of 97.2% (± 2.89, range: 91–99%, n = 14) of time during observations. There were no statistical differences between the involvement of males and females in incubation (Mann-Whitney U test, U = – 0.14, p = 0.891), 49.5% (range 29-75%, n = 14) and 50.2% (range 25-71%, n = 14; Fig. 1), respectively. The average length of a single incubation sequence was 35.30 min (± 24.8, n = 86) and did not vary significantly between the male and female (t-test, t_{84} = 1.19, p = 0.236). For the male, an incubation sequence averaged 39 minutes (± 26.56, with a range of 1-99 min, n = 39) and for the female, 32.36 min (± 22.51, with a range of 2.12 to 103.27 min, n = 47). When pairs exchanged places in the nest, incubation breaks lasted an average of 1.9 min (± 2.49, ranging from 0.03 to 21.51 min, n = 74) and accounted for 2.8% of the time. Breaks in incubation made by sexes during the day were similar (Mann-Whitney U test, Z = 0.55, p = 0.586). Males spent outside nest hole 39.20 min (± 29.46, with a range of 0.09 to 104.15 min, n = 42) on average and females 34.25 min (± 27.09, with a range of 0.08 to 98.31 min, n = 44).

Nestling feeding

The frequency of nestling feeding in each brood ranged from 4.69 to 12.06 food deliveries per hour with an average value of 7.95 (± 2.01, n = 11). Although the intensity of delivery was higher in pairs with larger broods (Spearman Correlation, r_s = 0.724, p < 0.05, n = 11; Fig. 2). The more nestlings in a brood, the more intensively males fed the nestlings (Spearman Correlation, r_s = 0.758, p < 0.05, n = 11). Such results were not observed for females (Spearman Correlation, r_s = 0.256, n.s., n = 11; Fig. 2). There was no statistical difference in the delivery rate of individual pairs (Kruskall-Wallis test, H_{10} = 10.04, p = 0.4374). Individual Syrian woodpecker nestlings received an average of 2.12± 0.52 food deliveries/hour (n = 11). Males and females provided food at an equal rate with an average of 1.06 trips/hr/nestling (Mann-Whitney U test, U = 0.10, p = 0.921). The share of male food deliveries (50.2%, ± 10.62) ranged from 35.0% to 67.4% and was greater as the number of nestlings in a brood increased (Spearman Correlation, $r_s = 0.681$, $p < 0.05$, $n = 11$). The frequency of food deliveries of individual broods ranged from 1.53-3.43 trips/hr/nestling. There were no statistically significant differences in the average intensity of feedings per one nestling per hour (Kruskall-Wallis test, $H_{10} = 5.849$, $p = 0.828$). Although there was a trend for the number of nestlings in a brood to be negatively related to the frequency of food deliveries by parents to one nestling in the nest hole, the small sample size yielded a statistically non-significant result (Spearman Correlation, $r_s = -0.588$, $p > 0.05$). Probably one outlier value gives near-significant result (Fig. 3). Significant differences in the intensity of food deliveries were found only between early and the late and near-fledging stage of nestlings' lives (Table 1). In specific seven-day periods of life, both parents fed nestlings with similar intensity, and the differences between males and females did not exceed 0.07 trips/hr/nestling (Table 1). The share of food deliveries between the pair ranged from 47.7-51.3% for the male and 48.7-52.3% for the female. A few days before fledging, two cases of nest abandonment by one member of the pair were found (Table 1). In one case in 2003, the brood was abandoned by the female, and in 2005, by the male. In these two cases both parents were not observed in spite of following nest inspection after study presented. They were observed while feeding their nestlings a few days after fledging.

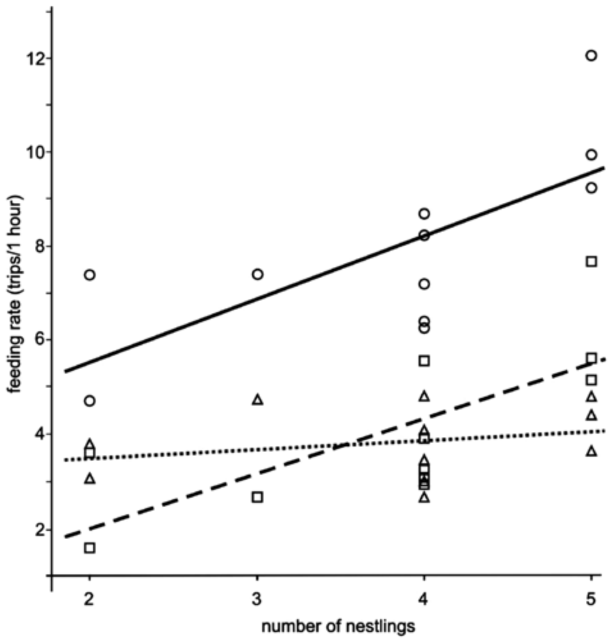

Fig. 2. The intensity of food deliveries (total – open dots and continuous line, males – squares and dashed line, females – triangles and dotted line) to nestlings in relation to brood size (n = 11)

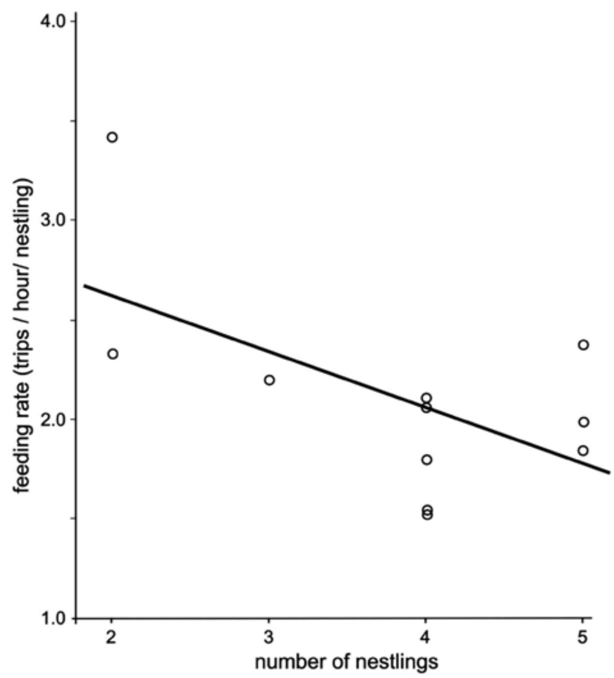

Fig. 3. Average food deliveries to nestlings in relation to brood size (n = 11)

Discussion

The investment borne by Syrian woodpeckers in reproductive activities are similar to those of other related woodpecker species. Their involvement in excavating nest holes is similar to the efforts of the great spotted woodpecker and lesser spotted woodpecker, devoting av. 62-65% of their time to nest building (Woźniak, Mazgajski 2003, Hogstad 2009). The length of a single excavation sequence confirmed during the study was similar to the time devoted to nest hole excavation of Syrian woodpeckers in Ukraine that took breaks after about 25-30 minutes of excavating (Afanasyev 1998). Just as with the great spotted woodpecker (Michalek, Winkler 2001, Woźniak, Mazgajski 2003), middle spotted woodpecker (Michalek, Winkler 2001) and lesser spotted woodpecker (Wiktander *et al.* 2000, Hogstad 2009), nest hole excavation was mainly carried out by the male. In the case of the great spotted woodpecker, females participated only rarely (3% of time) (Woźniak, Mazgajski 2003). The participation of male Syrian woodpeckers in nest hole excavation observed during this study was four times higher. The assistance of the female in nest construction was also noted in this species during research conducted in Ukraine (Marisova, Butenko 1976, Afanasyev 1998) and Vojvodina (Szlivka 1957). However, the authors did not specify the degree of involvement between the male and female, indicating only the domination of the male in nest hole excavation.

The increasing involvement of the pair, especially the female, in nest hole excavation in May confirmed during the study, enabled the woodpeckers to accelerate nest construction and begin breeding more quickly. During this period, nest holes were excavated by pairs that were originally usurped by starlings *Sturnus vulgaris*, which take over Syrian woodpecker nest holes mostly in late April and early May (Mityaj 1986, Michalczuk J., Michalczuk M., unpublished data). This is the reason, why Syrian woodpeckers lose about 31% of their broods (Michalczuk, Michalczuk 2016a). The level of losses resulting from starlings nest parasitism of other related woodpecker species nesting in central Europe is clearly smaller. This type of nest loss was either not recorded for the clutches of the great spotted woodpecker (Mazgajski 2002), or it accounted for only 8% of the losses (Kosiński, Ksit 2006). Losses at a similar level for the same reason, reaching 7%, were also reported for the middle spotted woodpecker (Kosiński, Ksit 2006). Syrian woodpecker brood losses due to starlings was not noted in Austria (Ruge 1969), nor in Israel (Branea 1982, Al-Safadi 2000), because starlings do not breed (Shirihai 1996). The weak nest parasitism pressure of starlings or the lack thereof in these regions probably allows the Syrian woodpecker to continuously occupy old nest holes (Barnea 1982, Mersten-Katz *et al*. 2012). This is also why Syrian woodpeckers occupying southern regions, such as Asia Minor, rarely excavate new nest holes, compared to the populations inhabiting central Europe, where starlings take over a significant proportion of old and new nest holes (Szlivka 1957, 1962, Mityaj 1986, Michalczuk *et al*. 2011). Probably in areas where there is a strong competition or nest parasitism of starlings, the Syrian woodpeckers must increase their efforts in building new nests. This is probably why female Syrian woodpeckers are observed helping males with nest excavation (Szlivka 1957, Marisova, Butenko 1976, Afanasyev 1998), whereas this is not seen in the subpopulations living in Asia Minor. In this region, the birds do not have to increase their investment in excavating new nest holes, as they do not significantly lose nests, which can be guarded by the male throughout the year (Barnea 1982, Mersten-Katz *et al*. 2012).

Exchanges of the male and female during egg incubation occurred at a similar frequency as with the birds in Austria, where during the day, pairs exchanged places also after about 30-35 minutes (Ruge 1969). Incubation exchanges occurred more frequently than with the great spotted woodpecker, in which the male and female exchanged places after about 55 minutes (Woźniak, Mazgajski 2003). But the share of male and female participation in incubation was the same as in other populations of the Syrian woodpecker (Ruge 1969, Marisova, Butenko 1976, Mersten-Katz *et al*. 2012) and in other species of woodpeckers: great spotted (Michalek, Winkler 2001, Woźniak, Mazgajski 2003), middle spotted (Michalek, Winkler 2001) and lesser spotted (Wiktander *et al*. 2000, Hogstad 2009, Rossmanith *et al*. 2009). Breaks in incubation taken by the great spotted woodpecker were about 6-7 times longer than for the Syrian woodpecker and accounted for about 16-22% of the time spent by the pair outside of the nest (Woźniak, Mazgajski 2003). The lesser amount of time taken for breaks by the Syrian woodpecker compared to the great spotted woodpecker, which has a very similar reproductive biology in terms of, for example, the size and weight of adults birds, dimensions and weight of eggs (Glutz von Blotzheim, Bauer 1980, Cramp 1985, Al-Safadi 2004, Mersten-Katz *et al*. 2012), suggests that the Syrian woodpecker, as a species originating from the south, may have higher thermal requirements during egg incubation.

The frequency of food deliveries to nestlings by Syrian woodpeckers was similar to the average intensity of food deliveries calculated for pairs nesting in Vojvodina (2.15 trips/hr/nestling, see Szlivka 1962) and Ukraine (2.30 trips/hr/nestling, see Marisova, Butenko 1976). As in other studies, e.g. of the lesser spotted woodpecker (Wiktander *et al*. 2000) and great spotted woodpecker (Woźniak, Mazgajski 2003), the intensity of food deliveries was positively correlated with the number of nestlings in a nest hole and increased as the nestlings grew (Hogstad, Stenberg 1997, Wiktander *et al*. 2000, Woźniak, Mazgajski 2003, Rossmanith *et al*. 2009). The evident increase in the demand for food during the first half of the time spent by nestlings in the nest hole should be linked to their intensive growth in this period (Ruge 1969, Al-Safadi 2004, Mersten-Katz *et al*. 2012). Immediately after hatching, a nestling of this species weighs about 4.6 grams, while at the age of 14-16 days, it weighs approximately 50-60 grams (Al-Safadi 2004, Mersten-Katz *et al*. 2012). During the first ten days of life, they increase their weight more than ten times and this is why their food supply significantly increases during this period. Later, the intensity of food deliveries stabilises, as the nestlings increase their weight by only approximately 5-10 grams during the remaining ten days in the nest hole, reaching an average weight of 59-65 grams when they fledge (Al-Safadi 2004, Mersten-Katz *et al*. 2012, Michalczuk J., Michalczuk M.

unpublished data).

The intensity of food deliveries may also depend on the type and size of food portions that are brought (e.g. Ruge 1969, Hogstad, Stenberg 1997). It is possible that this was the reason for such large, varying levels of effort among individual pairs during feeding. It may also be the result of considerable variation in the diet of Syrian woodpecker nestlings (Szlivka 1962, Ruge 1969, Marisova, Butenko 1976). As an opportunistic forager, this species may feed their young a variety of different food items (e.g. insects, spiders, *Lepidoptera* butterfly caterpillars, larvae of *Coleoptera* beetles, Cockchafers *Melolontha melolontha*, plant food, etc.) in specific breeding seasons (Michalczuk J., Michalczuk M. unpublished data). This is likely due to differences in the availability of various types of food in the territories of the birds (Ruge 1969, Winkler 1972, Gow *et al.* 2013).

As in other studies of the Syrian woodpecker (e.g. Szlivka 1962, Marisova, Butenko 1976, Mersten-Katz *et al*. 2012), the participation of both the male and female in feeding nestlings was the same. The similar involvement of both pair members in feeding nestlings was also found in the related great spotted woodpecker (Woźniak, Mazgajski 2003), whereas a male lesser spotted woodpecker was more likely to feed the young than the female, with its share of participation reaching 64% (Wiktander *et al*. 2000, Hogstad 2009). However, the increased investment in raising a greater number of nestlings may adversely affect the fitness and survival of the parents (e.g. Dijkstra *et al*. 1990, Golet *et al*. 1998), as well as their reproductive success in the long term (Slagsvold 1984, Martin 1995). This is probably why female Syrian woodpeckers reduce their participation in feeding larger broods, which was also found for the lesser spotted woodpecker (Wiktander *et al*. 2000).

Perhaps in order to reduce the reproductive costs a female or male may abandon a brood at the end of the nestling phase. This behaviour is also exhibited by the lesser spotted woodpecker, in which seven out of 15 broods were abandoned by the female at the end of the nestlings' stay in the nest. This was reported for smaller broods one – two days prior to fledging (Rossmanith *et al*. 2009). In these cases, the males alone fed all the nestlings without any loss incurring. Similar behaviour was noted in this species in studies conducted in Southern Sweden, where females abandoned approximately 40% of the broods, and the solitary males continued to feed the young (Wiktander *et al*. 2000). In the study of northern flicker *Colaptes auratus*, 36% of the broods were abandoned, but only by females (Gow, Wiebe 2014a). In our study, the extent of brood abandonment by one member of a pair was lower, approximately 20%. In both cases, the birds abandoned broods with four young a few days before fledging. Despite the noted abandonment, the lone pair member managed to feed the brood and all the nestlings fledged.

The involvement of Syrian woodpecker pairs in raising nestlings indicates that in colonising new areas of central Europe, this species may be incurring higher reproductive costs than the subpopulations of its original habitat in Asia Minor. This is mainly due to the greater amount of time incurred by the birds in nest hole excavation required to counteract the losses resulting from the nest parasitism and competition of starlings. This might be triggered by the lack of cavities in afforestations (trees in built-up areas) in the study area. Studies from North America showed that primary excavators would have to create more cavities too when colonising recently burned areas (e.g. Wiebe 2014). Additional costs of reproduction for the Syrian woodpecker may also be due to an increased investment in egg incubation. This may be a result of reproducing in the cooler climate of central Europe, as well as the greater thermal requirements of this species expanding from the south regions of Western Asia.

References

Afanasyev V. T. 1998. The Syrian Woodpecker in the Sumskoy Polesye Region. – Materials of the Third Conference of Young Ornithologists of Ukraine. Chernivtsi, 3-5. (In Ukrainian).

Al-Safadi M. M. 2004. On the breeding biology of the Syrian woodpecker, *Dendrocopos syriacus*, in the Gaza Strip. – *Zoology in the Middle East*, **32:** 7-12.

Barnea A. 1982. On the biology of the Syrian woodpecker in Israel. – MSc thesis. Tel Aviv University. (In Hebrew, English summary).

Cramp S. (Ed.). 1985. The Birds of the Western Palearctic. Terns to Woodpeckers. Vol. 4. – Oxford University Press. Oxford, London, New York, 960 p.

Dijkstra C., A. Bult, S. Bijlsma, S. Daan, T. Meijer, M. Zijlstra 1990. Brood size manipulation in the kestrel (*Falco tinnunculus*): effects on offspring and parent survival. – *Journal of Animal Ecology*, **59:** 269-285.

Fisher R., J. Wiebe K., L. 2006. Investment in nest defense by Northern Flickers: effects of age and sex. – *The Wilson Journal of Ornithology*, **118:** 452-460.

Glutz von Blotzheim U. N., K. Bauer (Eds.). 1980. Handbuch der Vögel Mitteleuropas. Columbiformes – Piciformes. Vol. 9. – Akademische Verlagsgesellschaft, Wiesbaden, 1148 p. (In German).

Golet G. H., D. B. Irons, J. A. Estes 1998. Survival costs of chick rearing in black-legged kittiwakes. – *Journal of Animal Ecology*, **67:** 827-841.

Gow E., A. Wiebe K., L. 2014a. Determinants of parental care and offspring survival during the post-fledging period: males care more in a species with partially reversed sex roles. – *Oecologia*, **175:** 95-104.

Gow E., A. Wiebe K., L. 2014b. Responses by Central-Place Foragers to Manipulations of Brood Size: Parent Flickers Respond to Proximate Cues but do not Increase Work Rate. – *Ethology*, **120:** 891-892.

Gow E.,A. Wiebe K., L. Higgins R., J. 2014. Lack of diet segregation during breeding by male and female Northern Flickers foraging on ants. – *Journal of Field Ornithology*, **84:** 262-269.

Gow E.,A. Wiebe K., L. Musgrove A. 2015. Nest sanitation in response to short- and long term changes of brood size: males clean more in a sex-role-reversed species. – *Animal Bahaviour*, **104:** 137-143.

Hogstad O. 2009. Sexual differences of labour during breeding activities and territory use in the lesser spotted woodpecker *Dendrocopos minor*. – *Ornis Norvegica*, **32:** 42-48.

Hogstad O., I. Stenberg 1997. Breeding success, nestling diet and parental care in the white-backed woodpecker *Dendrocopos leucotos*. – *Journal of Ornithology*, **138:** 25-38.

Holzer G., G. Holzer 1982. Erstnachweis der Brut des Blutspechtes (*Dendrocopos syriacus*) für Oberösterreich im Stadtgebiet von Linz. – *Öko- L*, **4:** 18-22. (In German, English summary).

Kondracki J. (Ed.). 2000. Regional geography of Poland. – PWN, Warszawa, 450 p. (In Polish).

Kosiński Z., P. Ksit 2006. Comparative reproductive biology of middle spotted woodpeckers *Dendrocopos medius* and great spotted woodpeckers *D. major* in a riverine forest. – *Bird Study*, **53:** 237-246.

Marisova I. V., A. G. Butenko 1976. Data on distribution and ecology of *Dendrocopos syriacus* in the Ukraine. – *Vestnik zoologii*, **2:** 29-34. (In Russian).

Martin T. E. 1995. Avian life-history evolution in relation to nest sites, nest predation and food. – *Ecology Monograph*, **65**: 101-127.

Mazgajski T. D. 2002. Nesting phenology and breeding success in great spotted woodpecker *Picoides major* near Warsaw (Central Poland). – *Acta Ornithologica*, **37:** 1-5.

Mersten-Katz C., A. Barnea, Y. Yom-Tov, A. Ar. 2012. The woodpecker's cavity microenvironment: advantageous or restricting? – *Avian Biology Research*, **5:** 227-237.

Michalczuk J. 2014. Expansion of the Syrian woodpecker *Dendrocopos syriacus* in Europe and Western Asia. – *Ornis Polonica*, **55:** 149-161.

Michalczuk J., M. Michalczuk 2006a. Reaction on playback and density estimations of Syrian woodpecker *Dendrocopos syriacus* in agricultural areas of SE Poland. – *Acta Ornithologica*, **41**: 33–39.

Michalczuk J., M. Michalczuk 2006b. The usefulness of the mapping method with playback in estimation of the numbers of the Syrian Woodpecker *Dendrocopos syriacus*. – *Notatki Ornitologiczne*, **47:** 175-184. (In Polish, English summary).

Michalczuk J., M. Michalczuk 2011. Syrian Woodpecker *Dendrocopos syriacus* in the Upper Huczwa River Watershed in 2004-2006. – *Chrońmy Przyrodę Ojczystą*, **67:** 426-432. (In Polish, English summary).

Michalczuk J., M. Michalczuk, R. Cymbała 2011. The usefulness of various methods of monitoring the population size of the Syrian Woodpecker *Dendrocopos syriacus*. – *Ornis Polonica*, **52:** 280-287. (In Polish, English summary).

Michalczuk J., M. Michalczuk 2015. Decline of the Syrian Woodpecker *Dendrocopos syriacus* population in rural landscape in SE Poland in 2004-2012. – *Ornis Polonica*, **56:** 67-75. (In Polish, English summary).

Michalczuk J., M. Michalczuk 2016a. The reproductive biology of the Syrian Woodpecker *Dendrocopos syriacus* in a newly colonized area of south-eastern Poland. – *Journal of Ornithology*, **157**: 179-187

Michalczuk J., M. Michalczuk 2016b. Habitat preferences of Picidae woodpeckers in the agricultural landscape of SE Poland: Is the Syrian Woodpecker Dendrocopos syriacus colonizing a vacant ecological niche?. – *North-Western Journal of Zoology* (online first): art.151603

Michalek K. G., H. Winkler 2001. Parental care and parentage in monogamus great spotted woodpeckers (*Picoides major*) and middle spotted woodpeckers (*Picoides medius*). – *Behaviour*, **138:** 1259-1285.

Mitjaj I. S. 1986. Syrian Woodpecker in the forest-steppe in Pridneprovsky Land. Birds distribution in SSSR, conservation and rational management. – Akademija Nauk SSSR, Leningrad, 70-71. (In Ukrainian).

Rossmanith E., N. Blaum, K. Höntsch, F. Jeltsch 2009. Sex-related parental care strategies in the lesser spotted woodpecker *Picoides minor*: of flexible mothers and dependable fathers. – *Journal of Avian Biology*, **40:** 28-33.

Ruge K. 1969. Beobachtungen am Blutspecht *Dendrocopos syriacus* im Burgenland. – *Vogelwelt*, **90:** 201-223. (In German, English summary).

Shirihai H. (Ed.). 1996. The birds of Israel. – Academic Press, London. 692 p.

Slagsvold T. 1984. Clutch size variation in birds in relation to nest predation: on the costs of reproduction. – *Journal of Animal Ecology*, **53:** 945-953.

Szlivka L. 1957. Von der Biologie des Blutspechts *Dendrocopos syriacus balcanicus*, und seinen Beziehungen zu den Staren, *Sturnus vulgar*is. – *Larus*, **9/10:** 48-70. (In German, English summary).

Szlivka L. 1962. Weitere Angaben über den Blutspecht aus der näheren Umgebung von Gunaroљ. – *Larus*, **14:** 121-134. (In German, English summary).

Wiebe K., L. 2008. Division of labour during incubation in a woodpecker *Colaptes auratus* with reversed sex roles and facultative polyandry. – *Ibis*, **150:** 115-124.

Wiebe K., L. 2014. Responses of cavity-nesting birds to fire: testing a general model with data from the Northern Flicker. – *Ecology*, **95:** 2537-2547.

Wiktander U., O. Olsson, S. G. Nilsson 2000. Parental care and social mating system int the lesser spotted woodpecker *Dendrocopos minor*. – *Journal of Avian Biology*, **31**: 447-456.

Winkler H. 1972. Beitrege zur Ethologie des Blutspechts (Dendrocopos syriacus). Das nicht-reproduktive Verhalten. – *Zeitschrift für Tierpsychol*, **31**: 300-325. (In German, English summary).

Winkler H., D. Christie 2002. Family Picidae (woodpeckers). – In: del Hoyo J., A. Elliott, J. Sargatal (Eds.): Handbook of the Birds of the World. Vol. VII. Jacamars to woodpeckers. Lynx Edicions, Barcelona, 296-558 p.

Winkler H., D. A. Christie, D. Nurney (Eds.). 1995. Woodpeckers. A guide to the Woodpeckers, Piculets and Wrynecks of the World. – Pica Press, East Sussex. 406 p.

Woźniak A., T. D. Mazgajski 2003. Division of parental labour in the great spotted woodpecker. – In: Pechacek, P. and D'Oleire-Oltmanns W. (Eds.): International Woodpecker Symposium. Proceedings. Forschungsbericht 48, Nationalparkverwaltung Berchtesgaden, 173–178 p. (In German, English summary).

Zavyalov E., V. G. Tabachishin, E. Y. Mosolova 2008. Expansion of Syrian woodpecker in European Russia and Ukraine. – *Dutch Birding*, **30:** 236-238.

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