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Small-scale differences in the breeding ecology of urban and rural Magpies *Pica pica*

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This study tested if urbanisation had small-scale effects on Magpie reproductive biology. It was carried out in 1999–2000 in Sofia, Bulgaria, where one of the highest Magpie population densities known is found. Breeding parameters were compared between an urban area and its rural surroundings extending 1 km out of it. Magpies in the urban area laid significantly earlier than those in the rural area. Clutch size and egg volume were similar between the two habitats. Fledging success was significantly higher in the urban area. Predation accounted for more losses in rural habitat while failures due to infertility and addling were more frequent among urban Magpies. Predation was higher at the egg stage than at the nestling stage, and this trend was more pronounced in the rural area. The probability of breeding success was significantly higher in the urban area due to lower predation most likely as a result of proximity to human activity. Urban birds, however, suffered more brood reduction and thus produced fewer fledglings per successful pair compared to rural pairs.

1. Introduction

Urbanisation is a global phenomenon, which reveals many problems of adaptation in birds (Fernández-Juricic & Jokimäki 2001, Marzluff *et al.* 2001). While many bird species have experienced significant declines due to expanding urbanisation, a number of others have adapted well to human environments and breed successfully there (e.g. Marzluff *et al.* 2001). Moreover, some of them have reached greater densities within human settlements than in their natural habitats (Sodhi *et al.* 1992, Hõrak & Lebreton 1998, Sorace 2002). On the other hand, density may be a misleading indicator of habitat quality (Van Horne 1983). While some bird species enjoy higher breeding success within urban areas (Cramp 1972, Monoghan 1979, Sodhi *et al.* 1992, Kosiński 2001) as compared to natural areas, others breed less successfully there, laying smaller clutches and/or fledging a lower proportion of young (Hõrak 1993, Boal & Mannan 1999, Solonen 2001). Thus, one step in assessing the quality of an urban environment as habitat for a species is to compare its breeding ecology and productivity in urban and rural areas (Gelbach 1988, Frimer 1989, Hõrak 1993, Solonen 2001).

The Magpie *Pica pica* is a widespread and numerous corvid species over most of the Palaearctic (Cramp & Perrins 1994). Its unspecialised diet (Tatner 1983) and very catholic habitat requirements (Birkhead 1991, Stepanyan 1997) have led to a substantial population increase in most parts of the range over the last 50 years (Birkhead

1991, Jerzak 2001). As a part of the overall population expansion, it has successfully colonised many cities (Birkhead 1991). Moreover, the rate of population increase in urban areas can be twice that in rural habitats (Birkhead 1991) and the species has reached its highest densities in urban environments over large geographic areas (Jerzak 2001). Therefore, it is interesting to know why Magpies colonise cities and what potential benefits urban areas offer them.

Studies that have compared breeding biology of urban and rural nesting Magpies showed that urban environment influences reproductive traits in this species. The most universal feature of urban Magpies is earlier onset of breeding (Tatner 1982, Eden 1985, Górski & Kotlarz 1997, Jerzak 2001). Urban Magpies were also shown to have a greater proportion of successful breeding attempts, while fledgling production per successful pair were similar to those in rural birds (Eden 1985, Jerzak 2001).

However, such studies are scanty and most of them involved comparisons of urban and rural locations that differed much in their areas and/or altitude (e.g. Tatner 1982, Eden 1985). Some studies also based their conclusions on the differences between urban and rural Magpies on comparisons with other studies conducted over different time periods (e.g. Jerzak 1995). Thus, other environmental factors than the effects of urbanization may have contributed to some extent to the observed differences in breeding biology of urban and rural Magpies. It is not clear if there are significant differences at a local scale, i.e. between contiguous areas with comparable sizes and urban and rural settings over the same period of time. Such small-scale effects should be best researched on both sides of the borderline of the built-up area of a city and its rural surroundings.

One of the highest known breeding densities of Magpies, 56.8 pairs/km^2, is recorded in the city of Sofia, Bulgaria (Antonov & Atanasova 2002). Magpies colonised the city in a circular manner, starting from the outskirts and moving inwards towards the inner, most urbanised parts (P. Iankov, unpubl.). All the area of the city is currently occupied and the density in some parts of the city is higher than in the surrounding rural areas from which colonisation has started (P. Iankov, unpubl., this study). Thus, nesting within the city probably has conferred benefits on Magpies that enabled their very successful establishment there.

We tested if urbanisation had small-scale effects on Magpie reproductive biology near the borderline of the urban and rural environment. Breeding parameters were compared between a peripheral highly urbanised part of the city and its immediate rural surroundings extending 1 km out of the built-up zone. We were interested if urban habitat affected: (1) laying dates; (2) clutch and egg sizes; and (3) breeding success and types of losses.

2. Material and methods

2.1. Study area

The study was conducted in 1999–2000 in the city of Sofia (273 252 inhabitants), Bulgaria (42°40′N,

Table 1. Differences in habitat characteristics of the urban and rural area.

Characteristic	Area	
	Urban	Rural
Available nesting substrates	Medium and high trees (mainly 8–12 m)	Thorny bushes and low trees (mainly 2.5–7 m)
Main tree/bush taxa	*Populus* spp., *Acer* spp., *Fraxinus* spp., *Picea pungens*	*Crataegus monogyna, Rosa canina, Prunus cerasifera, Acer campestre*
Buildings (cover)	12%	0%
Roads and playgrounds (cover)	5%	1%
Tree cover	33%	9%
Open grassy areas	50% dry managed	90% wet meadows, livestock grazing

23°20´E, altitude 550 m). The total study area comprised 908 ha (430 ha urban and 478 ha rural habitat). There was a clear-cut border between the urban and rural area without a transitional zone, including suburban outskirts. Some habitat characteristics of both areas are shown in Table 1. The urban habitat was part of a built-up area on the periphery of the city. The buildings were mostly 10–15 m high blocks of flats. The area was highly populated and the near-continual presence of crowds of people and traffic was typical. There were lots of open bins and food scraps that provided a plentiful food supply for Magpies throughout the year. Birds were habituated to humans (pers. obs.). Rural habitat included the adjacent areas outside the built-up area, within 1 km of it. There were not any residential buildings within the rural area and no additional food in the form of scraps was available there. People in either habitat did not persecute magpies.

The main predator of Magpie nests in the rural area was the Stone Marten (*Martes foina*), which was possibly responsible for part of the losses in the urban area as well. Domestic cats (*Felis catus*) were extremely rare and Red Squirrels (*Sciurus vulgaris*) were not recorded in the study area. Potential avian predators included Hooded Crows *Corvus corone cornix* and conspecifics.

2.2. Data collection, definitions and analyses

Nests were searched systematically from mid-February to early July. Only first breeding attempts are considered here. Each nest was visited every 2–5 days to record laying date, clutch size, number of chicks hatched and number of nestlings fledged. Nest checks rate was kept similar between the two areas in order to avoid any bias in breeding success due to differential disturbance levels.

For each studied nest we recorded nest height. It was estimated with the help of a 5 m pole with bright color bands at 1 m intervals. One of the observers held the pole vertically beside a tree and the other assessed the height. To achieve consistency, the same person assessed all the heights.

Mean laying dates differed significantly between the two seasons (see Results) and so we standardised them to allow comparisons between the two habitats on pooled data. The earliest laying date in a given year was set to 1 and all subsequent dates were counted accordingly. Urban Magpies re-use their old nests at a higher rate than rural ones, and laying in re-used nests takes place significantly earlier than in newly built ones (Tatner 1982). Thus when comparing laying dates, we made two analyses, the first including all nests and the second excluding re-used nests.

Clutch size between years was compared using ANCOVA with unstandardised laying date as covariate while between-habitat comparisons of clutch size involved standardised laying date as covariate (Conrad & Robertson 1993).

Egg size measurements were taken at full clutches or at those where at least 3 eggs were preserved. Egg volume index was calculated according to Hoyt (1979) using the formula:

$$VI = 0.5 \times L \times B^2/1000, \qquad (1)$$

where VI = egg volume index, L = egg length and B = egg breadth. Egg size was expressed as mean values per nest in order to avoid pseudoreplication.

Hatching success and fledging success between the two habitats were first compared using Mann-Whitney tests and second using univariate GLM procedure in SPSS 11.0 to account for several factors relevant to breeding success. Habitat type and year were entered as grouping variables. Since breeding performance in the Magpie is known to decline with laying date (Birkhead 1991) and the latter differed significantly between urban and rural area, laying date was entered as a covariate. Nest height also influences the probability of success in the Magpie (Antonov & Atanasova 2002) and it differed between the two habitats, thus nest height was accordingly entered as a covariate. Dependent variables were number of hatched chicks and number of fledged young per nest, respectively. Considering hatching success, clutch size was controlled for and in the case of fledging success we controlled for the number of chicks hatched per nest. Fledging success was expressed as the number of fledglings per pair that hatched at least one chick (successful and failed breeding attempts combined) and as the number of fledglings per successful pair (only successful breeding attempts included). Successful are breeding attempts that produced at least 1 fledgling. Separate analyses of successful pairs may reveal interesting relationships that might be hidden if all pairs are included (Stone & Trost 1996).

Since the study was conducted over a 2-year period at the same location, some birds likely contributed more than one observation considering breeding performance which implies a potential problem of pseudoreplication. However, by including year as a factor in the analyses, this problem was handled at least partially.

The following causes of nest failure were defined: (1) predation — the nest contents disappeared suddenly or eggshells or remains of eaten chicks and/or adults were present either in the nest or on the ground below nest; here we also included partial predation events which involved disappearance of 1–3 eggs from the clutch with subsequent desertion; (2) infertility and addling — this was proved by inspection of the egg contents after incubating birds exceeded the normal incubation time by more than ten days; (3) clutch desertion — eggs intact but untended and cold for several consecutive visits and often followed by building of a new nest.

An attempt was made to asses the importance of avian and mammalian predators. Suspected avian predators were assumed when the nest contents disappeared or were predated partially without any remains left; the nest structure (especially the nest lining) was undisturbed. Suspected mammalian predators were assumed if the remains of predated contents were present either in the nest or on the ground, and/or if the nest structure, particularly the lining, was noticeably damaged.

All statistical tests are two-tailed. Unless otherwise stated, the values reported below in the result section are mean ± SD.

3. Results

3.1. Breeding density and nest height

Both areas held very high breeding densities of Magpies but density in the urban area was significantly higher than that in the rural area (55.3 pairs/km^2 vs. 40.1 pairs/km^2; $\chi_1^2 = 11.02$, $P < 0.001$).

Nest-height in the urban area was significantly higher as compared to the rural one (5.4 ± 1.97 m vs. 3.8 ± 1.45 m; $t_{385} = -8.82$, $P < 0.0001$).

3.2. Laying dates

The median laying date over the two seasons was 2 April (range: 4 March–9 May). In 1999 laying took place on average 2.6 days earlier than in 2000 (1999: 29.3 ± 9.20, n = 146; 2000: 31.9 ± 10.21, n = 250; $t_{394} = -2.494$, $P = 0.013$). Urban birds laid on average five days earlier than birds in rural area (Table 2). The difference remained highly significant ($P < 0.0001$) even after excluding reused nests. Laying dates in the urban environment were also more variable (urban: CV = 42.5%; rural: CV = 28.3%).

Table 2. Breeding parameters of urban and rural Magpies. Means and standard deviations are reported, sample size in parenthesis.

Parameter	Rural	Urban	Statistic	P
Laying date[1]	31.88±9.04 (164)	26.53±11.18 (232)	U = 13096.0	<0.0001
Clutch-size[2]	6.29±1.15 (111)	6.43±1.15 (201)	$F_{1,309} = 0.011$	0.915
Egg volume, cm^3	8.49±0.72 (16)	8.23±1.02 (42)	$t_{56} = 0.951$	0.346
No. young hatched per pair	1.86±2.55 (159)	2.83±2.50 (224)	U = 14258.0	<0.001
No. young fledged per pair[3]	1.57±2.34 (159)	2.13±2.30 (225)	U = 15387.5	0.011
No. young fledged per successful pair[4]	4.24±1.86 (59)	4.03±1.51 (119)	U = 3187.5	0.310

Notes: U = Mann-Whitney U-test; t = independent samples t-test.

[1] Renovated nests included

[2] Compared via one-way ANCOVA with standardized laying date as a covariate

[3] Pairs that hatched at least 1 chick included (successful and failed breeding attempts combined)

[4] Only pairs that fledged at least 1 young included

3.3. Clutch size and egg volume

The mean clutch size was 6.38 ± 1.15 (2–9), n = 312. It did not differ significantly between the two years (1999: 6.46 ± 1.24, n = 117; 2000: 6.33 ± 1.09, n = 195; $F_{1,309} = 0.22$, $P = 0.636$). Controlling for laying date, clutch size of urban and rural Magpies was very similar (Table 2). Egg size did not differ significantly between urban and rural Magpies (Table 2). Frequencies of clutch sizes did not differ significantly between the two habitats (χ^2 tests, all $P > 0.10$). Clutches of nine eggs were only recorded in urban habitat. Clutch size decreased linearly with laying date ($r_s = -0.29$, $P < 0.0001$, n = 312). The relationship was similarly pronounced in urban ($r_s = -0.29$, $P < 0.0001$, n = 201) and rural habitat ($r_s = -0.25$, $P < 0.01$, n = 111).

3.4. Breeding success

Urban Magpies hatched significantly greater number of young per pair as compared to their rural counterparts (Table 2). However, the number of young hatched was significantly correlated with clutch-size (Table 3a). Hatching success did not differ between urban and rural birds when we controlled the clutch-size in our analysis (Table 3a). Hatching success did not differ between years and was not related to laying date or nest height (Table 3a).

The number of young fledged per pair was significantly higher among urban birds (Table 2). It was significantly correlated with the number of young hatched (Table 3b). Even after controlling for the latter, Magpies within urban habitat still had significantly greater fledging success than rural ones (Table 3b). Year and laying date did not affect fledging success but the latter was significantly correlated with nest height (Table 3b). Fledging success of successful pairs did not differ significantly (Table 2) between the two habitats but when the other relevant factors were taken into account in the ANCOVA analysis (Table 3c), a significant difference emerged. Successful urban birds fledged less young than successful rural ones. This reflected the fact that rural Magpies suffered more complete brood losses and less brood reduction and the reverse was true for urban ones. The proportion of successful breeding attempts was significantly greater in the urban habitat compared with the rural one (53.5% vs. 36.9%, $\chi_1^2 = 10.45$, $P < 0.01$).

Table 3. Comparison of hatching and fledging success of urban and rural Magpies. Univariate ANCOVAs.

Source of variation	F	df	P
a) Dependent: No. of young hatched			
Habitat	1.643	1, 294	0.201
Year	1.073	1, 294	0.301
Laying date	1.039	1, 294	0.309
Nest height	0.163	1, 294	0.686
Clutch-size	5.877	1, 294	0.016
b) Dependent: No. of young fledged[1]			
Habitat	8.317	1, 189	0.040
Year	0.556	1, 189	0.457
Laying date	0.018	1, 189	0.892
Nest height	8.509	1, 189	0.040
No. young hatched	80.755	1, 189	<0.001
c) Dependent: No. of young fledged from successful nests[2]			
Habitat	8.189	1, 166	0.005
Year	0.007	1, 166	0.931
Laying date	1.777	1, 166	0.184
Nest height	5.365	1, 166	0.022
No. young hatched	502.640	1, 166	<0.001

[1] Pairs that hatched at least 1 chick included (successful and failed breeding attempts combined)
[2] Only pairs that fledged at least 1 young included

3.5. Causes of breeding failure

Frequency distribution of types of breeding failures differed significantly between urban and rural habitats (Table 4). Predation was the main source of failure that in total accounted for 61.4% of all losses in both habitats. It accounted for a significantly higher proportion of failures in rural habitat (Table 4). Overall, 84.9% of predated nests

Table 4. Causes of breeding failure. Numbers are cases of failed nests. Overall $\chi_2^2 = 18.745$, $P < 0.001$.

Cause	Urban	Rural	χ^2	P
Predation	61	85	4.19	< 0.05
Infertility & addling	18	2	12.64	< 0.001
Clutch desertions	20	12	1.92	> 0.10

(124 of 146) were predated at the egg stage, with only 15.1% at the nestling stage (22 of 146). Predation in the rural habitat was concentrated to a greater extent at the egg stage than in the urban habitat ($\chi_1^2 = 13.41$, $P < 0.001$).

In both habitats combined, more predation events were due to suspected avian predators (62.3%; 91 of 146 losses) than to suspected mammalian predators (37.7%; 55 of 146 losses; $\chi_1^2 = 8.88$, $P < 0.01$). Urban and rural habitats did not differ significantly neither in the proportion of suspected avian predation events (67.2% vs. 58.8%; $\chi_1^2 = 1.06$, $P = 0.302$) nor in the proportion of suspected mammalian predations (32.8% vs. 41.2%; $\chi_1^2 = 0.46$, $P = 0.415$).

Infertility and addling of entire clutches was a significantly more frequent source of failure among urban nesting Magpies (Table 4).

4. Discussion

4.1. Laying dates and clutch size

Urban Magpies laid significantly earlier than their rural counterparts and thus confirmed the general trend in birds of earlier onset of breeding of urban populations of a species (Cramp 1972, Frimer 1989, Sodhi *et al.* 1992, Boal & Mannan 1999). Earlier laying of urban magpies was also reported in all other similar studies of the species (Tatner 1982, Eden 1985, Jerzak 1995, 2001). Our study demonstrated that the difference in laying dates between urban and rural birds can be pronounced even at a very small scale between contiguous areas. The higher proportion of renovated nests in urban habitat was not the cause for the trend, since results remained highly significant after their removal.

Several non-exclusive hypotheses have been put forward to explain earlier laying of urban Magpies. The "heat island" hypothesis states that the slightly higher temperatures within cities might cause physiological changes in birds and/or contribute to the earlier availability of ground invertebrates through the fewer ground frosts (Tatner 1982, 1983). Eden (1985) found that the mean temperature differed significantly between his urban and rural area even after controlling for altitude, being 1.2 °C higher in urban settings. Temperatures were not measured in our study but given the small size of the whole area at similar altitude, the temperature effect is likely to be too small to have solely produced the difference in laying dates. An alternative factor that might contribute to bringing urban birds into breeding condition earlier is the artificial light available in cities (Górski & Kotlarz 1997). However, we do not have any data to evaluate the "artificial light hypothesis" in this case.

Earlier laying might also be due to the more abundant food supply in cities in the form of discarded human food, which would help the females to accumulate the necessary resources for egg formation earlier (Jerzak 2001). Magpies in urban habitats will readily exploit discarded food, which could comprise 23%–40% of their diet (Jerzak 2001). Jerzak (2001) also showed that breeding density of Magpies was correlated with the distribution of bins. Thus, the availability of extra food in our urban area provided by the plenty of open bins and scattered food remains due to the low sanitary control could explain the earlier laying. Though the amount of anthropogenic food was not quantified, no such additional food source was available to rural birds. On the other hand, the quality of scraps as a food source is argued and scraps are unlikely to be a reliable source for the necessary aminoacids to be deposited into the eggs (Jerzak 2001, Solonen 2001). We suggest that the possible mechanism by which the additional food as scraps might advance laying of urban Magpies involves reducing costs of incubation and brooding by enabling males to feed their mates more regularly, thus maintaining high female condition. Male Magpies meet most of the food needs of incubating and brooding females which means that food supply must be adequate during these periods (Birkhead 1991) for a breeding attempt to be successful. Thus, males within urban environments, relying on availability of scraps, may be able to take charge of feeding incubating females earlier, i.e. before natural food becomes more abundant.

The "territory advertisement" hypothesis assumes that earlier nest building in urban environments might be an adaptation to advertise territory occupation in the conditions of higher population density (Jerzak 1995). Earlier nest building, however, need not translate directly into earlier laying (Birkhead 1991) and cannot therefore explain earlier laying dates *per se*.

Laying dates in urban habitat were also more variable compared to rural ones. The plentiful food supply might have allowed , first, some pairs of experienced breeders to lay much earlier than the rest, and second, the inclusion of more young and/or inexperienced breeders in the reproduction; these are known to lay later in the season (Birkhead 1991). Unfortunately, we had no data about the age structure of breeding birds to study this question more detailed.

Clutch size and egg size did not differ between the two habitats, which is in agreement with results from northern England (Eden 1985). Clutch size decreased significantly with season within both habitats but seasonal trend explained only about 8.4% of variance in clutch size. Similarly, a slight but significant decrease in clutch size with season in Magpies is reported for other populations (Tatner 1982, Birkhead 1991). The decrease of clutch size during the course of breeding season is a general phenomenon among single-brooded birds which is considered to be the result of deteriorating food supplies with season (Klomp 1970, Perrins 1970) or high quality parents breeding early on good territories and poor quality parents on poor ones (Birkhead 1991, Verhulst & Tinbergen 1991).

Though urban Magpies started breeding earlier than rural ones, they did not lay significantly larger clutches. As pointed out above, laying date had a relatively small effect on the variation of clutch-size. Thus, the mean difference in laying dates between urban and rural birds, being about 5 days, seems not large enough to result in significant differences in clutch-size.

4.2. Breeding success and losses

Predation was the main source of loss in both urban and rural habitats. The probability that a breeding attempt finally succeeded was significantly higher in the urban habitat, which resulted from the lowered predation risks there. Differences in fledging success between urban and rural habitats were found to be due to the greater incidence of total failures at the nestling stage among rural nests. Magpies in the rural area nested significantly lower above the ground than those in the urban area and this might explain the differences since nest height is a predictor of success in the Magpie (Jerzak 1995, Antonov & Atanasova 2002). Nest height in this study was also positively related to fledging success but even after controlling for it, urban birds still had significantly greater fledging success, which implies that other factors were mainly involved.

The proximity to humans and traffic might have accounted for the lowered incidence of predation within the urban area as should be predicted from the "distance to human activity" hypothesis (Collias & Collias 1984). Urban environments are considered as "safe zones" by virtue of the low abundance of natural predators (Gering & Blair 1999), which was supported for some species in which nesting success increased as the intensity of urbanization increased (Kosiński 2001). Magpies in the Netherlands benefited from proximity to man, suffering less predation from crows, when they nested close to buildings than further away (Baeyens 1981). However, the safe-zone hypothesis is also questioned in urban habitats (Jokimäki & Huhta 2000, Sorace 2002). Surprisingly, successful pairs produced significantly more fledglings in rural habitat. Thus, urban Magpies had more successful nesting attempts but also suffered more brood reduction. Nestling magpies require invertebrate food gathered on the ground in open grassy areas and parents will have less fledging success in the lack of enough suitable feeding grounds even when garbage is readily available (Jerzak 2001). Furthermore, breeding success in the magpie may be density-dependent as Stone and Trost (1996) found that Black-billed Magpies (*Pica hudsonia*) in Idaho, USA fledged fewer young at high density while at the same time the probability of nest predation was lower. Thus, the combination of higher density and the smaller proportion of open grassland in the urban area (Table 1) as compared to the rural area may have led to increased chick starvation. Eden (1985) did not find significant differences in breeding success between urban and rural habitats and reported that predation was much reduced in urban areas. Most of the predation in rural habitats in Eden's study was, however, by man.

This study revealed a high involvement of suspected avian predators in the predation of

Magpie nests. Magpies may suffer high losses to crows (Baeyens 1981, Vines 1981, Eguchi & Takeishi 1997), as well as to conspecifics (Baeyens 1981, Tatner 1982, Jerzak 2001). Hooded Crows were relatively rare (3 pairs in the urban area and 4 pairs in the rural one) in the study area but we did observe two attacks at higher nests. The very high densities of Magpies could also heighten the risk of conspecific predation. Our study did not find significant differences in distribution of losses to suspected avian and mammalian predators between urban and rural areas. Other studies on predation in urban environments have shown that avian nest predators were more important in urban environments, while the importance of mammalian nest predators was higher in less urbanized areas and in forests (e.g. Jokimäki & Huhta 2000). Most losses to mammalian predators in our rural habitat were probably to Stone Martens which were even seen resting in raided Magpie nests during the day (pers. obs.) and we suspect they were responsible for predation where nest linings were most damaged.

Most predation in both urban and rural area was at the egg stage and predation was more concentrated on eggs in the rural area. Predation pressure in many bird species was found to differ among the stages of nesting cycle and also a seasonal pattern may be involved (Burhans *et al.* 2002). Magpies begin to nest very early in the season when trees are not yet in leaf, which makes the bulky nests very prominent, which might explain the greater incidence of predation at the egg stage.

Breeding failures due to infertility and/or addling of entire clutches were significantly more frequent among urban Magpies. One possible explanation of this could be that the urban environment, due to the more abundant food supply, may have allowed more inexperienced breeders to attain the necessary condition to lay eggs, which subsequently failed to hatch. Young and/or inexperienced breeders are known to have lower hatching success (Birkhead 1991).

5. Conclusions

There were differences in reproductive parameters of Magpies breeding under urban and rural settings even at very small local scale. Magpies benefited from nesting in urban environments in increased breeding success. They started breeding significantly earlier as compared to their rural counterparts most likely due to the abundant food in the form of scraps. Their higher breeding success was not related to earlier laying and resulted from lowered predation pressure. Reduced predation was most likely due to the proximity to human activity and was not a result of greater nest height in the urban habitat. Despite the increased probability of success, breeding in urban environments under conditions of high density may lead to chick starvation and more brood reduction as compared to rural surroundings.

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Selostus: **Harakan pesimäekologiasta kaupungistuneella alueella ja maaseudulla**

Artikkelin kirjoittajat selvittivät, onko kaupungistumisella vaikutusta harakan pesimämenestykseen. Aikaisemmista tarkastelunäkökulmista poiketen tämä tutkimus tehtiin pienimittakaavaisena tutkimuksena Sofiassa vuosina 1999–2000. Harakan pesimämenestystä vertailtiin kaupungistuneen alueen ja läheisen maaseutumaisen alueen välillä. Maaseutututkimusalue sijaitsi kaupungistuneen tutkimusalueen välittömässä läheisyydessä ja ulottui noin kilometrin etäisyydelle kaupunkitutkimusalueen rajasta. Molempien tutkimusalueiden harakkatiheydet olivat suuria. Kaupungistuneella alueella tiheys oli suurempi (55.3 paria/km^2) kuin maaseudulla (40.1 paria /km^2). Harakat rakensivat pesänsä kaupunkialueella korkeammalle ($\bar{x}$ = 5.4 m) kuin maaseudulla ($\bar{x}$ = 3.8 m). Kaupungistuneella alueella pesivät harakat aloittivat muninnan noin viisi päivää aikaisemmin kuin maaseudulla pesivät harakat. Yleensä kaupunkilintujen aikaisen pesinnän aloituksen on selitetty johtuvan kaupunkien lämpimästä pienilmastosta ja ylimääräisestä, keinotekoisesta valaistuksesta. Sofian harakkatutkimus tehtiin kuitenkin niin suppealla alueella, etteivät nämä tekijät yksinään riitä selittämään harakan muninnan aikaisuutta kaupungistuneella tutkimusalueella. Kirjoittajat esittävät, että kaupungeissa tarjolla olevan ravinnon suuri määrä mahdollistaa pesinnän aikaisen aloituksen. Munamäärä ja munan koko eivät kuitenkaan eronneet tutkimusalueiden välillä. Lentopoikasten määrä kaikkia pesinnän aloittaneita harakkapareja kohden laskettuna oli kaupunkialueella korkeampi kuin maaseudulla. Pesäpredaatio oli kaupunkialueella vähäisempää kuin maaseutumaisella tutkimusalueella, missä pesäpredaatio havaittiin tärkeimmäksi pesinnän epäonnistumisen aiheuttajaksi. Pesäpredaation aiheuttamat tappiot olivat munavaiheessa suurempia kuin pesäpoikasvaiheessa etenkin maaseutualueella. Linnut aiheuttivat harakoille useammin pesätuhoja (91 tapausta) kuin nisäkkäät (55 tapausta). Kaupungistuneella alueella munien hedelmättömyys ja pilaantuminen aiheuttivat valtaosan pesätappioista. Kun poikastuottoa arvioitiin vähintään yhden lentopoikasen tuottaneiden parien osalta, havaittiin kaupunkiharakoiden onnistuvan pesinnässään kuitenkin heikommin kuin maaseutuharakkojen. Kaupunkialueen korkea harakkatiheys ja sopivien ravinnonhankinta-alueiden vähäisyys voi olla syy tähän. Tutkimustulosten mukaan harakoiden pesimämenestyksessä on havaittavissa eroja kaupunkialueiden ja maaseutujen välillä jopa pienen mittakaavan tarkastelussa. Vaikka kaupunkiharakoiden pesinnän onnistumisen todennäköisyys on suurempi kuin maaseutuharakoiden, voivat poikaset joutua kärsimään korkeasta harakkatiheydestä johtuvasta ravinnon puutteesta nimenomaan kaupungistuneilla alueilla. Myös tarjolla olevan ravinnon laatu voi kaupungeissa olla heikompaa kuin maaseudulla.

References

Antonov, A. & Atanasova, D. 2002: Nest-site selection in the Magpie Pica pica in a high-density urban population of Sofia (Bulgaria). — Acta Ornithol. 37: 55–66.

Baeyens, G. 1981: Magpie breeding success and Carrion Crow interference. — Ardea 69: 125–139.

Birkhead, T. R. 1991: The Magpies. — London, Poyser.

Boal, C. W. & Mannan, R. W. 1999: Comparative breeding ecology of Cooper's Hawks in urban and rural areas of southeastern Arizona. — J. Wildl. Manage. 63: 77–84.

Burhans, D. E., Dearborn, D., Thompson III, F. R. & Faaborg, J. 2002: Factors affecting predation at songbird nests in old fields. — J. Wildl. Manage. 66: 240–249.

Collias, N. E. & Collias, E. C. 1984: Nest building and bird behaviour. — Princeton University Press, Princeton, NJ.

Conrad, K. F. & Robertson, R. J. 1993: Clutch-size in eastern phoebes (Sayornis phoebe). I. The cost of nest building. — Can. J. Zool. 71: 1003–1007.

Cramp, S. 1972: The breeding of urban Woodpigeons. — Ibis 114: 163–171.

Cramp, S. & Perrins, C. M. 1994: The Birds of the Western Palearctic 8. — Oxford Univ. Press., Oxford. 889 pp.

Eden, S. 1985: The comparative breeding biology of magpies Pica pica in an urban and a rural habitat (Aves: Corvidae). — J. Zool. Lond. (A) 205: 325–334.

Eguchi, K & Takeishi, M. 1997: The ecology of the Black-billed Magpie Pica pica sericea in Japan. — Acta Ornithol. 32: 33–37.

Fernández-Juricic, E. & Jokimäki J. 2001: A habitat island approach to conserving birds in urban landscapes: case studies from southern and northern Europe. — Biodiversity and Conservation 10: 2023–2043.

Frimer, O. 1989: Breeding performance in a Danish suburban population of sparrowhawks, Accipiter nisus. — Dansk Ornitologisk Forenings Tidsskrift 83: 151–156.

Gelbach, F. R. 1988: Population and environmental features that promote adaptation to urban ecosystems: the case of eastern screech-owls (Otus asio) in Texas. — Proceedings of the International Ornithlogical Congress 19: 1809–1813.

Gering, J. C. & Blair, R. B. 1999: Predation on artificial bird nests along an urban gradient: predatory risk or relaxation in urban environments? — Ecography 22: 532–541.

Górski, G. & Kotlarz, B. 1997: Changes and breeding ecology in an urban population of the Magpie Pica pica in Slupsk, NW Poland. — Acta Ornithol. 32: 61–67.

Hõrak, P. 1993: Low fledgling success of urban Great Tits. — Ornis Fenn. 70: 168–172.

Hõrak, P. & Lebreton, J. D. 1998: Survival of adult Great Tits Parus major in relation to sex and habitat: a comparison of urban and rural populations. — Ibis 140: 205–209.

Hoyt, D. F. 1979: Practical methods for estimating volume and fresh weight of bird eggs. — Auk 96: 73–77.

Jerzak, L. 1995: Breeding ecology of an urban Magpie Pica pica population in Zielona Gora (SW Poland). — Acta Ornithol. 29: 123–133.

Jerzak, L. 2001: Synurbanization of the Magpie in the Palearctic. — In: Marzluf, J. M., Bowman, R. & Donnelly, R. (eds.), Avian Ecology and Conservation in an Urbanizing World. 403–425. Kluwer Academic Publishers, Massachusetts. 608 pp.

Jokimäki, J. & Huhta, E. 2000: Artificial nest predation and abundance of birds along an urban gradient. — Condor 102: 838–847.

Klomp, H. 1970: The determination of clutch size in birds. A review. — Ardea 58: 1–124.

Kosiński, Z. 2001: Effects of urbanization on nest site selection and nesting success of the Greenfinch Carduelis chloris in Krotoszyn, Poland. — Ornis Fenn. 78: 175–183.

Marzluff, J. M., Bowman, R. & Donelly, R. (eds.) 2001: Avian Ecology and Conservation in an Urbanizing World. — Kluwer Academic Publishers, Norwell, Massachusetts. 608 pp.

Monoghan, P. 1979: Aspects of the breeding biology of Herring gulls Larus argentatus in urban colonies. — Ibis 121: 475–481.

Perrins, C. M. 1970: The timing of birds' breeding seasons. — Ibis 112: 242–255.

Sodhi, N. S., James, P. C., Warkentin, I. G. & Oliphant, L. W. 1992: Breeding ecology of urban Merlins (Falco columbarius). — Can. J. Zool. 70(8): 1477–1483.

Solonen, T. 2001: Breeding of the Great Tit and Blue Tit in urban and rural habitats in southern Finland. — Ornis Fenn. 78: 49–60.

Sorace, A. 2002: High density of bird and pest species in urban habitats and the role of predator abundance. — Ornis Fenn. 79:60–71.

Stepanyan, L. 1997: Some geographical variations of Magpie behaviour between European Russia, Middle and Central Russia and Korea. — Acta Ornithol. 32: 132.

Stone, E. & Trost, C. H. 1996: Density-dependent reproductive success is mediated by nest predation in Black-billed Magpies (Pica pica). — Bird Behavior 11: 9–15.

Tatner, P. 1982: The breeding biology of magpies Pica pica in an urban environment. — J. Zool. (London) 197: 559–581.

Tatner, P. 1983: The diet of urban Magpies. — Ibis 125: 90–107.

Van Horne, B. 1983: Density as a misleading indicator of habitat quality. — Journal of Wildlife Management 47: 893–901.

Verhulst, S., & Tinbergen, J. M. 1991: Experimental evidence for a causal relationship between timing and success of reproduction in the great tit Parus m. major. — J. Anim. Ecol. 60: 269–282.

Vines, G. 1981: A socio-ecology of Magpies Pica pica. — Ibis 123: 190–202.