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Source: Acta Ornithologica, 37(1) : 15-19

Published By: Museum and Institute of Zoology, Polish Academy of Sciences

URL: https://doi.org/10.3161/068.037.0103

ACTA ORNITHOLOGICA
Vol. 37 (2002) No. 1

Nest site and breeding habitat characteristics in urban Jackdaws *Corvus monedula* in Rome (Italy)

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Salvati L. 2002. Nest site and breeding habitat characteristics in urban Jackdaws *Corvus monedula* in Rome (Italy). Acta Ornithol. 37: 15–19.

Abstract. The nest sites and habitat features of the area around nests in a population of Jackdaws breeding in the centre of Rome, Italy, were studied. Occupied nests (n = 41) had a predominantly south-easterly exposure and were located on average 20 ± 8 m above the ground. The availability of suitable nest holes positively influenced the size of breeding colonies. The preference for SE-facing holes could be affected by winter winds, which blow from the NW. To describe the habitat conditions in 20 Jackdaw nesting areas in Rome, in comparison with 14 randomly selected sites from the same area, 25 variables in plots within a 28.8 ha area were measured. Built-up districts covered on average 77% and 78% of the total area of occupied plots and random plots, respectively. Ruderal areas covered 5% of the total area in occupied plots and 0.4% in random ones, wooded areas correspondingly 20% and 12%. Stepwise discriminant function analysis carried out on habitat variables in nesting areas and random plots provided a model based on the proportion of ruderal areas and gardens that correctly classified 90% of cases. Jackdaws are associated with habitats characterised by the interspersion of ruderal areas, gardens, and built-up districts that provide suitable nest sites. Effective protection measures in urban areas should concentrate on the conservation both of suitable cavities in old buildings and of relict patches of ruderal and open habitats bordering city centres.

Key words: Jackdaw, *Corvus monedula*, nest characteristics, habitat preferences, urban habitat, Rome

Received — Dec. 2001, accepted — April 2002

INTRODUCTION

Urbanisation increases natural habitat loss and fragmentation, it also reduces open lands and green corridors (Mortberg 2001). With a range extended across the Palearctic region, the Jackdaw is a semi-colonial species that inhabits rocky, urban, and farmland areas, with some vertical structures like rock faces, quarries or buildings (Antikainen 1987, Vogel 1990). Open areas, where the birds forage, typically border rocky habitats or they are intermixed with them. Jackdaws are declining in a part of farmland Europe where changes in agricultural practices and massive losses of nest sites occur (Tucker & Heath 1994).

Urban areas hold high density populations of Jackdaws which colonise old buildings, ruins, churches, even in city centres (Antikainen 1987, Vogel 1990). They represent a model to study the effect of fragmentation, loss of original habitats, and human disturbance on breeding populations of this species. More information is needed about the influence of landscape variables such as amount of habitat, habitat patch size, and the effects of habitat fragmentation on Jackdaw distribution. The main aim of this paper is to contribute a knowledge in this field.

METHODS

The field work was conducted from March 1995 to July 2001 in Rome, central Italy (41°53′N, 12°28′E). The historic centre of Rome (c. 17 km^2) is an interspersion of built-up with ruderal areas and small gardens, mainly with pines *Pinus pinea*, cypresses *Cupressus sempervirens*, cedars *Cedrus* sp., and oaks *Quercus* spp. Jackdaws regularly breed in cavities of old buildings.

During winter suitable nest sites were mapped using 1:1000 and 1:10.000 maps, aerial photographs, and photos taken from panoramic spots, especially searching for cavities in man-made structures. During breeding season active nests were checked by searching for adults carrying food and young present at the nest. Observation of adults entering or leaving nests, nuptial displays, and collection of food remains and feathers often confirmed the nest occupation. All facades of ancient buildings and ruins were examined from multiple spots using panoramic sites and visiting courtyards and terraces to locate nests also on the internal facades. Those holes having an external opening larger than 100 cm², and more than 20 cm deep were considered as potential nests. Due to the impossibility to reach and measure many holes, they were classified into four categories according to the approximate measure of their width and depth (Table 1). Hole height and maximum height of nest buildings were measured by using a clinometer, a compass, and 1:1000 photographic maps of the historic centre of Rome. The orientation of the opening was measured as well. Nest availability was obtained in 15 man made structures of different size by counting all available scaffolding holes (e.g. Antikainen 1987). These buildings were chosen because their holes have about the same opening dimension. Nest availability was correlated with the number of breeding pairs by Spearman rank correlation. Wind direction was obtained from a meteorological station within the study area.

Table 1. Characteristics of nest sites occupied by Jackdaws — depth of the hole (cm), size of opening (cm²), height of the building (m) and nest/building height rate (N/B).

	cm	cm²	m	N/B
Eaves (n = 8)			15.2 ± 6.7	0.87
Small cavities (n = 8)	< 30	< 400	22.6 ± 5.1	0.86
Small holes (n = 15)	> 30	< 400	14.6 ± 5.3	0.83
Intermediate holes (n = 7)	< 30	> 400	31.1 ± 5.1	0.91
Large holes (n = 3)	> 30	> 400	24.3 ± 6.3	0.85

To describe habitat conditions at occupied nests and random sites, nests placed in the historic centre of Rome with occupation ≥ 3 years

Table 2. Habitat characteristics (means ± SD) of Jackdaw nesting areas (n = 20) and random plots (n = 14). *T*-test comparisons with df = 32 were performed on transformed data. * $p < 0.05$.

Habitat variables	Nesting areas	Random plots	p-level
Deciduous woods (%) DEW	0.68 ± 2.14	1.62 ± 2.28	ns
Pine woods (%) PIN	0.38 ± 0.97	0.34 ± 0.94	ns
Vegetable gardens (%) GAR	6.08 ± 5.32	11.87 ± 9.07	0.02*
Street trees (%) STR	5.03 ±2.63	4.69 ± 3.11	ns
Meadows (%) MEA	2.81± 4.87	1.86 ± 2.51	ns
Waterbodies (%) WAT	2.55 ± 4.92	0.69 ± 2.48	ns
Ruderal areas (%) RUD	5.06 ± 13.18	0.37 ± 0.67	0.04*
Old built-up areas (%) ADE	55.13 ± 38.76	34.67 ± 35.41	ns
Modern built-up areas (%) MDE	22.30 ± 31.50	43.89 ± 40.86	ns
Habitat diversity (Shannon-Weaver) Hhab	1.26 ± 0.12	1.27 ± 0.10	ns
Surface of green areas (ha) TGA	1.83 ± 0.42	2.16 ± 0.50	0.04*
Mean size of green area patches (ha) MSG	1.22 ± 0.19	1.30 ± 0.16	ns
Mean size of street trees patches (ha) MST	1.09 ± 0.05	1.08 ± 0.03	ns
Patchiness PAT	1.87 ± 0.28	1.89 ± 0.24	ns
Mean tree density (trees ha^{-2}) TDE	6.39 ± 1.58	6.11 ± 1.67	ns
Mean tree height (m) THE	3.09 ± 0.27	3.19 ± 0.20	ns
Mean diameter at the breast height (m) DBH	1.21 ± 0.04	1.22 ± 0.03	ns
Conifers (%) CON	4.72 ± 2.44	3.63 ± 2.07	ns
Quercus ilex (%) QIT	13.02 ± 22.05	26.66 ± 28.65	ns
Pinus pinea (%) PPT	24.74 ± 24.13	11.26 ± 14.14	ns
Cedrus sp. (%) CET	6.74 ± 24.76	11.12 ± 32.71	ns
Cupressus sempervirens (%) CST	16.29 ± 24.45	3.46 ± 5.77	0.07
Platanus sp. (%) PLT	12.47 ± 22.27	24.43 ± 34.63	ns
Other species (%) OTH	26.72 ± 28.66	22.14 ± 28.36	ns
Tree diversity (Shannon-Weaver) Htrees	1.34 ± 0.12	1.30 ± 0.17	ns

were chosen. Overall, 20 nesting areas were identified where habitat conditions within a 300 m radius circle (28.8 ha) centred over each nest were sampled. The size of plots (28.8 ha) was chosen as resembling the minimum available area per territory, calculated as 1/territory density. I delineated 14 identical circular plots around randomly chosen locations in the remaining part of the historic centre to estimate available habitats. None of the random plots overlapped with the area of occupied nests.

The territory characteristics was described using 25 variables (Table 2). Areas covered by different habitat types in each plot were identified on aerial photographs and with field verification were drawn on a 1:1000 map and measured by dot grid in hectares. Habitat and tree species diversity were calculated using the Shannon-Weaver index. Patchiness was calculated as the total number of patches divided by the number of habitats in each plot.

Vegetation structure and composition were measured in both nesting areas and control plots by means of circular plots located at random but always placed at least 10 m inside a boundary for a total of 53 vegetation plots. The number of vegetation plots in each nesting or random area was chosen according to their total surface of wooded area; multiple plots were used when the wooded area exceeded 1 ha. I sampled vegetation using a modification of the circular sample-plot method (James & Shugart 1970). I recorded tree number, height (using a clinometer), and diameter at breast height (using a dbh measuring tape) of all woody plants more than 5 m tall within a 20 m radius circular plot.

The mean values of all variables measured in nesting areas and in random sites were compared by means of two-tailed *t*-tests. Stepwise discriminant function analysis (DFA) was used to identify the subset of variables that best discriminated among occupied and random plots. I performed the analysis on each data sample using different subsets of variables: land cover, habitat fragmentation, vegetation structure, vegetation composition and all the above variables together (Table 2). Minimum value of *F* to allow a variable entered model was 4. Logarithmic transformation was performed on habitat structure and fragmentation variables. Arcsin square root transformations were used on habitat proportions and tree species frequencies. All statistical analyses were performed using STATISTICA package.

RESULTS

Based on 41 nests, occupied cavities, including scaffolding holes and eaves, were located on average 19.8 ± 7.8 m from the ground. Mean height of holes and eaves was 21.3 m and 15.2 m, respectively. Jackdaws tended to occupy nests located near to top of man-made structures (Table 1), the average rate between nest height and maximum building height being 0.82. The availability of scaffolding holes in each building sampled, positively influenced the number of breeding pairs ($r_s = 0.68$, $p = 0.005$, $n = 15$). The prevalent orientation (35%) of nest openings was SE (Fig. 1). The different exposition between scaffolding holes and eaves was not significant (Watson test, $U_2 = 0.13$, p = ns) The exposure of nest openings could be related to the cold wind that blows prevalently from north-west directions during February and March, which encompassed the period of Jackdaw laying (Fig. 1).

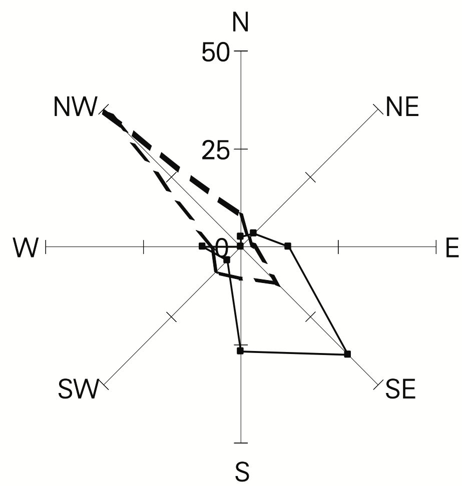

Fig. 1. Distribution (%) of entrance exposure of nesting cavities (n = 41) in horizontal plane (continuous line), and mean direction (%) of wind during late winter in the same area (filled line).

Densely built-up areas (ADE + MDE) covered an average 77% and 78% of the total surface in nesting areas and in random plots, respectively (Table 2). Old built-up areas (ADE) were positively correlated to nesting areas. Random plots had higher proportion of modern built-up areas (MDE) than nesting areas. Ruderal areas covered an average 5% and 0.4% of the total surface in occupied and random plots. Wooded areas (DEW + PIN + GAR + STR) comprised an average 20% of the nesting area and 12% of the total surface of random plots. Proportion of open areas (MEA) was slightly higher in nesting areas than in random plots.

The stepwise discriminant analysis carried out on land cover variables in occupied and control plots provided a model based on gardens (GAR) and ruderal areas (RUD) (Wilks' Lambda = 0.66, $F_{2,31} = 8.07$, $p = 0.001$) that correctly classified 70.6% of cases. No habitat fragmentation variables neither vegetation structure and composition variables entered a discriminant model. Using all the variables, GAR, RUD, TDE, QIT, and MEA entered a discriminant model (Wilks' Lambda = 0.36; GAR: $F_{1,28} = 27.16$, $p = 0.00002$; RUD: $F_{1,28} = 10.50$, $p = 0.003$; TDE: $F_{1,28} = 19.08$, $p = 0.0002$; QIT: $F_{1,28} = 12.46$, $p = 0.0015$; MEA: $F_{1,28} = 6.90$, $p = 0.01$). Thirty-one cases (91.2 %) were correctly classified.

DISCUSSION

In urban areas natural cavities are replaced by holes in man-made structures. Holes seem to be the most safe nests in cities (Plesnik 1991). Jackdaw colony size is positively influenced by the availability of this nest site. The choice of higher cavities may be attributable to a response to predation pressure by feral cats and human disturbance (e.g. Negro & Hiraldo 1993). Moreover, the preference of nest sites with SE exposition could be correlated to the predominant North-West direction of cold wind during the early stages of breeding. SE orientation could be an advantage for females needing a stable temperature for egg laying and incubation. An alternative explanation is that SE orientation of nest cavities implies longer time of solar radiation without suffering from direct radiations at the maximum radiation time (midday).

The composition of Jackdaw nesting areas differed from random plots mainly based on land cover variables, including the proportion of ruderal, garden, and meadow areas. Other important variables were tree height and percentage of oaks in each vegetation plot. Habitat diversity and fragmentation did not vary between nesting areas and random plots. Proportion of modern and old built-up habitats differed between nesting areas and random plots, likely indicating that Jackdaws selected those habitats which provide a quantity of nest sites in old buildings. Areas with interspersion of ruderal, old built-up, open areas, and small green areas seem to represent an optimal habitat configuration for urban Jackdaws, which avoided close vegetation of urban parks. These habitat preferences may account for the large distribution of Jackdaws in urban areas, even in the city centre.

The maintenance of relict open lands and ruderal habitats in the urban landscape seems useful to increase feeding areas near Jackdaw nesting areas. Moreover, Jackdaws are widely sensitive to nest site loss due to building repairing or reconstruction (Vogel 1990). Protection measures in cities should concentrate on nest site conservation in old buildings and ruins (e.g. Ramsden 1998) and on nest site (boxes, other cavities) installation on modern buildings.

ACKNOWLEDGEMENTS

C. Vogel and M. Vogrin discussed with me on the ecology of Jackdaw in Mediterranean areas.

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STRESZCZENIE

[Charakterystyka miejsc i środowisk lęgowych miejskiej populacji kawek w Rzymie]

Środowiska miejskie stwarzają kawce obfitość miejsc lęgowych, ale urbanizacja redukuje prze-

strzeń żerowisk (głównie użytków rolnych) i zmniejsza łączność między terenami odpowiednimi dla tych ptaków. W niektórych europejskich miastach populacje lęgowe kawki osiągają wysokie zagęszczenia. Środowisko miejskie stwarza zatem możliwość badania zależności tego gatunku, pierwotnie związanego z krajobrazem wiejskim, od fragmentacji i redukcji jego środowisk życiowych spowodowanych urbanizacją.

Badania były prowadzone w śródmieściu Rzymu, gdzie analizowano warunki na 20 terenach lęgowych kawki w porównaniu do 14 losowo wybranych terenów nielęgowych na tym samym obszarze. Środowisko każdego z terenów (lęgowych i nielęgowych) było analizowane w obrębie kolistej powierzchni próbnej o promieniu 300 m (28.8 ha). Na wszystkich tych powierzchniach zinwentaryzowano występowanie 25 składników środowiska (Tab. 2) od których mogło zależeć gnieżdżenie się kawki.

Zajęte gniazda (n = 41) znajdowały się głównie w zakamarkach starych budynków, na średniej wysokości 21.8 m (Tab. 1). Przeważał południowo-wschodni kierunek ekspozycji otworów miejsc gniazdowych, co mogło mieć związek z przewagą północno-zachodnich wiatrów w okresie zimowym (Fig. 1). Analiza wykazała, że występowanie lęgowe było uzależnione od ogólnej powierzchni terenów zielonych (TGA) oraz współwystępowania terenów ruderalnych (RUD), ogrodów (GAR) i zabudowy stwarzającej możliwości gnieżdżenia się (Tab. 2).