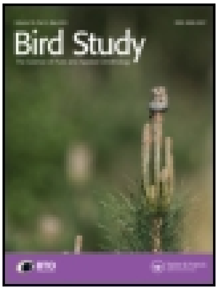

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Nest-site selection and nesting success in the Azure-winged Magpie in Central Spain

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Nest-site selection and nesting success in the Azure-winged Magpie in Central Spain

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Nest-site selection and nesting success in Azure-winged Magpies Cyanopica cyana *were studied in 1986 in central Spain. Preferred nest sites were a non-random subset of the available habitat. Nests built on evergreen trees had significantly earlier clutch initiation dates than those built on deciduous trees. Birds selected larger trees of each species for nesting, but nests built on very high trees had significantly lower nesting success. Birds tended to locate their nests in a central position relative to the canopy height and as far from the main trunk as possible, without being of the periphery. This may minimize nest accessibility and maximize concealment. Nesting success was higher in the preferred regions of the tree canopy. Predation and inclement weather were probably the factors selecting for the observed patterns in nest-site distribution.*

The Azure-winged Magpie *Cyanopica cyana* has two separate populations, in eastern Asia and in the Iberian Peninsula.[1] This extremely disjunct distribution, for which various contradictory explanations have been advanced,[2] poses interesting questions about the importance of habitat characteristics selected by this species. Nest-site selection is particularly closely related to fitness because it has obvious effects on offspring production.[3–5] As predation and weather are two primary causes of nesting mortality for most open-nesting passerine birds,[6] choice of habitat characteristics contributing to concealment and protection from adverse weather have presumably been paramount. Thus, we may expect to find that the preferred nest-sites are those in which success is highest.

In spite of the abundant literature on nest-site selection, relatively few studies deal with its relation to reproductive success.[5,7–14] In this paper we describe nest-site selection in Azure-winged Magpies in one of the areas of highest breeding density in Iberia.[15–18] The high population density may have forced some birds to occupy suboptimal nest-sites.[19] This feature, together with the relatively high rate of nest predation in our study area, provided an opportunity to study the effects of nest-site selection on nesting success. Previous descriptions of nest-sites of Azure-winged Magpies have been qualitative.[15–17,20] The objectives of this study were to document the physical characteristics of nest trees and nest-sites within the trees selected by the birds, and to examine possible relationships between nest-sites and nesting success.

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STUDY AREA AND METHODS

Data were collected in the Tiétar valley, 15 km SW of Candeleda (40°06′N, 05°17′W, about 300 m above sea level), in central Spain. The study area includes 160 ha of flat or very gently sloping ground, with open Holm Oak *Quercus rotundifolia* wood, some interspersed Cork Oak

Q. suber and a woodlot of Pyrennean Oak *Q. pyrenaica*. Ash *Fraxinus excelsior* grow along two streams that cross the area. Understory species include Hawthorn *Crataegus* spp., Blackberry *Rubus* spp., Cistus *Cistus ladaniferus* and saplings of the dominant tree species. Some parts are cultivated, mainly with oats *Avena sativa* and rye *Secale cereale*, the rest of the ground vegetation being pastureland devoted to sheep grazing. The climate is Mediterranean with hot dry summers and mild humid winters.

The area was visited every 5 days during April–July 1986. Each time we surveyed the whole area, locating trees with nests on aerial photographs and marking them individually with numbered tags. The selection of plant species used for nesting was compared with the frequency distribution of the various species in a random sample from the study area (χ^2 test). The characteristics of the nest site were studied only on Holm Oaks and Ash, which were the most commonly used species (78% of the nests). After the birds had left the nests we measured:

MXHT, maximum height;
MNHT, minimum height;
DTC, diameter of the tree canopy; and
TGC, type of ground cover (streams, margins, pasture land, ploughed fields, paths or bushes) under the tree, in samples of 54 Holm Oaks and 54 Ash trees with nests and 76 Holm Oaks and 14 Ash trees without nests. The latter were randomly selected from among the unused trees beside each tree with a nest. Nest sites were characterized using the following variables:

NH, nest height above the ground;
DTN, distance from nest to trunk;
DNP, distance to the perimeter of the tree canopy;
DB, diameter of the branch supporting the nest;
TB, type of branch supporting the nest (vertical, oblique, horizontal or hanging);
ORT, orientation of the nest relative to the trunk;
DNN, distance to the nearest nest;
DNT, distance to the nearest tree;
RHN, relative height of the nest within the canopy, i.e. RHN = (NH-MNHT)/(MXHT-MNHT), and
RDN, relative distance between nest and trunk (RDN = DTN / (DTN+DNP)).

All variables were transformed to obtain minimum skewness and kurtosis, and percentages were transformed using arcsin. Differences between the samples with and without nests were analysed using one-way ANOVAS. A possible preference in nest orientation was assessed with χ^2 and Rayleigh tests.[21] The selection of type of branch and type of ground cover were studied by χ^2-tests. To test whether RHN and RDN were randomly distributed. Kolmogorov–Smirnov one-sample tests were used, comparing the observed distributions with hypothetical uniform distribution of nests in 20 classes along RHN and RDN. We assumed that random distributions for these two variables were independent of the density of thin branches, provided that Azure-winged Magpies can nest anywhere inside the canopy and do not particularly need thin branches to build the nest.

Status and contents of each nest were recorded during each visit. To determine the laying date of the first egg we used only those nests found during the laying period, assuming that females lay one egg per day. We only considered as complete those clutches with at least four eggs, because this was the smallest clutch size producing fledged young. Eggs unhatched because of infertility or embryo death were grouped together. We found 163 nests, including those built but never containing eggs and those with incomplete clutches. Nests that fledged at least one young were considered successful. Unsuccessful nests were those found empty prior to expected hatching or fledging date. The success of 27 inaccessible nests could not be recorded. On several occasions, which were excluded from the analysis, the 5-day interval between visits was too long to assess the success of the nest.

The relationship between nest-site and breeding success was studied by comparing the 50% of the nests closest to the modal values for each of the nest-site characteristics in turn with the rest of the sample of nests. We used one-tailed Mann–Whitney *U*-tests to compare nest success, since our alternative to the null hypothesis was that nests placed around modal values were more successful. A high percentage of nest failures may be attributable to suboptimal nest-site selection. However, several other factors such as age and experience of the birds[3,22] and other social factors[23] may affect their breeding success. Thus, the differences in success between preferred sites and the rest will be subtle, at best. We therefore accepted the 0.10 significance level when testing these differences.[24–26]

RESULTS

Nest-site selection

Azure-winged Magpies built nests on several plant species, the difference between the sample of trees used and available being statistically significant ($\chi^2 = 168$, df = 5, $P < 0.001$). Birds clearly avoided bushes and preferred Ash trees for nesting (Table 1). Nesting density was 1.01 nests/ha, or 3.3 nests per 100 trees. The average nearest-neighbour distance between nests was 48.7 m, significantly lower in Ash than in Holm Oaks ($P < 0.001$, Table 2).

Characteristics of nest trees are shown in Table 2. Holm Oaks had significantly lower maximum height ($P < 0.001$) and greater diameter than Ash ($P < 0.05$), but did not differ in minimum canopy height. Distance to nearest tree was significantly shorter for Ash than for Holm Oaks ($P < 0.001$). The differences in diameter disappeared when considering the samples of trees with nests. Azure-winged Magpies selected larger trees of each species for nesting. There were no interactions between both classification factors (with nest versus random and Holm Oak *vs* Ash) for any of the 4 variables analysed (two-way ANOVA).

The most frequent ground covers were pasture under Holm Oak, and streams and their margins under Ash. Under Holm Oak with nests, however, pasture was less frequent ground cover, the difference between the samples of used and not used trees being

Table 1. Percentage of each species in the nest tree and random tree samples and relative number of nests for each tree species

Sample	*Holm Oak*	*Cork Oak*	*Pyrennean Oak*	*Ash*	*Bushes**	*Others†*	*Total* n
Nest trees	35.6	9.8	15.9	33.1	1.2	4.3	163
Random trees	35.7	1.8	6.9	13.9	38.0	3.7	4903

*Defined as less than 2.5 m high (mainly Blackberry and *Cistus*).
†Mainly Hawthorn.

Table 2. Characteristics of trees used and not used for nesting. All figures are metres. * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$

	Holm Oaks					*Ash*				
	Random (n = 76)		*With nest* (n = 53)			*Random* (n = 14)		*With nest* (n = 54)		
	Mean	*Se*	*Mean*	*Se*	P	*Mean*	*Se*	*Mean*	*Se*	P
MXHT	6.9	0.1	8.4	0.3	***	9.2	0.7	11.6	0.3	***
MNHT	1.7	0.1	2.0	0.1	**	1.5	0.3	1.8	0.1	ns
DTC	12.0	0.4	14.2	0.5	***	10.1	1.0	13.0	0.5	*
DNN	12.8	1.4†	66.6	7.6	***	2.3	0.4†	31.2	3.3	***

MXHT = maximum height of tree; MNHT = minimum height of tree; DTC = diameter of the tree canopy; DNN = distance to nearest nest.
†In the sample of random trees the distance to nearest tree (DNT) was used instead of DNN.

Table 3. Distribution of nests within the tree canopy and significance of the difference between observed distributions and even distributions (20 classes) (P, Kolmogorov–Smirnov test). Significance of the differences between tree species are also given (F). * = $P < 0.05$, *** = $P < 0.001$

	Holm Oak (n = 53)			Ash (n = 41)[†]			Differences between tree species	
	Mean	Se	P	Mean	Se	P	F	
RHN	0.54	0.03	***	0.43	0.03	***	6.2	*
RDN	0.80	0.03	***	0.69	0.05	***	4.7	*
ORT	13.8	76.1[‡]	ns	197.5	72.9	ns	—	—

RHN = relative height of the nest within the canopy; RDN = relative distance between nest and trunk; ORT = orientation, in degrees.
[†]The difference between this sample size and that of Table 2 was due to 13 nests having been destroyed before we could measure their variables.
[‡]Angular deviation (Batschelet, 1981).

significant only for Holm Oak ($\chi^2 = 54.2$, $P < 0.001$).

The mean absolute nest height was greater in Ash (6.12 m±0.33 se, $n = 54$) than in Holm Oak (5.27 m±0.20 se, $n = 53$) ($F_{1,93} = 5.27$, $P < 0.05$). However, the relative height of the nest within the tree canopy was greater in Holm Oak (Table 3). The absolute distance from trunk to nest did not differ between Holm Oak and Ash ($F_{1,93} = 0.98$, $P = 0.34$), whereas the distance from the nest to canopy perimeter was higher in Ash ($F_{1,93} = 5.52$, $P = 0.02$). Therefore, the relative distance from trunk to nest was higher in Holm Oak (Table 3). The frequency distribution of both relative height and relative distance differed significantly from random distributions: Azure-winged Magpies selected sites from the mid- to outer regions of the tree canopy, although they tended to avoid its periphery (Fig. 1).

We did not find selection of nest orientation relative to the trunk (Table 3). Nests were built on branches with an average diameter of 5.27 cm, with no significant differences between tree species ($F_{1,93} = 0.37$, $P > 0.05$). The branch supporting the nest was horizontal in 44% of the cases. The frequency distribution of types of branches supporting the nest (vertical, horizontal, oblique or hanging) was significantly different from 25% of each type only in Holm Oak ($\chi^2 = 25.6$, $P < 0.001$), in which more nests (53%) were built on horizontal branches. The frequency of nests built hanging from a branch was higher in Ash (28%) than in Holm Oaks (10%) ($\chi^2 = 5.2$, $P < 0,05$).

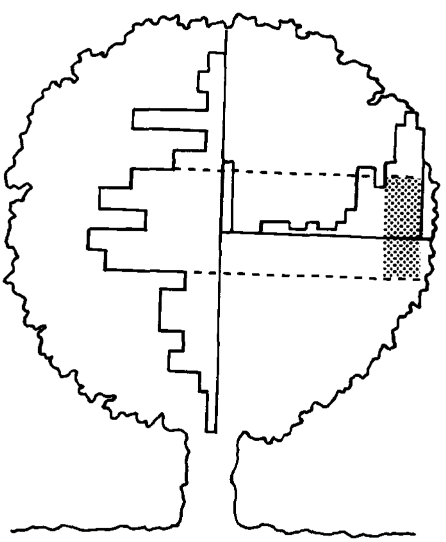

Figure 1. Frequency distributions of relative height of the nest and relative distance between nest and trunk within the tree canopy. Dotted lines delimit the modal values (see text) for each histogram. Their intersection (shaded area) corresponds to the zone preferred for nesting.

Relationships between nest-site selection and nest success

Nests built on evergreen trees (Holm and Cork Oak, $n = 20$) had significantly earlier clutch initiation dates (average 22 April) than those built on deciduous trees (Ash and Pyrennean Oak, $n = 19$; average 29 April) ($F_{1,38} = 4.65$, $P < 0.05$).

Table 4 shows the success of the nests placed around modal versus non-modal values for relative height (RHN), and relative distance between nest and trunk (RDN). Although clutch size was very similar or identical in modal nests and the rest ($P = 0.27$ for RHN, $P = 0.97$ for RDN), modal nests were more successful. The comparisons of orientation of the nest, diameter and type of the branch supporting the nest between modal and non-modal nests were all not significant.

We did not find a significant difference in nesting success related to the nest height above the ground ($P > 0.10$). The percentage of unsuccessful nests was significantly higher in Ash than in Holm Oak ($t = 2.60$, $n = 90$, $P < 0.02$).

DISCUSSION

Our results show that preferred nest-sites are a non-random subset of those available to Azure-winged Magpies. Birds tended to locate their nests in a central position relative to the canopy height and as far from the main trunk as possible, but not on the canopy periphery (Fig. 1). Because foliage is much denser in this part of the canopy, especially in Holm Oak, this may be a way to conceal the nest as much as possible against predators. Nests in the central zone of the canopy are more visible and accessible to ground predators. Peripheral locations are also vulnerable to flying predators and inclement weather. Nests located in a central position with respect to tree canopy height and on the outer half of the canopy were the most successful. Similar conclusions were found for Eastern Kingbirds *Tyrannus tyrannus*.[10]

As predation is the main cause of the 56% nest failure in our study area,[18] we suggest that predation pressure could be a major factor determining nest-site selection. Small to medium-sized mammals (e.g. Garden

Table 4. Relationship between nesting success and RHN and RDN. Both modal and non-modal classes include 50% of nests. $n = 50$ nests. † = $P < 0.10$; * = $P < 0.05$; *** = $P < 0.001$ (t-test for the first and second variable, χ^2 for the third)

	Relative height of the nest within the canopy			*Relative distance between nest and trunk*		
	Modal	*Non-modal*	P	*Modal*	*Non-modal*	P
Number of fledged young						
Mean	3.56	2.22	0.04*	3.83	2.44	0.06†
Se	0.55	0.61		0.68	0.51	
Nest success‡						
Mean	0.56	0.38	0.09†	0.61	0.40	0.06†
Se	0.08	0.10		0.10	0.08	
Successful nests/Total Nests§						
Mean	0.76	0.61	0.002***	0.72	0.64	ns

‡Number of young fledged divided by clutch size.
§This sample includes some inaccessible nests of unknown clutch size but whose outcome was certain.

Dormouse *Elyomis quercinus* and Genet *Genetta genetta*), reptiles (e.g. Montpellier Snake *Malpolon monspessulanus* and Ocellated Lizard *Lacerta lepida*) and birds (e.g. Magpie *Pica pica*) were the major potential nest predators in our study area. Azure-winged Magpies' nests are also sometimes parasitized by Common *Cuculus canorus* and Great Spotted Cuckoos *Clamator glanadarius* (J.A. Alonso *et al.*, pers. obs.).

We suggest that birds tended to place their nests in large trees as an additional way to conceal the nest, and enable the birds to nest high above the ground and far from the main trunk. That we did not find any trends relating nest success and absolute nest height supports our idea that selection of large trees is more related to maximizing nest concealment than increasing nest height.

Selection of large trees could be a reason for the high number of nests built on Ash, since these are on average taller than Holm Oaks. Loss of complete clutches and broods was higher on Ash, probably because of the lower protection provided by the lower foliage density and higher branch mobility. We suggest that Azure-winged Magpies counteract potential losses in Ash by decreasing both the relative distance from nest to trunk and the relative height of the nest within the tree canopy. Finally, later nesting on deciduous trees further supports the conclusion that nest concealment is the primary requirement related to nest-site selection.

We conclude that maximizing nest concealment is the most critical factor in the nest-site selection of Azure-winged Magpies. The same conclusion has been drawn from other studies.[5, 13, 27–29]

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