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ScienceDirect
Progress in Natural Science 19 (2009) 1253–1259
Progress in Natural Science
www.elsevier.com/locate/pnsc

Patterns of magpie nest utilization by a nesting raptor community in a secondary forest

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Received 9 January 2009; received in revised form 30 March 2009; accepted 31 March 2009

Abstract

For a total of 9 years, we examined the patterns of a nesting raptor community that utilized European Magpie (*Pica pica*) nests in the Zuojia Natural Reserve, northeast China. Eight raptor species and two other bird species were recorded nesting in magpie nests. The reuse rate of abandoned magpie nests was 51.6%, and the number of reused nests was positively correlated with their availability. Raptors utilized 83.3% of the reused abandoned magpie nests. Nests followed for more than 1 year were reused by raptors an average of 1.13 times. Interspecific nest usurpation was common, with 17.3% of new magpie nests being usurped by raptors, and four cases of usurpation occurred among different raptor species. At the community level, 8 of 11 raptor species took over magpie nests to breed in the study area, and 91.9% of their nests came from magpie nests. European Magpies represent the core species in the nest web of the local raptor community that utilizes magpie nests. At the forest stand level, closer proximity to forest edges and greater distances from occupied raptor nests were the best predictors of nest reuse. At the nest-site level, arbor density and canopy coverage were the best predictors of nest reuse.

Keywords: European Magpie; Nest reuse; Nest usurpation; Raptor community

1. Introduction

Nest sites are resources that have fundamental ecological consequences for individual fitness, population size, and community structure [1–5]. Some raptor species, like secondary cavity-nesting birds, do not build their own nests, but rely instead on ledges on cliffs [6,7], buildings [8,9], burrows [10,11], tree cavities [12–14] or on stick nests built by other bird species [15–19]. Consequently, the structure of raptor communities might be influenced by certain types of nest-site resources, such as the nests of European Magpies within their range.

European Magpies (referred to hereafter as magpies) occur throughout large parts of the Holarctic region [20,21]. They are long-lived, monogamous birds that breed once a year, but are able to lay a replacement clutch in response to nest depredation [21,22]. They typically build a new nest for each breeding attempt or use the same nest by adding new nest materials [22–24]. Magpie nests are usually covered by a dome-like canopy of sticks, with an entrance through an opening in the side of the nest [23,25,26]. Some studies demonstrate that higher quality magpie nests, such as large nests with integrated roofs, allow higher productivity by reducing nest predation, brood parasitism [27–30], and increasing clutch size [21,31].

Some raptors, including falcons and some owl species, use abandoned magpie nests or usurp new nests to breed [6,19,25,26,32–35]. Several studies indicate that raptors

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1002-0071/$ - see front matter © 2009 National Natural Science Foundation of China and Chinese Academy of Sciences. Published by Elsevier Limited and Science in China Press. All rights reserved.
doi:10.1016/j.pnsc.2009.03.006

prefer using abandoned magpie nests with roofs over those without roofs because roofed nests might provide better concealment and higher security [33,34,36]. Studies of some breeding falcon and owl species suggest that their breeding numbers were limited by lack of suitable nest sites and the shortage was due to territorial behavior in the vicinity of nests [15,37–39]. Also, ectoparasites may negatively affect the fitness of avian nestlings [40–42], and a greater preference for new magpie nests may be related to a relatively lower ectoparasite load compared with that of older magpie nests. Hence, by nesting in newer magpie nests, raptors might reduce immune response costs [19]. There is an extensive body of literature regarding raptors using other birds' nests. However, although magpie nests may be a critical resource for some species of nesting raptors, no studies on the patterns of raptors' use of magpie nests at the community level have been conducted.

Nest-site availability and patterns of nest use are key points for understanding the population and community ecology of raptors in natural forest ecosystems and may be useful in formulating plans for their conservation and management. In this paper, we report the results of a study regarding raptor utilization of magpie nests with the goal of developing a better understanding of the ecological role of magpies in structuring raptor communities in secondary forests.

2. Study area and methods

2.1. Study area

The study was conducted in the Zuojia Natural Reserve in northeast China. The Zuojia Natural Reserve runs from the eastern Changbai Mountains to the western plain (126°1′–127°2′N, 44°6′–45°5′E) and its elevation ranges from 200 to 530 m. The study area was approximately 748 ha. The region is subject to an eastern monsoon climate, characterized by hot, dry summers and cold, snowy winters. The vegetation within the study area was diverse although the existing forest was secondary. The most common trees in the study area were Mongolian oak (*Quercus mongolica*), Dahurian birch (*Betula davurica*), Manchurian linden (*Tilia mandschurica*), Japanese elm (*Ulmus davidiana var. japonica*), Scots pine (*Pinus sylvestris*), Korean larch (*Larix olgensis*), and Masson's pine (*Pinus massoniana*). The average age of the trees ranged from 40 to 50 years and the average height of the trees ranged from 12.7 to 16.2 m. Korean raspberry (*Rubus crataegifolius*), Dahurian rose (*Rosa dahurica*), Korean rose (*Rosa doreana*), Willowleaf spiraea (*Spiraea salicifolia*), Amur barberry (*Berberis amurensis*), Prickly rose (*Rosa acicularis*), Ural false spiraea (*Sorbaria sorbifolia*), Amur honeysuckle (*Lonicera maackii*), Manchur honeysuckle (*Lonicera ruprechtiana*), and Sakhalin honeysuckle (*Lonicera maximowiczii*) dominated the shrub layer. The study area was covered by approximately 35% open habitat and 65% forest habitat.

2.2. Survey methods

We monitored a nesting raptor community that utilized magpie nests to breed in Zuojia from 1996 to 2007, excluding the years 1997, 2001, and 2003. We marked all abandoned magpie nests on trees and on transmission tower platforms within the study area after defoliation each year, and checked those nests before the breeding season in the following year to assess their status. For magpie nests built in 1997, 2001, and 2003, we investigated only surviving nests in the subsequent breeding seasons. For new magpie nests, some were located before leaf-out, and the remainder was found and recorded when we revisited marked nests. We recorded all nest locations with a hand-held Global Positioning System (GPS) receiver with an accuracy range of <10 m.

We visited all old and new nests at least four times each year from early April to early July. We recorded all instances where nests became unavailable because the entire nest tree or the portion containing nests had fallen. When calculating nest recruitment, we did not include new nests that were destroyed before subsequent breeding seasons.

Nests located on thin trunks or branches that were inaccessible were considered to be used if we observed the presence of young or an adult in an incubation posture. If nests were within reach, we considered them used if we observed eggs or nestlings. We classified nests without any such evidence as unused. In addition to raptors, we also monitored nests occupied by other bird species such as magpies and Dollarbirds (*Eurystomus orientalis*) because those species may influence the availability and utilization of nests by raptors.

Besides magpie nests, we also monitored Eurasian Jay (*Garrulus glandarius*) nests and large, natural tree cavities with an entrance >10 cm in diameter and a depth of >15 cm below the entrance used by raptors within the study area. We located and monitored the Eurasian Jay nests using the same methods used to monitor magpie nests. We monitored seven large natural cavities over the study period; four were marked in 1996 by direct search during a study of secondary cavity-nesting birds [43] and three were located during the course of this field work. We used flashlights and mirrors to inspect large cavities to visually assess nesting status.

We did not include nests created prior to 1996 that were of unknown ages in the analysis of reuse rate by raptors. We used nests that survived and could be used by raptors or other birds, excluding nests in debris, to calculate the survival time of magpie nests. When analyzing the reuse rate of old magpie nests, we recorded new magpie nests surviving to the second breeding season as 1-year-old nests, those surviving to the third breeding season as 2-year-old nests, and so on.

The number of new magpie nests in 1997, 2001, and 2003 was estimated by using the number of nests that survived to the following year plus the annual loss of nests estimated from existing data. The estimated data were used for analyzing nest availability, recruitment, and loss.

To assess which variables at nest-site level were associated with nest reuse, we established 10 m radius circular plots centered at each nest tree. Within each plot the density, average diameter at breast height (DBH), average height, and canopy coverage of arbor were measured. We also measured several variables of the nests and nest trees, including nest height above ground, nest-tree DBH, canopy coverage above each nest, and distance to the forest edge. We visually estimated the canopy coverage above nests and canopy coverage of the 10 m radius plots using mean values of two independent estimates. The distance from the nests to the forest edge and distance from each nest to the nearest raptor nest was measured by using the navigation function of the GPS, and tree height and nest height above ground were measured using a laser rangefinder (4.5–720 m). To ascertain intraspecific and interspecific interactions, we recorded the distance to the nearest used nest of each species of raptor [44].

2.3. Data analysis

The relationship between the availability of magpie nests and use rate was analyzed using Spearman correlation coefficients. The backward stepwise logistic regression was used to evaluate which measured variables of nest, nest tree and nest site were associated with nest reuse [45]. Nine variables of 53 nests used by raptors and 42 unused nests were analyzed. Variables required a significance of 0.05 to enter and remain in the model. Independent sample t-tests were used to compare variables, which associated with nest reuse. A one-way ANOVA was used to determine differences of nest survival at different ages, and a χ^2 test was performed to determine the reuse rate of nests with different ages. We performed statistical tests with a two-tailed significance level of 0.05 by using SPSS for Windows version 13.0 (SPSS Science, Chicago, IL).

3. Results

3.1. Magpie nest availability, recruitment, and loss

We monitored 172 abandoned magpie nests of known age, 49 abandoned nests of unknown age, and 104 new nests over the study period. The average availability was 24.3 ± 6.0 nests per year (range = 17–34; $n = 12$). New magpie nests were produced at an annual rate of 11.2 ± 2.8 (range = 8–17; $n = 12$). Nest loss occurred at an annual rate of 11.2 ± 3.0 nests (range = 7–16; $n = 11$) (Fig. 1).

The average survival time of magpie nests after they were initially built was 3.1 ± 1.3 years (range = 1–5; $n = 80$). The survival rates of magpie nests at different ages varied ($F_{4,43} = 126.21$, $P < 0.0001$), and the survival rate decreased with increasing nest ages. For example, new

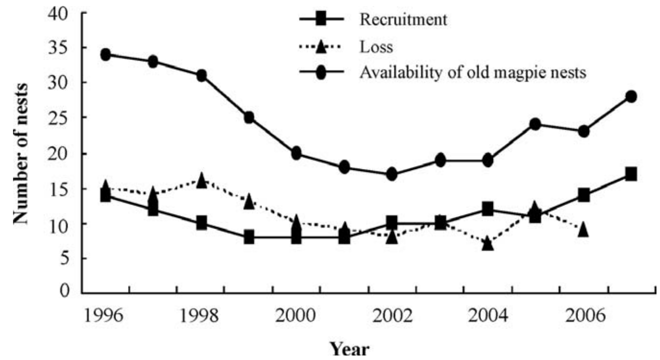

Fig. 1. The recruitment, loss and availability of magpie nests at the Zuojia Natural Reserve in Northeast China, 1996–2007.

nests had the highest survival rate (90.6%), while the survival rate was zero for 4-year-old nests.

3.2. Nest use

We recorded eight species of raptors and two other bird species nesting in magpie nests (Table 1). The reuse rate of abandoned magpie nests was 51.6%, and the number of reused nests was positively correlated with their availability ($r = 0.795$, $n = 9$, $P = 0.010$). Among reused abandoned nests, 83.3% were used by raptors and 16.7% were used by other bird species. In addition, 17.3% of new magpie nests were usurped by four species of raptors and 1.0% was usurped by Dollarbirds. Of the four species of raptors that usurped new magpie nests, the Eastern Red-footed Falcon (*Falco amurensis*) was dominant, followed by the Common Kestrel (*Falco tinnunculus*), Hobby (*Falco subbuteo*), and Long-eared Owl (*Asio otus*).

Rates of use of abandoned magpie nests by raptors varied with the ages of the nests ($\chi^2 = 41.701$, $df = 3$, $P < 0.0001$). Nesting raptors preferred using one and 2-year-old nests, with use rates of 51.3% and 42.1%, respectively (Table 1). Four-year-old nests were least likely to be used by raptors, with only two owl species occupying three of the 4-year-old nests. We monitored 63 abandoned magpie nests for at least 2 years (not sequentially) during the study, only one nest was reused by raptors three times, 26 nests were used twice, and 16 nests were used once. Nests followed for more than 1 year were reused by raptors for 1.13 ± 0.89 ($n = 63$) times on average.

At the community level, 8 out of 11 raptor species utilized magpie nests to breed in the study area, with 91.9% of their nests coming from magpie nests. The remainder was from Eurasian Jay nests, platforms on buildings, and large natural tree cavities. Three raptor species breeding in the study area were not observed to use magpie nests: Oriental scops Owls (*Otus sunia*) used natural tree cavities, whereas Besra Sparrow Hawks (*Accipiter virgatus*) and Eurasian Sparrow Hawks (*Accipiter nisus*) constructed nests. The number of nesting raptor pairs was positively correlated with the availability of magpie nests ($r = 0.810$, $n = 9$, $P = 0.008$).

Table 1
Different ages of magpie nests used by raptors and other species at the Zuojia Natural Reserve in Northeast China, 1996–2007 (except 1997, 2001, and 2003).

Species	Different ages of magpie nests (% of used)						Total pairs
	New $n = 104$	1-year-old $n = 78$	2-year-old $n = 57$	3-year-old $n = 26$	4-year-old $n = 11$	Unknown $n = 49$	
Raptor							
Eastern Red-footed Falcon	10.6	15.4	15.8	7.7	0.0	12.2	40
Common Kestrel	3.8	21.8	12.3	11.5	0.0	10.2	36
Grey-faced Buzzard	0.0	1.3	1.8	3.8	0.0	2.0	4
Northern Goshawk	0.0	0.0	1.8	3.8	0.0	0.0	2
Hobby	1.9	3.8	1.8	0.0	0.0	2.0	7
Long-eared Owl	1.0	7.7	7.0	7.7	18.2	8.2	19
Collared scops Owl	0.0	0.0	1.8	3.8	9.1	0.0	3
Northern eagle Owl	0.0	1.3	0.0	0.0	0.0	2.0	2
Total	17.3	51.3	42.1	38.5	27.3	36.7	113
Non-raptors							
Dollarbird	1.0	2.6	1.8	0.0	0.0	2.0	5
European Magpie	0.0	6.4	7.0	7.7	9.1	6.1	15
Total	1.0	9.0	8.8	7.7	9.1	8.2	20
Used	18.3	60.3	50.9	46.2	36.4	44.9	133

3.3. Interspecific and intraspecific interactions

We found that the phenomenon of nest usurpation among raptors and other bird species was common. Two reused nests of Long-eared Owls were usurped by Hobbies and Common Kestrels. Two nests occupied by Common Kestrels were usurped by Eastern Red-footed Falcons. Newly constructed magpie nests were also frequently usurped by raptors (Table 1). In addition, we often observed territorial fights among raptor species during this study. At least three abandoned nests of Long-eared Owls, three nests of Common Kestrels and one Eastern Red-footed Falcon nest should be considered abandoned due to territorial behavior. The aforementioned nests were abandoned after a more aggressive raptor species attempted to occupy a magpie nest or built nests nearby, such as the Grey-faced Buzzard (*Butastur indicus*), Northern Goshawk (*Accipiter gentilis*), and Besra Sparrow Hawk. The average distance between abandoned nests and subsequent nest location was 40.9 ± 24.2 m (range = 11–79 m; $n = 7$).

3.4. Nest, nest-tree and nest-site characteristics

Using backward stepwise logistic regression, we determined which suite of nest, nest-tree and nest-site characteristics best predicted nest reuse, distance to the forest edge (-2 log likelihood = 5.81, $P = 0.016$), distance to the nearest raptor nest (-2 log likelihood = 18.58, $P = 0.000$), arbor density of each 10 m radius plot (-2 log likelihood = 6.16, $P = 0.03$), and canopy coverage of each 10 m radius plot (-2 log likelihood = 11.92, $P = 0.001$) and which were significant predictors in the model. Used nests were closer to the forest edges, arbor density, and canopy coverage within a 10 m radius of used nests were greater than that of unused nests, and the nearest distance between unused and used raptor nests was significantly shorter than that between occupied raptor nests (Table 2).

4. Discussion

4.1. Nest availability

The availability of magpie nests varied significantly among years and depended on the number of magpies breeding in the previous year and the number of the nests that were destroyed or collapsed between breeding seasons. Magpie nests, as a type of nest resource, differ from other nest resources, because their survival time (3.1 ± 1.3 years) is shorter than other nest resources in forest ecosystems, such as the cavities of woodpeckers [45,46]. The short lifespan of magpie nests is primarily related to the composition of nest materials, because nest frameworks are composed of branches and sticks, which readily decay and fall apart. In this study, 62 of 97 recorded nest losses were caused by natural deterioration. Erpino reported that magpies occasionally take nest materials from old nests to

Table 2
Selected characteristics of nests that were used and not used by raptors at the Zuojia Nature Reserve in Northeast China.

	Used $N = 53$	Unused $N = 42$	t	p
Distance to forest edge (m)	70.94 ± 53.60	97.91 ± 77.72	-1.997	0.049
Distance to the nearest raptor nest (m)	151.06 ± 58.49	67.57 ± 44.69	-7.646	0.000
Arbor density within 10 m radius (trees/m^2)	0.15 ± 0.05	0.13 ± 0.04	-2.904	0.005
Canopy coverage of 10 m radius plots (%)	60.03 ± 9.45	51.49 ± 9.10	-4.444	0.000

construct new nests [25]. We found that magpies often dismantle old nests near newly built nests for nesting materials, and approximately 13 nests became unusable for this reason. In addition, strong winds and logging destroyed 7 new nests and 11 abandoned nests. Magpies breed once a year, but after a nest loss, they can lay a replacement clutch. A new nest is generally constructed for each breeding attempt, but old nests are sometimes used for replacement clutches after adding new material [22–25]. We recorded 15 abandoned magpie nests that were reused by magpies themselves. However, we could not confirm that all those reused nests were for replacement clutches, because at least six nests were reused early in the breeding season. Therefore, multiple factors influenced the availability of magpies in the area.

4.2. Nest use

The proportion of nests occupied by raptors and other birds varied between years in the area, but on average, only 51.6% of the nests that we judged as suitable in spring were actually used. Three potential factors may explain this observation.

First, attributes of a nest may become unsuitable, or the characteristics of a given nest may make it unacceptable to a particular species. Several studies have noted that raptors tend to select sites with maximum concealment. For example, kestrels and owls prefer abandoned magpie nests with a domed roof to those without a roof [33,34,47]. Also, owls select to nest in clumps of trees that provided more cover for nesting and roosting adults [17], and nests with a higher canopy offer additional concealment [47]. In this study, we found that arbor density and canopy coverage within a 10 m radius of plots centered on nest trees were significant predictors of nest use (Table 2) and higher arbor density and greater canopy coverage may provide concealment at the nest-site level. Some raptor species have been reported to use sites that offer a good view of surrounding terrain by selecting old nests of other species or building new nests in the upper reaches of large trees that emerge from the canopy [34,48,49]. Surprisingly, we did not find nest tree height and nest height to be significant contributing factors in regard to nest selection. Higher nests probably provide both good views of surrounding terrain and high risk of predator access to nests. However, the costs of selecting higher nests may outweigh the benefits. As results from prior studies have indicated, we found that raptors tend to select nests closer to the forest edge. Nests located close to woodland edges are probably located near favored foraging habitats and easily accessible nests [50–52] or reflected nest-site spatial distribution [17].

Second, nests may be unacceptable due to repeated use. The average reuse rate for nests followed for more than 1 year was 1.13 times in this study. Besides degradation from repeated use, nests may also have acquired large parasite populations. Reuse of nest sites leads to accumulation of ectoparasites [40,53–55]. A high density of ectoparasites in old nests may also explain why raptors preferred 1- and 2-year-old nests to 3- and 4-year-old magpie nests in this study.

Third, intraspecific and interspecific interactions among raptors may result in some nests being unusable because they fall within the territories of other raptors. Village suggested that the number of breeding kestrels was limited by lack of suitable nest sites and that the shortage was caused by the territorial behavior near potential nesting areas [15]. Territorial fights among raptors were often observed during this study, and the nearest distance between unused and used raptor nests was significantly shorter than the distance between raptor nests. Furthermore, seven occupied nests were deserted after a species of raptor with greater competitive ability occupied nearby magpie nests or built nests nearby. These observations suggest that true nest availability will be less than observed expected nest availability. Thus, a surplus of magpie nests in excess of expected raptor requirements is needed to support the maximum potential number of raptors.

Interspecific nest usurpation was frequently observed during this study, with 17.3% of new magpie nests being usurped by raptors. An extensive body of anecdotal literature on nest usurpation exists [19,56]. Prokop reported that 42% of new magpie nests were usurped by raptors [19]. Higher ectoparasite loads in old magpie nests and the availability of useable magpie nests may explain why kestrels invest time and energy in usurping newly constructed nests. Lindell stated that nest-site competition through usurpation may be more likely to occur in moderately open tropical habitats, due to the availability of enclosed nests, the limited structural heterogeneity of the vegetation, and the high diversity of potential nest competitors and predators [56]. In addition to these factors, we believe that nest usurpation may also be related to social cues derived from the behavior or the presence of other animals [57,58]. There is growing evidence that birds are able to monitor the current reproductive success of their neighbors when choosing subsequent breeding habitats or nest sites [58–60]. They might also dump eggs in the nest of successful conspecifics directly [61,62]. Therefore, it is possible that a breeding pair with greater competitive ability will usurp a nest that they have been monitoring.

A nest represents not only the concentration of building material but also the cost of construction. Magpies expend significant amounts of time and energy to build nests [26,63], and their old nests may remain in forest ecosystems for several years and be used multiple times. A wide variety of raptors and non-raptors exploit the new range of habitat niches created by magpies. We suggest that the raptor species diversity in secondary forest habitats is largely dependent upon the presence of magpies. Species that utilize magpie nests in secondary forest ecosystems constitute a structured community that interacts through the creation of and competition for nest sites. At the community level, 8 of 11 raptor species took over magpie nests to breed in our study area, and the number of nesting raptor pairs was positively correlated with the availability of magpie nests. Our results also supported the concept of a nest web structured around this central resource [64], and magpies represent the core species in the nest web of the local magpie nest utilizing raptor community. When assessing nesting habitat for raptors, resource managers should not overlook the availability of European Magpie nests because some local breeding raptor species may strongly depend on this nest resource.

Acknowledgements

This work was supported by the National Natural Science Foundation of China (Grant No. 30400047) and the Training Fund of the Northeast Normal University's Scientific Innovation Project (Grant No. 07013). The authors thank Mingyu Zhang, Wei Ou, Yonghong Pan, and Hanmei Sun for assistance in the field. We appreciate the improvements in English usage made by Jeff Lusk through the Association of Field Ornithologists' program of editorial assistance. Thanks also to X.Y. Gao and anonymous reviewers for providing comments to improve the article.

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