

## Interactions between ants and breeding Paridae in two distinct Corsican oak habitats

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**A b s t r a c t.** Insects and avian cavity-nesters share the same nest boxes in different oak habitat types on Corsica. The proportion of boxes occupied by ants did not differ between broad-leaf deciduous and evergreen oak woodland, but differed significantly between reproductive stages in two Paridae species. Different types of interactions between ants and avian hole-nesters are reported and discussed.

**Key words:** ant, *Crematogaster scutellaris*, Paridae, ant-bird interactions, Corsica

### Introduction

Different forms of interference or exploitation competition between avian species influence reproduction at ecological or evolutionary levels, and can vary spatially in relation to features of the habitat or the organisms involved (e.g. Dhondt 1977, Doutrelant et al. 2000, Wesolowski & Tomialojć 2005, Fontaine & Martin 2006, Rodriguez et al. 2007). Across-taxa interactions, including those between birds and various insects, can also be implicated in the expression of reproduction or other life-history traits (e.g. Loye & Zuk 1991, Clayton & Moore 1997). Interactions between birds and different species of ants can be costly and beneficial. Ants influence avian foraging behaviour (Haemig 1992, 1996) and success (Willis & Oniki 1978), or *vice versa* (Haemig 1997). Birds can exploit ants for feather maintenance or as food source (e.g. Judson & Bennett 1992). Ants sometimes have been reported to predate on bird chicks (Haemig 1999). Whether avian hole-nesters and ants share the same cavities and whether bird-ant interactions vary across habitat types, reproductive stages, or bird species, have been rarely investigated (e.g. Juškaitis 1995).

Different ant species, especially *Crematogaster scutellaris* (e.g. Soulié 1961), can explore or use avian nest boxes that were erected for breeding tits in the Mediterranean region (Touitou 2004). Here we explore with preliminary data potential consequences of the presence of these ants for nest box breeding blue (*Cyanistes caeruleus*) and great tits (*Parus major*) breeding in Downy (*Quercus humilis*) and Holm oak (*Q. ilex*) habitat on the island of Corsica.

### Material and Methods

Concrete avian nest boxes occupied by breeding blue and great tits and/or cavity exploring ants were visited following the basic protocols of the long-term monitoring program established in

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the Mediterranean region since 1976 (e.g. B l o n d e l & I s e n m a n n 1979, B l o n d e l et al. 2006). In the framework of this monitoring program, avian nest boxes were cleaned every year to protect breeding tits against other species occupying nest boxes (e.g. L a m b r e c h t s et al. 2007). Observers used twigs or leaves to remove old nest material or insects from nest boxes. Ants were removed during each nest box visit to reduce possible impacts of ants on breeding tits. Because tits may be sensitive to chemical changes in the nest (e.g. P e t i t et al. 2002), and to avoid possible negative consequences of pesticides on breeding tits, nest boxes were not chemically treated. Despite our efforts to remove ants from nest boxes, presence was often associated with large numbers of ants occupying either empty nest boxes or boxes used by breeding tits. Quantifying exact ant numbers was practically impossible, so our study only focuses on the presence versus absence of ants in avian nest boxes. Here we show data gathered in 11 broad-leaf deciduous and evergreen oak sub-plots distributed in mosaic in one valley (Muro) in Corsica (see L a m b r e c h t s et al. 2004 for details). Ants in nest boxes were reported by 23 different observers between 2000 and 2004 ( $8.2 \pm 2.6$  observers per season).

We analysed data gathered between 2000 and 2004, when the plots were checked at least once a week from prior to nesting till the tit chicks leave the nest, usually from March till June. Although nest boxes were cleaned after each breeding season, some boxes contained late tit nests that were still occupied after the monitoring period. Nest boxes containing old bird nests (i.e. from a former breeding season), or boxes occupied by mammalian hole-nesters (L a m b r e c h t s et al. 2007), were not considered in the analyses. For nest boxes in which ants were observed more than once during the same year (53.2% of the boxes occupied by ants), only the first ant observation in each box was selected for analysis. To increase sample sizes, data from sub-plots belonging to the same oak habitat type were lumped, and reproductive stages were subdivided into three periods, i.e. prior to egg laying (empty boxes or boxes with tit nests), during the egg and chick stage, and shortly after the chicks fledged. Tit species were always identified with certainty after egg hatching and adults were trapped on the nest when feeding chicks. We first tested whether the proportion of avian nest boxes containing ants differ between the two oak habitat types (Downy versus Holm oak) and the three reproductive stages defined using general linear mixed models (GLMMIX with binomial error and logit link function, Type 3) (SAS V9.1, Windows), also considering the interaction term in this analysis. In addition, we tested with a GLMMIX procedure the effect of oak habitat type on the proportion of nest boxes visited by ants more than once during a season. These analyses considered data from nest boxes without a bird nest, and nest boxes containing a nest without eggs, a nest with eggs for which the tit species was not identified with certainty, or a nest with nestlings for which the tit species was identified

**Table 1.** The percentage of avian nest boxes with ants for habitat dominated by broad-leaf deciduous Downy oak or evergreen Holm oak. The different reproductive stages indicated are before egg laying (empty box or nest), during breeding (nests with eggs or chicks), and shortly after chicks fledged. Between parentheses is the number of boxes monitored. More boxes were erected in downy oak habitat (see L a m b r e c h t s et al. 2004 and Methods).

Habitat type	Nest box type	% occupied
Holm oak (494)	Before eggs	14.6
	Eggs or chicks	6.7
	After fledging	1.6
Downy oak (579)	Before eggs	9.7
	Eggs or chicks	5.7
	After fledging	4.7

**Table 2.** The percentage of nest boxes with ants occupied by great or blue tits in two oak habitat types. The percentages are given for nests with chicks or empty nests shortly after fledging of chicks. Between parentheses is the number of boxes monitored. Breeding success was usually higher in downy oak habitat (see L a m b r e c h t s et al. 2004 and Methods).

Tit species	Habitat	Stage	% occupied
Blue tit	Holm oak	Chicks (236)	7.6
		After fledging (185)	3.2
	Downy oak	Chicks (351)	5.1
		After fledging (312)	9.9
Great tit	Holm oak	Chicks (49)	6.1
		After fledging (44)	9.1
	Downy oak	Chicks (68)	7.3
		After fledging (54)	16.7

(Table 1). Finally, we tested with a GLMMIX procedure, the effects of tit species (great tit versus blue tit), reproductive stage (nests with chicks versus the stage after chicks fledged) and their interactions on the proportion of avian boxes occupied by ants (Table 2). As the same nest boxes were monitored repeatedly each year of the study, this factor was included as a random term in these models. Sample sizes varied across habitat types or reproductive stages, because oak habitats or years varied in the number of nest boxes erected, in the number of nest boxes containing mammals or their nests, and/or in the number of nest boxes producing eggs or surviving chicks (e.g. see also L a m b r e c h t s et al. 2004, 2007). The statistically non-significant interaction terms between habitat type and reproductive stage are not presented.

## Results and Discussion

Despite our ant-removal procedures described above, ants were frequently reported in the nest boxes monitored, also during the breeding season (Tables 1, 2), suggesting ants were attracted to cavities shared with birds. The most frequent ant species observed was *C. scutellaris*. This species was identified in 86.2% of a sub-sample where ants have been described with phenotypic traits (see also S o u l i é 1961, C a g n i a n t 2005). Because we noticed that cavity-exploring ants can rapidly invade nest boxes in large numbers and sometimes found on bird eggs or chicks, cavities occupied by these ants may sometimes become unsuitable for breeding tits (see below). The occupation rate of avian nest boxes by ants could therefore be an important additional factor influencing breeding habitat quality in Paridae. However, in our study system, oak habitat type did not have a significant effect on the proportion of avian nest boxes explored by ants when all data were considered ( $F_{1,20}=0.22$ ,  $p=0.63$ , after controlling for reproductive stage and the interaction between habitat type and reproductive stage), or when only nest boxes producing chicks were selected for the analysis ( $F_{1,28}=0.00$ ,  $p=0.95$ , after controlling for tit species, reproductive stage, and their interactions). In addition, selecting only the boxes that have been occupied by ants for analysis, the proportion of nest boxes visited by ants more than once during a season did not differ between the two oak habitat types ( $F_{1,4}=0.09$ ,  $p=0.78$ ). The significant oak habitat type effect on tit breeding success previously reported in this Corsican landscape (L a m b r e c h t s et al. 2004) could therefore not be attributed to oak species related spatial variation in the level of competition between ants and avian cavity nesters.

Beginning in March, the activity of the ant *C. scutellaris* consists in part in digging the nest within the bark of various oak species (S o u l i é 1961, C a s e v i t z - W e u l e r s s e

1970, 1972). In this context, moving the nest in avian nest boxes or bird nests may be beneficial, because these boxes provide a lot of space for the ant colony. For instance, *Crematogaster* ants have been seen closing nest-box entrance holes after colonies settled in the boxes, making these cavities unsuitable for breeding tits. The interactions between ants and birds are probably determined by their encounter probability, which may differ temporally, perhaps because of micro-climatic or chemical fluctuations influencing ant activity (e.g. Schatz et al. 2003). For instance, increased spring temperatures may increase reproductive or other activities both in ants (Casevitz-Weulersse 1970) and in tits (e.g. Visser et al. 2004). In the analysis focusing on the whole data set, reproductive stage had a significant effect on the percentage of nest boxes containing ants ( $F_{2,20}=7.62$ ,  $p=0.0035$ , after controlling for oak habitat type), observing ants more often prior to the egg laying stage. Perhaps our ant-removal procedures efficiently reduced ant numbers during the egg laying and chick stages. In the analysis focusing on nests with chicks, a significant interaction was found between reproductive stage (with chicks versus after chicks fledged) and tit species ( $F_{1,28}=7.79$ ,  $p=0.0093$ , after controlling for oak habitat type), with a significant trend to find more ants in boxes occupied by great tits than by blue tits ( $F_{1,28}=10.74$ ,  $p=0.0028$ , after controlling for tit species, reproductive stage, and their interactions) (Table 2).

Based on own anecdotic observations in the Corsican study sites, foraging ants and tits seem to interact in different ways. For instance, food resources (e.g. proteins) produced by the birds or other occupants of these cavities may be exploited by ants foraging in nest boxes. *C. scutellaris* ants occasionally removed nest material from nest boxes. We occasionally observed this ant species attacking live chicks or predated on death chicks. Killed *C. scutellaris* ants were sometimes found at the edge of nests containing tit eggs or chicks, which indicates that cavity-nesting tits may protect themselves against foraging ants. In some occasions, we observed blue tit chicks been reared with success in the middle of an egg-producing colony of *C. scutellaris*. Previously described as predator of pollinating wasps (Schatz & Hossaert-Mckey 2003), *C. scutellaris* could easily capture various parasites. Perhaps the presence of ectoparasites in bird nests could be reduced by predation activity of *C. scutellaris* and by the effect of its alarm pheromone toxic and repellent towards different ant and invertebrate species (Marlier et al. 2004). Ants are known to attack potential bird parasites in avian systems not involving Paridae (e.g. Duffy 1991). Obviously, the different types of interactions between ants, ectoparasites attacking bird chicks (e.g. Hurrez-Bousès et al. 1997) and avian breeding success, and the avian chemical properties influencing bird-ant interactions, deserve more attention in future research not removing ants and other invertebrate species from nest boxes.

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