



## Research article

## Nest-site competition between invasive and native cavity nesting birds and its implication for conservation

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## ABSTRACT

Nesting cavities are often a limited resource that multiple species use. There is an ongoing discussion on whether invasive cavity nesting birds restrict the availability of this key limited resource. While the answer to this question has important conservation implications, little experimental work has been done to examine it. Here, we aimed to experimentally test whether alien cavity nesting birds affect the occupancy of cavities and the resulting breeding success of native cavity breeders in a large urban park located in Tel Aviv, Israel. Over three breeding seasons, we manipulated the entry size of nest boxes and compared the occupancy and breeding success of birds in nest boxes of two treatments. These included nest boxes with large-entrance and small-entrance holes. The large-entrance holes allowed access for both the native and invasive birds (the two main aliens in the park are the common mynas and rose-ringed parakeets). The smaller-entrance boxes, on the other hand, allowed only the smaller sized native cavity breeders (great tits and house sparrows) to enter the boxes but prevented the alien species from entering. We found that the large-entrance nest boxes were occupied by five different bird species, comprising three natives (great tit, house sparrow, Scops owl) and two invasive species (common myna, rose-ringed parakeet) while the small-entrance boxes were only occupied by the two native species. The alien common mynas and rose-ringed parakeets occupied 77.5% of the large-entrance nest boxes whereas native species, mainly great tits, occupied less than 9% of the large-entrance boxes and 36.5% of the small-entrance boxes. When examining the occupancy of those cavities that were not occupied by the aliens, natives occupied both the small and large-entrance nest boxes equally. Three quarters (78%) of the great tits breeding in the large-entrance boxes were usurped by common mynas during the breeding season and as a result breeding success was significantly lower for great tits breeding in the large-entrance boxes compared with the small-entrance boxes. The results of this study suggests that the invasive alien species can reduce the breeding potential of native cavity breeders both by exploiting the limited breeding resource (nest cavities) and by directly usurping cavities already occupied by the native species. Since the majority of large-entrance nest boxes were occupied by the larger alien birds, less native species bred in the limited number of unoccupied large-entrance nest boxes because of exploitation competition. We propose that for management purposes, nest-box programs that alter the entrance size of available natural cavities may be a practical approach, reducing the competition between native cavity breeders and alien invasive birds, and especially benefiting the smaller native cavity breeders.

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## 1. Introduction

Human-caused invasion of alien species has been suggested as one of the major factors leading to the rapid decline in native biodiversity (Dybas, 2004; McKinney and Lockwood, 1999). Alien species have wide-ranging economic, social health-related

(Pimentel et al., 2000) and ecological impacts (Lockwood and McKinney, 2002; Mack et al., 2000; Mooney and Hobbs, 2000; Simberloff, 2004; Shirley and Kark, 2009; Pimentel, 2011), and can transfer disease to humans as well as to domesticated and wild animals and plants (Altizer et al., 2003). After an alien species establishes itself, the damage to native biodiversity and to humans can be both difficult and expensive to mitigate. It is thus crucial to study alien species and to find practical ways to prevent, control, or at least retard, ongoing invasions using creative approaches that are both cost-effective and simple for managers to implement.

Alien invasive birds can negatively affect native species by a range of factors, such as predation (Elton, 1958; Moulton and Pimm, 1983; Simberloff and Boecklen, 1991; Duncan and Blackburn, 2004; Gurevitch and Padilla, 2004) and competition over resources. One of these factors is interspecific competition, which plays a major role in shaping ecological communities (Connell, 1983; Schoener, 1983; Roughgarden, 1983; Schluter, 2000; Dayan and Simberloff, 2005). Interspecific competition is mainly split into exploitation competition and interference competition (Case and Gilpin, 1974). Exploitation competition occurs indirectly through the use of a limited resource, which then becomes unavailable for other individuals (Minot and Perrins, 1986). Interference competition occurs when individuals prevent access to a limited resource through direct negative interactions such as aggressive acts (Wiens, 1989). Nest sites are one of the main limiting factors of population size for various secondary cavity breeding birds across a range of systems (Newton, 1994; Dhondt, 2011), and such sites are also used by many alien species.

Most studies dealing with nest-site competition between alien and native secondary cavity breeders have been observational (Pell and Tidemann, 1997; Harper et al., 2005; Hernández-Brito et al., 2014) rather than experimental (Strubbe and Matthysen, 2009). One of the limitations of observational studies seeking to study competition is that the less dominant species may be excluded and may therefore be missed entirely in the study, although they are central to testing exclusion by aliens. Experimental studies therefore have extra value in understanding the dynamics of the resource use. For example, Strubbe and Matthysen (2009) found a case of exploitation competition by experimentally blocking cavities used by the alien rose-necked parakeets in Belgium the previous year. The parakeets then switched to cavities previously occupied by the smaller native species, the nuthatches (*Sitta europaea*), thereby reducing the number of breeding attempts of the natives.

Two of the most successful alien birds globally, the common (Indian) myna (*Acridotheres tristis*; hereafter myna) and rose-necked parakeets (*Psittacula krameri*) are both cavity nesters. The common myna has been listed as one of the 100 worst (highest impact) alien invasive species globally by IUCN (Lowe et al., 2000). Mynas are very opportunistic birds when it comes to eating different types of food (Sol et al., 2012) and are known to cause damage to agriculture in their native India (Kale et al., 2012) and in several invaded areas. It has been suggested that the myna and ring-necked parakeets presence can lead to a decline in the breeding of native species (Feare and Craig, 1999; Blanvillain et al., 2003; Strubbe and Matthysen, 2007; Grarock et al., 2013a), because they breed in a variety of nest sites (Orchan et al., 2013) and in particular have been found to use nest cavities at high percentages (Pell and Tidemann, 1997; Harper et al., 2005; Orchan, 2007; Strubbe and Matthysen, 2009; Orchan et al., 2013). It is still unclear how much invasive species affect the occupation and breeding of other species (e.g., Strubbe and Matthysen, 2009; Grarock et al., 2013a).

The myna was first introduced into Israel in 1997 in the Yarkon Park in Tel Aviv (Holzapfel et al., 2006; Yom-Tov et al., 2012), and has an average weight of  $91.6 \pm 17.9$  g (Israel Bird Ringing Center). The rose-ringed parakeet (weight:  $137.5 \pm 23.3$  g, Israel Bird

Ringing Center) has been reported in the wild in Israel since as early as 1960 (Dvir, 1988), but expanded its range only in the 1980s (Shwartz et al., 2009). The house sparrow (*Passer domesticus*, average weight in Israel  $29.7 \pm 2.2$  g; Kobi Meryom unpublished data) and great tit (*Parus major*, average weight  $16.1 \pm 1.1$  g; Charter unpublished data) are the two most common native secondary cavity breeders in the Mediterranean ecosystem of Israel (Yavin, 1987; Charter et al., 2010; Yom-Tov et al., 2012) and both are significantly smaller than the two introduced species.

Nest predation of house sparrows and great tit nests in Israel by the two most common nest predators (black rats; *Rattus rattus* and Asian racer; *Coluber nummifer*) are rare (Charter, M., unpub. data). Since both predators are able to enter the smallest entrance nest cavities used for breeding birds, nest predation was probably not a major factor in shaping the evolution of nest site selection in Israel. In comparison, nest site competition between native species, both the inability of native cavity nesting species to breed due to lack of available nest sites (exploitation competition) (Charter et al., 2013; Goldshtein, 2013) and nest failure due to usurpation by larger native nest site competitors (interference competition) has been documented in Israel in areas without alien species (Charter et al., 2010a, Charter et al., 2013).

The two most common native cavity nesting species (house sparrow and great tit) are significantly smaller than the most common alien species (myna and rose-ringed parakeet). We therefore hypothesize that breeding of the native species may be limited due to the lack of nest sites resulting from both exploitation competition (cavities occupied by the alien species cannot be used by native species) and interference competition (alien species supplanting native species in the cavities). In this study, we aimed to experimentally examine the effect of cavity nesting alien bird species on the occupation of cavities and breeding success of native species, as well as to provide management recommendations for mitigating the impact of alien birds on native cavity breeders in the region.

We compared the occupancy of native birds in small vs. large-entry boxes. The alien birds in this system can only enter the larger entry boxes. We predicted that the number of native species breeding and the breeding success of the native birds would be higher in nest cavities that restrict the alien species from entering, thereby reducing nest site competition. Differences in the number of native breeding pairs in different nest boxes of different entry sizes may be due to a preference for a specific nest box entrance size (i.e. prefer one size entrance over the other) or to difference of availability of unoccupied nest boxes of a certain entrance size. Thus, our goal in this study was to use an experimental approach to examine whether invasive cavity nesting birds affect the breeding potential and success of native cavity breeders and to better understand their implications for conservation.

## 2. Methods

The study took place in the Yarkon Park in Tel Aviv ( $32^{\circ}02'N$ ,  $34^{\circ}47'E$ ), Israel's largest urban park, located in the northern area of the city along the Yarkon River and habitat to many alien avian species in Israel (Shwartz et al., 2009; Orchan et al., 2013). We placed nest boxes (20 cm W  $\times$  28 cm L  $\times$  36 cm H, wall thickness 17 mm) at 40–50 m intervals on eucalyptus trees (*Eucalyptus sp.*, the most common tree in the park) at a height of 3–4 m, using a ladder during October 2010. Similar-sized nest boxes were used to those that had been successfully used by native species (house sparrow, great tit, hoopoe *Upupa epops* and Scops owls *Otus scops*) in the area in Israel (Charter et al., 2008; M. Charter unpublished data). All nest boxes had an internal entrance size of 60 mm, while the external entrance holes could be adjusted to a size of either 60 mm (large entrance) or 39 mm (small entrance) using a small metal restrictor plate (Dhondt, 2011)

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