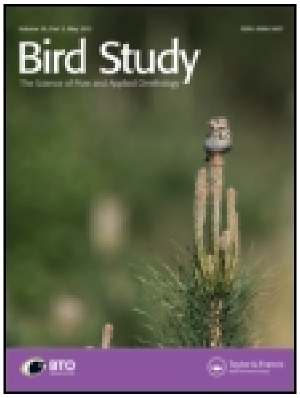

Bird Study
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tbis20

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Version of record first published: 27 Mar 2012.

To cite this article: Motti Charter, Yossi Leshem, Kobi Meyrom, Ori Peleg & Alexandre Roulin (2012): The importance of micro-habitat in the breeding of Barn Owls Tyto alba , Bird Study, 59:3, 368-371

To link to this article: http://dx.doi.org/10.1080/00063657.2012.669360

Bird Study (2012) **59**, 368–371

SHORT REPORT

The importance of micro-habitat in the breeding of Barn Owls *Tyto alba*

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Capsule Habitat parameters associated with 706 Barn Owl (*Tyto alba*) nesting boxes in Israel were analysed. Pairs bred in 259 of the boxes. The intensity of agricultural practices at nestbox sites were shown to have only a weak effect on aspects of Barn Owl breeding in this region.

The intensification of farming has been suggested to contribute to the decline of bird species in many countries (Benton *et al.* 2003, Billeter *et al.* 2008, Stoate *et al.* 2009), and notably in species exploiting the resources of farmlands (Donald *et al.* 2001, Newton 2004). Birds of prey, including owls, are no exception, and many conservation projects attempt to preserve native habitats and traditional farming.

Barn Owls *Tyto alba* are a model study species because they breed in open landscapes, sometimes at high densities, and their populations can be monitored easily using nestboxes. Barn Owls are distributed worldwide but populations are declining in many regions (BirdLife International 2004). Intensive farming is often cited as one of the reason for their decline (Taylor 1994). This is because less grain is left in the fields for small mammals to exploit than is the case with traditional farming. Furthermore, open grain stores are not used in intensive farming and these had once provided a dependable source of small mammals. There are also fewer borders and ditches available for rodents to exploit in the larger and homogenous fields (Shawyer 1987, Taylor 1994). Nonetheless, populations of Barn Owls can still be found in some intensively farmed areas provided that food is available in sufficient amounts and nest sites are available (Shawyer 1987, Taylor 1994). However, if intensive farming results in a loss of breeding sites and reduced food supply, Barn Owl populations will decline. In the mid-1990s the rapid introduction of field/waterway grass margins may have increased Barn Owl populations in some intensively farmed landscapes, but there still is a question of whether grass in these margins may be too high and thus prevents owls from catching rodents (Arlettaz et al. 2010). Due to a lack of studies, it remains unclear as to whether the change in farming practice is the real cause of this decline. Determining the cause, however, is problematic because it necessitates a comparison between the breeding parameters of owls in traditional and in intensive farming areas. Given that in most industrialized countries traditional farming has almost disappeared, it is still unclear whether variation in the degree of agricultural practice correlates with breeding parameters. This is an important issue, as it could inform appropriate conservation programmes aimed at the recovery of Barn Owl populations.

Here we studied a dense population of Barn Owls in a semi-arid region of the Middle East. Although farming practices have intensified here, as in Europe, the limiting factors for Barn Owls in the Middle East may be high temperatures (Charter *et al.* 2010), rather than the low temperatures associated with cold winters in Europe (Shawyer 1987, Altwegg *et al.* 2006). Barn Owls breed in the nestboxes that have been erected by farmers seeking to exploit the owls for rodent control (Meyrom *et al.* 2009). The effect of habitat on Barn Owl breeding has been studied mostly in Europe (Leech *at al.* 2009, Meek *et al.* 2009, Frey *et al.* 2011), and revealed very weak correlations between habitat characteristics and breeding parameters. This raises the question of whether the same applies in other climes, such as those in the Middle East. This is an important issue in determining whether findings for one

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Barn Owl population are applicable to other populations within their worldwide distribution.

The aim of the present study was to study Barn Owls in the Middle East and compare the results to research conducted in Europe (Leech *at al.* 2009, Meek *et al.* 2009, Frey *et al.* 2011). Specifically, we investigated whether the habitat surrounding nestboxes used by breeding Barn Owl pairs differs from the habitat surrounding unoccupied nestboxes, and whether reproductive parameters (i.e. laying date and number of fledglings) are associated with nestbox height, extent of arable fields, distance to closest road, and presence/absence of shade.

The study was carried out in 2011 in 8 study areas in Israel: the Hula Valley (33°70′N, 35°35′E), Golan Heights (32°52′N, 35°44′E), Lower Galilee (32°47′N, 35°17′E), Yavniel Valley (32°46′N, 35°28′E), Jezebel Valley (32°38′N, 35°18′E), Beit Shean Valley (32°30′N, 35°30′E), Judea (31°48′N, 34°49′E), and northern Negev (31°14′N, 34°42′E). We monitored 706 boxes fixed on poles, and obtained data on laying date (25 March ± 1.3 days; range: 7 February to 4 June) for 241 nests, and on number of nestlings (when the oldest nestling was 40 days old; 3.54 ± 0.14, range: 0–9) for 259 nests. Active nests were defined as a nest in which eggs were laid (Steenhof 1987). For each nestbox we recorded elevation (10.8 ± 7.7 m asl; range: −286 to 1043 m), measured the height of the nest boxes above the ground (2.69 ± 1.8 m; range: 1.55–5.0 m), the closest distance to roads (18 ± 2 m; range: 0–630 m), whether the nestbox was under shade ($n = 249$) or sun ($n = 454$; this variable was not recorded at three sites), and just before the breeding season we estimated the proportion of the habitat within a 300 m radius around each nestbox that comprised arable fields (wheat, alfalfa, corn, other crop; 43.4 ± 1.2 %; range: 0–100 %) versus natural fields, villages and date plantations. Statistical analyses were performed with the software JMP 8.0. Tests are two-tailed and P-values < 0.05 are considered significant. Means are quoted ± se.

In a logistic multiple regression analysis, we found that nestbox occupation differed between regions ($\chi^2_7 = 103.47$, $P < 0.0001$, Fig. 1) and was higher when boxes were located further away from roads than unoccupied boxes (22.9 ± 2.9 m versus 14.4 ± 2.6 m; same model: $\chi^2_1 = 4.30$, $P = 0.038$). In the same model, we also found that nestboxes were more often occupied when surrounded by many rather than few arable fields (46.8 ± 1.8 m versus 44.3 ± 1.6 m; $\chi^2_1 = 3.92$, $P = 0.048$); fixed at high rather than low heights above the ground (270.3 ± 4.2 cm versus 265.7 ± 2.4 cm; $\chi^2_1 = 31.30$, $P < 0.0001$); and located at a lower altitude (−62.5 ± 11.7 m versus 66.2 ± 11.3 m; $\chi^2_1 = 6.52$, $P = 0.01$). In the same model, shade had no significant effect on occupation probability ($\chi^2_1 = 0.18$, $P = 0.67$).

In a linear mixed model including region as a random factor, birds bred earlier at lower altitude ($F_{1,9.368} = 6.82$, $P = 0.027$), and when the nestbox was under shade rather than under sun (mean laying date is 21 March versus 26 March; $F_{1,253} = 4.42$, $P = 0.036$). The same model showed that laying date was not associated with distance between nestbox and closest road ($F_{1,245} = 0.01$, $P = 0.92$); nestbox height ($F_{1,197.6} = 0.04$, $P = 0.84$); and extent of arable fields ($F_{1,234.4} = 0.15$, $P = 0.70$). In the same model, the number of nestlings was not associated with elevation, extent of arable fields, distance to road, shade, and height (linear mixed-model with region as random variable, all P-values > 0.06) after controlling for date ($F_{1,208.6} = 66.74$, $P < 0.0001$, reproductive success decreased with date).

Barn Owls occupied nestboxes that featured a higher proportion of arable fields around them. Like many countries in the Middle East, in the past in Israel fields were previously semi-natural Mediterranean landscapes that were overgrazed by sheep and goats. During the past 60 years, however, agriculture has increased and become more intensive. Farmers have erected nestboxes for Barn Owls as a biological pest control method to reduce the number of rodent pests (Meyrom *et al.* 2009), and thereby reduce pesticide use. Even though many of the sites are located in semi-arid habitats, many fields are irrigated providing rodents with ample vegetation and seeds year round. The Barn Owls, therefore, have access to nest-sites and prey year round, with both considered the two most important factors for successful raptor populations (Newton 1979). Nestboxes in areas with more arable crops may be favoured due to more prey being available there, whereas non-arable fields may be too dry for many of the rodent species found in high numbers in agriculture (Tores & Yom-Tov 2003). The preference of Barn Owls to breed in arable fields may be because Barn Owl diet varies among microhabitats in Israel (Charter *et al.* 2009), with more Social Voles *Microtus socialis guentheri* found in arable fields. Voles are frequently considered the preferred prey of Barn Owls throughout most of their range (Taylor 1994).

Barn Owls bred more often in nestboxes away from rather than close to roads, as also found in Spain (Martinez & Zuberogoitia 2004), Switzerland (Frey *at al.* 2011) and the UK (Shawyer 1987, Shawyer & Dixon 1999). Roads may have a negative effect on Barn Owls due to both disturbance around the nest and traffic accidents (Taylor 1994, de Bruijn 1994, Roulin 2002). In

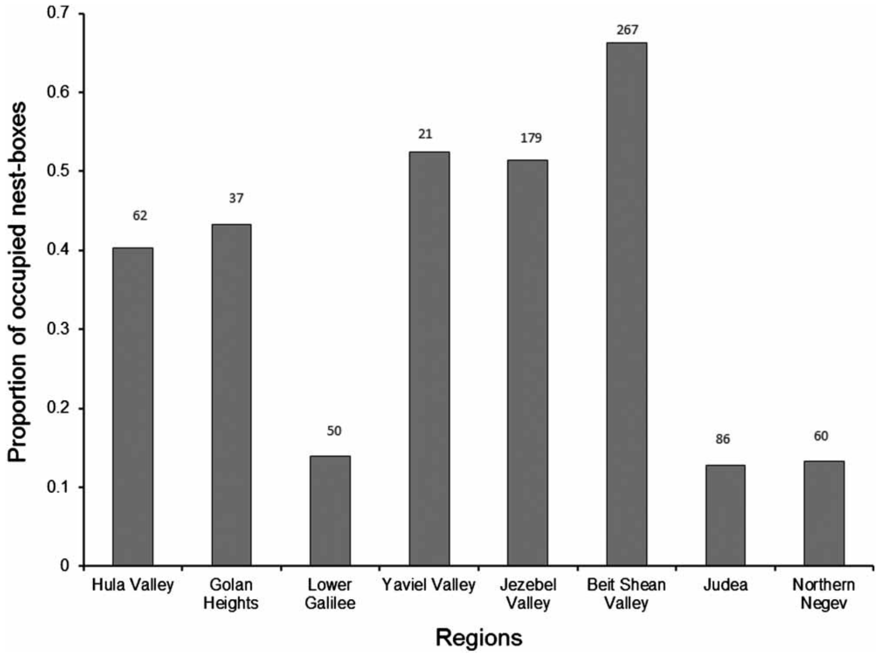

Figure 1. Proportion of nestboxes that were occupied in 2011 by a breeding Barn Owl pair in different regions in Israel. Numbers above bars indicate the number of boxes.

Israel, even though road casualties can be high (Charter unpubl. data), disturbances caused by cars, tractors and people around the nestboxes are probably more problematic because most nestboxes are located in proximity to some kind of road; the difference in distance is sometimes only metres to tens of metres.

More nestboxes were occupied when attached to high rather than short poles. Even though the difference in height of poles was not great, boxes on lower poles can be opened by a person without a ladder whereas those on higher poles are more difficult to reach and require a ladder. Similar to the proximity to roads, the risk of disturbance may be greater in lower than higher boxes, and therefore avoided. Another possibility is predation by mammals (Taylor 1994); in Israel, unlike Europe, however, there is no mammalian predator able to climb and, therefore, predation risk probably does not influence nest-site selection.

Even though lower altitudes have higher temperatures and less rain, Barn Owls occupied more nestboxes at lower than at higher altitudes. One possibility is that one of the three major prey species of Barn Owls in Israel, Tristram's Jird *Meriones tristames*, is found more in the hotter semi-arid environments (Charter unpubl. data) of low altitudes, in addition to the other two main prey species found in agriculture that occur at both low and high altitudes (Social Vole and House Mouse, *Mus musculus*). At lower altitudes the Barn Owls probably bred earlier than at higher altitudes, because spring starts earlier and rodents therefore reproduce earlier. Breeding earlier at lower altitudes has also been found in other bird species (Sanz 1998, Marchesi *et al.* 2002, Lu *et al.* 2010, Tieleman 2010).

Barn Owls initiated breeding earlier when boxes were shaded, possibly due to a preference for cooler nestboxes. Unlike the findings of Charter *et al.* (2010), no difference was found between breeding success of Barn Owls breeding in shade and other habitat variables. The much smaller sample size of the earlier study may have been the reason for the difference in results. Even though, as in Europe, climate and habitat may vary between locations, we found little evidence in the Middle East for the hypothesis that variation in habitat features surrounding the nestboxes explains variation in Barn Owl breeding performance (Frey *et al.* 2011, Meek *et al.* 2009). In contrast to those studies, Leech *et al.* (2009) found that Barn Owls were more successful in semi-natural than in arable fields. This suggests that in regions where agriculture is very intense, Barn Owls are equally successful in the different habitats; whereas in regions such as in the study by Leech *et al.* (2009), Barn Owls are more successful in habitats where human activities are less intensive. Indeed, the difference found in the studies may have been due to different methodologies. These findings are important in showing that in regions with highly intensive agricultural practices, most of the variation in reproductive success is caused by factors other than the habitat features that we measured around each nestbox, possibly that of prey availability (Arlettaz et al. 2010).

There is no conclusive evidence that Barn Owl decline in many countries is due to variation in intensive agriculture practices. Apart from the availability of breeding sites, micro-habitat seems to be important, as does local variation in food supply. More work is needed to consider specific micro-habitats, and also to study this species in other regions and determine whether habitat changes or other factors such as prey numbers and weather, combined or individually, are the reason for the population decline in this species. In addition to reproduction, future studies also need to determine the effect of habitat on adult survival (Altwegg et al. 2007).

ACKNOWLEDGEMENTS

We thank Shaul Aviel, Noam Weiss and Sameh Darahe for assistance in fieldwork; Gavin Siriwardena and Colin Shawyer for their comments on the text; and the Israel Hoopoe Foundation, Society for the Protection of Nature Israel, Israel Ministry of Agriculture and Israeli Ministry of Environmental Protection for funding. A. Roulin was supported by a grant from the Swiss National Science Foundation (3100AO_120517).

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(MS received 9 December 2011; revised MS accepted 21 February 2012)