האוניברסיטה העברית בירושלים
THE HEBREW UNIVERSITY OF JERUSALEM

EFFECT OF SUPLEMENTAL FEEDING ON NESTING SUCCESS IN THE LESSER KESTREL (FALCO NAUMANNI)

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Discussion Paper # 723 (September 2018)

מרכז פדרמן לחקר הרציונליות

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Effect of supplemental feeding on nesting success in the Lesser Kestrel (*Falco naumanni*)

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Abstract

The effect of food supplement to Lesser Kestrel (*Falco naumanni*) nests during the nestling period (from hatching to fledging) was studied in two nesting colonies in Israel – Alona and Jerusalem. Our hypothesis was that food supplement will have a greater effect on fledgling success in the food-limited, urban colony of Jerusalem, than in the rural colony of Alona. Indeed, food supplement had a significantly positive effect on breeding success in both colonies. However, and contrary to our prediction, the decrease in chick mortality between supplemented and control nests in Jerusalem was actually smaller than in Alona. This implies either that additional factors, possibly urbanization associated, other than food limitation, might be responsible for the difference in nesting success of Lesser Kestrels between Alona and Jerusalem, and/or that the amount of additional food provided to supplemented nests (three mice per chick per week), was not enough.

Key Words: Behavioral diversity; Breeding success; *Falco naumanni*; Lesser Kestrel; Nest productivity; Supplemental feeding; Urbanization effect

Introduction

The Lesser Kestrel (*Falco naumanni*) is a small falcon that breeds colonially and nests mainly in small cavities – on cliffs, on walls of abandoned quarries, under tiled roofs of rural and urban buildings, in barns and stables, or in old castles and churches (Cramp and Simmons 1980). It is a migrating species, breeding mainly in the Mediterranean and western and central Asia, and wintering mainly in sub-Saharan Africa. The European population suffered a rapid decline in the recent decades, and was declared as Vulnerable by the IUCN. Recent evidence, however, indicates a stable or slightly positive population trend overall during the last decade. Consequently it was downlisted from Vulnerable and now qualifies as Least Concern (IUCN 2018). The main cause for the past decline of the Lesser Kestrel population in its Palearctic breeding grounds has been habitat degradation, primarily because of agricultural intensification and the associated land use changes and the use of pesticides. Another cause is the loss of suitable breeding sites – the abandonment and collapse of old rural buildings on one hand, and restoration works of rural and urban buildings on the other hand (Iñigo & Barov 2011).

Liven-Schulman et al. (2004) conducted observations on Lesser Kestrels in three different breeding areas in Israel: a rural colony in the Alona district, an urban colony in Jerusalem and a cliff colony in the Judean desert (open-landscape colony) about 10 km east of Jerusalem. They found a significantly smaller mean fledgling number in Jerusalem, compared to the Judean desert and to Alona. They attributed this differential success to factors operating during the nestling phase – the lower success in Jerusalem is caused by the relatively long flight distances between the breeding and the main hunting sites (situated more than 10 km east of Jerusalem), and the use of pesticides in the city parks and lawns. A similar difference in mean fledgling number between Alona and Jerusalem was also reported by Bobek et al. (2018), who studied the effect of microclimatic conditions in the Lesser Kestrel nest on nest productivity.

In the present work we tried to learn if food limitation during the nestling period has an effect on the breeding success of Lesser Kestrels in two Israeli colonies, Alona and Jerusalem. More specifically, considering the findings of Schulman et al. (2004) and Bobek et al. (2018), we hypothesized that food supplement will have a greater effect on breeding success in the presumably more food-limited urban colony of Jerusalem than in the rural colony of Alona.

The effect of supplementary feeding during nesting has already been studied in several small raptors. Additional food provided to adult nesting Sparrowhawks (*Accipiter nisus*) during pre-laying and laying periods increased the numbers of eggs laid (Newton and Marquiss 1981). Feeding was stopped after clutch completion, and the fed birds subsequently showed no better hatching and fledging success than did unfed birds. Clutch size was larger and laying date was earlier also for Eurasian Kestrels (*Falco tinnunculus*) which received supplemental food during pre-laying period, compared to controls (Dijkstra et al. 1982). In the same species, food supplement during the post-hatching period until fledging increased fledging number in supplemented nests, compared to controls, not only in years of low but also in years of naturally higher food supply (Wiehn and Korpimäki 1997). Food supplement increased the number of fledglings in the Burrowing Owl (*Athene cunicularia*) by 47%, relative to control nests (Wellicome et al. 2013). The increase was contributed mainly to a lesser amount of chick starvation in the treatment nests, and was less evident in years of naturally higher food supply.

Methods

Study Area

The Lesser Kestrel is a summer visitor in Israel, arriving during the second half of February, and nesting usually terminates in early June. They breed in colonies, both adjacent to human settlements (rural and urban) and in the open country, where they are found usually on cliffs. Clutch size is between 3 to 6 eggs. The estimated breeding population in Israel is 364 pairs – 63% in rural settlements, 5% in urban and 32% in the open country, mostly in quarries (Perlman 2013). They feed almost exclusively on arthropods, mainly of the Coleoptera, Orthoptera and Solifugae orders, but also on reptiles and rodents (Kopij and Liven-Schulman 2012).

Observations were carried out in two colonies, each representing a different breeding area: (1) In the Alona Regional Council (32°34' N 35°01' E, 100 m above sea level), representing a rural colony. (2) In the city of Jerusalem (31°47' N 35°13' E, 800 m above sea level), representing an urban colony.

Observations

Observations took place during 2001–2004. We started by following 60 nests, 37 in Alona and 23 in Jerusalem. Out of these, 15 nests (12 in Alona and 3 in Jerusalem) failed as a result of factors not related to food shortage (e.g. eggs that did not hatch, nest predation or heat shock). The surviving nests (26 in Alona and 20 in Jerusalem) were divided into two groups: 19 nests received a supplement of food during the period from hatching to fledging, and 27 nests served as controls. The supplement consisted of 3 thawed laboratory mice (each measuring 6 cm without the tail) per chick per week, and was placed next to the nest entrance. The number of eggs laid, the number of eggs that hatched and the number of chicks that fledged were recorded for each nest (Table 1).

Table 1. Number of eggs, number of hatchlings and number of fledglings in each nest

Year	Colony	Treatment	Eggs	Hatched	Fledged
2001	Alona	Control	3	3	0
2001	Alona	Control	4	4	3
2001	Alona	Control	5	1	0
2001	Alona	Control	5	3	3
2001	Alona	Control	5	4	0
2001	Alona	Control	5	4	4
2001	Alona	Control	5	5	4
2001	Alona	Control	6	3	N/A
2001	Jerusalem	Supplement	N/A	3	2
2001	Jerusalem	Supplement	N/A	4	3
2001	Jerusalem	Control	5	2	2
2001	Jerusalem	Control	5	4	1
2001	Jerusalem	Control	7	3	1
2001	Jerusalem	Control	N/A	1	0
2002	Alona	Control	5	3	2
2002	Alona	Control	5	5	0
2002	Alona	Control	5	5	0
2002	Alona	Control	5	5	5
2002	Jerusalem	Supplement	4	4	3
2002	Jerusalem	Control	3	1	1
2003	Alona	Supplement	4	4	4
2003	Alona	Supplement	5	5	5
2003	Alona	Control	5	4	3
2003	Alona	Control	5	5	5
2003	Jerusalem	Supplement	5	3	2
2003	Jerusalem	Supplement	5	4	3
2003	Jerusalem	Control	4	4	2
2003	Jerusalem	Control	5	5	2
2003	Jerusalem	Control	8	3	3
2004	Alona	Supplement	4	2	2
2004	Alona	Supplement	4	3	3
2004	Alona	Supplement	4	3	3
2004	Alona	Supplement	5	4	4
2004	Alona	Supplement	5	4	4
2004	Alona	Supplement	5	5	5
2004	Alona	Supplement	6	5	5
2004	Alona	Supplement	6	5	5
2004	Alona	Control	4	1	0
2004	Alona	Control	4	3	3
2004	Jerusalem	Supplement	4	2	1
2004	Jerusalem	Supplement	4	3	3
2004	Jerusalem	Supplement	5	4	2
2004	Jerusalem	Supplement	6	4	2
2004	Jerusalem	Control	5	4	1
2004	Jerusalem	Control	5	4	1
2004	Jerusalem	Control	5	4	1

Statistical analysis

We used a generalized linear mixed model (GLMM) for testing the effect of Colony (Alona vs. Jerusalem) and Treatment (food supplement vs. control) on four measures of nesting success: Eggs (the number of eggs laid in the nest), Hatchlings (the number of eggs that hatched), Fledglings (the number of chicks that successfully fledged off the nest) and Chick Mortality (the number of hatchlings that did not survive). Colony and Treatment (with Colony×Treatment interaction) were considered as fixed effects and Year as a random effect, with Poisson distributed target variables (each of the nesting success measures mentioned above).

Results

Eggs

The Poisson distributed target variable was the number of eggs minus 3. We found no effect of Colony ($F_{1,38}$ = 0.265, P = 0.610) and no effect of Treatment ($F_{1,38}$ = 0.164, P = 0.688) on the number of eggs laid in a nest, and no interaction between Colony and Treatment ($F_{1,38}$ = 0.507, P = 0.481).

Hatchlings

We found no effect of Colony ($F_{1,41}$ = 0.822, P = 0.370) and no effect of Treatment ($F_{1,41}$ = 0.270, P = 0.606) on the number of eggs that hatched in a nest, and no interaction between Colony and Treatment ($F_{1,41}$ = 0.004, P = 0.951).

Fledglings

We found a significant effect of Colony on the number of chicks that successfully fledged from the nest: Alona 3.099 ± 0.414 (mean ± se), Jerusalem 1.837 ± 0.358,

$F_{1,41}$ = 6.941, P = 0.012; a significant effect of Treatment: supplement 3.213 ± 0.460, control 1.723 ± 0.313, $F_{1,41}$ = 8.900, P = 0.005; and no interaction between Colony and Treatment: $F_{1,41}$ = 0.805, P = 0.375.

Chick Mortality

We found a significant effect of Colony on the number of hatchlings that did not survive to fledging: Alona 0.767 ± 0.160, Jerusalem 1.465 ± 0.269, $F_{1,39}$ = 4.985, P = 0.031; a significant effect of Treatment: supplement 0.556 ± 0.176, control 1.676 ± 0.259, $F_{1,39}$ = 12.840, P = 0.001; and no interaction between Colony and Treatment: $F_{1,39}$ = 1.746, P = 0.194.

Our hypothesis was that food supplement would have a greater effect on breeding success in Jerusalem than in Alona. Nevertheless, contrary to our prediction, we found that supplemented nests in Alona had a mean decrease in mortality of 1.533 chicks per nest (compared to control nests), whereas in Jerusalem the mean decrease was only 0.707 chicks per nest.

Discussion

We studied two different Lesser Kestrel colonies in Israel: a rural colony in Alona district and an urban colony in Jerusalem, and found a significantly smaller fledgling success (per successful nest) in Jerusalem than in Alona. These findings substantiate those of the studies of Liven-Schulman et al. (2004) and of Bobek et al. (2018), which were conducted in the same colonies.

The main objective of our work was to analyze the effect of food supplement during the nestling period (from hatching to fledging) in these two colonies. Our hypothesis was that food supplement will have a greater effect on fledgling success in the presumed food-limited colony of Jerusalem than in Alona. Indeed, food supplement had a significantly positive effect on nesting success – supplemented nests had a greater mean fledgling number and a smaller chick mortality. However, and contrary to our prediction, the decrease in chick mortality between supplemented and control nests in Jerusalem was actually smaller than in Alona.

This finding might suggest that additional, possibly urbanization associated factors other than food limitation, can be responsible for the difference in nesting success of Lesser Kestrels between Alona and Jerusalem. Such factors can be the use of pesticides (mainly Diazinon) against mole-crickets *Gryllotalpa gryllotalpa* in the city parks and lawns, which negatively affects kestrels' activity. Another possible factor pertains to nest microclimate. Bobek et al. (2018) demonstrated the effect of microclimate conditions on nesting success, in particular the negative effect of extensive low humidity on nest productivity. The greater success of the Alona nests was attributed to the dryer conditions within the Jerusalem nests. From Bobek (2005) data, the percent of time during which humidity within the Jerusalem nests was below a certain low threshold, was almost five times larger than within the Alona nests.

A third possibility is that the amount of additional food provided to supplemented nests in our study was not enough. This possibility resembles the findings of Wiehn and Korpimäki (1997), where additional food to Eurasian Kestrel nests increased fledging number also in years of naturally high food supply.

Advocating the use of supplemental feeding during the nesting phase of Lesser Kestrels can gain support from many such examples. Yom-Tov (1974) reported an increased fledging success in nests of Carrion Crows (*Corvus corone*) where additional food was supplemented along the entire nesting period (including the nestling phase). Likewise, additional food supplemented during the entire nesting period (including the nestling phase) enhanced fledging success in Jackdaws (*Corvus monedula*) (Soler and Soler 1996) and Black-billed Magpies (*Pica hudsonia*) (Dhindsa and Boag 1989). In many areas, scavengers' survival is facilitated by supplementary feeding stations ('vulture restaurants'), which supply carrion where natural carrion has diminished or where modern agriculture, accompanied by sanitary measures, prevent scavengers' access to carrion (Terrasse 1985, Brown 1991, Mundy et al. 1992, Gilbert et al. 2007, Margalida 2010, Krüger 2014).

In addition to facilitating breeding success of target species, the negative aspects of food supplementation should not be ignored, and supplementation should be done with caution. These include: retarding the development of normal wide-range foraging behavior, altering time and energy budgets, and making birds prone to habituation to humans, which adversely affects other natural behaviors, thus restricting behavioral diversity (e.g. the California Condor *Gymnogyps californianus* – Walters et al. 2010). In addition, food supplementation can increase the abundance of other, non-target, species (Yarnell et al. 2014), or attract facultative scavengers that could predate on species living in the surroundings (Cortés-Avizanda et al. 2009). Other negative consequences can result from large aggregations of individual birds, such as the disruption of intraguild processes and the promotion of density-dependent decreases in productivity (Cortés-Avizanda et al. 2016).

While feeding kestrels near their nests is technically different from vulture restaurants, and the side effects of food supplementation may differ between species and community structures, some ecological repercussions of supplementary feeding are similar. Thus, as Moreno-Opo et al. (2015) recommend, the management of supplementary sites should be optimized from an ecological and conservation perspective, and be tailored to the specific target species needs.

Acknowledgements

We thank Bill Woodley and Igal Miller, The Society for the Protection of Nature in Israel, Israel Nature and Parks Authority and the Tisch Family Zoological Garden in Jerusalem for their help. We thank the Shulov Fund for a student's research grant (provided to A.G. by the Tisch Family Zoological Garden in Jerusalem).

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