

Effects of daily nest monitoring on predation rate – an artificial nest experiment

Kornélia KURUCZ^{1,*}, Péter BATÁRY², Krisztián FRANK¹ and Jenő J. PURGER¹

1. Department of Ecology, Institute of Biology, Faculty of Sciences, University of Pécs, H-7624 Pécs, Hungary.

2. Agroecology, Georg-August University, D-37077 Göttingen, Germany.

* Corresponding author, K. Kurucz, e-mail: kornelia.kurucz@gmail.com

Received: 01. September 2014 / Accepted: 15. December 2014 / Available online: 03. August 2015 / Printed: December 2015

Abstract. Nest predation studies provide important information about breeding success and predators, but the frequent monitoring of nests can influence survival rate, and disturbance-sensitive species may then abandon their nests. Since artificial nests provide an alternative tool to investigate nest predation rates and to roughly identify predators, we studied the potential negative effects of nest monitoring using artificial ground and shrub nests applying a visit/non-visit procedure in May and June. The nest predation rate was independent of month or disturbance alone, but it did depend on their interaction and on the nest type. The predator assemblages of the two nest types were different: ground nests were discovered mainly by mammals, but shrub nests by birds. Disturbance influenced the predation rate inversely in the two months, and had contradicting effects on the nest survival of both ground and shrub nests in our study, which phenomena was highly weather dependent. If possible we should avoid daily visits to nests, because frequent disturbance might bias the result of nest predation studies either positively or negatively and also threaten the breeding success of the real nests by affecting nest survival rates.

Key words: artificial nests, disturbance, Hungary, plasticine eggs, predation.

Introduction

The reproductive success of birds is mostly influenced by nest predation (Ricklefs 1969), which can affect the structure of bird communities, the selection of their habitats and nesting sites, and thereby the development of their populations' space-time dynamics (Söderström et al. 1998, Weatherhead & Blouin-Demers 2004). Hence, studying nest predation is important for landscape ecology, reproduction biology and also for conservation biology. Most nest predation studies are useful in estimating the threats to bird populations. Information gained regarding the predators from these studies may help researchers and conservation practitioners to manage effective conservation steps for maintaining bird populations (Major 1990, Martin 1993). Studies on real nests involve many difficulties; therefore, artificial nests with real and/or artificial eggs are an alternative, and a useful tool to represent trends in the nest predation rates, and to roughly identify predators (Bayne & Hobson 1999, Purger et al. 2004, Batáry & Báldi 2005, Kurucz et al. 2012). A great advantage of artificial nests is that one does not disturb the real nests or the breeding birds (Moore & Robinson 2004). Nevertheless, the reliability of artificial nests and eggs is often debated because they do not stimulate the same tactile-, visual- and olfactory reaction from

the predators as the real nests or real eggs. The existing comparative studies have led to contradictory results. Some have shown higher predation levels on artificial nests than on real nests (e.g., Berry & Lill 2003, Batáry & Báldi 2004, Lindell et al. 2004). However, there are studies that have shown the opposite results, i.e. higher predation on the real than on the artificial nests (e.g., Ortega et al. 1998, Robel et al. 2003, Colombelli-Négrel & Kleindorfer 2009), or those, which did not find any effect of nest type (e.g., Cresswell 1997, Butler & Rotella 1998, Grégoire et al. 2003, Kurucz et al. 2012). Predation rates can differ because different species of predators prey on real and artificial nests (Haskell 1995, Ortega et al. 1998, Davison & Bollinger 2000). Based on Major and Kendal's review (1996), in 70% of the cases predation rates on artificial nests were higher than on real nests. At the same time, for comparative purposes (i.e. for comparing different management types or different habitats or nesting sites) artificial nest experiments can be an appropriate and easy-to-use method. Namely, if the predation rates of the real nests were higher in a habitat, then the predation rates of the artificial nests were also higher (Major & Kendal 1996). Despite all the criticism, this method remains widely used because of its simplicity and advantage in conserving predator marks (Moore & Robinson 2004).

There can be important differences between the predation rates of the examined species, habitats and even between studies. Moreover, other factors affecting nest survival also need to be considered (Belthoff 2005). One such a factor is human disturbance resulting from frequent nest monitoring, but the presence of the researcher(s) can be also important. In studies on human disturbance effects, a prime focus of attention has been the effect on avian breeding success. Many studies have documented the negative effects (e.g., Bolduc & Guillemette 2003, Beale & Monaghan 2004, Medeiros et al. 2007), but few have attempted to explore in detail the relationship between visitor pressure and reproductive success, and even fewer still have so far attempted to understand why humans affect birds in the first place.

Nest survival usually varies during the breeding season (Martin 1988). As the breeding season proceeds, the predation pressure on bird nests generally increases (Ludvig et al. 1995, Batáry et al. 2004). This depends on the degree of nest concealment and predator activity (Wysocki 2005). In a former study, we showed that the survival probabilities of artificial shrub nests exposed in April were greater than those exposed in June (Kurucz et al. 2010).

Ground and shrub nests are thought to be visited by different predators (Ludwig et al. 2012), which might react in a different way to human presence or disturbance. On the one hand, frequent monitoring can attract the predators' attention (Vacca & Handel 1988, Beale & Monaghan 2004, Medeiros et al. 2007), and on the other, it might frighten them away (Götmark 1992, Ibáñez-Álamo et al. 2012). This involves the different survival probabilities of ground and shrub nests.

In this study, the effect of daily human disturbance (i.e. frequency of nest control) on nest survival probabilities was analysed during the breeding season using artificial nests. We aimed to answer the following questions: 1) Are there any differences between the survival rates of daily controlled and undisturbed nests? 2) Is there any change in this effect over time? 3) How does the position (ground vs. shrub nest) and visibility of the nests influence their predation rates? 4) Does the predator community of the artificial nests change due to disturbance (human presence)?

Materials and methods

Our study area was situated on the southern slope of the Mecsek Mountains, close to the north-eastern outskirts of the city of Pécs, in southern Hungary (46° 06' 58.28" N, 18° 13' 47.65" E). The Sub-Mediterranean climate influences the Mecsek Mts, so the mean annual precipitation is 710 mm and the mean annual temperature is 10 °C. Intensive opencast coal mining in Mecsek Mts lasted from 1968 to 1996. Following recultivation, the area was overgrown with herbaceous vegetation and the study area was planted with various tree saplings such as; mainly non-native oleaster *Elaeagnus angustifolia* and black locust *Robinia pseudoacacia*. The recultivated area is surrounded by native turkey oak forests *Potentillo micranthae* – *Quercetum dalechampii* from the east, north and west (Purger et al. 2004). The experiment was performed along these forest edges. The canopy layer consisted of pedunculate oak *Quercus robur*, sessile oak *Q. petraea*, silver lime *Tilia tomentosa*, common ash *Fraxinus excelsior*, manna ash *F. ornus* and common hornbeam *Carpinus betulus*. The shrub layer was composed of oak seedlings, black locust, dog rose *Rosa canina*, single-seeded hawthorn *Crataegus monogyna*, wild cherry *Cerasus avium*, European wild pear *Pyrus pyraster*, and European dewberry *Rubus caesius* bushes.

Along these forest edges in May (the middle of the breeding season) 2010, we designated ten spatially independent, 100 m long transects, with 100 m distance between the neighbouring transects (Appendix 1.). In each transect we exposed five ground and shrub nests in a varying order, which were ten meters apart from each other. The distance between the two nests of the same type was thus, 20 m. The artificial ground nests were formed by creating a depression in the soil using our heels (Marini et al. 1995, Fenske-Crawford & Niemi 1997), but we did not use any material for the nest itself. The artificial shrub nests, which were created by forming cup shapes (12 cm in diameter and 6 cm in deep) from fine wire mesh, were attached to the foliage using wires, and finally alined with grass and leaf litter (Bayne & Hobbs 1999, Melampy et al. 1999). The height of the shrub nest locations was 133 cm (1SE: 4). Each artificial nest contained one quail and one plasticine egg of the same size (Kurucz et al. 2010), which were aerated at least for one week prior to the beginning of the experiment (Bayne & Hobson 1997, Purger et al. 2004). We examined every second transect daily for seven days (disturbed) at the same time, (16:00-20:00) while the nests of the other five transects remained undisturbed from the start until the last exposure day (the seventh day). The study was repeated in June (the end of the breeding season), but this time we exchanged the sites of the ground and shrub nests as well as the disturbed and undisturbed transects. We considered a nest to be predated if any of the eggs were either damaged or missing (Trnka et al. 2008, Kurucz et al. 2010). For identification of the nest predators, we used the marks left on the plasticine eggs (e.g., Major 1991, Bayne et al. 1997, Kurucz et al. 2010). This identification at species level is often unreal, so we recognised some categories

ries of predator groups: e.g. small mammals (body mass ≤ 1 kg), large bodied mammals (body mass ≥ 1 kg), small birds (body length ≤ 20 cm) and large birds (body length ≥ 20 cm). In the artificial nests, we estimated vegetation coverage in one square meter (for ground nest vertical, and for shrub nest horizontal squares), and based on this, we classified the visibility of the nests into three categories (1: coverage $\leq \frac{1}{3}$, 2: $\frac{1}{3} < \text{coverage} < \frac{2}{3}$, 3: $\frac{2}{3} \leq \text{coverage}$). In addition, we registered the meteorological data (temperature, precipitation, global radiation) with the Meteorological Station of the University of Pécs in May and June.

The nest predation data was analysed using a generalised linear mixed-effects model (GLMM) with binomial errors, and fitted using the function “lmer” in the package “lme4” (Bates et al. 2011). The dependent variable was nest fate (0 = intact, 1 = predated). The full GLMM contained the following fixed effects: month (May or June), disturbance (0 = undisturbed, 1 = disturbed) and nest type (ground or shrub), and all the possible interactions between these factors (Appendix 2.). We included the appropriate random effects: transects (1-10) and nest positions (nest number, 1-10) within transect. The non-significant interactions ($p > 0.05$) were discarded using a manual stepwise backward selection procedure. In addition to the design-based GLMMs, we fitted an alternative model that included the visibility of the ground or shrub nests as a covariate. Additionally, we tested whether the visibility changed during the breeding period with the t-test between May and June. We also tested whether the visibility was different between the ground and shrub nests. Due to the violence of the homogeneity of the variance between the two nest types, we conducted the Mann-Whitney u-test. Finally, we compared the distribution of the nest predator types (based on the marks left on the plasticine eggs) of the ground and shrub nests, as well as the disturbed and undisturbed nests using the chi-square test. All the analyses were conducted using the R version 2.12.1 (R Development Core Team 2010).

Results

Among the total of the 200 surveyed artificial nests (100 in May and 100 in June) 112 (56%) remained intact, but 88 (44%) were predated. The nest predation rate was independent of month (May or June) or disturbance alone, but it did depend on the interaction of these, and on the nest type (Table 1.). The month-disturbance interaction means that the disturbance affected the nest predation inversely: reduced it in May, but increased it or did not modify it in June (Fig. 1.). This difference was more conspicuous in the case of shrub nests than for the ground nests. On the contrary, in June, the disturbance increased the predation rate mainly in the case of the ground nests (Fig. 1.).

The visibility of the nests did not change sig-

Table 1. The result of GLMM shows the effects of month (May or June), disturbance (undisturbed or disturbed nests - checked every day), the nest type (ground or elevated shrub nests) and interaction between month and disturbance on nest survival rates of the artificial nests ($n = 50$ ground nests and $n = 50$ shrub nests in May as well as in June).

	Estimate	SEM	z value	p
Month	0.09	0.42	0.21	0.834
Disturbance	-0.77	0.44	-1.73	0.084
Month×Disturbance	1.39	0.62	2.25	0.025
Nest type	1.21	0.31	3.91	< 0.001

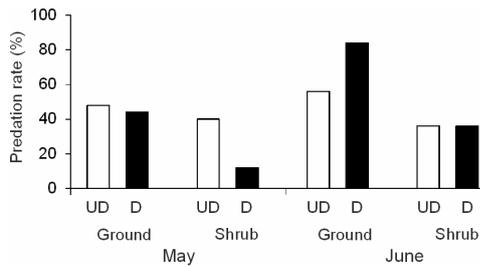


Figure 1. Predation rates of the ground and the shrub nests in May ($n = 50$, $n = 50$ respectively) and in June ($n = 50$, $n = 50$ respectively), (UD: undisturbed nests; D: disturbed nests - being checked every day).

nificantly during the breeding period (mean \pm SEM in May: 2.30 ± 0.06 , in June: 2.25 ± 0.06 ; $t = 0.5642$, $df = 197.54$, $p = 0.573$), meaning that the vegetation was already well developed during the first experiment in May, and did not change in June either. Indeed, we found a significant difference in the visibility of the ground and the shrub nest, with higher visibility of the ground nests (mean \pm SEM for the shrub nests: 2.40 ± 0.05 , for ground nests: 2.15 ± 0.07 , $W = 5897.5$, $p = 0.014$). In the case of the vegetation cover category 1 (coverage $\leq \frac{1}{3}$) more nests were depredated ($n = 13$) than intact ($n = 6$). However, in the case of the coverage category 2 ($\frac{1}{3} < \text{coverage} < \frac{2}{3}$) and category 3 ($\frac{2}{3} \leq \text{coverage}$): more nests remained intact ($n = 60$, 45) than predated ($n = 47$, 29). Overall, the nest visibility (vegetation cover) did not have a significant effect on the nest predation rate (estimate: -0.45 (1SE: 0.23), $z = -1.92$, $p = 0.055$). Based on registered meteorological data and our own observations, the weather conditions in May and June differed immensely. In May there was much more precipitation during the whole month (more rainy days), and also during the experimental period, and there was less sunshine when compared to June (Table 2.).

From 40 nests' (46% of the predated nests) eggs were taken away by predators without any indications. In the remaining 48 predation occurrences (54% of the predated nests) we managed to identify the predators: marks that were left on the plasticine eggs mainly originated from small mammals (55%) and small-bodied birds (31%); the presence of larger mammals (10%) and bird predators (4%) was less considerable.

More ground nests (58%) were depredated than the shrub nests (31%) and the predator communities of the two nest types were also different ($\chi^2_3 = 9.49$, $p = 0.02$) (Fig. 2.). In the case of both nest types, the main nest predators were small mammals and small-bodied birds. We found beak marks from larger birds only in the case of shrub nests, while tooth marks of large-bodied mammals only in the ground nests (Fig. 2.). The distribution of the nest predator types did not change due to disturbance ($\chi^2_3 = 0.20$, $p = 0.98$) (Fig. 2.).

Discussion

Contrary to the results of previous studies, ours suggest that there is no general effect of investigator disturbance on nest predation because it affected the predation rate inversely in these two months. Studies using the frequency of visits as an estimate of researcher disturbance are significantly more likely to find negative effects of investigator disturbance on predation rates, but not on those using a visit/non-visit procedure (Ibáñez-Álamo et al. 2012) such as in our experiment. The reversed effect of the disturbance-month interaction is difficult to explain. On the one hand, nest predators could be more active during June because their density has probably increased during the breeding period. On the other hand, this might also be explained by the different (extreme) weather conditions of the two study months. In sunny weather, predators may have been more active than in rainy weather. Birds tend to use visual cues to look for food, but mammals use mainly olfactory cues (Rangen et al. 2000, Colombelli-Négrel & Kleindorfer 2009), and the large amount of rain-fall could erase odour traces, which might have reduced the predation rates on the ground nests (Whelan et al. 1994). Despite the fact that during the whole experiment period it rained almost every day, in the month with the lower amount of precipitation, i.e. in June, predation from small mammals increased. Additionally, we

Table 2. Meteorological data during the whole month and during the sampling period (seven days of the experiment) in May and in June (source: Meteorological Station at Faculty of Sciences, University of Pécs, 5 km from the study area).

	May		June	
	whole month	7 days	whole month	7 days
Average temperature (°C)	16.6	13.8	20.8	18.8
Precipitation (mm)	251	170	165	85
Rainy days	23	5	10	6
Global radiation (MW/m ²)	8.4	1.3	9.7	1.8

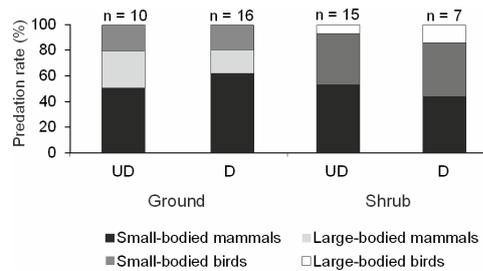


Figure 2. Predator community frequency of the ground and the shrub nests (based on the marks left on plasticine eggs $n = 48$) plotted against disturbance (UD: undisturbed nests; D: disturbed nests - being checked every day).

identified some predation events from larger mammals too. Overall, we did not discover a significant relationship between vegetation cover (visibility of nests) and the predation rate, but there was a tendency. As plant coverage becomes denser (category change from 1 to 3), the perceptibility of the nests decreases; therefore, less visible nests have a higher chance of remaining intact. Chapa-Vargas & Robinson (2006) measured the vegetation structure around the nests, and they found that the nest survival increased with the higher degree of nest concealment. Our results showed that nest survival depends on the nest type, namely on their positions. Nests located on the ground are accessible to all predators, but mostly for ground-dwelling mammals, while those situated higher above the ground are available to birds and some arboreal mammals. The survival rate of the ground nests is usually higher than that of the elevated nests (e.g., Söderström et al. 1998, Reitsma & Whelan 2000, Žmihorski et al. 2010, Ludwig et al. 2012), but in our study, more ground nests were depredated than shrub nests. The main nest predators of both nest types, according to the tooth marks on the plasticine eggs, were small mammals, but an earlier study in the

same area found more plasticine eggs with bill marks from small bodied birds or with tooth marks of small mammals (Purger et al. 2004). The shrub nests are often predated by corvids (Wysocki 2005, Weidinger 2009), who usually take away the eggs one by one from the nests (Nour et al. 1993, Rangen et al. 2000, Vigallon & Marzluff 2005). There is a big possibility that, during our study, the birds were responsible for the disappearance of many of the eggs, but we could not observe the predation events of the corvids. The predator community composition based on the marks on egg remains did not change due to disturbance in either ground nests or in shrub nests. This, however, contradicts the general view that human presence modifies predators' behaviour, and thereby affects nest predation rates (e.g., Götmark 1992, Zanette 2002, Beale & Monaghan 2004, Medeiros et al. 2007).

In many behavioural and population ecological studies it is necessary to visit and monitor real nests on a daily basis. We believe that nests should be visited frequently only if the experiment demands it. Researcher disturbance may bias the result of nest predation studies either positively or negatively and therefore, threaten the breeding success of the real nests by affecting the nest survival rates, so if possible we should avoid daily visits and controls of the nests.

Acknowledgements. P.B. was supported by the German Research Foundation (DFG BA 4438/1-1).

References

- Batáry, P., Baldi, A. (2004): Evidence of an edge effect on avian nest success. *Conservation Biology* 18: 389-400.
- Batáry, P., Winkler, H., Baldi, A. (2004): Experiments with artificial nests on predation in reed habitats. *Journal of Ornithology* 145: 59-63.
- Batáry, P., Baldi, A. (2005): Factors affecting the survival of real and artificial Great Reed Warbler's nests. *Biologia* 60: 215-219.
- Bates, D., Maechler, M., Bolker, B. (2011): lme4: Linear Mixed-effects Models Using Eigen and SVD. R package version 0.999375-42. URL: <<http://lme4.r-forge.r-project.org/>>
- Bayne, E.M., Hobson, K.A. (1997): Comparing the effects of landscape fragmentation by forestry and agriculture on predation of artificial nests. *Conservation Biology* 11: 1418-1429.
- Bayne, E.M., Hobson, K.A., Fargey, P. (1997): Predation on artificial nests in relation to forest type: contrasting the use of quail and plasticine eggs. *Ecography* 20: 233-239.
- Bayne, E.M., Hobson, K.A. (1999): Do clay eggs attract predators to artificial nests? *Journal of Field Ornithology* 70: 1-7.
- Beale, C.M., Monaghan, P. (2004): Human disturbance: people as predation-free predators? *Journal of Applied Ecology* 41: 335-343.
- Belthoff, J.R. (2005): Using artificial nests to study nest predation in birds. *American Biology Teacher* 67: 105-110.
- Berry, L., Lill, A. (2003): Do predation rates on artificial nests accurately predict predation rates on natural nests? The effects of nest type, egg type and nest-site characteristics. *Emu* 103: 207-214.
- Bolduc, F., Guillemette, M. (2003): Human disturbance and nesting success of Common Eiders: interaction between visitors and gulls. *Biological Conservation* 110: 77-83.
- Chapa-Vargas, L., Robinson, S.K. (2006): Nesting success of a songbird in a complex floodplain forest landscape in Illinois, USA: local fragmentation vs. Vegetation structure. *Landscape Ecology* 21: 525-537.
- Colombelli-Négrel, D., Kleindorfer, S. (2009): Nest height, nest concealment, and predator type predict nest predation in superb fairy-wrens (*Malurus cyaneus*). *Ecological Research* 24: 921-928.
- Cresswell, W. (1997): Nest predation rates and nest detectability in different stages of breeding in Blackbirds *Turdus merula*. *Journal of Avian Biology* 28: 296-302.
- Davison, W.B., Bollinger, E. (2000): Predation rates on real and artificial nests of grassland birds. *Auk* 117: 147-153.
- Fenske-Crawford, T.J., Niemi, G.J. (1997): Predation of artificial ground nests at two types of edges in a forest-dominated landscape. *Condor* 99: 14-24.
- Götmark, F. (1992): The effects of investigator disturbance on nesting birds. *Current Ornithology* 9: 63-104.
- Ibáñez-Álamo, J.D., Sanllorente, O., Soler, M. (2012): The impact of researcher disturbance on nest predation rates: a meta-analysis. *Ibis* 154: 5-14.
- Kurucz, K., Kallenberger, H., Szigeti, C., Purger, J.J. (2010): Survival probabilities of first and second clutches of blackbird (*Turdus merula*) in an urban environment. *Archives of Biological Sciences* 62: 489-493.
- Kurucz, K., Bertalan, L., Purger, J.J. (2012): Survival of blackbird (*Turdus merula*) clutches in an urban environment: experiment with real and artificial nests. *North-Western Journal of Zoology* 8: 362-364.
- Lindell, C.A., Cohen, E.B., Fritz, J.S. (2004): Are daily mortality rates for real and artificial clutches comparable? *Ornitologia Neotropical* 15: 201-208.
- Ludvig, E., Vanicsek, L., Török, J., Csörgő, T. (1995): The effect of nest-height on the seasonal pattern of breeding success in blackbirds *Turdus merula*. *Ardea* 83: 411-418.
- Ludwig, M., Schlinkert, H., Holzschuh, A., Fischer, C., Scherber, C., Trnka, A., Tschamtker, T., Batáry, P. (2012): Landscape-moderated bird nest predation in hedges and forest edges. *Acta Oecologica* 45: 50-56.
- Major, R.E. (1990): The effect of human observers on the intensity of nest predation. *Ibis* 132: 608-611.
- Major, R.E. (1991): Identification of nest predators by photography, dummy eggs, and adhesive tape. *Auk* 108: 190-196.
- Major, R.E., Kendal, C.E. (1996): The contribution of artificial nest experiments to understanding avian reproductive success: a review of methods and conclusions. *Ibis* 138: 298-307.
- Marini, M.A., Robinson, S.K., Heske, E.J. (1995): Edge effects on nest predation in the Shawnee national forest, southern Illinois. *Biological Conservation* 74: 203-213.
- Martin, T.E. (1988): Processes organizing open-nesting bird assemblages: competition or nest predation? *Evolutionary Ecology* 2: 37-50.
- Martin, T.E. (1993): Nest predation and nest sites: New perspectives on old patterns. *BioScience* 43: 523-532.
- Medeiros, R., Ramos, J.A., Paiva, V.H., Almeida, A., Pedro, P., Antunes, S. (2007): Signage reduces the impact of human disturbance on little tern nesting success in Portugal. *Biological Conservation* 135: 99-106.

- Melampy, M.N., Kershner, E.L., Jones, M.A. (1999): Nest predation in suburban and rural woodlots of northern Ohio. *American Midland Naturalist* 141: 284-292.
- Moore, R.P., Robinson, W.D. (2004): Artificial bird nests, external validity, and bias in ecological field studies. *Ecology* 85: 1562-1567.
- Nour, N., Matthysen, E., Dhondt, A.A. (1993): Artificial nest predation and habitat fragmentation: different trends in bird and mammal predators. *Ecography* 16: 111-116.
- Ortega, C.P., Ortega, J.C., Rapp, C.A., Backensto, S.A. (1998): Validating the use of artificial nests in predation experiments. *Journal of Wildlife Management* 62: 925-932.
- Purger, J.J., Mészáros, A.L., Purger, D. (2004): Ground nesting in recultivated forest habitats - a study with artificial nests. *Acta Ornithologica* 39: 141-145.
- Rangen, S.A., Clark, R.G., Hobson, K.A. (2000): Visual and olfactory attributes of artificial nests. *Auk* 117: 136-146.
- R Development Core Team (2010): R: a language and environment for statistical computing. Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL: <<http://www.R-project.org>>
- Reitsma, L.R., Whelan, C.J. (2000): Does vertical partitioning of nest sites decrease nest predation? *Auk* 117: 409-415.
- Ricklefs, R.E. (1969): An analysis of nesting mortality in birds. *Smithsonian Contributions to Zoology* 9: 1-48.
- Robel, R.J., Hughes, J.P., Keante, T.D., Kemp, K.E. (2003): Do artificial nests reveal meaningful patterns of predation in Kansas grasslands? *Southwestern Naturalist* 48: 460-464.
- Söderström, B., Pärt, T., Rydén, J. (1998): Different nest predator faunas and nest predation risk on ground and shrub nests at forest ecotones: an experiment and a review. *Oecologia* 117: 108-118.
- Trnka, A., Prokop, P., Batáry, P. (2008): Dummy birds in artificial nest studies: an experiment with red-backed shrike *Lanius collurio*. *Bird Study* 55: 329-331.
- Vacca, M.M., Handel, C.M. (1988): Factors influencing predation associated with visits to artificial goose nests. *Journal of Field Ornithology* 59: 215-223.
- Vigallon, S.M., Marzluff, J.M. (2005): Is nest predation by steller's jays (*Cyanocitta stelleri*) incidental or the result of a specialized search strategy? *Auk* 122: 36-49.
- Weatherhead, P.J., Blouin-Demers, G. (2004): Understanding avian nest predation: why ornithologist should study snakes. *Journal of Avian Biology* 35: 185-190.
- Weidinger, K. (2009): Nest predators of woodland open-nesting songbirds in central Europe. *Ibis* 151: 352-360.
- Whelan, C.J., Dilger, M.L., Robson, D., Hallyn, N., Dilger, S. (1994): Effects of olfactory cues on artificial-nest experiments. *Auk* 111: 945-952.
- Wysocki, D. (2005): Nest site selection in the urban population of Blackbirds *Turdus merula* in Szczecin (NW Poland). *Acta Ornithologica* 40: 1-8.
- Zanette, L. (2002): What do artificial nests tells us about nest predation? *Biological Conservation* 103: 323-329.
- Žmihorski, M., Lewtak, J., Brzeziński, M., Romanowski, J. (2010): Nest survival in a large river valley: an experiment using artificial nests on an island and bank of Vistula River (Poland). *Polish Journal of Ecology* 58: 197-203.

Appendix 1. The map of the study area, the situation of the transects (red and yellow 1--10) designated in the artificial nest experiment.

<https://sites.google.com/site/korneliakurucz/hu/projects/supporting-information/Kurucz_study_area_2010.kmz>
short URL: <<https://goo.gl/FjbZLD>>

Appendix 2. Model-formula in R-syntax

Full model:

"lmer(Predation~Month*Disturbance*Nesttype+1 | Transect/Nest_number),family=binomial)"

Minimal adequate model:

"lmer(Predation~Month*Disturbance+Nesttype+(1 | Transect/Nest_number),family=binomial)"