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Short research contribution

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NEST SURVIVAL IN A LARGE RIVER VALLEY: AN EXPERIMENT USING ARTIFICIAL NESTS ON AN ISLAND AND BANK OF VISTULA RIVER (POLAND)

ABSTRACT: Predation pressure, which varies among habitats, is important factor for selection of nesting sites by birds. We investigated artificial nest depredation on an island 23 ha in size and on the river bank covered by willow-poplar forest and meadows in the middle Vistula river valley, in the spring and autumn 2006. We used polyurethane thrush-size nests placed at three heights (ground, bush and tree) with one quail egg. Each nest was checked twice, 7 and 14 days after the beginning of the experiment, in total 381 nest-inspections was included. Additionally, we live-trapped rodents (data from 510 trapnights included) which are potential predators of broods. We found that the survival rate of artificial nests was higher on the island as compared to the bank. Artificial nests placed on the ground revealed the higher survival rate than the nests placed on trees and bushes. Nest survival rate was higher in the autumn than in the spring. Repeatability of the results (survived *vs*. depredated) for the first and second 7-day period was high but lower on the island as compared to the bank. The abundance of rodents was higher on the bank during the spring, but no difference was recorded in the autumn. Rodents were also more abundant in the autumn than in the spring. This may indicate that survival rates of nests were not affected by rodents directly.

KEY WORDS: breeding success, conservation, quail eggs, ground nests, nest predators, predation, small mammals, Vistula

Predation is the most important factor responsible for nest losses (Wesołowski and Tomiałojć 2005) that limits the productivity of bird populations (Newton 1998). High parental investment in nest building, production of eggs, incubation and finally feeding the nestlings may be lost as a result of predation on the eggs and chicks. Therefore, many strategies to avoid predation have developed in breeding birds. For example, birds prefer breeding habitats and places with lower predation pressure, they build their nests with materials avoided by predators, breed in colonies, synchronise clutching, actively defend their nests and young (Weidinger 2002, Fontaine and Martin 2006, Medlin and Risch 2006, Ekner and Tryjanowski 2008). In our research we investigated the variation in nest predation in a large river valley. River valleys are vital for breeding and migration of many rare and threatened bird species (Grimmett and Jones 1989) and are protected as relatively natural habitats. Thus, estimating predation pressure in these habitats may be important for biodiversity maintenance and selection of conservation areas. Moreover, highly dynamic character of the habitat, shaped by water level in the river, may additionally change prey-predators interactions, which gives opportunity for studying ecological proceses. The aim of this study was to test if the survival of nests on river islands differs, as compared to the ones on river banks. Additionally, we controlled nest location and rodent densities – two factors that can affect survival rates of experimental as well as natural broods.

The research was conducted in the middle part of the Vistula river valley, Central Poland, *ca.* 50 km NW from Warsaw (52°25'33.38"N, 20°32'33.72"E). The Vistula is a large river, 1047 km long, with the average water flow in the lower part exceeding 950 m^3s^{-1} (Kajak 1993). In the study area the river's width is over 800 m. Due to its high natural value, the Vistula valley is considered one of the most important ecological corridors for many animals (Romanowski 2007, Romanowski *et al.* 2008).

We chose a large natural island (*ca.* 1.5 km long, up to 200 m wide, area 23 ha), located >130 m from the nearest bank. The island was partially afforested with the willow-poplar forest and small patches of grassland and hawthorn bushes. The predominant habitat at the river bank was similar. In the spring, at the time of high water levels both the island and the river banks were flooded. During the study the water level in the river changed up to 3 m. Bird community inhabiting the study area consist of forest specialists (Picidae, Sylvidae, Paridae) and of birds typical for aquatic habitats (Anatidae, Scolopacidae, Laridae etc.).

We used artificial nests made of polyurethane spray foam, painted green one month before the beginning of the experiment to exclude the smell effect. The nests were 5 cm deep, with outer diameter 12.5 cm, and were similar to nests built by thrushes *Turdus* spp. They were placed on the island and on the river bank along two parallel transects, at 17 points per each transect. The points were located every 20–30 m, and at each point three nests were placed at different height: on the ground, on bushes (0.5–1.0 m above the ground) and on trees (2–3 m). Nests placed at one point were at least 6–10 m away from each other. One commercial quail egg was put into each nest. A nest was considered depredated if its egg was missing or damaged. Each transect was checked twice: 7 and 14 days after the beginning of the experiment. After the first check all depredated nests were supplemented with new eggs. Two trials were carried out: in the spring (May and June 2006) and autumn (September 2006). We tested whether the survival rate differed between the two seasons (spring *vs*. autumn), height of nest placement (ground *vs*. bush vs. tree) and location (island *vs.* river bank). In total, we collected data from 381 nest-inspections (i.e. results for 381 7-day periods, some of them collected for the same nests)

During the experiment we live-trapped rodents along the two transects (one on the island and one on the river bank) where the nests were set out, with 25 trapping points located every 10–15 m. At each point there were two live traps baited with oat. The trapping lasted 3 days in the spring and 2 days in the autumn of 2006. The traps were checked every day and the final results of the trapping were expressed as the number of catches per 100 trapnights. In total, we collected data from 510 trapnights.

With the use of a nonparametric chi-square test we investigated whether the results of the first and the second nest inspection were independent. Also, for each nest we assessed the repeatability of the results from the two inspections, i.e. we checked whether the results of the two inspections were the same (whether a nest had the same status in both inspections, either depredated or not depredated) or different (depredated in the first inspection and not depredated in the second inspection, or vice versa). Next, applying the multinomial logistic regression we tested which explanatory variables (season, nest placement or location) explained the repeatability of the two inspections in each nest. With the multinomial logistic regression we also checked how much variance in the probability of nest survival during the first 7 days of the experiment was explained by the dependent variables (data from the second inspection were excluded) (see Carignan and Villard 2002 for a similar statistical design). The three explanatory variables and their interaction terms were tested for significance and only significant predictors were left in the final model. The abundance of rodents was tested with a non-parametric chi square test. For statistical analysis we used the SPSS 15.0 software.

The initial logistic regression model showed that the interactions between placement and season as well as between season and location were not significant (Wald = 0.003; $P = 0.957$ and Wald = 0.007; $P = 0.934$, respectively), and were therefore excluded from the model. In addition, the nests situated on bushes and trees did not differ in terms of survival probability (Wald = 0.414; $P = 0.520$), and hence these two categories were pooled.

Nest survival rate was significantly higher on the island, as compared to the river bank, and the odds of nest survival during the 7 day period were 127 times higher on the island than on the mainland (Table 1). This pattern was visible for both spring and autumn as well as for nests placed both on and above the ground (Fig. 1). The nests placed on the ground had higher probability of survival: the ratio of survived to depredated nests increased ca 100-fold in the case of the nests placed on the ground, relative to the other nests. Predation level was significantly higher in spring. There was also a significant interaction between location and placement, with the island nests placed on the ground having significantly lower survival rate than expected (Table 1, Fig. 1).

The two inspections showed high within-nest repeatability. For over 79% of the nests the same result was obtained in both inspections, and the results from the second 7-day period were significantly dependent on the first 7-day period ($\chi^2 = 60.73$; df = 1; $P < 0.0001$). The survival rates of the nests during the first and the second 7-day period were not significantly different (58 and 57%, respectively; $\chi^2 = 0.01$; df = 1; $P = 0.934$).

The repeatability of the results obtained for the two inspections for a given nest did not depend on the interaction between the analysed factors ($P > 0.056$ in all cases). Consequently, the interactions were removed from the final logistic regression model. Season and nest placement did not explain the repeatability, however, the effect of nest location was significant. The nests located on the island showed significantly lower repeatability as compared to the nests located on the river bank (Table 2).

In total, we had 85 captures, with the Striped Field Mouse (*Apodemus agrarius* Pallas) as the most frequent rodent (66% of captures). Less abundant were the Bank Vole (*Myodes glareolus* Schreber), the Yellow-necked Mouse (*Apodemus flavicollis* Melchior) and voles (*Microtus* sp.). Rodent density increased significantly from the spring to the autumn at both localities (Fig. 2). Rodents were significantly more numerous on the bank than on the island in the spring, however, no significant differences were recorded in the autumn (Fig. 2).

Our experiment was conducted on one island and thus we are not able to distinguish between a general "island effect" and unknown factors specific to our island (Hurlbert 1984). This suggests that our results should be interpreted with caution and cannot be generalised.

Table 1. Parameter estimates of the logistic regression model explaining the survival rate of artificial nests in the Vistula river valley. For each effect its B parameter with standard error, Wald statistic, degrees of freedom, *P*-value and odds ratio (change in probability of nest survival/probability of nest depredation caused by a given factor) with 95% confidence interval are given. The reference category of dependent variable for the model is 0 (i.e. nest depredated).

Effect	B±SE	Wald	df	*P*	Odds Ratio (95%CI)
Intercept	−5.44±1.081	25.30	1	<0.00001	
Location – island	4.85±1.073	20.11	1	0.00001	127.29 (15.546–1042.290)
Location – bank	0[a]		0		
Placement – ground	4.59±1.123	16.73	1	0.00004	98.69 (10.933–890.805)
Placement – bush/tree	0[a]		0		
Season – autumn	2.09±0.439	22.58	1	<0.00001	8.05 (3.406–19.034)
Season – spring	0[a]		0		
Ground × island	−3.47±1.237	7.87	1	0.00502	0.03 (0.003–0.351)
Ground × bank	0[a]		0		
Bush/tree × island	0[a]		0		
Bush/tree × bank	0[a]		0		

[a] – this parameter is set to zero because it is redundant.

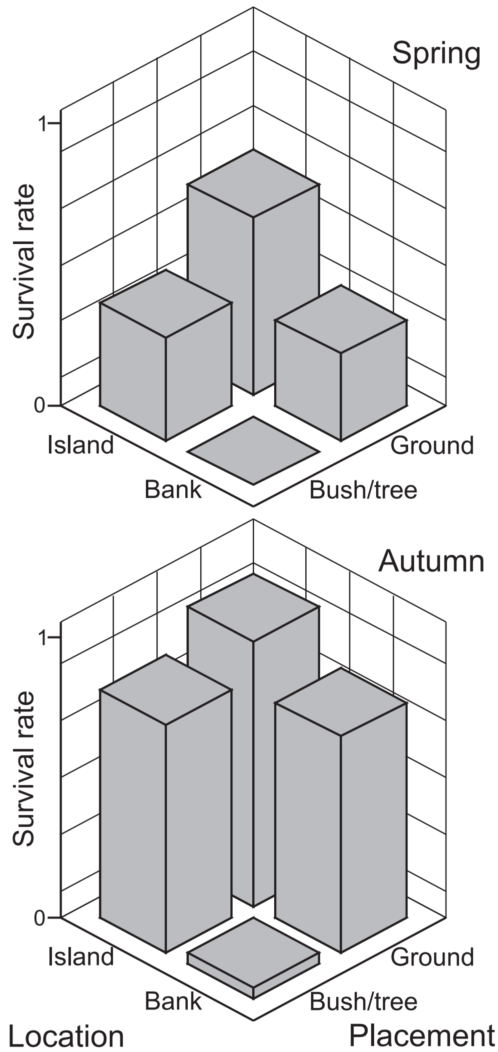

Fig. 1. Survival rate of artificial nests placed at two heights (ground *vs*. bush/tree) and in two locations (river island *vs*. river bank) in the Vistula river valley, in spring and autumn.

On the other hand, the island selected for the study is similar to other islands on the Vistula river in terms of size, habitat and vegetation. Therefore, one may expect that the recorded pattern of predation pressure may also hold for other islands. The reliability of experiments using artificial nests has been the subject of many discussions (e.g. Major and Kendal 1996, Zanette 2002), however, other papers suggest that differences between real and artificial nests are not large (Roos 2002, Pehlak and Lõhmus 2008). The use of artificial nests to compare nest predation between habitats or periods seems to be the most careful and reliable approach (e.g. Pehlak and Lõhmus 2008).

We observed higher survival rate on the island. This pattern is difficult to explain since we have no exact data on the community of predators inhabiting the study area. Neither do we know which predator species played the most important role in depredation of the artificial broods in this river valley. Nevertheless, the highly significant differences in egg survival rate between the island and the bank suggest that for some predators the river could be an effective barrier, which positively affects survival rates of the nests (Albrecht *et al.* 2006, Nielsen and Gates 2007, Salo *et al.* 2008, but see also Nilsson *et al.* 1985). It is important to note that the differences in survival rates between the island and the bank also concerned the nests above the ground. Therefore it seems that island effect concerns not only terrestrial predators that forage mainly on the ground (e.g. canids) but also species depredating nests located high above the ground (e.g. corvids).

The survival rate of the artificial nests was significantly higher in the autumn as compared to the spring. This pattern might have not been expected due to three reasons. First, predator densities are higher in the autumn, when most young predators born in the spring disperse and forage independently. Second, the rodents which can depredate bird nests (e.g. Bures 1997, Carignan and Villard 2002) are more abundant in the autumn (confirmed in the study area). Third, the density of vegetation, including tree foliage, is higher in the late spring than in the autumn which may increase nest survival rate (Remeš 2005, Albrecht *et al.* 2006, Němečková *et al.* 2008). However, the autumnal increase in rodent density do not have to affect negatively the survival rates of eggs in the nests because eggs of the commercial quail, used in our study, may be too large for some rodent species (Roper 1992, Marini and Melo 1998). It is also possible that high availability of natural bird nests in the spring leads to a shift in the foraging behaviour of generalist predators, which in the spring devote more effort to search for broods (Vigallon and Marzluf 2005, Purger *et al.* 2008). Moreover, the low availability of rodents in the spring forces predators to find alternative prey (e.g. bird broods), which in turn may decrease nest survival rate (Šálek *et al.* 2004) therefore increase in rodent densities in the autumn indirectly decreases pre-

Table 2. Parameter estimates of the logistic regression model explaining repeatability of the results obtained from the two inspections of artificial nests in the Vistula river valley. For each effect its B parameter with standard error, Wald statistic, degrees of freedom, *P*-value and odds ratio (change in probability of different result/same results of the two inspections caused by a given factor) with 95% confidence interval are given. The reference category of dependent variable for the model is 1 (i.e. the results are assumed to be the same).

Effect	B±SE	Wald	df	*P*	Odds Ratio (95%CI)
Intercept	−2.001±0.337	35.29	1	<0.00001	
Location – island	1.049±0.406	6.67	1	0.00979	2.85 (1.288–6.325)
Location – bank	0[a]		0		

[a] – this parameter is set to zero because it is redundant.

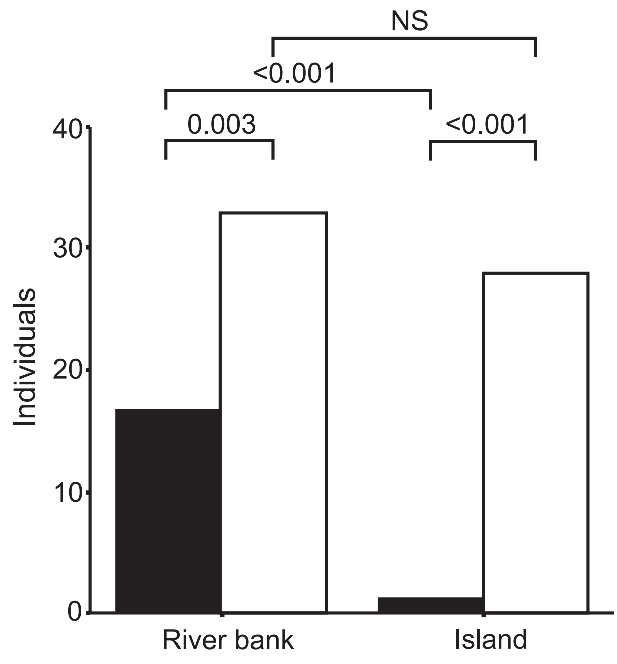

Fig. 2. Rodent density index expressed as number of catches per 100 traps per day, in the spring (black bars) and autumn (white bars). Significance of the χ^2 test is given above the bars.

dation impact on bird broods (Angelstam *et al.* 1985).

Nests located on the ground are available to all predators, while those situated higher above the ground are available only to birds and some arboreal mammals (e.g. the pine marten *Martes martes* L.). Therefore, we expected that the survival rate of nests on the ground would be the lowest. Again we obtained results that are contrary to our expectation: the nests on the ground had higher survival rate than those on trees. Interestingly, similar results were obtained in previous studies (Reitsma and Whelan 2000, Söderström *et al.* 1998). Possibly, the nests placed on the ground were less visible for predators. Moreover, this confirms the presumption that rodents were unimportant for the nests survival.

Predation pattern was significantly repeatable between the two 7-day periods, whereas overall predation pressure did not differ between the periods. This may be explained in two ways. First, the level of concealment, specific to each nest, may cause that a given nest is prone to or safe from predation in both 7-day periods (we did not change nest placement after the first inspection). Second, the high repeatability indicates that predators remember nest location after the first predation event, which has been confirmed in earlier studies (e.g. Sorace *et al.* 2004). The similar level of predation in both 7-day periods points to the first explanation. Interestingly, the repeatability of the results between the two inspections was significantly lower on the island as compared to the mainland. It is possible that the decrease in the repeatability on the island resulted from differences in predator community.

Our experiment conducted in a river valley suggests that predation on bird nests may be higher on the river bank than on the island. If this pattern is true for majority of islands, this leads to a conclusion that the role of islands as suitable nesting areas for birds is especially important.

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