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Provisioning nest material for Rooks; a potential tool for conservation management

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Abstract Active conservation measures often entail supplementing scarce resources, such as food or nesting site to high conservation value species. We hypothesized that adequate nest material in reasonable distance is a scarce resource for Rooks breeding in open grassland habitats of Hungary. Here we show that Rooks willingly utilize large quantities of provided excess nesting material, and that this procedure may alter nest composition, and increase the number of successful pairs. Our results show that while nest height remains constant, twig diameter is significantly larger, the number of twigs used per nest is presumably smaller, and that the ratio of nests with fledglings is higher in a rookery where supplementary twigs were present. Providing twigs and branches in the vicinity of rookeries may serve as an active conservation measure to increase the number of nests in a rookery, and thus the potential number of nesting possibilities for Red-footed Falcons.

Keywords: scarce resource, *Corvus frugilegus*, nest composition, Red-footed Falcon, *Falco vespertinus*, colony

Összefoglalás Aktív természetvédelmi beavatkozások gyakran egy faj számára fontos, ritka források pótlására irányulnak, ilyen lehet például megfelelő táplálék kihelyezése vagy fészkelőhely biztosítása. Hipotézisünk szerint a pusztai élőhelyen költő vetési varjak számára fontos limitáló tényező lehet a megfelelő és könnyen elérhető fészekanyag. Vizsgálatunk megmutatja, hogy a varjak a számukra a telep közelében kihelyezett nagy mennyiségű gallyat beépítik a fészkeikbe. Eredményeink szerint, míg a fészek magassága hasonló, a fészekben található gallyak átmérője, és a fiókás fészkek aránya is nagyobb azon a telepen, ahova fészekanyagot helyeztünk ki. Véleményünk szerint fészekanyag kihelyezése jó módszer lehet a vetésivarjú-telepek fészekszámának növeléséhez, melyek így több fészkelési lehetőséget biztosítanak az ezeken a telepeken költő, fokozottan védett kék vércsék számára.

Kulcsszavak: ritka forrás, *Corvus frugilegus*, fészek összetétel, kék vércse, *Falco vespertinus*, kolónia

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Introduction

Species-specific conservation efforts often consider shortage of resources that threaten the viability of a focal avian population, and present solutions to these (Palatitz *et al.* 2009). For instance, decay in food supply due to the degradation of foraging habitats evoke responses that entail the restoration or improvement through habitat altering regimes ranging from local to landscape levels (Donald *et al.* 2002, 2006, Franco & Sutherland 2004). Improving complex systems is often time consuming, thus conservationists may choose temporary solutions of directly providing scarce resources (Robb *et al.* 2008, Cortés-Avizanda *et al.* 2010). Consider the example of the declin-

ing European vultures, where the change in habitat usage altered animal husbandry, consequently creating a large scale shortage in carcasses (Wallace & Temple 1987, Green *et al.* 2004, Bose & Sarrazin 2007, Deygout *et al.* 2009). However, in certain cases, a network of supplementary feeding stations coupled with the promotion of vulture-friendly livestock keeping proved to be effective in halting the decline (Houston 2005). In case of cavity nesting/ non-nest building species, one of the key factors influencing reproduction may be the lack of nesting sites. Supplementing artificial nesting platforms, nest-boxes or artificial twig nests often resolves these issues (Hamerstrom *et al.* 1973, Avilés *et al.* 2000, Libois *et al.* 2012), however these efforts may inherently result in a highly conservation dependent population. For instance, Red-footed Falcons *(Falco vespertinus)* typically use rookeries for breeding (Ferguson-Lees & Christie 2001). Rooks *(Corvus frugilegus)* were considered as agricultural pests (Solt 2008), and were heavily persecuted in the last century in Central Europe (Kalotás & Nikodémusz 1981, Orłowski & Czapulak 2007, Fehérvári *et al.* 2009, Palatitz *et al.* 2009). This, coupled with altered land use of the past decades resulted in a dramatic decline of the rook population (Solt 2008), leaving suitable foraging habitats without nesting sites for the Red-footed Falcons in the Carpathian Basin. An over decade long country-wide nest-box scheme has temporarily resolved this resource shortage, however, sustainability of these breeding sites remains to be improved (Palatitz *et al.* 2009, 2015, Kotymán *et al.* 2015). Rooks are generalist feeders and build their own nests, hence supplementing breeding facilities, or foraging stations are unlikely to have a substantial effect on local or regional demography where natural foraging areas are still available (Olea & Baglione 2008). However, considering the scarcity of mature forest patches in typical habitats of Central European Rooks, a potential resource may be adequate nest material. The scarcity of twigs and sticks that build up the body of a nest may be even more apparent if one considers the facts that a) up to several hundred nests are built at the same location, b) the weight of a branch may be sizeable considering an individual's body mass, hence birds are likely to minimize search radii for this resource. Rooks have been observed to willingly steal nest material from conspecifics in a rookery (Goodwin 1955). Our personal, sporadic observations also support the prevalence of robbing twigs from neighbouring nests, and that actively built nests are seldom left unattended prior to incubation. A previous study explored the possibility of provisioning nest material to nest-building colonial Egrets (Baxter *et al.* 1996). The birds in this case willingly accepted the supplementary sticks.

In this study we first explored the possibility of provisioning nest material at a given rook colony. We then assessed its potential effect on nest material characteristics, and whether provisioning has any repercussions on the number of nests built, or the ratio of successful rook nests in supplemented colonies.

Materials and Methods

Study site

The study was conducted at the Red-footed Falcon study area, Vásárhelyi Plain (SE Hungary, see Kotymán *et al.* 2015 for details). This site holds one of the largest arti-

ficial nest-box colony systems in Hungary, however rooks were absent from the area since the 1990s. In 2009, a rookery formed in the immediate vicinity of an artificial colony (Colony A) and another in similar habitat 17 kms from the previous site (Colony B). Both colonies are located in tree plantations, Colony A in narrow-leafed ash *(Fraxinus angustifolia)* interspersed with oleaster bushes *(Eleagnus angustifolia)* and black locust *(Robinia pseudo-acacia)* trees, while Colony B is located in a black locust plantation with a loose oleaster bush hedge surrounding the location. The average height of trees is similar at both colonies (8–10 metres).

Supplementing nest-material

Initially, we supplied small quantities (approximately 0.5 m^3/year) of twigs for colony A between 2008–2013. The primary objective in this period was to confirm whether rooks use the provisioned nest-material and to qualitatively assess that birds use these resource in multiple seasons. Meanwhile no nest material was presented in Colony B. In 2014 we provided larger, up to 6 m^3 twigs and sticks of various length (range: 20–60 cm) width (range: 0.1–2 cm) at colony A. The nest material green refuse deriving from park maintenance works of nearby municipalities, thus constituted a variety of species (ash, hackberry, oak, maple, various fruit trees, dog rose and grape vines). We used various colour combinations of canned paint spray to mark the twigs, and allow us to identify them later in the nests.

Monitoring nest occupancy

The number of nests changes dynamically in a rookery, as rooks tend to demolish and rebuild their nests throughout the breeding season. Therefore, we assessed the maximum number of nests prior to all monitoring activities (March). Our primary focus was to monitor the breeding performance of Red-footed Falcons at the rookeries, however these birds commence their breeding 30–45 days later than Rooks. Thus, to minimize the disturbance for Rooks, no nest visits were carried out starting from early June. Rooks typically build their nests in the top third of the canopy, making regular controls difficult using conventional techniques like ladders. As an alternative, we used a 10 metre telescopic fishing pole with a large concave mirror attached to the end. The mirror is positioned over the nest, while a second person uses binoculars to check the reflected image of the nest content. All nests were individually labelled during the breeding season on the tree trunk. Due to the timing of nest visits we do not have data on clutch size, hatching and fledging success for Rooks, only the number of nests where fledglings are present can be accurately assessed. We considered a nest successful, if at least one nestling had nearly fully developed feathers.

Assessing nest material usage

Initially, we collected complete nests at both colonies. These were either found on the ground, or were taken off from the canopy using poles. Rooks often remain in the vicinity of the rookery and use the forest patches as roost-sites well after the breeding season. Therefore, to minimize disturbance, we only collected the nests once the birds left the area (November-December). By that time considerable proportion of the nests are either demolished by birds or by weather erosion, leaving a relatively low sample

size of 21 and 14 nests in Colony A and B, respectively.

For each collected nest we measured nest height (base to rim in cm) carefully dismantled the nests, counted the twigs and branches that build up the nest and identified the colour coded supplementary twigs used. We then randomly selected 20% of the twigs and measured their length and width to the nearest millimetre (n=2039 for Colony A and n=1545 for Colony B). All nest material that constituted the nest-lining was excluded from the analyses. The relatively long time period between the presentation of the supplementary nest material and the identification of marked twigs presumably allowed for the paint to dissolve or wear off from the marked twigs. Therefore, we only used the marked twigs to confirm the usage of the supplemented nest material, further quantitative analyses were not carried out.

Statistical analyses

We used Fisher's exact test to analyse the difference in the number of nests with fledged rook nestlings in relation to all nests in the year large scale nest-material provisioning was carried out (2014) and in the year preceding it. To understand potential effect of supplemented nest-material on twig composition of nests we used linear mixed effects models (Pinheiro & Bates 2000) to analyse mean differences in twig length and diameter between the two colonies. In case of both models we included colony as a fixed effect term. To avoid bias caused by individual preference for a certain twig size, we used nest identity as a random factor for both models. Dependent variables were log-transformed to meet model assumptions. All analyses were carried out using R.3.2.0 (R Core Team 2015).

Results

We found that all supplied nest material disappeared within days, in the initial phase of this study (2008–2013). In 2014, all presented supplementary nest material disappeared, despite the 12-fold increase in quantity. We found supplementary twigs in 100% of analysed nests.

The ratio of rook pairs with at least one fledged nestling in relation to all nests was similar in the year preceding the large scale supplementation of nest materials across colonies (Fisher's exact test; p-value=0.11). The number of total nests increased in both colonies *(Table 1)*, yet the ratio of successful nests was significantly higher for Colony A.

Nest height was similar (Welch two sample t-test; t-value: 0.03, p-value: 0.97) *(Figure 1)*, however, we found a near significant difference in the median number of twigs used/nest in the two colonies (Mann-Whitney-U test; U: 88.5, p-value=0.07, median difference=140 twigs) *(Figure 1)*. Mean twig length did not differ between colonies, however mean twig diameter was significantly higher for Colony A *(Table 2, Figure 2)*.

Discussion

This study is the first to show that nest building rooks willingly take supplementary nest materials presented close to the colony, and will incorporate it into their nests. Our observation, that regardless of the quantity of provisioned nest-material, birds utilized all sticks and twigs presented may indicate that suitable nest material is a scarce resource for Rooks in our study area.

We also found deviation of nest material composition and ratio of successfully

	Colony A		Colony B	
	2013	2014	2013	2014
Maximum number of nests in March	133	174	215	311
Rook pairs with fledged clutches	23	68	22	68
Other species	8	86	16	104
Empty nests in June	102	37	136	78
Nests demolished in March-June	0	0	41	61

Table 1. Monitoring results of the studied rookeries in 2013 and 2014. The maximum number of Rook nests was counted in March, however all other parameters were assessed starting from early June. Meanwhile, rooks may destroy/rebuild nests, and thus the total number of nests built, and the total number of nests monitored may deviate (Nests demolished in March-June). Other species predominantly entail Red-footed Falcons, but a small proportion of nests were used by Long-eared Owls and Kestrels

1. táblázat A vizsgált két vetési varjú telep monitoring eredményei 2013 és 2014-ben. A fészkek maximum számát márciusi számolással állapítottuk meg, de a fészkek foglalási mintázatát csak június elejével vizsgáltuk. A két időpont között a varjak tönkretehetnek fészkeket, melynek mértékét az utolsó sor jelzi. A többi faj elsősorban kék vércséket jelent, de kis számban mindkét kolóniában költött erdei fülesbagoly és vörös vércse is

fledged clutches/all nest in supplemented versus control rookery. However, our results remain tentative as our analyses may be confounded by several factors. Although the habitat composition of the two rookeries is largely similar, the tree species supporting the colonies are different. We hypothesize that the majority of nest material are collected in, or in close proximity of the colony, thus tree species composition considerably influences branch quality and availability. Increasing the sample size of treated and control colonies would also allow for more general inference of results.

However, if we entertain the possibility that our results were truly caused by the use of supplementary nest material, several intriguing hypotheses can be made on the mechanism of how it affects a rookery. If nest material is a scarce commodity, supplementing it may allow birds that would otherwise not breed to build nests, resulting in the increased number of pairs or increased number of unoccupied nests. In our case, the number of nests was larger in both colonies compared to a year before supplementing the nest material. Therefore, the observed pattern is probably reflecting an inter-annual difference in factors affecting both colonies, like weather or food availability. On the other hand we found that the number of successful clutches/all nests was higher where nest material was provided.

It has recently been proposed that woven or twig nests may serve as extended phenotype signals (Schaedelin & Taborsky 2009). For instance, Black Kites *(Milvus migrans)* use nest decorations to signal viability, nest quality and conflict dominance to conspecifics (Sergio *et al.* 2011). In passerines, nest building activity may be a post-mating, sexually selected signal for parental investment (Lens *et al.* 1994, Moreno *et al.* 1994, Soler *et al.* 2001), allowing sexes to adjust their reproductive behaviour to the quality of their mates. In case of Magpies *(Pica pica)*

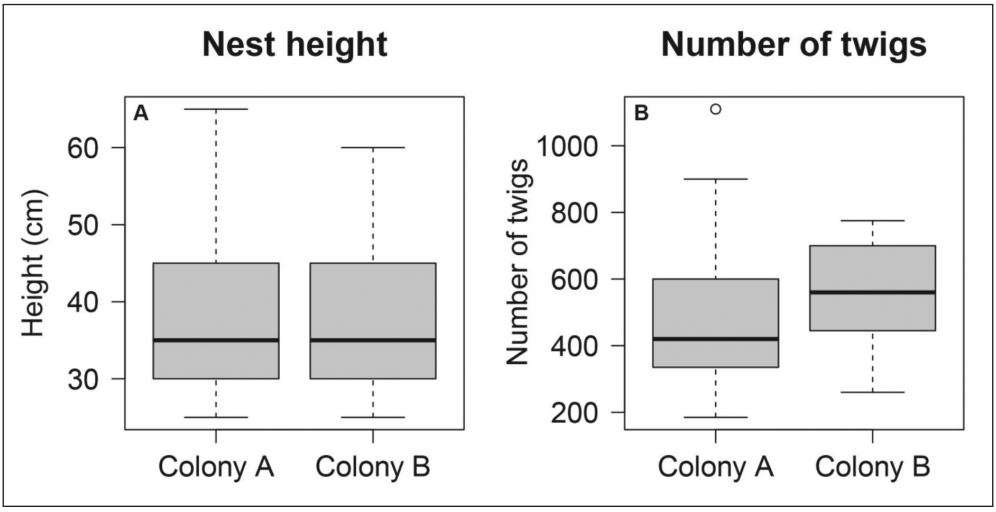

Figure 1. Boxplots on nest height and number of twigs found in nests collected at two rookeries. A total of 35 nests were analysed, 21 from colony A, and 14 from colony B. In case of colony A, we presented approx. 6 m^3 of supplementary twigs in the vicinity of the rookery prior to egg laying. Although median nest height was similar at both colonies we found a near significant (p=0.07) difference in median number of twigs used, with lower number of twigs/nest in colony A

1. ábra A fészkek magasságára és a fészkekben található gallyak számára illesztett boxplotok két vetési varjú telepen (A és B kolónia). Összesen 35 teljes fészek került elemzésre, 21 az A kolónia és 14 a B kolónia esetén. 2014-ben az A kolónia közvetlen környezetében mintegy 6 m^3 fészekanyag lett kihelyezve. Bár a két telepen található fészkek magasságában nem találtunk eltérést, a fészkeket alkotó gallyak száma közel szignifikánsan (p=0,07) eltért

Twig length	Estimate (mm)	Standard Error	p-value
Colony A	299.58	1.03	<0.001
Colony A – Colony B	0.92	1.05	0.117

Twig diameter	Estimate (mm)	Standard Error	p-value
Colony A	5.38	1.02	<0.001
Colony A – Colony B	0.88	1.05	0.008

Table 2. Fixed effect parameter estimates of the LME fitted on length and width of twigs found in nests of the two studied rookeries. We found no significant difference in mean length, however mean twig diameter was larger for colony A, where supplementary nest material was presented to the Rooks

2. táblázat Gally hosszra és gally vastagságra illesztett lineáris kevert modellek paraméter becslései a kolóniák függvényében. A gally hosszban nem találtunk szignifikáns eltérést a két telep fészkei között, azonban az átlagos gally vastagság szignifikánsan nagyobb volt ott, ahol fészekanyag kihelyezést végeztünk

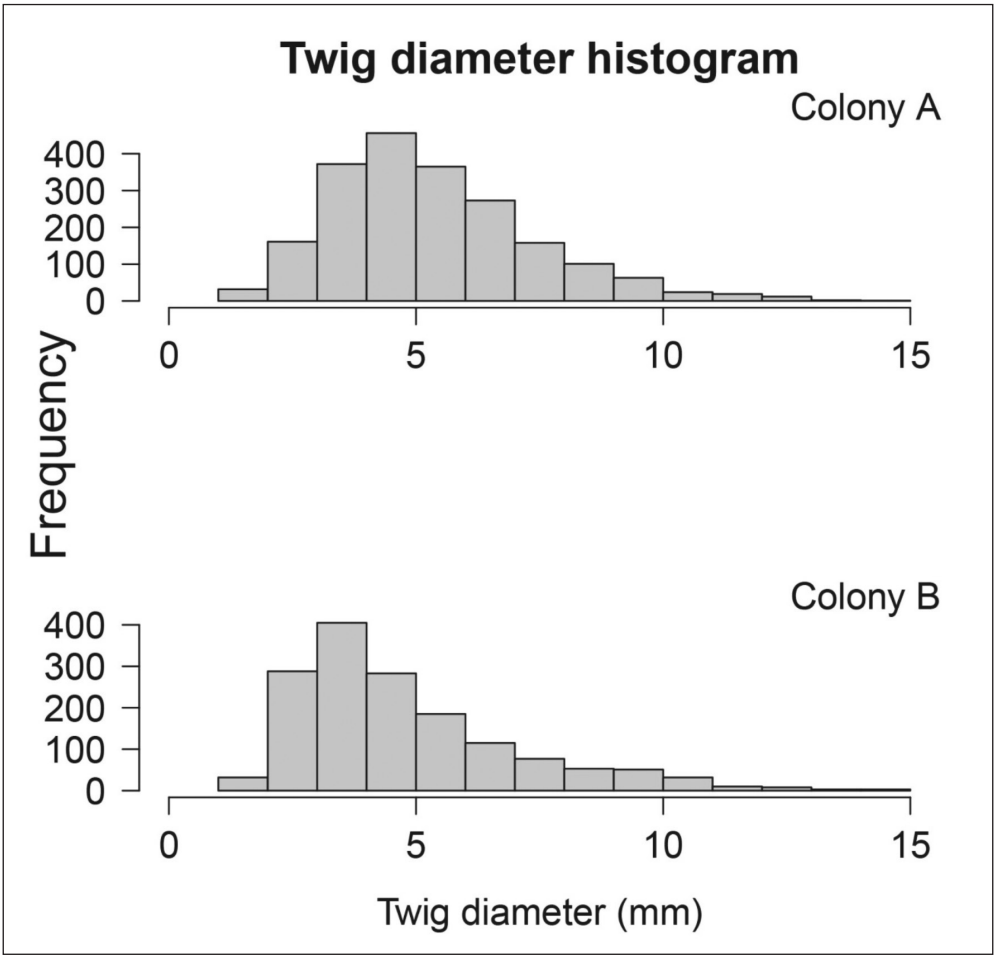

Figure 2. Histogram of twig diameters measured used as building material for nests in two rookeries. Rooks in colony A used sticks with significantly larger diameters compared to colony B (see also *Table 2*)

2. ábra Két vetési varjú-telepen talált fészkeket alkotó gallyak átmérőjének hisztogramja. Az A kolóniában a fészkeket szignifikánsan vastagabb gallyak alkották (lásd *2. táblázat*-ot is)

experimental studies show convincing relationships between reproductive decisions of females and nest-size (Soler *et al.* 2001, de Neve & Soler 2002). The close evolutionary relationship with Magpies may allow to hypothesize that nest size or nest building activity is also associated with courtship behaviour in Rooks. In theory, a scarce resource used by all individuals, and presented clearly visible for conspecifics may serve as an ample honest signal (Zahavi & Zahavi 1997) of individual quality, or parental investment. If this is so, supplementing nest materials, or in other words inflating the value of a scarce commodity associated with courtship, may allow less competitive individuals to breed, thus corroborating our findings. For instance, our results show that in the supplemented colony, twigs in nests had on average larger diameter, yet the

heights of the nests at both colonies are similar. Also we have indication that probably less twigs were used per nest in the supplemented colony. From an individual's perspective this may result in less time used for nest building, allowing allocating resources into mate choice, nest/mate guarding etc. In any case, future investigations may focus on whether relationship exists between nest quality and individual fitness, and thus help reveal the mechanisms of how supplementary nest material provisioning alters breeding behaviour of Rooks.

From a conservation perspective, nest-material provisioning carried out on a large spatial scale may have a substantial effect on strengthening or even increasing the number of rook pairs breeding in non-urban habitats. It may also be possible that provisioning nest material in areas where the expected intensity of human conflicts is low would lure the Rooks to breed there and thus allow a non-invasive conflict management of the species. Stabilizing already existing colonies or even increasing their number in grassland type habitats would also aid the sustainability of the Red-footed Falcon population (Palatitz *et al.* 2015). Our results show that a medium sized colony of under 200 pairs may use large quantities of provisioned nest-material. Acquiring and transporting large quantities of sticks and twigs may be problematic and/or expensive, potentially limiting the usability of the method on a large scale. However, local municipalities near our study site proved to be helpful in providing and even transporting the nest material once the aims of the usage was explained. We believe that their willingness will set an example for other communities throughout the country. Various other sources may be also be requested to provide large quantities of sticks and twigs, like forestries, tree nurseries, sawmills or potentially cleaned and chopped Christmas trees may also be exploited for this purpose. However, we emphasize that as with all direct conservation measure tools, one has to first understand the effects of the manipulation, and consider potential side effects. Therefore we recommend that further studies have to carried out to evaluate the mechanisms and ultimate consequences of nest material provisioning near rookeries prior to large scale adaption of the method.

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