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Ornis Hungarica 2020. 28(2): 135–145.
DOI: 10.2478/orhu-2020-0022

Does human hair attract or deter potential ground nest predators?

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Received: June 23, 2020 – Revised: August 06, 2020 – Accepted: August 08, 2020

Purger, J. J., Szegleti, Zs. & Szép, D. 2020. Does human hair attract or deter potential ground nest predators? – Ornis Hungarica 28(2): 135–145. DOI: 10.2478/orhu-2020-0022

Abstract The nests of rare and threatened bird and reptile species that breed on the ground are often attempted to be protected from predators with fences, grids, and various repellent materials. Results of some experiments refer to the repellent function of human scent, whereas others suggest that it has an attractive role. We aimed to investigate how effectively ground nests can be protected from predators if human hair is placed around nests. We performed the experiment in a riverine oak-elm-ash forest using 90 artificial nests, each with 1 quail and 1 plasticine egg: 30 nests were protected with a game fence, 30 nests were surrounded with human hair and 30 nests were unprotected (control). During the 24 days, predators damaged 23% of the nests protected by a game fence, 40% of unprotected nests and 47% of the nests surrounded with hair. The daily survival rate of quail eggs in nests protected with a game fence was significantly higher than the ones in the nests surrounded with human hair. Only 18% of the quail eggs and 36% of plasticine eggs were damaged. Such difference can be explained by the fact that small-bodied birds and mammals could pass through the game fence and left traces on plasticine eggs but they were unable to crack the shell of quail eggs. Within the game fence, denser vegetation can provide better nesting conditions and result in greater breeding success. The repellent role of human hair has not been proved, on the contrary, in some cases we have observed signs of its attractant role, such as small-bodied birds took hair away for nest building.

Keywords: birds, game fence, human scent, predation, repellent

Összefoglalás A talajon költő ritka és veszélyeztetett madár- és hüllőfajok fészkeit gyakran kerítésekkel, rácsokkal és különböző repellens anyagokkal próbálják megvédeni a predátoroktól. Egyes kísérletek eredményei az emberszag repellens, mások attraktáns funkciójára utalnak. Célunk az volt, hogy megvizsgáljuk, a talajfészkek mennyire hatékonyan védhetők a predátoroktól, ha emberi hajjal szórjuk körbe őket. A kísérletet egy keményfás tölgy-kőris-szil ligeterdőben hajtottuk végre. A vizsgálathoz összesen 90 mesterséges fészket használtunk 1 fürj- és 1 gyurmatojással: 30 fészket vadkerítéssel védtünk, 30 fészket emberi hajjal szórtunk körbe, és 30 fészket nem védtünk (kontroll). A predátorok 24 nap alatt a vadkerítéssel védett fészkek 23%-át, a nem védett fészkek 40%-át és a hajjal körbeszórt fészkek 47%-át fedezték fel és károsították a tojásokat. A vadkerítéssel védett fészkekben a fürjtojások napi túlélési rátája szignifikánsan magasabb volt, mint a hajjal körbeszórt fészkekben lévőké. A fürjtojások csak 18%-a, míg a gyurmatojások 36%-a sérült. Ez a különbség azzal magyarázható, hogy a kis testű madarak és emlősök átjuthattak a vadkerítésen és nyomokat hagytak a gyurmatojásokon, de nem tudták feltörni a fürjtojások héját. A vadkerítésen belül a sűrűbb növényzet jobb fészkelési feltételeket biztosíthat és nagyobb költési sikert eredményezhet. Az emberi haj reppellens szerepét nem bizonyítottuk, inkább bizonyos esetekben attraktáns szerepére utaló jeleket tapasztaltunk, például a kis testű madarak elhordták a kihelyezett hajat és fészeképítéshez használták.

Kulcsszavak: madarak, vadkerítés, emberszag, ragadozás, repellens

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Introduction

Breeding success and population dynamics of birds are strongly influenced by the predation of their nests (eggs, nestlings) (e.g. Ricklefs 1969, Martin 1993, 1995). Predation is a selective pressure on species coexistence, habitat selection, and life strategies (Ibáñez-Álamo *et al.* 2015). To maximize their reproductive success, birds have adequate strategies for site selection to protect themselves more effectively against potential nest predators (Fontaine & Martin 2006, LaManna *et al.* 2015). The type of nests can vary considerably because birds can breed in cavities and holes, can make open or closed nests, while some species use nests of other species or just lay their eggs on the ground (e.g. Collias & Collias 1984, Mainwaring *et al.* 2014). Bird species that do not build a nest with such behaviour do not attract the attention of potential predators to themselves or the nest (Moreno 2012). The identification of nest predators and environmental factors associated with predation is essential to understand the reproductive ecology of birds, conservation of endangered bird species and the management of habitats (Lyons *et al.* 2015, Bu *et al.* 2019).

Ground nesting bird species hide their nests well, their eggs and the plumage of female camouflage into the environment (Haskell 1996, Albrecht & Klvaňa 2004). However, they are also sensitive to nest predation, as their nests are easily accessible for both terrestrial and aerial predators (Ricklefs 1969, Collias & Collias 1984). Birds are visually oriented predators, which can rob ground nests and also nests in bushes and trees (Rangen *et al.* 2000). Unlike birds, mammals rely not only on their visual sense but also on their sense of smell (Wyatt 2014). Many of them are also active at night and, as a result, respond more strongly to scent (Storaas 1988).

The populations of ground-nesting bird species have a declining trend worldwide, partly due to nest predation (Isaksson *et al*. 2007). This negative trend can be mitigated by predator control or by protecting the nests. The regulation of the number of predators by lethal methods is objectionable from the aspects of ethics and conservation impact (e.g. Macdonald & Baker 2004, Latham *et al.* 2019). Therefore, several non-lethal techniques have been developed to increase the breeding success of birds and to mitigate the damage caused by potential nest predators (Harriman *et al.* 2007). For example, fences (e.g. Fitzwater 1972, Hayward & Kerley 2009), electric fences (e.g. Hygnstrom & Craven 1988, Curtis *et al.* 1994), and various alarm substances so-called repellents (e.g. Andelt *et al.* 1994, Milunas *et al.* 1994, Belant *et al.* 1998, Macdonald & Baker 2004, Ward & Williams 2010, Miller *et al.* 2014) have long been used to prevent damage. These methods can be used to protect ground-nesting birds and also turtle nests (e.g. Cox *et al.* 2004, Düttmann *et al.* 2007, Harriman *et al.* 2007, Vilardell *et al.* 2008, Kurz *et al.* 2011).

Artificial nests and clutches have long been used to understand predation events (e.g. Major & Kendal 1996, Bateman *et al.* 2017). Apart from its weaknesses, the method has many advantages, such as its ability to test the effectiveness of certain treatments (Báldi 1999, Moore & Robinson 2004). The effectiveness of methods used to protect birds' nests can also be tested without disturbing the birds. Indeed, in experiments with real nests it is a question how often we should check nests to avoid exposing birds to disturbance or to draw the attention of predators that rely on their vision or their smell in searching for prey (Whelan *et* *al.* 1994, Harriman *et al.* 2007, Kurucz *et al.* 2015). Some studies prove that frequent check attracts potential nest predators (e.g. Vacca & Handel 1988, Hockin *et al.* 1992, Bolduc & Guillemette 2003, Beale & Monaghan 2004, Medeiros *et al.* 2007), but some results suggest that certain scents can also keep unwanted visitors away (Götmark 1992, Ibáñez-Álamo *et al.* 2015). Some studies suggest that human odour (sweat, urine and hair) can also provide effective protection against predators (Rosell & Czech 2000, Harriman *et al.* 2007). The methods used to control wildlife damage can also be used to protect the nests of ground-nesting bird species, but under certain conditions their effectiveness should be tested by using artificial nests.

Our study aimed to explore how effectively the nests of ground-nesting bird species can be protected by a game fence and by surrounding them by human hair. We wanted to analyse separately the predation of quail eggs, which model the clutch of medium-bodied birds, and plasticine eggs, which may only be suitable for studying the nest predation of small-bodied birds.

Material and methods

Study area

The study was carried out in Duna-Drava National Park (DDNP), 8 km west from the city Barcs, in a riverine oak-elm-ash forest next to the Old-Drava oxbow (Csete & Purger 2019) *(Figure 1)*.

To increase shrub layer diversity and to protect plants from grazing by game, DDNP staff designated 15 plots (20×20-meter squares) in the forest patch in the fall of 2015, and fenced them with a game fence *(Figure 1)*. The shrub layer of the fenced areas consisted almost exclusively of red dogwood *(Cornus sanguinea)*, therefore some clearings were made and then tatarian maple *(Acer tataricum)*, European spindle *(Euonymus europapeus)*, European crab apple *(Malus sylvestris)*, wild pear *(Pyrus pyraster)* and European hornbeam *(Carpinus betulus)* were planted instead. This treatment was repeated in the summer of 2016, in the spring of 2017 when tatarian maple and hornbeam were planted. The fences were made primarily to exclude games, since in this game-rich area Red Deer *(Cervus elaphus)*, Fallow Deer *(Dama dama)* and Roe Deer *(Capreolus capreolus)* can cause severe damage by chewing or biting plants, while Wild Boar *(Sus scrofa)* can cause harm by digging holes. The nests of ground-nesting bird species are threatened by Wild Boar and Red Fox *(Vulpes vulpes)*, Golden Jackal *(Canis aureus)* and Badger *(Meles meles)*, as well as by Otter *(Lutra lutra)* appearing in the nearby oxbow. These larger mammals can be excluded by game fencing. In the forests surrounding the oxbow, Beech Marten *(Martes martes)*, Pine Marten *(Martes foina)* and Wildcat *(Felis silvestis)* occur (Purger 2019) and destroy not only the nests on the ground but also those in the shrub layer or the canopy level.

So far, 127 bird species are known to occur in and around the Old-Drava oxbow near Barcs, of which 68 species have been proven to breed here (Purger & Fenyősi 2019). From these, only 11 species breed on the ground or in shrubs close to the ground. Among the

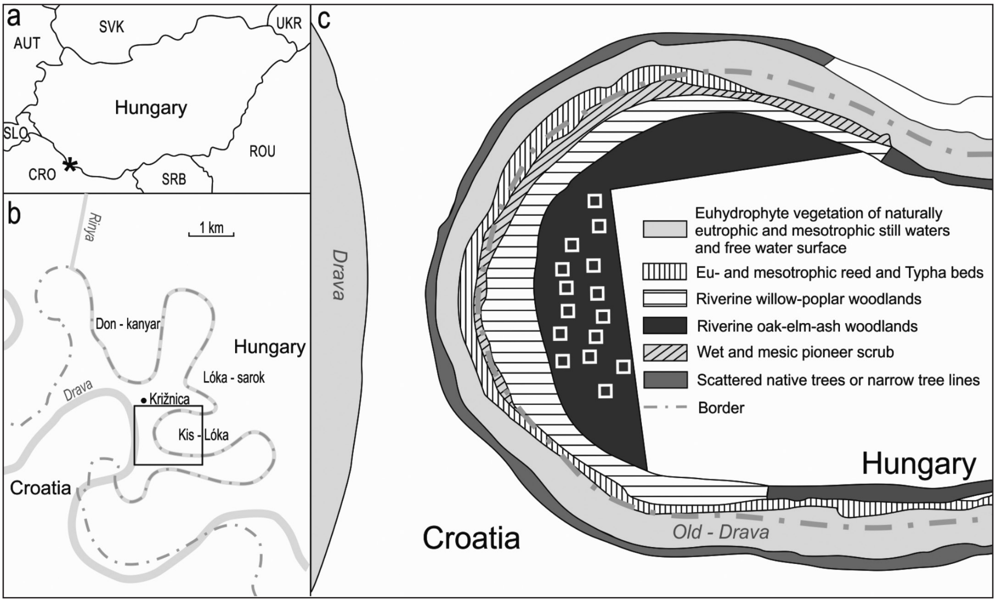

Figure 1. The study was carried out in the south-western part of Hungary (black asterix) in close proximity to the Hungarian-Croatian state border (a), in a patch of hardwood riverine oak-elm-ash forest on the left bank of the Old-Drava oxbow near Barcs (b) (c), where the 15 white squares show the location of the game fences

1. ábra A vizsgálat Magyarország délnyugati részén (fekete csillag) a magyar-horvát országhatár közvetlen közelében (a), a Barcsi Ó-Dráva holtág (b) bal partján lévő keményfás tölgy-kőris-szil ligeterdő foltban (c) folyt, ahol a 15 fehér négyzet a vadkerítések elhelyezkedését mutatja

larger species, the Pheasant *(Phasianus colchicus)* and Mallard *(Anas platyrhynchos)*, while among the smaller songbirds, the Eurasian Sylark *(Alauda arvensis)*, the Wood Warbler *(Phylloscopus sibilatrix)*, the Common Chiffchaff *(Phylloscopus collybita)*, the Eurasian Wren *(Troglodytes troglodytes)*, the European Robin *(Erithacus rubecula)*, the Tree Pipit *(Anthus trivialis)*, the White Wagtail *(Motacilla alba)*, the Yellowhammer *(Emberiza citrinella)* and the Corn Bunting *(Emberiza calandra)*, nest in small numbers in the study area or on its edge (Purger & Fenyősi 2019).

Following the preliminary fieldwork, our experiment started on 19 May 2017 and lasted for 24 days. The 90 artificial nests were made in the hardwood riverine oak-elm-ash forest, of which 30 were set within the fenced areas of the forest (originally set to protect plants from grazing by game), 30 nests were surrounded with human hair (repellent) and 30 nests were placed without any protection (control). No nest material was used for the nests, only a quail egg and a plasticine egg of similar size were placed on the leaf-litter, forming the clutch.

Quail eggs along with plasticine eggs coated with liquid rubber (PlastiDip) were stored in a cool, ventilated place for two weeks before use (Purger *et al.* 2012). Before the experiment with the eggs, the people carrying out the work wore sterile rubber gloves and rubbed their hands with leaf-litter at the site. Two nests were randomly placed in two of the four corners of the square in each fenced area *(Figure 1)*. Outside the fence, 2 nests surrounded with human hair and 2 unprotected nests (control) were formed in random order at least 15 meters from the corners. The location of the nests was recorded with a GPS, and it was marked with a yellow 5 cm long tape attached to a nearby branch for easier finding. Checkings were carried out on the third (May 22), sixth (May 25), twelfth (May 31), eighteenth (June 6), and twenty-fourth (June 12) days after launching of the experiment. During the last checking, the remaining eggs and marker strips were collected and removed from the area.

To determine and compare the predation rates of the three nest types, nests were considered predated if either of the egg types were missing or damaged in some way (e.g. Bayne *et al.* 1997, Clark & Wobeser 1997, Purger *et al.* 2012, Bocz *et al.* 2017). The daily survival rates of quail and plasticine eggs were analysed separately: quail eggs were used to estimate the survival chances of a clutch of medium-bodied birds, while plasticine eggs were used to estimate the survival chances of a clutch of small-bodied ground-nesting birds. Daily survival rates of eggs were calculated with the Mayfield (1975) method and compared using the test proposed by Johnson (1979). For comparisons, the freeware "J-test" developed by K. Halupka (2009) was used. To determine the difference between the number of predated plasticine and quail eggs, Chi-Square goodness of fit for two categories was used (Zar 2010). The minimum probability level of $P < 0.05$ was accepted for all the statistics.

Results

During the 24 days, predators damaged 23.3% (n = 7) of the nests protected by a game fence, 40% (n = 12) of unprotected nests and 46.6% (n = 14) of the nests surrounded with human hair. From the total number of quail eggs (n = 90) used in the experiment, 82.2% (n = 74) remained intact, 12.2% (n = 11) disappeared, and 5.6% (n = 5) were damaged, i.e. the predators managed to break them. Two eggs in nests protected by a game fence, 4 in unprotected nests, and 10 quail eggs in nests surrounded by human hair were damaged, respectively. The daily survival rate of quail eggs in nests protected by the game fence was significantly higher than that of nests surrounded by human hair *(Table 1).*

Table 1. Comparison of daily survival rates (DSR) of quail eggs, in nests protected by a game fence, surrounded by human hair, and in unprotected (control) nests

1. táblázat A vadkerítéssel védett, hajjal körbeszórt, valamint a védelem nélküli (kontroll) fészkekben lévő fürjtojások napi túlélési rátáinak (DSR) összehasonlítása

		Fenced	**Hair scent**	**Control**
	DSR	**0.997**	**0.985**	**0.994**
Control	Z	0.862	-1.638	
	P	0.389	0.101	
Hair scent	Z	2.378		
	P	0.017*		

*P<0.05

Table 2. Comparison of daily survival rates (DSR) of plasticine eggs in nests protected by a game fence, surrounded by human hair, and in unprotected (control) nests

2. táblázat A vadkerítéssel védett, hajjal körbeszórt, valamint a védelem nélküli (kontroll) fészkekben lévő gyurmatojások napi túlélési rátáinak (DSR) összehasonlítása

		Fenced	**Hair scent**	**Control**
	DSR	**0.989**	**0.977**	**0.981**
Control	Z	1.151	-0.466	
	P	0.249	0.642	
Hair scent	Z	1.632		
	P	0.103		

Significantly more (χ^2 = 8.225, df= 2, P = 0.0164) plasticine eggs (n = 32) than quail eggs (n=16) were damaged. From the total number of plasticine eggs (n = 90) used in the experiment 64.4% (n = 58) remained intact, 18.9% (n = 17) disappeared and 16.7% (n = 15) were damaged (in 12 cases teeth marks of small mammals, in 3 cases small bird's beak marks were preserved). Seven plasticine eggs in nests protected by a game fence, 11 in unprotected nests, and 14 plasticine eggs in nests surrounded by human hair were damaged, respectively. The comparison of daily survival rates (DSR) of plasticine eggs in nests protected by a game fence, surrounded by human hair, and in unprotected (control) nests showed no significant difference *(Table 2)*.

Discussion

Nests protected by a game fence were less predated than unprotected (control) as well as nests surrounded by human hair. This result is expected and is not surprising, as the effectiveness of the game fence has been supported by several experiments and has therefore long been used to protect nests of ground-nesting bird species (e.g. Smith *et al.* 2011, Homberger *et al.* 2017, Roos *et al.* 2018, Berger-Geiger *et al.* 2019). Since fencing does not exclude bird predators, its use is recommended only in areas where terrestrial nest predators, primarily mammals, predominate (Sargeant *et al.* 1993). It should be stressed that in our study area the vegetation was more diverse and dense in the fenced plots, due to the shrub planting carried out in previous years, while the other parts of the forest were dominated by dogwood. Dense vegetation plays an important role in hiding nests and thus, can contribute to breeding success (e.g. Rangen *et al.* 1999, Seibold *et al.* 2013, Bu *et al*. 2019). Although the fence does not provide protection against all types of predators, it significantly increases the daily survival rate of eggs (Homberger *et al.* 2017, Cocquelet *et al.* 2018), even more effectively than repellents (Santangeli *et al.* 2015).

In our experiment, nests surrounded by hair were slightly more attractive to predators than unprotected (control) nests, but this was not significant. Our results are in line with uncertainty of earlier studies that the role of human hair is not only questionable as a repellent but on the contrary, it may attract even more predators to the nests (e.g. Whelan *et al.* 1994, Skagen *et al.* 1999, Harriman *et al.* 2007). Human scent has no alarming effect on predators accustomed to human settlements, neither does on birds (Düttman *et al.* 2007).

Hardly 18% of the total number of quail eggs suffered some damage. The daily survival rate of quail eggs protected by the game fence was significantly higher than that of eggs surrounded by human hair. Based on our results, the predators of quail eggs may have been primarily larger mammals moving on the ground, excluded by the fence, but which may have been attracted by hair or human odour. However, we could not prove this with our experiment, as some of the eggs disappeared and there were no marks on the broken eggs that could have allowed the identification of predators. Quail eggs may also have been taken away by Common Jays *(Garrulus glandarius)* frequently occurring in the area (Purger & Fenyősi 2019), but we have no evidence for this, and nor did we find any marks on plasticine eggs that could have confirmed this assumption. These results also suggest that the experiments with quail eggs should not be used to infer the predation rate of real nests, but rather to compare habitats and nesting sites (Roper 1992).

During the experiment, significantly more plasticine eggs than quail eggs were damaged, which can be explained by the fact that plasticine can also preserve beak marks of small-bodied birds and the tooth prints of small mammalian predators, which cannot damage quail eggs (e.g. Roper 1992). Partly for this reason, in many cases, artificial nests are considered predated only if the real eggs (in this case quail eggs) disappear or are damaged in some way (Bayne & Hobson 1999), while plasticine eggs are used only to identify predators (Major 1991, Niehaus *et al.* 2003). Nest predation experiments have been widely criticized in the past for the use of plasticine eggs particularly because their odour has attracted predators with a good sense of smell (Rangen *et al.* 2000, Maier & DeGraaf 2001). In a previous study, we found that if small mammals find the nest and leave a mark on plasticine eggs, with their presence or urine and faeces, they could attract larger predators to the nest, which can break the real eggs (Purger *et al.* 2008). To hide the characteristic odour of the plasticine, eggs were coated with liquid rubber in this experiment, so this confounding factor was excluded (Purger *et al.* 2012). However, in the course of our study, instead of the odour of plasticine, the human odour appeared in some nests, which was achieved by the appearance of human hair placed around the nest. We did not anticipate that hair could be attractive not only to typical nest predators. On the very first days, we noticed that hair almost completely disappeared from 3 nests. In one case, we observed a Great Tit *(Parus major)* that flew up from the nest, with hair in its beak, which was probably used as nest-building material. The beak prints of the small-bodied birds found on the plasticine eggs suggested that the hair tended to attract them to the nests. While a fence can keep large-bodied mammals moving on the ground away from nests, they can be easily approached by birds or small mammals, and if they leave marks only on plasticine, erroneous conclusions can be drawn. The listed facts also confirmed that the predation events for the two egg types should be separate, as quail eggs model the clutch of medium-sized ground-nesting species, while plasticine eggs are used as a model of the clutch of small-bodied birds.

Conclusion

Based on the results of our study, we can conclude that the nests of medium-sized birds that breed on the ground can be protected from predators more effectively by game fence, rather than by repellents, e.g. human hair. Game fences are used primarily to protect plants from grazing by game, though this additional role showed in our study should be explored more thoroughly. However, human hair has an attractive effect rather than a repellent. The nests surrounded by human hair were more frequently visited by small mammals and small-bodied birds and with their increased presence they could draw the attention of other larger nest predators to the nests. In several cases, human hair was even removed from the site by birds and used as nest-building material.

Acknowledgements

Mobility for the research was facilitated by Duna-Drava National Park Directorate (project: LIFE 13/Nat/HU000388 Life Old-Drava).

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