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Nestsite characteristics of the European Bee-eater (*Merops apiaster* L.) in the Gödöllő Hills

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Abstract According to our surveys carried out in the Gödöllő Hills between 2009–2012, a relatively high proportion (39–57%) of the known 36–40 Bee-eater nesting sites can be found in natural habitats, on hillsides as opposed to nests excavated into man-made artificial walls. 51.8% of the nesting population breeds under such natural circumstances in loess and sandy hillsides, and the nests are excavated into the soil covered by vegetation. We have shown that 61.9% of the nests were built in loess, 28.4% in sandy and 9.7% in mixed type of substrate. Bee-eaters nesting on hillsides prefer the slopes between 11-30°. The slope of the hill is higher on loess grounds (average: 24.67°) as opposed to the sandy ones (average: 13.97°). The length of the nesting cavities differs significantly between the two substrate, those built in sandy areas being longer. The cavities in loess are deeper underground. The Bee-eaters nesting on hillsides prefer places with low vegetation cover.

Keywords: substrate, length of cavities, hillside, slope, vegetation cover

Összefoglalás A Gödöllői-dombságban 2009–2012 között végzett felméréseink szerint az ismert 36–40 költőterület közül viszonylag magas (39–57%) a természetes körülmények között, vagyis domboldalakon fészkelő gyurgyalag állományok aránya. A löszös és homokos domboldalakon a gyurgyalagok nem függőleges kiképzésű mesterséges, ember alkotta falakba, hanem növényzettel borított talajba ássák üregeiket. Ilyen körülmények között költ a dombság gyurgyalag állományának 51,8%-a. A mi munkánk középpontjában ezen fészeküregeknek a vizsgálata állt. Kimutattuk, hogy a domboldalakba vájt üregek 61,9%-a löszben, 28,4%-a homokban és 9,7%-a löszös-homokos kevert helyeken található. A domboldalba fészkelő gyurgyalagok a 11-30° lejtőszög értéktartományon belül keresnek maguknak helyet. A lejtőszög löszös talajon nagyobb (átlag: 24,67°), mint homokon (átlag: 13,97°). A kétféle alapkőzet típusba vájt üregek átlagos hossza szignifikánsan eltér egymástól, a homokba készített járatok hosszabbak. Ugyanakkor a löszbe vájt üregek a talaj felszínétől számítva mélyebben helyezkednek el. A domboldalba üreget vájó gyurgyalagok előnyben részesítik a kisebb növényzeti borítású helyeket a fészkelőhely kiválasztásakor.

Kulcsszavak: alapkőzet, járathossz, domboldal, lejtőszög, növényborítás

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Introduction

In the Carpathian Basin the European Bee-eater nests in a high diversity of nesting substrates and habitats: loess walls, bigger grooves and eroded riverbanks, hillsides on loess ground and in different types of sand and loess mines (Bankovics 1998, Gyurácz *et al.* 2004). At the end of the 19th and at the beginning of the 20th century the species was found mainly in the southern part of Hungary, usually in riverside banks, where meadows, pastures and plains with patches of woodland could be found (Chernel 1899, Herman 1908). Today the populations on riversides are declining as a consequence of disappearing banks and walls, and hence the importance of loess hillsides and sand- and clay-mines has grown. Nowadays the most important breeding sites are the not very intensively cultivated marginal zones of agricultural fields, where the mosaic of dry and semi-dry grasslands and meadows, pastures, bushes, forest fringes, vineyards, orchards, loess and sand pits show some kind of woodland steppe characters (Bagdi 2007).

In the Gödöllő Hills there are three types of substrates that are important for the Bee-eaters: sand, loess and the mixture of those. Despite this hilly area being basically a woodland steppe, where loess and sand is found in large quantity and hence offering good conditions for the Bee-eater, there are only a few publications on the distribution of the species (Szijj 1955, Papp 1980, 1984, Kertész 1991). Since 1997 data for the whole area can be found owing to the MME RTM (BirdLife MME Hungary Rare and Colonial Breeders Monitoring) program. In the 36-40 colonies regularly monitored today approximately 480-550 pairs of Bee-eaters breed (Ivók 2012).

The Bee-eater population of the Gödöllő Hills is especially important compared to the other nesting places surveyed in Hungary as the ratio of colonies with pairs between 21 and 50 is higher than in other parts of Hungary (Gyurácz *et al.* 2004). In Hungary 75–79% of the colonies can be found in places of anthropogenous origin (e.g. mines, roadsides, potholes, motocross racing tracks) and the proportion of natural colonies is only 10-11% (MME Monitoring Központ 2004). Whereas here the proportion of natural nest sites is 39–57% according to the surveys of the last years (Ivók 2010, 2012). Out of the natural nesting places the loess and sandy hillsides play the most important role, where the nesting cavities are not dig in walls but into the ground with vegetation cover. More than half (51.8%) of the population investigated breeds like that. Although this type of breeding is well-known (White *et al.* 1978, Szalczer 1981), it is very rarely studied and mentioned in the literature. Since measurements were mainly taken only in walls until now, the majority of publication is discussing those (Fintha 1968, White *et al.* 1978, Ar & Piontkewitz 1992, Gyovai 1993, Petrescu 1998, Casas-Crivillé & Valera 2005), hence we focused on the investigation of hillside breeders, besides the comparison with wall-breeding populations.

Our aims were:

(1) to quantify the ratio of nests on loess and sandy grounds,
(2) to give estimations of the vegetation cover near the nest sites in hillsides,
(3) to measure the slope of the hillside at the entrances of nesting cavities,
(4) to investigate the correlation between type of substrate and slope measured,
(5) to compare the length of cavities on loess and sand, in walls and hillsides,
(6) to find correlation between type of substrate and length of cavities,
(7) to estimate the distance of nests from the surface in loess and sand, and in walls or hillsides.

Methods

The monitoring of Bee-eaters was carried out from 2009 according to the RTM (Rare and Colonial Breeders) protocol of BirdLife Hungary (MME) (Nagy *et al.* 2008). We have documented the exposure and size of walls, the numbers of nesting cavities (used and unused).

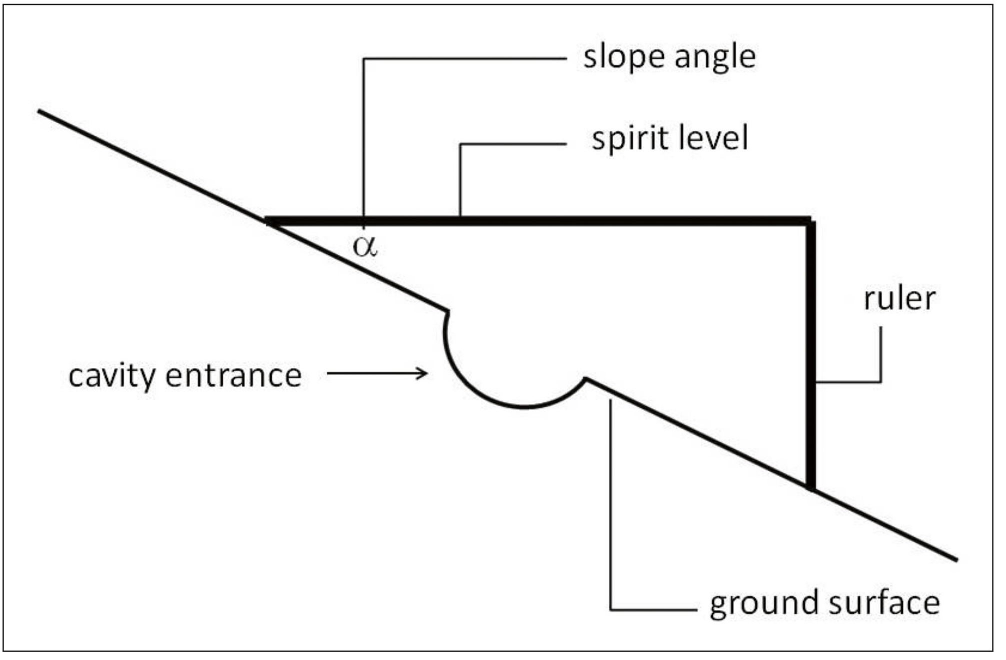

Figure 1. Sketch on the measurement of the slope inclination
1. ábra A lejtőszög mérésének vázlatos rajza

In 2011 and 2012 we measured the length of ducts leading to the nesting chamber, the distance between the entrance and the top of the wall, in hillsides the slope at the entrance and estimated the vegetation cover. In the two years we have measured 346 cavities, 96 in walls and 250 in hillsides (98 on sand and 248 on loess).

To measure the length of ducts, after the breeding season we inserted a 5 meter long measuring-tape into the cavities used in the given year. The distance from top of the wall was measured similarly. The ducts of hillside breeders were regarded as horizontal, and the distance from the surface was estimated taking into account the slope. The slopes were measured with a spirit level and a ruler, according to *Figure 1.*

Around the cavities in hillsides we estimated the vegetation cover in a 1 m^2 area using the Braun-Blanquet scale (coverage < 1%: +, 1-5%: 1, 6-25%: 2, 26-50%: 3, 51-75%: 4, 76-100%: 5) (Borhidi 2003). In case of the walls this was not possible in lack of vegetation on the vertical surfaces.

To process data and for statistical analyses we have used Microsoft Office Excel 2007 and SPSS 16.0. software (Gupta 1999, Huzsvai 2004–2011). To compare the samples t-test were applied with a preceding check of applicability (Kolmogorov-Smirnoff test). According to the results of the F-test we have chosen the appropriate t-test (Précsényi 1995). Linear regression was used to find correlation (Précsényi 1995).

Results

Most of the nesting cavities were found in loess both in the case of hillside breeders and wall breeders *(Table 1)*. 61.86% of hill-

	loess	sand	mixed (sandy loess)
hillsides (n=257)	61.86%	28.40%	9.73%
walls (n=239)	72.80%	23.43%	3.77%
total (n=496)	67.14%	26.01%	6.85%

Table 1. Distribution of nesting cavities of Bee-eaters on different types of substrate, 2012
1. táblázat A gyurgyalag üregek százalékos aránya a különböző alapkőzetekben, 2012

side nests were excavated into loess, 28.4% into sand, while the remaining 9.73 percent into mixed loess and sand. Among nests excavated into walls the ratio of those in loess is a bit higher: 72.8%, and hence only 23.43% was found in sand walls.

Based on the measurements the Bee-eaters prefer a slope of 11-30° *(Figure 2)*, 76.8% of the nesting cavities were found in this slope range. There is a difference between loess and sandy grounds in this respect: on loess the slope is significantly steeper than on sand (loess: $m = 24.67°$, $SD = 7.43$, sand: $m = 13.97°$, $SD = 4.27$, $t = 14.236$ $p < 0.01$).

The length of the ducts leading to the breeding chambers is different in wall breeders and hillside breeders, and also between sand and loess: ducts in sand are longer (walls: $p < 0.05$; hillsides: $p < 0.01$, *Table 2*). The ducts dug in hillsides are longer than those in walls (loess: $p < 0.05$, sand: $p < 0.01$, *Table 3*).

The distances of breeding chambers from the surface are not different between walls

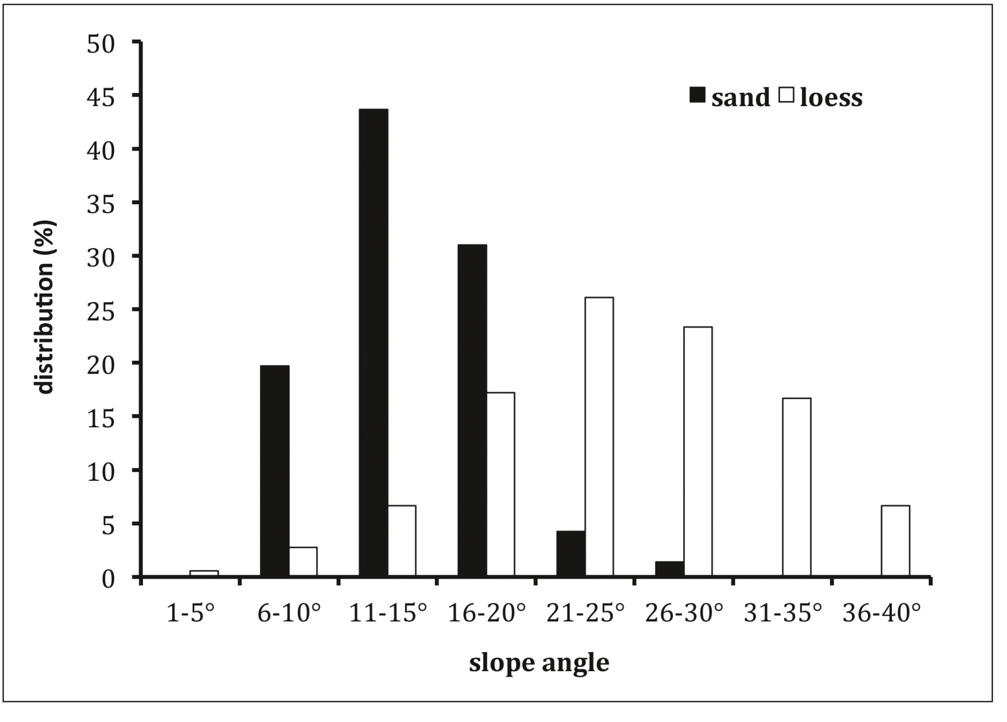

Figure 2. Distribution of the cavities according to inclination of slope, Gödöllő Hills, 2011–2012
2. ábra A gyurgyalag üregek lejtőszög szerinti megoszlása. Gödöllői-dombság, 2011–2012

	sand			loess				
	n	m	SD	n	m	SD	t	p
length of duct in hillsides (cm)	71	163.48	27.08	179	136.73	26.38	7.176	0.01
length of duct in walls (cm)	38	136.55	30.84	91	123.52	26.39	2.431	0.05

Table 2. Average lengths of the ducts leading to nesting chambers in hillsides and walls
2. táblázat Fészkelő üregekhez vezető járatok átlagos hossza domboldalakban és partfalakban

	hillside			wall				
	n	m	SD	n	m	SD	t	p
length of duct in loess (cm)	179	136.73	26.38	91	123.52	26.39	3.891	0.01
length of duct in sand (cm)	71	163.48	27.08	38	136.55	30.39	4.711	0.01

Table 3. Average lengths of the ducts leading to nesting chambers in sandy and loess grounds
3. táblázat Fészkelő üregekhez vezető járatok átlagos hossza homokos és löszös alapkőzeten

	sand			loess				
	n	m	SD	n	m	SD	t	p
distance of nesting chamber from surface in hillsides (cm)	71	40.81	14.39	179	62.86	22.27	–9.25	0.01
distance of nesting chamber from surface in walls (cm)	27	52.11	27.36	69	58.8	39.54	–0.81	n.s.

Table 4. Average distances of the nesting chambers from the surface in hillsides and walls, sandy and loess grounds
4. táblázat A fészkelő üregek talajfelszíntől való átlagos távolsága homokos és löszös alapkőzeten, domboldalakban és partfalakban

and hillsides (walls m = 54.94, SD = 31.10, n = 95; hillsides: m = 56.60, SD = 22.63, n = 250, t = –0.476, NS). There is no difference between ground types in the distance from the surface (in both cases cc. 50-60 cm) in walls, but in the hillside breeders the chambers in loess are deeper ($p < 0.01$, *Table 4*).

On loess the slope and length of the duct show a negative correlation: the steeper the hill, the shorter the duct ($R = 0.297$, $p < 0.01$, *Figure 3*). Such a correlation was not found on sand ($R = 0.054$, NS).

For Bee-eaters nesting in hillsides a lower vegetation cover could be found in the 1 m^2 area around the entrance. On sandy ground 98.5% of the pairs nest in areas with cover below 25% and 99.9% below 50%. On loess ground this numbers are 43.5% and 71.3%, respectively. Together 60% of pairs prefer coverage lower than 25% and 80% that of 50% *(Figure 4)*.

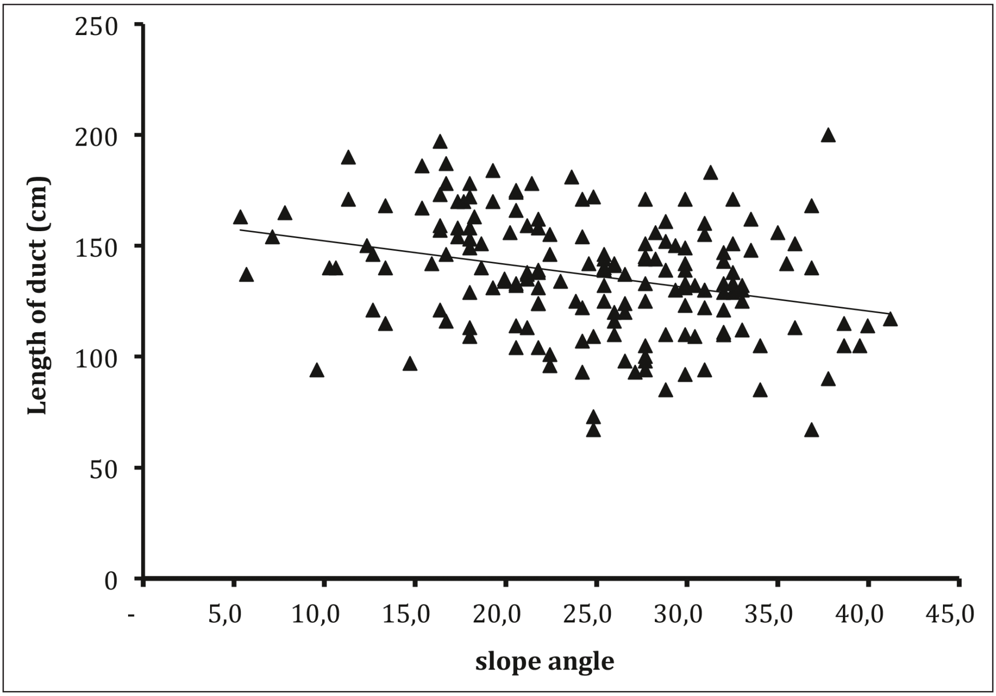

Figure 3. Correlation between length of the duct and slope of the hillside on loess ($y=-1,0555x+162,77$; $R=0,297$; $p < 0.01$)

3. ábra Kapcsolat az üreg hossza és a löszös domboldal meredeksége között (az egyenes egyenlete: $y=-1,0555x+162,77$; $R=0,297$; $p < 0.01$)

Discussion

Bee-eaters prefer to nest in loess. The distribution of the European populations shows significant overlaps with the loess surfaces (Smalley *et al.* 2013). Based on the soil samples taken from the vicinity of nesting cavities water permeability is an important factor in the choice of nesting places. This value is 164.7±89.6 kPa for – the soils of Bee-eater nest locations (Heneberg 2009). In the preferred areas of the species the average diameter of soil granules is 42.763±13.58 μm (min. 20.10 μm, max. 66.82 μm). Bee-eaters favour soils with particle size between 20 and 70 μm (Heneberg & Šimeček 2004). This size is the dominant fraction of a typical loess (Smalley & Leach 1978). In the Gödöllő Hills Bee-eaters prefer loess just like in other parts of their area, e.g. Romania (Petrescu 1998), Serbia (Purger 2001) or the Czech Republik (Heneberg & Šimeček 2004).

Nesting in cavities as opposed to open nests might be advantageous, because the nest cavity offers protection against predators and from harsh weather conditions (Birchard *et al.* 1984, Ar & Piontkewitz 1992), and minimise the stress caused by temperature fluctuations in the period of brooding and chick hatching (White *et al.* 1978). The birds have to optimise the length of the duct and the depth from the surface. Nest predators have more difficulties with detecting and excavating the deeper cavities, but on the other hand the ventilation, the diffu-

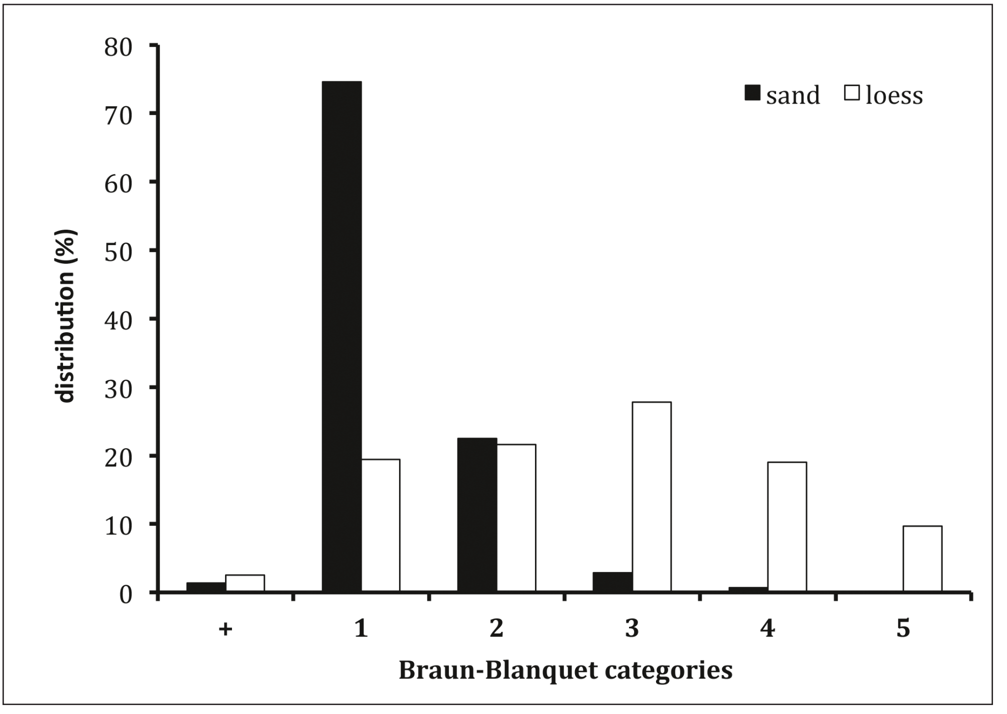

Figure 4. Distribution of Bee-eater cavities according to vegetation coverage, Gödöllő Hills, 2011–2012 (based on the Braun-Blanquet scale: coverage < 1%: +; 1-5%: 1; 6-25%: 2; 26-50%: 3; 51-75%: 4; 76-100%: 5)

4. ábra A gyurgyalag üregek eloszlása a növényzet borítása függvényében. Gödöllői-dombság, 2011–2012 (A Braun-Blanquet skála szerint +: a növényzet a mintaterület < 1%-át, 1: a mintaterület 1-5%-át, 2: 6-25%-át, 3: 26-50%-át, 4: 51-75%-át, 5: 76-100%-át borítja)

sion of oxygen and carbon dioxide is important, too (White *et al.* 1978). Besides protection from predators it is important, how far the nesting chamber is from the entrance and from the surface is.

On different climates the length of ducts was different in the loess walls. A precise comparison is impossible because of the differences in the data presented (mean, minimum-maximum, both). The average length in Israel is 180 ± 21.7 cm (Ar & Piontkewitz 1992), in southern Romania 112 cm (min. 90, max. 143 cm) (Petrescu 1998), in south-eastern Spain 142.8 cm ± 9.9 cm (Casas-Crivillé & Valera 2005). According to former studies this value is 70-120 cm in Hungary (Fintha 1968), but it can reach up to 180-200 cm (Bankovics 1998). The harness of the soil might strongly affect the length of the duct: in a study carried out around Hódmezővásárhely, Hungary in a sand excavation pit, the ducts were 29 cm shorter in hard sand, than in soft sand (Gyovai 1993). The lengths of the ducts were different in the Gödöllő Hills between loess and sand, this result is in concordance with the literature.

The average distance of cavities from the surface was 50 cm (Ar & Piontkewitz 1992), and 40-100 cm (Petrescu 1998) in case of walls. In the Gödöllő Hills the distances showed similar values, both in hillsides and walls or sand and loess. When the birds were breeding on hillsides the breeding chamber was located deeper in loess, than is sand.

Our results suggest that booth the type of substrate and the slope of the hillside have an effect on the length of the ducts leading to the nesting chambers. In walls, where the ducts are more or less perpendicular to the wall surface and parallel with the soil surface above the bank, the length of the duct depends on the type of substrate: in loess, which is harder and consisting of smaller granules, it is shorter. In birds breeding in hillsides the slope has an important effect: the Bee-eaters dig until they reach cc. 40-60 cm depth from the surface, which is a similar value to that measured in birds nesting in walls. As Bee-eaters in the Gödöllő Hills breeding in sandy areas choose less steep slopes, than those breeding in loess area, the ducts are accordingly longer, so that the nesting chambers are in an appropriate depth from the soil surface. This depth is important as a defence against predators and it has implications connected to the microclimate and ventilation ability of the chamber.

Bee-eaters prefer surfaces with a low vegetation cover. This preference could be connected to the differences in water retention and permeability of the soils formed on sand and loess. On sand, where the water flows through quickly (sandy plains and pastures), the vegetation is not that dense, as on loess soils with a better water retention (loess plains). Therefore Bee-eaters find lower vegetation coverage on sand, but at the same time nearly ¾ of them prefer a cover under 50% even on loess.

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