



The High Level of Between-Year Burrow Reuse in a European Bee-Eater *Merops apiaster* Colony

Ivana Novčić^{1*}, Miloš Radaković^{1,2} & Marko Raković³

¹University of Belgrade – Faculty of Biology, Studentski trg 16, 11000 Belgrade, Serbia; E-mail: inovcic@bio.bg.ac.rs

²Institute for Nature Conservation of Serbia, Japanska 35, 11070 Belgrade, Serbia; E-mail: milos.radakovic@zzps.rs

³University of Belgrade – Institute for Multidisciplinary Research, Kneza Višeslava 1, 11000 Belgrade, Serbia;
E-mail: markorakovic@imsi.bg.ac.rs

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Abstract: In this paper, we report a high level of burrow reuse by European bee-eaters (*Merops apiaster*) in a mixed colony shared with common starlings (*Sturnus vulgaris*) and common swifts (*Apus apus*) at Višnjička Kosa, a suburban area of Belgrade, Serbia. The study was conducted during the breeding season in 2023 and 2024. Of the 255 burrows examined in 2024, 123 (48.23%) had been used in a previous breeding year, 88 (34.51%) were completely or partially excavated prior to 2024 but not used in 2023 and 36 (14.12%) were newly excavated in 2024. These results demonstrate a substantial level of burrow reuse within the studied colony, suggesting that reusing existing burrows may allow birds to conserve the energy and time otherwise required for new excavation.

Key words: burrow re-occupation, cavity-nesting birds, colonial birds, European bee-eater

Introduction

Birds either build new nests or reuse old ones at the onset of the breeding season. Species with nests that degrade over time, such as the open cup nests of many passerines, typically construct new nests each breeding season (Hansell 2000). By contrast, durable nests that can withstand deterioration for extended periods may be reused for multiple years, as is the case for the nests of storks, raptors and cavity-nesting species (Aitken et al. 2002, Vergara 2010; Jiménez-Franco et al. 2014). Although previously used nests tend to contain higher parasite loads and may be more easily located by predators, nest reuse

conserves time and energy, enabling earlier clutch initiation (Barclay 1988, Wiebe et al. 2007, Pakkala et al. 2017, Batisteli et al. 2021). Consequently, nest reuse is common among species with structurally stable nests and among those that do not construct their own nests, such as secondary cavity nesters i.e. species that do not excavate cavities but breed in existing ones (Aitken et al. 2002, Vergara 2010).

The European bee-eater (*Merops apiaster*; hereafter, the bee-eater) is a long-distance migratory species that breeds across Europe, Asia, the Mediterranean region and Southern Africa and winters in Western, Central and Southern Africa (Bastian & Bastian 2024). The bee-eater is a cavity-nesting species that excavates its

*Corresponding author: inovcic@bio.bg.ac.rs

burrows, typically in loess, clay or sand cliffs, forming colonies that range in size from a few to several hundred breeding pairs (Cramp 1985, Bastian & Bastian 2024). Each burrow consists of a tunnel and a chamber and is approximately 1.5 m long, ranging from less than 1 m to as much as 3 m (Fry 1984, Bastian & Bastian 2024). Both sexes participate in burrow excavation, a process that takes 10–20 days; during this period, the birds may remove up to 12 kg of soil (Fry 1984). As excavators, bee-eaters function as ecosystem engineers by creating nesting sites for other cavity-nesting birds, as well as shelters and breeding habitats for various amphibians, reptiles and mammals (Purger 2001, Casas-Crivillé & Valera 2005, Gyurácz et al. 2013). Due to the lack of nest sanitation, earlier research suggested that bee-eaters construct new burrows each breeding season (Fry 1984). However, although they are capable of excavating new burrows annually, bee-eaters may also reuse old burrows: a nesting behavior that has only recently been thoroughly documented (Brust et al. 2015). In this paper, we report a high level of nest reuse by bee-eaters in a mixed colony shared with common starlings (*Sturnus vulgaris*, hereafter, the starling) and common swifts (*Apus apus*, hereafter, the swift).

Materials and Methods

The study was conducted on a mixed colony of bee-eaters, starlings and swifts located in Višnjička Kosa, a suburban area of Belgrade, Serbia (44.8°N, 20.6°E), during the 2023 and 2024 breeding seasons. The colony was likely established in the early 2010s on a 550-meter-long loess bank, ranging from 2 to 8 m in height, resulting from historical clay excavation. Currently, it comprises approximately 300 active bee-eater burrows, over 120 starling nests and about a dozen swift nests. Both starlings and swifts, as secondary cavity nesters, breed in burrows excavated by bee-eaters during previous breeding seasons (Novčić et al. 2025). Since 2024, the 30-ha area, including the studied bank, has been protected under the Law on Nature Protection as a site of local significance, named “Glinara” (Official Gazette of the City of Belgrade 2024).

In order to identify active burrows, we recorded the colony using high-definition digital camcorders in both years and examined selected burrows with an endoscope camera. Each segment of the colony was recorded several times during the study period: for 15-minute sessions in 2023 and 30- to 60-minute sessions in 2024. The recorded material was reviewed on a computer and a burrow was classified as active if it met at least one of the following criteria: (1) birds entered the burrow at least twice

during the study period; (2) birds entered the burrow at least twice during a single observation session or (3) the presence of eggs or nestlings inside the burrow was confirmed.

From the video recordings, we were also able to determine which burrows were newly excavated in 2024 and which had been excavated prior to 2024 and used in 2023. Additionally, for a subset of burrows, we identified those that had been excavated, at least partially, before 2024 but were not used in 2023. For these burrows, we could not determine whether the burrows had been fully excavated prior to 2024 (i.e., containing both a tunnel and a chamber) or whether they were incomplete, consisting only of a partial tunnel. For a small number of burrows, the timing of burrow excavation could not be determined.

To examine whether bee-eaters reused burrows or excavated new ones based on their relative position on the bank, we followed the methodology described in Novčić et al. (2025). In brief, for each burrow, we calculated its relative position as the distance from the ground to the burrow entrance divided by the total height of the bank. Burrows were then classified into three vertical categories: bottom portion (relative burrow position $\leq 1/3$ of bank height), middle portion (relative burrow position $> 1/3$ and $\leq 2/3$) and top portion (relative burrow position $> 2/3$ of bank height). Measurements were conducted using tpsDig2 software, version 2.32. To test for differences in the number of reused and newly excavated burrows across height categories, we performed pairwise binomial tests for proportions. The proportions of burrows were compared between each pair of height categories; false discovery rate (FDR) adjustments were applied to account for multiple comparisons (Crawley 2013). All statistical analyses were conducted in R, version 4.4.0, using the stats package (R Development Core Team 2024).

Results and Discussion

We monitored 255 bee-eater burrows in 2024. Of these, 36 burrows (14.12%) were newly excavated in 2024; 120 burrows (47.06%) were used by bee-eaters in 2023; three burrows (1.18%) were previously used by starlings in 2023; 88 burrows (34.51%) were completely or partially excavated prior to 2024 but not used in 2023 and for eight burrows (3.14%), we were unable to determine the timing of excavation (Figures 1 and 2). Among the 123 burrows used in 2023, birds reused significantly more burrows in the top ($N = 55$) and middle ($N = 59$) portions of the bank than in the bottom portion ($N = 9$; binomial test: $p < 0.01$ for both comparisons). Similarly, when

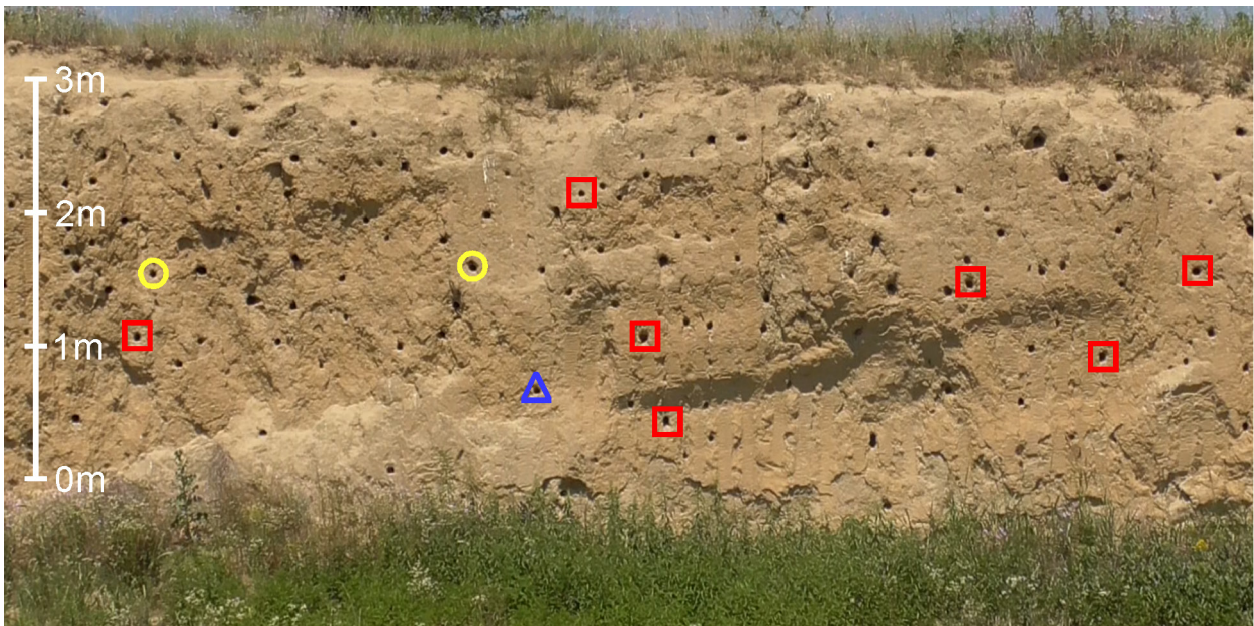


Fig. 1. A section of the bank showing bee-eater nests, including a scale indicating bank height in meters. Square markings indicate nests used in both 2023 and 2024; circular markings indicate nests used in 2024 that were excavated prior to 2024 and a triangular marking indicates a nest excavated in 2024.

partially excavated burrows and tunnels were also taken into account, birds reused significantly more burrows in the top (N = 89) and middle (N = 101) portions of the bank than in the bottom portion (N = 21; binomial test: $p < 0.01$ for both comparisons). Bee-eaters also excavated significantly more new burrows in the top (N = 21) and middle (N = 12) portions than in the bottom portion (N = 3; binomial test: $p < 0.01$ and $p = 0.03$, respectively).

Nest reuse by bee-eaters at the Višnjička Kosa colony was notably high during the 2024 breeding season. Nearly half of the nests were located in burrows that had also been used during the previous breeding season, while a substantial portion were placed in burrows or tunnels that had been at least partially excavated prior to 2024. Such a high level of burrow reuse cannot be attributed to a lack of available bank surface for all breeding pairs, as the study area includes additional loess banks that remain uncolonised by birds. In a long-term study of a bee-eater colony monitored over 11 years, Brust et al. (2015) reported that 54% of broods occurred in existing burrows, with a 26% probability that any given burrow would be reused in subsequent years. Additionally, the authors concluded that the probability of burrow reuse declines with the age of the breeding bank, most likely due to an increased risk of burrow collapse. Similarly, Rupp et al. (2011) reported that suitable burrows in solid loess may remain well preserved and be used by bee-eaters for

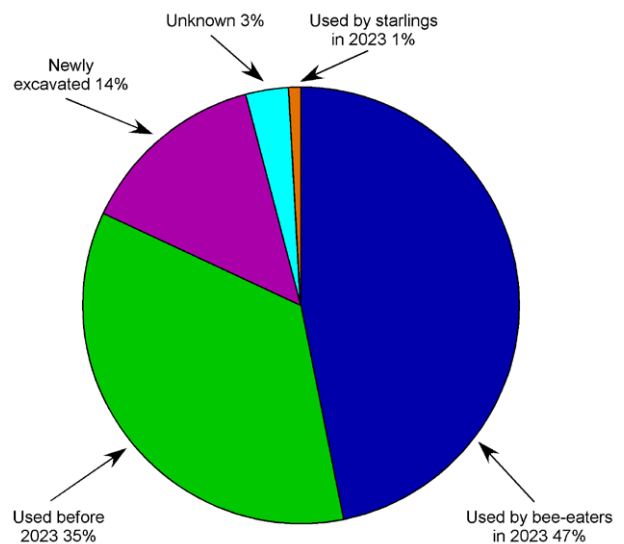


Fig. 2. Proportion of reused and newly excavated bee-eater burrows in 2024.

many years. Loess, as a substrate, is suitable for burrowing birds because it is easy to excavate yet compact enough to provide structural stability to the tunnels (Smalley et al. 2013). The colony studied at Višnjička Kosa is located in a loess bank composed of sand, silt and a relatively high proportion of clay particles (Rudolf-Vesić 1955, Bogojević 1968), which likely makes this substrate more difficult to excavate (Heneberg 2009). This soil characteristic may be one of the reasons for the high level of nest

reuse, as the energy costs associated with excavation could be offset by repeated use of existing burrows. For example, the common kingfisher (*Alcedo atthis*) often reuses its breeding burrows, as it typically nests in banks with relatively high compactness (Heneberg 2013). Similarly, the sand martin (*Riparia riparia*) frequently reuses its burrows in Yukon, Canada, where frozen soil can limit excavation during early spring (Sinclair et al. 2020).

Although nest reuse may increase the risk of predation since predators may learn the locations of active nests (Otterbeck et al. 2019), birds may preferentially reuse previously successful nests while avoiding those that were depredated (Styrsky 2005). Brust et al. (2015) reported that bee-eaters were less likely to reuse burrows in older breeding banks, suggesting that reuse was influenced more by burrow age than by its quality, including factors such as predation risk. Nevertheless, the overall predation level in their study colony was very low. By contrast, our previous research documented a high level of nest predation by the Caspian whipsnake (*Dolichophis caspius*) within the bee-eater colony at Višnjička Kosa, where the likelihood of predation increased for nests located near the top and bottom of the bank (Raković et al. 2024). In 2024, bee-eaters reused significantly more nests in the top and middle portions of the bank than in the bottom portion. However, of the 38 nests with known predation status in 2023, 12 were reused in 2024; only two of these had been depredated the previous year. These findings suggest that bee-eaters may preferentially reuse successful burrows, regardless of their position within the breeding bank, while avoiding those associated with previous predation, although this hypothesis requires further studies.

Conclusions

This study provides evidence of high nest reuse among bee-eaters in a mixed colony at Višnjička Kosa, Serbia. Nearly half of the burrows examined in 2024 had been used during the previous breeding season, while over 30% had been excavated prior to 2024 but were not used in 2023. These results suggest that nest reuse in this species may be more common than previously assumed. The observed behavior likely offers advantages such as conserving the energy and time required to excavate new burrows. However, it raises questions about the trade-offs between these benefits and potential risks, such as increased parasite loads or predation. Future studies should explore the long-term consequences of nest reuse on reproductive success, as well as its implications for colony dynamics and conservation strategies.

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