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CHARACTERISTICS OF A MIXED COLONY OF BEE-EATERS, STARLINGS AND SWIFTS WITHIN THE PROTECTED HABITAT "GLINARA", BELGRADE, SERBIA

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We examined the characteristics of a colony of European Bee-eaters (*Merops apiaster*), Common Starlings (*Sturnus vulgaris*), and Common Swifts (*Apus apus*) in a loess bank located within the Protected habitat "Glinara", Belgrade, Serbia. Using video observations recorded during the 2023 breeding season, we documented 305 active bee-eater nests, 127 starling nests, and 13 swift nests. Bee-eaters and starlings placed significantly more nests in the top and mid portions of the bank compared to the bottom portion, while swift nests were exclusively recorded in the mid and top portions of the bank.

Keywords: cavity-nesters; nest position, *Merops apiaster*, *Sturnus vulgaris*, *Apus apus*

INTRODUCTION

Coloniality is widespread among avian taxa (Rolland *et al*. 1998) and is characterized by the breeding of varying numbers of individuals in a typically centralized location at the same time (Brown & Brown 2001). Although various factors may drive the evolution of colonial breeding in birds, three are considered the most influential: (1) the limitation of suitable nesting sites; (2) antipredator benefits, including collective detection of predators, the dilution effect, confusion of predators, or group defense; and (3) foraging benefits, as individuals may locate food patches more quickly by observing their colony mates (Brown & Brown 2001). These factors can lead to the aggregation of birds from different species and the formation of mixed-species colonies (Burger 1981, Goodale *et al*. 2017). Additionally, members of one species, through their activities (e.g., nest construction), may create breeding habitats for other species, further facilitating the development of mixed-species colonies (Goodale *et al*. 2017). Colonies can vary greatly in size, ranging from a few individuals to hundreds or thousands, even within the same species. This variation may result from the patchy distribution of food and suitable breeding sites or the phenotypic sorting of individuals based on preferences for colonies of a particular size (Brown *et al*. 1990, Brown 2016).

In this study, we examined the characteristics of a colony of European Bee-eaters (*Merops apiaster*; hereafter bee-eaters), Common starlings (*Sturnus vulgaris*; hereafter starlings), and Common Swifts (*Apus apus*; hereafter swifts) in a loess bank located within the Protected habitat “Glinara”, Belgrade, Serbia. The bee-eater is a cavity-nesting species that excavates its nests, typically in loess, clay, or sand cliffs, within colonies ranging from a few to several hundred breeding pairs. Its nest consists of a burrow, including a tunnel and a nest chamber, with an average length of approximately 1.5 *m* (Bastian & Bastian 2024). As an excavator, the bee-eater is considered an ecosystem engineer, providing breeding sites for various cavity-adopting bird species, including starlings, swifts, Eurasian Hoopoes (*Upupa epops*), Great Tits (*Parus major*), Eurasian Tree Sparrows (*Passer montanus*), and House Sparrows (*Passer domesticus*), among others (Petrescu & Adam 2001, Purger 2001, Casas-Crivillé & Valera 2024, Shupova *et al*. 2022). Additionally, bee-eater burrows are used as shelters or breeding sites by various amphibians, reptiles, and mammals (Casas-Crivillé & Valera 2024).

The bee-eater is a long-distance migrant with a breeding range across Europe, Asia, the Mediterranean, and southern Africa, and non-breeding ranges in western, central, and southern Africa (Hahn *et al*. 2019, Bastian & Bastian 2024). Its population in Serbia is estimated at 5,200–8,500 breeding pairs, with an increasing long-term population trend (BirdLife International 2021a). The swift is also a long-distance migrant, breeding across the Palearctic and wintering in sub-Saharan Africa. It breeds in cavities, mainly within buildings, but also in nest boxes, tree holes, and rock crevices (Chantler *et al.* 2020). Its population in Serbia is estimated at 4,200–6,700 breeding pairs, with an increasing long-term population trend (BirdLife International 2021b). However, its breeding population is declining across Europe, where it is listed as a Near Threatened species (BirdLife International 2021b). Starlings breed in various types of existing cavities but can occasionally excavate their own holes in soft soil (Cabe 2020). They are widely distributed in Serbia, with an estimated population of 313,000–483,000 breeding pairs and a declining long-term population trend (BirdLife International 2021c). Recent research indicates that bee-eater nests located closer to the ground or the top of the bank are more susceptible to predation than those placed more centrally (Raković *et al.* 2024). Accordingly, the specific objectives of this study were: (1) to assess the number of active nests of bee-eaters, starlings, and swifts within the colony, and (2) to determine the positions of these nests relative to the ground and the top of the bank. Given the limited information on the breeding biology of bee-eaters, starlings, and swifts in Serbia, this study will likely enhance our understanding of these species and support future research and conservation efforts in the country.

MATERIAL AND METHODS

The study took place in the Protected habitat “Glinara”, located in Višnjička Kosa, a suburban area of Belgrade, Serbia (44.8°N, 20.6°E), between April 10 and July 11, 2023. The study site features a diverse landscape, including a mix of agricultural and ruderal habitats, forests, thickets, hedgerows, and steep, exposed loess slopes formed by past clay excavation for nearby brickyards (Jakovljević *et al.* 2008) (Figure 1). Although no information on the establishment of the colony is available in the literature, it is assumed that birds colonized this area following the closure of the brickyards (Divac *et al.* 2023), which, based on Google Earth satellite imagery, likely occurred at the beginning of 2010s. The studied colony is located along a 550-meter-long bank with a height ranging from 2 to 8 meters. The 30-hectare area, including the studied bank, has been protected by the Law on Nature Protection as a site of local significance since 2024 (Official Gazette of the City of Belgrade 2024) (Figure 2).

To identify active nest holes, we recorded the colony using a high-definition digital camcorder from a distance of 50–60 *m*. Each segment of the colony was recorded for 15 minutes per session, multiple times during the study period. The recorded material was observed on a computer screen several times to ensure the accuracy of the collected data. A nest was considered active if: 1) birds entered the hole two or more times over the course of the study period, or 2) birds entered the hole two or more times within a 15-minute observation session, often carrying insects in their beaks. To corroborate these observations, we inspected several nest holes using an endoscope camera, confirming the presence of adults with nestlings (Figure 3). Additionally, we photographed each section of the bank with a one- or three-meter scale, depending on the height of the bank segment.

Fig. 1. – The Protected habitat” Glinara” (photo: Srđan Marinčić).

For each nest, we determined the total bank height as the distance between the ground and the top of the bank using tpsDig2 software, version 2.32. We also calculated the nest position relative to the total bank height as the distance from the ground to the nest divided by the total height of the bank. The relative nest position was expressed as a percentage. Nests were then categorized into three height categories: bottom portion (relative nest position ≤ 1/3 of the bank height), mid portion (relative nest position > 1/3 and ≤ 2/3), and top portion (relative nest position > 2/3 of the bank height). Differences among species in nest distance from the top of the bank, and relative nest position, were analyzed using Welch’s t-test, as Bartlett’s test revealed heteroscedasticity ($p < 0.01$). Differences among species in the distances of nests from the ground were assessed using a standard t-test (McDonald 2014). To test for differences in the number of nests within height categories, we performed binomial tests for proportions for each species (Crawley 2013), with Bonferroni adjustments applied for pairwise comparisons (McDonald 2014). The nests of swifts were not included in analyses due to small sample size. All statistical analyses were conducted in R version 4.4.0, using the stats package (R Development Core Team 2024).

Fig. 2. – Map illustrating the boundaries of the protected habitat "Glinara" (cyan line) and the location of the studied loess bank (yellow line).

RESULTS

During the 2023 breeding season, we recorded 305 active bee-eater nests, 127 starling nests, and 13 swift nests. The average distance (± SD; range) from the ground to the bee-eater nest hole was 3.25 *m* (± 1.40; 0.56–7.38), while the distance from the top of the bank to the nest hole was 1.78 *m* (± 1.22; 0.11–6.16). Bee-eaters placed significantly more nests in the top (N = 152) and mid portions of the bank (N = 124) compared to the bottom portion (N = 29; binomial tests: $p < 0.01$).

For starlings, the average distance from the ground to the nest hole was 3.70 *m* (± 1.40; 0.60–6.69), and the distance from the top of the bank to the nest hole was 1.78 *m* (± 0.90; 0.35–4.48). Starlings also placed significantly more nests in the top (N = 62) and mid portions of the bank (N = 63) compared to the bottom portion (N = 2; binomial tests: $p < 0.01$). The distance from the ground to the nest hole was significantly different between bee-eaters and starlings ($t = -3.02$, $df = 234.46$, $p < 0.01$). However, there were no significant differences in the distance from the top of the bank to the nest hole ($t = -0.002$, $df = 314.71$, $p = 1.00$) or in the relative position of nests ($t = -1.01$, $df = 295.30$, $p = 0.31$) between these two species.

For swifts, the average distance from the ground to the nest hole was 4.19 *m* (± 1.44; 1.43–6.35), and the distance from the top of the bank to the nest hole was 2.04 *m* (± 1.44; 0.51–6.50). Seven swift nests were placed in the top portion of the bank, six in the mid portion, and none in the bottom portion of the bank. Two burrows used by starlings at the beginning of May were subsequently occupied by bee-eaters. Similarly, two nests initially occupied by starlings were later used by swifts as the breeding season progressed.

DISCUSSION

We found that the colony within the Protected habitat “Glinara” comprises over 300 active bee-eater nests, making it the largest bee-eater colony in Serbia. The highest number of bee-eaters breeds in Vojvodina, which accounts for 60% of the breeding population in the country (Puzović *et al*. 2015). High numbers of bee-eaters have been recorded at Titelski Breg, with an estimated 400–700 breeding pairs, and along the Danube loess bluffs (eastern Srem), with an estimated 200–400 breeding pairs (Puzović *et al*. 2009). However, at Titelski Breg, bee-eaters breed in dozens of scattered colonies, none exceeding 100 breeding pairs (D. Radišić, pers. comm.). Additionally, the sizes of these colonies, including those in the

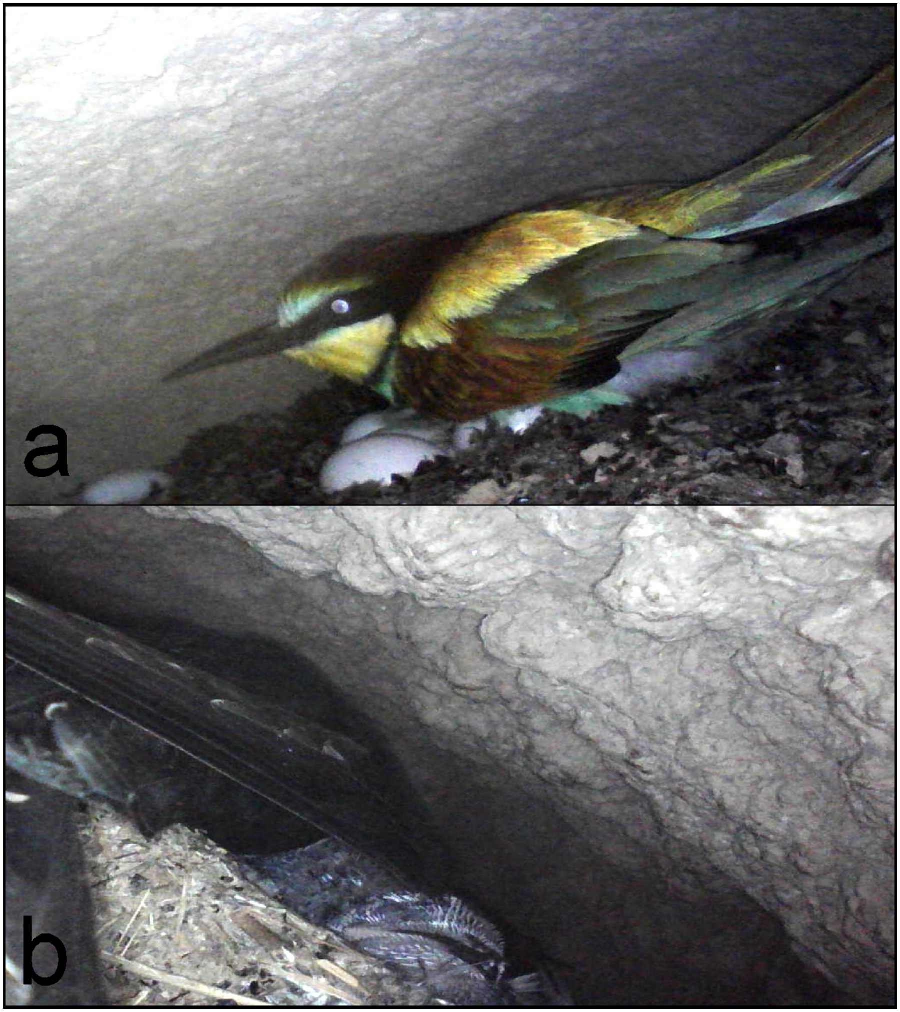

Fig. 3. – The burrows recorded by an endoscope camera showing (a) a bee-eater laying on eggs, and (b) a swift with nestlings.

Deliblato Sands, were estimated by counting the number of adult individuals (D. Radišić, pers. comm.), a method that typically overestimates colony size (Mere 2008). By video-recording the colony in Višnjička Kosa, we provided accurate estimates of its size, showing that it contains a high number of active nests within a considerably smaller area compared to other colonies in the country, including those in Titelski Breg, the Danube loess bluffs, and the Deliblato Sands (Puzović *et al*. 2015, Šćiban *et al*. 2015). This density likely makes the Višnjička Kosa colony the most densely populated bee-eater colony in Serbia. Moreover, the broader area of Višnjička Kosa, extending beyond the boundaries of the protected area, contains additional loess banks that support breeding pairs of bee-eaters not included in this study. Accordingly, this entire area represents an important breeding site for this species in the country.

By digging their burrows, bee-eaters provide breeding sites for starlings and swifts, with the former being particularly abundant. Both species were observed flying into the nest holes at the end of April, confirming their breeding activity. During this period, bee-eaters had just begun arriving at the colony, with their numbers progressively increasing by mid-May. The early arrival of swifts from their wintering grounds, along with the year-round presence of starlings, likely gives these species a competitive advantage in occupying suitable burrows before the bee-eaters appear. The use of bee-eater burrows by these two species has been previously documented. For example, Purger (2001) and Petrescu and Adam (2001) reported their co-occurrence in Vojvodina and Romania, respectively, where other bird species, particularly tree sparrows, often occupied empty bee-eater nests.

Although starling nests were positioned higher above the ground compared to bee-eater burrows, all three species avoided breeding in the bottom portion of the bank. In newly established colonies, bee-eaters tend to dig burrows just below the top of the hill, whereas nests are added to lower portions of the banks in re-used colonies (Bastian & Bastian 2024). Nest placement near the cliff top may reduce disturbances from neighboring birds digging their own nests. Additionally, birds are less prone to predation during nest construction by mammals approaching from the ground (Petrescu 1998). However, nests located near the top of a bank are more susceptible to predation by mammals that can easily excavate them from above (Bastian & Bastian 2024). Furthermore, nests closer to both the top and bottom of cliffs are more vulnerable to predation by the Caspian Whipsnake (*Dolichophis caspius*), as demonstrated for this colony (Raković *et al*. 2024). Thus, the positioning of bee-eaters nests within the vertical bank surface may be influenced by factors other than predation. As cavity adopters, starlings and swifts are limited by the availability of existing burrows excavated by bee-eaters. Consequently, these birds placed their nests in the mid and upper portions of the bank, where cavities were most abundant. Additionally, swifts may be restricted to the higher portions of the bank due to the minimum height required for successful take-off.

The study area has been protected as a site of local significance due to its role as a habitat for protected and endangered species of animals and plants (Divac *et al*. 2023). An additional value of the area lies in its proximity to the country's largest metropolitan center, providing the public with opportunities for biodiversity education and conservation awareness. This study represents the first comprehensive description of the protected mixed-species bird colony, providing a potential foundation for future research and contributing to efforts in conservation and management planning.

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REFERENCES

Bastian, H-V., Bastian, A. (2024): European Bee-eater (*Merops apiaster*), version 3.0. In: Billerman. S. M., Keeney, B. K. (*ed.*): Birds of the World. – Cornell Lab of Ornithology, Ithaca. [https://doi.org/10.2173/bow.eubeat1.03]

BirdLife International (2021a): *Merops apiaster* (Europe assessment). The IUCN Red List of Threatened Species 2021: e.T22683756A166218648. [https://www.iucnredlist.org/species/22683756/166218648]

BirdLife International (2021b): *Apus apus* (Europe assessment). The IUCN Red List of Threatened Species 2021: e.T22686800A166220766. [https://www.iucnredlist.org/species/22686800/166220766]

BirdLife International (2021c): *Sturnus vulgaris* (Europe assessment). The IUCN Red List of Threatened Species 2021: e.T22710886A166360937. [https://www.iucnredlist.org/species/22710886/166360937]

Brown, C. R. (2016): The ecology and evolution of colony-size variation. – **Behavioral Ecology and Sociobiology 70**: 1613–1632.

Brown, C. R., Brown, M. B. (2001): Avian coloniality: progress and problems. – **Current Ornithology 16**: 1–82.

Brown, C. R., Stutchbury, B. J., Walsh, P. D. (1990): Choice of colony size in birds. – **Trends in Ecology and Evolution 5**: 398–403.

Burger, J. (1981): A model for the evolution of mixed-species colonies of Ciconiiformes. – **Quarterly Review of Biology 56**: 143–167.

Cabe, P. R. (2020): European Starling (*Sturnus vulgaris*), version 1.0. In: Billerman. S. M. (*ed.*): Birds of the World. – Cornell Lab of Ornithology, Ithaca. [https://doi.org/10.2173/bow.eursta.01]

Casas-Crivillé, A., Valera, F. (2005): The European bee-eater (*Merops apiaster*) as an ecosystem engineer in arid environments. – **Journal of Arid Environments 60**: 227–238.

Chantler, P., Boesman, P. F. D., Kirwan, G. M. (2020): Common Swift (*Apus apus*), version 1.0. In: del Hoyo, J., Elliott, A., Sargatal, J., Christie, D. A., de Juana, E. (*ed.*): Birds of the World. – Cornell Lab of Ornithology, Ithaca. [https://doi.org/10.2173/bow.comswi.01]

Crawley, M. J. (2013): The R book, ed. 2. – John Wiley & Sons Ltd, West Sussex.

Divac, M., Zatezalo, A., Ivanović, S., Marinčić, S., Obradović, T., Radaković, M., Simić, M., Stanić, M., Stojanović, V. (2023): Study of the protection of the Protected Habitat “Glinara”. – Institute for Nature Conservation of Serbia, Belgrade.

Goodale, E., Beauchamp, G., Ruxton, G. D. (2017): Mixed-species groups of animals: behavior, community structure, and conservation. – Academic Press, London.

Hahn, S., Alves, J. A., Bedev, K., Costa, J. S., Emmenegger, T., Schulze, M., Tamm, P., Zehtindjiev, P., Dhanjal‐Adams, K. L. (2020): Range‐wide migration corridors and non‐breeding areas of a northward expanding Afro‐Palaearctic migrant, the European Bee‐eater *Merops apiaster*. – **Ibis 162**: 345–355.

Jakovljević, K., Lakušić, D., Vukojičić, S., Teofilović, A. Jovanović, S. (2008): Floristic characteristics of Višnjička Kosa near Belgrade, Serbia. – **Archives of Biological Sciences 60**: 703–712.

McDonald, J. H. (2014): Handbook of Biological Statistics, ed. 3. – Sparky House Publishing, Baltimore.

Mero, T. O. (2008): Number of pairs of European Bee-eater *Merops apiaster* in three colonies in northwestern Bačka. – **Ciconia 17**: 47–50.

Official Gazette of the City of Belgrade (2024): Odluka o proglašenju Zaštićenog staništa „Glinara“.

Petrescu, A. (1998): Study on the placement and architecture of the nests of *Merops apiaster* L. (Aves: Coraciiformes) in colonies from Southern Romania. – **Travaux du Muséum National d’Histoire “Grigore Antipa” 40**: 383–402.

Petrescu, A., Adam, C. (2001): Interspecific relations in the populations of *Merops apiaster* L. (Aves: Coraciiformes) of Southern Romania. – **Travaux du Muséum National d’Histoire “Grigore Antipa” 43**: 305–322.

Purger, J. J. (2001): Numbers and breeding distribution of the Bee-eater *Merops apiaster* in province Vojvodina (northern Serbia) between 1987 and 1990. – **Vogelwelt 122**: 279–282.

Puzović, S., Radišić, D., Ružić, M., Rajković, D., Radaković, M., Pantović, U., Janković, M., Stojnić, N., Šćiban, M., Tucakov, M., Gergelj, J., Sekulić, N., Agošton, A., Raković, M. (2015): Birds of Serbia: Breeding population estimates and trends for the period 2008–2013. – Bird Protection and Study Society of Serbia, and Department of Biology and Ecology, Faculty of Sciences, University of Novi Sad.

Puzović, S., Sekulić, G., Stojnić, N., Grubač, B., Tucakov, M. (2009): Značajna područja za ptice u Srbiji. – Ministarstvo životne sredine i prostornog planiranja, Zavod za zaštitu prirode Srbije, Pokrajinski sekretarijat za zaštitu životne sredine i održivi razvoj.

R Development Core Team (2024): A Language and Environment for Statistical Computing. R Foundation for Statistical Computing. – Vienna, Austria.

Raković, M., Bjelica, V., Novčić, I. (2024): The nest position and bank height of a bee-eater colony affect the likelihood of nest loss due to predation. – **Journal of Ornithology 165**: 1085–1089.

Rolland, C., Danchin, E., Fraipont, M. D. (1998): The evolution of coloniality in birds in relation to food, habitat, predation, and life-history traits: a comparative analysis. – **The American Naturalis 151**: 514–529.

Shupova, T. V., Koniakin, S. M., Grabovska, T. O. (2022): Multi-species settlement by secondary hollow-nesting passerine birds in a European Bee-eater colony. – **Ornis Hungarica 30**: 179–188.

Šćiban, M., Rajković, D., Radišić, D., Vasić, V., Pantović, U. (2015): Birds of Serbia – critical list of species. – Institute for Nature Conservation of Vojvodina Province and Bird Protection and Study Society of Serbia, Novi Sad.

КАРАКТЕРИСТИКЕ МЕШОВИТЕ КОЛОНИЈЕ ПЧЕЛАРИЦА, ЧВОРАКА И ЦРНИХ ЧИОПА НА ПОДРУЧЈУ ЗАШТИЋЕНОГ СТАНИШТА „ГЛИНАРА“, БЕОГРАД, СРБИЈА

ИВАНА НОВЧИЋ, МИЛОШ РАДАКОВИЋ, ТАМАРА СТЕВОВИЋ, МАРКО РАКОВИЋ

РЕЗИМЕ

У раду смо описали карактеристике мешовите колоније пчеларице (*Merops apiaster*), чворка (*Sturnus vulgaris*) и црних чиопа (*Apus apus*) на подручју Заштићеног станишта „Глинара“, на Вишњичкој коси у Београду. Подручје је од 2024. године Одлуком скупштине Града Београда заштићено као подручје III категорије, односно заштићено подручје локалног значаја. Истраживана колонија је смештена у 550 *m* дугом лесном одсеку, који је настао ископавањем земљишта за оближњу фабрику цигала. Ради пребројавања активних гнезда током сезоне гнежђења 2023. године, колонија је снимана камером у периоду од маја до јула. Сваки сегмент одсека је сниман неколико пута у трајању од по 15 минута. Прегледањем видео материјала, установили смо да се колонија састојала од 305 активних гнезда пчеларица, 127 гнезда чворака и 13 гнезда црних чиопа. Просечно растојање од тла до отвора гнезда пчеларица износило је 3,25 *m*, док је просечно растојање од врха одсека до отвора гнезда износило 1,78 *m*. Просечно растојање од тла до отвора гнезда чворака износило је 3,70 *m*, а просечно растојање од врха одсека је такође износило 1,78 *m*. Гнезда црних чиопа су у просеку од тла била удаљена 4,19 *m*, а од врха одсека 2,04 *m*. Значајно више гнезда пчеларица и чворака је било у горњем и средњем делу одсека у односу на доњи део, док црне чиопе ниједно гнездо нису имале у доњем делу одсека. Колонија у Заштићеном станишту „Глинара“ је једна од највећих колонија пчеларица у Србији. Подаци изнети у раду представљају први детаљан опис мешовите колоније птица у овом заштићеном станишту, те могу послужити као основ за будуће планове управљања и заштите подручја које у свом саставу укључује ове врсте као гнездарице. Уједно, наведена методологија утврђивања величине популације гнездарица у мешовитим колонијама је први пут примењена у Србији и показала је висок ниво прецизности у дефинисању величине популација гнездећих парова.