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Size of sand grains as a significant factor affecting the nesting of bank swallows (*Riparia riparia*)

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Granulometric analysis was performed on 1,652 sand sample particles over 0.9 mm (megapsephitic, psephitic and psamitic fractions of sand and gravel) collected from 82 nesting sites of bank swallows (*Riparia riparia*) in the Czech Republic, Germany, and Great Britain. Most samples were collected from burrows, or above and below them. Bank swallows nested only in sand with grains up to 60 mm (99.8%, the one exception destroyed by rainfall). The mean percentage structure of sand from burrows was: < 0.9 mm 59.26%, 0.9–1.25 mm 8.27%, 1.25–2 mm 2.82%, 2–3 mm 13.19%, 3–4 mm 8.00%, 4–10 mm 7.53%, and 10–60 mm 0.92%. Differences between samples collected from burrows and from sites around burrows on colonized faces were significant in all cases. It was found out that bank swallows selected nest sites based upon the size of grains composing the bank (determined through the building of new nestwalls).

Key words: sandpits, nesting habits, bank material, burrow digging, *Riparia riparia*, granulometry.

Introduction

The bank swallows [*Riparia riparia* (Linnaeus, 1758)] is the smallest bird in the swallow family. They frequently nest in areas of quaternary sediment, which contains the alluvium of river or sea banks. Recently, large numbers of birds have left their native nestsites on river banks and moved their colonies to the vertical embankments of sandpits and claypits, as well as in various piles of sand, earth, and gravel. There is an increasing number of cases of breeding in panel openings, drainage pipes, and even in stone river embankments. They usually nest in colonies numbering from tens to thousands of pairs, and only rarely nest individually. The nest is typically in a chamber at the end of a burrow dug into a vertical, typical sand bank. Digging and nest construction are carried out by both parents (Bencúr, 1977; Cramp, 1988; Turner & Rose, 1994; Heneberg, 1997).

One of the most significant and underestimated factors affecting breeding is the granulometric characteristic of sand. This factor may play a significant role in the nesting of bank swallows, but has been given relatively little attention to date. The granulometric characteristics of megapsephitic, psephitic and psamitic fractions of sand in relation to the nesting of this endangered bird species has not been researched. I therefore conducted the analysis of samples of material from the nestwalls of the bank swallow from the perspective of the granulometric analysis of particles over 0.9 mm in size.

Material and methods

1,652 samples from 82 nest sites in 20 districts from three European countries were collected between 1994 and 1999. Locations in the Czech Republic (Bohemia and Moravia), Southern Germany, and Scotland were used. Most samples come from the district of České Budějovice, Jindřichův Hradec and Břeclav (all in the Czech Republic). Sand samples analysed in this study represent 41% of current bank swallow sites in the Czech Republic (HENEBERG, in press.).

Samples were collected from 12 types of site. The majority of samples were collected from sand quarries (1,358 – 82.2% of samples), 3.5% were from ash dumps, 2.7% from mass kaolin sediment, 2.7% from slopes, 2.6% from gravel sand quarries, 2.0% from feldspar deposits, and 1.8% from the banks of rivers or reservoirs. Less than 1% of the samples were collected from brown coal open-cast mines, clay-pits, piles of earth, quarries and gravel pits. The proportion of nest sites in different sites is similar to that found by HENEBERG (in press) from the Czech bank swallow census 1999 (sandpits – 82.7% of burrows, gravel sand quarries 7.9%, banks of rivers or reservoirs 1.9%, slopes 1.2%, ash dumps 0.4%, and feldspar deposits 0.4% of burrows).

A sample of bank material was defined as the amount of sand (ash, earth, etc.) on the surface of the bank weighing more than 150 g (collected at least one centimetre under the surface of the bank). The position of each sample collection site on the bank was also recorded. Most samples were collected on the left or right side of the burrow (556 samples – 34.1%, designated as "from the burrow"), 26.4% of samples from above the burrow and 26.2% below burrows. 3.9% of the samples came from uncompleted bank swallow burrows. "Uncompleted burrows" were abandoned burrows shorter than 20 cm and without nests. The term "burrow" is used only for completed burrows used by bank swallows for nesting. 2.0% of samples were collected from above uncompleted burrows, and 1.7% from under uncompleted burrows. 2.3% of samples came from layers of sand outside burrows, and 2.0% from banks without burrows. Other collection sites represent less than 1.5% of the samples. Samples from different collection sites were analysed separately.

If a sample was collected from the area around a burrow, the following features of the burrow were usually measured: height and width of the entrance opening, the depth of the burrow, the grade of the burrow, the distance from the upper edge of the bank and the distance from the base of the bank.

Each sample was sifted to determine the content of rough particles (using mesh hole dimensions of 60, 40, 20, 10, 4, 3, 2, 1.25, and 0.9 mm, for 151 samples a fraction share from 0.9–0.0071 mm was established). These mesh hole dimensions were intentionally selected to include the individual grain sizes of the sand in which the bank swallows nest, encompassing the megapsephitic, psephitic and psamitic fractions of sediment (BLAŽEK et al., 1978). A study of the pelitic and aleuritic fractions (under 0.09 mm) (BOUYOUCOS, 1934; CASAGRANDE, 1934) was not carried out.

Data for statistical analysis were grouped by the collection site and analysed separately. Significance was assessed using Student's unpaired t-test. Probabilities less than 0.05 were accepted as indicating significant differences. Data were compared between completed burrows ($n = 556$) and from places without burrows on colonized faces ($n = 946$).

Results

Relationship between bank swallow breeding and the content of grains larger than 60 mm

Only 18 samples collected from 7 sites contained grains larger than 60 mm. The > 60 mm component totalled a maximum of 45.5%; 44.0% of the samples containing particles > 60 mm were collected from under the burrows, then from above the burrows, under unfinished burrows, from layers without burrows and from banks without burrows. Only one sample (0.2%) with large particles came from a burrow, but those particles constituted only 6.2% of the overall weight of this sample. The burrow where this sample was collected was entirely destroyed by heavy rainfall (the poor sand structure probably contributing to the destruction of this burrow by rain). This grain size had a statistically significant effect on bank swallow breeding ($P < 0.01$) compared to places without burrows.

Breeding of bank swallows in embankments containing sand grains larger than 10 mm

Most (90.8%) burrows were excavated from substrate that did not contain this fraction of small particles at all. More than 10% of these particles was found in 19 samples (3.4%) from 7 sites (8.5%). Only 6 samples contained more than 20%. The largest proportion from any burrow was 59.6% (the same burrow described above containing particles > 60 mm). All burrows located in sand in which the > 10 mm fraction exceeded 10% were in small colonies of 10–50 pairs (Fig. 1).

A component of 10–20 mm grains was found in only 36 burrows (6.5%). This fraction comprised more than 10% only in one case (0.2%), and here the figure was only 10.2% of the total weight of the sample. Although samples with a higher proportion of this fraction were collected frequently (194 cases, 11.7%), including layers close to burrows (often just above or below burrows), bank swallows tend to avoid breeding in layers in which 10–20 mm grain sizes are common (e.g. in the Vlkov sand gravel pit in South Bohemia, the layer below the burrow contained 52.9% of this fraction, while the layer inside the burrow and above did

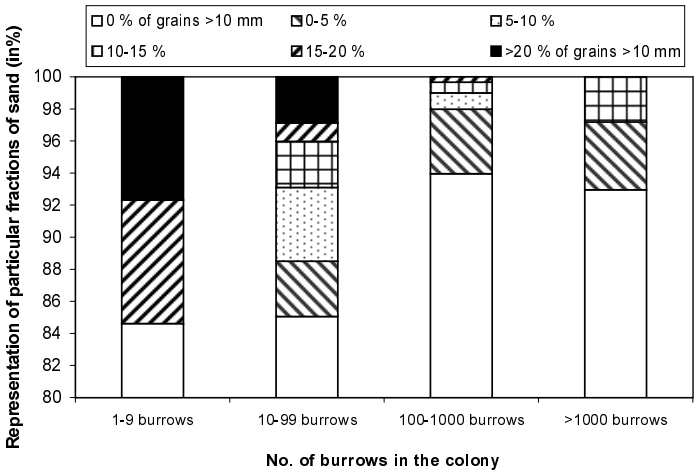

Fig. 1. Representation (in %) of fractions over 10 mm in sand samples from completed burrows of the bank swallow. Samples are divided according to the size of colony (n = 556).

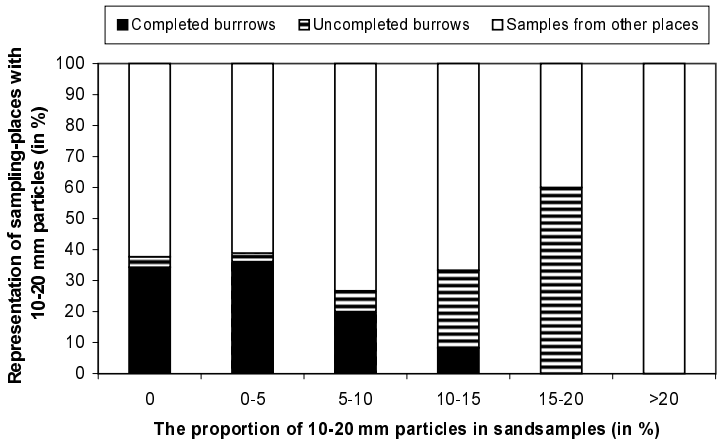

Fig. 2. Representation (in %) of 10–20 mm grains in sand samples from completed burrows, uncompleted burrows, and in samples from other sampling places on embankments (embankments without burrows and layers without bank swallow burrows) (n = 946).

Table 1. The average portions of particles 0.9–10 mm for samples from burrows of the bank swallow (itemized on fractions 0.9–1.25 mm, 1.25–2 mm, 2–3 mm, 3–4 mm and 4–10 mm).

Range of particles size (mm)	Mean ± S.D.	Max.	Median (burr.)	Median (uncompl.)
0.90–1.25	8.27 ± 4.61	25.19	7.78	8.00
1.25–2.00	2.82 ± 2.71	33.42	2.26	2.83
2.00–3.00	13.19 ± 9.46	47.99	13.36	14.83
3.00–4.00	8.00 ± 7.45	32.82	7.33	9.95
4.00–10.00	7.53 ± 9.91	74.46	3.89	9.00

Key: max. – maximum; median (burr.) – the median from completed burrows; median (uncompl.) – the median from uncompleted burrows; data are given for completed burrows (medians were calculated for data from uncompleted burrows too, because of comparison of these two basic groups of burrows); all data are given in percents, size of particles in mm.

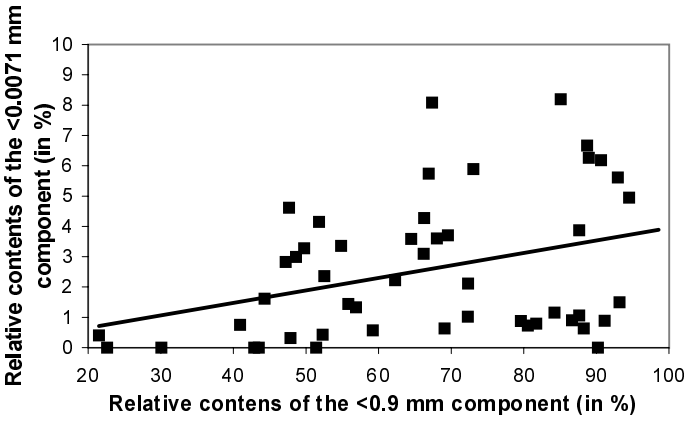

Fig. 3. Number of completed burrows dug in the sand in dependence on $<$ 0.9 and $<$ 0.0071 mm components (n = 49). Correlation coefficient: 0.36.

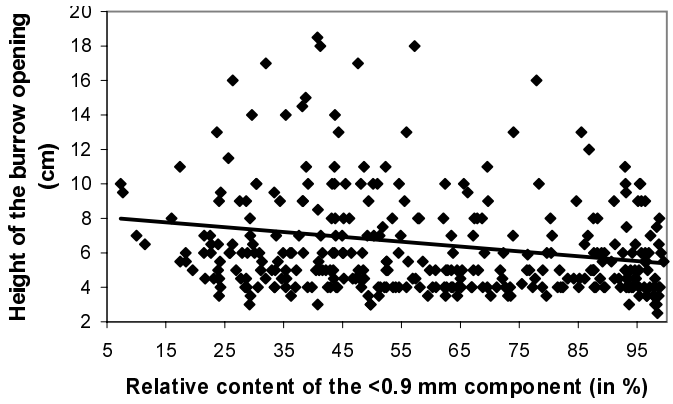

Fig. 4. The dependence of the height of the burrow openings on the contents of the $<$ 0.9 mm component based on results of sifting analysis of sand samples from 331 burrows. Correlation coefficient: 0.20.

not contain any sand particles of this size). This fraction had a statistically significant influence on bank swallow nesting ($P < 0.05$) when compared with places without burrows. Layers with a greater proportion of this fraction are frequent. The size of particles in individual horizontal layers is extremely variable, depending on the manner of settling of the sediment (Fig. 2).

Contents of skelet under 10 mm and sand

The term "skelet" is given to the fraction containing particles $>$ 2 mm (Blažek et al., 1978). Proportions were determined for 2–3, 3–4, and 4–10 mm. None of these size ranges (when compared with uncompleted burrows) had a statistically significant influence on bank swallow breeding ($P >$ 0.05). The term "sand" designates the fraction between 1 (0.9) and 2 mm in size. This range also had no statistically significant influence on bank swallow breeding ($P > 0.05$). Only small differences were found between completed and uncompleted burrows (Tab. 1.). The larger differences between samples from completed and uncompleted burrows were measured for particles 4–10 mm in size. The median was 3.89% for material from completed burrows and 9.00% for samples from unfinished burrows. There was no statistically significant difference between the proportion of this fraction in samples from finished and unfinished burrows ($P > 0.05$).

Contents of the $<$ 0.9 mm component

This fraction consists of sand dust, dust, clay, and physical clay and comprised the largest proportion by mass, of the substrates in which bank swallows dig burrows (59.26% ± 24.87). Some burrows were dug in material containing 100% of this fraction (n = 5; 0.9% of total burrows; 4 sites), while the minimum found in burrows was 7.31% (median = 55.83%).

Fig. 4 shows the dependence of burrow opening height on the proportion of particles $<$ 0.9 mm. This fraction had a statistically significant influence on bank swallow breeding ($P < 0.05$) in comparison with places without burrows.

Analysis of the $<$ 0.0071 mm and $<$ 0.9 mm

(151 cases) fraction showed that bank swallows do not occupy banks where sand grains < 0.9 mm constitute 100% of the substrate (at least 5% of this formed by particles with grain size < 0.0071 mm) and do not occupy embankments where the particles < 0.0071 mm constitutes more than 10% of the substrate (Fig. 3).

Discussion

There is little research regarding the nesting habits of birds that dig burrows in vertical walls of sandy sediment. The existing papers deal only with bank swallow nesting. SANDMANN-FUNKE (1972) merely presents the profile of embankments for a few colonies in Germany, together with rough classification of soil types and sediment types. The majority of the results are established subjectively, or through estimation. With respect to granulometry, only megapsephitic particles are mentioned, i.e. several centimetres thick, which do not form a bank foundation. The study concludes only that the bank swallow breeds in various types of sand. SPENCER (1962) studied similar parameters as SANDMANN-FUNKE (1972). He also determined that bank swallows nest in clayey sand or sandy clay.

The most interesting research on this topic was carried out by SIEBER (1980), who examined the proportion of clayey particles (< 0.002 mm). He determined that burrows are most likely to be found in sand with a clay content of 0–6%. These results correspond with this study and show that bank swallows prefer sand with a proportion of the < 0.0071 mm particles over 10% only in cases where the < 0.9 mm component is less than 20%.

There appears to be no research on the granulometry of megapsephitic, psephitic and psamitic sand fraction in relation to the nesting of the bank swallow. Based on the current results, it is possible to determine what kind of walls are suitable for bank swallow breeding. Taking into account other known factors (such as the absence of trees or shrubs near the embankment or a bank height over 1 m, HENEBERG, 1997), we may predict whether bank swallows will use a potential nesting site.

Based on these results, a study on the success of nestwall construction has been carried out by our co-workers in the Slavkov region (South Moravia), Trhové Sviny, and Homole (South Bohemia) (HENEBERG (unpublished)). It was found that the willingness of the birds to nest is entirely dependent on the composition of the bank material, which confirmed the hypothesis summarized below.

From the current results, it is concluded that:

1. Bank swallows do not nest in layers that contain grains larger than 60 mm (the only burrow containing these grains was destroyed by rainfall).

2a. Bank swallows rarely nest in banks containing more than 10% of grains > 10 mm and the maximum proportion founded in any sample was 10.2%. However, layers with a higher content of this fraction are frequent. The composition of particles in individual horizontal layers is extremely variable, depending on how the sediment has settled (Fig. 2).

2b. Only 9% of the burrows were found in layers containing particles from 10–60 mm in size (median = 0, mode = 0, mean = 0.92% of this component in the sample).

3. Particles measuring 4–10 mm had a mean proportion of 7.53% (± 9.91) (S.D.) in samples from burrows and did not exceed 75%.

4a. Burrows are not dug in layers where there is more than 99% of grains < 0.9 mm (Pleistocene dune sand, clay, and claystone), if the layer contains more than 5% of the < 0.0071 mm component. Bank swallows are also are absent from embankments where the < 0.0071 mm particles comprise more than 10% of the substrate (see Fig. 3) nest only in chinks and cracks. Bank swallow burrows were never found in these types of banks. Similar biotopes are often found in the surface mines in Northern Bohemia, where there are tens of metres of thick clays and claystone, uninhabitable to the bank swallow for these reasons.

4b. The optimal portion of particles < 0.9 mm is 59.26% (± 24.87), or possibly more if the material contains less than 10% of < 0.0071 mm particles.

4c. The ratio of < 0.9 mm and < 0.0071 mm particles is the most important factor determining the disposition of breeding for bank swallows, regardless of the proportion of other fractions of sand particles. Some of these components are conducive to water erosion of the banks during the breeding season, which causes considerable losses, especially during rainy years [as in 1997 in the Czech Republic when due to extensive flooding over 30% of burrows were damaged by rain, even in areas that were not directly flooded (HENEBERG, 1998)]. The collapse of nestwalls is correlated to the proportion of this fraction, although this is not discussed here.

The establishment of basic granulometric sand characteristics may be used in the protection of the nestwalls of this endangered and legally protected species, especially during the creation of new banks (based on these results, new walls were

proposed for the nesting of bank swallows in the Kroclov Hill Country (Southern Bohemia), where bank swallows are already successfully nesting the population is increasing).

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