SOME PHYSICAL CHARACTERISTICS OF NESTING SITES USED BY BANK SWALLOWS

By Selden James Spencer

(Based on a doctoral dissertation completed at The Pennsylvania State University, 1962, under the direction of Professor Merrill Wood)

Introduction One of the most cosmopolitan species of birds nesting in the northern hemisphere is the Bank Swallow, Riparia riparia. It has been reported nesting in much of the North American continent in all but the extreme southern states, and from Alaska eastward across Canada, in the northern European countries, and as far east as Finland.

Despite their wide distribution, the nesting sites of these birds are very local, even though food supply and climate conditions are the same in surrounding unoccupied areas as they are in those places used for nesting. It was the aim of this study to determine what physical characteristics their nesting sites might have in common and, hence, why they were found in some localities and not others.

Three people have contributed much to the literature on the habits and behavior of the Bank Swallow. They are: Leonard K. Beyer (1938), Arnold J. Petersen (1955), and Dayton Stoner (1925, 1926, 1936, and 1941). Though their studies were quite comprehensive, they left a number of unanswered questions as to the physical characteristics of nesting sites. Petersen found that burrows were deeper in banks with a higher percentage of sand. In a bank with 94 per cent sand the average burrow depth was 33.0 inches, while at the other extreme a bank with 75 per cent sand contained burrows averaging only 20.7 inches in depth. His analyses were confined to determining the ratio of total sand to fine material, with no attempt being made to analyze the fine material as to percentage clay and percentage silt. Likewise, apparently no attempt was made to divide the sand into its various fractions. Beyer confirmed the findings of Petersen in noting that in the rather loosely packed, coarse sand banks of Northumberland County, Pennsylvania, burrows averaged about 30 inches in depth, while in the tightly packed boulder "clay" of the Sodas Bay, New York, area on Lake Ontario, burrows were only 14 to 18.5 inches deep.

Stoner (1936) partially contradicted the findings of Beyer and Petersen in regard to burrow depth. He remarked that excavations made in fine, sandy soil are likely to be deeper than those in a harder or a gravelly soil. In addition, he proposed that burrow depth was related to the degree of development of the eggs in females. He verified this hypothesis by performing autopsies on several females, and he found that shallow burrows were dug by swallows whose egg development was far advanced,

while deeper burrows were made by those females that had only partially developed eggs.

Though the three investigators discussed above agreed that these birds would excavate for burrows only in perpendicular surfaces, several other questions concerning nesting sites were left largely unanswered. These problems included: height of the banks, direction faced by each of them, and such physical characteristics of the soils of the banks as liquid limit, plastic limit, and porosity. These factors, plus a detailed analysis of the soil separates, were considered in this study.

The primary hypothesis proposed by this investigator was that certain physical properties of a bank are factors in determining whether it will be used for nesting by Bank Swallows. In addition, the following hypotheses were made concerning the physical properties of a bank:

1. The banks are always perpendicular, or nearly so.
2. The soil separates of the bank are within a given range of sizes, and similar in the percentage of each separate.
3. The soils in the banks used for nesting sites have a certain ability to retain their shape and resist collapsing on a burrow.
4. Some of the physical properties of the soil in a bank (Baver, 1956) help to determine the depth to which burrows are excavated. Among these properties are the ratio of fine to coarse material and the degree to which soil is compacted.
5. Some of the physical characteristics of the soil in the bank help to determine the number of burrows found. These characteristics include liquid limit, soil porosity, plastic limit, and the percentages of various fractions.

For practicality, the study was limited to 25 nesting sites in two states, Vermont and Pennsylvania. Of the 25, 8 were located in Pennsylvania and 17 in Vermont, 7 of the latter being studied during the nesting season of 1960. Eighteen of the locations were investigated in August, September, and October of 1959 and 1960 when the burrows were not occupied.

Procedures Field work consisted of making observations, taking measurements, photographing the banks, and sampling. Measurements and observations included: number and depth of the burrows; number of birds seen; dimensions of the total bank, including the nesting area; dimensions of the occupied area,

including burrow spacing and distance from the top of the bank; and direction faced by the bank.

One sample was taken for general laboratory analysis, and it was collected with a garden trowel from the same stratum in which the holes were found. A second sample was taken with a special core sampler for bulk density determinations. The use of this instrument made it possible to collect an undisturbed soil sample of exactly 69 ml volume (Lyon, Buckman, and Brady, 1952; Baver, 1956).

Laboratory investigations, with the exception of bulk density (soil porosity), were performed in the winter of 1960 and 1961. Those properties of soils studied were: liquid limit (that moisture content at which a soil assumes liquid properties); plastic limit (the moisture content of a soil when it changes from a semi-solid to a plastic state, and can be rolled into a 1/8-inch thread); soil fractions, both determination of percentages of each sand, silt, and clay by the Bouyoucos hydrometer method (Baver, 1956; Bouyoucos, 1926, 1934, and 1951) and division of sand into its various fractions by means of No. 10, 20, 40, 60, 100, 200, and 270 mesh sieves; and total soil porosity, computed directly from the bulk density (Baver, 1956), using the undisturbed sample taken in the field. Details of procedures may be obtained in a microfilm copy of the complete manuscript of this 115-page dissertation from University Microfilms, Inc., Ann Arbor, Michigan.

Results Field observations of the burrow locations will be considered first.

It was noted that, without exception, all 25 nesting sites lay within the flood plain of some stream, and the normal level of the stream was never over 1/4 mile from the sites under investigation.

The origin of the perpendicular surfaces was also considered, and pertinent data are summarized in the following table.

Table 1. Observations made during 1959 and 1960 on the locations of the nesting sites of Bank Swallows in certain areas of Pennsylvania and Vermont.

Type of location	Number of locations observed
Gravel and/or sand pit	13
Road cut	5
Excavation for building site	5
Reserve coal pile	1
River bank	1
Total	25

It should be noted that the majority of the nesting sites in this study were found in gravel and/or sand pits. It might be observed also that all of the sites except one, the river bank, were man-made.

Burrows were sometimes found in more than one wall of a nesting site and usually faced in more than one direction, particularly in the U-shaped sand pits. However, the majority of the burrows at a nesting site were oriented in one direction, and the following table indicates the exposure of the majority of the burrows.

Table 2. Observations made during 1959 and 1960 on the exposure of twenty-five nesting sites of Bank Swallows in certain areas of Pennsylvania and Vermont.

Exposure	Number of sites observed
Eastern	5
Southeastern	5
Northeastern	4
Southwestern	4
Southern	3
Northwestern	3
Western	1
Northern	0
Total	25

Although no single exposure was predominant, 14 of the 25 sites, or 56 per cent, faced east, southeast, or northeast. Of the remainder, 8, or 32 per cent, faced southwest, west, or northwest; 3, or 12 per cent, faced south; and none faced north.

Mean hole depth of all of the sites was 23.2 inches. Seventy-six per cent, or 19 of the 25 nesting sites, had hole depths from 18.3 to 27.0 inches, a range of only 8.7 inches. Lest the reader be misled, measured hole depths ranged widely, from 10 to 40 inches. Hole depth was not within narrow limits and was not a constant physical factor when considered by itself.

It was found that the mean number of burrows was 95.36 per site, with a range from 13 to 300. When the burrows were grouped in class intervals of 50, it was found that 44 per cent of the nesting locations had 50 or fewer burrows, and 24 per cent had between 51 and 100. This meant that 68 per cent of the sites had 100 burrows or fewer.

Two sets of dimensions of the nesting sites were taken. One consisted of the total dimensions of the banks containing burrows, and the other, the measurements of only that section of the bank used by the swallows. The

object was to determine the amount of available perpendicular space used. Occupied areas were found to be 1 to 4 feet in perpendicular dimension in 80 per cent of the banks, and in sections 10 to 69 feet long in 88 per cent of the sites studied. Total vertical measurement of the banks was 3 to 25 feet, with an average of 10.36 feet. The occupied section of the banks ranged in its perpendicular dimension from 1 to 15 feet, with an average of 3.89 feet. This meant that an average 37.5 per cent of available vertical space contained burrows.

Laboratory analyses of textural classes are summarized in the following table. As described in Procedures, the Bouyoucos hydrometer method was used to determine percentages of sand, silt, and clay, while sieves were used to separate the sand into its various fractions.

Table 3. A summary of the soil textural classes of twenty-five Bank Swallow nesting sites observed in 1959 and 1960 in certain areas of Pennsylvania and Vermont.

Textural class	Number of banks	Percentage of total banks
Gravelly soil (20 per cent or more gravel)	2	8
Sands:		
Coarse sand	2	8
Sand	0	0
Fine sand	2	8
Very fine sand	1	4
Loamy sands:		
Loamy coarse sand	1	4
Loamy sand	1	4
Loamy fine sand	4	16
Loamy very fine sand	6	24
Sandy loams:		
Coarse sandy loam	1	4
Sandy loam	0	0
Fine sandy loam	0	0
Very fine sandy loam	5	20

It will be observed from the above table that 48 per cent of the banks in this study were loamy sands, and, of these, 40 per cent were either loamy fine or loamy very fine sand. However, no single subgroup seemed to be conclusively dominant. Further combinations of groups will show that the finer soils are apparently preferred to the coarser sands

and gravels. If loamy sands and sandy loams are combined, it will be found that 72 per cent of the banks studied fell into this grouping.

Although the sand and gravel fractions varied from 47.6 to 95.2 per cent, and silts varied from 5.5 to 48.3 per cent, relatively little variation occurred in the clay fractions. There was a total variation of 10.4 per cent clay, with a decided clustering in the 4 to 4.9 per cent group, or 48 per cent of the nesting sites. In fact, 88 per cent of the soils analyzed had a clay content ranging from 2 to 5.8 per cent.

Upon determining liquid limits of the soils, it was found that 79.12 per cent of the nesting sites contained soils with liquid limits between 16.9 and 25.9 per cent, a range of 9 per cent. This includes 19 out of the 24 samples analyzed for liquid limits (high gravel content of one soil made it impossible to determine either the liquid or the plastic limit).

Although it was hypothesized that soils must be plastic in order for the swallow to make a burrow that will retain its shape, it was found by performing plastic limit determinations that all of the soils were non-plastic. However, six samples were very nearly plastic due to appreciable amounts of silt, clay, or finer sand fractions. Soils are plastic only when these three are all present in more than minimal amounts, but the soils in this study all lacked this combination.

Total soil porosity was indirectly determined by finding the bulk density of the undisturbed soils. Percentage of voids, which is also indicative of the degree of soil compactness, is summarized in the table which follows.

Table 4. Frequency distribution of voids, or percentage of space occupied by air, in the soil at twenty-three* Bank Swallow nesting sites observed in 1959 and 1960 in certain areas of Pennsylvania and Vermont.

Percentage of space occupied by air	Number of sites	Percentage of sites
28.1 - 34.0	1	4.3
34.1 - 38.0	0	0.0
38.1 - 43.0	0	0.0
43.1 - 48.0	7	30.5
48.1 - 53.0	6	26.1
53.1 - 58.0	7	30.5
58.1 - 63.0	1	4.3
63.1 - 68.0	1	4.3

*Two sites destroyed at the time samples were taken.

It will be noted that 87.1 per cent of the banks had air spaces occupying 43.1 to 58.0 per cent, inclusive, of the volume of an undisturbed sample, a range of 14.9 per cent. These figures, coupled with a mean air space of 50.4 per cent, indicate that Bank Swallows prefer soils that are not tightly packed.

Analysis of Findings Burrow depth seemed to show some relationship to textural class. Mean depth increased generally as progression was made from the coarser to the finer classes. The presence of somewhat shallower burrows in very fine sandy loam suggested that in textural classes finer than very fine sand or coarse sandy loam the burrows may be somewhat less deep.

There seemed to be no correlation between mean hole depth and soil porosity. Even in soils having identical porosities, the mean burrow depth varied considerably, as was noted at four nesting locations. Two sites with identical porosity differed in mean burrow depth by only 1.1 inches, but this appeared to be only by chance.

After comparing burrow depth with percentages of various soil fractions (sand, gravel, coarse sand, and finer divisions of sand, silt, and clay), it was found that these depths were not related to percentage of any of the various soil fractions found in the banks. Likewise, no relationship seemed to exist between hole depth and soil liquid limit.

The number of burrows was also compared to other physical characteristics. It was found that no relationship appeared to exist between the number of burrows and textural class of the soil, porosity, or percentages of various soil fractions. The number of holes inconclusively appeared to vary inversely with the percentage of coarse sand and gravel present. Further investigation of many more sites would be needed to support or oppose this finding. Burrow abundance seems to be most closely related to the degree of uniformity of texture of the bank. Presque Isle Peninsula, Erie, Pennsylvania, a site with uniform texture, contained 300 burrows, while a gravel pit at Guys Mills, Pennsylvania, boasted only 18 swallow nests. These latter were in isolated pockets of finer material which was in the textural class of coarse sand. These findings were confirmed by Petersen (1955), who commented that where stratification occurred in a bank, preference was shown for the more sandy layers, and gravelly layers were avoided.

Implications for Bird Banders This study revealed that Bank Swallows nest most frequently in man-made vertical banks usually found in sand and/or gravel pits. Further, these sites are located most frequently in the flood plain of some stream, and usually in glaciated areas.

Contacting local sand and gravel pit operators would be a good beginning to locate nesting sites.

Few studies have been made to determine whether these birds return to the same locations year after year, and those studies made (Stoner, 1941, and Wood, 1935) are contradictory and inconclusive. Intensive, long-range banding programs would be necessary to determine the extent of site utilization from one year to the next. Simple methods for the capture of these swallows are described by Ralph W. Dexter in Bird Banding 13(3): 120 (1942) and William A. Morris, Bird Banding 13: 83-84 (1942).

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State University College, New Paltz, New York

WALDEN APPOINTED NATURALIST AT WASHINGTON CROSSING

Ryan B. Walden, EBBA member from Wisconsin, has been appointed to the position of Naturalist of the Washington Crossing Nature Education Center, Washington Crossing, Pa.

Dr. Paul H. Fluck, former EBBA president, is Executive Director of the project (he founded it some years ago). His letter to the Editor follows:

Dear Frank:

I would like to express my thanks to the many banders who offered their services to the Center in response to the recent advertisement in EBBA News.

It was a difficult choice to make among the well qualified applicants; but it was encouraging to find banders of both sexes, and of all ages, genuinely concerned about the need for conservation education. A number offered their services gratis to keep the Center's programs going until a full time naturalist teacher could be located.

I regret that it was impossible for me to answer even half the letters we received. Our mail is very heavy -- we actually measure it in peach baskets -- and we still have no secretarial staff. So perhaps in some coming issue of the News you may find space to express my thanks to the many conservation minded banders who offered to help at the Center.