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Effects of Bridge Design on Placement and Shape of Cliff Swallow (*Petrochelidon pyrrhonota*) Nests in Southern Arkansas

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Running title: Bridge Design Affects Shape of Cliff Swallow Nests

The Cliff Swallow (*Petrochelidon pyrrhonota*) is identifiable by its orange rump, pale forehead patch, and square tail. In Arkansas, its historic range was limited to the Ozark Mountains (Baerg 1931, James and Neal 1986). The breeding range of this migratory species did not include the southeastern United States (Brown and Brown 1995) until construction of concrete bridges and dams provided suitable nesting sites (Stewart 1976, Erskine 1979). Due to the use of concrete in bridges, the species now breeds all across southern Arkansas (Tumilson 2007, 2009)

Porous concrete surfaces promote adherence of mud, thereby allowing nest construction by Cliff Swallows. Rainfall levels in western Arkansas are lower than in the more mesic east (<http://www.worldatlas.com/webimage/countrys/namerica/usstates/weathermaps/arprecip.htm>). This moisture gradient could have an effect on shape and location of nests as rainfall dampens concrete or humidity condenses on cool concrete undersurfaces of bridges, which can render sites unusable for successful nest construction. However, sites not usable for the conventional nest might still be usable if alternative designs of construction were possible. No study previously has been conducted to evaluate the shape of Cliff Swallow nests in relation to bridge design.

Typical nests are shaped like a gourd, attached to 2 surfaces with most of the nest built on a vertical surface and a smaller “neck” attached to a 90° overhang and pointing outward (Fig. 1). The neck becomes a downward-oriented entrance tube of dry mud (Brown and Brown 1995).

During an examination of bridges in southern Arkansas to determine use by Cliff Swallows (Tumilson 2007, 2009) observations of unusual nest construction were noted. We found designs as well as uses of substrates not previously reported in literature.

We examined 193 bridges in southern Arkansas (see Tumilson 2007, 2009), and most of them (62.2%) had 90° junctions that might be suitable for nest construction. In some cases, both surfaces were made

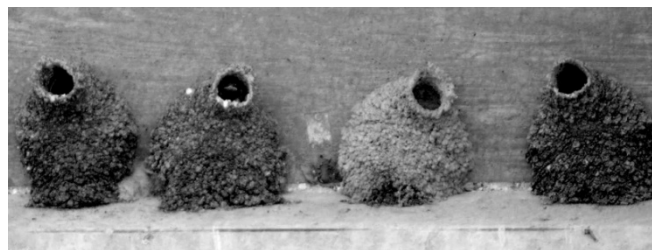


Figure 1. Typical gourd-shaped nests of Cliff Swallows on the U.S. Hwy 82 Bridge, Ouachita River (Union Co.). Vertical surface at bottom; entrances are tubes pointing downward.

of concrete, but in others the vertical surface was steel (sometimes painted) and at least some of the horizontal surface was concrete. Other bridges were constructed with some sections of concrete (often the part over land) and other sections of steel (usually over water), in which both surfaces in a given section were of the same material. Some bridges of concrete construction had 45° bevels so no 90° angle was available. Bridges of all steel construction also were examined. Because bridges in southern Arkansas have various designs of construction and exist in different humidities, we were able to qualitatively evaluate where and how Cliff Swallows utilized potentially suboptimal construction sites, and their effect on nest shape and location.

Choice of concrete versus steel 90° angles

Design of some bridges, particularly over larger rivers, offered 90° angles presenting a choice between sections of all steel (usually over water) versus all concrete construction (usually over land). Where both were available, Cliff Swallows with rare exception built their nests on the concrete areas and avoided the steel construction. Examples include the U.S. Hwy 67 Bridge, Caddo River (Clark County), the U.S. Hwy 82 Bridge, Mississippi River (Chicot County), the U.S. Hwy 82 Bridge, Ouachita River (Ashley and Union Counties), and the AR St. Hwy 160 bridge, Red River (Lafayette County).

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On U.S. Hwy 70 over Rock Creek (Howard Co.), bridge design presented 2 conditions of 90° angles, one of concrete just above the other made of steel. Of the 38 Cliff Swallow nests present, all but 1 was located on the concrete. The single nest constructed on steel was detaching from the upper surface of the angle.

Two other bridges of mixed construction further exemplified selection of available concrete. The AR St. Hwy 8 Bridge over the Ouachita River at Arkadelphia (Clark Co.) is primarily of steel construction but with limited concrete support structure located only above vertical steel beams. All Cliff Swallow nests were built on the concrete 90° angles. On the U.S. Hwy 278 Bridge over the Saline River (Bradley Co.), a 90° concrete angle extends downward only a few centimeters before meeting steel structure (Brown and Brown (1995) noted 10–12 cm are needed). Cliff Swallows on Hwy 278 used only the concrete and made their nests shallow and horizontally elongated, creating triangular nests (Fig. 2). The entrance was only a short downspout attached to the concrete.

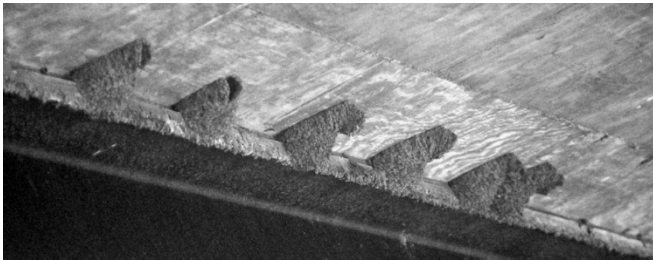


Figure 2. Triangular shapes of Cliff Swallow nests on the U.S. Hwy 278 Bridge, Saline River (Bradley Co.).

Effects of 45° beveled joints

Where concrete construction was beveled presenting a 45° rather than 90° angle, gravity likely would inhibit normal construction of gourd-shaped mud nests (Brown and Brown 1995). Cliff Swallow nests constructed on beveled concrete were uncommon (we found only 7 bridges with examples), and were elongated and tube shaped with short necks (Fig. 3).

Once a nest was established on a bevel, other Cliff Swallows sometimes clustered new, normally-shaped nests using the existing nest structure as part of the support for the new construction (ex.: AR St. Hwy 53 bridge, Little Missouri River (Clark Co.)).

Another Cliff Swallow design on beveled concrete was to build the nest as an addition to an old Barn Swallow (*Hirundo rustica*) nest, using the old nest as a support for the renovation. These nests tended to have the characteristic gourd shape, sometimes slightly

elongated vertically, which was determined by the pre-existing bowl shape of the Barn Swallow nest (Fig. 4). This innovation also was used in areas where higher humidity could be an issue. Sometimes, the entrance was attached laterally to the concrete rather than being directed forward, as is most typical (Fig. 4).

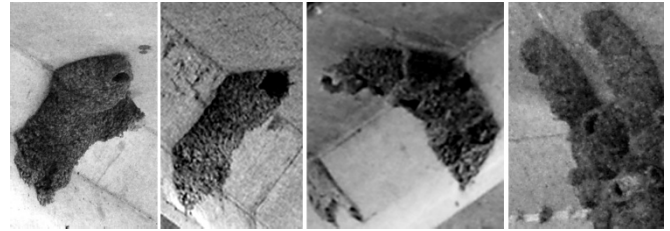


Figure 3. Tubular shapes of Cliff Swallow nests built on 45° concrete bevels – from left to right: AR St. Hwy 53, Little Missouri River (Nevada and Clark Cos.); U.S. Hwy 79, Saline River, (Cleveland Co.); AR St. Hwy 24, Cossatot River (Sevier Co.); U.S. Hwy 67, Red River (Miller Co.). Notice in the last image that the elongated nests built on the bevel were built with extra support from other, typically-shaped Cliff Swallow nests attached below the bevel.

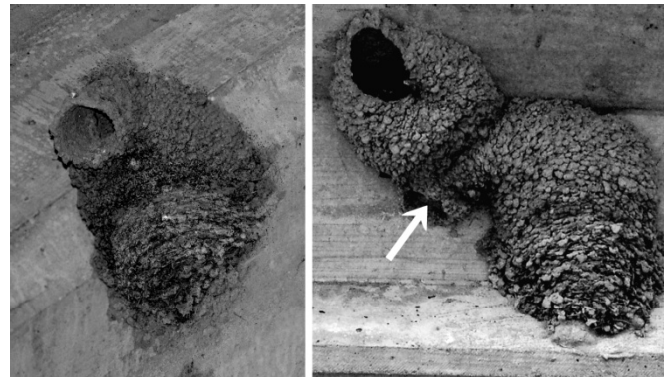


Figure 4. Cliff Swallow nests built on a bevel using old Barn Swallow nests for support. Left, AR St. Hwy 7, Caddo River (Clark Co.); right, U.S. Hwy 79, Saline River (Cleveland Co.). Arrow indicates opening to nest attached to concrete rather than projecting outward. A second nest was built above, and supported by, the neck of the nest on the bevel.

Construction on steel

Stant nests are those constructed over existing structures for support. Samuel (1971) noted that Cliff Swallows in West Virginia only built adherent nests, although Mayhew (1958) had observed Cliff Swallows building stant nests over old Barn Swallow nests in California.

We found 3 bridges on which Cliff Swallows constructed nests where only steel was available. Where the vertical surface was of painted steel and

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therefore likely not a good adhesive surface for mud, we found stant nests constructed over protruding rivets as support. Where multiple nests were present on a steel bridge, all were built only over rivets. Clusters of nests were supported by rivets and by each other (Fig. 5). Alternatively, existing mud nests of Barn Swallows or mud-daubers on steel were used as support for the construction of nests by Cliff Swallows, (Fig. 5). These nests tended to reflect the characteristic gourd shape.

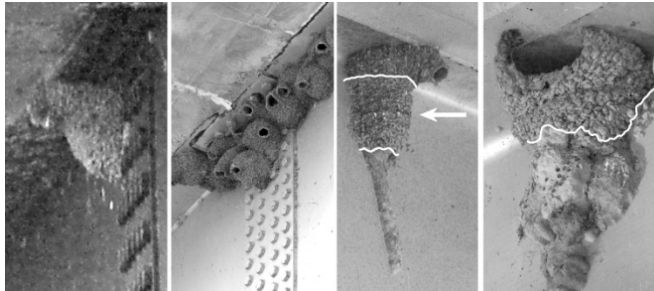


Figure 5. Cliff Swallow nests built on supportive structures on steel bridge construction. From left: single nest on rivets, U.S. Hwy 67, Ouachita River (Hot Spring Co.); nest cluster on rivets, U.S. Hwy 67, Red River (Miller Co.); Cliff Swallow nest built on top of Barn Swallow nest (note: arrow indicates where 2 Barn Swallow nests were built on top of each other) built on mud-dauber nest, AR St. Hwy 53, Little Missouri River (Clark-Nevada Cos.); Cliff Swallow nest built on mud-dauber nest, but note neck is not a complete circle (perhaps the nest was abandoned before completion), AR St. Hwy 144, Lake Chicot (Chicot Co.).

Effects of mesic conditions

Generally, those bridges with stant nests were elevated well above the landscape and presumably subject to lower humidities. Most of the 193 bridges we examined were nearer the level of the surrounding landscape and within 3 meters of the streambed surface, so likely were subject to higher humidities. Cliff Swallow nests were not present on bridges that showed strong evidence of frequent dampness (stalactites of road salts, water streaks, and greenish tinge due to algal growth). Still, at some locations Cliff Swallows did build nests on lower concrete bridges, but these were always over bolts (often rusty from moisture) embedded in the cement or over nests of Barn Swallows or mud-daubers.

Brown and Brown (1995) commented that Cliff Swallows will take over active Barn Swallow nests and dome them to become typically-shaped Cliff Swallow nests. We found such reconstructions at many bridges. On low-lying bridges nests of Cliff Swallows were absent if there was no pre-existing support structure,

such as a Barn Swallow nest or a bolt. It was also common to see a Cliff Swallow nest over a Barn Swallow nest which had been built over either a bolt or mud-dauber nest (Fig. 6).

In southeastern Arkansas we found some bridges where concrete construction formed several rectangular boxes under the bridge. In these mesic conditions, it was most common to see nests built in the corners of the boxes, where 3 concrete surfaces (a top and two sides) provided areas for attachment. The resulting nests had the same overall shape as typical nests, but the sides were produced by the concrete and required less mud to be supported. Other Cliff Swallows built nests attached to those initial nests (Fig. 7).

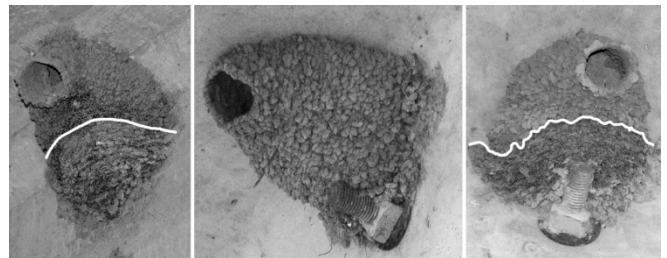


Figure 6. Cliff Swallow nests built over support structure on concrete bridge construction, where bridges were low and humidity was high. From left: nest constructed over nest of Barn Swallow, AR St. Hwy 7, Mill Creek (Clark Co.); Cliff Swallow nest built over a bolt, AR St. Hwy 387, White Oak Lake (Ouachita Co.); nest built over Barn Swallow nest that was supported by a bolt, AR St. Hwy 387, White Oak Lake (Ouachita Co.). White lines indicate separation between nests of Barn and Cliff Swallows.

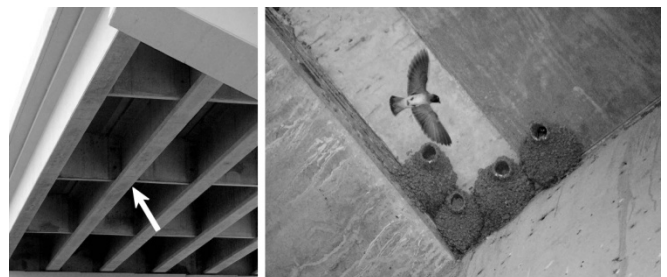


Figure 7. Box-shaped concrete understructure (left image) in a mesic environment was used first by construction in the corners, using 3 concrete surfaces for attachment (right image). Additional nests used 2 surfaces of concrete and attached to the initial nest Mississippi River (Chicot Co.). Arrow indicates location of nests.

Exceptional examples of construction

Brown and Brown (1995) described nest-building as beginning with a narrow mud ledge affixed to a wall and positioned about 10 cm below an overhang. Mud is added to the structure until it joins the overhang. This

presumes that acceptable surfaces are available for nest construction. Further, Cliff Swallows prefer unpainted surfaces (Townsend 1917). We found a few nests constructed in manners not previously reported in literature.

An elevated bridge over the Cossatot River (Sevier Co. in SW AR) was constructed of painted steel supports which formed the 90° angle, and the preferred concrete matrix was available only horizontally and several centimeters from the angle. On that part of the bridge, Cliff Swallows avoided the painted metal and hung their nests entirely from the ceiling, using only 1 surface for attachment. Those nests were slightly flattened and lacked the deeper rounded bowl characteristic of Cliff Swallow nests (Fig. 8).

We also discovered a case where Cliff Swallows built nests attached to a galvanized metal undersurface of a bridge. This metal might have been more able to hold mud than other steel structures, but it also presented a top and 2 sides for attachment. The resulting shape was globular and the neck was short (Fig. 8).

Barn Swallows commonly build statant nests supported on the bottom by horizontal processes of steel I-beams, but Cliff Swallows have not been reported to use this support structure. We found only 1 instance in which Cliff Swallows used such a bottom support. The U.S. Hwy 79 Bridge over the Ouachita River (Ouachita Co.) has construction along the sides of the bridge incorporating metal crossbars, upon which several nests of Cliff Swallows were built (Fig. 8). Other parts of the nest used painted steel surfaces for attachment. To our knowledge, this is the first report of this kind of construction by Cliff Swallows.

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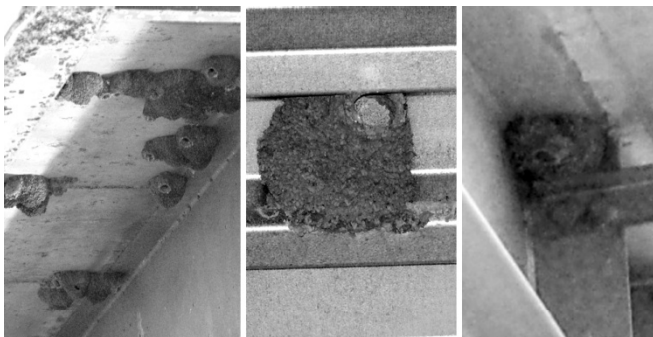


Figure 8. From left: Cliff Swallow nest attached only to ceiling concrete, AR St. Hwy 24, Cossatot River (Sevier Co.); nest attached to galvanized metal, AR St. Hwy 26, Saline Creek (Pike Co.); statant nest on metal crossbeam, U.S. Hwy 79, Ouachita River (Ouachita Co.).