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ABSTRACT: Cliff swallows (Petrochelidon pyrrhonota) nesting in colonies on man-made structures can cause aesthetic problems and health hazards. Cliff swallows are migratory, wintering in South America and breeding throughout most of North America. Cliff swallows have a homing tendency to old colonies and are attracted to the gourd-shaped mud nests. Egg laying begins before nest construction is finished; clutch size averages 3 or 4 eggs. Renesting is common if a nest fails and some pairs may raise 2 broods in 1 nesting season. Cliff swallows may be present at a colony for up to 132 days. Cliff swallows are protected by the Migratory Bird Treaty Act of 1918, and a permit from the United States Fish and Wildlife Service is required for certain control activities. Successful control methods include nest removal by water hose or a pole, and exclusion using netting, poultry wire, or strip doors. Nest substrate modification is successful in some instances. Methods employed with little success or that remain unproven include metal spines, repellents, frightening devices, predator models, taped alarm calls, and a fresh coat of paint. Attention to architectural design may alleviate cliff swallow nesting problems.

INTRODUCTION

Cliff swallows (Petrochelidon pyrrhonota) are colony nesting birds that often live in close association with man. While most cliff swallow colonies on buildings and other structures are innocuous, in some situations they can become a nuisance, primarily because of the dropping they deposit. In such instances they may interfere with man's activities by creating aesthetic problems, fouling machinery, and causing health hazards by contaminating foodstuffs. Their mud nests eventually fall to the ground and can cause similar problems. Cliff swallows are host to hematophagus arthropods including ticks (Baerg 1944, Kohls and Ryckman 1962), fleas (Eads 1956, Haas and Wilson 1980, Wheeler et al. 1970), and various other insects including the swallow bug (Oeciacus vicarius) (Hicks 1959, Myers 1928). Man and his domestic animals may be threatened at various times by these ectoparasites, although they are not the usual hosts. In addition, cliff swallow nests are often parasitized by house sparrows (Passer domesticus), introducing another avian pest with its attendant aesthetic damage and potential health hazards (Weber 1979).

The objective of this paper is to outline control methods for cliff swallows nesting on buildings and other structures. Certain control methods are applicable to other species around buildings: house sparrows, rock doves (Columba livia), and starlings (Sturnus vulgaris). As with the control of any species, a knowledge of the biology and behavior of the target species is essential and will be reviewed with emphasis on California conditions.

BIOLOGY AND BEHAVIOR

Description

Eight members of the swallow family Hirundinidae breed in North America: the tree swallow (Iridoprocne bicolor), violet-green swallow (Tachycineta thalassina), purple martin (Progne subis), bank swallow (Riparia riparia), rough-winged swallow (Steligidopteryx ruficollis), barn swallow (Hirundo rustica), cave swallow (Petrochelidon fulva), and the cliff swallow. Of the 8 species, only barn and cliff swallows regularly build mud nests attached to buildings and other structures.

The cliff swallow, 13 to 15 cm in length, is the only square-tailed swallow in most of North America. It is recognized by a pale, orange-brown rump, white forehead, dark rust-colored throat and steel-blue crown and back. The cave swallow is similar in appearance but has a rust-colored forehead and pale throat. It is restricted to southeast New Mexico and central, south, and west Texas. The barn swallow is distinguished by its long, deeply forked tail.

Distribution and Habitat

Cliff swallows are found throughout most of North America. Breeding occurs northward to central Alaska and Yukon, across the central provinces to southern Quebec. Breeding occurs throughout the western United States south to central Mexico (AOU 1957). Until recently cliff swallows did not breed in the southern United States east of central Texas and south of west central Tennessee or western Kentucky. Several recent reports of new colonies in eastern Tennessee (Koella 1980), Louisiana (Eyster 1980), Alabama, Arkansas, and Mississippi (Jackson 1980) and Florida (Sykes 1976) suggest a southward range expansion similar to that of barn swallows. In California cliff swallows are found throughout the state except in high mountains and the dry southeastern desert (Small 1974).

Four basic conditions are found at most cliff swallow colonies: (1) an open habitat for foraging, (2) a vertical surface beneath an overhang or ledge for nest attachment, (3) a supply of mud of the proper consistency for nest building, and (4) a body of fresh water for drinking (Emlen 1954, Grinnell and Miller 1944).

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The original nesting sites of cliff swallows were cliffs and walls of canyons. Man's structures (e.g., buildings, bridges, overpasses) and agricultural activities (e.g., irrigation, canals, reservoirs) have increased the number and distribution of suitable nesting sites and cliff swallow populations have increased accordingly. Historically, cliff swallows were presumed to be most common in the western mountains and spread eastward following man's settling and development of eastern North America (Erskine 1979).

In California, a change in distribution and abundance has occurred in the Central Valley. Mayhew (1958) stated cliff swallows were abundant in the Sacramento Valley with its wide expanses of agriculture (rice, wheat, barley) and many bridges, culverts and irrigation ditches. In contrast, relatively few colonies were in the San Joaquin Valley to the south. He suggested the sandy soils found there were unsuitable for nest building. Recent surveys, however, indicate cliff swallows are widespread and abundant in the San Joaquin Valley (Gorenzel, unpubl. ms.). This change is attributed to the expansion of irrigated agriculture and highway construction resulting in water availability throughout the nesting season and more bridges and overpasses for nesting.

Migration

Cliff swallows winter in South America from southern Brazil south to central Chile and central Argentina (AOU 1957). In late winter and early spring, they begin a northward migration over land through Central America and Mexico. Arrival dates can vary greatly due to weather conditions. In general, cliff swallows enter the southern United States in mid-March to mid-April and reach the northern portions of their range in early to mid-May (Lincoln 1979). In California, the first migrants usually appear by mid-February to early March and reach northern California 2 or 3 weeks later. Cliff swallows migrate during the day and catch flying insects en route. Swallows will not penetrate regions unless flying insects are available for food. This occurs after a few days of relatively warm weather, 16-21°C or more (Mayhew 1958).

Site Selection

Most cliff swallows arrive at a particular colony within a 24-hour period. At large colonies swallows may arrive in successive waves. There is a definite homing tendency among adults that previously nested at the colony. These birds are the first to return, followed by adults who bred at other colonies and by young birds who have not yet bred. The younger birds include individuals not born at the selected colony (Mayhew 1958).

In addition to their homing tendency, breeding swallows are attracted to old nests. Under suitable conditions, a nest is quite durable and can be used in successive years. Old nests are usually claimed on the first day of arrival, although probably not by the original makers. Dilapidated nests are quickly occupied and repaired (Emlen 1954, Mayhew 1958).

Colonies are often abandoned for no apparent reason after 2 or 3 consecutive years of use (Grinnell 1937). Factors that may contribute to the use of alternate sites include: (1) deterioration of old nests and nesting substrate, (2) parasitism by house sparrows, and (3) buildup of nest ectoparasite levels. Ectoparasites can significantly increase cliff swallow nestling mortality (Chapman 1973).

Nest Construction

Cliff swallow nests are gourd-shaped enclosed structures built of mud pellets, consisting primarily of sand with smaller amounts of silt and clay (Kilgore and Knudsen 1977). The nest chamber is lined sparingly with grasses, hair and feathers (Harrison 1975). In contrast, barn swallow nests are cup-shaped and the pellets contain coarse organic matter such as grass stems, horse hairs and feathers. The nest cup is profusely lined with grasses and feathers, especially white feathers (Harrison 1975). The cliff swallow nest chamber is globular and extends forward into an entrance tunnel which opens downward. The tunnel may be absent from some nests. Nest dimensions vary from 14 to 27 cm in length and 14 to 20 cm basal width, and the opening averages 4.4 cm in diameter (Emlen 1954). The nest is cemented with mud under the eave of a building, bridge or other vertical surface. On structures, the first nests are usually located at the highest point possible with subsequent nests attached below it, forming a dense cluster.

Both sexes construct nests, proceeding slowly to allow the mud to dry and harden. Depending on mud supply and weather, nest construction takes 1 to 2 weeks. Mud is collected at ponds, puddles, ditches and other sites up to 0.8 km away with many birds participating at the same mud source (Emlen 1952, 1954). A typical nest contains 900 to 1400 pellets, each representing 1 trip to and from the nest (Emlen 1954, Withers 1977).

Mud-gathering and nest construction are social activities; even unmated birds will start nests. Mated birds may build more than 1 nest per season, even though not all will be used (Emlen 1952, 1954). Therefore, a count of nests under construction will not give an accurate estimate of the number of breeding birds.

Egg Laying

Egg laying usually begins before the entrance tunnel is completed (Emlen 1954). Each day 1 egg is laid until the clutch of 3 or 4 eggs is completed. Clutch size ranges from 2 to 6 eggs (Grant and Quay 1977, Mayhew 1958). In central California, egg laying generally occurs between late April and the

end of May. In southern California, nesting can begin during late March and in the extreme northeastern part of the state as late as June. Within a large colony, the date of egg laying varies due to the staggered arrival dates of the birds. For small colonies, laying may be more synchronous (Myres 1957).

Nest Failures

Re-nesting will occur if nests or eggs are destroyed. Nests may fall because they were built too rapidly or may crumble because of prolonged humid weather (Emlen 1954). House sparrows sometimes usurp empty swallow nests and may also drive off swallows from new nests (Emlen 1954, Mayhew 1958, Samuel 1971, Stoner 1939). A cliff swallow nest taken over by house swallows is identified by the abundant nest lining (grasses, weeds, feathers and litter) protruding from the entrance.

Hatching and Feeding

Both sexes incubate the eggs. Incubation begins the day before the last egg is laid (Mayhew 1958, Samuel 1971) and ranges in length from 11 days (Grant and Quay 1977) to 16 days (Mayhew 1958). Other studies typically report 14 or 15 days' incubation (Burns 1915, Myres 1957, Samuel 1971). Whitewash on the lower rim of the nest entrance is a sign of newly hatched nestlings inside the nest. This marking occurs when adults remove fecal sacs from the nest and later when nestlings defecate from the nest entrance.

All swallows are insectivores, but the food habits of cliff swallows are not well documented. Beal (1918) examined 375 stomachs taken from March to September apparently in different areas of the West. Prey taken included flying insects from the orders Hymeroptera (29%), Coleoptera (27%), Hemiptera (26%), and Diptera (13%). Adults may forage over areas up to 6.4 km distant from the nest (Emlen 1952). They forage as a loose unit and, prior to the young hatching, adults may be away from the colony for hours. After hatching a more or less steady stream of adults returns to the colony with food for the nestlings. Occasionally, long periods of continuous rainfall make it difficult for adults to find food, causing nestling mortality (Stewart 1972).

Fledging and Post-Nesting Period

The nestlings fledge 20 to 25 days after hatching (Grant and Quay 1977, Mayhew 1958, Samuel 1971). In central California, flying young are usually seen by mid- to late-May and 1 to 3 weeks earlier in southern California. The juvenile swallows appear similar to adults but are dullish colored and have less sharply defined color patterns. The fledglings will return to the nest 2 or 3 days to be fed before leaving it permanently (Mayhew 1958). Within a week, juveniles will join feeding flocks and leave the colony (Samuel 1971).

There is some dispute concerning the number of broods produced each year. Most observers agree that at least some cliff swallows raise 2 broods in any 1 breeding season. Second broods are documented from Virginia (Grant and Quay 1977), West Virginia (Samuel 1971), and suggested from Texas (Chapman 1973) and Pennsylvania (McCann 1936). On the other hand, Mayhew (1958) suggested second broods were uncommon in central California and, along with Grinnell (1937) and Buss (1942), felt late nests were birds renesting after a first failure or just late nesters. The time required from start of nest building to departure after raising a brood is 46 to 63 days: 7 to 14 days nest building, 3 to 6 days egg laying, 14 to 15 days incubation, 20 to 25 days to fledging, and 2 or 3 days to leave the nest. Reports by Grinnell (1937) of 117 days occupancy, Samuel (1971) of 120 days, Grant and Quay (1977) of 132 days, and Chapman (1973) of about 110 days indicate ample time for 2 broods. However, Foster (1968) in California reported total brood mortality of late nesting cliff swallows and few successful second nests and suggested there is only a narrow span of time during which broods are reared.

After leaving the nesting colony, cliff swallows may remain in the general area for several weeks. In California by mid-August there is a general southward movement, and by the end of September few swallows remain, except in southern California where a few linger into October (Small 1974). Eyster (1980) also mentions fall migration in August in Louisiana. Fall migration of cliff swallows is not well documented.

CONTROL

Legal Status

In the United States, all swallows are classified under the Migratory Bird Treaty Act of 1918 as migratory insectivorous birds and are protected. The Treaty arose from a Convention between the United States and Great Britain concerning protection of migratory birds in Canada and the United States. Similar agreements have been signed by the United States with Mexico in 1936, Japan in 1972, and the U.S.S.R. in 1978. In the U.S. swallows are also protected by state regulations. Under the articles of the Convention, it is illegal for any person to take, possess, transport, sell or purchase swallows or their parts, such as feathers, nests or eggs, without a permit. As a result, certain activities affecting swallows are subject to legal restrictions.

Permit Requirements

Regardless of the time of year, a depredation permit issued by the U.S. Fish and Wildlife Service is required before swallow nests can be removed. This includes nests under construction, completed nests and nests abandoned after the breeding season. It is a common misconception that nests may be removed without a permit after the swallows complete nesting and depart.

During nesting, permits authorizing nest removal are issued only if strong compelling reasons exist. Some examples are safety and health hazards posed by a nesting colony located over a doorway/entrance, near loading areas at warehouses and food-processing centers, or at airports where aircraft safety is impaired. During the nonbreeding season and before nests are completed at the start of nesting, the justification required to issue a permit for nest removal is not as strong. In such instances, aesthetics or a past history of problems and the expectation of future problems are sufficient reasons for permit issuance.

A permit application may be obtained by contacting the U.S. Fish and Wildlife Service. The permit is usually valid 1 nesting season only and is free of charge. The permit authorizes the permittee to use specified methods to remove nests. The permittee is required to record the number of nests removed and to report these removals within 10 days after the permit expires. In California a state permit is not required.

Timing is critical. It may take 1 to 2 weeks to obtain a permit. If a problem is expected it is not advisable to wait until nest building begins to apply for a permit, since swallows build their nests and lay eggs in a short time. If eggs or young are in the nest, a permit probably won't be issued.

Nest Removal

Method(s) of nest removal will be specified by the permit. Usually nests may be washed down with a water hose or knocked down with a pole. Swallows are strongly attracted to old nests or to the remnants of deteriorated nests so all traces of mud should be removed. Removing nests by these methods is a messy and time-consuming process and may cause dispersal of nest parasites. At one location mud and water from hosing seeped inside a building, leaked onto the ceiling and left stains (Gorenzel, unpubl. ms.).

As builders of mud nests, cliff swallows have evolved with rain or moisture induced nest failure. Washing down nests is nothing more than an artificial rainstorm. Therefore, during nest building, nest removal will require many days because the birds will persistently rebuild nests. Persistence is undoubtedly affected by the physiological condition of the birds, past nesting history at the site, and the availability of alternate sites. The swallows usually return the following year and, unless additional control measures are implemented, the whole process must be repeated.

Exclusion

Exclusion refers to any control method that denies physical access to the nest site area. Exclusion represents a relatively permanent, long-term solution to the problem. A permit is not required for this method if it is applied before the birds arrive or after they have left for the winter. If swallows are nesting and have eggs or young, exclusion may not be used without a permit.

Plastic net or poultry wire can provide a physical barrier between the birds and the nest site. The mesh size should be 1.3 to 1.9 cm; however, 2.5 cm has been used successfully. If plastic net is used, it should be attached so that it is taut. This reduces flapping in the wind, which looks unsightly and results in tangles or breakage at mounting points. Do not use mist net or any other thin, flexible net with loose pockets or wrinkles that could trap or entangle birds. Netting or poultry wire should be attached to buildings before the birds arrive and may be left up permanently or removed after nesting season.

Attachment methods may vary according to site requirements and the degree of permanence desired. It can be attached directly using tape, staples, trash bag ties, or plastic fasteners. More elaborate are hooks, such as brass cup hooks, mounted on the eaves and the side of the building. An advantage of hooks is that the net can be easily taken down during the nonbreeding period or for maintenance of light fixtures, painting, etc. If hooks or staples are used, they should be rust-resistant to avoid unsightly rust stains on the building. For netting, a supporting framework of wooden dowels, wood laths or even metal rods along the edges can ease attachment to the hooks and create a more equal tension on the net (Fig. 1). Netting may also be stapled to or wrapped once or twice around wood laths and nailed directly

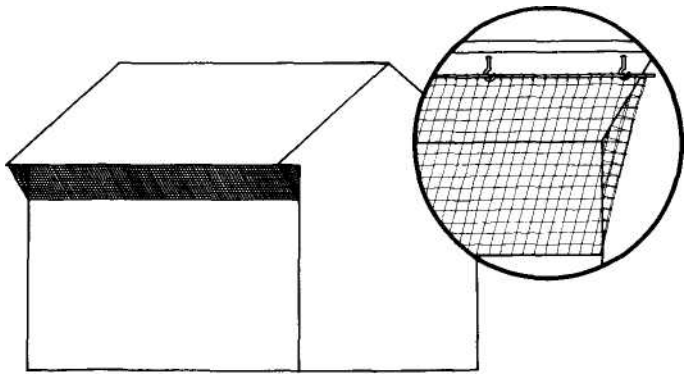

Fig. 1. Netting mounted on building from outside edge of eave down to the side of the building. Insert shows a method of attachment using hooks and dowels.

to the structure. On a concrete or cement structure, a power-activated tool, sometimes called a stud gun, can be used to nail the wood lath. The netting or wire should extend from the outer edge of the eave down to the side of the building so the protection from the elements given by the eaves is lost to the swallows (Fig. 2). No openings should remain where swallows might enter. Hanging a curtain of netting from the eave is reported effective (Fig. 2). The curtain should be 7.6 to 10 cm from the wall and extend down from the eave 46 cm or more. Plastic netting is reported to be effective 3 to 5 years before replacement is necessary (Anonymous 1981).

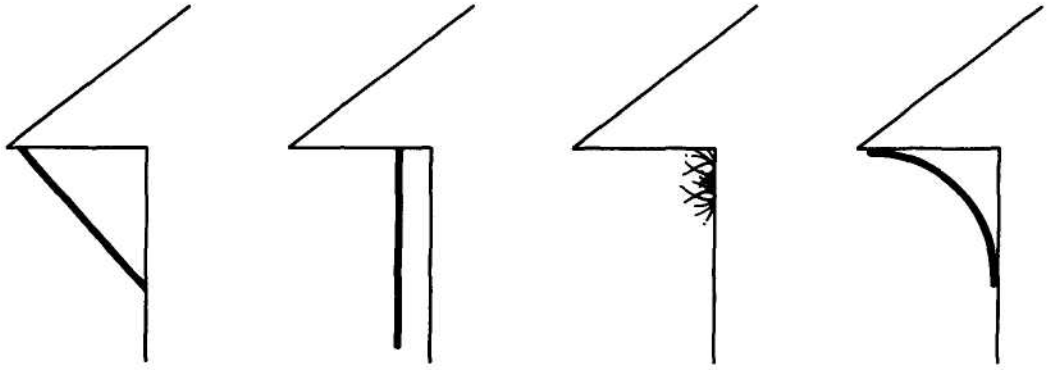

Fig. 2. Four methods which may deter cliff swallow nesting: From left to right: Netting attached from the outer edge of the eave down to the side of the building; a curtain of netting; metal projections attached along the junction of the wall and eave; fiberglass panel mounted to form a smooth, concave surface.

Cliff swallows occasionally enter buildings through doors or other open entry ways and nest inside on the rafters. In some instances simply closing the entrance or blocking it with net or wire is practical and effective (Fig. 3). Samuel (1967) reported cliff swallows abandoned nests inside barn lofts when entrance ways were partially closed. At warehouses and other buildings with frequent

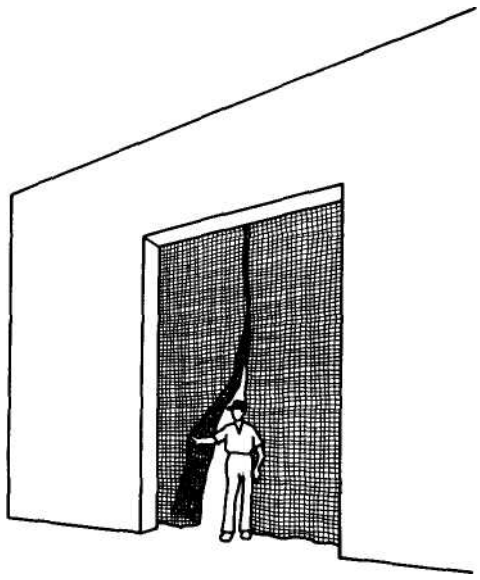

Fig. 3. Netting hung as a curtain at entrance way.

pedestrian or equipment passage, opening a closed entrance way may be bothersome and impractical. In these situations strip doors of vinyl plastic may be installed. Primarily used to control temperature in refrigerated areas, strip doors are approximately 20 cm wide strips of vinyl hung like a curtain. Strips overlap about 8 cm. Strip doors do not require opening and closing like a conventional door and are not damaged by passage of equipment. The use of netting hung as a curtain to block an entrance is recommended only where there is no possibility of its being caught and ripped by equipment. Weighting the bottom of netting will help keep it reasonably taut and in position during windy weather.

Usually, swallows will not fly into a net or other obstruction, but will stop and hover in front of it. If only that section of a building where swallows have nested is netted, the swallows will often choose alternative sites on the same structure. Therefore, any part of a building suitable for nesting must be netted.

Other Methods

Metal spines, nest substrate modification, repellents and frightening devices have been employed with varying degrees of success or are unproven (L. Martin, N. Holgersen, personal communication).

Metal projections are sharp, needle-like wire devices generally installed on building ledges and window sills to discourage rock doves and starlings from roosting. Although adaptable to mounting and use under eaves, metal spines have not been widely used for swallow control (Fig. 2). In one instance cliff swallows learned to land on the metal spines and eventually built nests attached to them (L. Martin, personal communication).

Modification of the nest substrate has proven effective. Swallows prefer surfaces that provide a good foothold and nest attachment. Removal of the rough surface of a wall and/or overhang makes a site less attractive. This may be accomplished in various ways. Fiberglass panels installed between the eave and wall to form a smooth, concave surface make nest attachment difficult (Fig. 2). A curtain of aluminum foil or plastic tarp draped from a wire strung along the junction of the wall and roof overhang creates a smooth surface. Other smooth-surfaced materials to deter nesting include glass and sheet metal. A fresh coat of paint that dries to a slick surface is sometimes cited as effective. However, with regard to fresh paint, any of a number of plausible reasons could result in the failure of cliff swallows to reoccupy a colony. The fact that cliff swallows don't occupy a newly painted site does not prove the method effective. On rough surfaces, painting is of doubtful value because it does nothing to alter the basic rough texture of the surface. Painting may be effective on smoother surfaces but requires testing.

Most other methods have shown little, if any, success or are unproven against cliff swallows. These include hawk, owl or snake models, noisemakers, and revolving lights. As evidenced by colonies on buildings, cliff swallows are relatively tolerant of human activity and other disturbances. Chemical roost repellents have not proven effective. Roost repellents are normally applied in narrow strips. Unless a suitable nesting site is almost entirely covered with repellent, cliff swallows will still be able to land, gain a foothold, and begin nest construction. A sticky repellent may actually be counter-productive by improving nest adherence. Cliff swallow nests built over a sticky repellent have been observed (Gorenzel, unpubl. ms.). There are no chemical toxicants registered for cliff swallow control and shooting, trapping or harming swallows are not permitted.

Architecture

Although all the factors that constitute a suitable colony site are not yet understood or documented, architectural design does influence colony site suitability. Buildings with overhanging eaves at acute to right angles with the wall are potential nest sites. Conversely, sites where the overhang and wall meet at an obtuse angle or are rounded and concave are rarely used. This is commonly observed on high-way bridges in California. Recent statewide surveys of 263 cliff swallow colonies on man-made structures revealed nesting at only 1 location with an obtuse angle interface and 2 locations with concave surfaces (Gorenzel, unpubl. ms.). The width of the overhang may be important to site suitability, although the point at which this becomes critical is unknown. Few colonies are observed with an overhang of less than 15 to 20 cm. Texture is a factor; wood, stucco, masonry and concrete surfaces are favorable substrates. Metal as a substrate is rarely used, a statement supported by observation of road bridges. Nests on a metal surface are usually located at a crotch or joint where the bird can gain a foothold. In situations where construction is planned and cliff swallows are present on a nearby structure, consideration to materials and design may eliminate future problems. This is important because cliff swallows may move to nearby structures if control is applied at an existing colony.

Future Research

Research is needed to identify factors important in colony site selection. A knowledge of preferred habitat types, site orientation, substrate type and texture, and width of overhang might allow the construction of a predictive model and indicate potential habitat modifications. Examination of the distribution and location of nests in a colony in regard to physical factors such as site orientation and overhang width may illuminate a relationship helpful for solving swallow nesting problems. For example, the current recommendation is to extend netting from the overhang down to the wall far enough so that protection offered by the elements is lost. Presently the distance required is at best an intuitive judgment.

Finally, future efforts should be directed toward improved application of existing methods, the development of less labor-intensive new methods, and the documentation of the effectiveness of new and existing methods. Unfortunately, many commonly cited methods, such as frightening devices, taped alarm calls, predator models and a fresh coat of paint, are unproven.

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