

The apparent motivational state of a bird was strongly related to the number of perch songs given. Undisturbed birds were seen to initiate 58 perch-song bouts, while disturbed birds initiated 114 perch-song bouts ($\chi^2 = 24.08$, $df = 1$, $P < 0.001$). Initiation of flight-song bouts was not significantly different between undisturbed and disturbed birds.

The relationship of flight song frequency to time of year is interesting, especially in light of the fact that the reproductive stage of the singers was unknown. Territorial boundaries were well defined early in the season, and after the first week of May in both field seasons intense territorial encounters became uncommon. This decline in territorial disputes may have been the result of resident males having established territorial boundaries and learned the songs of their immediate neighbors (Wunderle, *Auk* 95:389–395, 1978). The analysis of the yellowthroat flight-song recordings showed that the perch-song portion incorporated in the flight-song vocalization is characteristic of the individual, making individual recognition on the basis of the flight song performance possible. Song without visible displays has been shown to be sufficient to maintain territorial boundaries (Peek, *Anim. Behav.* 20:112–118, 1972; Krebs, *New Scient.* 70:534–536, 1976), and the increased visibility of a yellowthroat in flight song would further enhance the deterrent effect of the vocalization. I therefore suggest that the yellowthroat flight song functions to maintain territorial boundaries, once these boundaries have been established. The relative infrequency of flight songs at all times during the season (Stewart 1953) may reflect the fact that this vocalization serves primarily to discourage trespassing by other males, unlike the perch song, which is used during the initial setting up of territories and territorial disputes, as well as for advertising for, and maintaining a pair bond with females (Wunderle 1978).

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Vocalizations and behavior of Violet-green Swallows in the Chiricahua Mountains, Arizona.—The Violet-green Swallow (*Tachycineta thalassina*) has been largely ignored by ornithologists. The only published accounts of its basic biology date from the 1940s (Bent, U.S. Natl. Mus. Bull. 179, 1942; Edson, *Auk* 60:396–403, 1943) or must be gleaned from generalized state bird-books (e.g., Bailey, *Birds of New Mexico*, New Mexico Dept. Game Fish., 1928; Phillips et al., *The Birds of Arizona*, Univ. Arizona Press, Tucson, Arizona, 1964). Virtually nothing has been reported about its vocalizations.

In May–July 1980 I studied Violet-green Swallows and recorded their vocalizations in the Chiricahua Mountains, Cochise County, Arizona. Recordings were made with Uher 4000 Report L and 4000 Report IC tape recorders and Uher M517 and Electrovoice Soundspot microphones, the former mounted in a 60-cm parabolic reflector. Tape speeds were 19 and 9.5 cps. Sonagrams were made on a Kay Elemetrics Corp. Sona-Graph Model 6061-B using wide-band pass setting and linear scale. All observations and recordings were made near Rustler Park (elev. 2545 m) and at the Southwestern Research Station (elev. 1636 m). I tape-recorded approximately 35 different individual swallows.

Violet-green Swallow vocalizations can be grouped into two broad classes, *chee-chee* and “twitter” calls.

Chee-chee calls.—These calls are generally mono- or disyllabic (syllable defined as a con-

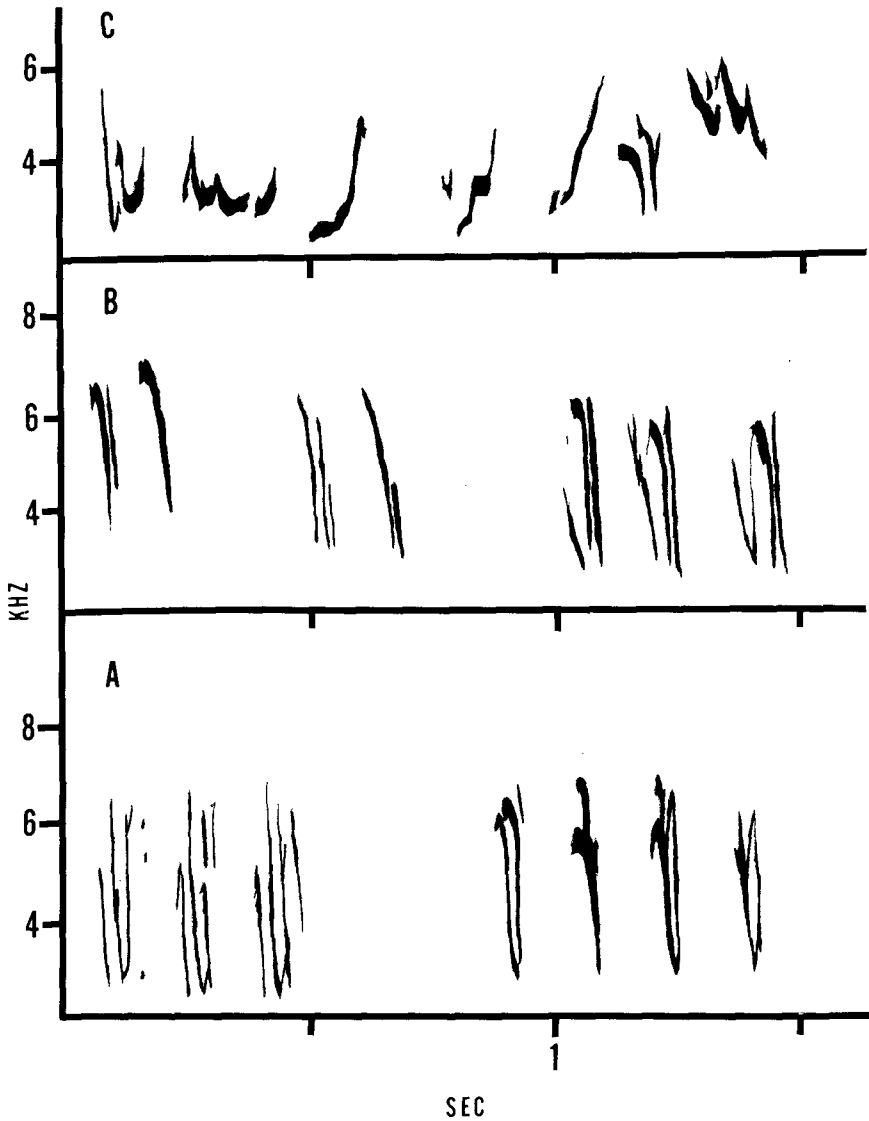


FIG. 1. Sonagrams of Violet-green Swallow vocalizations from the Chiricahua Mountains, Arizona: A. *chee-chee* calls of adults, first three tracings from one bird, latter four each from different birds; B. *chee-chee* calls from three different juveniles, first two tracings from one bird, middle two from a second bird, latter three from a third; C. representative "twitter" calls, all from one individual.

tinuous tracing on a sonagram), range from about 2.5 to over 7 kHz, last about 165 msec, and occur in pairs or series (up to 4 sec in duration) with intervals of 85–165 msec between calls (Fig. 1A–B).

These vocalizations were used in several behavioral contexts, but almost invariably when one bird was associating with at least one other swallow. Many were recorded from foraging swallows. Violet-green Swallows regularly foraged on emerging crepuscular insects over the grounds of the Southwestern Research Station in late afternoon with White-throated Swifts (*Aeronautes saxatalis*) and bats (*Myotis* spp.). The calls were often given when two birds passed near each other in flight, or during intra- and interspecific chases. Violet-greens frequently chased each other during these foraging bouts, and on two occasions swallows chased bats. During June and July, Violet-green Swallows appeared at the research station only in the late afternoon, apparently being confined to coniferous forest at higher elevations at other times. Adult violet-greens also gave *chee-chee* calls when traveling to and from nesting sites at higher elevations. Occasionally *chee-chee* calls were mixed with “twitter” calls (see below). In flocks *chee-chee* calls possibly serve to promote social cohesion (“contact” calls), especially if these birds forage socially as suggested for Bank Swallows (*Riparia riparia*) (Emlen and Demong, *Science* 188:1029–1031, 1975).

I also recorded *chee-chee* calls (Fig. 1B) from perched juveniles of at least five broods assembled (at different times) in a large Arizona sycamore (*Platanus wrightii*) on the grounds of the research station. These juveniles apparently were still dependent on their parents for food. None was seen catching insects itself, and adults dropped insects into the juveniles’ mouths while hovering above them, as described for Purple Martins (*Progne subis*) (Brown, *Wilson Bull.* 90:376–385, 1978). The juveniles generally perched on an exposed branch, calling repeatedly, especially whenever another swallow flew near. The juveniles and their parents left at nightfall and returned at daybreak, suggesting that this tree was a “grouping area” (Brown 1978). These juveniles had probably been out of the nest at least 2–3 days when I recorded their vocalizations. They had to be old enough to travel a considerable distance, because I found no violet-green nest within 1 km.

Although the birds were unmarked, apparent nonparental swallows harassed these juveniles, and were chased away by parents. This behavior was similar to raider behavior described for Purple Martins (Brown and Bitterbaum, *Wilson Bull.* 92:452–457, 1980). Independent juvenile Violet-green Swallows (known by their more squarish tails) seemed attracted by the activity of the parents and the broods in the sycamore and acted as raiders. They gave *chee-chee* calls when chased away by parental swallows, and as they foraged and passed near other flying birds.

Chee-chee calls may also serve as contact calls between parents and offspring. When juveniles sat in dense foliage, parents probably could locate them only by sound. If parent-offspring recognition occurs in Violet-green Swallows, it may involve auditory recognition, as suggested by Beecher et al. (*Anim. Behav.* 29:95–101, 1981) for Bank Swallows.

“Twitter” calls.—These calls are generally monosyllabic (Fig. 1C). They range from 2–ca. 6.5 kHz. Some syllables have a duration as long as 125 msec and are longer than syllables of *chee-chee* calls. I detected no recognizable, repeating series of syllables which could be interpreted as a song.

“Twitter” calls apparently were restricted to interactions associated with courtship and territory establishment. They were recorded from recently arrived birds at Rustler Park near nesting sites. The calls were given only in flight as swallows flew to and from dead snags, investigating woodpecker holes. Some birds appeared to be paired and presumably the male was escorting the female to and from the site. Some individuals tried to establish ownership of certain holes, but interference from other swallows and Acorn Woodpeckers (*Melanerpes formicivorus*) prevented this. The Violet-green Swallows made low swoops, uttering a guttural

alarm call, at Acorn Woodpeckers in the snags. I was unable to record this alarm call, but it sounded similar to the *zurack* alarm call of the Purple Martin (Johnston and Hardy, Wilson Bull. 74:243–262, 1962; Brown, pers. obs.). “Twitter” calls accompanied intraspecific fights, which consisted of short chases from the snags. I detected no obvious differences between sonagrams of “twitter” calls used when escorting mates and those used when chasing intraspecific competitors.

At active nesting sites where violet-green pairs had established territories (and later as they built nests and incubated), “twitter” calls were never recorded. In such circumstances, the only vocalizations I recorded were occasional *chee-chee* calls as members of the pair circled nearby or flew away together. Once established at a site the swallows were largely nonvocal. Active nests were not studied during feeding of the young, so I do not know if the parents or young vocalized at that time.

Violet-green Swallows in the Chiricahua Mountains, although decidedly gregarious at times, were solitary nesters. Flocks of up to 40 birds foraged together at the research station, and groups of 10 commonly investigated unused nesting sites at Rustler Park or foraged together high in the mountains. But of the three active nesting sites I located in the Chiricahuas, all contained single pairs only. Other holes were present in the snags containing active nests but were unused or defended by Acorn Woodpeckers that nested in adjacent snags. The situation in the Chiricahuas is markedly different from the 20 pairs of violet-greens nesting as a colony near Santa Fe, New Mexico (Bailey 1928) or Bent’s (1942) reports of 20 pairs in a “single dead pine” in Colorado, colonies of up to 100 or more pairs in cliffs in Washington, and colonies of from 6–50 birds in Alaska. Thus, it seems that the Violet-green Swallow is highly colonial yet may also be a solitary nester. (However, to my knowledge there have been no reliable reports of large colonies in the last 40 years.)

Little has been published on vocalizations of other North American swallows, so it is difficult to compare violet-green vocalizations with those of other species (but see Samuel, Auk 88:839–855, 1971). With only two kinds of calls, however, it is possible that Violet-green Swallows do not rely heavily on vocal communication. If violet-greens are colonial through most of their range, this may have shaped the evolution of the vocal repertoire. As suggested by Marler (Behaviour 11:13–39, 1957), Wiley (Anim. Behav. 24:570–584, 1976), and Smith (The Behavior of Communicating, Harvard Univ. Press, Cambridge, Massachusetts, 1977), vocal communication in particular may be inefficient in colonies of birds because too many signals from different individuals impinge on the receiver at any given time, creating confusion (the “cocktail party effect”). Directional visual displays, which can be oriented to specific individuals, may be favored in colonial birds. Violet-green Swallows possess visual displays such as white flank patches that can cover the rump, and these birds may emphasize vocal displays only when moving flocks or concealed offspring cannot maintain visual contact.

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