

PRESUMED NOCTURNAL FLIGHT CALL OF THE GREEN-TAILED TOWHEE

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ABSTRACT: A large sample of nocturnal flight calls of warblers and sparrows recorded on the outskirts of Nogales, Arizona, from mid-August through October 2015 included an unknown call-type that has not been documented in extensive monitoring of nocturnal flight calls across the eastern United States. Though variable, it averages 213 milliseconds in duration and consists of two simultaneous sounds differing in pitch and whose frequency is often modulated at a rate about 59 hertz. The call-type occurred primarily during September with a peak in the middle of the month. This corresponds with the peak in migration of the Green-tailed Towhee (*Pipilo chlorurus*) near Nogales. That species affords the closest match to a diurnal contact call of a migratory species common in the area whose nocturnal flight call is as yet undescribed.

An emerging field of birds' aeroecology is the recording and analysis of their nocturnal vocalizations (flight calls). Many species vocalize while migrating at night, and monitoring these calls at one or more sites currently provides the only direct means of learning what species are in active nocturnal migration and the geographic and temporal extents of their flights. Such information is becoming increasingly important to help predict (and possibly mitigate) potential collisions with man-made structures and to assist with long-term population monitoring (Evans and Mellinger 1999, Evans and Rosenberg 2000, Farnsworth 2005).

One of the challenges inherent in monitoring nocturnal flight calls is confidence in species identification by sound alone. The ease of establishing the species identity of a nocturnal call varies with the ease of matching it with its cognate call from a species visually confirmed during the day. The extent to which there may be other species with similar calls that need distinguishing is also a major factor. For example, the Killdeer (*Charadrius vociferus*) is a widespread species in North America that is quite vocal during the day and easily recognized by its distinctive calls. It is known to migrate at night largely because nocturnal flight calls that sound like the Killdeer are regularly recorded, but it is easily identifiable at night because no other North American species gives a similar call with which it might be confused.

Evans and O'Brien (2002) compiled recorded audio examples and documented what was known about the flight calls of migrant passerines in east-central North America. Of the species they covered, many have quite distinct calls, but calls of others are remarkably similar. This compilation was complete enough that a recorded nocturnal flight call of a passerine in that region can in most cases be categorized to species or species complex by sound alone. In western North America, no overarching compendium of passerine flight calls has been produced. Lanzone et al. (2009) presented spectrographs of the flight calls of five species of western warblers, and Farnsworth (2011) followed with single spectrographic examples that included all the warblers breeding in the western United States. Many species of western passerines also migrate through eastern North America, and their flight calls are covered by Evans and O'Brien (2002).

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With the advent of online bird-sound archives such as Xeno-Canto (<http://www.xeno-canto.org>) and the Macaulay Library (<https://www.macaulaylibrary.org>), flight calls of other passerines in western North America are becoming known.

From mid-August through October 2015, I recorded a large sample of nocturnal flight calls of warblers and sparrows in the foothills northeast of Nogales, Arizona. During my analysis of these calls, I noticed a distinctive call-type that I did not recognize from my 35 years of studying nocturnal flight calls across eastern North America. Here I describe this call and present indirect evidence implying the caller was the Green-tailed Towhee (*Pipilo chlorurus*).

METHODS

I made audio recordings of the sky from 20:00 to 06:00 MST (UTC-7) on 72 nights during the period 18 August–30 October at 78 Circulo Montana Dr., Nogales, Arizona (Santa Cruz County; 31.4655° N, 110.8575° W; one night missed). I used the software Tseep (<http://www.oldbird.org>) on the 10-hr audio files to extract the nocturnal flight calls of warblers and sparrows. See Evans (2021) for more details on the recording station and process of extracting and categorizing the calls.

For spectrographic analysis of the unknown calls, I used the program Raven Pro 1.6 (<http://ravensoundsoftware.com>). Spectrograms were computed with a 180-sample Hanning window, a hop size of 20 samples, and a discrete Fourier transform size of 256 samples (Charif et al. 2010). For measurement, I selected spectrograms that appeared to show the complete call. To reduce the chances of an individual bird contributing multiple calls to measurement statistics, I selected calls separated by at least 2 minutes.

I measured the calls' duration, modulation rate, modulation bandwidth, and the maximum frequency range between the call's two simultaneous tones (see Figure 1). This last variable was an approximation based on measuring the apparent broadest separation between the tracks representing the two simultaneous sounds. A call's modulation rate was based on the duration of the longest segment of a call with at least four uniform cycles of modulation, calculating the average duration of a cycle in that segment, and expressed as cycles per second (hertz). The duration, modulation rate, and frequency bandwidth of the calls are reported as average values plus or minus standard deviation. I conservatively estimate the accuracy of my measurements as ± 5 milliseconds (ms) and ± 100 hertz (Hz). I also assessed the spectrograms visually to categorize the call as ascending, descending, or steady in frequency over the middle two thirds of the call. The beginning and end portions of the calls often have steeper inflections and unique modulations that differ from the typically more homogeneous middle portion.

To link the unidentified calls to a species, I assessed calls of all passerines known to migrate regularly through the Nogales region during September, the primary period when the unknown call-type was detected. I excluded from the comparisons species such as the Fox Sparrow (*Passerella iliaca*) and the White-throated Sparrow (*Zonotrichia albicollis*), which, although they have a flight call somewhat similar to the unknown, do not normally migrate near my study site in September. For species whose flight call had not been clearly described, I searched the public archives of the Macaulay Library (ML) and

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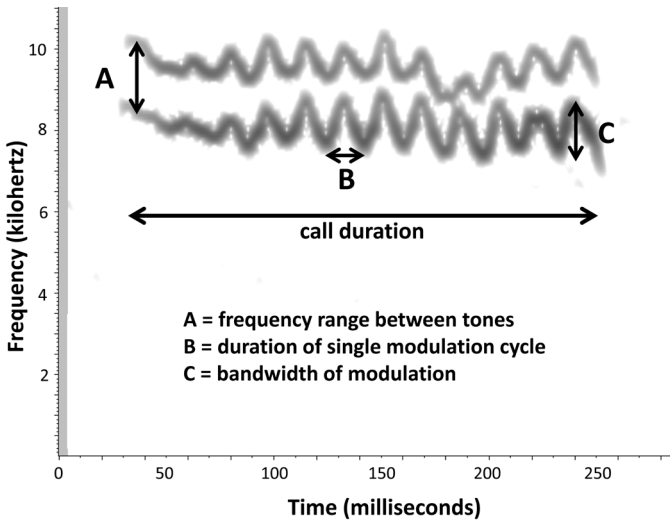


FIGURE 1. Characteristics measured of unknown nocturnal flight call recorded near Nogales, Arizona, fall 2015.

Xeno-Canto (XC) for any diurnal calls similar to the unknown call I recorded. Upon finding a potential match, I inspected the frequency of its reports to eBird (<https://www.ebird.org>) in Santa Cruz County to see how well the temporal pattern of reports fit the seasonal detection pattern of the unknown call (e.g., Evans and Conway 2021). In the case of one prospective matching species, the Spotted Towhee (*P. maculatus*), I also included reports from Pima County, adjacent to Santa Cruz County to the west and north, because of its proximity and because the high number of checklists submitted to eBird from the Tucson area enlarged the sample substantially. I presumed that the larger dataset should improve the resolution of a weak migration signal.

RESULTS

Calls of the unknown type stood out from other calls by their relatively long duration and wide frequency range between coincident tones. But within the subset of calls with this commonality, there was a wide range in modulation bandwidth. I found 195 examples of the unknown call-type among more than 20,000 flight calls of other species with sound energy between the frequencies of 6 and 10 kHz. The period of detection of the unknown call was from 1 September through 7 October with a peak in mid-September.

Call Characteristics

Of the 195 examples, there were 159 cases of the unknown calls being separated by at least 2 minutes. Spectrograms of 117 of these show a distinct beginning and end that allow the call's duration to be measured—average 213 ms (SD \pm 40, range 100–308 ms).

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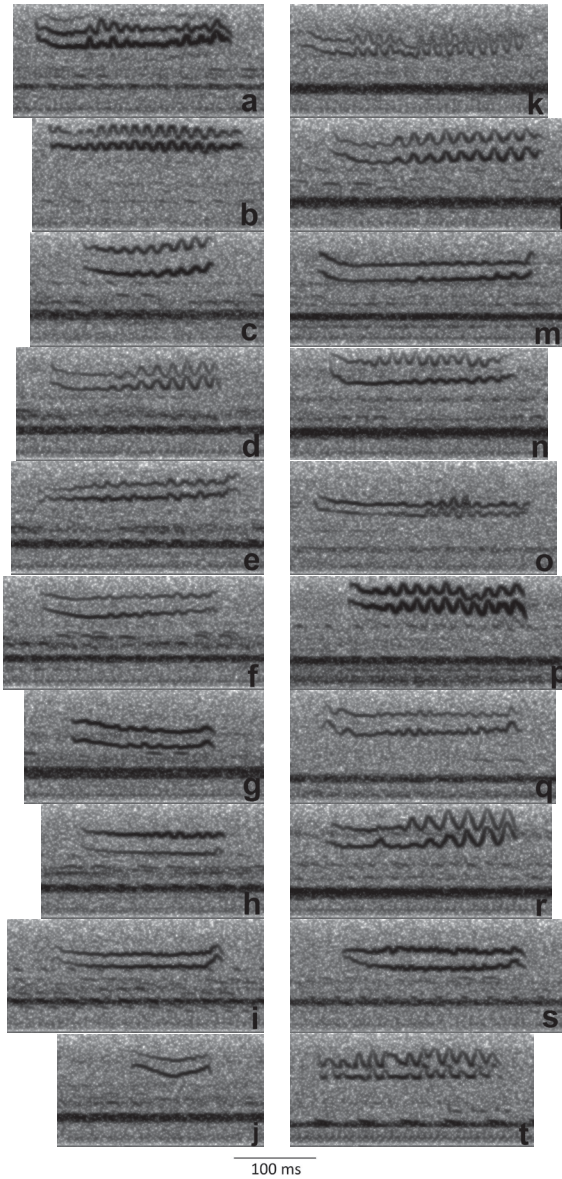


FIGURE 2. Examples of spectrograms of the unknown nocturnal flight call recorded near Nogales, Arizona, selected to show its range of variation. The *x* axis is time in milliseconds (ms), and most calls are between 200 and 300 ms in duration. The *y* axis is frequency in kilohertz (kHz), presented linearly within the range 0–11 kHz. The calls occur in the 5- to 10-kHz range.

The call's frequency modulation most often appears as uniform sinusoids but also commonly as irregularly shaped toothed cycles in which the modulation bandwidth, rate, and the slope of a cycle's rise and descent may vary from one cycle to the next. The modulation bandwidth ranges from roughly 100 to 1400 Hz. Only 58 of the spectrograms have uniformly modulated sections with at least 4 continuous cycles that can be measured for modulation rate. Of these the average rate is 59 cycles per second (SD ± 9 , range 42–79).

Nearly all calls are composed of two concurrent sounds, each generated independently in the syrinx—none of their spectrograms show harmonics or side-band phenomena (as defined by Greenewalt 1968). Figure 2 illustrates a range of spectrograms. The dual tracks tend to parallel one another but occasionally deviate in unique ways; for example, see Figure 2(p, t). In a few cases they are very different, for example, as in Figure 2(n), in which the upper track is strongly modulated and the lower purer toned. In several cases, the higher-frequency track is louder in amplitude, for example, as in Figure 2(h). A distinctive characteristic apparent in most of the calls is the relatively large difference in frequency between the two tracks, for example, as in Figure 2(c). In 142 calls where it can be measured, the largest difference in frequency averages 1600 Hz (SD ± 300 , range 950–2600 Hz). I recorded three cases in which it appears that just one sound track was produced—the distinctive characteristics of call length and modulation of the single track resemble those of an individual track in the two-tracked versions. The calls often begin with a segment that descends in frequency, but thereafter the bulk of the call tends to be evenly pitched or slightly rising, as in Figure 2(e), for example, and less commonly slightly descending in frequency, as in Figure 2(g).

Species Determination

My experience with identifying nocturnal flight calls in eastern North America led to me to suspect the mystery call to be an undescribed nocturnal flight call from a western passerine. From this presumption, I eliminated the vireos and tyrant flycatchers from consideration because in east-central North America species of these families rarely vocalize in their fall nocturnal migrations. Then elimination of the species whose calls Evans and O'Brien (2002), Lanzone et al. (2009), and Farnsworth (2011) identified left few passerines that migrate regularly through Santa Cruz County in September whose nocturnal flight call is not known or suspected. These are the Botteri's, Cassin's, and Black-throated Sparrows (*Peucaea cassinii*, *P. botterii*, and *Amphispiza bilineata*, respectively) along with the Green-tailed Towhee. I tentatively eliminated the first three from consideration because none of their calls in the XC and ML archives resembles the unknown call. Initially, I did not suspect the Green-tailed Towhee because common phonetic descriptions of the call surmised to be its flight call represent it as disyllabic (Sibley 2000, Pieplow 2019), while the unknown call-type is monosyllabic. But in the process of inspecting examples of Green-tailed Towhee calls in the XC and ML archives, among the more common longer disyllabic examples, I found several shorter monosyllabic-sounding examples that bear resemblance to the unknown call-type (Figure 3).

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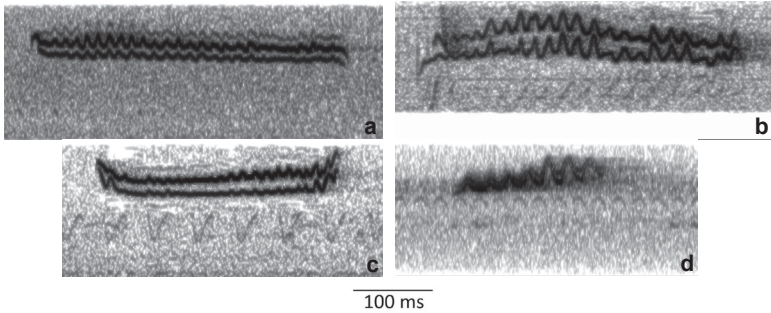


FIGURE 3. Spectrographic examples of the Green-tailed Towhee's diurnal contact call that resemble the unknown nocturnal flight call. The x axis is time in milliseconds (ms). The y axis is frequency in kilohertz (kHz), presented linearly within a range from 0 to 11 kHz. (a) Call recorded by Matt Wistrand, central Colorado, 18 October 2018 (<https://www.xeno-canto.org/438092>). Duration 402 ms; modulation rate 70 Hz (8 cycles measured beginning at 30 ms). (b) Call recorded by Richard E. Webster, Cochise County, Arizona, 29 September 2010 (<https://www.xeno-canto.org/112052>). Duration 394 ms; modulation rate 54 Hz (7 cycles measured beginning at 83 ms). (c) Call recorded by Tom Johnson, Cassia County, Idaho, 16 July 2018. (<https://macaulaylibrary.org/asset/107809051>). Duration 314 ms; modulation rate 69 Hz (7 cycles measured beginning at 160 ms). (d) Call recorded by Michael O'Brien, Big Bend National Park, Texas, 14 April 2021 (<https://macaulaylibrary.org/asset/329982521>). Duration 175 ms; modulation rate 37 Hz (5 cycles measured over whole length of call).

Temporal Correspondence with Reports to eBird

The temporal occurrence of the unknown nocturnal flight call suggests that in 2015 the species' migration near Nogales lasted about 5 weeks and peaked during the third week of September. Figure 4 shows the correspondence of the seasonal occurrence of the unknown call with reports of the Green-tailed Towhee via eBird during fall migration in Santa Cruz County from 2010 to 2020. Of the 846 eBird checklists submitted from Santa Cruz County in the third week of September during this period, 18% reported the Green-tailed Towhee, the highest rate of all weeks in the year.

DISCUSSION

The Green-tailed Towhee breeds across much of the mountainous interior western United States. The closest substantial breeding to Nogales is about 250 km to the northeast, with the bulk of the breeding population north of that latitude, extending north to Oregon, southeastern Washington, Idaho, and Montana (Dobbs et al. 2012). Post-breeding, the nocturnal flight call of the Green-tailed Towhee is not anticipated over a Nogales recording station until late summer dispersal and fall migration begin. It is a fairly common wintering species in Santa Cruz County, so reports to eBird should increase as its fall migration through the area begins, then plateau depending on the consistency of the wintering population. The eBird data shown in Figures 4 and 5 reflect these expectations. The acoustic evidence of a peak of the unknown nocturnal

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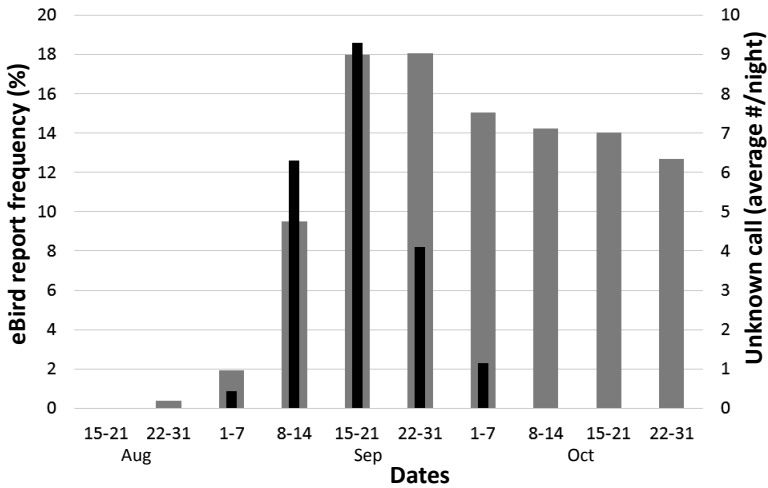


FIGURE 4. Light gray bars, percentage of weekly checklists submitted to <https://ebird.org> from Santa Cruz County, Arizona, between 15 August and 31 October, 2010–2020, that report the Green-tailed Towhee. Each value represents the percentage of checklists reporting the species during the period indicated, which are weeks except note that the last period in each month has 10 days. Dark bars show the nightly average number of the unknown nocturnal flight calls that were at least 2 minutes apart, during the same 7- or 10-day periods in 2015. The increase in detections of the unknown call corresponds well with the increase in the rate of reports of the Green-tailed Towhee through mid-September. The rate of the calls then falls off while the rate of reports via eBird checklist declines but remains at a fairly steady level through October. The difference in patterns presumably reflects the detection of birds in active migration versus the combination of migrants and wintering birds observed on the ground during the day.

flight call in the third week of September corresponds well with the reports of the Green-tailed Towhee in Santa Cruz County, a well-birded region of south-central Arizona (Figure 4). Although the Spotted Towhee is reported to have a diurnal flight call similar to the Green-tailed Towhee’s (Pieplow 2019, Sibley 2000), so its nocturnal flight call may also be similar, there is no correspondence in the rate of reports of the Spotted Towhee to eBird from Santa Cruz and neighboring Pima County with the pulse of the unknown call (Figure 5). In mid-September the rate of Spotted Towhee reports is at its lowest point during the fall migration season in this region (Figure 5). In fact, Figure 5 implies there is little signal of fall migration of the Spotted Towhee in Santa Cruz and Pima counties at all, unless it begins in October. Inspection of eBird data across the wider region of southern Arizona, southern New Mexico, and central Texas reveals clear evidence of migration of the Spotted Towhee in this broader latitudinal stratum in October. Although I cannot rule out that some of the unknown calls may belong to the Spotted Towhee, the eBird data for Santa Cruz County support the idea that the bulk of the unknown calls are likely from the Green-tailed Towhee.

The 195 examples of the unknown call-type I recorded in 2015 vary widely

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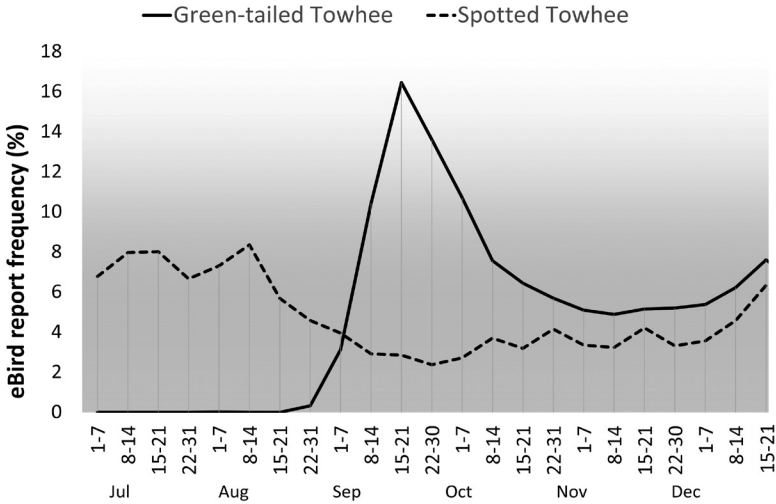


FIGURE 5. Percentage of checklists submitted to <https://eBird.org> from Santa Cruz and Pima counties, Arizona, 2010–2020, that report the Spotted Towhee (dashed line) and Green-tailed Towhee (solid line). Each value represents the average percentage of checklists reporting the species during the period indicated, which are weeks except note that the last period in each month has more than seven days. During the four weeks in September, the number of checklists submitted ranged from 4244 to 5303 per period. The data for the Green-tailed Towhee reflect the absence of the species in the region until late August when the first migrants arrive, the peak of fall migration in mid-September, and the smaller numbers remaining to winter. In contrast, the data for the Spotted Towhee reflect the late-summer presence of local breeders, no September migration peak, and only a small influx beginning in October of birds staying through the remainder of the year.

in the bandwidth of their frequency modulation. My initial inclination was not to group together calls with extremes in modulation bandwidth such as those shown between Figure 2(s) and Figure 2(t). But as the call analysis progressed, I discovered intermediate calls in which the modulation bandwidth is broader in a portion of the call and narrower in another portion. For example, Figure 2(a) shows a call that has alternating sections of modulation bandwidth wider and narrower, and in Figure 2(n) the bandwidth of frequency modulation of the top track is much wider than that of the lower track. I gained further confidence that these variations represent a single species when I found examples of the Green-tailed Towhee’s diurnal contact calls with a similar wide range in bandwidth of frequency modulation. The four diurnal examples shown in Figure 3 demonstrate that the Green-tailed Towhee can give a long monosyllabic contact call that varies greatly in modulation bandwidth.

Once the rough limits of the unknown call-type began to take shape, each new call discovered contributed to my understanding of its potential variation. In the 195 calls recorded, some characteristic variations show up regularly, suggesting a diversity of calls among individuals and/or the possibility of variations associated with different populations. The extent of this call-type’s variation in an individual bird is unknown. Sorting out the meaning of this call-

type's variation will take extensive study of both the nocturnal flight call and its diurnal counterpart from multiple regions within the Green-tailed Towhee's range. In such an investigation, it is important to recognize that some variations of the nocturnal flight call may not be given during the day. In his extensive study of the Gray-cheeked Thrush complex, Marshall (2001) found variations in nocturnal flight calls presumed to represent both *Catharus bicknelli* and *C. minimus aliciae* that were not represented by diurnal calls he had recorded. Yet he concluded that his sample size was not adequate to determine whether "a migrating group of these thrushes is reserving or improvising particular calls for nocturnal migration, different than those on the ground." In my experience, I have seen variations in nocturnal flight calls in many passerine species for which there is no similar variation documented during the day, but, as Marshall found, it is challenging to accumulate enough information to prove it. Inherent differences between the nocturnal and diurnal versions of the Green-tailed Towhee's presumed flight call may be a reason why there is not a more precise match between the diurnal examples in Figure 3 and the nocturnal flight calls presented in Figure 2. Another reason is likely the paucity of diurnal examples of this call-type available in the ML and XC public archives.

While the evidence strongly suggests that the highly variable nocturnal flight call I have described is from the Green-tailed Towhee, there are still a few alternative possibilities to be resolved. As of this writing, the nocturnal flight calls of the Cassin's, Botteri's, and Black-throated Sparrows are yet to be described. There is no evidence in the XC and ML archives, *Birds of the World* accounts (<https://birdsoftheworld.org/>), or Pieplow (2019), however, that any of these three species gives a long, high-pitched contact call. Furthermore, while all three may be migrating through Santa Cruz County in September, the rates at which they are reported from the county to eBird do not stand out as a strong match as that of the Green-tailed Towhee does. So, it seems unlikely that one of these species could be the source of the unknown call.

Another challenging possibility regards two species thought to be non-migratory, the Rufous-crowned Sparrow (*Aimophila ruficeps*) and Canyon Towhee (*Melospiza fusca*). Both have considerable populations around and to the north of Nogales, and both have long contact calls that are similar to, and potentially overlap with, those of the Green-tailed Towhee. It seems highly unlikely that one or the other could be responsible for all the unknown nocturnal flight calls, but perhaps one or both make undescribed nocturnal movements in which they emit flight calls—if so, there is a possibility some of the 195 unknown calls may be theirs.

Identification to species of nocturnal flight calls and documentation of regional patterns of nocturnal flight calling can take many years of study; publications tend to be progress reports (e.g., Evans et al. 2017, Evans and Conway 2021). The case for the unknown call being from the Green-tailed Towhee rests on (1) general resemblance of the unknown call to the Green-tailed Towhee's diurnal flight call; (2) good correspondence of the unknown call's seasonal pattern with the Green-tailed Towhee's schedule of migration; (3) lack of correspondence of the seasonal pattern of the unknown call with the timing of migration of the Spotted Towhee, a species with a potentially similar nocturnal flight call, and (4) extensive previous study of nocturnal flight calls that excludes most other species as possibilities.

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