

MECHANICAL SOUNDS THAT OCCUR DURING THE AERIAL DISPLAY OF THE RED-TAILED COMET (*Sappho sparganurus*)

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ABSTRACT: The Red-tailed Comet (*Sappho sparganurus*) is related to *Lesbia* and *Ramphomicron*, which produce ‘sonations’ (mechanical sounds with communicative function). Here I describe the display with sonations of the Red-tailed Comet observed in Argentina and Bolivia. This display, performed by males, was ‘pan-shaped’ and consisted of a ca. 25 m long straight, slow, suspended flight, some 20 m above the ground, with the tail held stiff, followed by a high-speed, nearly vertical dive towards a shrub (possibly comprised of two species) until reaching 2 m from the ground. Towards the bottom of the dive an impulsive, and dry, double ‘tec...tec’ or single ‘tec’ mechanical sound was given before ascending at a high angle up to the height from which it dove, making a U turn in the horizontal plane, to repeat the same display 3-4 times with an identical orientation. The display occurred sporadically, seemingly only during the breeding season (August to March). Based on what is known of the Black-tailed Trainbearer (*L. victoriae*), I speculate that the sound is produced by an intra-wing mechanism. The aerial display of *Sappho* includes vocal song-like sounds and well-spaced sonations, whilst those of *Lesbia* include only sonations consisting of trains of notes in the Green-tailed Trainbearer (*L. nuna*) or trains of couplets in the Black-tailed Trainbearer.

KEYWORDS: *dive, sexual display, sonation, Trochilidae*

The Red-tailed Comet (*Sappho sparganurus*), the only species in the genus *Sappho*, is phylogenetically related to the genera *Lesbia* and *Ramphomicron* (McGuire et al. 2014). At least three of the four species in these latter two hummingbird genera produce snapping mechanical sounds, which have been recorded in the Black-tailed Trainbearer (*Lesbia victoriae*; Rico-Guevara et al. 2022) and the Green-tailed Trainbearer (*Lesbia nuna*; Fjeldså & Krabbe 1990, Schulenberg et al. 2010) and have only been described in the Purple-backed Thornbill (*Ramphomicron microrhynchum*; Hilty & Brown 1986), whereas no mechanical sounds are known in the Black-backed Thornbill (*R. dorsale*; Hilty & Brown 1986, Züchner & Boesman 2020). Here I 1) describe for the first time the aerial display of the Red-tailed Comet and the mechanical sounds that accompany it, based on fieldwork in northwestern Argentina and southern Bolivia, 2) discuss the existence (or the

lack of) modifications in the primary feathers that produce these sounds, 3) compare these sounds with those of the two *Lesbia* species, and 4) conclude with a brief discussion of snapping sounds in the Strisores.

The observations reported here were made during fieldwork aimed at recording the vocalizations of the Red-tailed Comet, and serendipitously while conducting studies of other bird species. I detected the aerial display of the Red-tailed Comet (subspecies *sappho*) on three occasions: on 2 August 2015 at 9:49 h in Camino de Cornisa, Salta (24°31’S, 65°20’W, 1450 m.a.s.l.; recorded and partially observed), on 21 December 2024 at 8:03 h at Yavi, Jujuy, Argentina (22°08’S, 65°28’W, 3455 m.a.s.l.; recorded and observed), and on 30 March 2025 at 8:45 h at Chorro de Jurina, Tarija, Bolivia (21°25’S, 64°48’W, 2170 m.a.s.l.; observed). The display of the Red-tailed Comet appears to occur

infrequently and unpredictably, but perhaps seasonally, at least based on my extensive experience with the species, to which I have paid particular attention while trying to document individual variation in male songs ($n \approx 60$ individuals recorded). Observations in August, December and March (spanning 8 of the 12 months of the year) indicate that its occurrence is not restricted to a short timeperiod, although they do fall within what can be considered the species' breeding season (e.g., a female with a nest under construction at Camino de Cornisa on 8 September 2012 signals early breeding, while a female with a nest containing eggs at Cuesta del Obispo, Salta, on 13 March 2021 indicates a later case).

The aerial displays observed at Yavi and Chorros de Jurina were very similar. In each case, an adult male traced a 'pan-shaped' trajectory, beginning with a straight, relatively slow horizontal flight, suspended like a kite in mid-air for about 25 m, always at about 20 m above the ground, with the tail held stiff, followed by an almost entirely vertical, high-speed descending dive towards a shrub until reaching about 2 m from the ground (Fig. 1A). Towards the bottom of the dive it produces an impulsive and dry mechanical sound, a double '*tec...tec*' or a single '*tec*', which partially overlaps with the onset of a vocalization (song) or is followed by the vocalization; the male then ascends at a high angle (but possibly lower than the diving angle), up to the same height at which the dive began, making a U-turn (180 degrees) in the horizontal plane, flying back horizontally past the starting point of the display, then turning in a U again, to repeat the same display three to four times, with an identical orientation in each event (Fig. 1A). The recording made at Camino de Cornisa shows two display events within 9 s (with a 7 s interval), each with a double '*tec...tec*' (separated by ca. 0.4 s) and overlap of the onset of the song with the first and/or second '*tec*' (Fig. 1B, XC1086374); the male could be seen diving by A. H. Centeno, but the observation did not allow a detailed description of the trajectory. The recording made at Yavi (Fig. 1C, XC1086388) contains only the last sonation event, consisting of a '*tec*' followed by song, from a series of four display events in which the first three events contained the double '*tec...tec*' followed by song. Each '*tec*' lasts approximately 1 ms, as measured on its oscillogram in Raven Pro 1.5 (Bioacoustics Research Program 2017). The songs accompanying the display are similar to those given while perched: a fast, screechy succession of explosive events with an electric-sounding quality that is somehow reminiscent of an infernal typewriter. It was not possible to compare

perched and display songs of the same individuals to assess whether they differ in syntax or spectral composition.

I presume that the shrubs towards which the displays at Yavi and Chorros de Jurina were repeatedly directed at contained another perched bird (possibly a female), and that the display was directed at this individual (see below). In both cases, isolated shrubs were located near a valley bottom in a xeric mountain habitat. The display observed at Camino de Cornisa occurred on a very steep slope in an area where individuals, mainly males, gather seasonally during some months of the dry season to feed mainly on Azafrán de Cerro (*Cnicothamnus lorentzii*), singing repeatedly from preferred perches and chasing other males that approach the flower patches they defend.

Although the function or role of the pan-shaped aerial display of the Red-tailed Comet is not clear, I hypothesize that it is a courtship display. In the Black-tailed Trainbearer, the apparently homologous display appears to have a courtship function, since it is performed only by males and is sometimes directed at perched females, although the recipient of this display is often unclear (Rico-Guevara et al. 2022). Aggressive vocal interactions at a distance between perched males and aggressive in-flight chases of the Red-tailed Comet are accompanied by a long, repetitive vocalization '*teee-ti-trrrrr-teee-ti-trrrrr-teee-ti-trrrrr-teee-ti-trrrrr-teee-ti-trrrrr*' (the 'somewhat high-pitched warble' or 'victory call' of Contino 1975). However, this aggressive vocalization is not part of the aerial display, which suggests that the latter does not have an aggressive function or role.

The naturalist Francisco Contino (1975, p. 266) appears to be the only one to report the existence of apparent mechanical sounds in the Red-tailed Comet, based on detailed observations of a marked male: 'His territory, covering about twenty square meters, contained one large and two small *Acnistus* shrubs, which he watched over from a nearby tree, where he perched about four meters high. From there he would dive onto hummingbirds that came to feed on his plants. His attacks were accompanied by noises produced with the bill and very fierce wingbeats; he chased intruders over distances of 100 to 200 m and returned to his watch plant, where he uttered a song resembling a somewhat high-pitched warble, which can be interpreted as a victory call, followed by movements of the tail, wings, and plumage in general.' It is difficult to draw correspondences between Contino's observations (omitted by Schulenberg & Jaramillo 2020) and those I report here for the displays.

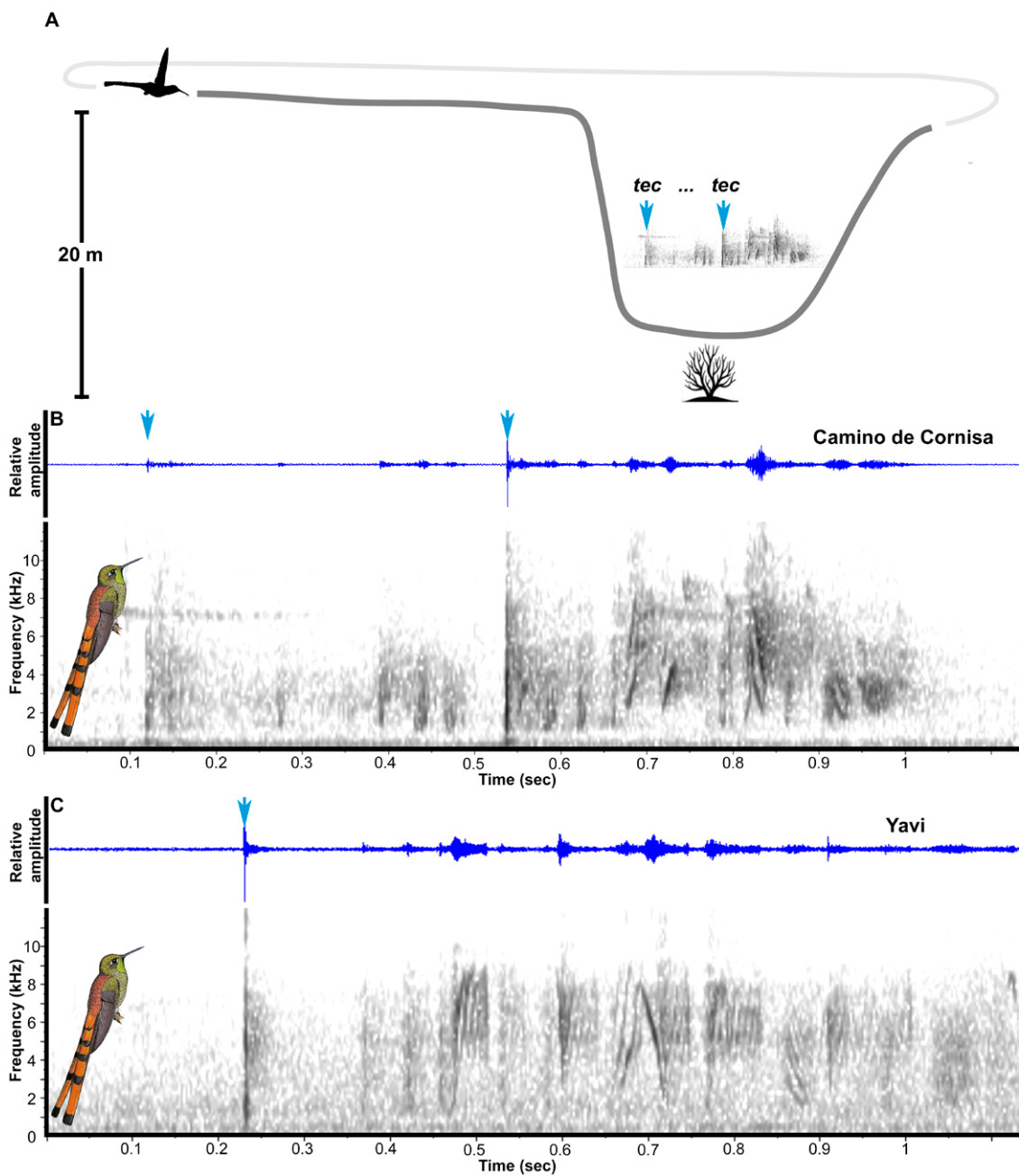


Figure 1. Diagram of the trajectory and of the mechanical (arrows) and vocal sounds produced during the pan-shaped aerial display with dive of the Red-tailed Comet (*Sappho sparganurus*). A) Approximate outbound, diving and return trajectory in each of the displays observed at Yavi (Jujuy, Argentina) and Chorros de Jurina (Tarija, Bolivia), B) Double 'tec...tec' and song during the final phase of the dive (XC1086374; 2 August 2015, Camino de Cornisa, Salta, Argentina, JI Areta), C) Single 'tec' and song during the final phase of the dive (XC1086388; 21 December 2024, Yavi, Jujuy, Argentina, JI Areta). Illustrations courtesy of the Cornell Lab of Ornithology [illustrations by Hilary Burn] (<https://doi.org/10.2173/bow>).

However, I have neither recorded nor heard active chases with mechanical sounds such as those he describes, whereas the vocal and aggressive behavior he describes matches exactly what I have observed numerous times.

The mechanical origin of the ‘tec’ can be inferred for three reasons: 1) the overlap of the ‘tec’ sound with vocal sounds allows us to infer the existence of at least two independent sound sources, 2) the impulsive quality of the sound (abrupt onset and offset, broad bandwidth) is consistent with what is expected for sounds produced by ‘snaps’ or ‘claps’ (Clark 2021, Areta & Clark 2026), and 3) the highly specific, stereotyped context and the exclusive diving behavior during which they are produced suggest that the sound cannot be produced while the bird is perched, unlike song and calls, which can be done both while perched and in flight. Furthermore, the overlap of vocal and mechanical sounds allows us, in this case, to infer that the sound is not produced by a bill snap (collision of mandible and maxilla), which would interfere with normal song production, but rather by some other external structure. The best candidates for producing the ‘tec’ are the wing and tail feathers. Different authors have proposed that the snapping sounds in *Lesbia* are produced with the tail (Hilty & Brown 1986, Schulenberg et al. 2010) or with the wings (Fjeldså & Krabbe 1990). Of these two, the modified wing kinematics during the production of a chain of doublet impulsive sounds in the Black-tailed Trainbearer show a 1:1 correspondence between movements and sounds, thus demonstrating that in this species the sound is produced by the wings and not by the elongated tail (Rico-Guevara et al. 2022). The exact mechanism of sound production in the Black-tailed Trainbearer is unknown, but the brief appearance of a gap between primary feathers during kinematically modified wingbeats suggests that an intrawing feather collision (‘snap’) or the rapid escape of air after being compressed (‘clap’) is involved, whereas the lack of tonality and the broad bandwidth of the sound refute the existence of aeroelastic oscillations (Clark 2021). Based on the spectral and temporal similarities between each note of the doublets of the Black-tailed Trainbearer and the ‘tec’ of the Red-tailed Comet (Fig. 2), I speculate that the latter is produced by an intrawing-mechanism, and not by a wing clap or by the tail. Naturally, the same can be expected for the Green-tailed Trainbearer (Fig. 2). Nevertheless, high-speed videos, preferably synchronized with audio recordings, are needed to elucidate in fine detail the kinematics and physical

mechanisms of mechanical sound production in the clade *Sappho-Lesbia-Ramphomicron*.

Mechanical sounds are often produced by obviously modified feathers (Clark et al. 2018, Jordan & Areta 2020), although this is not always the case (Clark et al. 2016, Clark & Areta 2023). I examined museum specimens of the Red-tailed Comet (five males and five females; Instituto Miguel Lillo, Tucumán) in search of obvious structural modifications in their flight feathers that could be linked to the production of mechanical sounds or that showed sexual dimorphism (given that only males display). As in the Black-tailed Trainbearer (Rico-Guevara et al. 2022), my visual examination found no obvious differences between the sexes, nor any peculiar features of the external anatomy of the wing feathers that could be hypothesized to relate to the production of snapping sounds. It is possible that structural differences in the wing feathers of *Sappho*, *Lesbia* and *Ramphomicron* are subtle, and that thorough examinations, such as those possible through computed tomography and aerodynamic experiments, are required to understand the modifications that allow these wings to produce snapping sounds.

The aerial display in *Sappho* always appears to include one or two well-separated mechanical notes and vocalizations that structurally resemble the perched song. In contrast, the aerial displays in *Lesbia* contain trains of doublets (*L. victoriae*; ML622757827) or trains of notes (*L. nuna*; XC238420) and do not include vocal components (Fig. 2). A single evolutionary origin has been hypothesized for the snapping mechanical sounds in the clade *Sappho-Lesbia-Ramphomicron* (Rico-Guevara et al. 2022), but in *Ramphomicron* the mechanical sounds appear to be produced during a different display. Males of the Purple-backed Thornbill trace shallow side-to-side arcs in front of a female while sometimes producing snapping sounds (Hilty & Brown 1986; I was unable to find recordings of these sounds on Xeno-canto or the Macaulay Library). This display resembles an additional display of the Red-tailed Comet that I witnessed on a single occasion. On 16 September 2016 at 8:38 h at Abra Yacones, Salta, Argentina (24°37’S, 65°29’W, 1665 m a.s.l.), I recorded an adult male Red-tailed Comet singing an unusually long version of the song while hovering in suspended flight in front of another individual, with its body vertical (and perhaps also making lateral movements, although the vegetation prevented a detailed observation). Accompanying this song, a buzzing sound was heard, presumably produced by the wings of the vocalizing individual

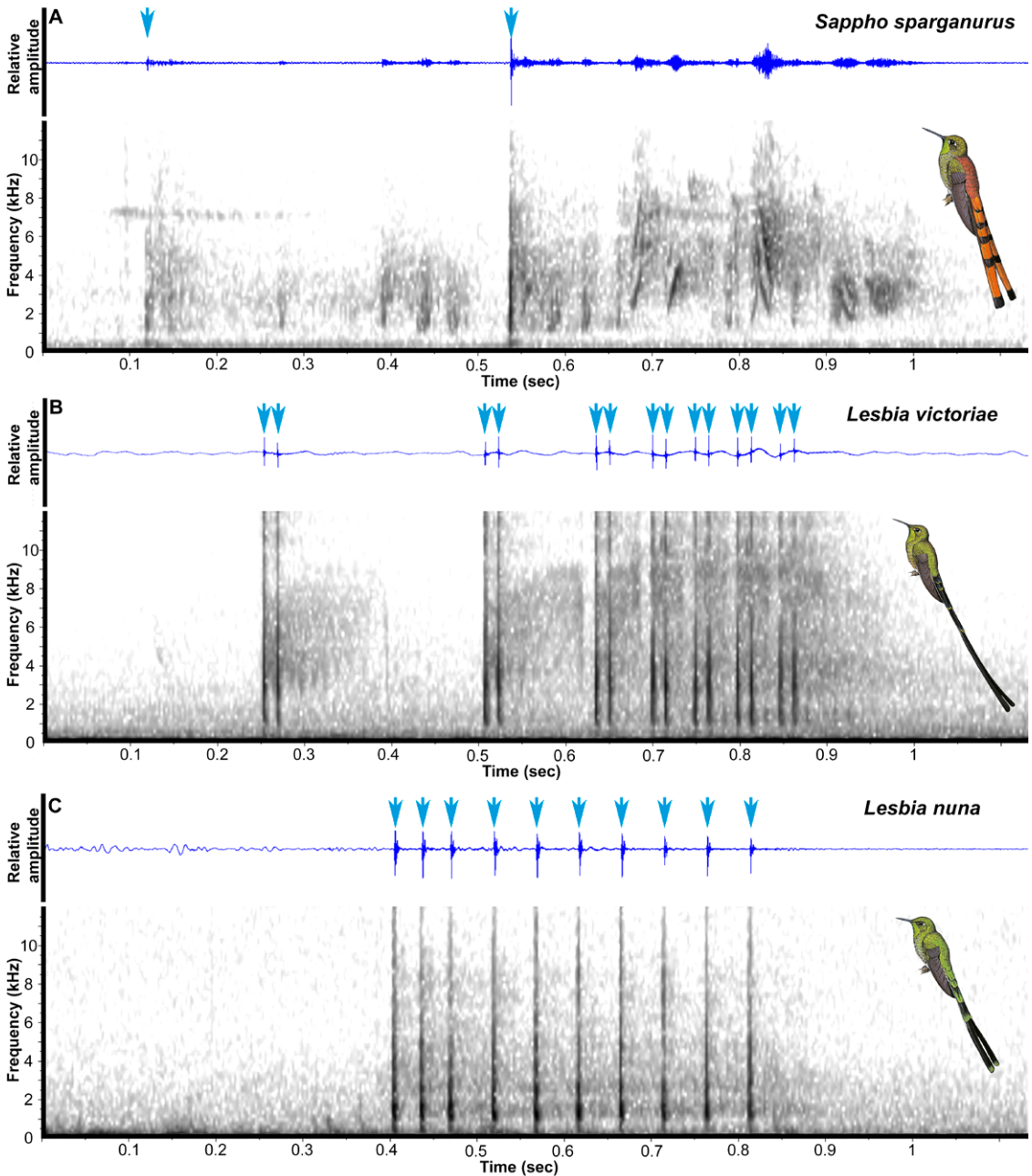


Figure 2. Comparison of the mechanical (arrows) and vocal sounds produced during the pan-shaped aerial displays with dive in *Sappho* and *Lesbia*. A) Red-tailed Comet (*Sappho sparganurus*; XC1086374; 2 August 2015, Camino de Cornisa, Salta, Argentina, JI Areta), B) Black-tailed Trainbearer (*Lesbia victoriae*; ML622757827; 29 March 2016, Observatorio de Colibries, Cundinamarca, Colombia, CJ Clark) and C) Green-tailed Trainbearer (*L. nuna*; XC238420; 8 April 1991, 2 km E Cariamanga, Loja, Ecuador, NK Krabbe). Illustrations courtesy of the Cornell Lab of Ornithology [illustrations by Hilary Burn] (<https://doi.org/10.2173/bow>).

(XC1086382). Afterwards, the perched individual, whose sex I do not know, chased off the vocalizing bird, and the scene was not repeated. The behavior described here for the Red-tailed Comet and that reported for the Purple-backed Thornbill resembles the 'shuttle displays' of other hummingbirds (Stiles 1982, Clark 2009). To understand the evolution of the loss or emergence of vocal and mechanical sounds and their homologies in the displays of *Sappho-Lesbia-Ramphomicron*, it is essential to obtain more information to characterize them and to obtain recordings, currently nonexistent, of the two *Ramphomicron* species.

The Strisores (Caprimulgiformes and Apodiformes) appear to be a particularly rich group that produce mechanical sounds. Snapping mechanical sounds appear to be comparatively common in various contexts within the Caprimulgidae (Coward 1928, Mengel et al. 1972, Eddowes & Lea 2021, Areta & Clark 2026), but rare in the family Trochilidae (Rico-Guevara et al. 2022), where tonal sounds appear to be much more frequent (Clark & Prum 2015, Clark et al. 2018), whereas in the family Apodidae apparently mechanical sounds seem to be more frequently of the snapping type, although 'thundering' sounds (perhaps lower-pitched and non-impulsive) have also been reported (Sick 1959, Collins 1968). The use of snapping sounds both in aggressive contexts and in displays thought to function in sexual attraction indicates that it is not easy to generalize the function of sonations from their spectral features (Clark & Areta 2023, Areta & Clark 2026). We need more detailed observations documenting the natural history of mechanical sounds to understand their acoustic characteristics and the physical mechanisms that produce them, as well as the contexts in which they are used and the functions they serve. Only in this way will we be able to move closer to unraveling the underlying evolutionary processes of these complex behaviors.

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USE OF ARTIFICIAL INTELLIGENCE

I did not use artificial intelligence for anything related to this article.

REFERENCES

- Areta JI, Clark CJ (2026) High-speed infrared video analysis of sonations in the Scissor-tailed Nightjar (*Hydropsalis torquata*). *Journal of Avian Biology* 2026(3):e03631. <https://doi.org/10.1002/jav.03631>
- Bioacoustics Research Program (2017) Raven Pro: Interactive Sound Analysis Software (Version 1.5) [Computer Software]. Ithaca, NY: The Cornell Lab of Ornithology
- Clark CJ (2009) Courtship dives of Anna's hummingbird offer insights into flight performance limits. *Proceedings of the Royal Society B: Biological Sciences* 276(1670):3047-3052. <https://doi.org/10.1098/rspb.2009.0508>
- Clark CJ, Prum RO (2015) Aeroelastic flutter of feathers, flight, and the evolution of non-vocal communication in birds. *Journal of Experimental Biology* 218(21):3520-3527. <https://doi.org/10.1242/jeb.126458>
- Clark CJ, Kirschel ANG, Hadjioannou L, Prum RO (2016) *Smithornis* broadbills produce loud wing song by aeroelastic flutter of medial primary wing feathers. *Journal of Experimental Biology* 219(7):1069-1075. <https://doi.org/10.1242/jeb.131664>
- Clark CJ, McGuire JA, Bonaccorso E, Berv JS, Prum RO (2018) Complex coevolution of wing, tail, and vocal sounds of courting male bee hummingbirds. *Evolution* 72(3):630-646. <https://doi.org/10.1111/evo.13432>
- Clark CJ (2021) Ways that animal wings produce sound. *Integrative and Comparative Biology* 61(2):696-709. <https://doi.org/10.1093/icb/icab008>
- Clark CJ, Areta JI (2023) Adaptive hypotheses on the evolution of non-vocal communication sounds in birds. *Forum Acusticum* 2023 10:4847-4853. <https://doi.org/10.61782/fa.2023.0066>
- Collins CT (1968) The comparative biology of two species of swifts in Trinidad, West Indies. *Bulletin of the Florida State Museum* 11(5):257-320 <https://doi.org/10.58782/flmnh.htio6291>
- Contino F (1975) Observaciones sobre la conducta de *Sappho sparganura* en el cerro de Santa Bárbara, Jujuy, Argentina. *Hornero* 11(4):265-270. <https://doi.org/10.56178/eh.v11i4.1255>
- Coward TA (1928) The 'wing-clapping' of the nightjar. *British Birds* 22(6):134-136
- Eddowes MJ, Lea AJ (2021) A review of 'wing clapping' in European Nightjars. *British Birds* 114(10):629-632

- Fjeldsø J, Krabbe NK (1990) Birds of the High Andes. Zoological Museum, University of Copenhagen and Apollo Books, Copenhagen and Svendborg, Denmark
- Hilty SL, Brown WL (1986) A guide to the birds of Colombia. Princeton University Press, Princeton, NJ
- Jordan EA, Areta JI (2020) Bionic mechanical wing songs and complex kinematics in aerial displays of the Subtropical Doradito (*Pseudocolopteryx acutipennis*). Integrative and Comparative Biology 60(5):1173-1187. <https://doi.org/10.1093/icb/icaa062>
- McGuire JA, Witt CC, Remsen Jr, JV, Corl A, Rabosky DL, Altshuler DL, Dudley R (2014) Molecular phylogenetics and the diversification of hummingbirds. Current Biology 24(8): 910-916. <https://doi.org/10.1016/j.cub.2014.03.016>
- Mengel RM, Sharpe RS, Woolfenden GE (1972) Wing clapping in territorial and courtship behavior of the Chuck-will's-widow and Poor-will (Caprimulgidae). Auk 89(2):440-444. <https://doi.org/10.2307/4084219>
- Rico-Guevara A, Echeverri-Mallarino L, Clark CJ (2022) Oh, snap! A within-wing sonation in black-tailed trainbearers. Journal of Experimental Biology 225(8):jeb243219. <https://doi.org/10.1242/jeb.243219>
- Schulenberg TS, Stotz DF, Lane DF, O'Neill JP, Parker TA III (2007) Birds of Peru. Princeton University Press, Princeton, NJ
- Schulenberg TS, Jaramillo A (2020) Red-tailed Comet (*Sappho sparganurus*), version 1.0. En Schulenberg TS (ed) Birds of the World. Cornell Lab of Ornithology, Ithaca, NY, USA. <https://doi.org/10.2173/bow.retcom1.01>
- Sick H (1959) Notes on the biology of two Brazilian swifts, *Chaetura andrei* and *Chaetura cinereiventris*. Auk 76(4):471-477. <https://doi.org/10.2307/4082314>
- Stiles FG (1982) Aggressive and courtship displays of the male Anna's hummingbird. Condor 84(2):208-225. <https://doi.org/10.2307/1367674>
- Züchner T, Boesman PFD (2020) Black-backed Thornbill (*Ramphomicron dorsale*), version 1.0. En: del Hoyo J, Elliott A, Sargatal J, Christie DA, de Juana E (eds) Birds of the World. Cornell Lab of Ornithology, Ithaca, NY, USA. <https://doi.org/10.2173/bow.blbtho1.01>