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Photo: Hein van Grouw, Natural History Museum (Tring)

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Last search for the Jamaican Golden Swallow (*Tachycineta e. euchrysea*)

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Abstract The Golden Swallow (*Tachycineta euchrysea*) is an aerial insectivore and obligate secondary cavity nester endemic to the Caribbean islands of Jamaica and Hispaniola. The declining Hispaniolan subspecies (*T. e. sclateri*) is estimated at 1,500–7,000 individuals and the population is categorized as Vulnerable by the International Union for Conservation of Nature. The nominate race on Jamaica (*T. e. euchrysea*) has not been unequivocally observed since the early 1980s. We conducted surveys for the critically endangered Jamaican Golden Swallow in Cockpit Country and the Blue Mountains to complement extensive surveys carried out by Graves (2014). Between January and March 2015 (52 field days), we performed 635 standardized point counts and surveyed more than 480 km of trail in remote landscape. The presence and identification of all diurnal aerial insectivores were determined at each designated census site. No Golden Swallows were observed. Despite the infinitesimal probability that a relict population persists undetected, there is strong evidence that the Jamaican Golden Swallow is extinct.

Keywords aerial insectivores, Blue Mountains, Cockpit Country, extinction, Golden Swallow, Jamaica, *Tachycineta euchrysea*

Resumen Búsqueda final de la Golondrina Verde de Jamaica (*Tachycineta e. euchrysea*)—La Golondrina Verde (*Tachycineta euchrysea*) es un insectívoro aéreo que anida obligadamente en cavidades secundarias y es endémico a las islas Caribeñas de Jamaica y La Española. La población de la subespecie de La Española (*T. e. sclateri*) se estima en unos 1.500–7.000 individuos, está considerada en declive y ha sido catalogada como Vulnerable por la Unión Internacional para la Conservación de la Naturaleza. La raza nominal de Jamaica (*T. e. euchrysea*) no ha sido inequívocamente observada desde comienzos de 1980. Realizamos observaciones de búsqueda de la críticamente amenazada Golondrina Verde de Jamaica en Cockpit Country y Blue Mountains para complementar la búsqueda extensiva realizada por Graves (2014). Entre los meses de enero y marzo de 2015 (52 días de campo), realizamos 635 observaciones estandarizadas de conteo por puntos y muestreamos más de 480 km de senderos en áreas remotas. Identificamos y determinamos la presencia de todos los insectívoros aéreos en cada sitio designado para censo. No se observaron Golondrinas Verdes. A pesar de la infinitésima posibilidad de que persista una población relictica que no ha sido detectada, existen fuertes evidencias de que la Golondrina Verde de Jamaica está extinta.

Palabras clave Blue Mountains, Cockpit Country, extinción, Golondrina Verde, insectívoros aéreos, Jamaica, *Tachycineta euchrysea*

Résumé Dernière recherche pour l'Hirondelle dorée Jamaïcaine (*Tachycineta e. euchrysea*)—L'Hirondelle dorée (*Tachycineta euchrysea*) est un insectivore aérien et diurne. Elle est obligée de se nicher en cavités secondaires et est endémique aux îles Caraïbes d'Hispaniola et la Jamaïque. La sous-espèce d'Hispaniola (*T. e. sclateri*) comprend entre 1.500 et 7.000 individus. Cette population est en déclin et est classée comme Vulnérable selon l'Union internationale pour la conservation de la nature. La race nominale en Jamaïque (*T. e. euchrysea*) n'a pas été observée de façon claire depuis le début des années 1980. Dans le but de compléter des enquêtes approfondies menées par Graves (2014), nous avons mené des enquêtes concernant l'Hirondelle dorée, qui est en danger critique d'extinction, dans le Cockpit Country et les Blue Mountains. Entre janvier et mars 2015 (soit 52 jours sur le terrain), nous avons réalisé 635 points d'écoute standardisés et sondé plus de 480 km de sentiers dans le paysage isolé. La présence et l'identification de tous les insectivores aériens diurnes ont été déterminées sur chaque site de recensement désigné. Aucune Hirondelle dorée n'a été observée. Malgré la probabilité infime qu'une population relique persiste à être inaperçue, il y a des fortes raisons de croire que l'Hirondelle dorée Jamaïcaine soit éteinte.

Mots clés Blue Mountains, Cockpit Country, extinction, Hirondelle dorée, insectivores aériens, Jamaïque, *Tachycineta euchrysea*

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Although considerably smaller than Cuba (109,884 km²) to the north and Hispaniola (76,192 km²) to the east, the island of Jamaica at 10,982 km² hosts 30 endemic bird species—the highest

number for any West Indian island—and 307 bird species overall, including breeders, migrants, vagrants, etc. (Haynes-Sutton et al. 2009). In total, the island boasts 16 breeding species of aerial insectivores represented by five families: nightjars (Caprimulgidae), potoos (Nyctibiidae), swifts (Apodidae), flycatchers (Tyrannidae), and swallows (Hirundinidae) (Haynes-Sutton et al. 2009). Jamaica's swifts and swallows are collectively called "rainbirds" in rural Jamaica as they are frequently observed foraging in mixed flocks after rain showers and at storm fronts. Even though they belong to the same broad dietary guild, flycatchers, and nocturnal potoos and nightjars are often assessed separately because of their distinct foraging styles and nocturnal activity, respectively. The most commonly observed Jamaican aerial insectivore species include the Antillean Nighthawk (*Chordeiles gundlachii*; summer breeder), Black Swift (*Cypseloides niger*; resident), White-collared Swift (*Streptoprocne zonaris*; resident), Antillean Palm-Swift (*Tachornis phoenicobia*; resident), Caribbean Martin (*Progne dominicensis*; summer breeder), Tree Swallow (*Tachycineta bicolor*; migrant), Northern Rough-winged Swallow (*Stelgidopteryx serripennis*; migrant), Cave Swallow (*Petrochelidon fulva*; resident), and Barn Swallow (*Hirundo rustica*; migrant).

The Jamaican Golden Swallow (*Tachycineta euchrysea euchrysea*), known only from Jamaica since its description by the naturalist Philip Henry Gosse (Gosse 1847), was once a species of "rainbird" foraging among the others. Although always considered uncommon and locally distributed (Graves 2014), the Jamaican Golden Swallow showed noticeable signs of decline by the mid-20th century (Kidd 1964, 1965, Downer and Sutton 1972, Lack 1976) and disappeared altogether by the mid-1980s (Downer 1982, Graves 2014). What would become the last unequivocal sighting occurred on 11 September 1982, prompting a concerned communication by the local ornithologist Audrey Downer (Downer 1982:13):

Is The Golden Swallow Declining?: In 1858 Osburn wrote to Gosse...describing Golden Swallows as appearing

"in great numbers" over the canefields of Trelawny. Several years ago when Robert Sutton and I saw them at Ram Goat Cave there were only 5 or 6 seen at a time. No report has recently been recorded in the Broadsheet, but some visitors to the island in August this year [1982] reported seeing them on the Barbeque Bottom Road. In order to verify this report, a group of us headed by Robert Sutton went along this same road in the Cockpit Country on Sept. 11th. 1982. After stopping at Ram Goat Cave and Barbeque Bottom where we heard swallows but saw only Cave [Swallows] and [Antillean] Palm Swifts we stopped between the 15th and 14th mile-post at a spot overlooking the ruins of Stonehenge. Immediately below us was a grassy area with canefields in the distance. This looked like the spot described by the visitors, and sure enough Robert soon spotted a Golden Swallow circling with Cave Swallows. . . . The visitors reported seeing 7 Golden Swallows, and we saw between 6 and 9 at a time. This is a far cry from the numbers reported by Osburn. Are they declining or are they more numerous after a rainy spell?

The Hispaniolan Golden Swallow (*T. euchrysea sclateri*; Fig. 1) was described by the American ornithologist Charles B. Cory (1886), and though considered common in the early 20th century, it too has become increasingly rare and is thought to be restricted to the highlands of Haiti and the Dominican Republic (Keith et al. 2003, Rimmer et al. 2003, 2005, 2010, Latta et al. 2006, Townsend et al. 2008). In 2000, the population was estimated at 1,500–7,000 individuals, although data quality was admitted to be poor (BirdLife International 2012). The population is categorized as Vulnerable by the International Union for Conservation of Nature (BirdLife International 2017).

Graves (2014) conducted island-wide surveys for the Jamaican Golden Swallow from 1994 to 2012. Though his extensive search efforts did not produce a positive sighting, two large tracts of land remained to be fully explored, including the interior of



Fig. 1. Hispaniolan Golden Swallows in Parque Valle Nuevo, Dominican Republic. Left to right: adult in flight; adult perched on artificial nest-box; and nestlings 25 days after hatching—1 day prior to fledging (Proctor et al. in press). The Jamaican Golden Swallow would be difficult to distinguish from the Hispaniolan Golden Swallow under normal field conditions, although the white collar may not have extended as far around the lower nape. Golden Swallows can be distinguished at a distance from other *Tachycineta* swallows by the presence of an almost complete white collar, green luster especially noticeable on the head and upper mantle, and comparably smaller size and less robust build. Photographs by C. Justin Proctor.

Cockpit Country in western Jamaica and some remote valleys in the Blue Mountains to the east. Here we discuss the results of additional searches for the swallow in these areas. We also present observations of other aerial insectivores observed during the searches, and recommend that the status of the Jamaican Golden Swallow be changed to extinct based on sufficient historical and contemporary evidence suggesting its extirpation from the island.

Methods

CJP, SEI, and JMZ conducted surveys of swallows and swifts in Cockpit Country (St. Ann, St. Elizabeth, St. James, Trelawny, and Manchester Parishes) from 16 January to 12 February 2015 (28 field days). A second set of surveys was conducted in the Port Royal Mountains, Blue Mountains, and John Crow Mountains (St. Andrew, Portland, and St. Thomas Parishes in eastern Jamaica) from 4 to 23 March 2015 (20 field days) and in Cockpit Country (Trelawny Parish) from 24 to 27 March 2015 (4 field days). We refer to the eastern surveys as “Blue Mountain” censuses in the remainder of the paper. Census sites were selected based on several, often overlapping, criteria including (1) areas where the species had occurred in the past, (2) remote, difficult-to-access terrain as well as large parcels of private property—both of which are greatly under-surveyed, if ever surveyed, by bird watchers or ornithologists, (3) habitat that closely resembled that which is currently used by the Hispaniolan Golden Swallow, and (4) regions not previously surveyed by Graves (2014), as well as those deemed worthy of repeat surveying.

We selected census sites that offered the maximum available field of view within a local area. Nearest-neighbor distance between sites generally exceeded 300 m, but a few census sites were as close together as 100 m because they offered significantly different vistas (e.g., on opposite sides of a knife-like ridge). Additionally, if aerial insectivores were spotted at any time, a census was promptly carried out at that location. For each census, observers positioned themselves to best complete a 360° scan of the area while simultaneously listening for vocal-

izations. Field of view was dependent on topography as well as on canopy cover and tree height. The duration of point counts was 5 min. If aerial insectivores were observed, we remained on site until the birds were identified and counted or until they disappeared. Extended behavioral observations of aerial insectivores were made at nightly campsites in remote areas. The team used a handheld Garmin Oregon® 650 (Garmin Ltd., Olathe, KS, USA) with high-sensitivity GPS and GLONASS satellite tracking to navigate in remote settings, as well as to accurately record census count locations.

Historical records of Jamaican Golden Swallows and contemporary observations of the Hispaniolan Golden Swallow confirm that both commonly intermix with other aerial insectivores when foraging (reviewed in Graves 2014; CJP pers. obs.). These mixed flocks forage from ground level to well over 100 m above ground level, and are often composed of fast-moving congregations of swallows and swifts. This scenario can present an identification challenge. In response, aerial insectivore surveys carried out by Graves (2014) and our team focused on closely analyzing these mixed flocks to reduce the likelihood of overlooking Golden Swallows.

Statistical Analyses

We examined the co-occurrence patterns among aerial insectivores observed during census counts using a C-score (checkerboard score), a statistic in biodiversity studies that determines the incidence of distribution overlap between two or more species across a survey area (Stone and Roberts 1990). The quantitative index is defined as $(R_i - S) \times (R_j - S)$ where R_i and R_j represent the total number of occurrences of species i and j , respectively, and S is the number of shared occurrences. The higher the C-score generated by two species, the more segregated they were, and thus the less likely they were to co-occur at a census site. Since aerial insectivores frequently move across the landscape to forage, we predicted equiprobable detections across sites. Instead of the standard fixed-fixed model, we utilized a fixed-equiprobable model that is more appropriate for

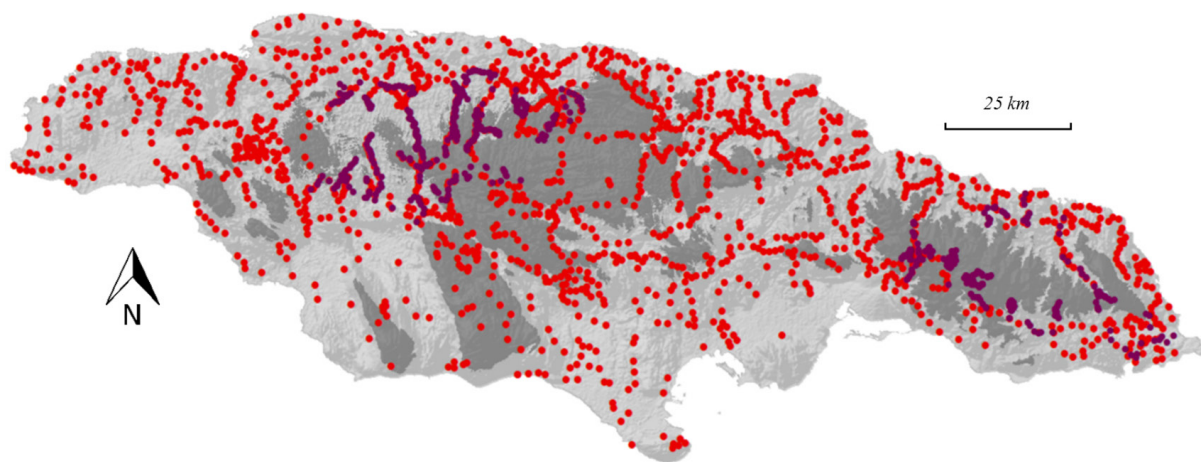


Fig. 2. Standardized census sites for Golden Swallows in Jamaica ($N = 2,067$). Red circles indicate 1,281 sites where censuses were conducted by Graves (2014) and 151 sites where unpublished censuses were compiled by Graves in December 2013. Dark purple circles indicate census sites ($n = 635$) reported in the present study. Collectively, informal surveys and standardized censuses were conducted from 1994 to 2015. Map shading depicts topography, with colors darkening as elevation increases.



Fig. 3. Barbecue Bottom, Trelawny Parish, in eastern Cockpit Country, site of the last known observation of the Jamaican Golden Swallow. Photograph by C. Justin Proctor.

matrices with few species and equiprobable sites (Gotelli 2000). We performed the statistical analysis using the software R (version 3.0.1; R Core Team 2013) and the package EcoSimR (Gotelli and Ellison 2013).

Results

Over the course of 52 field days, CJP, SEI, and JMZ completed 635 standardized point counts while surveying more than 480 km of trail across Cockpit Country and the Blue Mountains (Fig. 2). In Cockpit Country, we conducted censuses at 386 sites ranging from 84 m to 978 m above sea level: (i) 0–300 m (*n* = 115 sites); (ii) 301–600 m (*n* = 225 sites); and (iii) > 600 m (*n* = 46 sites). We conducted 249 censuses in the Blue Mountains at sites ranging from 10 m to 2,251 m above sea level: (i) 0–700 m (*n* = 117 sites); (ii) 701–1,400 m (*n* = 87 sites); and (iii) > 1,400 m (*n* = 45 sites). A disproportionate number of census points were located in the last known strongholds for the Jamaican Golden Swallow, particularly Barbecue Bottom, Trelawny Parish, and Cinchona, St. Andrew Parish (Figs. 2 and 3). Three species of diurnal aerial insectivores were observed during censuses: the White-collared Swift, Antillean Palm-Swift,

and Cave Swallow. Barn Swallows were observed on two occasions (two individuals flying over the beach at Eight Mile, Bull Bay, St. Andrew Parish, on 9 March 2015, and two individuals foraging with Cave Swallows over the rocky shoreline northeast of Rio Bueno, Trelawny Parish, on 29 March 2015), but were not recorded on any of the standardized censuses. One tightly packed, fast-moving flock of swifts seen in the vicinity of Hardwar Gap, Portland Parish, on 13 March 2015 likely consisted of Black Swifts although a positive identification could not be made. No Golden Swallows or other species of *Tachycineta* swallow were observed. Aerial insectivores were observed at 71 sites (18% of regional total) in Cockpit Country and at 45 sites (18% of regional total) in the Blue Mountains (Table 1). The Cave Swallow was the most common and widespread aerial insectivore in the Cockpit Country region, recorded at 50 census sites (13% of regional total). In contrast, the White-collared Swift was the most common aerial insectivore in the Blue Mountains, with records at 37 census sites (15% of regional total). Aerial insectivores co-occurred less frequently than expected by chance (observed C-score = 1,876.3; mean and standard deviation of simulated C-scores = 1,302.6

Table 1. Aerial insectivores observed in the Cockpit Country region (16 January–12 February 2015 and 24–27 March 2015) and the Blue Mountain region (4–23 March 2015) of Jamaica.

Species	Cockpit Country (<i>n</i> = 386 Sites)		Blue Mountains (<i>n</i> = 249 Sites)	
	Number of Census Sites Observed	Number Observed per Occupied Site; Range ($\bar{x} \pm SD$)	Number of Census Sites Observed	Number Observed per Occupied Site; Range ($\bar{x} \pm SD$)
White-collared Swift	21	1–100 (19.9 \pm 30.6)	37	1–471 (28.7 \pm 76.4)
Antillean Palm-Swift	42	1–85 (7.5 \pm 16.3)	14	1–7 (2.6 \pm 1.9)
Cave Swallow	50	1–90 (13.5 \pm 17.4)	12	1–55 (21.4 \pm 17.8)

Table 2. Summary of observed and simulated C-scores in pairwise comparisons of aerial insectivores. WCSW = White-collared Swift, APSW = Antillean Palm-Swift, and CASW = Cave Swallow. *P*-values < 0.05 are considered statistically significant.

	Observed C-score	Simulated C-score; $\bar{x} \pm SD$	<i>P</i> -value
<i>Cockpit Country</i>			
WCSW & APSW	540	365.6 \pm 88.4	0.011
WCSW & CASW	492	372.4 \pm 99.5	0.083
APSW & CASW	713	516.2 \pm 106.6	0.018
<i>Blue Mountains</i>			
WCSW & APSW	330	158.2 \pm 52.1	< 0.0001
WCSW & CASW	264	145.2 \pm 56.1	0.015
APSW & CASW	63	105.7 \pm 27.6	0.901

± 117.0 ; $p = 0.001$; Table 2). Patterns of few co-occurrences in the Cockpit Country region were driven by significantly few pairwise co-occurrences of White-collared Swifts and Antillean Palm-Swifts ($p = 0.011$) and Antillean Palm-Swifts and Cave Swallows ($p = 0.018$). In the Blue Mountains, patterns of few co-occurrences of White-collared Swifts with Antillean Palm-Swifts ($p < 0.0001$) and again with Cave Swallows ($p = 0.015$) were statistically significant.

Discussion

The Golden Swallow is not a cryptic species. Their diurnal acrobatic foraging behavior and commonly exhibited curiosity towards humans make them an easily detectable search target (Proctor et al. in press). More than 30 yr have passed since the last confirmed sighting of the Jamaican Golden Swallow. There have been no documented sightings from local birdwatchers or the hundreds of international observers who have visited the traditional locations that were the strongholds of the species from the 1850s through the 1950s. Additionally, there is no evidence that the swallow has ever migrated off Jamaica (Graves 2014), so we do not anticipate that this subspecies persists elsewhere in the Caribbean or on the continental mainland.

Focused search efforts for the Jamaican Golden Swallow collectively span two decades. In particular, areas historically supporting populations of the swallow in the period from the mid-1950s to 1982 (i.e., Windsor and Barbecue Bottom Road, Trelawny Parish) have been subjected to hundreds of observer hours in recent years with negative results. Despite the infinitesimal probability that a relict population continues to persist undetected in some remote highland glade, there is no logical foundation for optimism. We recommend a change of conservation status of the Jamaican Golden Swallow (*Tachycineta e. euchrysea*) to extinct.

In a broader context, the potential causes of extinction of the Jamaican Golden Swallow need to be fleshed out, and those risks should be considered in conservation management plans for the declining Hispaniolan Golden Swallow. These risk factors will be addressed in a future paper. Whether or not the Jamaican Golden Swallow was ever numerous or widespread, its extinction is a significant event in terms of Jamaica's biodiversity loss.

In the blunt yet ultimately hopeful words of Lack (1976:30–31), effective conservation efforts are essential in keeping Jamaica's avifauna abundant and diverse:

How long the native birds of Jamaica will survive is doubtful, though as yet only two species of land birds, a macaw and a nightjar have become extinct, and two others, a pigeon and a swallow, are rare. The record is, however, far better than that for nearly all other islands in the world, and could be maintained, since conservation could save the remaining species by keeping parts of the three main forests intact.

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