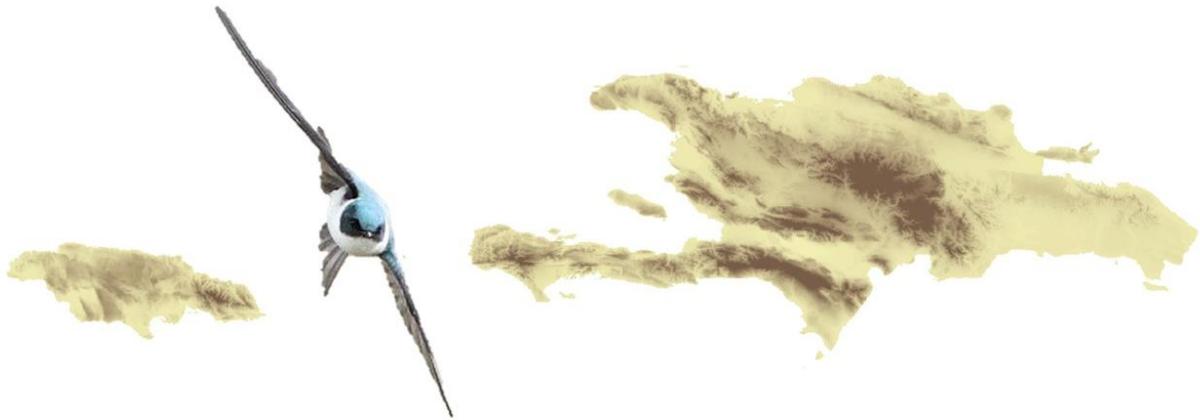


DISCOVERING GOLD IN THE GREATER ANTILLES –  
THE NATURAL HISTORY AND BREEDING BIOLOGY  
OF THE HISPANIOLAN GOLDEN SWALLOW,  
FOLLOWED BY  
THE STATUS OF THE CRITICALLY ENDANGERED JAMAICAN GOLDEN SWALLOW



Thesis Presented to the Faculty of the Cornell University Graduate School  
In Partial Fulfillment of the Requirements for the Degree of Master of Science

by

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## **ABSTRACT**

This thesis is divided into two parts that collectively tell the contemporary stories of both Golden Swallow subspecies known to the Greater Antilles islands of Hispaniola and Jamaica. Part I constitutes the first in-depth look at the natural history and breeding biology of the Hispaniolan Golden Swallow derived from a three year study of a breeding population in the high-altitude pine forests of the Dominican Republic's Cordillera Central. The results and their respective discussions are extensive, and have therefore been organized in a more or less chronological format that adheres to particular stages of the breeding season. Some themes that have yet to be fully explored have also been included in order to highlight important gaps in our knowledge of the species. The idea behind this is simple – to inform the scientific community and public of what we know and what we still do not, the latter being just as important as the former, since this project was always designed to act as both a catalyst and a transparent, educational framework for future avian investigation in the Dominican Republic. Part II of the thesis declares the Jamaican subspecies of Golden Swallow extinct. This work concludes the long-term search (following Graves 2014) for the swallow, and should be received by conservationists and ornithologists in the Dominican Republic as a warning of how quickly an endemic species can be lost forever. Moreover, the extinction should be treated as motivation for improving local stewardship and scientific knowledge surrounding Hispaniola's avian species.

## BIOGRAPHICAL SKETCH

While the Voyager 2 was making its first fly-by of Uranus and Jack Nicholson was celebrating his freshly won Golden Globe Award for his lead role in Prizzi's Honor, a small – but not inconsequential – miracle took place in the sleepy little farm town of Springville, New York. Christopher Justin Proctor (hereafter referred to as Justin) was born to his loving mother, Sharon L. Proctor, and father, W. Christopher Proctor. Not knowing at the time that he was named after Alan A. Milne's adorable Winnie-the-Pooh character, Christopher Robin, Justin reduced his first name to the letter "C" (not formally, of course, that would have involved paperwork and money) so as to make sure he was not confused for his father, whom we would also come to find out did exactly the same thing a half century earlier.

Justin grew up slowly, as all kids removed from the trials and tribulations of life should do. He collected, repaired, and organized peacock feathers to pass the time in his younger days, and was thought to be the closest thing to an angel that heaven could have afforded to lend to the world. Fast-forward about 12 years and change that image to one of burning cars, broken hearts, and petty larceny (mostly undocumented = never happened). Yes, the teenage years were governed by testosterone, and testosterone alone, yet that corner would eventually be rounded and what emerged was something rare – an immaculate blend of both common sense and intelligence.

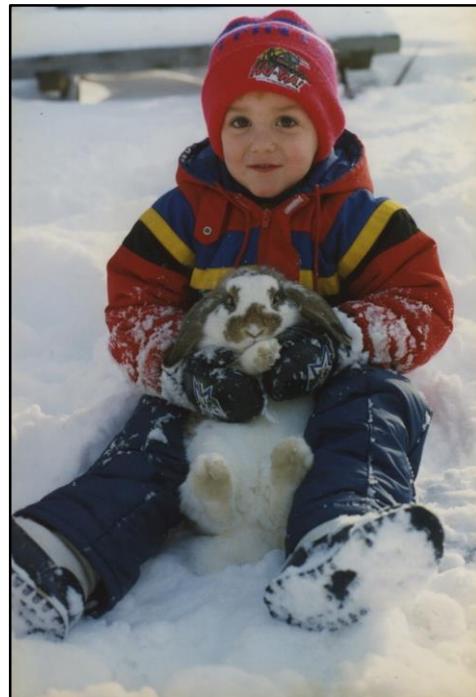
Incredibly happy to have survived to adulthood (despite the 30-1 odds his brother was betting against it), Justin was energized with an urge to explore and conquer. His love of nature guided him to the coast of Maine, where he studied marine biology under the direction and iron fist of his mentor Dr. Brian Beal at the University of Maine at Machias. After graduating summa cum laude in 2008, Justin wandered down the coast to the University of Maine's Darling Marine Center, where he worked as a technician for the infamous water skier and ecologist, Dr. Richard Wahle. Had winters not been so damn cold and dark, Justin probably would have never left the Maine shores, and so the tropical waters began to call to him. The subsequent years he spent in St. Martin and Costa Rica working with adventure diving programs

were something straight out of a dream, and so began Justin's long-term love of Latin America (as well as the women he found residing there).

An impromptu internship was offered to Justin in 2010 by Cornell University that involved a less wet approach to biology via an ornithological study on swallows (not sparrows!). The next five years and four months offered by far the most challenging yet rewarding adventures he could have never imagined. From the Canadian Rockies to the depths of Patagonia, Justin grew ever more fascinated with new cultures, new languages, as well as the biological relationships that transcended from one place to the next. Along the way, he met and courted his current (and hopefully only) wife, Marisol, four-time Miss Universe winner from the north of Argentina. If the thought of having children ever comes to fruition (their current residence in a 2004 Pontiac Vibe makes the possibility seem distant), be forewarned that little Jack and Jill Proctor-Mata will be nothing short of Gods amongst men.

Under the spirited leadership of Cornell's Dr. David Winkler, Justin went on to execute what he considers to have been a very fruitful three-year campaign in the Dominican Republic studying the Golden Swallow. And that, my friends, is where this omnipotent third-person voice leaves you, and the ~70 page story you are about to read begins.

Justin and Bun-bun;  
ages 3 and 2, respectively



**DEDICATED TO:**

Grandma Syl, who taught us all how to love the world around us...

to Pops, the leader of my support team...

to little Max, who will change the world in so many ways...

and to the rest of my beautiful family.



## ACKNOWLEDGMENTS

I've got a laundry-list worth of people and groups to thank for helping make this thesis come true. That's a good thing. Thankfully, I've already done a damn good job of making sure that I have included 99% of them in the acknowledgment sections of each of the two collated papers that compose this thesis. So instead, let me use this space to give a few special shout-outs that are more than well-deserved.

First and foremost, to Marisol Mata, who started as my girlfriend at the beginning of all this work, and finished as my wife. According to the US Citizenship and Immigration Services, as well as the four affidavits I signed in order to please them, we are – and always will be (as long as we reside in the USA) – a blessed and happy couple with no underlying financial or emotional hardships. Yes....that sounds....just about right.

Next up comes my brother, Duncan. Remembering back twenty years ago, as he pummeled me mercilessly when our parents weren't watching, I never thought our relationship would go beyond the classic “older brother-younger brother” dynamic. Yet here we are, now both in the prime of our lives, a team that cannot be broken by any hardships, and one made even stronger as the world continues to throw everything it has at us. Dunc – thanks for keeping a watchful eye on your little brudder all this time.

Of course, there is a lot more family scattered out there that has had a helping hand in my achievements over the years. It was Dad who routinely visited me throughout my college years and sternly reminded me to “make good choices”, while Mom on the other hand continually reminded me how nice it was to take extended vacations to Sanibel Island each year. Meanwhile, Aunt Sisi and Uncle Jim always kept the lights (and hot tub) on at Hotel Anzalone for all those times that I needed a home, not just a house, to keep me feeling grounded. Uncle Randy and John always brought humor to the occasion, and taught me to never underestimate a good meal. My grandma Dottie was thoughtful – she always knew that a cold mug of loganberry and frequent notes in the mail would make my day. There are others – the Anzalones, Brzykcys, Bungos, Lijewskis, Kaczanowskis, Bartkowskis, y mi familia Argentina – that have always had encouraging things to say to me. Thank you.

On the Dominican Republic end, I want to thank the Guzman family for extending a hand and opening their doors to my wife and me when we first arrived to the Dominican Republic. I hope they recognize that their selfless act of kindness is the reason that this has all been able to come to fruition.

And last, but certainly not least, my full gratitude goes out to Wink. I never thought myself to be Cornell material, yet Wink never stopped reminding me that I was. You haven't seen the end of me, Wink... I promise. Thank you for everything, and I mean that.

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THE NATURAL HISTORY AND BREEDING BIOLOGY OF THE HISPANIOLAN GOLDEN  
SWALLOW (*TACHYGINETA EUCHRYSEA SCLATERI*)

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*Abstract:* The Hispaniolan Golden Swallow (*Tachycineta euchrysea sclateri*) is a diurnal aerial insectivore and obligate secondary cavity-nester almost entirely restricted to patches of pine forest found at higher elevations across the island of Hispaniola's major mountain chains. Here we provide the results from a three-year nest-box study of the swallow from one of the species' principal nesting grounds in the Dominican Republic's Cordillera Central. We present the first comprehensive and detailed look at the swallow's natural history and breeding biology, and format our results to facilitate comparisons with congeners already present in the literature. In an effort to inspire additional – and much-needed – research on the Hispaniolan Golden Swallow, we have also highlighted ecological and biological topics on which our knowledge is still incomplete. Furthermore, we hope that our improved understanding of the swallow can be inform the development of conservation strategies surrounding one of Hispaniola's most beautiful endemic birds.

*Key words:* aerial insectivores, Dominican Republic, Golden Swallow, Hispaniola, natural history, nest-box, *Tachycineta*

*Resumen.* — La Golondrina Verde de La Española (*Tachycineta euchrysea sclateri*) es un ave insectívora aérea diurna que anida obligadamente en cavidades secundarias. Esta especie está restringida casi enteramente a fragmentos de bosque de pino que se encuentran en elevaciones altas a lo largo de las cadenas montañosas de la isla de La Española. En este estudio se presentan los resultados de una investigación de tres años realizada utilizando cajas-nido en uno de los principales sitios de anidación de la especie, ubicado en la Cordillera Central de la República Dominicana. Se presenta la primera observación exhaustiva a la historia natural y la biología reproductiva de la Golondrina Verde, incluyendo los resultados en un formato que permitirá facilitar comparaciones con los congéneres ya representados en la literatura. También se incluye información acerca de aspectos ecológicos y biológicos en los que el conocimiento es incompleto, con la intención de inspirar estudios adicionales – y muy necesarios– de esta especie. Además, se espera que una mayor comprensión de la Golondrina Verde pueda resultar informativa y aplicable al desarrollo de estrategias de conservación para una de las especies endémicas más hermosas de La Española.

*Palabras clave:* caja-nido, Golondrina Verde, Hispaniola, historia de vida, insectívoros aéreos, República Dominicana, *Tachycineta*

*Résumé:* L'Hirondelle Verte (*Tachycineta euchrysea euchrysea*) est un insectivore aérien et diurne qui est obligée de se nicher en cavités secondaires et elle est presque complètement limitée à des parcelles de forêt de pins qui se trouvent à des altitudes élevées dans les principales chaînes de montagne d'Hispaniola. Ici, nous fournissons les résultats d'une étude nichoir sur les hirondelles dans un des sites de nidification dominant de la cordillère centrale en République dominicaine. Nous présentons la première recherche approfondie sur l'histoire naturelle et biologie reproductive de l'Hirondelle dorée, et nous arrangeons nos résultats pour faciliter les comparaisons avec les congénères déjà présents dans la

littérature. Afin d'inspirer des analyses additionnelles – et bien nécessaires – sur l'Hirondelle dorée, nous avons également mentionné des sujets sur lesquels notre connaissance est encore incomplète. En outre, nous espérons que notre entendement amélioré de l'hirondelle peut être informatif et utile dans le développement de stratégies de conservation concernant l'un des plus beaux oiseaux endémiques d'Hispaniola.

*Mots-clé:* Hirondelle dorée, Hispaniola, histoire naturelle, insectivores aériens, nichoir, République dominicaine, *Tachycineta*

## INTRODUCTION

Over the last three decades, aerial insectivores have experienced population declines throughout North America (Nebel et al. 2010). Specifically, in many families of flycatchers, swifts, swallows, and nightjars, ornithologists are noticing a dramatic downward trend in the sizes of well-studied populations. There are many theories concerning the widespread decline across this guild of birds, with the strongest evidence pointing toward changes happening at the ecosystem level. Some hypotheses include: the reduction of adequate nesting structures such as barns and open chimneys (McCracken 2013), a decrease in the quantity of preferable foraging habitat (Evans et al. 2007, Gruebler et al. 2010), lower availability of calcium necessary for egg and bone development as a result of acid rain (McCracken 2013), and changes in food availability in the form of flying insects (Nebel et al. 2010, Robillard et al. 2012, Pomfret et al. 2014). As one might suspect, the informal consensus for explaining the aerial insectivore decline tends toward an amalgam of these elements.

Aerial insectivore species in the Greater Antilles of the Caribbean are almost completely absent from the scientific literature. The paucity of work being conducted on this guild makes broad-scale and comparative population assessments almost impossible. In fact, even basic natural history for many of the aerial insectivores is incomplete, and even more surprising, roosting and nesting localities for many

common, resident species have yet to be found. Here we present a comprehensive look at both the natural history and breeding biology of a threatened aerial insectivore endemic to the island of Hispaniola, the Hispaniolan Golden Swallow (*Tachycineta euchrysea sclateri*), with intentions of laying down a foundation of knowledge that can be used to inform conservation efforts and help us better understand if and how the species may fit into the larger story of aerial insectivore decline.

Two subspecies of Golden Swallow have been described. The nominate subspecies (*T. e. euchrysea*) was first recorded by Philip H. Gosse in 1847 and was always considered endemic to the island of Jamaica (Gosse 1847, Ridgway 1904, Graves 2014). This subspecies declined significantly throughout the 20th century (King 1981, Downer 1982) and is now believed to be extinct (Raffaele et al. 1998, Haynes-Sutton et al. 2009, Graves 2014, Proctor et al. in review; This Thesis Chapter 2.). The extant race and focus of this article, the Hispaniolan Golden Swallow (*Tachycineta e. sclateri*) (Gosse 1847), was first distinguished from the Jamaican race (*Hirundo euchrysea* var. *dominicensis*) by naturalist Dr. Henry Bryant, who noticed that *H. dominicensis* had a smaller bill, but gave no further description (Bryant 1866). It was not until 1884 that ornithologist Charles B. Cory described the bird in greater detail, presenting it with the taxonomic distinction of *Hirundo sclateri*, the species name having been chosen as a compliment to P. L. Sclater, Esq., of London, England (Cory 1884:2):

“The present species differs decidedly from *Hirundo euchrysea* [*Tachycineta euchrysea euchrysea*] from Jamaica, that species having the upper parts bright golden-green, and lacking the blue on the forehead entirely. The Santo Domingo bird [*T. e. sclateri*] is also larger, and the bill is apparently somewhat more slender.”

The Hispaniolan Golden Swallow (hereafter also referred to as “swallow,” unless distinction from *T. e. euchrysea* is needed) is believed to be endemic to the island of Hispaniola (Latta et al. 2006). The most recent estimates generated in 2000 (IUCN data quality: poor) gauge population size at anywhere from 1500-7000 mature individuals with a declining trend. This assessment justifies placement of the species

into “Vulnerable, Category B” (small range and fragmented, declining or fluctuating) on the IUCN Red List of Threatened Species (BirdLife International 2012). From the earliest known records to today’s most current sightings, the swallow has been described as a bird of the mountains (Cory 1884, 1886, Bond 1928, 1936, 1943, Wetmore and Swales 1931, Raffaele 1998, Latta et al. 2006, eBird 2015).

Wetmore and Swales (1931:315-316): “This handsome swallow is found among the interior hills and is greeted with delight wherever seen from its graceful actions and pleasing coloration. As one climbs over steep slopes in the mountains among dead trunks of pine a long-tailed swallow may come circling through the air to display in passing a white breast and glossy back. In its active evolutions it is certain to attract the eye and the traveler is sure to pause to observe its course as it circles quickly away.”

At present, the species is found in the Sierra de Neiba (highest point: Pico Neiba – 2,279 m), Cordillera Central (Pico Duarte – 3,098 m) and Sierra de Bahoruco (Loma Gaio en Medio – 1,779 m) mountain chains of the Dominican Republic (Turner and Rose 1989, Dod 1992, Klein et al. 1998, Fernandez and Keith 2003, Rimmer et al. 2004, Townsend 2006, Townsend et al. 2008) and within the Massif du Nord (near Morne Beaubrun – 1,160 m), Massif de la Hotte (Pic de Macaya – 2,347 m), Montagnes Noires (near Morne Boeuf – 1,760 m) and Massif de la Selle (Pic la Selle – 2,680 m) of Haiti (Bond 1928, Woods and Ottenwalder 1986, Raffaele et al. 1998, Dávalos and Brooks 2001, Keith et al. 2003, Rimmer et al. 2005, 2010) (Fig. 1).

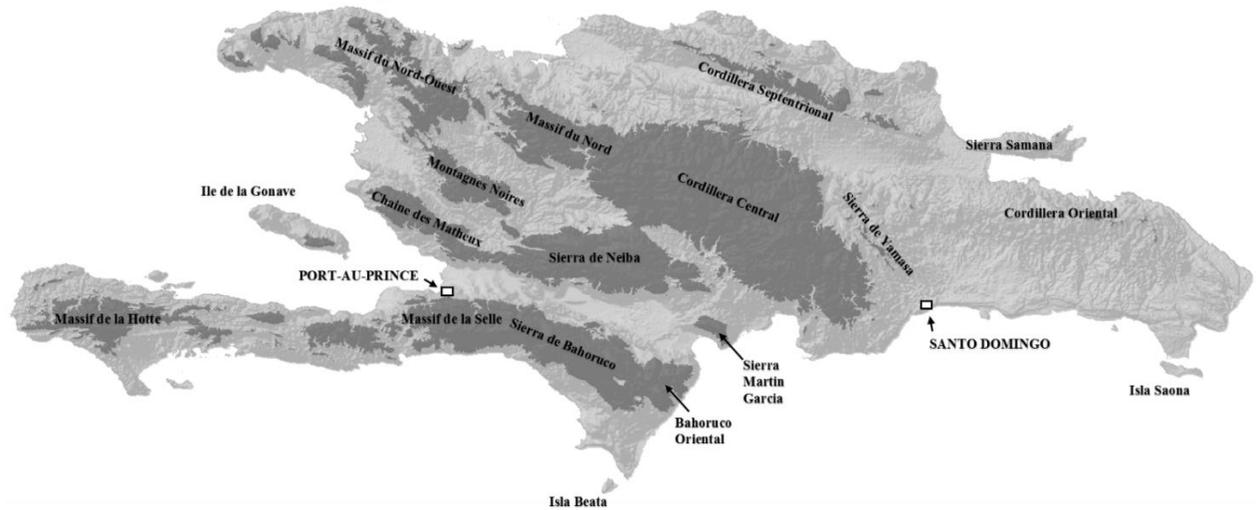


Figure 1. Map of Hispaniola, Greater Antilles with major mountain chains and islands labeled, as well as the capital cities Port-au-Prince and Santo Domingo of Haiti and the Dominican Republic, respectively. Darker shading denotes elevations > 475 masl.

Throughout its range, the swallow is thought to be increasingly restricted to isolated remnant patches of montane forest dominated by Hispaniolan pine (*Pinus occidentalis*) (Keith et al. 2003, Latta et al. 2006, Townsend et al. 2008), a trend that is congruent with a notable decrease in the species' presence at lower elevations over the last century (Wetmore and Swales 1931, Latta et al. 2006, eBird 2015). The species is believed to have declined over the past several decades (Dod 1992, Keith 2003, BirdLife International 2015); though some localized populations may have recently stabilized (Rimmer 2004). Some authors attribute the decline to habitat loss and degradation within native pine forests (Keith 2003) - a concern echoed by scientists studying the congener *T. cyaneoviridis* in the Bahamas (Allen 1996). Others have highlighted high rates of nest depredation by invasive mammals including the small Indian mongoose (*Herpestes aurovinctatus*; additional common names: small Asian mongoose, Javan mongoose, marsh mongoose) (Hays and Conant 2007, Veron et al. 2007) and black rat (*Rattus rattus*) (Townsend 2006). Though the underlying causes are not definitive, the species' increasing sparsity over its historical range has been the catalyst for the scientific community's growing advocacy towards implementing conservation measures (Rimmer et al. 2005, Townsend et al. 2008).

While Golden Swallows are endemic to the Greater Antilles islands of Jamaican and Hispaniola, the *Tachycineta* genus to which they belong is composed of nine species whose collective ranges extend from Alaska, USA to Tierra del Fuego, Argentina (Turner and Rose 1989), making them the largest genus of endemic New World swallows (Sibley and Monroe 1990). The most recent phylogeny by Cerasale et al. (2012) groups *T. euchrysea* and *T. cyaneoviridis* into a North American clade as sisters to the widespread continental species, the Violet-green Swallow (*T. thalassina*). This hypothesis differs slightly from an earlier phylogenetic reconstruction by Whittingham et al. (2002) that placed *T. thalassina* only as a sister to *T. euchrysea*. Interestingly, the distribution of *T. thalassina* on the mainland spans the combined latitudinal ranges of *T. cyaneoviridis* and *T. euchrysea*, while its breeding grounds on the Mexican mainland are comparable in altitudinal variation to those used by *T. euchrysea* on Hispaniola (BirdLife International 2015, eBird 2015). The temperate-nesting congeners, in particular the Tree Swallow (*T. bicolor*), have been much more extensively studied in comparison to their tropical counterparts (Martin 1996, Jones 2003). Moreover, the two tropical island-endemic species (*T. cyaneoviridis* and *T. euchrysea*) are only beginning to show up on the scientific radar (Allen 1996, Townsend et al. 2008, Graves 2014), and their life history strategies – once better understood – will be invaluable to understanding avian life history theory across a genus of birds that is collectively distributed throughout the entirety of the Western Hemisphere.

What is known about the natural life history and breeding biology of the Hispaniolan Golden Swallow has been primarily drawn from scattered and brief interactions with the species throughout the past two centuries. Here we provide the results from the first comprehensive life history study of the swallow on one of its principal nesting grounds in the high altitude, pine forests of the Dominican Republic's Cordillera Central. Tables and figures in the results section of this paper are presented in a format that allows for efficient comparison with previously published life history and breeding biology studies of *Tachycineta* congeners, including the Mangrove Swallow (*T. albilinea*) (Dyrce 1984), White-winged Swallow (*T. albiventer*) (Struve et al. unpubl. data), Bahama Swallow (Allen 1996), Violet-green Swallow (Brown et al. 1992), Tree Swallow (Robertson et al. 1992, Winkler 1993, Winkler et al. 2011),

White-rumped Swallow (*T. leucorrhoa*) (Massoni et al. 2007), Chilean Swallow (*T. meyeri*) (Liljestrom 2011), and Tumbes Swallow (*T. stolzmanni*) (Stager et al. 2012).

#### STUDY AREA AND METHODS

From April to July of 2012, 2013, and 2014, we studied a breeding population of Hispaniolan Golden Swallows within the Dominican Republic's Parque Nacional Juan Bautista Pérez Rancier using an extensive network of artificial, wooden nest-boxes.

Parque Nacional Juan Bautista Pérez Rancier, locally referred to as Parque Valle Nuevo and hereafter referred to as JBPR, is approximately 910 km<sup>2</sup> in size and situated in the heart of Hispaniola's highest and most extensive mountain chain, La Cordillera Central. The park is contained within the provinces of Monseñor Nouel, La Vega, Azua y San José de Ocoa, and is currently delineated between the latitudes 18°36'10" and 18°57'52"N and 70°26'56" and 70°51'44"W (Guerrero and McPherson 2002). The park was decreed a Protected Area under the category of Scientific Reserve in 1983 and in 1996 became a National Park overseen by the Ministerio de Medio Ambiente y Recursos Naturales of the Dominican Republic government and co-managed by Fundación Propagas. Geographically, JBPR is in large part dominated by a northwest to southeast running highland plateau, paralleled laterally by strings of higher mountain peaks. Appropriately designated "The Mother of Waters," heavy annual rainfall (>250 cm) in JBPR drains quickly off the steep outer slopes of the park, giving birth to an estimated 769 rivers across the island. Temperatures in the winter months fall below 0 °C and mornings with ice are not uncommon, while summertime temperatures can easily exceed 40 °C (Pedersen 1953, Guerrero and McPherson 2002). The landscape is largely dominated by sub-tropical, high altitude monospecific pine forest from the summit of the Caribbean's highest peak (Alto Bandera, 2,842 m) down to ~ 2,250 m where pine forest begins to transition over to lower elevation cloud forest (Sherman et al. 2005, Latta et al. 2006, Perdomo et al. 2010). The park is subjected to strong anthropogenic illegal disturbance through

farming, timber-harvesting, and irrigation (Guerrero and McPherson 2002, Nuñez et al. 2006). Meanwhile, fires ranging in magnitude from small and localized up to landscape-sized conflagrations are common in the Cordillera Central and are known to play a large role in shaping the vegetation and succession of forests across JBPR (Horn et al. 2000, Martin and Fahey 2005, Nuñez et al. 2006). Despite these disturbances, and taking into account the park's relatively small size and considerable variations in topography, altitude, and climate, JBPR boasts 77 species of birds representing 29 families. Twenty-six of these species are endemic to Hispaniola and sixteen fall under some level of vulnerability on the IUCN Red List of Threatened Species (BirdLife 2012, Brocca and Landestoy in prep.). This level of biodiversity coupled with high numbers of endemic and/or threatened birds has led to the park's designation as both a Key Biodiversity Area (KBA) (Anadón-Irizarry 2012) and Important Bird Area (IBA) (Perdomo et al. 2010, BirdLife International 2015).

In an effort to attract and study a returning population of breeding swallows, artificial nest-boxes were originally placed and monitored in several locations across JBPR from 2008 to 2010 through a collaboration between Cornell University's Golondrinas de Las Américas project (<http://golondrinas.cornell.edu>) and local Dominican biologists. The 88 original nest-boxes present in 2012 were attached by wire to Hispaniolan pine trees at a height of 2.1 m to 3.3 m. They were designed using a set of standard parameters outlined in the Golondrinas de Las Américas handbook (<http://golondrinas.cornell.edu>). The nest-box network was amplified from 88 to 172 to 185 units in the study years 2012, 2013, and 2014, respectively. Before the beginning of the 2013 breeding season, all nest-boxes were removed and replaced with a conceptually identical, but smaller design attached to a free-standing post (described in Fig. 2). The overhaul of nest-boxes was necessary to allow for the addition of anti-predator baffles (no effective baffle system could be designed to protect nest-boxes attached to trees) in response to high levels of nest depredation by invasive mammals during the 2012 breeding season. The reduction in height of the original nest-boxes was prompted by initial observations that this swallow species was building a comparably shorter nest compared to congeners and also because two adults were found dead in empty nest-boxes, likely as a result of investigating the boxes and not

being able to physically climb out again. The internal surface area of the nest-box floor did not change from the Golondrinas de Las Américas design, but overall internal volume was reduced.

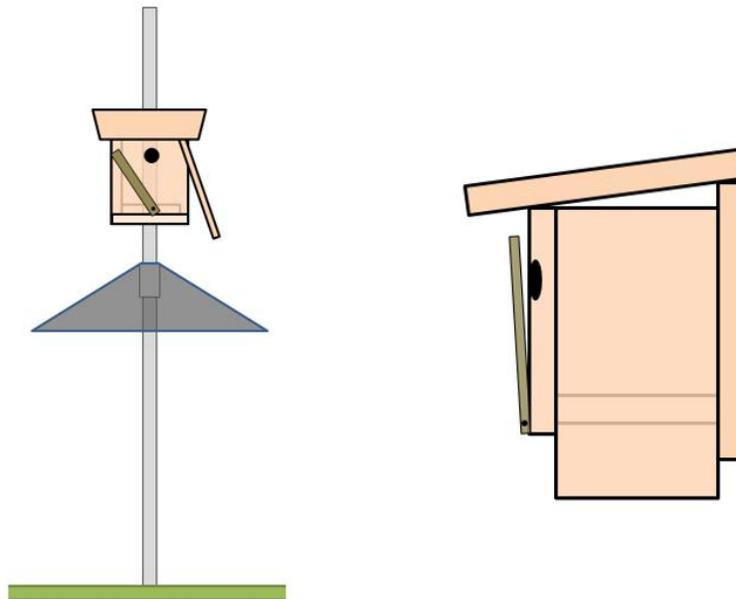


Figure 2. Schematic of nest-box setup in Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic. Nest-box dimensions: front face: 21 cm x 16.5 cm; back wall: 23.5 cm x 16.5 cm; side wall: 21 cm x 12.7 cm; door: 23.5 cm x 12.7 cm; floor: 12.7 cm x 11.5 cm; roof: 23 cm x 23 cm. All six sides of the nest-box are 2.54 cm thick. The back wall is raised so as to angle the roof approximately 5 degrees off the horizontal plane, thus shedding rainwater while simultaneously creating small triangular slits above the side wall and door that aid in ventilation. The entrance hole (3.81 cm diameter) of each nest-box is located at an approximate height of 1.7 m from the ground.

We recognize that the nest-boxes themselves may have influenced clutch size, reproductive success, survival, vulnerability to predators, as well as overall breeding distribution (Robertson 1989, Major and Kendal 2000). Great care was taken to maintain consistency in nest-box design across the entire study area, as well as to address in this study the limitations of a nest-box approach to studying wild bird populations. Furthermore, we acknowledge the importance of documenting nest-box parameters for the improvement of future comparisons between cavity-nesting species (Lambrechts et al. 2010). Nest-boxes were originally placed in JBPR in order to attract and study a returning population of breeding Hispaniolan Golden Swallows. Over time, however, the nest-box developed into a vital tool for the conservation of the species, as well as a tangible asset for outreach.

Nest-boxes were constructed of treated, recycled pine boards (1" thick) and were mounted to a vertical stainless-steel post above a cone-shaped anti-predator baffle made from smooth sheets of steel. For the purpose of trapping breeding adults, nest-boxes were equipped with wooden "wigwag" devices that could be activated to cover the entrance hole of the nest-box by pulling on an attached piece of monofilament line. Nest-boxes were designed with a hinged door that allows researchers access to swallow nests throughout the breeding season.

Upon the arrival of the field team at the beginning of the breeding season, nest-boxes were examined for any signs of new activity (i.e. confirmation of swallows entering the box and/or nesting material inside). Nest-boxes were monitored daily between 0900 and 1300 during the nest-building and egg-laying stages to determine the pace of nest construction, date of clutch initiation, clutch size, and date of clutch completion. Nesting attempts were established upon the laying of the first egg.

In those clutches that were visited daily throughout the egg-laying stage, we numbered eggs sequentially the morning after which they were laid. Eggs in nests that were left undisturbed were measured on the day of clutch completion and marked with letters (A, B, C, D). Eggs were marked for later identification with water-proof ink at the lesser pole. Egg length (L) and width (W) were measured using dial calipers ( $\pm 0.1$  mm). Egg volume (V) was calculated using Winkler's (1991) formula derived from accurate volume measurements achieved through water displacement tests of Tree Swallow eggs, in which  $V = 0.077L + 0.007W^2 - 1.020$ . We massed eggs using a digital scale ( $\pm 0.01$  g).

We considered the incubation period to begin the day the clutch was completed (clutch completion = incubation day 1) and to conclude when the first chick in a clutch hatched (hatch = day 0 for entire brood). Nestlings were given unique toe-nail clippings to serve as individual identifiers. On days 3, 6, 9, and 12, each nestling was measured for (1) mass using a digital scale ( $\pm 0.01$  g), (2) flattened wing length taken from the bend of the wing to the tip of the longest primary feather (9th) using a ruler with a wing stop ( $\pm 0.5$  mm), and (3) head-bill length measured as the maximal distance between the back of the head and the bill tip, using dial calipers ( $\pm 0.1$  mm). Two nestlings from one brood in 2014 were measured for the aforementioned biometrics daily from day 0 to day 20 to look for the timing at which

maximum weight is achieved. All nestlings on day 12 received a numbered aluminum band from National Band & Tag Co. (size 1242F0; note that size F1 bands were found to be too large). Nest-boxes were discreetly checked for fledging events every two days after day 20 in 2012, and every day after day 22 in 2013 and 2014. In deducing brood age at the time of fledging, the nestling period was considered to span the time from when the first egg in the clutch hatched to the day when the last chick fledged (Fig. 3).

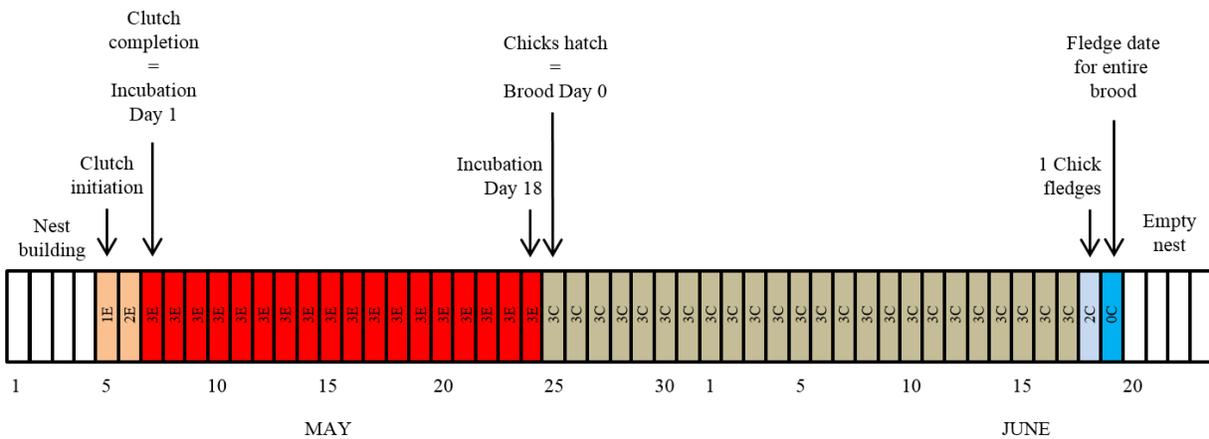


Figure 3. Example timeline of critical nesting events, advocating the importance of clarifying and standardizing what have become comparative baseline measurements across studies of *Tachycineta* swallows. Nesting events are noted above, hypothetical nest occupancy is abbreviated within the timeline (E=egg, C=chick), and corresponding calendar dates are noted along the bottom.

Adult female and male swallows were captured using two different methodologies. Females were trapped when their associated brood was 1-4 days old using a “flap-trap” that involved the use of a raw spaghetti noodle to prop up a rectangular piece of cardboard hinged inside the box above the entrance hole, which would collapse to seal the nest-box when knocked over by a female entering the nest-box. Males were trapped between nestling days 2 and 4 using the earlier described “wig-wag” method [although these methods are effective, protocols for trapping males should be altered for reasons discussed in the *Tolerance to Disturbance* section of this paper]. We confirmed the sex of each individual in the hand by determining the presence/absence of a brood patch. Morphometric data (mass, flattened

wing length, and head-bill) were obtained using the same methodology as for nestlings, with the additional measuring in 2013 of bill and tail length using digital calipers ( $\pm 0.1$  mm). Ventral and profile pictures of the adults were taken during captures in 2013 and 2014 for plumage analyses. Because there are only subtle differences in plumages between sexes, we used an indelible marker to darken the chest feathers of females so as to allow observers to more easily distinguish between the sexes in flight. Bolus samples retained in the bills of adults post-trapping or in the bills of chicks post-feeding were collected opportunistically and stored in 70% isopropyl alcohol for analysis.

Extensive behavioral observations of swallow activity around the nesting sites were conducted throughout the entirety of the breeding season, with the greatest effort spent on observations of incubation and feeding bouts, as well as mate interactions and foraging patterns. Observations entailed one to three observers monitoring activity using binoculars or the naked eye at a distance of 20-40 m from the nearest active nest-box, depending on geographical constraints and the presence of natural blinds offered by the vegetation.

Nest-boxes were not emptied after the successful fledging of chicks in 2012 in order to test for the possibility of second-clutches that could occur outside the known breeding season. With no evidence of second-clutches found in early 2013, we modified the protocol, emptying nest-boxes after either the successful fledge of chicks from a nest or after three weeks of inactivity around a nest (assuming abandonment). Finally, we photographed and dissected nest contents to better identify materials used for construction and lining, as well as to assess fecal remains and the potential presence of parasites.

Sound recordings and videography of the species have been catalogued and made available through the Cornell Laboratory of Ornithology's Macaulay Library online database (<http://macaulaylibrary.org>).

*Statistical Analyses.*— For all analyses and figures we used software R (version 3.1.1). All graphs were plotted using base R graphics. In the histograms of daily nest initiations for each year, all nesting attempts were pooled because it was not possible to separate first nesting attempts from second attempts

(explained in *Nesting activity and phenology*). The graphs comparing clutch size with lay date (Fig. 6) as well as the histogram of weekly initiations across all years (Fig. 8) also include all nesting data. We fit a linear regression line to the graphs of clutch size over lay date for each breeding season. Clutch size is defined as the total number of eggs the female lays and incubates per nesting attempt during a breeding season.

The growth curve for the individual chick mass data was fitted using nonlinear mixed-effects models in the package nlme written in the software R (version 3.1.1). The logistic growth equation was chosen to model chick growth in the Golden Swallow since it has been employed to model growth data in two other *Tachycineta* swallows: the Tree Swallow (Zach and Mayoh 1982) and Tumbes Swallow (Stager et al. 2012). The logistic formula is  $M_x = M_\infty / (1 + (((M_\infty - M_i) / M_i) * e^{-K * x}))$  where  $M_x$  is the mass at age  $x$ ,  $M_\infty$  is the asymptote,  $K$  is the growth rate, and  $M_i$  is the initial mass (Ricklefs 1983). Individual measurements of mass were taken on day 3, 6, 9, and 12. Chicks that did not survive to day 12 were excluded from the dataset; chicks that had missing measurements over the 12-day measurement period were also excluded. A large percentage of fledging events were not observed, therefore excluding chicks on the basis of mortality before fledging was not possible for this analysis.

The best growth model was determined using a forward stepwise model selection procedure. A random intercept formula was used to estimate how much of the variation in the data could be attributed to the nested random effects of year, nest, and chick. Each parameter and grouping variable added to the random effects component of the model was tested to see if it significantly improved the model fit using the log-likelihood ratio test (LTR). A term was omitted from the model only if the P-value of the LTR was greater than 0.05.

Welch's *t*-tests were used to test for effect of lay order on the morphology of eggs and the effect of sex and year on the morphology of adults. Detailed results of these tests can be found in more detail in the Appendices.

## RESULTS AND DISCUSSION

Here we describe in detail the natural history and breeding biology of the Hispaniolan Golden Swallow. We have arranged the material so as take the reader somewhat chronologically through a breeding season, and have combined results with their respective discussions in order to create better coherency within and between topics.

*Nest-site characteristics.*— Nest-boxes were established in small aggregations in open savannas and along pine forest edges across a 20 km span of JBPR. Only a handful of experimental nest-boxes were erected in lower elevation broadleaf forest along the lower boundaries of the park. All nest-boxes were located within 5 km of the Carretera de Ocoa, the principal dirt road that cuts north to south through the park, connecting the towns of Constanza and San Jose de Ocoa, respectively.

The habitat surrounding the nest-boxes is a mosaic of Hispaniolan pine stands interlaced with pajón (*Danthonia domingensis*), a dense, native tussock grass (up to ~ 1.5 m tall during later summer months) that dominates the ground cover (Clark et al. 2002). Fires and agricultural practices have contributed to creating a patchy arrangement of forest and savanna grasses (Martin and Fahey 2006, Sherman et al. 2008). Despite the region's importance as a catchment area for rainfall, the steep edges of the high-altitude plateau allow for very little water retention, so even after weeks of heavy rain the landscape can appear dry. More gently sloped valleys can remain wet for longer periods of time and were found to attract notably higher densities of foraging swallows. Some of the higher peaks are thought to show signs of glacial origin, however most of the park's geology was derived from an igneous intrusion through a metamorphic base, leaving behind volcanic rock (most notably basalt) surrounded by a layer of tertiary sediments (Pronatura 2010).

Throughout the forests of JBPR, scars from logging, sheep grazing, and various agricultural practices are noticeable, with increasing frequency nearest to the park's borders and roads. The historical and continued influence of human presence brings with it a collection of invasive – and now feral –

animals, including rabbits, rats, mongoose, dogs, and cats. Abandoned buildings, as well as some occupied ones, are scattered loosely across the higher regions, while larger communities encircle the lower-elevation boundaries of the park.

We found that dead, upright snags were rare among the pine forests situated on the highland plateau, but that they were noticeably more common at higher elevations (>~2400 m) and along the steeper mountain- sides and ravines. This patchy distribution may be driven by human harvesting for firewood and building materials, but is likely also influenced by the local fire regime and the structural integrity of dead Hispaniolan pine. In terms of cavity availability, the Hispaniolan Woodpecker (*Melanerpes striatus*) is the only arboreal cavity-producing bird species on the island (Latta et al. 2006), and though extremely abundant and obvious at lower elevations in the Cordillera Central and across the Dominican Republic, it is extremely rare at our high-elevation field sites (a total of three individuals were observed across all field seasons, and no signs of nesting were discovered).

*Nesting locations.*— Golden Swallows have been historically found to nest in both pine and montane humid forests from 800 to 2000 m on Hispaniola (BirdLife International 2015). Nesting preference by the species has been most commonly associated with arboreal cavities created by woodpeckers in dead emergent snags, predominantly in Hispaniolan pine (Wetmore and Swales 1931, Bond 1943, Rimmer et al. 2005, Townsend et al. 2008). Wetmore and Swales (1931:316) describe it well:

“The birds were regularly at home about knolls where standing trunks of dead trees afforded them nesting cavities. About such places they circled tirelessly, swinging gracefully out among the pines or over the dense stands of rain-forest, but returning always to more open localities.”

Across its range the species has been found to occasionally nest in Yagrumo trees (*Cecropia peltata*) (Dod 1992) and *Didymopanax tremulus* (synonymous with *Schefflera tremula* and endemic to Hispaniola, GBIF Secretariat) (Townsend et al. 2008), both of which can be found in mid to low elevation broadleaf

forests within the Cordillera Central (Sherman et al. 2005). Swallows have also been found nesting in the eaves of abandoned buildings (Bond 1936, Wetmore and Lincoln 1933) and in the rocky banks of abandoned bauxite mines (Fernandez and Keith 2003, Townsend 2006, Townsend et al. 2008).

The swallows demonstrated a strong attraction to the nest-boxes erected in JBPR, whereas identical nest-boxes placed in the Aceitillar region of the Sierra de Bahoruco have been completely unsuccessful (Proctor and Greig in prep.). It was not uncommon for newly-erected nest-boxes to be investigated by breeding pairs of swallows within five minutes of their initial placement. We have observed the species successfully nesting in nest-boxes at elevations between 2149 m and 2642 m in pine forest habitat, with available nest-boxes currently spanning an elevational gradient of 1973 m to 2838 m. At the end of the 2014 breeding season, a male swallow in flight was seen investigating our highest located nest-box on the summit of JBPR's tallest peak, Alto Bandera (2838 m). Swallows were rarely found nesting outside of our nest-boxes despite the considerable amount of time that field crews spent specifically searching for occupancy of other cavities within JBPR. Across three breeding seasons, we were able to identify four non-nest-box nesting situations, described below:

1) 10 June 2012; an active nest was found built overtop a flat, wooden board serving as the upper window frame on the second floor of an abandoned building at a height of 6-7 m from the ground (lat: 18°45'55.28"N, lon: 70°38'35.32"W, elevation 2261 m). The nest was constructed with the usual pine needle framework and Spanish moss lining, but was not built against any vertical structures and as a result appeared more loosely constructed and without a defined shape. Two healthy chicks estimated at 14 days of age were being routinely provisioned by an adult female that entered from a gap in the side of the window and exited via another opening opposite to it. Both chicks fledged successfully.

2) 25 May 2013; an adult female swallow was observed making return trips into a dense clump of intertwined bromeliads and pine needles that had formed on a Hispaniolan pine bough approximately 10 m off the ground (lat: 18°45'55.73"N, lon: 70°38'45.16"W, elevation 2270 m). The nest itself was

positioned out of view; however, we speculate that the hollowed-out clump of vegetation that the female was using could have been an abandoned black rat nest, as they are known to be arboreal nesters (Ewer 1971) and common in the area (Proctor in prep). The frequency and duration of visits by the female to the nest, as well as the timing in nest activity compared with swallows nesting nearby in nest-boxes, was indicative that the female was likely incubating. Follow-up observations throughout the first week of June saw no activity around the nest and we presumed that the nest had failed.

3) 15 May 2014; two swallows were observed investigating small cavities in a mixed rock/earthen bank located alongside the main road in JBPR (Ivan Mota pers. comm.) (lat: 18°48'31.35"N, lon: 70°40'51.95"W, elevation: 2304 m). Later investigation revealed a loose conglomeration of pine needles and Spanish moss wedged into a shallow hole formed by erosion beneath a small boulder on the hillside. Follow-up visits confirmed that the nest was never finished nor used. It is important to mention that a small population (three active pairs as of 2014) of Hispaniolan Golden Swallows nest in the banks of abandoned bauxite mines in the Aceitillar region of the Sierra de Bahoruco mountains (Fernandez and Keith 2003, Townsend 2006, Townsend et al. 2008), though that unique location as well as the behavior of the swallows nesting there are described elsewhere (Proctor and Greig in prep.).

4) 20 May 2014; we confirmed a natural cavity breeding attempt in an old woodpecker hole located approximately 17 m high on the west face of a dead snag. The snag, believed to be Ebano Verde (*Magnolia pallescens*), is located in dense broadleaf forest on the southern end of JBPR (lat: 18°41'47.05"N, lon: 70°35'34.24"W, elevation: 2259 m) and was simultaneously being occupied by a pair of swallows and Hispaniolan Trogons (*Priotelus roseigaster*) nesting in separate cavities one meter apart. We observed the snag for one hour and found that the presence of an adult trogon near the nesting cavities provoked a strong alarm response by the swallows. The swallows would fly in tight circular patterns around the snag while vocalizing aggressively, and did not attempt to approach their cavity until the trogons had vacated the immediate area. Three weeks later, we were unable to ascertain whether the

swallow and trogon nests were successful in fledging chicks or not, as no activity was seen around the snag. A similar situation, with Hispaniolan Woodpeckers in place of Hispaniolan Trogons, was documented by Bond (1928:507) in the mountains of Haiti:

“These graceful and beautiful [Golden] swallows are common in the mountains of Haiti, particularly in La Selle and La Hotte. On June 5<sup>th</sup>, a pair was seen entering an old woodpecker hole in a dead pine about forty feet above the ground. A woodpecker, nesting directly above, was frequently attacked with great vigor by the swallows, which probably had young.”

The species’ tendency to nest colonially appears to depend on the availability of cavities and their proximity to one another, such as when Dod (1992) observed “more than a dozen nests in about four or five [Yagrumo] trees”. We have no knowledge of any current sightings that indicate such high numbers of nests within a stand of trees, though aggregations of nest-boxes create a pseudo-context of coloniality, resulting in densities as high as 17 pairs in an area smaller than 0.5 km<sup>2</sup>.

Swallows do not appear to be averse to nesting near human disturbance. Chicks successfully fledged across all three study years from nest-boxes located within ten meters of the main road in JBPR. Though traffic is considerably minimal, at times large caravans of vehicles can pass by on a daily basis. Most noteworthy was the fledging of a brood of three chicks in July 2013 from a nest-box located fifteen meters from a fully functional park ranger station, complete with two full-time park guards and roaming animals consisting of two dogs, a mule, and chickens.

*Inter-specific competition for cavities.*— We did not observe any direct competition between swallows nesting in nest-boxes in JBPR and other avian species. In three breeding seasons, only one isolated event occurred in which a female Rufous-collared Sparrow (*Zonotrichia capensis*) constructed a small nest and laid two eggs within an unused nest-box. Observations of the nest and surrounding active swallow nests did not show any evidence of aggression or competition for resources between the two

species. Our sole brief encounter with the sparrow nest resulted in the female abandoning and not returning to any other nest-box to initiate another nesting attempt.

Non-avian species encountered within nest-boxes consisted solely of a resident katydid species (*Polyancistrus loripes*, Rehn 1936), which was found to inhabit nest-boxes only when the nest-boxes were attached to trees in the 2012 breeding season. Their abundance could number from one to over forty individuals, and removing them did not deter their continual efforts to reoccupy the same nest-box. Swallows never nested in a nest-box that was already inundated with *Polyancistrus*; however, had swallow nesting already begun in an empty nest-box, the subsequent arrival of *Polyancistrus* did not dissuade the resident female swallow from continuing to nest. In most cases *Polyancistrus* remained under the nesting material or in the high corners of the nest-box where we assume they had very little interaction with the swallows. In 2013 we observed one extreme situation in which a nest-box contained a female swallow covered with four *Polyancistrus* individuals while she lay incubating her clutch. This nest-box was only visited monthly because of its remote location, and thus we cannot know for sure whether *Polyancistrus* were present before the nesting attempt began. The nesting pair of swallows was ultimately not dissuaded from raising and successfully fledging three chicks. We considered the possibility of there being a mutualistic relationship between *Polyancistrus* and swallows in that perhaps the highly vocal katydid is able to sound a warning call in the presence of danger (a black rat climbing the nest-box post) that would alert the female swallow to flee. However, six nests attacked by black rats in 2012 were examined to find that the swallow and katydid coinhabitants were preyed upon together. A more likely explanation is that the katydids are simply cohabiting the nest-boxes if conditions are favorable for some aspect of their life histories.

Knowledge of interspecific competition for *natural* cavities is more limited. Other obligate secondary cavity nesters such as the Caribbean Martin (*Progne dominicensis*) are extremely rare in the high altitude pine forests of JBPR, though the swallow and martin overlap geographically during their breeding seasons in the Sierra de Bahuco (Proctor pers. obs.). Only at the lower limit of their breeding distribution in JBPR have swallows been found to co-occur with nesting Hispaniolan Trogons (see

*Nesting Locations*). The House Sparrow (*Passer domesticus*) is an introduced permanent breeding resident on Hispaniola, but despite their rapid spread across the lowlands and some interior valleys (Latta et al. 2006), they have not been observed in JBPR (Brocca and Landestoy in prep., eBird 2015). Because House Sparrows can be aggressive competitors for nesting cavities used by other species (Gowaty 1984, Cordero 1986, Cordero and Senar 1990), they should not be overlooked as a potential historical cause of swallow displacement from the lowlands and thus an ongoing barrier to swallows attempting to breed at lower elevations on the island.

*Copulation*.— We observed the occurrence of only one mating event by Hispaniolan Golden Swallows, which occurred on 31 May 2014 in the region known locally as Nizaito (lat: 18°44'25.70"N, lon: 70°37'27.76"S, elevation: 2204 m). Two males pursued a female in flight until she landed on an exposed tip of a Hispaniolan pine branch hanging approximately 5-7 m off the ground. One male landed less than a meter down the branch while the other male maintained flight and approached the stationary female. After a moment of the male hovering directly behind the female (Fig. 4), the female raised her rump while remaining perched, allowing the male to make brief cloacal contact. The interaction occurred twice over a ten-second time period, and concluded with the female taking flight. The first male remained perched throughout the copulation event. All three swallows were highly vocal throughout the encounter, though we are unsure whether or not these vocalizations were distinctive.

In all three field seasons a significant amount of time was spent observing nest-boxes specifically for the occurrence of mating, as the event had yet to be formally described in the species. No acts of copulation were witnessed on the roofs of nest-boxes though it is a common occurrence among other *Tachycineta* species (Proctor pers. obs.). The difficulty in observing this behavior in Hispaniolan Golden Swallows leads us to speculate that the act of copulation in this species is most likely occurring within the forest canopy, where it can easily go unnoticed.



Figure 4. Male Hispaniolan Golden Swallow (*Tachycineta euchrysea sclateri*) hovers momentarily in flight prior to making cloacal contact with female perched on the tip of a Hispaniolan pine (*Pinus occidentalis*) branch in Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic. Photo taken by lead author.

*Nest construction and materials.*— Female swallows build the bulk of their nests with dry needles from Hispaniolan pine. As the nest construction advances, the needles are often arranged and stacked in a way that closely imitates the walls of a traditional log cabin, consistent with what was observed by Townsend et al. (2008) in nests found in abandoned bauxite mines in the Sierra de Bahoruco. Once the desired abundance of pine needles is achieved, females gather pieces of two different species of lichen - *Usnea* sp. and *Teloschistes flavicans* – the former found growing in heavy abundance on the branches of Hispaniolan pine throughout JBPR and the latter found growing upon the pajón. Females are often seen hovering momentarily in flight at the lower hanging end of a strand of *Usnea* as they tear it free from its attachment to Hispaniolan pine branches, frequently including a small flake of bark onto which the *Usnea* was originally attached. The *Usnea* is gathered in large quantities and ultimately becomes a dense mat lying on top of the pre-established pine needle base. Simultaneously, the female begins molding out a depression in the nest, hereafter referred to as the “nest-cup.” Once the nest-cup is layered with lichen,

adults will continually seek out and add feathers and feather-like materials to the nest-cup through to the nestling stage of the breeding season (Table. 1, Fig. 5). Non-feather items found lining the nests included tissue paper, airborne seeds, rabbit hair and small scraps of cloth.

	Height (cm)	Cup rating	Feathers-in	Feathers-out
2012; n=10				
$\bar{x} \pm SE$	$7.4 \pm 1.56$	$4 \pm 0.0$	$1.1 \pm 1.37$	$2.2 \pm 2.04$
range	4 to 10	4 to 4	0 to 4	0 to 5
2013; n=11				
$\bar{x} \pm SE$	$7 \pm 2.0$	$4 \pm 0.0$	$0.5 \pm 0.89$	$0.3 \pm 0.62$
range	4 to 10	4 to 4	0 to 2	0 to 2
2014; n=12				
$\bar{x} \pm SE$	$6 \pm 1.53$	$4 \pm 0.0$	$1.8 \pm 1.69$	$0.7 \pm 1.03$
range	3 to 9	4 to 4	0 to 4	0 to 3
2012-2014; n=33				
$\bar{x} \pm SE$	$6.8 \pm 1.81$	$4 \pm 0.0$	$1.2 \pm 1.46$	$1.0 \pm 1.56$
range	3 to 10	4 to 4	0 to 4	0 to 5

Table 1. Measurements of Hispaniolan Golden Swallow (*Tachycineta euchrysea sclateri*) nests on the day prior to clutch initiation broken down by year and averaged across years 2012-2014 in Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic. Nest height was measured from the base of the nest to the highest point. Cup rating is an index of cup shape measured with a scoring scale of 0-4, ranging from no cup present to a full, deeply molded cup, respectively (Appendix 1). Feathers-in are numbers of feathers that were positioned in the nest so as to have contact with the nest cup. Feathers-out are numbers of feathers that were positioned outside of the nest cup. Across three study years we measured 140 nests, 33 of which – due to a nest-box monitoring routine of every second day prior to clutch initiation (to reduce disturbance) – were measured the day prior to clutch initiation and used here for analyses. Nest measurements are further fleshed out by year, with n=10, n=11, and n=12 in 2012, 2013, and 2014, respectively.



Figure 5. Hispaniolan Golden Swallow (*Tachycineta euchrysea sclateri*) nest in an artificial nest-box one day prior to clutch initiation in Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic. Hispaniolan pine (*Pinus occidentalis*) needles are arranged log-cabin style, after which an *Usnea* sp. and *Teloschistes flavicans* are added to fill the center of the nest. A cup-like depression is molded into the lichen into which feathers or feather-like materials are added as lining. Photo taken by lead author.

Our field teams did not observe male swallows carrying nest material in flight nor entering the nest-box while the nest was being constructed by the female, so we assume that males do not contribute to nest building. Males were often seen escorting females in their collecting trips, and would occasionally perch on the nest-box roof while the female was inside constructing the nest. We found gender roles to be strongly partitioned at this stage of the breeding season, with the female more likely to partake in nest building while the male defended the territory and competed with conspecifics for feathers with which to line the nest cup. Nests rarely possessed more than three feathers, and we attribute the low numbers to overall lack of feather availability in the high elevation pine forests of JBPR where there are very few plumaceous bird species (Proctor pers. obs.). Feathers found in swallow nests came solely from three species of birds: domestic chickens, locally nesting Red-tailed Hawks (*Buteo jamaicensis*), and the swallows themselves. Reinforcing the hypothesis that feathers are desirable but unavailable in the surrounding landscape, our presentation of small veined feathers with downy bases tossed into the air at

breeding sites elicited an immediate and aggressive response from swallows in the immediate area and often resulted in prolonged aerial skirmishes.

In those instances when nest-boxes were not cleaned between breeding seasons, we observed swallows building new nests on top of old nests. New nests were constructed in the same manner architecturally but with reduced height (2-4 cm) compared to original nests built in empty nest-boxes. This stunted second nest could be attributed to original nests already occupying a significant volume of the nest-box, and a subsequent decision by the swallows to not add so much new material that the resulting nest could be seen through the entrance hole.

*Nesting activity and phenology.*— The active breeding season for swallows sees nesting activity beginning prior to mid-April and late second attempts fledging chicks into early August. Nest building had already begun when field crews arrived in mid-April across all three study years. The timing of the first nesting attempt (first egg laid) was extremely consistent, with a calendar date of 30 April, 1 May, and 30 April in 2012, 2013 and 2014, respectively. Interestingly, an After-Second-Year (ASY) female that we first banded as a breeding adult in 2012 returned in 2013 to end up pairing with the same male in the same nest-box. This female initiated the first nesting attempt across all nest-boxes in both years. Nest fidelity from one year to the next by individual females, males, and pairs was noticeably high and is discussed in more detail elsewhere (Proctor et al. in prep.).

Nest failures occurred in all three years, prompting second nesting attempts. We define a second attempt as a pair of swallows re-laying a clutch of eggs (either within the same or a different nest box) after losing the first clutch. Clutch loss can result from females breaking eggs during incubation, eggs not hatching, the nest being preyed upon, or the chicks dying after being abandoned by the adults. Recognizing second attempts in our study population, however, was challenging. Because we were unable to identify previously unbanded adults until we captured and banded them during the brood stage, a nesting attempt that failed prior to that did not allow us to re-identify the birds if they began a second attempt. Even if activity began again in the same nest-box only a few days later, it cannot be assumed that

this was always the same nesting pair of swallows, as competition for an empty nest from other nesting pairs and/or unpaired satellite swallows is common (see *Tolerance to Disturbance*). Despite these discrepancies, we deduced with a fairly high level of confidence the occurrence of 4, 3, and 10 second attempts across years, respectively. However, with the potential for those second attempts to have been observer-induced, as well as our inability to track the movements of unbanded birds and validate a second attempt with full certainty, we did not include data from second-attempts in some analyses.

We found no indication of double broods in our study population. We define a double brood as a pair of swallows rearing and fledging a set of chicks and afterwards attempting to do so again within the same breeding season (whether the same nesting cavity is used or not). Nest-boxes were *not* cleaned at the end of the 2012 field season in order to allow swallow pairs to continue nesting undisturbed. At the commencement of the subsequent field season we found no evidence that further activity had taken place after our departure the previous year (i.e. new nests built over top of old ones, sterile eggs, dead nestlings). Furthermore, nest-boxes cleaned at the end of the 2013 field season showed no signs of activity (i.e. nesting material) when the field crew arrived in April of the following year. We noticed each year that after broods had fledged, adults and their fledglings would vacate the breeding sites. After chicks were known to have fledged, we visited nest-boxes in order to look for evidence of fledglings returning post-fledge to the nests. No fledglings were ever found back inside of a nest-box nor seen entering or exiting a nest-box after they had initially fledged.

Year-round community residents and military personnel living inside JBPR have not observed swallows in the vicinity of the nest-boxes from September through the end of November. Larger flocks, on the magnitude of 10 to 50 individuals, have reliably been seen foraging along the lower, northern boundaries of the park (~ 2100 m) beginning in early December (Jose Delio Guzman pers. comm.). The arrival date of the swallows to their breeding grounds as well as their behavior at that point in time is not yet fully known; however the degree of nesting activity found upon the fieldcrew's arrival indicates that the swallows begin building nests in early April, if not earlier. Our phenology (Table 2) of the Hispaniolan Golden Swallow breeding season is consistent with historical observations, including

Wetmore's (1933) observation of mating and cavity searching behavior occurring between 10 and 15 April, Dod's (1992) report of adults provisioning nestlings in May of 1975, Bond's (1928) discovery of a nest on 5 June, Bond's (1943) observation of eggs and young on 6 June, and young of another nest on 12 June, and Cory's (1884) collection of an immature bird on 28 July.

	2012	2013	2014
Study period	18 Apr. – 5 Jul.	20 Apr. – 26 Jun.	26 Apr. – 27 Jun.
Field sites	6	10	13
Nest-boxes	88	172	185
First attempts	40	51	72
Second attempts	4	3	10
First egg / nesting attempt	30 Apr.	1 May	30 Apr.
Median lay date	15 May	13 May	17 May
Median clutch completion date	17 May	15 May	19 May
First hatching event	20 May	21 May	20 May
Median hatch date	4 Jun.	4 Jun.	6 Jun.
First chick fledged	15 Jun.	17 Jun.	16 Jun.
Last known fledging	2 Jul.	24 Jun.	25 Jun.
Last estimated fledging	7 Aug.	29 Jul.	6 Aug.

Table 2. Synthesis of field season parameters, nesting activity, and the breeding phenology of the Hispaniolan Golden Swallow (*Tachycineta euchrysea sclateri*) across three years of study in Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic. Field sites are recognized as clusters of nest-boxes and distinguished as separate field sites only if clusters are separated by >1 km. Final fledging dates were estimated by taking the newest nesting attempt upon the time of field crew departure and adding to it an estimated period of incubation and nestling times based on yearly averages (18 and 26 days, respectively).

	2012			2013			2014		
	n	$\bar{x} \pm SE$	Range	n	$\bar{x} \pm SE$	Range	n	$\bar{x} \pm SE$	Range
Egg length (mm)	127	18.34 $\pm$ 0.85	15.70 – 20.36	68	18.80 $\pm$ 0.73	16.68 – 21.0	150	18.49 $\pm$ 0.83	15.78 – 20.16
Egg width (mm)	127	13.16 $\pm$ 0.35	12.25 – 14.0	68	13.21 $\pm$ 0.30	12.33 – 13.79	150	13.02 $\pm$ 0.36	12.10 – 13.90
Egg mass (g)	121	1.70 $\pm$ 0.13	1.36 – 2.13	68	1.75 $\pm$ 0.12	1.45 – 2.15	129	1.69 $\pm$ 0.13	1.42 – 2.11
Egg volume (cm <sup>3</sup> )	127	1.61 $\pm$ 0.10	1.31 – 1.90	68	1.65 $\pm$ 0.09	1.40 – 1.89	150	1.59 $\pm$ 0.10	1.33 – 1.87
Clutch size	48	3.0 $\pm$ 0.41	2 – 4	44	3.09 $\pm$ 0.42	2 – 4	62	2.94 $\pm$ 0.44	2 – 4
Egg Survival	43	84%	n/a	40	98%	n/a	49	99%	n/a
Incubation period (d)	30	17.97 $\pm$ 0.89	17 – 20	24	17.79 $\pm$ 0.51	17 – 19	35	17.67 $\pm$ 0.76	17 – 20
Hatching success	37	96%	n/a	39	95%	n/a	48	91%	n/a
Brood size	37	2.89 $\pm$ 0.46	2 – 4	39	3.0 $\pm$ 0.51	2 – 4	48	2.67 $\pm$ 0.69	1 – 4
Nestling success	31	63%	n/a	14	57%	n/a	27	47%	n/a
Nestling period (d)	7	25.85 $\pm$ 0.69	25 – 27	2	25.5 $\pm$ 0.71	25 – 26	11	25.55 $\pm$ 1.04	24 – 27

Table 3. Brood parameters of the Hispaniolan Golden Swallow (*Tachycineta euchrysea sclateri*) in Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic. Hatching success is synonymous with egg viability and thus the percentage of eggs that survived through to hatching. Nestling period is defined as the number of full days the latest fledging nestling from a brood was found inside the nest-box. All nesting events were used in calculations, whether possibly a second attempt or not.

*Eggs and Incubation.*— Female swallows lay one egg daily until clutch completion. All eggs are a brilliant, white color. Only four times (once in 2012, twice in 2013, and once in 2014) did we observe a “skip day” in laying – in that there was a delay of approximately 24 hours in the laying of the subsequent egg – which in all four cases occurred between the laying of the first and second egg. All four circumstances involved different females. Eggs were laid prior to 0900, with very few exceptions. The median lay date (clutch initiation) was consistent across years: 15 May, 13 May, and 17 May, with the highest concentrations of nests initiated the week of 12 May (Table 2). Clutches ranged from 2 to 4 eggs with a mean clutch size of 3.0 ( $\pm$  0.43 SE) (n=154) across all three years (Table 3). Neither a clutch size of one or five eggs was ever observed. Although not statistically significant, we found a downward trend in lay date regression (decrease in clutch size as the breeding season progresses) in all three years of the study (Fig. 6). We found an effect of lay order on the mass ( $t=2.5$ ,  $df=54$ ,  $P=0.02$ ), length ( $t=2.0$ ,  $df=57$ ,  $P=0.05$ ), and width ( $t=2.0$ ,  $df=54$ ,  $P=0.05$ ) of the first- and third-laid eggs (Welch’s  $t$ -tests, Appendix 2), in that 3<sup>rd</sup> laid eggs were longer ( $\bar{x}$  = 18.86 mm vs. 18.48 mm), wider (13.20 mm vs. 13.02 mm), and heavier (1.75 g vs. 1.69 g) compared to 1<sup>st</sup> laid eggs. In a study on Tree Swallow egg composition, Ardia

et al. (2006a) suggest that females are allocating more resources towards later eggs, and that total egg mass was determined by insect availability two and three days prior to egg laying,

We considered clutch completion to equal the first day of incubation, though it was frequently noted that the first and second eggs laid in a clutch were warm to the touch before the clutch was completed. This hints at the possibility of an earlier onset of incubation with earlier laid eggs in many clutches as has been documented in the congener Tree Swallow (Ardia et al. 2006b, Wang and Beissinger 2011); however, all eggs hatched within 24 hours of one another. Conversely, in some cases eggs were not warm to the touch on the day of clutch completion, suggesting a delayed onset to incubation. Therefore our estimation of incubation duration may not necessarily reflect the precise length of time an adult female was actively incubating the clutch. Despite this discrepancy, this protocol is standard across the Golondrinas de Las Américas network (<http://golondrinas.cornell.edu>), and in all observed cases the entirety of the clutch hatched within a 24-hour time period.

The length of time required to incubate clutches ranged from 17 to 20 days with a mean duration of  $17.80 \pm 0.76$  (n=89) days across all three years. Only female swallows were seen entering the nest-boxes during incubation, and all females caught exhibited an obvious brood patch. We found no evidence suggesting that males play a role in incubating the clutch in contrast to Chilean Swallows breeding at the southern tip of South America, where Ospina et al. (2015) recorded intermittent male incubation that compensated for times when the female had to leave the nest. In 2012, 31 nests undergoing incubation were observed for one hour each. Incubation bouts – the time (in minutes) during which a female was inside the nest-box and presumed to be incubating – were found to range from 30 sec to greater than 21 min with a mean time of 9.32 min. The frequency of incubation bouts in one hour's time ranged from 1-9 bouts with a mean of 5.1 bouts. Average egg survival (proportion of total eggs that persisted to the end of incubation) was 93.7%. Average hatching success (proportion of eggs present at the end of incubation that hatched = egg viability) was 94%. There were a total of four instances in which females defecated over their clutch. All females continued to incubate the excrement-covered eggs, but only two of these four clutches remained viable and hatched in their entirety. Primary causes of egg loss (i.e. egg mortality)

included observer-induced breakage, predation, and abandonment. In 2012, before the addition of predator guards, three nests with eggs were preyed upon by black rats. One nest with eggs suffered the same fate in 2014 as it was a newly erected box yet to have a predator guard installed.

In 2012, nest-boxes were more closely monitored during the incubation stage. Upon opening the nest-box, it was most common for females to remain motionless over their clutch. However, three different females, on only one occasion each, emitted a quick, low pitched “growl” sound. One female simultaneously made a fast dashing movement toward the observer, leading with her bill, and then quickly retreated back to cover her clutch.

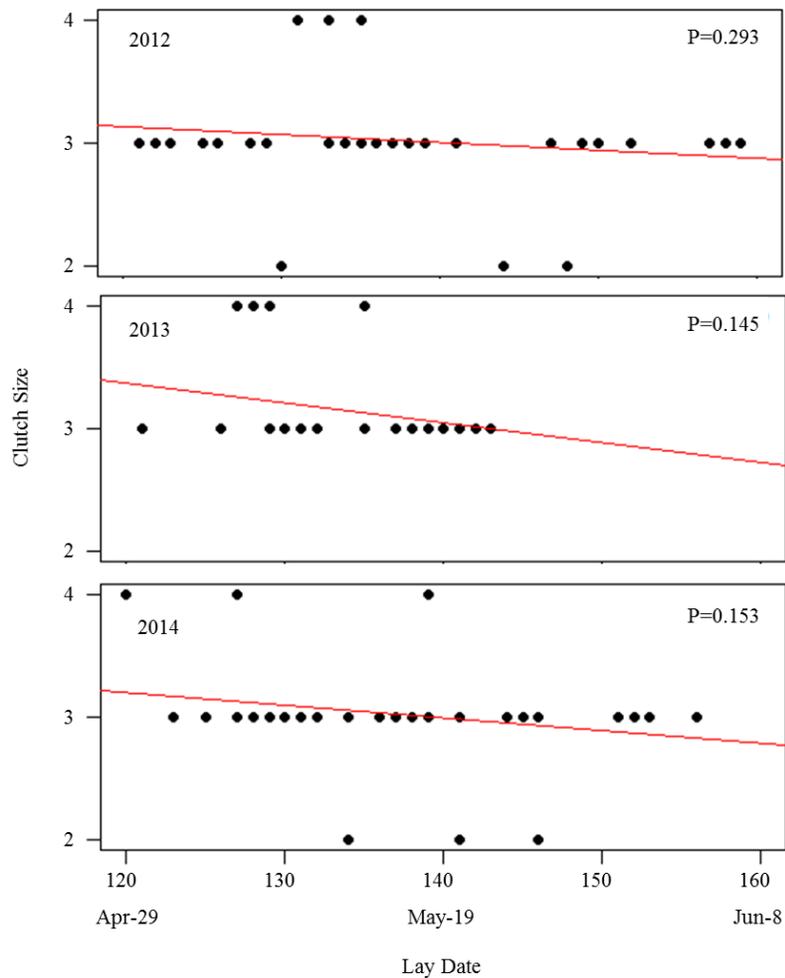


Figure 6. Recorded clutch sizes of Hispaniolan Golden Swallows (*Tachycineta euchrysea sclateri*) plotted as a function of lay date in Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic. Red lines are linear regressions and P-values are considered significant when  $<0.05$ . N's = (2012=44, 2013=34, 2014=44).

We graphed clutch initiations by day for each study year (Fig. 7) and by week with all years pooled together (Fig. 8). Later clutch initiations in 2012 and 2014 were likely a mix of re-nests (second attempts) and late first attempts. In 2013, a lesser degree of nest abandonment early in the season (likely due to a more conservative nest-box checking methodology and therefore fewer observer-caused abandonments) probably accounts for the lack of clutch initiations from late May onwards.

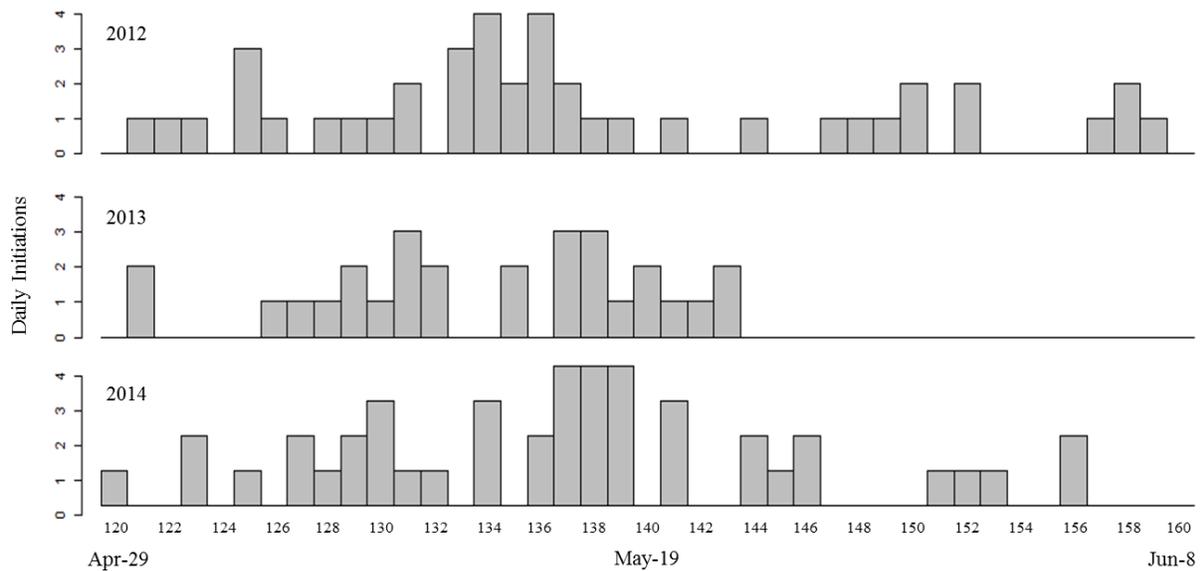


Figure 7. Number of nests of the Hispaniolan Golden Swallow (*Tachycineta euchrysea sclateri*) initiated daily in Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic.

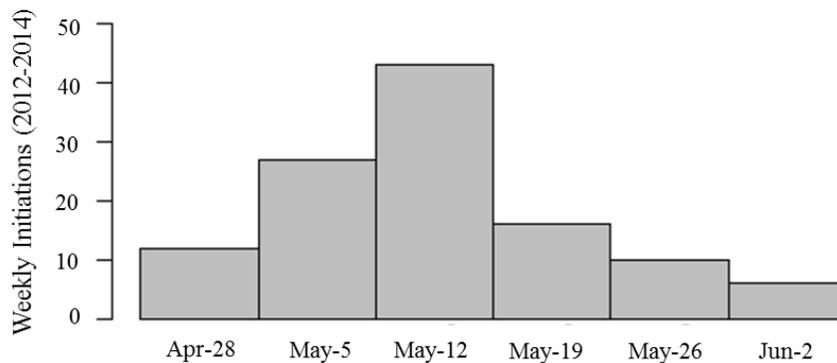


Figure 8. Number of nests of the Hispaniolan Golden Swallow (*Tachycineta euchrysea sclateri*) initiated weekly, pooled across years (2012-2014), in Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic.

*Nestlings.*— The nestling stage of the breeding season taken from the earliest recorded and latest estimated dates across three years extended from 20 May to 7 August (Table 2). The average brood size ranged from 1 to 4 with a mean size of  $2.84 \pm 0.59$  ( $n=124$ ) nestlings across all three years. Clutches of four eggs were not uncommon (4 in 2012, 6 in 2013, 4 in 2014), often yielding broods of four chicks (50%, 83%, 50% respectively). Survival in clutches of four eggs from egg-laying through fledging was 25%, 67%, and 25% across years. The length of time from hatching to fledging, with hatch day = chick day 0, ranged from 24 to 27 days with a mean duration of  $25.65 \pm 0.88$  ( $n=20$ ) days across all three years. Average nestling success (proportion of chicks that survived from hatching to fledging) was 55.7% (Table 3). However, this percentage is likely to be low as it only factors in fledging events (synonymous with survival) that occurred while field crews were present at the breeding sites. When field crews left for the season there still remained a significant number of healthy broods within the nest-boxes ready to fledge. We did not account for these broods in the nestling success analyses as their ultimate fates could not be determined. However, if we were to assume that all those undetermined broods were to fledge successfully, the average nestling success across years would rise to 78%. Primary reasons for nestling mortality included abandonment by adults and predation. Black rats accounted for the loss of five broods in 2012 and one brood in 2013 due to the absence and malfunctioning of predator guards, respectively.

We measured the body mass of 113 nestlings repeatedly on day 3, day 6, day 9, and day 12 of their lives and plotted the results (Fig. 9). Our sigmoidal growth curve is derived from nestling body mass measurements terminating at day 12, causing the curve to level off at a value larger than the measured average adult mass. We know from two nestlings measured beyond that time frame (through to day 20) that nestling growth appears to peak around day 15, after which weight recession occurs through to at least day 20 and likely longer (Fig. 10).

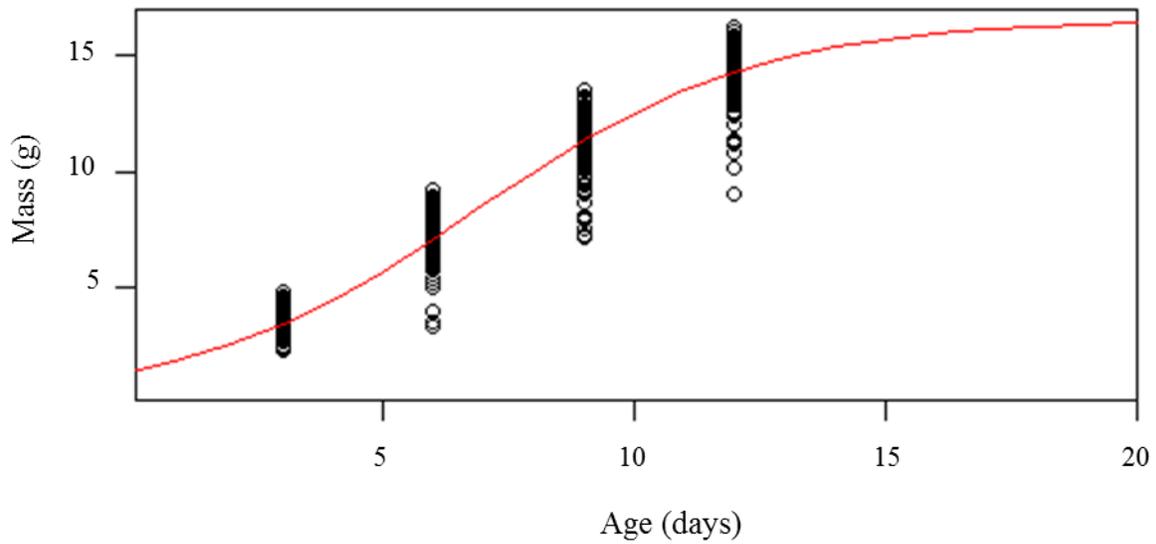


Figure 9. Measurements of body mass of 113 nestlings (pooled from 2012-2014) of the Hispaniolan Golden Swallow (*Tachycineta euchrysea sclateri*) taken on days 3, 6, 9, and 12 in Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic. The growth curve was fitted using the parameters  $M_i$ ,  $M_\infty$ ,  $M_x$  and  $K$ .

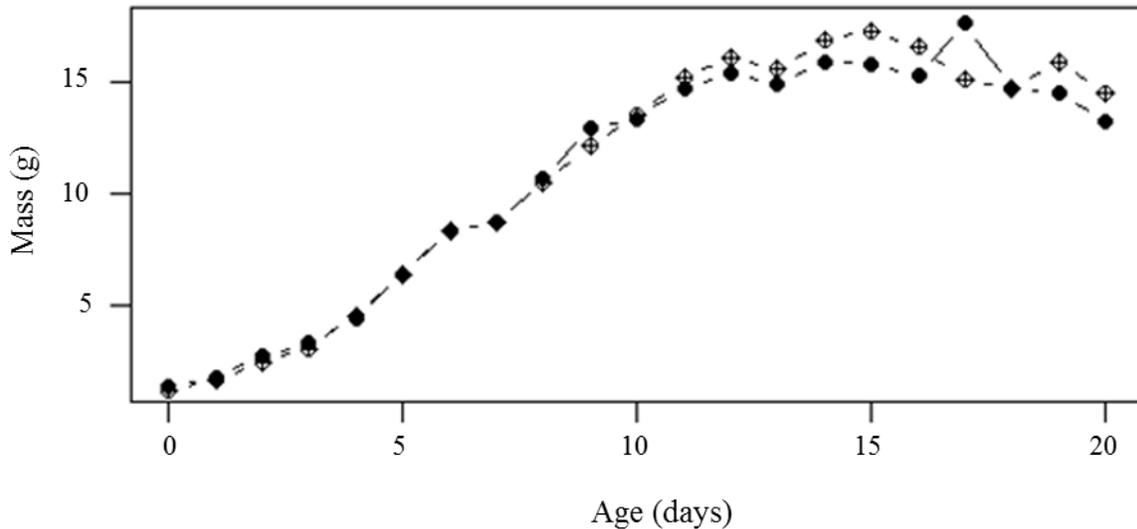


Figure 10. Daily mass measurements from day 0 (hatch day) to day 20 of two Hispaniolan Golden Swallow (*Tachycineta euchrysea sclateri*) nestlings from the same brood in 2014 in Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic

The nestling stage of the breeding season is the first and only time during which we observed adult *males* entering the nest-box, and we observed both sexes attending the nestlings. We found that chicks produced fecal sacs through to fledging, and that either all nest-boxes were either completely clean of feces after the nestlings fledged or fecal sacs remaining inside the nest-box had been excreted or carried beyond the rim of the nest cup. In a nest located in an abandoned building (see *Nesting Locations*), we observed a day 14 (estimated) nestling rise from a resting position inside the nest cup, walk along the rim of the nest, turn 180 degrees, and defecate out of the nest. In a shallow-depth natural cavity, this behavior may be sufficient in maintaining cleanliness within the nest when nestlings are older. This behavior, however, was not observed in nestlings within any of the nest-boxes. The vertical distance from the nest to the entrance hole in the nest-boxes ranged from 5-10 cm and nestlings are likely incapable of making such a demanding maneuver in order to remove their defecation from the vicinity of the nest. Furthermore, we never observed feces staining the front face of the nest-box below the entrance hole. Rather, we often observed adults removing nestling fecal sacs from the nest-box, at which point they would drop the fecal sacs from the air no closer than 2 m to the nest-box.

No ectoparasites were observed in any swallow nests or on any nestlings in JBPR, despite the ectoparasitic fly, *Philornis pici* (Diptera, Muscidae), having been documented infecting other avian taxa in the Dominican Republic, including the endemic and endangered Ridgway's Hawk (*Buteo ridgwayi*, C. D. Hayes and T. I. Hayes pers. comm., (Woolaver et al. 2014)), White-necked Crow (*Corvus leucognathus*, Wiley 2006), Palmchat (*Dulus dominicus*, J. B. LaPergola unpubl. data), Hispaniolan Woodpecker (Macquart 1853, Pont 2012, J. B. LaPergola unpubl. data), Hispaniolan Trogon (S. Guerrero pers. comm.), and very recently, the Antillean Palm-Swift (*Tachornis phoenicobia*, LaPergola in prep.). Nesting trogons and woodpeckers are found within the boundaries of JBPR while the swifts are known to forage – albeit infrequently – alongside breeding swallows in close proximity to the nest-boxes. Although *Philornis* has not yet been documented inside of JBPR, the species that are susceptible to parasitism may act as vectors for introducing *Philornis* into the higher mountains. Researchers and bird-watchers

spending time at higher elevations in Hispaniola should pay close attention for any signs of parasitism on either nestlings or adults of bird species that occur there.

Disturbing *Tachycineta* nests late in the nestling period can result in premature fledgling (Kuerzi 1941, Ardia 2006), so our limited interactions with nests at that stage provide us with little insight on the behaviors surrounding the fledging events. From a distance we would often observe day 23-26 nestlings perched in the entrance hole of the nest-box peering outwards. We also know from several repeated visits to nest-boxes between nestling days 24-27 that not all nestlings fledged at the same time, and in one case more than 48 hours had passed between subsequent fledging events from the same nest.

*Fledglings.*— Recently fledged nestlings can be identified by their “stockier” build, shorter wings and tail, and obvious yellow gape. Fledglings assumed flight and foraging behavior in abbreviated bouts, with intermittent time spent perched on low Hispaniolan pine branches where they preened and received food from parents. Adults were sometimes seen contacting fledglings bill to bill while both birds were in flight and we assume the behavior involved an exchange of food.

While observing adult swallows around our active nest-boxes on 14 June 2014, we opportunistically photographed a swallow in flight that exhibited a bright yellow gape and short, blunt rectrices and remiges – the characteristic traits of a recently fledged juvenile. The first chick to fledge from our nest-boxes that year would not do so until two days later (16 June), and so we know for certain that the juvenile in question had fledged from a natural cavity.

Swallow fledglings were never observed returning to nest-boxes during the day or at night. It was uncommon, once nestlings had fledged, for a family group to remain near the breeding site for more than a couple days. This tendency for parents and offspring to disappear after a few days around the breeding site resulted in a continuous decline in the number of swallows observed around the breeding sites from mid-June onwards.

*Adults.*— We measured morphological traits in a total of 157 adults (125 females and 32 males) over three years (Table 4). Females and males showed significant differences in flattened wing length ( $P < 0.0001$ ) and body mass ( $P < 0.0001$ ) (Welch's *t*-tests, Appendix 3), with males possessing longer wings and females a larger body mass. We opportunistically captured and measured the mass of the same female on two consecutive occasions in 2012. Twelve days into incubation (20 May) she weighed 14.45 g. Though she continued to incubate the clutch, none of the eggs hatched, leading her to bury the old eggs and lay a new clutch of three in the same nest, all of which hatched. Forty-three days after her first capture, now caring for three, day 16 nestlings, the female was recaptured and weighed 11.45 g, exactly 3 grams (21%) less. There was no evidence of molt occurring in the remiges or rectrices of any adult female or male that we captured. No captured adults were hosts to ectoparasites nor showed signs of recent ectoparasite damage.

Territoriality behavior around the breeding ground was exhibited throughout the breeding season. Male swallows perched on top of their respective nest-boxes during the nest building stage of the breeding season were observed repeatedly raising and lowering the plumage around the upper nape and crown when other swallows flew past. The presence of a Red-tailed Hawk in flight around the breeding sites elicited a strong mobbing behavior by the swallows; however, hawks perched on a branch at the forest edge drew little if no attention at all. The arrival of an observer to a breeding site would often elicit an alarm response from nearby nesting pairs that would dissipate within 10 min. Upon an observer visiting a nest-box, the associated breeding pair would engage in alarm calling while circling the nest-box repeatedly in flight at a radius of 5 to 15 m. Territorial and anti-predator diving behavior (Winkler 1992, 1994) toward an observer was very infrequent, and even when it occurred, the aggressing swallow would never come closer than 5 m from the observer.

Adult swallow mortality during the breeding seasons was predominantly due to depredation by black rats. Across all three study years, a total of thirteen individuals were killed and consumed within nest-boxes during the night during all stages of the nesting season. Remains often consisted of nothing more than the wings. In all cases there was no anti-predator baffle present. One adult was found dead

inside of an empty nest-box due to unknown causes; it is not uncommon, however for Tree Swallows to become trapped in empty nest-boxes if the depth of the box and lack of texture on the inside face of the nest-box create a scenario in which the adult cannot escape after entering (Proctor pers. obs.). In one case an adult was found dead in a narrow slit created by an ill-fitted door of a nest-box after becoming wedged in an attempt to leave through that slit as opposed to the entrance hole. Lastly, one brooding female was found dead in the back corner of a nest-box with what appeared to be only signs of a broken neck. Her brood was gone with no evidence of remains inside the nest-box. Because the nest-box contained a functioning baffle, we hypothesize that a feral cat was able to circumvent the predator guard, reach into the nest-box and remove the chicks, and mortally wound the adult swallow in the process. A feral cat was discovered in 2014 sitting on top of a baffle attempting to reach into the entrance hole of a nest-box. The cat was removed before the brood of swallows inside was harmed, but the observation of the event confirms that cats are – to our knowledge – the only predator on Hispaniola capable of bypassing our predator guards.

2012	n	$\bar{x}$ Female $\pm$ SE	RangeF	n	$\bar{x}$ Male $\pm$ SE	RangeM
Head-bill (mm)	41	26.10 $\pm$ 0.34	25.35 - 26.90	2	25.58 $\pm$ 0.18	25.45 - 25.70
Flatwing (mm)	41	110.07 $\pm$ 2.41	106.0 - 114.50	2	116 $\pm$ 1.41	115.0 - 117.0
Mass (g)	41	13.21 $\pm$ 0.89	11.02 - 14.58	2	11.32 $\pm$ 0.13	11.23 - 11.41
2013	n	$\bar{x}$ Female $\pm$ SE	RangeF	n	$\bar{x}$ Male $\pm$ SE	RangeM
Head-bill (mm)	38	26.01 $\pm$ 0.42	24.60 - 26.95	18	26.20 $\pm$ 0.42	25.30 - 26.72
Flatwing (mm)	38	111.26 $\pm$ 2.30	104.0 - 115.0	18	116.25 $\pm$ 2.07	112.50 - 119.50
Mass (g)	37	13.08 $\pm$ 0.83	11.43 - 15.22	18	12.35 $\pm$ 0.54	11.10 - 13.07
2014	n	$\bar{x}$ Female $\pm$ SE	RangeF	n	$\bar{x}$ Male $\pm$ SE	RangeM
Head-bill (mm)	46	25.95 $\pm$ 0.48	25.30 - 27.25	12	26.09 $\pm$ 0.37	25.40 - 26.65
Flatwing (mm)	46	112.21 $\pm$ 2.64	107.30 - 118.0	12	115.99 $\pm$ 1.99	113.10 - 119.50
Mass (g)	46	13.08 $\pm$ 0.96	11.07 - 15.59	11	12.42 $\pm$ 0.61	11.62 - 13.28

Table 4. Adult male and female Hispaniolan Golden Swallow (*Tachycineta euchrysea sclateri*) morphological measurements and associated statistics taken across three years (2012-2014) from Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic.

*Foraging and Diet.*— Foraging activity for aerial plankton began around dawn, increased throughout the morning, and then slowly tapered off in the afternoon. Activity was noticed to reduce on cooler, strong-winded, or lightly rainy days, and all but ceased during periods of strong rain. We observed swallows foraging over nearly every habitat found in the JBPR landscape, except for within dense forest where we assume that they are deterred by the inability to forage within the constricted structural nature of the trees, rather than by a deficiency in food abundance. Adults have been seen making quick and calculated passes into loosely vegetated forest edges, but never into the forest proper. We documented foraging occurring routinely in all three years of our study over the following landscapes: grassy fields, tussock grass savannas, stagnant and running streams, wet depressions in clearings and at forest edges, agricultural fields – including onion, garlic, carrots, and mixed gardens, horse and sheep pastures, around both occupied and abandoned human structures, over the pine forest canopy, and throughout the windy updrafts and spray generated by waterfalls. On one occasion, an adult foraging low to the pasture ground flew under the belly (between the fore and hind limbs) of a temporarily motionless, grazing sheep. Most swallow foraging was observed within 1-20 m of the ground, which corresponds respectively with the average height of the ground vegetation and surrounding pine forests. Only very rarely were swallows seen flying higher than 30 m, and though it was difficult for us to observe behavior at that height, the acrobatic, non-directional flight patterns seen were indicative of foraging.

Swallows would frequently forage in close proximity to Black Swifts (*Cypseloides niger*), but only when the swifts descended to within approximately 20 m of the ground and were foraging adjacent to swallow breeding sites. We observed three swallows foraging closely alongside Antillean Palm-Swifts at a location where we had never before observed the swallows foraging independently, alluding to the possibility that the swallows respond to visual and/or vocal cues given by other foraging aerial insectivores in the presence of prey. Swallows were never observed in close proximity to the locally common White-collared Swifts (*Streptoprocne zonaris*).

Bolus samples were taken opportunistically from adult swallows during capture events in 2013 (n=11) and 2014 (n=12). Provisioning loads regardless of sex ranged from 1-58 insects with a mean of

16.7, though these numbers are likely conservative as a result of insects possibly falling from the mouths of adults during the interval of time (15 sec. - 1 min.) between which an adult entered the nest-box to provision the chicks and when the field crew was able to extract that adult.

We analyzed a total of 383 insect specimens from 23 bolus samples that belonged to 9 orders, 47 families, and 71 genera (Tables 5, 6). The order Diptera constituted the great number of individuals by far with 265 specimens total, of which the families Bibionidae (58.0%) and Drosophilidae (12.1%) were most abundant. The Bibionids caught by the swallows consisted mostly of march flies, which are typically herbivorous, range from 3-14 mm in length (Fitzgerald 2005), and are found most frequently in grassy habitats (Hardy 1966). We observed a large pulse of emerging Bibionids each year as the wet season transitioned to the dry season (~ June). Dense swarms would be found flying 1-5 m above dirt roadways and at similar heights in adjacent pine forest. Drosophilidae is a diverse family, whose individual species are usually small (2-4 mm in length) herbivores (Wheeler 1981). Hemiptera, comprised of 87 specimens, was the second-most abundant order identified and was dominated by the family Cixiidae (55.2%), which are largely represented by herbivorous planthoppers. It should be noted that the contents of bolus samples (food being provisioned to nestlings) are not necessarily synonymous with adult diet. A comparison between adult swallow stomach contents and bolus samples would allow us to better understand whether or not different prey items are chosen based on who they are provisioning.

2013 bolus samples: 11		
Taxa	n	% of total
Diptera	185	81.86%
Hemiptera	24	10.62%
Psocoptera	8	3.54%
Coleoptera	2	0.88%
Lepidoptera	2	0.88%
Trichoptera	2	0.88%
Araneae	1	0.44%
Hymenoptera	1	0.44%
Neuroptera	1	0.44%

2014 bolus samples: 12		
Taxa	n	% of total
Diptera	80	51.61%
Hemiptera	63	40.65%
Psocoptera	5	3.23%
Hymenoptera	3	1.94%
Coleoptera	2	1.29%
Lepidoptera	1	0.65%
Unidentified	1	0.65%

Table 5. Total number of insects and corresponding taxonomic families identified from Hispaniolan Golden Swallow (*Tachycineta euchrysea sclateri*) bolus samples in 2013 and 2014 from Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic.

2013					2014						
		♀ bolus: 3		♂ bolus: 8				♀ bolus: 1		♂ bolus: 11	
Taxa	n	% of total	n	% of total	Taxa	n	% of total	n	% of total		
Diptera	50	79.37%	135	82.82%	Hemiptera	1	4.35%	62	46.97%		
Hemiptera	8	12.70%	16	9.82%	Diptera	22	95.65%	58	43.94%		
Psocoptera			8	4.91%	Psocoptera			5	3.79%		
Coleoptera			2	1.23%	Hymenoptera			3	2.27%		
Trichoptera			2	1.23%	Coleoptera			2	1.52%		
Lepidoptera	2	3.17%			Lepidoptera			1	0.76%		
Araneae	1	1.59%			Unidentified			1	0.76%		
Hymenoptera	1	1.59%									
Neuroptera	1	1.59%									

Table 6. Total number of insects and corresponding taxonomic families identified from Hispaniolan Golden Swallow (*Tachycineta euchrysea sclateri*) bolus samples in 2013 and 2014 from Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic arranged to show comparative differences in foraging selection between males and females.

*Plumage.*— Several books have done an exceptionally accurate and thorough job of describing general patterns in Hispaniolan Golden Swallow plumage, including *A Handbook to the Swallows and Martins of the World* by Turner and Rose (1989) and *Birds of the Dominican Republic and Haiti* by Latta et al. (2006). Our ability to photograph swallows in the hand provided a unique opportunity to more

closely study the subtleties in plumage coloration between adult males, adult females, and nestlings. Here we elaborate on two regions of the body – the chest and lateral regions of the neck (collar) – that we believe justify additional attention based on their potential for distinguishing sex and age in the species.

We photographed AHY (After hatch year), SY (Second year), ASY (After second year), TY (Third year), and ATY (After third year) birds. All males photographed (AHY n=19, ASY n=6, TY n=4, ATY n=2; unique individuals: 25) had snowy-white chests and collars entirely clean of mottling. We were unable to capture and photograph a known SY male and are therefore unable to say whether males of that age exhibit mottling. All females photographed (AHY n=31, SY n=2, ASY n=23, TY n=2, ATY n=14; unique individuals: 57) exhibited some degree of mottling in the chest and collar regions as well as an off-white colored chest (the intensity of a male's white chest, in a handheld comparison against a female, would be a sharper, more contrasting white) (Fig. 11).



Figure 11. Hispaniolan Golden Swallow (*Tachycineta euchrysea sclateri*) photographs from Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic. From left to right: adult ASY male with snowy-white chest and collar; adult AHY female with mottling on chest and collar; day 24 nestling with incomplete breast band and yellow gape. Photos taken by second author.

The variation in the amount of mottling across females was noticeable, and we decided to test for any possible correlation to age. We developed a basic scoring system in an attempt to measure the amount of gray mottling on one side of the breast and collar (using the side most visible in a  $\frac{3}{4}$  view photo). We scored SY, TY, and ATY females (all photographed females in which relative age to each other was

known) according to the following scale, in which the score increases from 1 to 5 as the abundance of mottling increases and the contrast transitioning from regions adjacent to the breast and collar (i.e. green neck line plumage) decreases (Fig. 12).

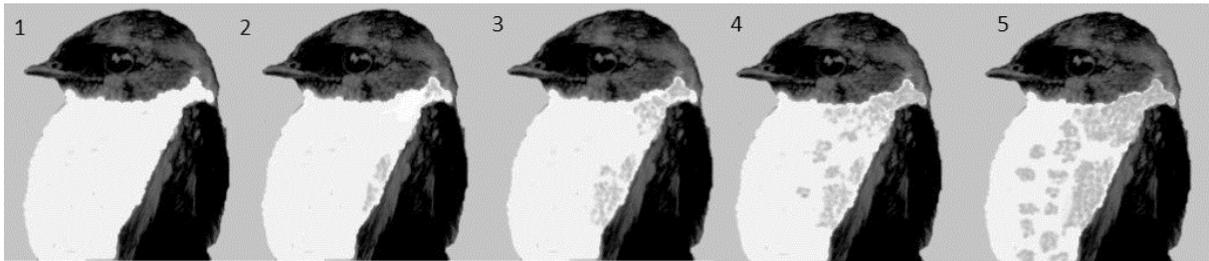


Figure 12. Diagram depicting the scoring system used to assess the extent of mottling observed around the collar and breast regions of adult female Hispaniolan Golden Swallows (*Tachycineta euchrysea sclateri*). 1: Complete absence of gray feathers on collar or breast; extreme contrast between dark and light areas; 2: Few gray patches; feathers restricted to collar and extreme sides of breast; heavy contrast between dark and light areas; 3: Gray mottling restricted to collar and breast, mostly along edges; slight gradient between dark and light areas; 4: Gray mottling present throughout collar and away from edges of breast; clear gradient between light and dark areas; 5: Gray mottling throughout collar and many patches near center of breast; little contrast between light and dark areas.

There was no strong pattern observed within the 18 females assessed; the highest score of 4, however, was assigned to a SY bird, and the lowest score of 1 was assigned to two ATY birds. All other females were assigned scores of 2 or 3, or were unable to be accurately scored based on image quality. We went one step further in analyzing the score changes within females that were caught and photographed in 2013 and then again in 2014. Of 15 repeat captures, 10 sets of photographs were of the quality needed to be scored. One individual was of known age in both years, and changed from a score of 4 as a SY to a score of 3 as a TY. The other nine females were known to age by one year between photographs, but their exact ages are unknown as they were originally banded as AHY adults. Six females scored the same in both years and three scored one ranking lower. Though our sample size is small and performing visual analyses from photographs is often an inexact procedure, our results show evidence for a reduction in mottling (and thus heightened contrast against adjacent green plumage) in the breast and collar regions of females over time. Investigators should continue to look for patterns in ongoing capture

and banding programs, since the degree of mottling shows the most promise for aging females at this time.

Nestlings were photographed opportunistically (n=6) on day 25 (just prior to fledging). None of the nestlings had mottling around the collar region, but all showed significant mottling on the chest. Five of the six nestlings exhibited mottling (in this case best described as short vertical bands rather than spots or patches of color as were observed in adult females) either extending out toward the center of the chest from the “armpit” region of the wing (Fig. 11), or as isolated bands on the center of the chest. One nestling exhibited a full chest band. Late nestling and early fledgling plumage is overall more drab than adults, though the iridescent green by which the species is most recognizable is present in nestlings on the mantle, scapulars, and back, albeit to a lesser degree than that found on mature individuals.

*Tolerance to Disturbance.*— The responses of the swallow to various natural as well as observer-induced disturbances during the breeding seasons were recorded. During the first year of study, we noticed an increase in parental investment towards a nest as the breeding season progressed (cf. Winkler 1991). This resulted in higher levels of nest abandonment due to observer-generated disturbance around the nest-boxes during earlier stages of the nesting season (egg laying and early incubation, in particular). Beginning in 2013, we modified our monitoring protocols to be more conservation-minded, and consequentially data-conservative, by reducing our interaction with the nest-boxes during these vulnerable nesting stages. Though still able to deduce clutch size, as well as clutch initiation and completion dates, lay order was only obtained opportunistically.

After encountering sudden predation pressures from the black rat in our first year of study, we were forced to relocate original tree-mounted boxes to freestanding metal posts with baffles. The relocation required each nest-box to be lowered vertically by approximately one meter, and moved horizontally one to three meters from the forest’s edge (there was concern that proximity to overhanging branches would allow the arboreal black rat to jump onto the nest-box from above). Nineteen of the relocated nest-boxes were at some various stage of nesting. There were 16 nest-boxes that were in the

nest-constructing stage during the relocation event, 14 of which quickly resumed building, and two that abandoned (but were believed, based on initiation dates, to have begun nesting again in adjacent nest-boxes). The remaining three relocated nest-boxes were each at a more advanced nesting stage (one laying, one in early incubation, and one in late incubation), yet all three pairs of swallows resumed their nesting activity within several hours. It became apparent that the black rat was capable of climbing the smooth metal posts on which the nest-boxes were newly attached, prompting the quick addition of a metal cone-shaped baffle below each nest-box. In an attempt to minimize the amount of disturbance caused by such a novel object, we spread a mixture of black paint and sawdust chips over the top of the metal baffles in order to eliminate the metal's reflective properties and thus better camouflage the baffle with the natural colors of the adjacent groundcover. Thirty-three baffles were added to active nest-boxes. Of the 27 nest-boxes in the nest building phase, 22 pairs of swallows continued building, three pairs discontinued building, and in two other nest-boxes the female continued to pass time in the nest but no eggs were laid. Two nest-boxes were early in incubation when the baffles were added, one of which continued incubating while the other abandoned, and all four nest-boxes with swallows in the late stage of incubation continued incubating.

Though these substantial changes made to the nest-box units were generally tolerated by the swallows, we found that the act of handling adults, particularly males, often produced negative consequences. Both adult males trapped in 2012 exhibited high levels of stress in the hand (i.e. eyes closing, lack of movement) after only ten seconds of handling, which deterred the field team from any further captures of males that field season. While we did not observe that magnitude of stress during handling in subsequent years, we did suffer several nest failures in 2014 occurring at nest-boxes after we had captured the associated male. Shortly thereafter, nearby nests would begin to fail from rather atypical causes, such as broken or buried eggs. We therefore hypothesize that when a male abandons his nest due to a stressor, he becomes a temporary vagrant, acting aggressively towards neighboring nesting pairs in order to establish himself a new territory and nesting site. Thus, the consequences of handling adult males during the breeding season may set into action a chain of disturbances that affect more than just the

targeted nest. This behavior and its implications at different stages of the breeding season should be studied in greater detail to refine the best capturing and handling methods for this species.

*Behavior Change in Response to Nest-box Relocation.*— As summarized in the methods section of this article, nest-boxes were relocated from tree trunks to freestanding metal poles between the 2012 and 2013 breeding seasons. Interestingly, swallows were never observed perched on the roofs on nest-boxes while they were attached to trees, with visits to the nest always involving a fast and direct entry. This behaviour changed completely when nest-boxes were attached to posts, with the immediate area around each nest-box becoming a focal point for activity. Before any nesting attempts began, males were often found perched on the segment of roof located directly above the entrance hole vocalizing aggressively toward other males flying past. Atop nearly every nest-box we observed both males and females perching and preening for prolonged periods of time. This apparent increase in level of comfort around the nest-boxes may have been a result of several changes, including the cavity's now greater distance from the edge of the forest as well as the swallow's increased capacity to view the entirety of the surrounding landscape from a fixed (perched) position. Both changes would presumably allow a perching swallow to respond sooner to threats approaching from any direction. It is also possible that the swallows had originally developed a behavioral response to arboreal black rats, in that by refraining from activity around an arboreal cavity (in our case a nest-box attached to a tree in 2012) they had reduced the chance of exposing their nest's location to potential depredation. Two additional and unique anecdotes support this hypothesis. First, the movement of three nest-boxes from trees to posts occurred under situations in which the post was not shifted away from the forest's edge and into the open fields, but rather remained several meters inside the forest. Though each nest-box became active with a nesting pair, swallow behavior around the nest-box remained as it had been when the nest-box was originally attached to the tree. In the second instance, two nest-boxes remained attached to trees that stood solitary in open fields, and despite subsequent nesting activity, no swallows were ever observed perching on those nest-boxes. These behavioral changes stayed consistent throughout the 2014 breeding season.

## CONCLUSION

Here we have reported the first systematic natural history observations of the Hispaniolan Golden Swallow. Though, it is important to remember that understanding and documenting the natural history of a resident and threatened species provides a necessary fundamental base from which more detailed scientific investigations and conservation can grow. Furthermore, we have looked in detail at the swallow's breeding biology across three reproductive seasons; we should be cautious, however, in generalizing this information across the whole of the species as a whole until breeding swallow populations in other mountain chains in Hispaniola are studied more extensively. Our results stem specifically from a high-elevation breeding population in the montane pine forests of the Cordillera Central, yet the swallows are known to breed elsewhere. There exists the possibility that movements of populations between mountain chains is limited – and may have been for quite some time – which leads us to wonder if any genotypic or phenotypic changes due to isolation occur in these populations.

The nest-box monitoring program continues to be overseen by local Dominican organizations, with all nest-boxes being monitored and documented throughout the breeding seasons. Data collected is being continually added to a growing, central database from which long-term analyses will be able to be conducted. We are particularly interested in continuing to study the limitations and determinants of the species' survival and reproductive success so as to allow more informed conservation management plans on the island of Hispaniola. Additionally, we will be excited to put the breeding biology of the swallow into context with its *Tachycineta* congeners.

With the establishment of a breeding population of swallows returning annually to the network of nest-boxes, the opportunities for conducting a wider breadth of scientific research on the species are many. We strongly encourage Dominican (as well as international) students to consider investigating some of the many unknown life history traits that still surround the Hispaniolan Golden Swallow. Such topics could include migration and dispersal, conditions on the wintering grounds, annual survival, and adult and fledgling return rates. Additionally, more direct conservation efforts, such as designing and

implementing methods for invasive mammal control, are in need of attention. In a time of serious concern over aerial insectivore decline in North America, much of what is to be learned about the Hispaniolan Golden Swallow could shed invaluable light on relevant issues impacting other species within the guild.

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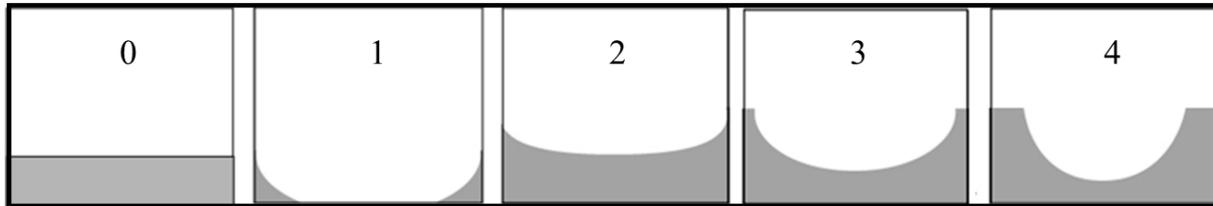
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APPENDIX

Appendix 1. Cup nest scoring index ranging from 0 to 4, adopted from the Golondrinas de Las Américas project (<http://golondrinas.cornell.edu>). Diagram depicts nest shape (grey shading) seen from a profile view.



Appendix 2. Welch's *t*-test analysis of the effect of lay order on Hispaniolan Golden Swallow (*Tachycineta euchrysea sclateri*) egg mass, width, and length, pooled across years (2012-2014) in Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic. N's = (1<sup>st</sup> egg: l=36, w=36, m=32), (2<sup>nd</sup> egg: l=16, w=16, m=14), (3<sup>rd</sup> egg: l=28, w=28, m=27), (4<sup>th</sup> egg: l=4, w=4, m=3) where l=length, w=width, and m=mass.

<i>t</i> -Test	Mean <sub>1</sub>	Mean <sub>2</sub>	<i>t</i>	df	<i>P</i>
1 <sup>st</sup> egg vs 2 <sup>nd</sup> egg: mass (g)	1.69	1.76	1.6	20	0.12
1 <sup>st</sup> egg vs 2 <sup>nd</sup> egg: width (cm)	13.05	13.25	1.8	33	0.08
1 <sup>st</sup> egg vs 2 <sup>nd</sup> egg: length (cm)	18.51	18.67	0.5	21	0.60
1 <sup>st</sup> egg vs 3 <sup>rd</sup> egg: mass	1.69	1.75	2.5	54	<b>0.02</b>
1 <sup>st</sup> egg vs 3 <sup>rd</sup> egg: width	13.05	13.23	2.0	54	<b>0.05</b>
1 <sup>st</sup> egg vs 3 <sup>rd</sup> egg: length	18.51	18.88	2.0	57	<b>0.05</b>
1 <sup>st</sup> egg vs 4 <sup>th</sup> egg: mass	1.69	1.78	1.2	2	0.34
1 <sup>st</sup> egg vs 4 <sup>th</sup> egg: width	13.05	12.98	0.5	4	0.62
1 <sup>st</sup> egg vs 4 <sup>th</sup> egg: length	18.51	19.13	1.2	2	0.33
2 <sup>nd</sup> egg vs 3 <sup>rd</sup> egg: mass	1.76	1.75	0.3	16	0.80
2 <sup>nd</sup> egg vs 3 <sup>rd</sup> egg: width	13.25	13.23	0.3	24	0.80
2 <sup>nd</sup> egg vs 3 <sup>rd</sup> egg: length	18.67	18.88	0.7	19	0.48
2 <sup>nd</sup> egg vs 4 <sup>th</sup> egg: mass	1.76	1.78	0.2	3	0.87
2 <sup>nd</sup> egg vs 4 <sup>th</sup> egg: width	13.25	12.98	1.9	4	0.12
2 <sup>nd</sup> egg vs 4 <sup>th</sup> egg: length	18.67	19.13	0.8	3	0.46
3 <sup>rd</sup> egg vs 4 <sup>th</sup> egg: mass	1.75	1.78	0.3	2	0.76
3 <sup>rd</sup> egg vs 4 <sup>th</sup> egg: width	13.23	12.98	2.0	3	0.15
3 <sup>rd</sup> egg vs 4 <sup>th</sup> egg: length	18.88	19.13	0.5	2	0.65

Appendix 3. Welch's *t*-test analyses (a) and summary of all three years (2012-2014) pooled together (b) of the effect of sex on each of three morphometric traits measured in adult Hispaniolan Golden Swallows (*Tachycineta euchrysea sclateri*) in Parque Nacional Juan Bautista Pérez Rancier, La Vega Province, Dominican Republic. N's = (2012: F-hb=41, F-fw=41, F-m=41; M-hb=2, M-fw=2, M-m=2), (2013: F-hb=39, F-fw=39, F-m=38; M-hb=18, M-fw=18, M-m=18), (2014: F-hb=46, F-fw=46, F-m=46; M-hb=12, M-fw=12, M-m=11), where F=female, M=male, hb=head-bill, fw=flatwing, and m=mass.

(a)

<i>t</i> -Test	Mean <sub>1</sub>	Mean <sub>2</sub>	<i>t</i>	df	<i>P</i>
2012 Female vs 2013 Female: head-bill (mm)	26.10	26.02	0.9	69	0.359
2012 Female vs 2013 Female: flatwing (mm)	110.07	111.24	2.2	76	<b>0.033</b>
2012 Female vs 2013 Female: mass (g)	13.21	13.08	0.7	76	0.476
2012 Female vs 2014 Female: head-bill	26.10	25.95	1.8	83	0.077
2012 Female vs 2014 Female: flatwing	110.07	112.20	3.9	85	<b>&lt;0.0002</b>
2012 Female vs 2014 Female: mass	13.21	13.08	0.7	85	0.509
2013 Female vs 2014 Female: head-bill	26.02	25.95	0.7	79	0.463
2013 Female vs 2014 Female: flatwing	111.24	112.21	1.8	80	0.079
2013 Female vs 2014 Female: mass	13.08	13.08	0.0	80	0.967
2012 Male vs 2013 Male: head-bill	25.58	26.02	3.1	2	0.111
2012 Male vs 2013 Male: flatwing	116.00	111.24	4.4	1	0.095
2012 Male vs 2013 Male: mass	11.32	13.08	10.7	10	<b>&lt;0.0001</b>
2012 Male vs 2014 Male: head-bill	25.58	26.04	2.9	3	0.071
2012 Male vs 2014 Male: flatwing	116.00	115.79	0.2	2	0.875
2012 Male vs 2014 Male: mass	11.32	12.42	5.4	10	<b>&lt;0.0004</b>
2013 Male vs 2014 Male: head-bill	26.02	26.04	0.2	20	0.832
2013 Male vs 2014 Male: flatwing	111.24	115.79	6.5	19	<b>&lt;0.0001</b>
2013 Male vs 2014 Male: mass	13.08	12.42	2.9	22	<b>0.009</b>
2012 Adult vs 2013 Adult: head-bill	26.07	26.07	0.0	96	0.974
2012 Adult vs 2013 Adult: flatwing	110.35	112.88	4.2	96	<b>&lt;0.0001</b>
2012 Adult vs 2013 Adult: mass	13.13	12.84	1.6	83	0.119
2012 Adult vs 2014 Adult: head-bill	26.07	25.96	1.4	97	0.169
2012 Adult vs 2014 Adult: flatwing	110.35	112.9	4.6	94	<b>&lt;0.0001</b>
2012 Adult vs 2014 Adult: mass	13.13	12.95	0.9	90	0.371
2013 Adult vs 2014 Adult: head-bill	26.07	25.96	1.4	110	0.172
2013 Adult vs 2014 Adult: flatwing	112.88	112.90	0.0	107	0.970
2013 Adult vs 2014 Adult: mass	12.84	12.95	0.7	109	0.485
2012 Female vs Male: head-bill	26.10	25.58	3.8	1	0.105
2012 Female vs Male: flatwing	110.07	116.00	5.5	1	0.073
2012 Female vs Male: mass	13.21	11.32	11.5	10	<b>&lt;0.0001</b>
2013 Female vs Male: head-bill	26.02	26.02	0.0	72	1.000
2013 Female vs Male: flatwing	111.24	111.24	0.0	72	1.000
2013 Female vs Male: mass	13.08	13.08	0.0	72	1.000
2014 Female vs Male: head-bill	25.95	26.04	0.8	19	0.441
2014 Female vs Male: flatwing	112.21	115.79	5.1	20	<b>&lt;0.0001</b>
2014 Female vs Male: mass	13.08	12.42	2.9	23	<b>0.008</b>

(b)

<i>t</i> -Test	Mean <sub>1</sub>	Mean <sub>2</sub>	<i>t</i>	df	<i>P</i>
Female vs Male: head-bill (mm)	26.12	26.02	1.2	45	0.241
Female vs Male: flatwing (mm)	116.11	111.23	11.4	59	<b>&lt;0.0001</b>
Female vs Male: mass (g)	13.12	12.31	6.1	67	<b>&lt;0.0001</b>

LAST SEARCH FOR THE JAMAICAN GOLDEN SWALLOW

(*TACHYGINETA 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 1500 – 7000 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 634 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*

*Resumen.* — 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 1500 – 1700 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 634 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 relictas 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.*

## INTRODUCTION

Although considerably smaller than Cuba (109,884 km<sup>2</sup>) to the north and Hispaniola (76,192 km<sup>2</sup>) to the east, the island of Jamaica at 10,982 km<sup>2</sup> hosts 30 endemic bird species—the highest number for any West Indian island. In total, the island boasts about 16 breeding species of aerial insectivore (and 307 bird species overall), represented by five families: potoos (Nyctibiidae), nightjars (Caprimulgidae), 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 at storm fronts. Even though they belong to the same broad dietary guild, flycatchers and nocturnal 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 gundlachi*), Black Swift (*Cypseloides niger*), White-collared Swift (*Streptoprocne zonaris*), Antillean Palm-Swift (*Tachornis phoenicobia*), Caribbean Martin (*Progne dominicensis*), Tree Swallow (*Tachycineta bicolor*), Northern Rough-winged Swallow (*Stelgidopteryx serripennis*), Cave Swallow (*Petrochelidon fulva*), and Barn Swallow (*Hirundo rustica*).

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-20<sup>th</sup> 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 1982:32):

"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 Barbecue 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*) was described by the American ornithologist, Charles B. Cory (1884), and though considered common in the early 20<sup>th</sup> 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. 2004, 2005, 2010, Latta et al. 2006, Townsend et al. 2008) (Fig. 1). The current population is estimated to range from 1500 to 7000 individuals (BirdLife International 2012) and is categorized as vulnerable by the International Union for Conservation of Nature (BirdLife International 2015).



Figure 1. Hispaniolan Golden Swallows (*Tachycineta. euchrysea sclateri*) in Parque Valle Nuevo, Dominican Republic. Left to right: adult in flight; adult perched on artificial nest-box; nestlings 25 days after hatching - one day prior to fledging (Proctor thesis). The Jamaican Golden Swallow would be difficult to distinguish from the Hispaniolan Golden Swallow under field conditions. Photos taken by lead author.

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 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.

#### STUDY AREA AND 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 survey was conducted in the Port Royal Mountains, Blue Mountains, and John Crow Mountains (St. Andrew, Portland, and St. Thomas parishes) from 4–23 March 2015 (20 field days) and in Cockpit Country (Trelawny Parish) from 24–27 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 and/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-degree scan of the area while simultaneously listening for vocalizations. Field of view was dependent on topography as well

as on canopy cover and tree height. The duration of point counts was 5 minutes. 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 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. 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 between two or more studies 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 are, 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 matrices with few species and equiprobable sites (Gotelli 2000). We performed the statistical analysis using the software R (version 3.0.1) and the package EcoSimR (Gotelli and Ellison 2013).

## RESULTS

Over the course of our 52 field days, CJP, SEI, and JMZ completed 634 standardized point counts while surveying more than 480 km of trail across Cockpit Country and the Blue Mountains (Appendix 1). 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); (iii) >600 m (n = 46 sites). We conducted 249 censuses in the Blue Mountains at sites ranging from 10 m to 2251 m above sea level: (i) 0–700 m (n = 117 sites); (ii) 701–1400 m (n = 87 sites); (iii) >1400 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 (Figs. 2, 3), and Cinchona, St. Andrew Parish.



Figure 2. Barbecue Bottom, Trelawny Parish, in eastern Cockpit Country, site of the last known observation of the Jamaican Golden Swallow. Photo taken by lead author.

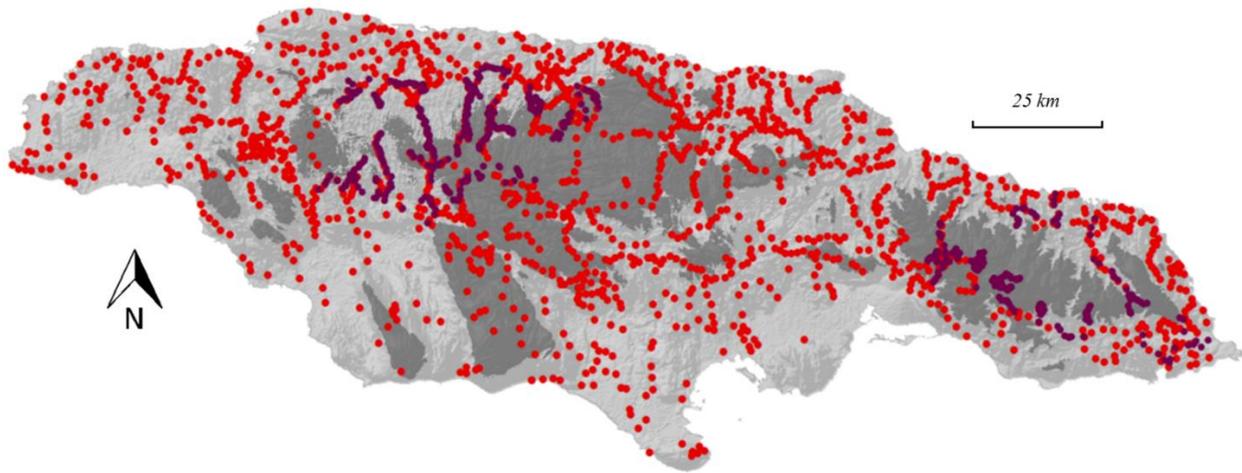


Figure 3. Standardized census sites for Golden Swallows in Jamaica ( $N = 2,066$ ). Red circles indicate 1,281 census sites conducted by Graves (2014) and unpublished census sites ( $n = 151$ ) compiled by Graves in December 2013. Dark purple circles indicate census sites ( $n = 634$ ) reported in the present study. Collectively, informal surveys and standardized censuses were conducted from 1994 to 2015. Map shading depicts topography, with colors darkening as elevation increases.

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), 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 was likely referable to the Black Swift 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 (see Tables 1, 2). 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 more frequently than expected by chance (observed C-score = 1876.3; mean and standard

deviation of simulated C-scores =  $1302.6 \pm 117.0$ ;  $P = 0.001$ ) (Table 3). Patterns of aggregation in the Cockpit Country region were driven by significant 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, aggregations of White-collared Swifts with Antillean Palm-Swifts ( $P < 0.0001$ ) and again with Cave Swallows ( $P = 0.015$ ) were statistically significant.

Species	Number of census sites observed	Number observed per occupied site; range ( $\bar{x} \pm SD$ )
Cave Swallow <i>Petrochelidon fulva</i>	50	1–90 ( $13.5 \pm 17.4$ )
White-collared Swift <i>Streptoprocne zonaris</i>	21	1–100 ( $19.9 \pm 30.6$ )
Antillean Palm-Swift <i>Tachornis phoenicobia</i>	42	1–85 ( $7.5 \pm 16.3$ )

Table 1. Aerial insectivores observed at 386 census sites in the Cockpit Country region of Jamaica (15 January–12 February, 2015 and 24–27 March 2015)

Species	Number of census sites observed	Number observed per occupied site; range ( $\bar{x} \pm SD$ )
Cave Swallow <i>Petrochelidon fulva</i>	12	1–55 ( $21.4 \pm 17.8$ )
White-collared Swift <i>Streptoprocne zonaris</i>	37	1–471 ( $28.7 \pm 76.4$ )
Antillean Palm-Swift <i>Tachornis phoenicobia</i>	14	1–7 ( $2.6 \pm 1.9$ )

Table 2. Aerial insectivores observed at 248 census sites in the Blue Mountain region of Jamaica (4–23 March, 2015)

	Observed C-score	Simulated C-score; $\bar{x} \pm SD$	P-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

Table 3. Summary of observed and simulated C-scores in pairwise comparisons of aerial insectivores. WCSW = White-collared Swift, APSW = Antillean Palm-Swift, CASW = Cave Swallow. P-values < 0.05 are considered statistically significant.

## DISCUSSION

Golden swallows are not cryptic. Diurnal acrobatic foraging and often curious demeanor toward humans make them an easily detectable search target (Proctor et al. in prep.). More than 30 years 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 the species persists elsewhere in the Caribbean or on 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 the extinction of the Jamaican Golden Swallow should be fleshed out, and those risks should be considered in conservation management plans for the declining Hispaniolan Golden Swallow. Whether or not the Jamaican Golden Swallow was ever numerous and/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 will be key to 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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APPENDIX

Appendix 1. List of all 634 standardized census counts conducted in the Cockpit Country and Blue Mountain regions of Jamaica, Greater Antilles, in 2015.

#	Latitude	Longitude	Date	Time	#	Latitude	Longitude	Date	Time	#	Latitude	Longitude	Date	Time
1	18.3494	-77.6439	1/16/2015	13:47	212	18.2205	-77.7187	1/31/2015	9:24	423	18.0461	-76.6206	3/6/2015	9:49
2	18.3458	-77.6410	1/16/2015	14:16	213	18.2220	-77.7195	1/31/2015	9:35	424	18.0462	-76.6237	3/6/2015	10:11
3	18.3457	-77.6402	1/16/2015	14:30	214	18.2247	-77.7191	1/31/2015	9:57	425	18.0479	-76.6236	3/6/2015	10:23
4	18.3433	-77.6391	1/16/2015	14:45	215	18.2007	-77.7137	1/31/2015	10:19	426	18.0135	-76.6153	3/6/2015	13:32
5	18.3419	-77.6401	1/16/2015	15:01	216	18.1948	-77.7144	1/31/2015	10:38	427	18.0084	-76.6107	3/6/2015	13:45
6	18.3414	-77.6407	1/16/2015	15:09	217	18.1891	-77.7185	1/31/2015	10:50	428	18.0085	-76.6051	3/6/2015	13:56
7	18.3384	-77.6410	1/16/2015	15:38	218	18.1887	-77.7221	1/31/2015	11:02	429	18.0075	-76.6015	3/6/2015	14:16
8	18.3343	-77.6415	1/16/2015	15:44	219	18.2003	-77.7427	1/31/2015	11:17	430	18.0039	-76.5984	3/6/2015	14:24
9	18.3321	-77.6381	1/17/2015	9:14	220	18.2085	-77.7509	1/31/2015	11:31	431	17.9964	-76.5933	3/6/2015	14:35
10	18.3321	-77.6360	1/17/2015	9:25	221	18.2195	-77.7564	1/31/2015	11:46	432	17.9889	-76.5871	3/6/2015	14:44
11	18.3270	-77.6318	1/17/2015	11:08	222	18.2260	-77.7541	1/31/2015	12:00	433	17.9902	-76.5870	3/6/2015	14:52
12	18.3249	-77.6312	1/17/2015	11:30	223	18.2298	-77.7643	1/31/2015	15:17	434	17.9700	-76.5447	3/6/2015	15:14
13	18.3234	-77.6312	1/17/2015	11:46	224	18.2286	-77.7648	1/31/2015	15:25	435	17.9833	-76.5409	3/6/2015	17:06
14	18.3222	-77.6327	1/17/2015	12:04	225	18.2200	-77.7677	1/31/2015	15:38	436	17.9833	-76.5409	3/7/2015	7:15
15	18.3206	-77.6340	1/17/2015	13:37	226	18.2129	-77.7735	1/31/2015	15:55	437	17.9841	-76.5423	3/7/2015	7:59
16	18.3127	-77.6283	1/18/2015	8:17	227	18.2117	-77.7731	1/31/2015	15:58	438	17.9900	-76.5416	3/7/2015	8:39
17	18.3118	-77.6283	1/18/2015	8:25	228	18.2363	-77.7587	2/1/2015	8:15	439	17.9912	-76.5444	3/7/2015	8:51
18	18.3091	-77.6287	1/18/2015	8:37	229	18.2398	-77.7570	2/1/2015	8:25	440	17.9934	-76.5448	3/7/2015	9:17
19	18.3072	-77.6287	1/18/2015	8:49	230	18.2445	-77.7498	2/1/2015	8:43	441	17.9955	-76.5445	3/7/2015	9:30
20	18.3043	-77.6290	1/18/2015	9:05	231	18.2491	-77.7477	2/1/2015	9:07	442	17.9973	-76.5436	3/7/2015	9:43
21	18.3030	-77.6274	1/18/2015	9:20	232	18.2498	-77.7449	2/1/2015	9:22	443	18.0005	-76.5426	3/7/2015	10:04
22	18.3015	-77.6271	1/18/2015	9:30	233	18.2547	-77.7407	2/1/2015	9:55	444	18.0026	-76.5419	3/7/2015	10:17
23	18.3007	-77.6259	1/18/2015	9:42	234	18.2549	-77.7401	2/1/2015	10:06	445	18.0025	-76.5397	3/7/2015	11:00
24	18.2998	-77.6253	1/18/2015	9:56	235	18.2597	-77.7383	2/1/2015	11:36	446	17.9995	-76.5370	3/7/2015	11:15
25	18.2991	-77.6248	1/18/2015	10:05	236	18.2108	-77.7718	2/1/2015	14:37	447	17.9956	-76.5372	3/7/2015	12:01
26	18.2973	-77.6241	1/18/2015	10:23	237	18.2055	-77.7785	2/1/2015	14:48	448	17.9911	-76.5357	3/7/2015	12:12
27	18.3030	-77.6274	1/18/2015	11:30	238	18.2204	-77.7870	2/1/2015	15:04	449	17.9878	-76.5375	3/7/2015	12:33
28	18.3430	-77.6394	1/18/2015	15:22	239	18.2293	-77.7991	2/1/2015	15:19	450	17.9629	-76.5111	3/7/2015	14:17
29	18.3781	-77.6401	1/20/2015	8:13	240	18.2204	-77.8060	2/1/2015	15:31	451	17.9562	-76.5069	3/7/2015	14:26
30	18.3797	-77.6324	1/20/2015	8:24	241	18.2137	-77.8095	2/1/2015	15:40	452	17.9459	-76.4998	3/7/2015	14:34
31	18.3904	-77.6345	1/20/2015	8:35	242	18.2042	-77.8211	2/1/2015	15:58	453	17.9433	-76.4914	3/7/2015	14:42
32	18.3895	-77.6367	1/20/2015	8:47	243	18.3238	-77.5175	2/3/2015	17:00	454	17.9439	-76.4866	3/7/2015	14:51
33	18.3905	-77.6469	1/20/2015	9:05	244	18.3633	-77.4338	2/3/2015	10:53	455	17.9444	-76.4650	3/7/2015	15:04
34	18.3895	-77.6491	1/20/2015	9:12	245	18.3665	-77.4488	2/3/2015	14:35	456	17.9704	-76.4557	3/8/2015	8:24
35	18.3923	-77.6517	1/20/2015	9:40	246	18.3648	-77.4476	2/3/2015	14:47	457	17.9726	-76.4568	3/8/2015	8:39
36	18.3936	-77.6592	1/20/2015	10:05	247	18.3642	-77.4479	2/3/2015	14:55	458	17.9743	-76.4605	3/8/2015	8:53
37	18.3914	-77.6652	1/20/2015	10:20	248	18.3642	-77.4456	2/3/2015	15:05	459	17.9811	-76.4581	3/8/2015	9:29
38	18.3906	-77.6681	1/20/2015	10:40	249	18.3735	-77.4480	2/3/2015	8:25	460	17.9845	-76.4606	3/8/2015	9:51
39	18.3922	-77.6774	1/20/2015	10:55	250	18.3708	-77.4477	2/3/2015	8:53	461	17.9864	-76.4605	3/8/2015	10:09
40	18.3887	-77.6806	1/20/2015	11:15	251	18.3701	-77.4477	2/3/2015	9:06	462	17.9899	-76.4573	3/8/2015	10:27
41	18.3941	-77.6862	1/20/2015	12:00	252	18.3678	-77.4483	2/3/2015	9:22	463	17.9927	-76.4568	3/8/2015	10:50
42	18.3959	-77.6927	1/20/2015	12:13	253	18.3639	-77.4427	2/3/2015	10:19	464	17.9980	-76.4544	3/8/2015	11:22
43	18.3717	-77.7223	1/20/2015	13:38	254	18.3668	-77.4364	2/3/2015	10:44	465	17.9992	-76.4534	3/8/2015	12:23
44	18.3707	-77.7203	1/20/2015	13:46	255	18.3614	-77.4313	2/3/2015	11:27	466	18.0406	-76.7315	3/9/2015	15:22
45	18.3677	-77.7178	1/20/2015	14:00	256	18.3589	-77.4304	2/3/2015	11:33	467	18.0463	-76.7283	3/9/2015	15:31
46	18.3667	-77.7170	1/20/2015	14:12	257	18.3577	-77.4269	2/3/2015	11:51	468	18.0528	-76.7226	3/9/2015	15:45
47	18.3648	-77.7168	1/20/2015	14:20	258	18.3519	-77.4276	2/3/2015	12:13	469	18.0660	-76.7159	3/9/2015	16:01
48	18.3639	-77.7170	1/20/2015	14:25	259	18.3490	-77.4290	2/3/2015	12:24	470	18.0724	-76.7143	3/9/2015	16:22
49	18.3605	-77.7164	1/20/2015	14:40	260	18.3439	-77.4296	2/3/2015	12:37	471	18.0850	-76.7315	3/10/2015	8:15
50	18.3619	-77.7151	1/20/2015	14:52	261	18.3399	-77.4324	2/3/2015	12:49	472	18.0832	-76.7357	3/10/2015	8:27
51	18.3565	-77.7106	1/20/2015	15:15	262	18.3389	-77.4338	2/3/2015	13:32	473	18.0839	-76.7365	3/10/2015	8:34
52	18.3528	-77.7123	1/20/2015	15:22	263	18.3411	-77.4343	2/3/2015	13:40	474	18.0831	-76.7382	3/10/2015	8:49
53	18.3519	-77.7121	1/20/2015	15:33	264	18.3451	-77.4357	2/3/2015	13:56	475	18.0803	-76.7413	3/10/2015	9:04
54	18.3798	-77.7484	1/21/2015	8:30	265	18.3445	-77.4402	2/3/2015	14:06	476	18.0785	-76.7420	3/10/2015	9:10
55	18.3783	-77.7503	1/21/2015	8:43	266	18.3475	-77.4412	2/3/2015	14:23	477	18.0591	-76.7226	3/10/2015	11:08
56	18.3764	-77.7586	1/21/2015	9:05	267	18.3484	-77.4444	2/3/2015	14:33	478	18.0734	-76.6541	3/10/2015	14:53
57	18.3751	-77.7606	1/21/2015	9:22	268	18.3558	-77.4443	2/3/2015	15:01	479	18.0747	-76.6590	3/10/2015	15:12
58	18.3676	-77.7629	1/21/2015	10:03	269	18.3560	-77.4428	2/3/2015	15:09	480	18.0703	-76.6554	3/10/2015	16:13
59	18.3654	-77.7667	1/21/2015	10:28	270	18.3588	-77.4441	2/3/2015	15:23	481	18.0699	-76.6561	3/10/2015	16:24
60	18.3643	-77.7690	1/21/2015	10:40	271	18.3735	-77.4480	2/3/2015	15:38	482	18.0709	-76.6562	3/10/2015	16:34
61	18.3647	-77.7732	1/21/2015	11:07	272	18.3301	-77.5166	2/4/2015	8:46	483	18.0786	-76.6542	3/11/2015	8:38
62	18.3632	-77.7763	1/21/2015	11:23	273	18.3325	-77.5178	2/4/2015	9:00	484	18.0802	-76.6553	3/11/2015	8:52
63	18.3606	-77.7837	1/21/2015	11:53	274	18.3366	-77.5188	2/4/2015	9:24	485	18.0815	-76.6530	3/11/2015	9:39
64	18.3900	-77.7600	1/21/2015	14:00	275	18.3373	-77.5188	2/4/2015	9:33	486	18.0815	-76.6523	3/11/2015	9:54
65	18.3900	-77.7600	1/22/2015	8:00	276	18.3384	-77.5204	2/4/2015	9:41	487	18.0815	-76.6499	3/11/2015	10:04
66	18.3900	-77.7600	1/22/2015	9:00	277	18.3390	-77.5204	2/4/2015	9:49	488	18.0851	-76.6485	3/11/2015	10:18
67	18.3900	-77.7600	1/22/2015	9:00	278	18.3406	-77.5190	2/4/2015	9:59	489	18.0924	-76.6493	3/11/2015	10:48
68	18.3900	-77.7600	1/22/2015	9:10	279	18.3420	-77.5190	2/4/2015	10:06	490	18.0937	-76.6426	3/11/2015	11:25
69	18.3900	-77.7600	1/22/2015	10:20	280	18.3458	-77.5179	2/4/2015	10:29	491	18.0837	-76.6491	3/11/2015	13:28
70	18.3900	-77.7600	1/22/2015	12:00	281	18.3471	-77.5168	2/4/2015	10:57	492	18.0773	-76.6513	3/11/2015	13:54
71	18.3796	-77.7677	1/22/2015	12:30	282	18.3486	-77.5171	2/4/2015	11:06	493	18.0752	-76.6607	3/11/2015	14:29
72	18.3900	-77.7600	1/22/2015	13:40	283	18.3494	-77.51							

73	18.3900	-77.7600	1/22/2015	17:28	284	18.3403	-77.5090	2/4/2015	17:30	495	18.0780	-76.6649	3/11/2015	14:50
74	18.3961	-77.7670	1/22/2015	18:00	285	18.3403	-77.5090	2/5/2015	6:50	496	18.0773	-76.6629	3/11/2015	15:14
75	18.3738	-77.7552	1/23/2015	10:55	286	18.3182	-77.5103	2/5/2015	9:02	497	18.0752	-76.6515	3/12/2015	8:24
76	18.4002	-77.7305	1/23/2015	11:18	287	18.3146	-77.5084	2/5/2015	9:15	498	18.0785	-76.6493	3/12/2015	8:34
77	18.3961	-77.7670	1/23/2015	17:00	288	18.3133	-77.5051	2/5/2015	9:28	499	18.0823	-76.6448	3/12/2015	8:55
78	18.3979	-77.5590	1/23/2015	17:10	289	18.3122	-77.5008	2/5/2015	9:41	500	18.0832	-76.6440	3/12/2015	9:03
79	18.3969	-77.5577	1/24/2015	8:00	290	18.3145	-77.4941	2/5/2015	10:05	501	18.0775	-76.6460	3/12/2015	9:26
80	18.3957	-77.5577	1/24/2015	8:08	291	18.3126	-77.4894	2/5/2015	10:20	502	18.0759	-76.6462	3/12/2015	9:37
81	18.3944	-77.5572	1/24/2015	8:27	292	18.3107	-77.4835	2/5/2015	10:58	503	18.0743	-76.6457	3/12/2015	9:48
82	18.3921	-77.5547	1/24/2015	8:38	293	18.3403	-77.5090	2/5/2015	11:07	504	18.0696	-76.6458	3/12/2015	10:28
83	18.3911	-77.5530	1/24/2015	8:52	294	18.3061	-77.4825	2/5/2015	11:20	505	18.0696	-76.6458	3/12/2015	10:28
84	18.3880	-77.5512	1/24/2015	9:10	295	18.3033	-77.4773	2/5/2015	11:48	506	18.0692	-76.6517	3/12/2015	11:07
85	18.3855	-77.5516	1/24/2015	9:38	296	18.3054	-77.4769	2/5/2015	12:05	507	18.0627	-76.6517	3/12/2015	11:32
86	18.3857	-77.5533	1/24/2015	10:02	297	18.3075	-77.4774	2/5/2015	12:16	508	18.0622	-76.6534	3/12/2015	12:01
87	18.3838	-77.5562	1/24/2015	10:15	298	18.3097	-77.4788	2/5/2015	12:25	509	18.0632	-76.6558	3/12/2015	12:46
88	18.3878	-77.5505	1/24/2015	10:57	299	18.3090	-77.4807	2/5/2015	12:37	510	18.0656	-76.6584	3/12/2015	13:03
89	18.3871	-77.5483	1/24/2015	11:07	300	18.3124	-77.4852	2/5/2015	14:04	511	18.0756	-76.6421	3/12/2015	16:11
90	18.3865	-77.5456	1/24/2015	11:13	301	18.3133	-77.5051	2/5/2015	14:58	512	18.0916	-76.6988	3/14/2015	8:25
91	18.3877	-77.5449	1/24/2015	11:22	302	18.3166	-77.5106	2/5/2015	15:20	513	18.0952	-76.7111	3/14/2015	8:40
92	18.3827	-77.5499	1/24/2015	11:53	303	18.3403	-77.5090	2/5/2015	16:10	514	18.1050	-76.7124	3/14/2015	8:52
93	18.3807	-77.5495	1/24/2015	12:00	304	18.3403	-77.5090	2/6/2015	6:45	515	18.1189	-76.7184	3/14/2015	9:36
94	18.3708	-77.5512	1/24/2015	12:23	305	18.3852	-77.4460	2/6/2015	10:04	516	18.1225	-76.7185	3/14/2015	9:53
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97	18.3585	-77.5559	1/24/2015	14:00	308	18.3728	-77.3302	2/6/2015	14:01	519	18.1424	-76.7192	3/14/2015	11:30
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103	18.3880	-77.5512	1/25/2015	8:30	314	18.3442	-77.3467	2/6/2015	16:15	525	18.0170	-76.3845	3/15/2015	7:41
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107	18.3783	-77.5435	1/25/2015	10:42	318	18.3413	-77.3690	2/7/2015	8:18	529	17.9863	-76.3839	3/15/2015	10:53
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109	18.3761	-77.5403	1/25/2015	12:08	320	18.3390	-77.3755	2/7/2015	8:51	531	18.0094	-76.3821	3/15/2015	13:17
110	18.3775	-77.5444	1/25/2015	13:15	321	18.3359	-77.3773	2/7/2015	9:19	532	18.0169	-76.3844	3/15/2015	13:43
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121	18.3819	-77.5470	1/25/2015	16:20	332	18.3027	-77.3998	2/7/2015	13:45	543	18.0181	-76.3812	3/16/2015	18:12
122	18.3997	-77.5372	1/26/2015	9:18	333	18.3046	-77.3979	2/7/2015	13:56	544	18.0279	-76.3888	3/17/2015	9:50
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134	18.3020	-77.5535	1/27/2015	7:50	345	18.2948	-77.5539	2/8/2015	14:55	556	18.1422	-76.5116	3/17/2015	14:33
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136	18.3123	-77.5569	1/27/2015	8:13	347	18.2267	-77.5334	2/9/2015	9:16	558	18.1730	-76.5702	3/18/2015	8:38
137	18.3186	-77.5577	1/27/2015	8:37	348	18.2261	-77.5325	2/9/2015	9:31	559	18.1708	-76.5704	3/18/2015	8:56
138	18.3191	-77.5578	1/27/2015	8:41	349	18.2250	-77.5346	2/9/2015	9:40	560	18.1647	-76.5584	3/18/2015	9:24
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143	18.3360	-77.5577	1/27/2015	11:38	354	18.2208	-77.5569	2/9/2015	11:13	565	18.1626	-76.5900	3/18/2015	11:02
144	18.3432	-77.5580	1/27/2015	12:00	355	18.2198	-77.5588	2/9/2015	11:19	566	18.1525	-76.5834	3/18/2015	11:34
145	18.3455	-77.5574	1/27/2015	12:45										

157	18.2479	-77.6086	1/28/2015	10:30	368	18.2054	-77.5957	2/9/2015	14:34	579	17.9308	-76.2710	3/19/2015	12:40
158	18.2501	-77.6117	1/28/2015	10:54	369	18.2071	-77.5961	2/9/2015	14:43	580	17.9262	-76.2577	3/19/2015	12:52
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162	18.2763	-77.6185	1/28/2015	12:16	373	18.4183	-77.5041	2/10/2015	10:37	584	17.9779	-76.2959	3/19/2015	14:33
163	18.2804	-77.6227	1/28/2015	12:41	374	18.4185	-77.5086	2/10/2015	10:45	585	18.0310	-76.6568	3/20/2015	11:02
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165	18.2790	-77.6271	1/28/2015	13:03	376	18.4190	-77.5267	2/10/2015	11:03	587	18.0535	-76.6004	3/21/2015	6:20
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169	18.2893	-77.6253	1/28/2015	14:50	380	18.3708	-77.5512	2/11/2015	9:08	591	18.0450	-76.5852	3/21/2015	9:09
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172	18.2467	-77.6284	1/29/2015	9:16	383	18.3445	-77.5582	2/11/2015	10:30	594	18.0464	-76.5793	3/21/2015	10:14
173	18.2576	-77.6401	1/29/2015	9:27	384	18.3652	-77.5550	2/11/2015	15:22	595	18.0465	-76.5795	3/21/2015	10:21
174	18.2605	-77.6397	1/29/2015	9:36	385	18.3880	-77.5512	2/11/2015	16:35	596	18.0471	-76.5790	3/21/2015	10:29
175	18.2621	-77.6512	1/29/2005	9:55	386	18.4082	-77.5382	2/12/2015	9:03	597	18.0554	-76.6028	3/21/2015	16:45
176	18.2696	-77.6567	1/29/2015	10:34	387	18.0850	-76.7292	3/4/2015	8:17	598	18.0535	-76.6004	3/21/2015	17:50
177	18.2699	-77.6577	1/29/2015	11:25	388	18.0858	-76.7299	3/4/2015	8:27	599	18.0535	-76.6004	3/22/2015	6:21
178	18.2413	-77.6183	1/29/2015	12:31	389	18.0860	-76.7267	3/4/2015	8:47	600	18.0514	-76.6065	3/22/2015	9:08
179	18.2288	-77.6210	1/29/2015	12:40	390	18.0861	-76.7271	3/4/2015	9:15	601	18.0493	-76.6094	3/22/2015	9:24
180	18.2196	-77.6217	1/29/2015	13:09	391	18.0871	-76.7281	3/4/2015	10:31	602	18.0481	-76.6114	3/22/2015	9:35
181	18.1914	-77.6327	1/29/2015	13:30	392	18.0893	-76.7288	3/4/2015	10:43	603	18.0432	-76.6274	3/22/2015	11:44
182	18.1851	-77.6383	1/29/2015	14:33	393	18.0910	-76.7278	3/4/2015	10:57	604	18.0343	-76.6219	3/22/2015	12:08
183	18.1888	-77.6243	1/29/2015	14:51	394	18.0919	-76.7253	3/4/2015	11:13	605	18.0861	-76.7271	3/23/2015	5:55
184	18.1835	-77.6226	1/29/2015	15:00	395	18.0923	-76.7247	3/4/2015	11:21	606	18.0736	-76.7136	3/23/2015	9:11
185	18.1774	-77.6195	1/29/2015	15:23	396	18.0950	-76.7248	3/4/2015	11:37	607	18.0777	-76.7100	3/23/2015	9:30
186	18.1692	-77.6140	1/29/2015	15:46	397	18.0956	-76.7254	3/4/2015	11:47	608	18.0796	-76.7075	3/23/2015	9:41
187	18.1608	-77.6148	1/29/2015	16:09	398	18.0893	-76.7103	3/4/2015	13:08	609	18.0771	-76.7027	3/23/2015	10:15
188	18.1451	-77.6280	1/29/2015	16:48	399	18.0865	-76.6884	3/4/2015	13:41	610	18.0902	-76.6895	3/23/2015	12:08
189	18.2680	-77.6174	1/29/2015	19:00	400	18.0847	-76.6896	3/4/2015	13:54	611	18.0921	-76.6904	3/23/2015	12:15
190	18.1711	-77.6715	1/30/2015	7:59	401	18.0834	-76.6898	3/4/2015	14:05	612	18.0977	-76.6927	3/23/2015	13:04
191	18.1841	-77.7040	1/30/2015	8:15	402	18.0770	-76.7246	3/4/2015	15:38	613	18.0997	-76.6915	3/23/2015	13:21
192	18.1961	-77.7025	1/30/2015	8:27	403	18.0764	-76.7266	3/4/2015	16:12	614	18.0938	-76.6876	3/23/2015	13:42
193	18.2037	-77.6983	1/30/2015	8:41	404	18.0307	-76.6098	3/5/2015	10:48	615	18.0912	-76.6848	3/23/2015	13:59
194	18.2099	-77.6921	1/30/2015	8:53	405	18.0311	-76.6081	3/5/2015	11:07	616	18.0861	-76.7271	3/23/2015	15:30
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196	18.2272	-77.6921	1/30/2015	9:39	407	18.0289	-76.6018	3/5/2015	11:53	618	18.2457	-77.5006	3/24/2015	16:58
197	18.2346	-77.7003	1/30/2015	9:49	408	18.0288	-76.6001	3/5/2015	12:15	619	18.3355	-77.5600	3/24/2015	18:48
198	18.2417	-77.7011	1/30/2015	10:08	409	18.0269	-76.5996	3/5/2015	12:26	620	18.3355	-77.5600	3/25/2015	15:00
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205	18.2758	-77.7130	1/30/2015	12:00	416	18.0303	-76.6134	3/5/2015	18:12	627	18.3053	-77.5186	3/27/2015	8:50
206	18.2795	-77.7153	1/30/2015	12:19	417	18.0303	-76.6134	3/6/2015	6:51	628	18.3026	-77.5197	3/27/2015	9:01
207	18.2868	-77.7192	1/30/2015	12:39	418	18.0334	-76.6119	3/6/2015	8:24	629	18.2970	-77.5221	3/27/2015	9:19
208	18.2940	-77.7153	1/30/2015	13:10	419	18.0372	-76.6108	3/6/2015	8:38	630	18.2939	-77.5235	3/27/2015	9:59
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