Nesting of the Puerto Rican Emerald (*Chlorostilbon maugaeus*) and a record of nestling parasitism by botflies (*Philornis* sp.)

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Photo: Spencer C. Schubert

Birds Caribbean

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Abstract This study presents details of the reproductive biology of the Puerto Rican Emerald (*Chlorostilbon maugaeus*) and the first detailed record of its interactions with botfly (*Philornis* sp.) parasites. The data and observations are based on a nest found on 15 April 2015 in the Luquillo Experimental Forest, Luquillo, Puerto Rico. I monitored the nest and the behavior of the female parent for 29 days, beginning 5 days prior to egg-laying and continuing until the nestlings were found dead in the nest. Incubation lasted 15–17 days and the nestlings died 5–7 days after hatching. A photograph taken 2 days before the nestlings were found dead revealed the presence of subcutaneous botfly larvae, suggesting the parasites may have contributed to their deaths. This case is among the first recorded instances of botfly parasitism of a hummingbird in the Antilles. I compare these findings and other behavioral observations to known natural history of the Puerto Rican Emerald and other hummingbirds while addressing the implications of the effects of botfly ectoparasitism on Caribbean avifauna.

Keywords *Chlorostilbon*, hummingbird, *Philornis* ectoparasitism, Puerto Rican Emerald

Resumen Nidificación de *Chlorostilbon maugaeus* y un registro de pichones con parasitismo por moscas (*Philornis* sp.)—Este estudio presenta detalles sobre la biología reproductiva de *Chlorostilbon maugaeus* y el primer registro detallado de sus interacciones con una mosca parasítica (*Philornis* sp.). Los datos y las observaciones están basados en un nido encontrado el 15 abril 2015 en El Bosque Experimental de Luquillo, Luquillo, Puerto Rico. Realicé el monitoreo del nido y de la conducta de la hembra por 29 días, comenzando 5 días antes de la puesta de huevos y hasta que los pichones se encontraron muertos en el nido. La incubación duró 15–17 días y los pichones murieron 5–7 días después de la eclosión. Una foto tomada dos días antes de que los pichones se encontraran muertos reveló la presencia de larvas subcutáneas de *Philornis* sp., sugiriendo que los parásitos podrían haber contribuido a su muerte. Este caso está entre los primeros que documenta a *Philornis* parasitando un colibrí (Trochilidae) en Las Antillas. Comparo estos resultados y otras observaciones conductuales con la historia natural conocida de *Chlorostilbon maugaeus* en Puerto Rico y otros colibríes; a la vez que abordamos las implicaciones del ectoparasitismo por moscas para la avifauna del Caribe.

Palabras clave *Chlorostilbon*, colibrí, ectoparasitismo, *Philornis*, Zumbadorcito de Puerto Rico

Résumé Nidification de l'Émeraude de Porto Rico (*Chlorostilbon maugaeus*) et cas de parasitisme par des mouches du genre *Philornis*—Cette étude présente des informations précises sur la biologie de la reproduction de l'Émeraude de Porto Rico (*Chlorostilbon maugaeus*) et la première mention détaillée de ses interactions avec des mouches parasites du genre *Philornis*. Les données et les observations sont basées sur un nid trouvé le 15 avril 2015 dans la forêt expérimentale de Luquillo, Luquillo, Porto Rico. Un suivi du nid et du comportement de la femelle a été mené pendant 29 jours, en commençant 5 jours avant la ponte, et jusqu'à ce que les oisillons soient trouvés morts dans le nid. L'incubation a duré de 15 à 17 jours et les oisillons sont morts 5 à 7 jours après l'éclosion. Une photographie prise deux jours avant que les oisillons soient retrouvés morts révèle la présence de larves sous-cutanées de mouche du genre *Philornis*, ce qui suggère que les parasites pourraient avoir contribué à leur mort. Il s'agit d'un des premiers cas enregistrés de parasitisme d'un colibri par ces mouches aux Antilles. Ces résultats et autres observations comportementales sont comparés aux éléments connus pour l'Émeraude de Porto Rico et d'autres colibris, tout en abordant les implications des effets de l'ectoparasitisme par des mouches du genre *Philornis* sur l'avifaune des Caraïbes.

Mot clés *Chlorostilbon*, colibri, ectoparasitisme par des *Philornis*, Émeraude de Porto Rico

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The Antillean islands of the Caribbean host 17 resident species of hummingbirds (Raffaele *et al.* 2003). Three of these belong to the genus *Chlorostilbon*, represented by single island endemic species on Cuba, Hispaniola, and Puerto Rico. The genus itself contains 17 species that range as far south as northern Argen-

tina (Stiles and Skutch 1989). Aspects of nesting biology have been described for only 12 of these species (Wolf 1964, Hilty and Brown 1986, Stiles and Skutch 1989, Thomas 1994, Howell and Webb 1995, Stiles 1996, Oniki and Antunes 1998, Schuchmann 1999, Garrido and Kirkconnell 2000, Sandoval and Escalante 2010). Hummingbirds of this genus typically lay two eggs in a small cup nest with incubation periods commonly lasting 13–18 days and nestlings fledging 19–22 days after hatching (Schuchmann 1999).

The Puerto Rican Emerald (*Chlorostilbon maugaeus*) is listed by the International Union for Conservation of Nature as a species of Least Concern and is endemic to the island of Puerto Rico (BirdLife International 2016). Information pertaining to the nesting biology of the Puerto Rican Emerald presented by Schuchmann (1999) notes a breeding period between February and May, during which females incubate two eggs for 14–16 days and care for nestlings until they fledge at 20–22 days old. However, this information is a summary of anecdotal reports, and there were no studies from the primary literature available at the time of writing this manuscript.

The larvae of flies in the genus *Philornis* interact with bird populations throughout the tropical and subtropical regions of the Americas as scavengers of fecal matter (coprophages) or parasites that consume fluids and tissue from their host (hematophages) (Aiken 1913, Nielsen 1913, Aldrich 1923, Dodge 1955, Héctor 1982, Couri 1985, Uhazy and Arendt 1986, Young 1993). Within the hematophages, both subcutaneous and free-living larvae can occur (Dodge 1963, Couri 1999). Subcutaneous *Philornis* larvae are known to cause mortality and other deleterious effects on fitness in a variety of avian taxa across their range (Arendt 1985a, 1985b, 2000, 2006, Rivera Irizarry 1990, Delannoy and Cruz 1991, Dudaniec and Kleindorfer 2006, Rabuffetti and Reboreda 2007). Bird populations threatened by changing environments can become especially vulnerable to *Philornis* parasites (Wiley and Wunderle 1993, Arendt 2006, O'Connor *et al.* 2010). Yet, more research is needed to determine the full range of host taxa at the regional level and how changing environmental conditions may be influencing the frequencies of host-parasite interactions. In this paper, I give a detailed description of a Puerto Rican Emerald nest and report on the subsequent nestling mortality apparently caused by botfly (*Philornis* sp.) parasites, followed by a discussion of the implications of my findings for Caribbean avifauna.

Methods

The observations for this study occurred between 15 April and 13 May 2015 in the Luquillo Experimental Forest, Luquillo, Puerto Rico, at an elevation of approximately 400 m above sea level. The site can be appropriately described as an aseasonal wet forest, receiving approximately 3,500 mm of rainfall each year and typically no less than 200 mm in any given month (Brokaw *et al.* 2004). The habitat immediately surrounding the nest was Tabanuco forest, consisting of a dominant overstory of *Dacryodes excelsa*, *Guarea guidonia*, and *Sloanea berteriana* with canopy height averaging 20 m (Brokaw *et al.* 2004). The sierra palm (*Prestoea montana*) is another abundant plant of varying heights reaching into the midstory. The forest understory, where the nest was found, is relatively open with scattered saplings and

ferns. The nest coincided temporally with an uncharacteristic drought in the forest with only 16 mm of accumulated precipitation during the 23 days that the nest was active (J.K. Zimmerman pers. comm.). More extensive information about the field site characteristics is available in Brokaw *et al.* (2004).

Data were collected opportunistically during the fieldwork for another study. I monitored the nest from a distance of 8 m at irregular intervals with focal observation periods lasting 10–90 min. Other brief visits were made to check nest contents. I was confident that my presence did not alter behavior, since on several occasions I attempted to gently flush the bird without success. Despite my hand and face being < 30 cm from the incubating female, the bird never left the nest, and I had to wait patiently for her to leave of her own accord before checking the nest. In total, I spent 13 hr observing the nest or checking its contents. Since most of my observations were 30-min periods, I chose to consider only full 30-min intervals (first 30 min) within the longer observation periods when calculating mean time at the nest for the female during the different stages of development. I photographed the nest, eggs, and nestlings to aid my documentation of the nesting cycle, but I did not handle or otherwise contact the eggs or nestlings at any time.

Results

Nest Description and Cycle

I first observed the nest at 1145 on 15 April 2015 when the female Puerto Rican Emerald (identified by plumage) flew to and from the nest multiple times. During short visits to the nest, the bird would sit in the cup and repeatedly drag her bill across the outer rim, apparently lining the nest materials with spider silk. Additionally, the female spent considerable time during these visits within the cup, shuffling her tail and feet while turning her body. These movements were reminiscent of those exhibited by birds in several disparate taxa during the late stages of nest building. The nest was positioned at a height of 1.9 m in a tree (*Trichilia pallida*) 4.5 m tall, fastened to a secondary branch

Fig. 1. Photograph of the nest and the female Puerto Rican Emerald sitting on eggs (24 April 2015). Photograph by Spencer C. Schubert.

Fig. 2. Photograph of the first nestling shortly after hatching, lying beside the unhatched egg (6 May 2015). Photograph by Spencer C. Schubert.

~25 cm from the trunk in a manner resembling the construction of a nest by a Blue-tailed Emerald (*Chlorostilbon mellisugus*) in Venezuela (Thomas 1994). The nest was constructed almost entirely from dry plant fibers, possibly from grasses or strands of palm fronds, all held together and lined with spider silk (Fig. 1). From the differences in nest material color and irregularity of the shape, a stacked two-layer construction was apparent. The external height of the nest was 49 mm, not including stray hanging material. The nest diameter, based on the shortest and longest measurement, was 32 mm × 37 mm, and the interior cup measured 24 mm × 30 mm.

I documented the first egg at 1205 on 20 April and the second egg, which completed the clutch, at 0900 on 21 April. Though I did not physically measure the two eggs, I used a photograph taken from directly above the nest with known nest dimensions to estimate their sizes. One egg measured approximately 13.3 mm × 8.2 mm; however, the other egg's full dimensions were not sufficiently visible in the photograph to give a confident estimate. I found the first hatchling at 1717 on 6 May (Fig. 2), and the second egg was in the process of hatching at 0642 on 7 May with a large crack in the shell. On the next check at 1654 on 8 May, the second nestling had completely hatched. From these observations, I estimate the time between clutch completion and initial hatch date to be 16 days. However, since the eggs were not uniquely marked and the order of hatching was unknown, I concluded that the actual incubation time for an individual egg could have ranged 15–17 days. The hatchlings emerged with two rows of rufous down running vertically along either side of the vertebrae, whereas the rest of the skin was bare and dark gray in color (Fig. 2). I found the nestlings dead on 13 May at 1145, having last seen them alive on 11 May at 1450, which indicates that their deaths occurred 5–7 days post-hatch. Only bones and other hard remains could be found in the nest that was now covered in a horde of ants (*Wasmannia auropunctata*) most likely performing sanitary predation (Leopold 1933). Two days prior to confirmed nest failure, I photographed the nestlings, which ex-

hibited deformations of the skin characteristic of subcutaneous parasitism by *Philornis* larvae (Fig. 3).

Parental Care

In addition to nest building observed in the days prior to egg-laying, the female displayed highly aggressive territorial behavior toward *Anolis gundlachi* lizards. If a lizard moved too high up the trunk of the nest tree when the hummingbird was present or upon the bird's return, she would respond by flying repeatedly at the intruder until it either retreated down the tree, moved to a branch more distant from the nest, or leaped off. The female ignored small sub-adult lizards, but one large (~6 cm snout-to-vent) displaying male received a disproportionate number of attacks. I observed no further harassment of lizards once the clutch had been completed, nor did I see the large male lizard on the tree after that time.

During the incubation stage, the female spent 78% of the time on the nest (*n* = 4 visits, 2 hr total time). The mean time of trips away from the nest was 4 min 57 s (*n* = 5 trips, based on departure and return times). On 20 April, the day before clutch completion, the female never approached the nest during a 25-min observation period beginning at 1205. After nest construction was completed, I observed the female adding material only once, at 1541 on 23 April, when she lined the rim of the nest with spider silk.

Between hatching of the first and second eggs, the female was present 83% of the time (*n* = 2 visits, 1 hr total time) including one bout of provisioning. Large egg shell fragments remained in the nest until 4 days post-hatch, after which point they had apparently been ejected from the nest and only small fragments remained. Once both eggs hatched, the female was present 51% of the time (*n* = 4 visits, 2 hr total time) including three sessions

Fig. 3. Photograph of both nestlings 5 days post-hatch (11 May 2015). In the bottom left corner of the photograph, evidence is visible of three botfly (*Philornis* sp.) larvae on the nestling. The largest furuncle bulges from the nape, while two others can be seen on the dorsum and wing. The nestling higher in the photograph has at least one furuncle visible on its back. Photograph by Spencer C. Schubert.

of provisioning the nestlings. Provisioning was observed only a few times, given the short life of the offspring. The behavior was fairly consistent: the arriving female would perch on the rim of the nest and lower her bill to the nestlings' mouths 4–5 times per visit, spending about 20 s in this state before sitting to brood. The nest's height prevented me from seeing which nestling was being fed or whether they were raising their heads during feeding. No male Puerto Rican Emerald was detected in the proximity of the nest during the study.

Nestling Parasite Load and Death

As early as 2 days before hatch, I saw a muscid fly that could have been a botfly persistently perching on the rim and outer edge of the nest during my observations. From the photograph of the nestlings taken 5 days post-hatch, furuncles were seen on both nestlings (Fig. 3). Though not all of the skin surface area could be seen, one nestling had three larvae infesting the nape, dorsum, and upper wing, whereas only one larva could be seen near the shoulder joint of the other nestling. Each furuncle was characterized by a small hole marking the entrance of the larva with the skin raised around it, similar to the description provided by Oniki and Willis (2000) for a nestling Swallow-tailed Hummingbird (*Eupetomena macroura*) in Brazil. Because I did not physically inspect each nestling, these counts serve only as a minimum. I did not find evidence of any pupated larvae in the nest material after its failure.

Discussion

Overall, my descriptions of this Puerto Rican Emerald nest are in agreement with other reports available; the use of plant fibers in the construction of the nest is a common practice in the reports for the three species in the Antilles (Schuchmann 1999). However, I did not find lichen or moss present in the nest as is common in the genus, and the heavy utilization of spider silk is not mentioned elsewhere for this species. One thing that stands out from my study was the fortunate and relatively uncommon opportunity to find a hummingbird nest before the first egg was laid and then be able to closely monitor the length of the incubation period, which in this case was 15–17 days. This observation generally reflected the reports of Schuchmann (1999) for the species and its congeners on the neighboring islands. In the more intensely studied Glittering-bellied Emerald (*Chlorostilbon lucidus*), incubation periods have been reported between 14 and 18 days (Ruschi 1982, Fraga 1984, Contreras 1987). Thus, there is clearly a need for monitoring a larger number of nests to determine what variations in nesting cycle and phenology might exist within this and other species. The single estimate that I produce for egg size of 13.3 mm × 8.2 mm is somewhat larger than would be expected based on the reported egg sizes from other members of the genus (Thomas 1994, Oniki and Antunes 1998). However, due to the opportunistic nature of my study and not having prior permission to use invasive methods, I was unable to collect the high resolution data on egg size and nestling growth rates that are still needed to assemble a more complete profile of this species.

Another curious behavior exhibited by the female Puerto Rican Emerald was its apparent lack of fear of me, a potential predator. The bird was reluctant to leave the nest even when I came in close proximity to the nest while attempting to check the contents. As an insular species on an island with no native mammalian predators, there is a strong likelihood that this species has not evolved predator avoidance or nest defense behaviors to these threat stimuli. By contrast, the aggression displayed towards *Anolis* lizards suggests that the hummingbird's response to this potential nest predator is innate. Though the sample size is small, my observations raise concerns that the introduced mongoose (*Herpestes auropunctatus*) and rats (*Rattus norvegicus*) could threaten this hummingbird during the vulnerable nesting cycle. I believe that studies addressing questions pertaining to predator recognition and response behavior of Caribbean hummingbirds would benefit our understanding of their evolutionary history and current ecological status.

While the ectoparasitism and apparent nest failure from *Philornis* botflies prevented me from determining the length and details of the entire nest cycle, it presents another opportunity to examine the implications of this parasite on hummingbirds and other bird populations in the region. Documentation of hummingbird interactions with botflies is largely absent in the Antilles and rare elsewhere, with only four species having been identified as hosts to *Philornis* spp. on the American continent, including the congeneric Glittering-bellied Emerald (Oniki and Willis 2000, Salvador and Bodrati 2013). Oniki and Willis (2000) monitored the growth of a nestling Swallow-tailed Hummingbird that was found several days after hatching. The investigators found and removed *Philornis* larvae from the nestling's skin daily, resulting in 58 larvae in total. They concluded that the nestling likely would have died without their intervention. Snyder *et al.* (1987) monitored nests of several species in the Luquillo Experimental Forest and in the surrounding area, finding botfly parasitism in the Puerto Rican Sharp-shinned Hawk (*Accipiter striatus venator*), Puerto Rican Screech-Owl (*Megascops nudipes*), Puerto Rican Tody (*Todus mexicanus*), Puerto Rican Parrot (*Amazona vittata*), and Pearly-eyed Thrasher (*Margarops fuscatus*). The only hummingbird nests monitored in the study were from the Green-throated Carib (*Eulampis holosericeus*) in a low coastal site of eastern Puerto Rico, but no parasites were seen on the 13 nestlings that were handled. Upon further investigation into reports of Puerto Rican Emerald interactions with *Philornis* beyond the primary literature, I learned of two other known cases. The first of these was a case of botfly parasitism of the species near Comerío, Puerto Rico, in 2005 (R. Pérez-Rivera pers. comm.). Further evidence of nestling parasitism is apparent from a YouTube (www.youtube.com) video from an unknown location by user "avespuertorico," uploaded in 2015 around the time of this study, which appears to show a dead Puerto Rican Emerald nestling with several subcutaneous larvae moving beneath the skin.

The recent discovery of *Philornis* parasitism of Puerto Rican Emerald nestlings from this study and other anecdotal accounts raises concerns over the potential changes that may be occurring in avian and parasite populations. Although *Philornis* spp. have been shown to be generalists (i.e., lacking strong host preference), infestation rates can be exceptionally high in some host species, leading to a "reservoir" or "spillover" effect on other host populations sharing the same habitat (Loye and Carroll 1995, Wunderle and Arendt 2011). Given the relative scarcity of

reports of hummingbirds as hosts of *Philornis* compared with other avian taxa, an increasing frequency of their interactions could indicate an increasing trend in the parasite's populations at local and perhaps regional scales. Recent research suggests that the intensity of *Philornis* infestation in bird nests is positively correlated with mean daily maximum temperature and rainfall (Antoniazzi *et al.* 2011). Assuming current projections of a warming climate at the global scale are accurate (Henereh *et al.* 2016), increasing temperatures may lead to greater pressures on avian populations by *Philornis* parasites. The results of some field studies have indicated that *Philornis* parasitism occurs more frequently in bird nests near forest edges and in human-disturbed environments, a relationship which could exacerbate the negative effects of development and land-use change (Oniki 1983, Le Gros *et al.* 2011). Nevertheless, this concept conflicts with the observations of researchers who have conducted long-term studies and observations of nesting birds in the mature forests of Luquillo Experimental Forest, where botfly densities are high (W.J. Arendt and J.M Wunderle, Jr. pers. comm.). My findings, together with those of other researchers, underscore the need for more directed study of botfly populations and the parameters influencing their densities in different habitats in order to uncover the climatic, ecological, and stochastic mechanisms behind the current trends in *Philornis* ectoparasitism of Caribbean birds.

Acknowledgments

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