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Interactions between the Avian Parasite, *Philornis downsi* (Diptera: Muscidae) and the Galapagos Flycatcher, *Myiarchus magnirostris* Gould (Passeriformes: Tyrannidae)

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ABSTRACT: An incidental observation of the fly *Philornis downsi* parasitizing a Galapagos Flycatcher (*Myiarchus magnirostris*) nest has revealed new insights into the searching behavior and biology of this invasive fly parasite and its interactions with endemic landbirds in the Galapagos Islands. Observations suggest that *P. downsi* relies on olfactory cues, or olfactory cues combined with the activity of adult birds, to locate nests and that flies continue to visit nests when chicks are >3 d old. At least 200 eggs were laid by *P. downsi* in different parts of the nest and >40 early-instar larvae were found inside the head of one chick, with additional larvae found in the base of the nest. Parasitism was the likely cause of mortality of both chicks found in or near the nest. This description of *P. downsi* parasitizing chicks of *M. magnirostris* highlights the vulnerability of this endemic bird species to this invasive fly.

Key words: Galapagos Flycatcher, invasive species, landbird conservation, *Myiarchus*, parasite, *Philornis*.

Recent reports of population declines of 11 passerine species endemic to the Galapagos Islands have alerted conservation practitioners to the need to better understand the ecology of landbirds and their principal threats (Cunninghame et al. 2012; Dvorak et al. 2012). Landbird species declines are thought to be mainly attributable to introduced species, in particular the invasive parasitic fly *Philornis downsi* Dodge & Aitken (Kleindorfer et al. 2014, and references therein). Fly parasitism in the Galapagos was first reported in 1997 in Woodpecker Finch (*Camarhynchus pallidus* Sclater and Salvin) nestlings, and since then has become the main threat to the survival of at least 16 Galapagos-endemic passerines (Fessl and Tebbich 2002; Causton et al. 2013). Research to understand the ecology of *P. downsi* and to develop methods for mitigating its impacts on Galapagos landbirds is in process and is a priority for Galapagos conservation organizations (Causton et al. 2013).

The Galapagos Flycatcher, *Myiarchus magnirostris* Gould, is endemic to the Galapagos and is thought to have arrived less than one million years ago through a single colonization event (Sari and Parker 2012). This flycatcher is the smallest bird in the genus *Myiarchus*, approximately 15 cm long, and is the only representative of this genus in the Galapagos (Wiedenfeld 2011). This species is the only hole-breeding landbird in the archipelago and occupies a wide range of elevations and habitat types. It is found on all of the main islands including Española, Fernandina, Floreana, Isabela, Santiago, Santa Cruz, and San Cristobal (Wiedenfeld 2011). Although it is one of the most common landbirds on the Galapagos Islands, it is one of the least studied, and little is known about its biology and ecology and whether breeding success has been affected by the increased abundance of introduced species over the last decades (Ervin 1992; Wiedenfeld 2011). *Philornis downsi* was first observed on Galapagos Flycatcher chicks in 2004 and again in 2008 (B. Fessl pers. comm.). Although the flycatcher is named as a host (Fessl et al. 2006), nothing was known about the impacts of *P. downsi* on this endemic species.

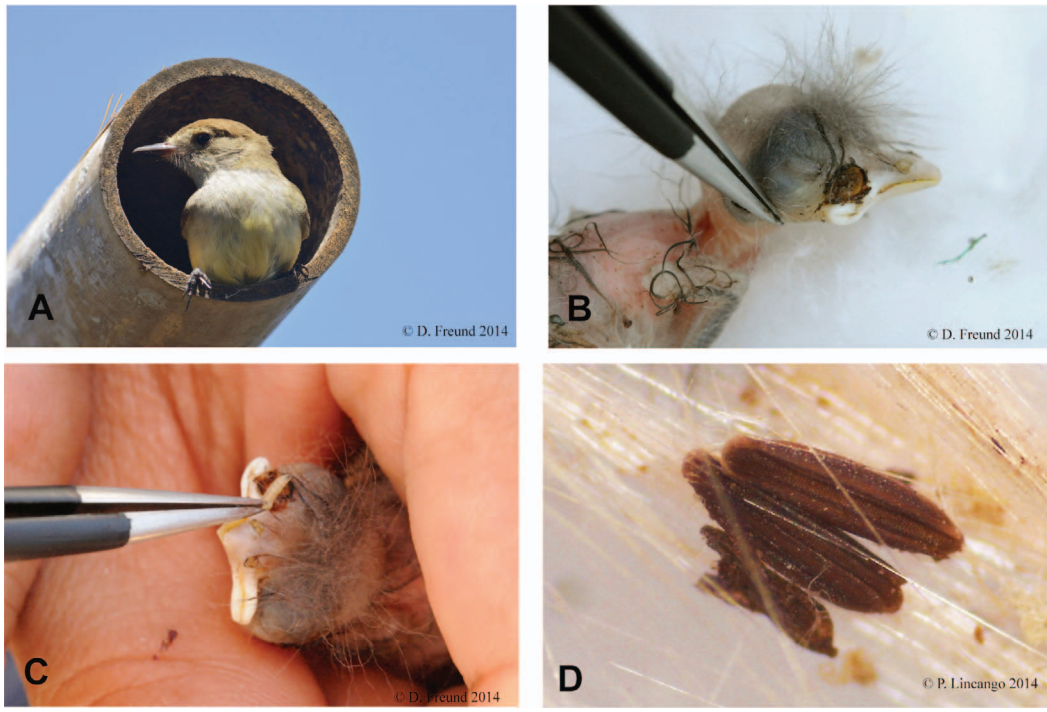

FIGURE 1. Parasitism by *Philornis downsi* in the Galapagos Flycatcher (*Myiarchus magnirostris*) in the Galapagos Islands, Ecuador. (A) Adult flycatcher exiting nest constructed inside a bamboo pole. (B) 3–4-d-old chick with flesh wound caused by feeding of *P. downsi* larvae. (C) One of 44 late first-instar and early second-instar *P. downsi* larvae extracted from 3–4-d-old chick. (D) *P. downsi* eggs deposited on nest material.

On 5 August 2014, a female flycatcher was observed on several occasions entering and exiting a 9-cm-diameter bamboo pole that formed part of a roof of a shade house maintained by the Charles Darwin Research Station at Puerto Ayora, Santa Cruz (0°45′0″S, 90°19′0.1″W; Fig. 1A). After determining that the parents were not in the vicinity, a nest was found inside the pole approximately 20 cm from the opening. Inside the bamboo pole, about 5 cm from the opening, a moribund chick (~3–4 d old) was found. Further investigation with a 1-m wireless snake plumbing inspection camera with an LCD monitor (distributed by Brainydeal, New York, New York, USA) revealed a live chick inside the nest. The moribund chick was later examined and 44 first- and second-instar *P. downsi* larvae were collected (Fig. 1B, C). Most of the larvae were found in a large hole made by the larvae at the base of the beak. No other lesions were observed on the hatchling.

Two days after the first observation, and after confirming that the parents had abandoned the nest, the nest material was removed. At least 80% of the nest was made of feathers from other bird species, including feathers that appeared to belong to feral chickens (A. Llerena pers. comm.). A dead chick (~2–3 d old) was found inside the nest with large holes around its beak; however, no larvae were visible on the chick. This chick appeared to have been dead for at least 1 d, and it is possible that this was not the same chick we observed alive in the nest 2 d earlier. Because there was no evidence of egg shells in the nest, we could not tell if there had been more than two chicks in the nest; Galapagos Flycatchers are thought to lay 3–5 eggs (Wiedenfeld 2011).

Approximately 70% of the nest material was inspected (some of the outer nest

material was needed for an experiment). Upon dismantling the nest, 42 live *P. downsi* larvae were found (32 second-instar and 10 third-instar larvae). In addition, 203 *P. downsi* eggs were found in the feathers and other material used to build the nest (Fig. 1D), both inside and outside of the nest. Of these, 21 eggs were unhatched and opaque, 30 contained fully formed larvae, and 152 eggs were empty following larval eclosion. Eighty-six of the larvae that hatched were found on the chicks or in the nest material, but 66 were unaccounted for and may have been inside the dead chicks, on the parents, or in the nest material that was not inspected. No pupae were found in the nest and there was no evidence of other Diptera. The fact that no pupal exuviae were found eliminates the possibility that some of the fly eggs might have originated from a cohort of chicks that had occupied this nest previously.

The day the nest was discovered, two adult female *P. downsi* were found resting on the black mesh of the shade house wall about 30–50 cm from the entrance to the nest. The flies were observed for >40 min at 1000 hours and did not change position even when they were approached to confirm their identity. We did not observe any interactions between them. On checking the area at 1430 hours, two female flies were observed close to the bamboo pole and nest. Soon after, a female flycatcher emerged from the pole and one of the flies flew to the edge of the bamboo pole and entered the pole walking. The fly remained inside the bamboo pole for about 8 min, even after the female flycatcher returned to the nest. As the flycatcher emerged from the nest, the fly was observed flying over the bird's head.

These observations provide new insights into the behavior and ecology of *P. downsi* in the Galapagos Islands, and on the impacts it is having on the Galapagos Flycatcher, and suggest the following. 1) *Philornis downsi* may not require a visual "nest image" cue to locate nests as we had suspected—the flycatcher nest was hidden and did not possess the typical dome shape of finch nests. *Philornis downsi* was recently recorded parasitizing chicks in rectangular nest boxes on mainland Ecuador (Bulgarella et al. 2015), suggesting that adult flies may locate nests by orientating to olfactory cues or to olfactory cues combined with the activity of the adult birds. 2) Adult flies showed interest in the nest when chicks were >3 d old, similar to observations of O'Connor et al. (2010) on the interactions of *P. downsi* and two finch species. This suggests that, if there are olfactory cues, they are not just associated with eggs or egg hatch and that female flies that arrive at the nest later in the reproductive phase of the birds may be responding to cues produced by the chicks, the fly larvae, or the action of the larvae feeding on the birds. 3) Flies waited to enter the nests until adult birds were absent (confirming the observations of O'Connor et al. [2010]). 4) Flies did not fly directly into the nest; rather they flew close to the nest and then walked. 5) Flies entered the nest even though chicks were already parasitized and there were numerous fly larvae and eggs already present in the nest. Nest infestation by multiple *P. downsi* females has been confirmed by microsatellite studies (Dudaniec et al. 2010); however, to our knowledge, this is the first record of a *P. downsi* female visiting a nest with a known number of conspecific larvae and eggs. 6) Early-instar *P. downsi* larvae can affect other areas of the heads of the chicks in addition to the nostrils, beak, and ears (Fessl et al. 2006), suggesting subcutaneous habits (M. Quiroga pers. comm.). 7) *Philornis downsi* lays its eggs in other parts of the nest, not just on the inner surface of the nest where the baby chicks are found or on the chicks themselves (O'Connor et al. 2010). 8) The chicks are not necessarily dead when the parents take them out of the nest (Small Ground-finch [*Geospiza fuliginosa* Gould] adults were filmed removing dead chicks from nests by O'Connor et al. [2014]); in our study a moribund flycatcher

chick was observed outside the nest for at least 3 h after the nest was discovered. 9) Parasite load in the Galapagos Flycatcher can be high; >40 first- and second-instar larvae were found on or inside the head of one of the chicks and additional larvae were found in the base of the nest.

The impact of *P. downsi* larvae on newborn Galapagos Flycatchers highlights the vulnerability of these small birds and the urgent need to find a method for controlling *P. downsi*. A pilot study was initiated in May 2014 in the arid zone of Santa Cruz Island to learn more about the nesting and reproductive behavior of the Galapagos Flycatcher and to determine the degree of parasitism by *P. downsi*.

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