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Avian Behavior, Ecology, and Evolution

Persistence of the Brujo Flycatcher (*Pyrocephalus nanus*) on Cerro Azul Volcano, Isabela Island, Galápagos

Persistencia de *Pyrocephalus nanus* en el volcán Cerro Azul, isla Isabela, Galápagos

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ABSTRACT. The Brujo Flycatcher (*Pyrocephalus nanus*) is endemic to the Galápagos Archipelago, where its population has declined and even disappeared from three islands. Cerro Azul Volcano, the southwesternmost volcano of Isabela Island, has lacked confirmed records of this species in recent decades, with BirdLife International listing it as presumed extinct there. In February 2023, during systematic surveys for giant tortoises (*Chelonoidis vicina*) on Cerro Azul Volcano, we opportunistically recorded 19 individuals of *P. nanus*. These included 11 adult males, four adult females, and three nestlings on the volcano's northern flank, as well as one adult male on its northwestern flank. No individuals were encountered elsewhere on the volcano. Detections of *P. nanus* were concentrated on the volcano's northern flank, an area characterized by arid conditions and relatively low levels of exotic plant invasion. Our findings provide new evidence of the presence and reproduction of *P. nanus* on Cerro Azul Volcano, confirming its occurrence after several decades without verified reports and underscoring the conservation importance of this area for the species.

RESUMEN. *Pyrocephalus nanus* es endémico del archipiélago de Galápagos, donde su población ha disminuido e incluso ha desaparecido de tres islas. El volcán Cerro Azul, el más sudoccidental de la isla Isabela, no ha contado con registros confirmados de esta especie en las últimas décadas, por lo que BirdLife International la ha clasificado como presuntamente extinta en esa zona. En febrero de 2023, durante unos estudios sistemáticos sobre las tortugas gigantes (*Chelonoidis vicina*) en el volcán Cerro Azul, registramos de forma fortuita 19 ejemplares de *P. nanus*. Estos incluyeron 11 machos adultos, cuatro hembras adultas y tres polluelos en el flanco norte del volcán, así como un macho adulto en su flanco noroeste. No se detectaron individuos en otras zonas del volcán. Los avistamientos de *P. nanus* se concentraron en el flanco norte del volcán, una zona caracterizada por condiciones áridas y niveles relativamente bajos de invasión de plantas exóticas. Nuestros hallazgos proporcionan nueva evidencia sobre la presencia y reproducción de *P. nanus* en el volcán Cerro Azul, confirmando su ocurrencia después de varias décadas sin reportes verificados y resaltando la importancia de conservación de esta área para la especie.

Key Words: *Brujo Flycatcher (Pyrocephalus nanus); Cerro Azul Volcano; Galápagos Islands; habitat degradation; persistence*

INTRODUCTION

The avifauna of the Galápagos Islands is emblematic of both evolutionary diversification and notable conservation vulnerability. Of the 28 native species of small landbirds (passerines, cuckoos, and doves) recognized in the archipelago, nearly half are threatened with extinction, according to the IUCN Red List (Fessl et al. 2017, Dvorak et al. 2021), because of declines or disappearances of many species' populations during the past century, particularly on inhabited islands (Causton et al. 2006, Dvorak et al. 2012, 2017, 2020, Fessl et al. 2018, Bulgarella et al. 2019, Mosquera et al. 2022). Recent surveys have documented local extinction of several landbird species on Floreana and San Cristóbal Islands (Dvorak et al. 2020, 2021), highlighting the vulnerability of the archipelago's small and isolated landbird populations.

The Brujo Flycatcher (*Pyrocephalus nanus*), a small insectivorous Tyrannid endemic to Galápagos, is among the threatened passerines in the archipelago. Formerly treated as part of the widespread *P. rubinus*, genetic analyses confirm its status as a distinct species, along with its congener *P. dubius* of San Cristóbal Island, now considered extinct (Carmi et al. 2016, Dvorak et al. 2020, Anchundia et al. 2026). During the past two decades, *P. nanus* has suffered severe declines, having disappeared from Floreana and Santa Fé Islands (Merlen 2013) and was last reported on Santiago Island in 2016 (Fessl et al. 2017). On Santa Cruz Island, restoration efforts are currently underway to prevent the extirpation of *P. nanus* there (Merlen 2013, Anchundia et al. 2024, BirdLife International 2025; Fig. 1). The main threats identified for *P. nanus* include nest failure due to parasitism by the avian vampire fly *Philornis downsi* and degradation of breeding habitats by exotic, invasive plants (Leuba et al. 2020, Mosquera et al. 2022, Anchundia et al. 2024).

On Isabela Island, *P. nanus* remains relatively common on four of its five volcanoes (Wolf, Darwin, Alcedo, Sierra Negra), occupying arid and transitional habitats (Fessl et al. 2017). In contrast, no confirmed records are available from Cerro Azul Volcano prior to 2023, despite ornithological searches conducted on the southern slopes of the volcano in 2018 (Charles Darwin Foundation, Landbird Conservation Program, *unpublished data*), resulting in *P. nanus* being categorized as possibly extinct on the volcano (BirdLife International 2025; Fig. 1).

Our study focuses on a small breeding population of *P. nanus* we located on the northern flank of Cerro Azul Volcano, based on incidental records obtained during a population survey for giant

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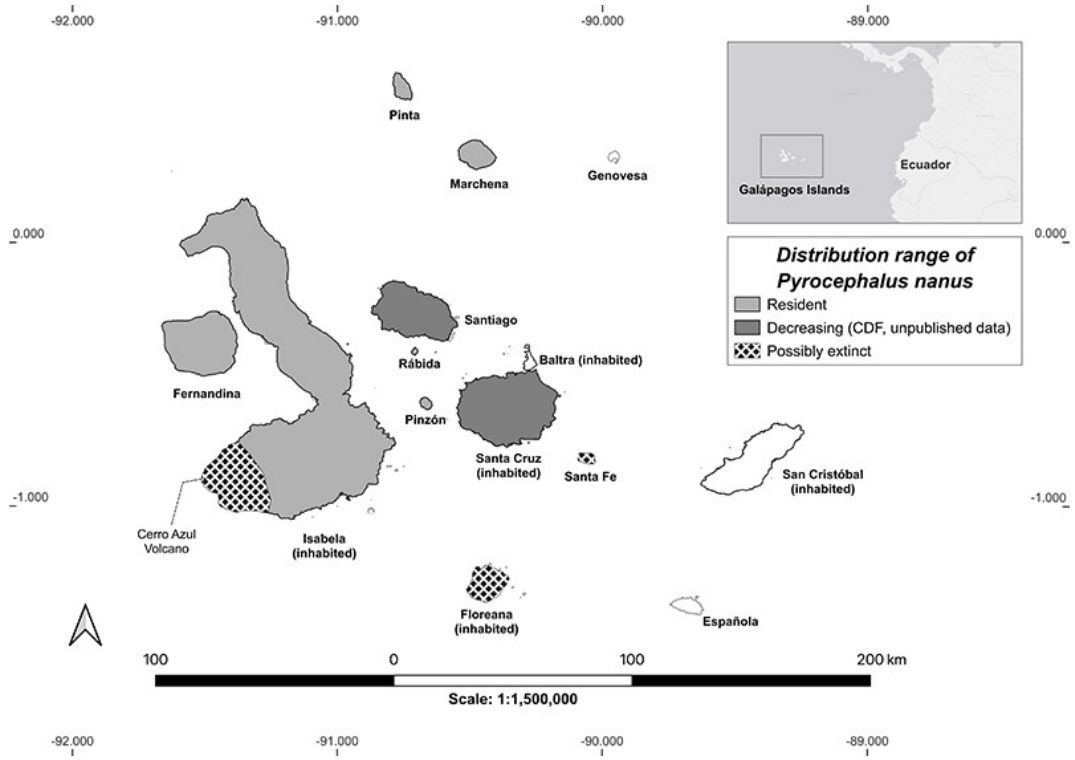
Fig. 1. Map of the Galápagos Islands showing the current distribution of the Brujo Flycatcher (*Pyrocephalus nanus*), indicating islands or places where the species is resident, decreasing, possibly extinct, or extinct according to BirdLife International (2025). San Cristóbal Island was home of *P. dubius*, now considered extinct.



tortoises (*Chelonoidis vicina*) across the volcano in 2023. Descriptions of the distribution, age, and sex of the *P. nanus* individuals we observed, along with their ecological conditions, may explain the species' persistence on the volcano and highlight the importance of the area for the conservation of this declining species.

MATERIALS AND METHODS

Study area

Cerro Azul Volcano (0°58′S, 91°25′W) is the southwesternmost of the five major volcanoes that comprise Isabela Island, Galápagos, rising to 1640 m above sea level. Southeasterly trade winds bring greater humidity and rainfall to the volcano's southern and southeastern slopes, whereas the northern and northwestern flanks are more arid because of orographic effects (Trueman and d'Ozouville 2010). The volcano hosts extensive arid and transitional shrubland interspersed with recent, intermediate and older lava flows (Naumann and Geist 2000). Exotic plants, mainly blackberry (*Rubus niveus*) and guava (*Psidium guajava*), have invaded most flanks of the volcano but to a lesser degree on its northern flank (Rivas-Torres et al. 2018; J. Carrión-Tacuri, Galápagos Conservancy Inc., *personal observation*). This likely reflects its isolation from humid windward areas where these invasive plants typically proliferate. In addition, a large number of feral cattle (*Bos taurus*) and feral pigs (*Sus scrofa*) occur on all flanks of the volcano and disturb the vegetation.

Field surveys

Fieldwork was conducted 10–20 February 2023 as part of a population survey and habitat characterization of the volcano's endemic species of giant tortoise (*Chelonoidis vicina*). Teams of three observers simultaneously walked pre-defined polygons ranging between six and eight km² in area on each flank of the volcano, ensuring comparable effort and survey coverage across all flanks of the volcano, with their trajectories tracked by handheld GPS units. Although the surveys were aimed at recording tortoises, occurrences of other species of interest, including *P. nanus*, were also noted.

Pyrocephalus nanus observations

Whenever a *P. nanus* was observed, its position was georeferenced with hand-held GPS unit (accurate to ± five m). Designation of apparent sex and age class (adult male, adult female, juvenile) of each individual was noted based on plumage. No individuals were captured or handled. Because individuals were not marked, individual identity could not be confirmed such that nearby detections of adult males (e.g., < 100 m apart) could represent repeated observations of the same individual. Accordingly, detection points were interpreted conservatively as indicators of spatial occurrence, and no attempt was made to estimate population size. Survey trajectories were later mapped to illustrate their spatial coverage and *P. nanus* detections mapped to highlight the species' distribution on the volcano. Research was conducted under authorization PC-05-22 provided by the Galápagos National Park Directorate.

RESULTS

We recorded a total of 19 individuals of *P. nanus* during our surveys (Fig. 2; Table 1). Of these, 18 were observed on the volcano's northern flank, sympatric with the giant tortoise population, known as Gavilanes, in an area of approximately 15.7 km². Observations at Gavilanes included 11 adult males, four adult females, and three nestlings detected between 627 and 968 m above sea level. One adult male was detected on the volcano's northwestern flank in the tortoise area known as Tablas (Fig. 2; Table 1) at 569 m above sea level (Table 1). Despite extensive survey effort and systematic coverage across all flanks of the volcano (Fig. 2), no *P. nanus* were detected on the volcano's eastern, western, or southern sectors of Cerro Azul Volcano, where searches collectively covered approximately 82.7 km².

Adult males and females were identified based on plumage characteristics, as documented in Fig. 3. The three nestlings observed in a cup nest at Gavilanes were estimated to be 9–11 days old based on developmental features, including sparse down, dull coloration, and overall body size, interpreted using field experience and general patterns of nestling development in passerine birds. Nestlings were assigned to *P. nanus* based on their distinct nestling plumage and association with attending adults. The nest was built approximately three m above ground in a Palo Santo (*Bursera graveolens*) tree, a tree widely distributed in this sector of the volcano (Fig. 4). Five older and inactive nests (without adults, eggs, or nestlings; unknown if previously used), were opened to search for traces of the presence of puparia of *Philornis downsi.* Because of the parasitic larvae pupate in the nest, nest infestation and its severity can be assessed after nesting activity has ceased (Fessl et al. 2006); however, no pupal remains were found. This procedure did not affect active breeding attempts or individuals.

DISCUSSION

Pyrocephalus nanus has been considered as possibly extinct on Cerro Azul Volcano (BirdLife International 2025), and systematic surveys conducted on the southern slope of the volcano in 2018 did not detect the species (Charles Darwin Foundation, Landbird Conservation Program, *unpublished data*). However, our field observations of adult males, females, and nestlings demonstrate that a small breeding population persists on the volcano, suggesting that the species may have remained undetected in spatially restricted habitats rather than being absent there.

Our surveys were conducted across all flanks of Cerro Azul Volcano as part of a systematic giant tortoise census, providing extensive spatial coverage of the volcano. Despite this broad survey effort, *P. nanus* was detected exclusively on the northern flank, and no individuals were recorded in other sectors of the volcano. The pattern is consistent with the lack of detections during systematic surveys on the southern slope in 2018 (M. Dvorak, University of Vienna, Austria, *unpublished data*) and further supports the interpretation that *P. nanus* persists in spatially restricted habitats on Cerro Azul Volcano.

The restriction of observations of *P. nanus* to the northern and northwestern flanks of Cerro Azul Volcano may reflect variation in habitat quality for the species around the volcano. Our field observations indicated that the northern and northwestern flanks are comparatively less invaded by exotic plants than the volcano's other flanks (J. Carrión-Tacuri, Galápagos Conservancy Inc., *personal observation*). This pattern is confirmed by vegetation mapping that has demonstrated reduced proliferation of invasive plants on the northern flanks of the volcano (Rivas-Torres et al. 2018). The interpretation that *P. nanus* is associated with areas less invaded by exotic plants is further supported by patterns observed on the northern volcanoes of Isabela Island, including those of Alcedo, Darwin and Wolf, where *P. nanus* maintains relatively robust populations, and where invasive plants such as guava and blackberry are largely absent or not yet widespread. Positive population responses of *P. nanus* to invasive plant reductions have been reported on Santa Cruz Island (Fessl et al.

Fig. 2. Cerro Azul Volcano, Isabela Island, showing locations where Brujo Flycatcher (*Pyrocephalus nanus*) individuals were recorded (♀ = Female, ♂ = Male, Triangle = Nestling), as well as tracks (darker lines) of field surveys carried out in February 2023.

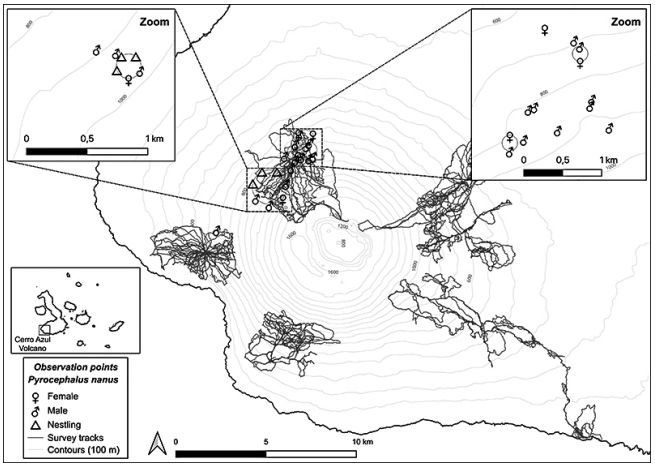


Table 1. Records of Brujo Flycatchers (*Pyrocephalus nanus*) individuals observed on Cerro Azul Volcano, Isabela Island, Galápagos, in February 2023, including sex (M = Male; F = Female; U = Undetermined), age (A = Adult; N = Nestling), locality, coordinates, elevation (m.a.s.l.), and date of observation.

Sex	Age	Locality	Latitude (°)	Longitude (°)	Elevation	Date
F	A	Gavilanes	-0.88489	-91.41518	821	2023-02-11
M	A	Gavilanes	-0.88488	-91.41518	821	2023-02-11
M	A	Gavilanes	-0.88442	-91.41354	839	2023-02-11
M	A	Gavilanes	-0.88094	-91.41302	792	2023-02-11
M	A	Gavilanes	-0.88064	-91.41233	799	2023-02-11
M	A	Gavilanes	-0.87973	-91.40569	842	2023-02-11
M	A	Gavilanes	-0.88333	-91.40964	873	2023-02-11
M	A	Gavilanes	-0.89769	-91.42744	890	2023-02-11
M	A	Gavilanes	-0.89899	-91.42508	953	2023-02-12
F	A	Gavilanes	-0.89899	-91.42508	953	2023-02-12
U	N	Gavilanes	-0.89899	-91.42508	953	2023-02-12
U	N	Gavilanes	-0.89899	-91.42508	953	2023-02-12
U	N	Gavilanes	-0.89899	-91.42508	953	2023-02-12
M	A	Gavilanes	-0.88301	-91.40369	890	2023-02-13
M	A	Gavilanes	-0.87453	-91.40708	718	2023-02-13
F	A	Gavilanes	-0.87452	-91.40707	718	2023-02-13
M	A	Tablas	-0.91976	-91.45181	569	2023-02-16
M	A	Gavilanes	-0.89796	-91.42601	912	2023-02-17
F	A	Gavilanes	-0.87158	-91.41115	627	2023-02-17

Fig. 3. Pair of adult Brujo Flycatchers (*Pyrocephalus nanus*) photographed on Cerro Azul Volcano, Isabela Island, in February 2023. The male (below) shows the characteristic bright vermilion plumage, whereas the female (above) exhibits a grayish-brown coloration. (Photo credit: Jorge Carrión-Tacuri.)

Fig. 4. Cup nest containing Brujo Flycatchers (*Pyrocephalus nanus*) in a palo santo tree (*Bursera graveolens*), containing three nestlings aged 9–11 days, on the northern flank of Cerro Azul Volcano, Isabela Island, Galápagos, February 2023. (Photo credit: Jorge Carrión-Tacuri.)

2017, Anchundia et al. 2024), where habitat restoration and control of invasive plants in the highlands have been associated with recruitment of new individuals into the local *P. nanus* population. These cases highlight the central role of invasive plant management for the conservation of *P. nanus* across the archipelago.

The presence of many giant tortoises on the volcano's northern flank may also contribute to local habitat suitability for *P. nanus.* Associations between *P. nanus* and giant tortoises during foraging, whereby flycatchers exploit insects flushed by the tortoises' movements, have been documented on Wolf Volcano (Galápagos Conservancy, *unpublished data*). However, tortoises are abundant in many areas elsewhere on Isabela Island where *P. nanus* is rare or absent, so this interaction alone is unlikely to explain *P. nanus'* distribution.

Despite this encouraging rediscovery, the long-term viability of the *P. nanus* population on Cerro Azul Volcano population remains uncertain. The species likely faces similar threats to those documented on other islands, including nest parasitism by the invasive fly and avian parasite *Philornis downsi* (Fessl et al. 2018, Leuba et al. 2020, Mosquera et al. 2022), which is known to cause high nestling mortality in humid habitats but may have reduced prevalence under the arid conditions of northern Cerro Azul Volcano, as has been reported for small and arid islands in Galápagos (Fessl and Tebbich 2002, Wiedenfeld et al. 2007). The orientation and dry climate of the northern sector of the volcano may also limit both the establishment of invasive plants and the severity of *Philornis downsi* parasitism, in contrast with the volcano's more humid southern flanks. Without targeted management, however, ongoing spread of invasive plants into the volcano's northern sector could undermine it as a refuge for *P. nanus*.

Our study was based on opportunistic detections of *P. nanus* made during systematic surveys of giant tortoises, rather than standardized avian censuses, limiting our ability to estimate *P. nanus* abundance or density. However, the extensive spatial coverage of survey tracks across all flanks of Cerro Azul Volcano supports the conclusion that *P. nanus* is currently restricted to the volcano's northern and northwestern flanks. The number of individuals recorded likely represents only a subset of the population, because *P. nanus* detectability is expected to be imperfect and to vary across habitats. In addition, the observed male-biased sex ratio may reflect differences in detectability rather than true population structure, because males are more conspicuous and active, making them easier to detect than females. Future research should include systematic assessment of population size, reproductive success, and habitat quality, as well as the management of invasive species and ongoing assessment of the potential impacts of *Philornis downsi*.

The discovery of *P. nanus* on Cerro Azul Volcano confirms that the species remains distributed across all of Isabela Island and highlights the island's importance as host to populations of *P. nanus* in the archipelago. The species is now considered extinct on Floreana and Santa Fé Islands and critically reduced on Santa Cruz Islands, where only a small remnant population persists (Merlen 2013, Leuba et al. 2020, Dvorak et al. 2021, Anchundia et al. 2024). On San Cristóbal Island, its congener *P. dubius* is considered to be extinct (Carmi et al. 2016, Dvorak et al. 2020). By comparison, populations of *P. nanus* on Isabela Island have remained relatively stable across all the island's five volcanoes. Persistence on Sierra Negra Volcano is possibly due to management of the invasive fly and avian parasite *Philornis downsi* there over several reproductive seasons (Fessl et al. 2017, Leuba et al. 2020, Mosquera et al. 2022).

Our documentation of *P. nanus* on Cerro Azul Volcano demonstrates that the species persists in habitats where it had not been detected in recent decades. This finding highlights the conservation relevance of Cerro Azul Volcano as habitat for the species on Isabela Island and underscores the importance of protecting the volcano's relatively intact northern flank from further invasion by exotic plants and feral animals. By documenting both presence and evidence of reproduction of *P. nanus*, our study supports the inclusion of Cerro Azul Volcano in future management strategies for *P. nanus* and other Galápagos landbirds.

Author Contributions:

Conceptualization: J.C-T., C.G-J., and J.G. Data curation: J.C-T., C.G-J. and J.G. Formal analysis: J.C-T., C.G-J., B.F., and J.G. Funding acquisition: J.C-T., and J.G. Supervision: J.C-T., and J.G. Investigation: J.C-T., and C.G-J. Methodology: J.C-T., C.G-J., C. S., and J.G., Project administration: J.C-T., and C.S. Supervision. J.C-T., and J.G. Validation: J.C-T., C.G-J., B.F., and J.G. Visualization: J.C-T., C.G-J., and J.G. Writing–original draft: J.C-T., and C.G-J. Writing–review & editing: B.F., and J.G.

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Data Availability:

All relevant data supporting the findings of this study are provided within the manuscript and associated tables and figures. The study is based on field observations and spatial records, and no custom analytical code was generated or required.

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