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Communication

First Recorded Evidence of Invasive Rodent Predation on a Critically Endangered Galápagos Petrel (*Pterodroma phaeopygia*) Nestling in the Galápagos Islands

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Simple Summary

The Galápagos Petrel (*Pterodroma phaeopygia*) is a Critically Endangered seabird that nests exclusively in the Galápagos Islands. While invasive species such as rats are widely known to threaten these birds, evidence of predation has remained indirect. Here, we present the first confirmed visual documentation of a rat preying on a Galápagos Petrel nestling, captured by a camera trap on Santa Cruz Island. This event occurred during a period when the nestling was left unattended while the parents foraged at sea. The parent Petrels continued to return to their nest for 91 days after the predation event, suggesting strong nest fidelity. Our findings emphasize the vulnerability of nestlings during early development and the urgent need for conservation efforts on private farmland outside Galápagos National Park areas.

Abstract

The Galápagos Petrel (*Pterodroma phaeopygia*) is a long-lived Critically Endangered seabird endemic to the Galápagos Islands and faces severe threats from invasive species, particularly rodents. Until now, evidence of rat predation on Galápagos Petrel nestlings has been largely indirect, inferred from indirect evidence and predator control outcomes. Here, we present the first photographic documentation of a presumed black rat (*Rattus rattus*) preying on a Galápagos Petrel nestling, captured by a camera trap on private farmland on Santa Cruz Island. The predation event occurred during a period of parental absence, when the nestling was left unattended while adults foraged at sea. Notably, the parent Petrels continued returning to the nest for 91 days following nestling loss, suggesting strong nest fidelity and highlighting potential energetic costs associated with breeding failure. Our findings reveal critical vulnerabilities during the nestling-rearing phase and emphasize the urgent need to enhance rodent control efforts and protect nesting areas, particularly on farmland outside the Galápagos National Park boundaries. We conclude by providing targeted conservation recommendations to mitigate invasive predator impacts and improve breeding success for this emblematic and imperiled seabird.

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Keywords: Galápagos Petrel; *Pterodroma phaeopygia*; invasive species; rodent predation; burrow-nesting seabirds; nest monitoring; Galápagos Islands

1. Introduction

The Galápagos Petrel (*Pterodroma phaeopygia*) is a long-lived seabird endemic to the Galápagos Islands, Ecuador [1]. It is currently listed as Critically Endangered due to a severe decline of all breeding populations over the past 60 years [2]. There are only a few thousand breeding pairs left across five islands: Floreana, Isabela, San Cristóbal, Santa Cruz, and Santiago [3].

The Galápagos Petrel plays a vital ecological role by transporting marine-derived nutrients to terrestrial ecosystems, influencing soil fertility and plant growth [4]. Beyond its ecological significance, the species holds cultural importance as part of the endemic biodiversity of the Galápagos Islands, reinforcing the importance of conservation efforts [5,6].

The Galápagos Petrel primarily nests in the highlands, typically between 150 and 700 m above sea level, where breeding sites often overlap with agricultural land [7]. This overlap increases exposure to invasive species, habitat degradation from farming activities, and direct human disturbances [8]. These pressures are compounded by the species' life history traits, including burrow nesting, a slow reproductive rate (one egg per year), and prolonged parental care [3]. Other threats such as bycatch, pollution, and climate change further challenge its survival, although their specific impact remains unclear [9,10].

Invasive species such as black rats (*Rattus rattus*), Norway rats (*Rattus norvegicus*), feral cats (*Felis catus*), feral dogs (*Canis lupus familiaris*), and pigs (*Sus scrofa*) are well-known predators of the Galápagos Petrel, preying on eggs, nestlings, and even adults [3,8,11]. In addition to animal predators, invasive plants such as blackberry (*Rubus niveus*), guava (*Psidium guajava*), and quinine (*Cinchona pubescens*) degrade nesting habitat, limiting breeding success [9]. Poorly managed livestock also encroach upon national park areas, causing soil erosion and nest destruction, further exacerbating habitat degradation [12]. However, evidence of rat predation remains indirect (i.e., indirect observations or inferred from rodent control efforts that have led to measurable increases in Petrel breeding success) [8,13,14]. This study provides the first visual documentation of a predation event, offering critical insights into the threats posed by invasive rodents.

While most conservation actions have focused on protected breeding grounds within the Galápagos National Park, populations nesting in agricultural areas remain underprotected [15]. The absence of regulatory oversight and targeted management in these unprotected areas presents a major conservation challenge, making agricultural land a priority for intervention [4].

2. Methods

Recognizing the importance of unprotected breeding grounds, the Jocotoco Conservation Foundation initiated monitoring and conservation efforts in 2024 to identify and protect Galápagos Petrel nests on private farmland. These farms are located in the highlands of Santa Cruz Island (0.64769° S, 90.33432° W). Field expeditions were first conducted to locate Galápagos Petrel nests, resulting in the identification of 74 active nests in two colonies situated along a ravine that crosses three private farms (Figure 1).

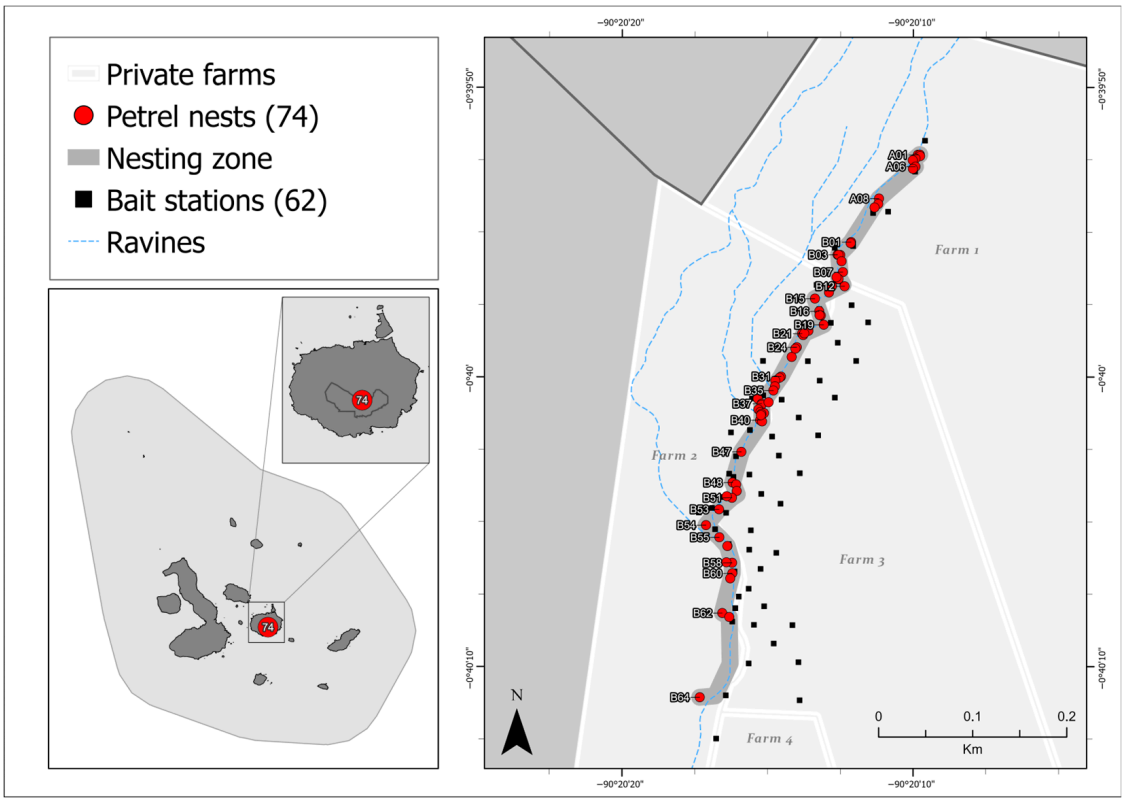


Figure 1. Study area showing the location of Galápagos Petrel (*Pterodroma phaeopygia*) nests and bait stations on private farmland in the highlands of Santa Cruz Island, Galápagos, Ecuador.

Between June and November, we implemented a series of conservation actions, including rodent control through toxic baiting, removal of invasive plants (primarily blackberry and guava), habitat restoration, and regular nest monitoring. These interventions aimed to enhance the resilience of the Galápagos Petrel population on Santa Cruz Island by mitigating key threats in non-protected nesting sites.

Rodent control was conducted using Bromadiolone-based bait deployed in 114 bait stations around the perimeter of the study area. This created a buffer zone designed to lure rodents away from Petrel nests, reducing disturbance within the colonies by encouraging rodents to consume the bait and die outside the nesting area.

In addition to the perimeter stations, we installed 37 bait stations within and around the Petrel colonies to provide localized rodent control and enhance nest protection. All bait stations were inspected every four weeks. During these inspections, we recorded bait consumption and replenished bait as needed to maintain consistent control throughout the breeding season.

All 74 nests were monitored monthly. At each visit, we recorded nest status as active or inactive, based on visual indicators such as the presence of adults, eggs, nestlings, fresh feathers, feces, etc. Observed categories included adult, adult pair, adult and egg, adult pair and egg, egg, and nestling.

To monitor predator activity and capture behavioral data, we installed five motion-activated Browning Dark Ops Extreme camera traps at five nests. Nest selection for camera placement was based on accessibility, visibility, and the presence of a nestling at the time of deployment. The cameras, equipped with infrared sensors for nighttime monitoring and high-resolution lenses, were placed at nest entrances to capture detailed visual data under varying light conditions. These cameras operated continuously, and we checked them monthly for battery replacement and data retrieval. Footage was manually reviewed

and annotated for key behavioral events, including predator visits, parental care, and nestling development.

3. Results

During the 2024 nesting season, camera trap No. 4 monitoring at nest 47 on Santa Cruz Island documented the complete timeline of a Galápagos Petrel nestling from late development to post-predation parental behavior. The nest was first monitored on 20 June 2024, at which point a nestling was already present.

3.1. Initial Approaches and Parental Defense

The first interactions between invasive rats and the Petrel nest were recorded while at least one parent was present. On 29 June 2024, a juvenile rat approached the entrance of nest 47, but the attending adult Petrel exhibited defensive behavior and successfully deterred it (Figure 2A,B). A similar incident occurred on 24 July 2024, when an adult rat retreated immediately upon detecting the presence of a parent Petrel inside the burrow (Figure 2C). These events highlight the potential protective role of adult presence at the nest site. Full behavioral details and timestamps are provided in Table 1.

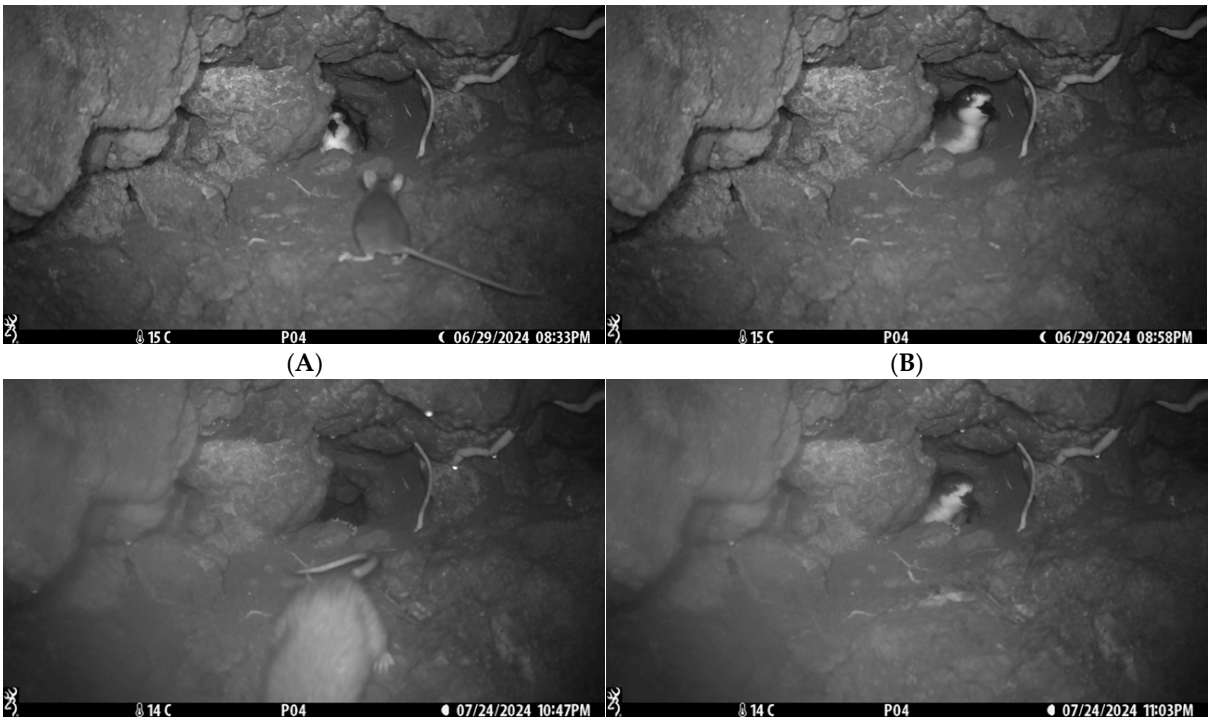


Figure 2. (**A**) A juvenile invasive rat approaching nest 47 while an adult Galápagos Petrel (*Pterodroma phaeopygia*) is present, protecting the nestling; (**B**) the parent Petrel actively defending the nest, preventing the rat from entering. (**C**) An adult rat retreating after detecting an adult Petrel's presence inside nest 47; (**D**) the parent Petrel remains inside, having successfully deterred the rat.

Table 1. Timeline of parental attendance, rat activity, and predation at nest 47 on Santa Cruz Island during the 2024 Galápagos Petrel (*Pterodroma phaeopygia*) breeding season. See also Figures 2–5 for visual documentation of selected events.

	Date	Parent 1 Activity * (In/Out)	Parent 2 Activity (In/Out)	Nest Left Unattended (# Hours)	Rodent Visit (Time)	Observational Notes
Initial Approaches	29 June	In (entire day)	–	0 h	20:33	The juvenile rat approached the nest and was immediately deterred by the attending parent.
	24 July	In (entire day)		0 h	22:47	The adult rat approached the nest and retreated after detecting the parent.
Nest Vulnerability	25 July	Out 00:32	In (00:21–19:19)	0 h	–	Both parents remained inside for 11 min before one departed to forage. Parent 2 left after 18 h and 47 min.
	26 July	In 02:31	–	7 h 12 min	–	
	27 July	Out 02:26	In 04:30	2 h 4 min		Parent 1 left after 23 h and 55 min.
	28 July		Out 03:21			Parent 2 left after ~24 h.
	29 July	In 21:54 Out 23:35	–	42 h 33 min	–	Brief return, then departure.
Predation Event	31 July	–	–	46 h 49 min	22:24	The nestling was left unattended for the longest period. Nestling killed and removed by an adult rat.
Nest Fidelity	2 August	In 04:43 Out 05:05	–		21:28	Parent searched 22 min for nestling. An adult rat visited the nest and stayed for 2 min.
	3 August	–	–		01:55	An adult rat visited the nest and stayed for 1 min.
	4 August	–	–		21:19	Adul rat visited the nest and stayed for 1 min.
	5 August	–	In 03:45 Out 04:23	70 h 40 min	02:27	The presumed second parent returned and searched the nestling for 38 min.
	5 August–30 October	Periodic visits every~2 days		–	–	Nest inspections and vocalizations from visiting parents searching for the nestling. Frequent visits from rats were recorded.

* Activity: we are reporting the times at which the parent Petrels visited the nest. "In" refers to the time they arrived at the nest and "out" refers to the time they departed from the nest.

3.2. Parental Absence and Nest Vulnerability

Over the following days, alternating parental visits were recorded, with progressively longer absences. On 25 July, after a short overlap between the two parents, the nestling was left unattended for 7 h and 12 min (Figure 3A,B). This pattern intensified until 27 July, when the nest remained completely unattended for a continuous period of 42 h and 33 min (Figure 3D,E). These increasingly prolonged absences likely correspond to typical foraging demands but significantly elevate the vulnerability of the unattended nestling (see Table 1).

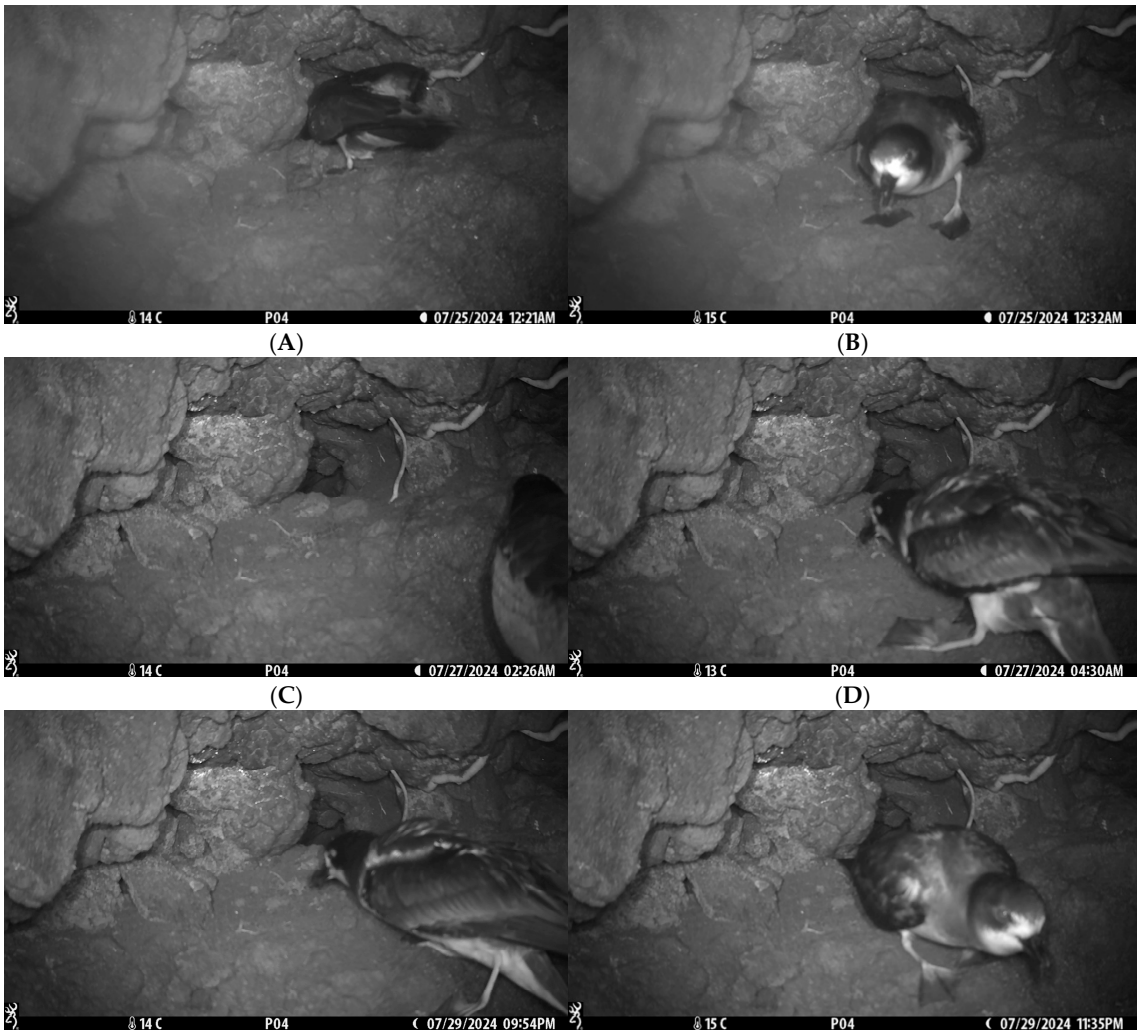


Figure 3. (**A**) A second parent Galápagos Petrel (*Pterodroma phaeopygia*) returning to nest 47 after a foraging trip while the first parent remains inside; (**B**) one of the parents departing from the nest after briefly overlapping with its mate. (**C**) A parent Petrel departing nest 47; (**D**) a returning parent entering the nest; (**E**) a parent arriving at the nest after a prolonged period of nest abandonment; (**F**) the same parent departing shortly after, leaving the nestling unattended.

3.3. Predation Event

On 31 July 2024, after a total of 46 h and 49 min without parental presence, an adult invasive rat—presumably a black rat (*Rattus rattus*)—entered the nest burrow and attacked the nestling. The rat killed the nestling, dragged it out of the nest, and began feeding on it (Figure 4). The camera captured subsequent scenes of other rats arriving and competing for access to the remains. This sequence provides confirmation of predation and scavenging behavior by invasive rats.

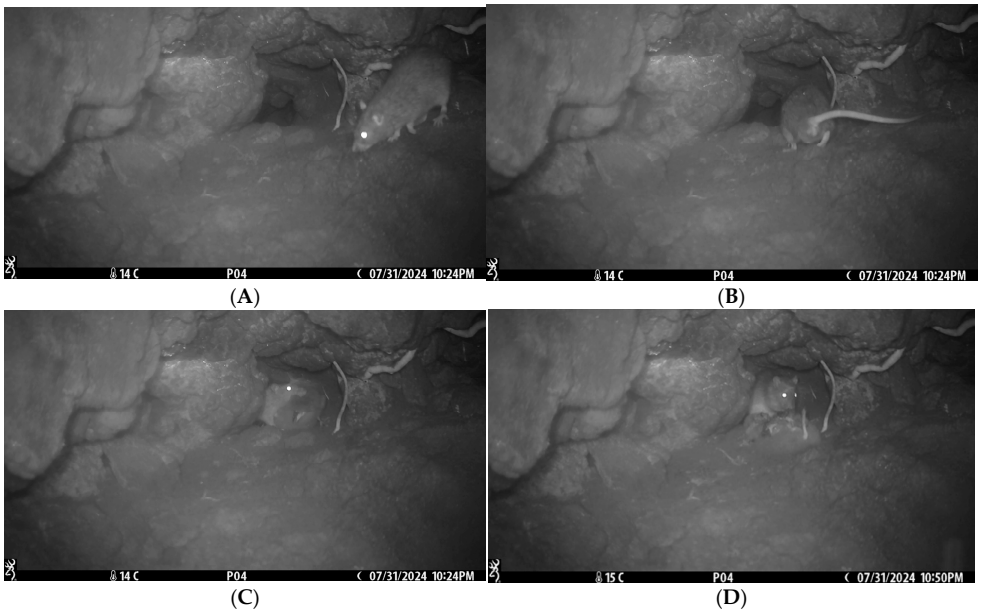


Figure 4. (**A**) A presumed invasive black rat (*Rattus rattus*) approaching nest 47, where a Galápagos Petrel (*Pterodroma phaeopygia*) nestling is unattended; (**B**) the rat entering the burrow; (**C**) the rat biting and dragging the nestling out; (**D**) the rat feeding on the nestling outside the nest.

3.4. Parental Return and Nest Fidelity

Despite the loss of their nestling, the parent Petrels returned to the nest. Beginning 02 August, a parent was recorded entering the nest and searching for the nestling (Figure 5). Over the following months, the parents continued to visit the nest regularly, on average every two days for 91 days after the predation event (see Table 1). During these visits, they were recorded entering and inspecting the nest and vocalizing nearby.

The average time spent at the nest during these post-predation visits was 2.95 h, ranging from 0.19 to 17.22 h. This prolonged attendance at an unsuccessful nest may reflect strong nest fidelity and difficulty in recognizing breeding failure.

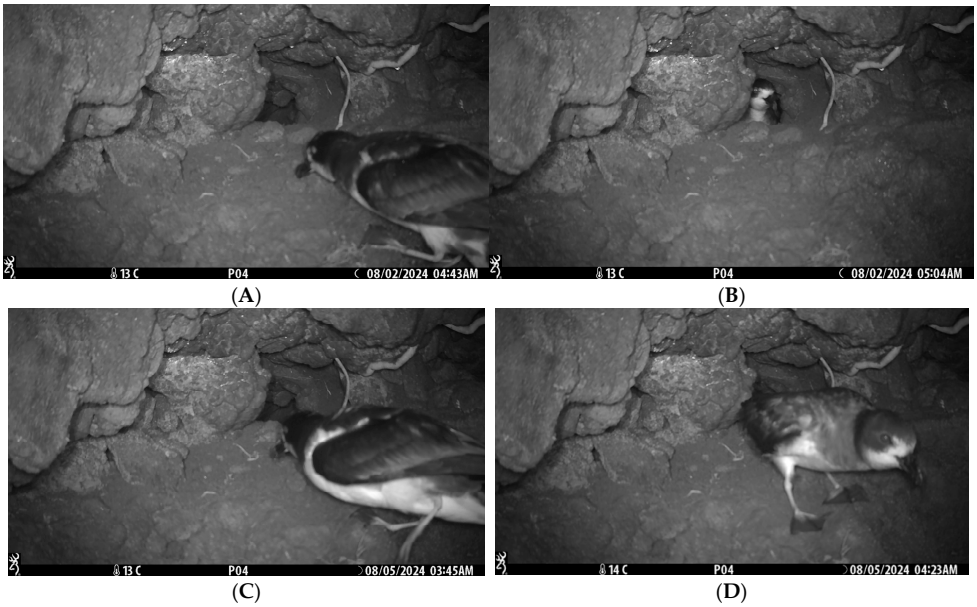


Figure 5. (**A**) A parent Galápagos Petrel (*Pterodroma phaeopygia*) returning to nest 47 after its nestling was killed by a presumed invasive black rat (*Rattus rattus*); (**B**) the same parent inside the burrow searching for its nestling; (**C**) a presumed second parent arriving at the nest (after the first parent had already departed); (**D**) the Petrel departing after unsuccessfully locating the nestling.

4. Discussion

Our findings provide the first direct visual documentation of predation by a presumed black rat (*Rattus rattus*) on a Galápagos Petrel nestling, confirming a threat that has previously been inferred only through indirect evidence, such as the presence of rat feces, gnawed remains, or Petrel reproductive success changes before and after rat control efforts [3,8,16,17]. However, previous scientific studies have produced mixed results when attempting to detect Petrel predation through indirect methods such as dietary and isotopic analyses. For instance, Riofrío-Lazo and Páez-Rosas (2015) [18] did not find Galápagos Petrel remains in rat stomach contents or isotopic signatures during a study on San Cristóbal Island. However, this may reflect the timing of sampling relative to nestling vulnerability, nestling developmental stage, or low detection probabilities. Their sample size was limited (47 rats), the study occurred when only 26% of monitored nests had nestlings and did not specify nestling age, a key factor, as parental presence reduces early-stage vulnerability to rats [3]. Similarly, an earlier study by Clark (1981) [19] found evidence of general animal consumption in black rats' stomach content on Santa Cruz Island, but no indication of Petrel predation. However, this absence may again relate to low sampling resolution or opportunistic foraging patterns typical of invasive rats [20].

In contrast, our camera trap footage offers a continuous and detailed sequence of events, from early rat approaches to the fatal attack and subsequent parental responses. This direct evidence confirms that invasive rats not only enter active nests but that, under the right conditions, they can and do prey on Galápagos Petrel nestlings, filling a crucial gap in the existing literature for Galápagos.

Initial rat incursions were deterred by the presence of adult petrels, highlighting the protective role of parental attendance. As foraging absences became longer, culminating in a 46 h unattended period, the likelihood of predation increased, resulting in the death and consumption of the nestling. Therefore, the prolonged absence of adult Petrels during foraging trips—common in procellariform birds [10]—creates predictable windows of vulnerability for nestlings. This supports broader findings from other oceanic islands where nest success of burrow-nesting seabirds declines dramatically in the presence of invasive rodents [21–24].

Prolonged parental attendance to the nest following the predation event is a particularly novel finding due to its duration. Galápagos Petrel nestlings typically remain in the nest under parental care for an average of 103.7 days (range: 98–108) [3], yet in this case, the parents continued returning to the nest for 91 days after the nestling's death. The nestling was already present when the camera trap was installed on 20 June 2024, meaning it was at least 42 days old at the time of predation. This extended period of attendance closely mirrors a full rearing cycle, despite the absence of a living nestling. The total duration of parental presence likely exceeded the expected rearing timeframe for the species.

Although we cannot confirm individual identity without marked adults, we assume that the returning birds were the original parents based on established species traits. The Galápagos Petrel is known to exhibit strong mate and nest-site fidelity, with a high degree of philopatry and minimal, if any, inter-island breeding during the nesting season [25]. Moreover, this event occurred well into the breeding season, when new adults are unlikely to be arriving or searching for nest sites [3]. These factors make it improbable that the repeated nest visits were by unrelated individuals.

On one hand, continued parental return to a nest after breeding failure reinforces evidence of strong nest fidelity in the species, incurring substantial energetic and behavioral costs for the parents, and raises questions about their ability to recognize nest failure and the potential consequences for future reproductive success. While similar persistence has been observed in other Procellariiformes, where adults continue returning to nests even after

breeding failure [26], our time-stamped footage provides rare empirical documentation of this behavior in the Galápagos Petrel. On the other hand, this prolonged investment may suggest that the Galápagos Petrel's rearing period exceeds previously reported maximums or reflect inter-island differences in breeding ecology. The most recent study on this species' breeding biology dates back to 2010 and was based on data from 2002–2003 from San Cristóbal Island [3]. Our findings suggest a need for updated and island-specific research on breeding phenology.

Our findings also illustrate how species-specific life history traits, such as long foraging trips, low reproductive output, and delayed maturity, interact with invasive species pressures to elevate extinction risk. These traits are shared by many island-nesting seabirds globally, which helps explain why even sporadic predation by rodents can have outsized population-level effects [21,27]. Notably, this predation event occurred on Santa Cruz Island, where rat control efforts are permanent, underscoring the importance of aligning control actions with seabird breeding phenology.

While other invasive predators, such as feral cats, pigs, and dogs, are also known to prey on ground- and burrow-nesting birds, including the Galápagos Petrel [4,15], our camera traps on Santa Cruz Island captured only rodent-related predation during the monitoring period. However, broader predator pressure must be acknowledged. During the same breeding season, a mass predation event by dogs was reported at a nearby nesting site within the Galápagos National Park area in Media Luna, where multiple adult Petrels were killed [14]. In our study area, a dog was also detected by camera trap at a nest entrance, and at Los Petreles Reserve on San Cristóbal Island, a feral cat was recorded attempting to access nests but was unsuccessful, likely due to the narrower, deeper burrow entrances. In contrast, the burrow nests we monitor on Santa Cruz and Floreana tend to be shallower and more accessible. These observations suggest that nest structure and microhabitat features may influence predation risk. Further research is needed to evaluate how burrow depth, entrance size, vegetation cover, and colony location modulate vulnerability to different predators. Spatial modeling of predation patterns and environmental variables could help refine management strategies.

Finally, our study area was located on privately owned agricultural land. This setting, outside the boundaries of Galápagos National Park protection, faces compounding threats, including habitat degradation and unregulated predator pressure [3,4,7,8]. While most research and conservation efforts have focused on protected colonies, our findings show that unprotected agricultural zones also host active, multi-nest colonies. This is especially relevant given that a substantial proportion of known petrel nests are found on private land in Santa Cruz and San Cristóbal, which are the two most populated islands in the archipelago. For example, over 90% of nests on San Cristóbal Island are located on private agricultural land [3]. Therefore, conservation strategies must extend beyond national park boundaries to include private landowners through collaborative management approaches.

Key Conservation Recommendations

To mitigate the ongoing threat of invasive predators, especially rodents, to the Galápagos Petrel, we propose the following conservation actions:

First, rodent control should be expanded and intensified, particularly in and around active nesting areas and buffer zones. This includes establishing permanent control efforts and increasing the frequency of bait station inspections, especially during the nestling-rearing phase when vulnerability peaks.

Second, Petrel conservation should adopt an adaptive management framework. A collaborative initiative should be launched to systematically map nesting colonies across both protected areas and agricultural land. This landscape-level understanding is essential

for guiding targeted conservation actions, monitoring efforts, and resource allocation. Enhanced use of motion-activated camera traps can support predator monitoring and help identify high-risk areas. Additionally, incorporating artificial intelligence systems to detect rodent activity in real-time can improve the efficiency and responsiveness of control efforts. These tools should be paired with a standardized monitoring protocol that integrates camera trap observations, bait consumption data, nest monitoring records, and a capture-mark-release-recapture framework.

Third, habitat restoration must complement control strategies. This includes the sustained removal of invasive plant species, particularly guava, quinine, and blackberry, as well as planting endemic and native vegetation to improve habitat quality. Creating ecological corridors between fragmented nesting sites in protected and unprotected areas will enhance connectivity and resilience.

Finally, long-term conservation success will depend on community engagement and inclusive stewardship. We recommend the creation of a formal collaboration framework between conservation practitioners and farm owners to protect nesting areas located on private land. Since legal protection cannot be extended to private properties, strong partnerships and cooperation agreements with landowners are critical. Offering tangible benefits to participating landowners, such as technical support for sustainable farming, ecological certification, or other conservation-based benefits, will help align conservation priorities with local livelihoods. Camera trap footage and other tools should also be used in outreach and education to foster emotional connections with the species and mobilize community support for conservation.

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Conflicts of Interest: The authors declare no conflicts of interest.

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