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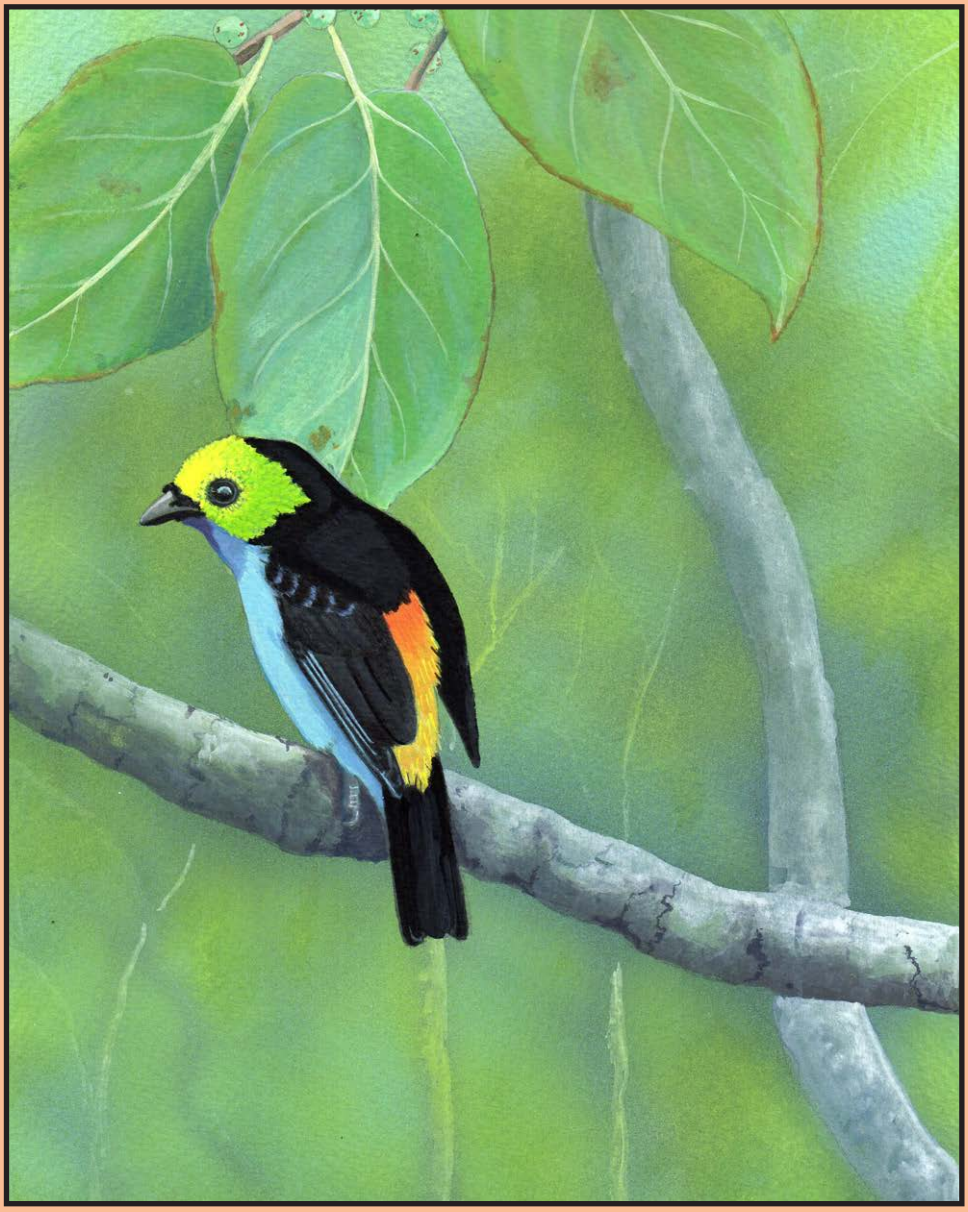

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A new breeding site for Markham's Storm-Petrel *Hydrobates markhami* in northernmost Chile

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La Golondrina de Mar Negra *Hydrobates markhami* (Procellariiformes) es un ave marina de tamaño mediano (21–23 cm) distribuida principalmente a lo largo de la corriente de Humboldt entre el norte de Chile y el sur de Ecuador. En Perú y Chile, se conocen 13 sitios de reproducción entre la península de Paracas (Perú; 13˚54'03''S) y Antofagasta (Chile; 23˚47'16,8''S). Estos sitios albergan una población reproductiva de aproximadamente 58.000 parejas. En este trabajo, informamos sobre un nuevo sitio de reproducción de *H. markhami*, ubicado en Pampa Colorada (18˚22'55,2''S 70˚10'51,6''O) en el extremo norte de la región de Arica y Parinacota, cerca del límite de Chile con Perú. El sitio de reproducción se encuentra sobre un sustrato de arena rojiza fina y gruesa con una costra salina parcialmente protuberante creando cavidades naturales en los salares del desierto. Durante tres campañas de monitoreo, registramos 92 nidos; 24 tenían crías, 26 crías y adultos y 42 evidencias indirectas de reproducción. La conservación de este sitio es fundamental para mantener la conectividad genética de las poblaciones del norte de Chile y las presentes en el sur de Perú.

Markham's Storm-Petrel *Hydrobates markhami* is a medium-sized (21–23 cm) pelagic tubenose (Procellariiformes) found mainly in tropical waters of the Pacific Ocean, between 5˚N and 29˚54'S, and 71˚W and 118˚W[7,14,20]. It breeds in 13 colonies grouped in four dispersed sites in the Sechura and Atacama Deserts (southern Peru and northern Chile), nesting in fissures and holes created by saltpetre deposits in saline areas[1,9–11,17,21]. The northernmost colony is in Paracas, Ica, Peru, where the species breeds at small, dispersed sites on sloping ground, up to 5 km from the sea[9,10]. There are two additional colonies in Peru: Isla La Vieja (Ica)[5] and Pampa Pie de Candela (Tacna)[4]. The 10 other known colonies are all in Chile located in the Atacama Desert, up to 50 km inland[1,11,12]. From north to south, these are Arica, Chiza, Jarza, Quiuña, Caleta Buena, Carmen Norte, Salar Grande, Pampa Hermosa, Loa and Salar Navidad[11,12].

Throughout the species' range, reproduction is asynchronous[1,12]. In the northern colonies of Paracas and Arica, most pairs lay eggs between May and August, and birds attend nestlings between July and January[1,10,12]. In the colonies of Caleta Buena, Salar Grande and Salar Navidad, however, breeding pairs lay eggs between November and January, and adults attend nestlings between January and April[1,12]. The species' population size is estimated at 2,305–4,362 breeding pairs in Peru[9,10] and 55,308–55,733 breeding pairs in Chile[1,12]. Markham's Storm-Petrel is currently classified as Near Threatened globally and Endangered in Chile[13], mainly due to its declining population and extended threats across all breeding colonies[1,12]. Here, we report a new breeding site for Markham's Storm-Petrel in northernmost Chile, near the border with Peru.

Methods

The study area corresponds to road A-135 Sector de Acceso Central – Coronel Alcérreca, in Arica y Parinacota region, northern Chile. This road is north of the Río Lluta basin, north of Arica, and in the extreme southwest of General Lagos (Fig. 1). Focussed searches for storm-petrels (Hydrobatidae and Oceanitidae) were conducted during 14–19 June, 30 September and 28 October 2023. Searches for reproduction clues within potential cavities (i.e., tracks, scents, faeces, feathers and bones) were conducted within the areas identified as possible breeding sites, following guidelines described by Barros *et al.*[1,2].

In addition, because adults usually respond to vocalisations[1], recordings of conspecific calls (Macaulay Library ML83166671) were played at the entrance of cavities to confirm activity in nests. Storm-petrel calls were also recorded using an autonomous AudioMoth v1.2 recorder[6]. This was installed at a potential ground-level breeding site during 14–19 June. Acoustic monitoring comprised four 1-minute recording sessions per hour, each followed by a 14-minute pause, for 24 hours per day: this generated 96 1-minute recordings on each of four days. The sampling frequency ranged from 4–96 kHz, which is adequate for bat and bird recording. Fine-scale measurements were taken, and sonograms were prepared using the Raven Pro 1.5 program[3].

We used digital elevation models (DEM-ALOS PALSAR) with geological maps[18], slope, orientation and contour lines to delimit the breeding site.

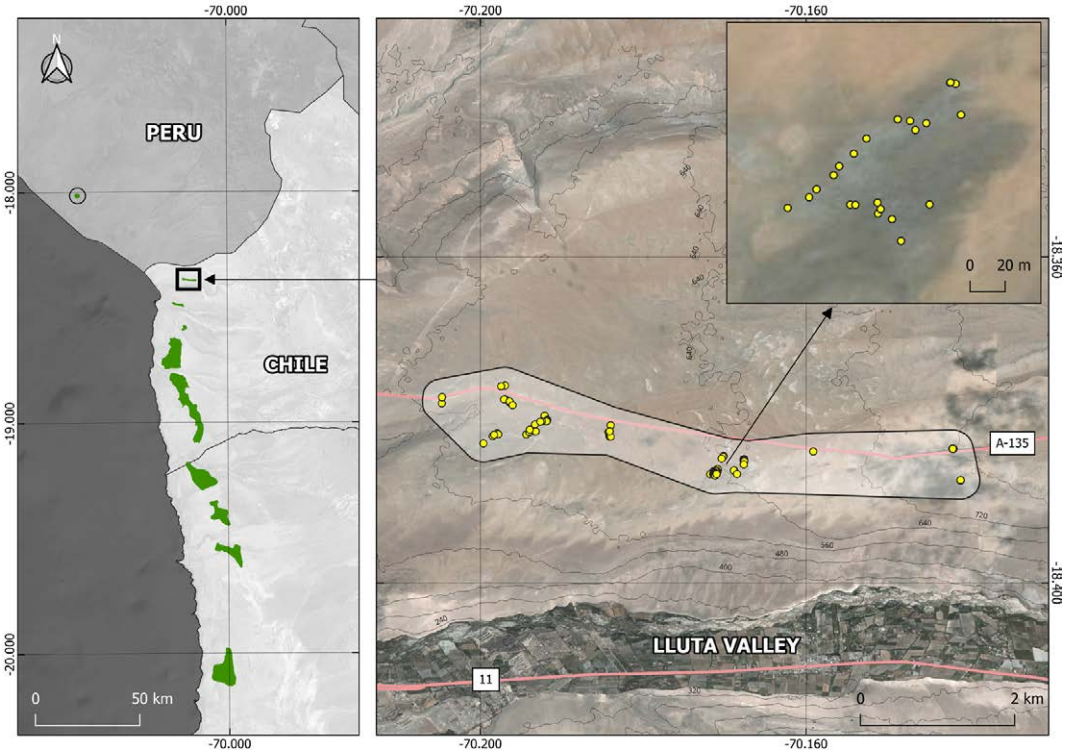

Figure 1. Location of the newly discovered Markham's Storm-Petrel *Hydrobates markhami* breeding site and the distribution of nests at Pampa Colorada, Arica y Parinacota region, Chile. In the left-hand map, the 12 known colonies in northern Chile and southern Peru are marked in green. In the right-hand map, nest sites are indicated with yellow dots and the colony boundary is outlined in black. Main roads are marked in pink; contours are marked at 80 m elevational intervals. The inset (top right) shows the detailed location of nests in one of the densest parts of the colony, superimposed upon the saline substrate (coloured greyish). The map was produced using the spatial data management software QGIS.

Information was also gathered on the location of streams and basins in the region[8]. Breeding-site limits were established with a buffer distance of 250 m from each nest, following the guidelines in ROC (2022)[16], and the potential edges of the site were identified in the field.

Results

We found a new breeding site for Markham's Storm-Petrel located at c.550–800 m elevation, either side of the A-135 road, in a desert plain called Pampa Colorada, which rises between the Concordia ravine to the north and the Río Lluta valley to the south. It is located 14–22 km from the coast, just 7 km from the border with Peru, around 18˚22'55.2''S, 70˚10'51.6''W (Fig. 1). In this area, cavities were found on the salt-flat coast that extends from the dune system (Fig. 2A–C). Across the three monitoring campaigns, we recorded 92 potential nests: 24 contained hatchlings; 26 contained hatchlings and adults (Fig. 2E/F); and 42 showed indirect signs of reproduction, such as bird tracks, odour, old eggs/eggshells and feathers. The nests were found in desert pavement characterised by saline crusting of the geological formations known as 'quaternary eolian deposits' (n = 44) and 'sedimentary sequences of alluvial fans' (n = 48).

The surface area where active and potential nests were recorded covered a polygon of 6.14 km^2 (Fig. 1). The actual colony area is probably larger since there is additional terrain to the north of the road within inaccessible military property (Fig. 1) that could potentially hold an important number of nests, given the extent of the salt crust where the nests of Markham's Storm-Petrel are usually recorded[1,12]. Thus, our area estimate should be interpreted as a minimum polygon for this colony. The timing of reproductive activity recorded at Pampa Colorada matches that described for the colonies of Arica and southern Peru[1,4,12]. We recorded seven *H. markhami* calls from nests during 18h00–21h00 on 14–19 June 2023; a sample recording was deposited with the Macaulay Library (ML589117151).

Figure 2. Photographic evidence confirming Pampa Colorada as a breeding site for Markham's Storm-Petrel *Hydrobates markhami*, Arica y Parinacota region, Chile (Benjamín Gallardo). **A** Habitat at Pampa Colorada, 30 September 2023; **B** nest cavity, 30 September 2023; **C** nest inspection with an endoscopic camera, 28 October 2023; **D** Markham's Storm-Petrel egg, 28 October 2023; **E** Markham's Storm-Petrel nestling, 28 October 2023; **F** Markham's Storm-Petrel adult and nestling, 28 October 2023.

Discussion

Considering the high fidelity of this species to its breeding sites[9,10,12] and the strong population genetic structure[15], this newly discovered colony is critical for the conservation of this globally Near Threatened species. Potential threats to this site are vehicular traffic along the A-135 road, which borders the area and will soon incorporate lighting into its improvement plan; the risk of collisions between storm-petrels and power lines; and garbage thrown out of vehicles. Management measures should be considered to prevent impacts on this breeding site (see Silva et al.[19]). Some effective practices include installing warm-toned lighting and placing lighting near the ground to reduce birds' attraction to lamps.

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