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ORIGINAL ARTICLE

Range expansion of the screaming cowbird (*Molothrus rufoaxillaris*) mediated by a new brood parasite-host interaction in central Chile

Expansión del rango del Mirlo de pico corto (*Molothrus rufoaxillaris*) mediada por una nueva interacción parásito-huésped en Chile central

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ABSTRACT

The Screaming Cowbird (*Molothrus rufoaxillaris*) is a brood-parasite specialized in parasitizing the Grayish Baywing (*Agelaioides badius*). Recently, it started to parasite a new host, the Austral Blackbird (*Curaeus curaeus*), which has driven the expansion of its range to central Chile. However, its actual and potential distribution and the natural history of this interaction are scarcely known. In this note, we describe the distribution, habitat use and phenology of the species in Chile. Additionally, we present data on feeding events of Screaming Cowbird fledglings by Austral Blackbirds. For doing so, we analyzed data from a citizen-science project using Maxent and Random Forest models. We found that the Screaming Cowbird is distributed mainly in urban and agricultural habitats, avoiding native shrublands and forests. The potential distribution is driven by the temperature and the Austral Blackbird distribution. This note confirms the relationship between both species of icterids and gives new insights into how new host-parasite interactions can drive the range expansion of brood parasitic birds.

Keywords: austral blackbird, biogeography, blackbirds, brood parasitism, eBird, host use.

RESUMEN

El mirlo de pico corto (*Molothrus rufoaxillaris*) es un ave parásita especializada en parasitar al tordo músico (*Agelaioides badius*). Recientemente, comenzó a parasitar a un nuevo huésped, el tordo (*Curaeus curaeus*), lo que ha llevado a la expansión de su rango de distribución a Chile central. Sin embargo, su distribución actual y potencial, y la historia natural de esta interacción son poco conocidas. En esta nota, describimos su distribución, uso de hábitat, fenología y algunas observaciones de dieta de la especie en Chile. Para hacer eso, analizamos datos de un Proyecto de ciencia ciudadana, usando modelos Maxent y Random Forest. Encontramos que el Mirlo de pico corto se distribuye principalmente en hábitats urbanos y agrícolas, evitando matorral y bosques nativos. La distribución potencial está influenciada por la temperatura y por la distribución del Tordo. Esta nota confirma la relación entre ambas especies de ictéridos y aporte nuevos conocimientos acerca de cómo estas interacciones pueden conducir a la expansión del rango geográfico de las aves parásitas de cría.

Palabras clave: biogeografía, eBird, mirlo austral, mirlos, parasitismo de cría, uso de hospedadores.

INTRODUCTION

Interspecific brood parasitism is a breeding strategy that avoids the costs of incubation and chick-rearing for the parents but requires specific adaptations to exploit the parental care of heterospecific hosts (Payne 1977). This reproductive strategy has evolved in approximately 1% of bird species (Fiorini *et al.* 2019), being cowbirds and cuckoos the most extensively studied (Davies, 2000). In continental Chile, three of the 304 breeding birds are brood parasites: one Anatidae, the Black-headed duck (*Heteronetta atricapilla*), and two Icteridae, the Shiny Cowbird (*Molothrus bonariensis*), and the recently discovered Screaming Cowbird (*Molothrus rufoaxillaris*) (Medrano *et al.* 2018).

The Screaming Cowbird mainly parasitizes the Grayish Baywing (*Agelaioides badius*) (Fiorini *et al.* 2019). This specialization in host use has resulted in many specific adaptations, including the resemblance of the host's eggs in color and shape (Fraga 1983), and the visual and vocal mimicry of host chicks (De Mársico *et al.* 2014, Rojas Ripari *et al.* 2019). As expected, the Screaming Cowbird's geographic range mainly fits that of the Grayish Baywing (Lowther 2020). However, the range of the Screaming Cowbird has been recently expanded to areas where the Baywing is not present, presumably due to new host-parasite interactions involving other species of icterids (Lima 2021). The Screaming Cowbird is also known to parasitize the Chopi Blackbird (*Gnorimopsar chopi*), the Brown-and-yellow Marshbird (*Pseudoleistes virescens*) (Mermoz & Reboreda 1996; Mermoz & Fernández 2003; reviewed by Fiorini *et al.* 2019) and the Scarlet-headed Blackbird (*Amblyramphus holosericeus*) (Mermoz *et al.* 2021). It is also suspected to parasite the Pale Baywing (*Agelaioides fringillarius*) and the Yellow-rumped Marshbird (*Pseudoleistes guirahuro*) in Brazil, but these reports require confirmation (Fiorini *et al.* 2019, Lima 2021). The use of Chopi Blackbirds has driven a northward range expansion (Fraga 1996, Lima 2021), whereas the recent colonization of the Austral Blackbird (*Curaeus curaeus*) allowed the parasite to expand its range to Central Chile (Barros 2015).

The interactions between the Screaming Cowbird and the Baywing have been well described (see the review of De Mársico *et al.* 2019). However, the interactions between the Screaming Cowbird and the Austral Blackbird, as well as the breeding range of the species in Chile, are poorly known (Pantoja *et al.* 2018). For example, it is not yet clear how the Austral Blackbird distribution influences the Screaming Cowbird distribution.

This note aims to assess whether the expansion of the Screaming Cowbird in Chile is mainly driven and limited by their interaction with the Austral Blackbird. Specifically, we: (i) describe the historical, current and potential range of the Screaming Cowbird in Chile, ii) examine the relevance of the Austral Blackbird's distribution and environmental factors on the distribution of the species; (iii) describe the breeding and molting phenology of the Screaming Cowbird in Chile; and (iv) describe behavioral interactions of the Screaming Cowbird with its new parasite, the Austral Blackbird.

METHODS

To describe the range of the Screaming Cowbird in Chile, we compiled historical (already compiled in Barros 2015) and recent data on sightings of the species in Chile. To increase the number and quality of observations available in the eBird database, we created a Citizen Science project named ''Proyecto Mirlo de pico corto" ("Screaming Cowbird project") in January 2017, together with the Chilean NGO Red de Observadores de Aves y Vida Silvestre de Chile (ROC). This project included an identification guide, a web page (https://www.redobservadores.cl/?p=888), and vocalizations of the species to facilitate the differentiation between this species and the Shiny Cowbird. We encouraged birdwatchers to upload their records to eBird with photos, sounds, and descriptions of their observations. We next searched eBird for records of the species in Chile, including comments, breeding codes, and pictures when available. For this note, we included information between January 2003 and May 2022. We also described the breeding phenology, including courtship, egg hatching and fledging using eBird data.

For mapping the potential distribution, we modeled the range distribution of the Screaming Cowbird using known locations and environmental variables using Maxent and Random Forest models, through the dismo and randomForest packages in R 4.1.2 (Liaw 2002, Hijmans *et al.* 2017). In the models, we used eBird locations for the Screaming Cowbird in Chile, with one record for each 1x1 km grid, resulting in 106 localities. To obtain environmental information, we used different sources. We obtained an Elevation Model from an ASTER satellite sensor with a spatial resolution of 30 m (https://earthexplorer.usgs.gov/) to get data on the elevation (meters above sea level), the slope, and the aspect. We also obtained 19 temperature and precipitation rates from Chelsa and the Net primary productivity (https://chelsa-climate.org/bioclim/), with a spatial resolution of 1 km. We chose these variables since they are built with updated climatic means from the period 1979-2013, and provide higher predictive models than other variables (Maria & Udo 2017). We also included data on land cover obtained from Hernández *et al.* (2016), with a spatial resolution of 30 m (Supplementary

Material 1). Finally, we built a layer with presence/absence of Austral Blackbird as an input, with a spatial resolution of 1x1 km (Supplementary Material 2). All the layers were homogenized to equal size and extent of the study area, with a spatial resolution of 1x1 km. To obtain more accurate models, we did 50 iterations of both Maxent and Random Forest models, calculating a weighted average, using an AUC value for weighting its relative importance with the dismo package (Araújo & New 2007).

RESULTS

We collected 352 Screaming Cowbird records from 124 localities (Fig. 1). One hundred and eleven people participated in the project by uploading their records to eBird.

Historical, current, and potential distribution

The first record of Screaming Cowbird in Chile is from January 2003 near San Clemente town (-35.52, -71.44; Maule Region), when two juveniles were sought within a flock of Austral Blackbirds. The next record is from December 2010 near Chimbarongo (-34.67, -71.035, O'Higgins Region), also of two juveniles within an Austral Blackbird flock. From 2013 onwards (Fig. 1), the species was recurrently recorded, especially in San Fernando area (-34.55, -70.95; O'Higgins Region). In 2014 it was first recorded in Buin (-33.72, -70.73; Metropolitana Region), in 2021 in Santo Domingo (-33.65, -71.62; Valparaíso Region) and in 2022 in San Carlos (-36.47, -72.00; Ñuble Region). Up to date, the species has been recurrently recorded in all the mentioned locations.

The current range of this species spans from Lo Barnechea (-33.35, -70.52; Metropolitana Region) to San Carlos (-36.47, -72.00; Ñuble Region) (Fig. 2). Almost all the records were done in anthropized habitats, including urban areas (31 localities), urban parks (5 localities), and rural areas (86 localities), with only two records in native shrublands or forests, despite the high sampling effort in these habitats. The altitudinal distribution ranged from the sea level to the 750 m.a.s.l. (Supplementary Material 3).

Regarding the species distribution model, the Screaming Cowbird has the potential to colonize areas in the valleys of the Coquimbo and Valparaiso regions in its Northern distribution and the coastal Bio-Bio region in the South (see Fig. 2). The most important explanatory variable was the presence of Austral Blackbird (mean 46.6%), followed by mean daily mean air temperatures of the driest quarter (9) and mean daily maximum air temperature of the warmest month (5) in Random Forest, and precipitacion seasonality (15) and net primary productivity (19) in Maxent model (see Supplementary Material 1).

Breeding and molting phenology

In our project, we registered 184 records with comments or breeding codes, concluding that courtship behavior occurs between 2 September (Barros 2021), 8 December (Barros 2018a, 2018b). We did not record laying and hatching dates. Fledging of Screaming Cowbird chicks was recorded at the end of November and juveniles were seen flocking with Austral Blackbirds until the end of March. By that time, juveniles would presumably join other Screaming Cowbirds (Fig. 3).

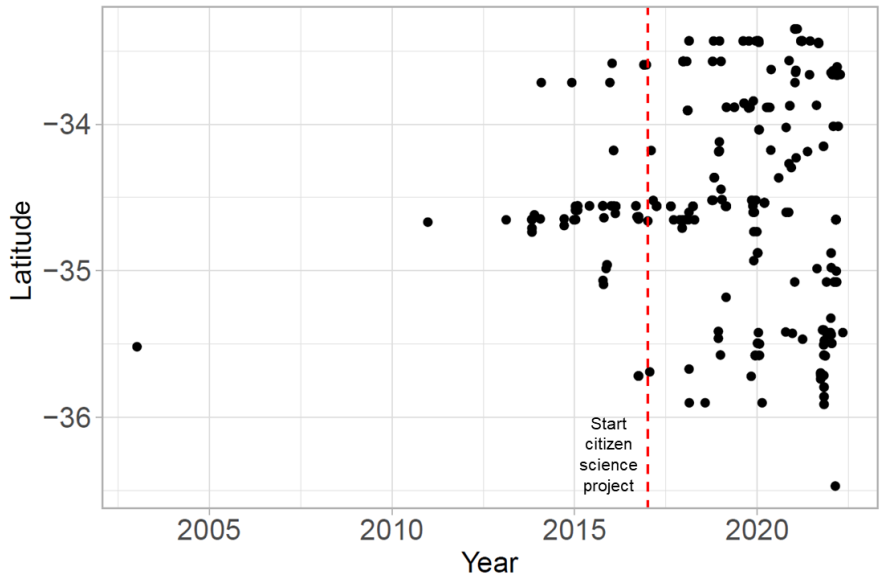

Figure 1. Screaming Cowbird records in Chile by year and latitude. / Registros del Mirlo de pico corto en Chile por año y latitud.

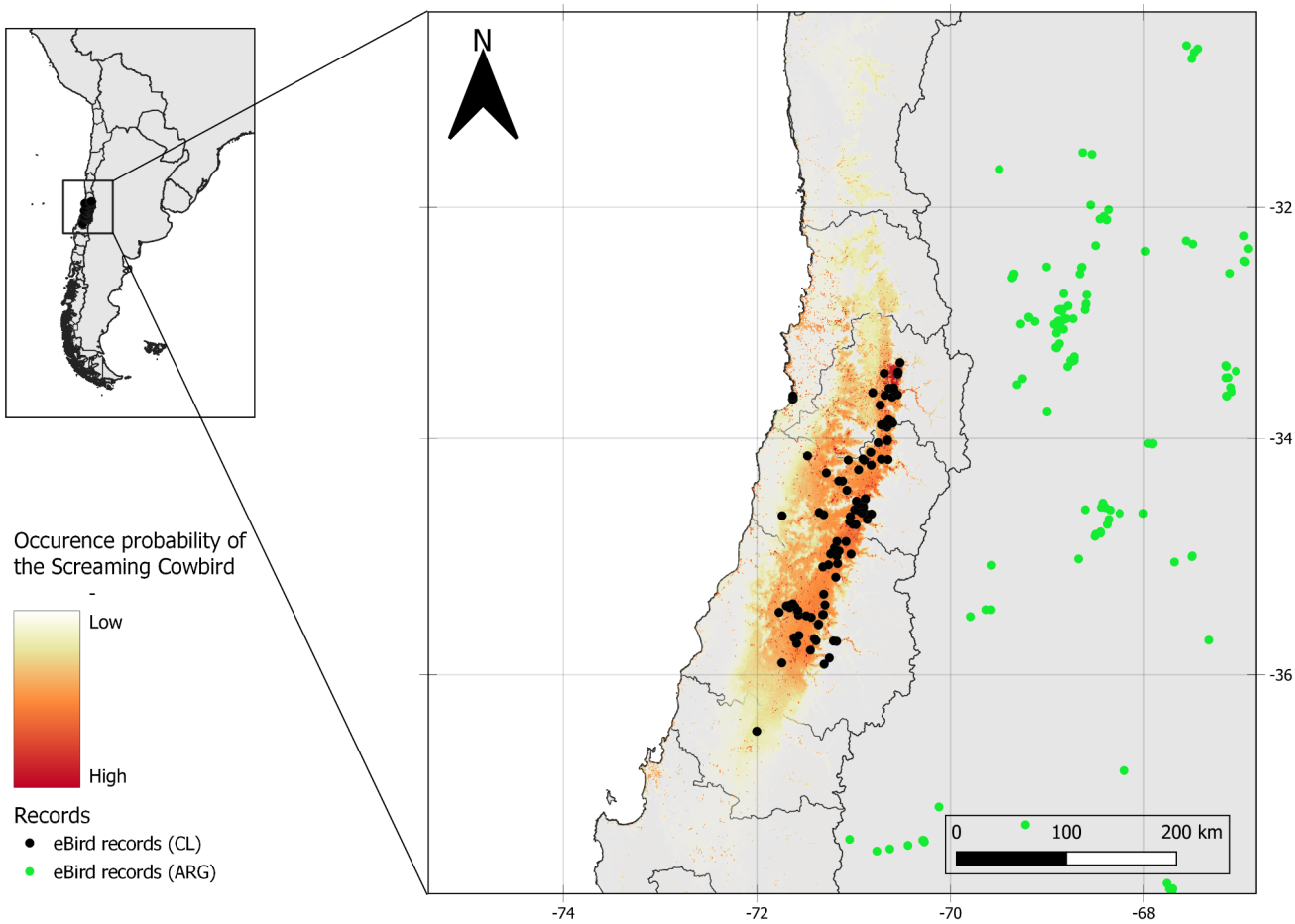

Figure 2. Map of the range of the Screaming Cowbird in Chile, showing eBird records and the model of occurrence based on Maxent and Random Forest models. These models were built using the distribution of the Austral Blackbird and environmental and geographical variables (see Methods for details). / Mapa del rango del Mirlo de pico corto en Chile, mostrando los registros de eBird y el modelo de ocurrencia obtenido en base a los modelos Maxent y Random Forest. Estos modelos fueron construidos utilizando la distribución del Tordo y variables ambientales y geográficas (ver detalles en Métodos).

Post-fledging ecology

From 224 unique records, 92 (41%) were of juveniles. Seventy-six out of these 92 records involved as many as two Screaming Cowbird fledglings with a pair of Austral Blackbirds. From the remaining fledgling records, 8 did not mention Austral Blackbirds and 8 were incomplete lists. Records outside the breeding season indicate that Screaming Cowbirds flock with Shiny Cowbirds.

We found reports of Austral Blackbirds feeding the fledglings of Screaming Cowbird with plums (*Prunus sp.*) (Cabrera in eBird 2017; Canales in eBird 2018), figs (*Ficus carica*) (Quintanilla in eBird 2018) and walnuts (*Juglans regia*) (Recordón in eBird 2018). Additionally, there is one record of adults feeding the chicks with cherries (*Cerasus sp.*) (Díaz in eBird 2014).

DISCUSSION

We collated a total of 352 records of Screaming Cowbirds in 124 localities, spanning from Lo Barnechea (Latitude: -33.34) to San Carlos (Latitude: -36.47), and our model analysis suggests that they could potentially colonize the valleys of the Coquimbo and Valparaiso regions to the north, and the coastal Bio-Bio region to the south of their range in Chile (Fig. 1 and 2). Almost all the records were done in anthropized habitats (agricultural and urban landscapes), and the presence of the Austral Blackbird appears as the most important explanatory variable in our models of Screaming Cowbird expansion, and consequently, it seems to have favored the expansion of this species.

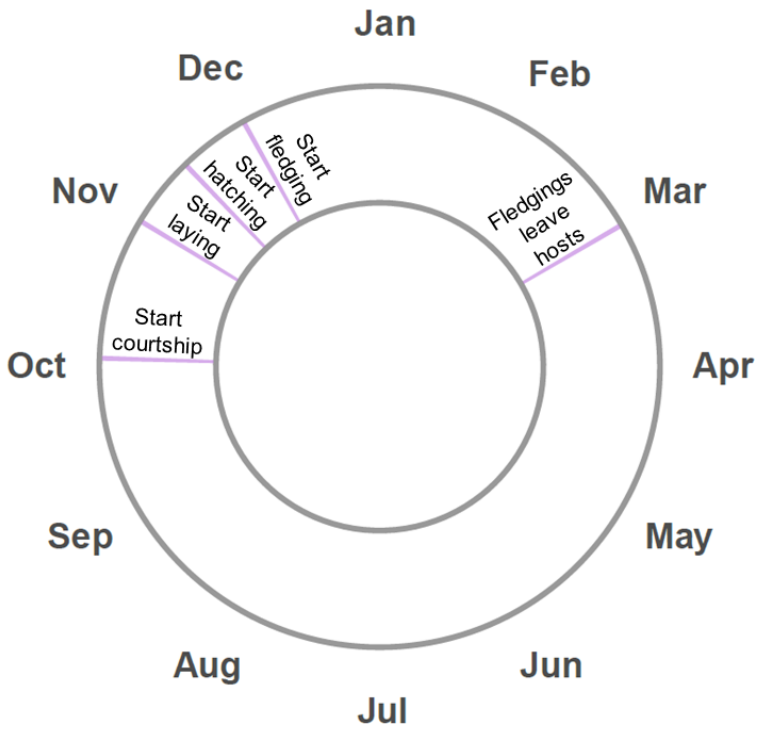

Figure 3. Phenology of the Screaming Cowbird in Chile. / Fenología del Mirlo de pico corto en Chile.

The species colonized Central Chile from Argentina, presumably in the O'Higgins Region (Fig. 2), but it is unclear when this process occurred since this Region remains largely unsampled. However, it seems unlikely that the Screaming Cowbird have colonized Santiago before the beginning of this project, considering the high sighting effort within this city and the unmistakable plumage of the juveniles. For this reason, we consider that the species is currently in expansion. Considering our findings, the expansion appears to be constrained to the distribution of the Austral Blackbird, therefore Screaming Cowbirds would potentially colonize other agricultural valleys in Coquimbo, Valparaiso, and Bio-Bio where the Austral Blackbird is present. It would be valuable to understand whether the species expansion was also promoted by deforestation, as has happened with other species in Central Chile (e.g., Chilean Mockingbird, Marin 2012). In addition to the presence of Austral Blackbirds, the distribution was explained by several variables related to the temperature of the air, which would currently constrain the species to the Bio-Bio region. However, it is not possible to discard a southward expansion, considering that climate change and land use will probably modify the landscape in southern Chile in the following decades (Araya-Osses *et al.* 2020) and that the Austral Blackbird is distributed until southern Patagonia (Supplementary Material 2). Further, other known host species (i.e., Grayish Baywing, Brown-and-Yellow Marshbird) are not present in Chile, and there is no evidence of Screaming cowbird parasitism in other potential hosts.

The breeding phenology of the Screaming Cowbird ranged from October to March, which matches the phenology of the Austral Blackbird in Chile (Venegas 2018). So far, it is not known how many Screaming Cowbird eggs are laid per Austral Blackbird nest, but the records examined here show as many as two cowbird fledglings per Austral Blackbird couple, which suggests that multiple parasitism would be common, as seen in nests of the primary host (Ursino *et al.* 2020).

We found that Austral Blackbird fed Screaming Cowbird fledglings with several agricultural-made items. Considering that all these items came from fruit plantations, this would suggest that the Austral Blackbird- Screaming Cowbird association may occur especially on anthropized environments. However, those records on chick diet based in citizen science might be biased and should be taken cautiously. It is likely that this species feed the chicks mainly with arthropods, as in other icterids (Winkler *et al.* 2020).

In conclusion, we described the current range of the Screaming Cowbird in central Chile, which appears to be

expanding mediated by parasitism on the Austral Blackbird. We showed that most of the distribution in Chile is constrained to anthropized habitats, including agricultural and urban habitats. Further research is needed to assess the breeding success of Screaming Cowbird parasitizing this host species and better understand the host-parasite interactions between these species.

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