

Hybridization between Yellow-billed Cardinal *Paroaria capitata* and Red-crested Cardinal *P. coronata* in southern Argentina

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ABSTRACT: The genus *Paroaria* is a group of conspicuous songbirds widely distributed in South America that has been studied recently to delimit its species and establish their phylogenetic relationships. Although hybridization has been reported between the most phylogenetically related species of the genus, we here present a case of hybridization between the Yellow-billed Cardinal (*P. capitata*) and Red-crested Cardinal (*P. coronata*) for the first time, two phylogenetically unrelated members of the group. This data contributes to the knowledge of this avian group whose systematics is still under debate.

KEY-WORDS: breeding biology, hybrids, interbreed, Neotropical birds, Patagonia

Species delimitation has been a crucial topic in the natural history of birds, both for systematic and ecological studies (de Queiroz 2007). Systematic studies on the genus *Paroaria*, a group of conspicuous songbirds widely distributed in South America (Jaramillo 2011), indicate that it comprises six to eight species splitted into two ecological groups: the riparian species (*P. gularis*, *P. baeri*, *P. xinguensis*, *P. capitata*, *P. cervicalis* and *P. nigrogenis*) and the open-forest species (*P. coronata* and *P. dominicana*) (Dávalos & Porzecanski 2009). Estimated divergence times range from 3.7 to 5.0 mya for the split between the open-forest *vs.* riparian clades, which has led them to show at present both morphological (Jaramillo 2011) and genetic (Dávalos & Porzecanski 2009, Areta *et al.* 2017) differences. During the last decades, it has been reported some natural hybridization between species of this genus, for example between *P. baeri* and *P. gularis* (Jaramillo 2011, Lopes & Gonzaga 2013, Areta *et al.* 2017), two non-sister species but still phylogenetically close “riverines” (Dávalos & Porzecanski 2009). However, in captivity conditions, hybridization has also been reported among less related *Paroaria* species (*P. dominicana* and *P. nigrogenis*, two genetically distant species; McCarthy 2006) and even with species of other genera and even families (*P. coronata* with *Sicalis flaveola*, *Gubernatrix cristata*, *Cardinalis cardinalis*, *Chrysomus ruficapillus* and *Molothrus bonariensis*; McCarthy 2006). In this contribution, we present the first record of natural hybridization between

Yellow-billed and Red-crested Cardinal (a riverine and an open-forest cardinal respectively, two phylogenetically distant species in *Paroaria*).

This study was conducted at Viedma, Río Negro province, northeastern Patagonia, Argentina (40°48'S; 63°01'W; Fig. 1). The study area is representative of the “Monte” ecoregion (Brown *et al.* 2006), with large areas of native xerophytic vegetation altered by extensive and low-density cattle grazing. This region is characterized by warm summers (maximum temperature of 42.3°C) and cold winters (minimum temperature of -13.5°C), with most precipitations occurring between November and March. The National Meteorological Survey of Argentina from 1987–2017 reports mean annual rainfall as 257 mm and mean annual temperature as 15°C. At the local scale, the nesting territory was located on the southern margin of the Negro River, in a wetland dominated by the exotic *Salix viminalis* (Salicaceae). The area was surveyed every 5–8 days, since the first evidence of hybridization, with the help of binoculars and photographic cameras.

In March 2016 (end of 2015–2016 breeding season) we located an interspecific pair moving together in the nesting area (Fig. 2A). We inspected the surroundings shrubs and forests to locate the nest (see details in Segura *et al.* 2015), but we could not find it. On 18 April, we saw both parents with a fledgling for the first time (Fig. 2B & C) and delivering food to it. We observed the family group until the beginning of June, and since then, we

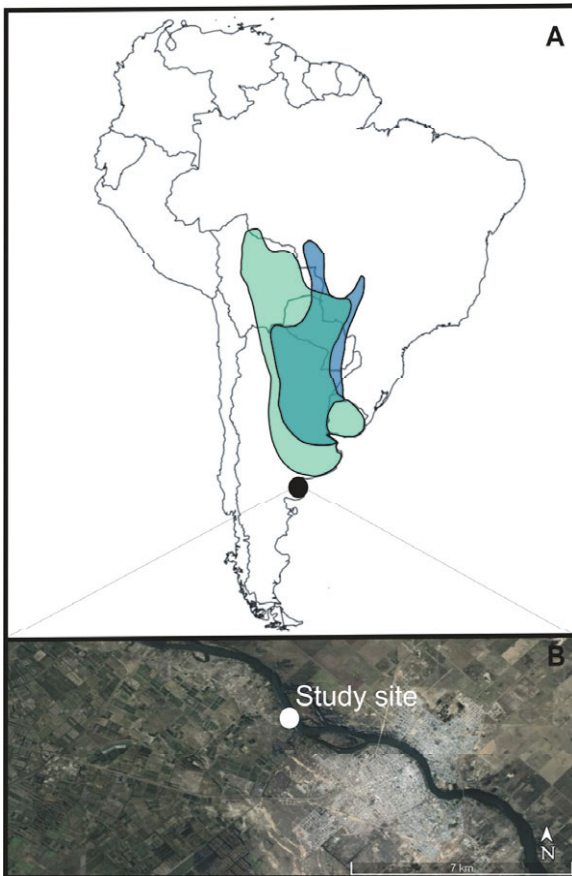


Figure 1. Distribution area of the Yellow-billed Cardinal *Paroaria capitata* (blue shaded) and Red-crested Cardinal *P. coronata* (green shaded) in South America (A); Jaramillo 2011). Area surveyed in this study (B).

detected only adults throughout the winter, until spring began. The size and plumage of our hybrid juvenile (Fig. 2D) strikingly resembled that of *P. capitata* juveniles (Fig. 2E), although the bill color and tarsus were gray, like *P. coronata*.

In the last decades, individuals of both species have been reported in atypical southern localities in relation to the original distribution (Fig. 1). For example, on web platforms such as EcoRegistros (2018) or eBird (2018), the records of both species in the Negro River (northern Patagonia) and cities in southern Buenos Aires province (central-eastern Argentina) are increasingly frequent. A possible explanation is that both species are traditionally captured and sold in illegal trade in a large fraction of their distribution area (UNEP-WCMC 2009), and the release of individuals from captivity in areas near urban centers would explain this atypical distribution.

The sympatry area between both species is extensive (Fig. 1) and the contact is not recent (Dávalos & Porzecanski 2009, Areta *et al.* 2017). However, no hybrids have been reported within this area. On the one hand, this lack of previous reports could be simply due to an artifact of poor sampling, but considering that both species are conspicuous and relatively common in their respective habitats, it is unlikely that this could be the reason. However, there may be some behavioural or ecological barriers within their sympatry area (Randler 2006) that keep them from hybridizing in a natural way. Although our birds paired and reproduced in natural conditions, we

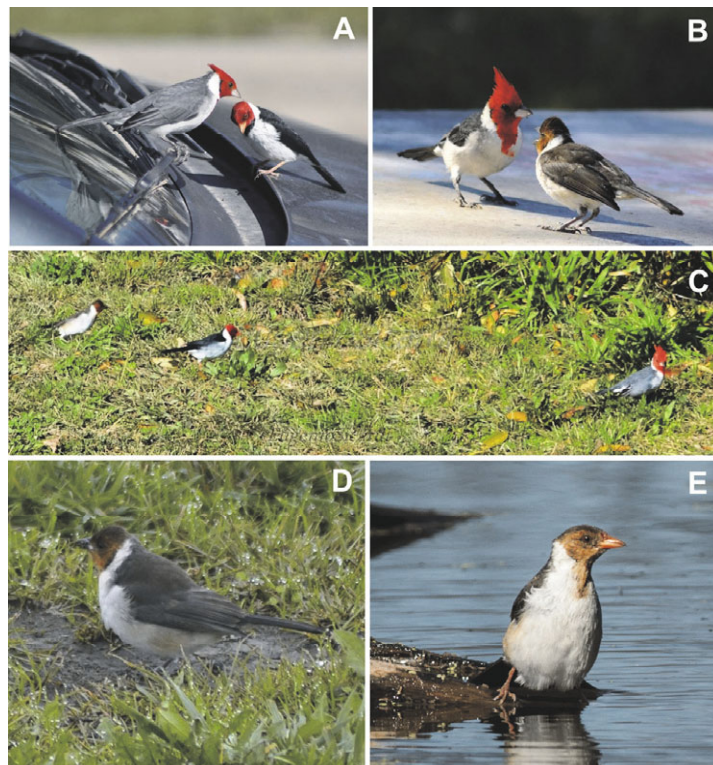


Figure 2. Mixed breeding pair composed by a Yellow-billed Cardinal, *Paroaria capitata*, and a Red-crested Cardinal, *P. coronata* (A). Red-crested Cardinal feeding the hybrid fledging (B). Familiar group moving together on the ground (C). The hybrid fledging (D). A pure Yellow-billed fledging (E). Photo authors: Graciela Balda (A, B, D), Eugenio Sicardi (D), Giselle Mangini (E).

do not ignore the particular situation regarding the lack of conspecifics in an unusual austral distribution area for both species, which could have favored the interspecific hybridization (see Baker 1996).

It has been discussed that genetic differences between the related *P. capitata* and *P. cervicalis* (and even *P. gularis*) are so small that cases of hybridization are expected (Dávalos & Porzecanski 2009), but *P. capitata* and *P. coronata* are more divergent (Dávalos & Porzecanski 2009, Areta *et al.* 2017). In this sense, phylogenetic results within *Paroaria* indicate that the mitochondrial gene tree contained a deep split between open-forest (*P. dominicana* and *P. coronata*) and riparian species (all other *Paroaria*). Our results show that, despite this genetic split, they still maintain the ability of interbreeding as an ancestral condition (see Podos & Nowicki 2004).

Even though we cannot infer if the hybrid offspring has post-zygotic barriers to freely interbreed with the parental species, the fact that two genetically distant *Paroaria* may naturally hybridize, as first reported here, may be an additional evidence that tropical bird species, and *Paroaria* species in particular, may hold the potential to mate and interbreed for a very long time after speciation (Weir & Price 2011, Areta *et al.* 2017). The genus *Paroaria*, therefore, may represent an interesting system to further research on the role of hybridization on the evolution and speciation of birds.

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