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Short Communication

Brood parasitism leads to zero recruitment in the globally endangered Yellow Cardinal *Gubernatrix cristata*

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Summary

The Yellow Cardinal *Gubernatrix cristata* is an 'Endangered' passerine from southern South America. For the past three years a management plan for Yellow Cardinals has been implemented in Argentina, in which rescued individuals from the illegal cage bird trade were released back into suitable habitats within their population of origin. We studied the reproductive success of a mixed population of released and wild Yellow Cardinals in La Pampa province, Argentina, during the reproductive season of 2019. The population was highly parasitized by the brood parasitic Shiny Cowbird *Molothrus bonariensis*. The frequency of parasitism was 100% and the intensity of parasitism was 4.5 ± 3.4 (mean ± SD) eggs per parasitized nest (range 1–13). No Yellow Cardinal chicks were recruited in the monitored nests, mainly as a consequence of Shiny Cowbird parasitism. The unusually high rate of parasitism led to a poor outcome of the reintroduction programme and indicates the need to update the conservation actions that have been carried out for the Yellow Cardinal so far. Shiny Cowbird abundance varies within the distribution of Yellow Cardinals, related to habitat modification and farming activities. Thus, further research on habitat suitability and assessment of Shiny Cowbird abundance should be incorporated into future strategies for the conservation of the Yellow Cardinal.

Resumen

El Cardenal Amarillo *Gubernatrix cristata* es un paseriforme endémico del sur de América del Sur. En los últimos tres años, se ha llevado a cabo un plan de manejo para Cardenales Amarillos en Argentina, en el cual los individuos rescatados del tráfico ilegal de aves de jaula fueron liberados en ambientes adecuados dentro de sus poblaciones de origen. Estudiamos el éxito reproductivo de una población mixta de Cardenales Amarillos liberados y silvestres en La Pampa, Argentina, durante la temporada reproductiva de 2019. La población fue altamente parasitada por el parasito de cría Tordo Renegrido *Molothrus bonariensis*. La frecuencia de parasitismo fue del 100% y la intensidad de parasitismo fue de 4,5 ± 3,4 (promedio ± DS) huevos por nido parasitado (rango 1–13). No se reclutaron pichones de Cardenal Amarillo en los nidos monitoreados, principalmente como consecuencia del parasitismo por parte del Tordo Renegrido. Estas tasas de parasitismo inusualmente

altas han provocado resultados poco exitosos en el programa de reintroducción y llaman a una actualización en las acciones de conservación que se han estado llevando a cabo para el Cardenal Amarillo hasta ahora. La presión de parasitismo de Tordos Renegridos varía a lo largo de la distribución del Cardenal Amarillo, relacionado a la modificación de hábitat y actividades agropecuarias. Por lo tanto, llevar a cabo más trabajos de investigación en temas de aptitud de hábitat, así como considerar la abundancia de Tordos Renegridos deberían ser incorporados como estrategias futuras para la conservación del Cardenal Amarillo.

Keywords: Yellow Cardinal, reintroductions, recruitment, brood parasitism

Palabras clave: Cardenal Amarillo, reintroducciones, reclutamiento, parasitismo de cría

Introduction

The Yellow Cardinal *Gubernatrix cristata* (Aves: Thraupidae) is a passerine from southern South America categorised as 'Endangered' by IUCN (BirdLife International 2020). Historically, Yellow Cardinals were distributed throughout the southern tip of Brazil (Rio Grande do Sul), Uruguay, and central and northern Argentina (BirdLife International 2020). Habitat loss and the capture of individuals for the illegal cage bird market are reportedly the biggest threats that have led to the species' decline (BirdLife International 2020). Currently, its distribution is discontinuous with the largest populations found in Argentina (Reales *et al.* 2019, Domínguez *et al.* 2020), mainly in non-modified areas within the Espinal ecoregion. Natural habitats of this ecoregion are characterized by patches of thorny trees and shrub forests, interspersed with pastures as well as woodlands and more open savanna-like habitats (Cabrera 1976). Even though habitat loss and illegal wildlife trafficking are the main threats to the species, Domínguez *et al.* (2015) reported the negative impact of brood parasitism by Shiny Cowbirds *Molothrus bonariensis* as an additional threat for Yellow Cardinals. Puncturing of host eggs by parasite females resulting in brood reduction and often in nest abandonment was identified as the main impact of Shiny Cowbird parasitism on the reproductive success of Yellow Cardinals (Domínguez *et al.* 2015). Brood parasitism by cowbirds has been suggested to compromise the viability of populations of threatened species by negatively affecting the reproductive success of hosts (Brittingham and Temple 1983, DeCapita 2000, Rothstein and Cook 2000, Oppel *et al.* 2004).

As part of a conservation plan for Yellow Cardinals in Argentina, a reintroduction programme for individuals rescued from the illegal wildlife trade has been carried out for the past three years. Rescued individuals went through a sanitary rehabilitation at the Fundación Temaikèn recovery centre and were subsequently released back into areas with suitable habitat within their area of provenance, previously determined by the use of molecular markers (Domínguez *et al.* 2019).

Information on the breeding biology of released individuals along survival and persistence are the main demographic parameters needed to evaluate the success of a reintroduction programme (Seddon 1999, Parker *et al.* 2013). In this contribution we report the impact of Shiny Cowbird parasitism on the recruitment of released and wild Yellow Cardinals in La Pampa province, Argentina.

Methods

Study site

The study took place in a private livestock ranch in La Pampa province, Argentina (36°48'S; 64°37'W) from early October to late December 2019, covering almost the entire breeding season of the species (late September–early January; Domínguez *et al.* 2015, Segura *et al.* 2019). The ranch contains thorny shrubland forests with different vegetation densities, dominated by calden mesquite *Prosopis caldenia*, within the Espinal ecoregion (Morello *et al.* 2012), covering a total area of 1,320 ha.

Data collection

Nine Yellow Cardinal reproductive pairs were followed during the 2019 breeding season within the private ranch and surrounding areas (1–2 km into the neighbouring ranches). Six of these pairs were composed of (either one or both) individuals recovered from illegal wildlife traffic, released in the study site in 2017, 2018 or 2019. The remaining three pairs were wild Yellow Cardinals found within the study site. In order to identify and follow the wild reproductive pairs, they were captured with mist nets and banded on the tarsus with a numbered aluminium ring and a combination of two-coloured plastic rings. The released Yellow Cardinals had been banded before release.

We monitored the activity of the reproductive pairs and determined their territories. We searched for nests within these territories and followed reproductive attempts by visiting the nest every 1–4 days until the reproductive attempt concluded. During nest localizations and nest visits, disturbance of the brood was minimised by following standardized techniques described in Martin and Geupel (1993). During each visit, the content of the nest was examined, and eggs were marked with waterproof ink. Yellow Cardinal nests have a modal clutch size of three eggs (range 2–4) of a bluish background colour with black spots (Dominguez *et al.* 2015), and are easily distinguishable from brood parasite eggs since Shiny Cowbirds do not lay eggs with such characteristics (Ortega 1998, de la Colina *et al.* 2011, Hanley *et al.* 2019).

To estimate the frequency of brood parasitism we calculated the proportion of nests with Shiny Cowbird eggs. Intensity of parasitism was estimated by averaging the number of parasite eggs in parasitized nests that were found during construction, laying, or incubation after laying had been completed.

Results

We found 17 nests during the study period, three during construction, six during laying and eight during incubation corresponding to nine reproductive pairs. We followed 15 of these nests, until the reproductive attempt ceased (from now on "monitored nests"). Six of the nine reproductive pairs had re-nesting attempts, five of them with one re-nesting attempt and one with three. The frequency of Shiny Cowbird parasitism was 100% ($n = 17$) and its intensity was 4.5 ± 3.4 (mean $\pm$ SD) eggs per parasitized nest (range 1 – 13; $n = 15$; Fig. 1A). All monitored nests lost Yellow Cardinal eggs. In 13 nests, we found convincing evidence that eggs were lost as a consequence of Shiny Cowbird parasitism. In most cases ($n = 10$) Yellow Cardinal eggs were found punctured (Fig. 1B) or ejected from the nest (broken eggs found on the ground; Fig. 1C), most likely as a consequence of the egg punctures. In three nests, Yellow Cardinal eggs had disappeared by the time of appearance of parasite eggs. Since these nests were not found empty or abandoned, predation was not a likely cause for host egg losses. The remaining two nests were found with parasite eggs only and therefore we cannot draw conclusions on the mechanism that led to the loss of host eggs. These two nests were found active.

All monitored nests failed to fledge Yellow Cardinals. Seven showed a complete loss of host eggs. In two of these cases, Yellow Cardinals managed to rear parasite chicks (one fledged and the other was depredated 10 days after hatching), whereas in the other five cases nests were abandoned. In the remaining eight nests, egg losses were not total (one host egg remained). Three of these nests were abandoned, four were depredated (nest content disappeared between consecutive visits with no parental activity near the nest) and one failed for unknown reasons.

Discussion

This is the first study on the reproductive success of a mixed population of wild and released Yellow Cardinals. The population of Yellow Cardinals monitored in this study had zero recruitment since none of the reproductive pairs were able to fledge their own chicks. Because of the conspicuous territorial behaviour of this species (mainly during the early stages of nesting), it is unlikely that

Figure 1. Nest and eggs of Yellow Cardinals in La Pampa province, Argentina. (**A**) Nest with eight parasite eggs and one host egg; (**B**) Punctured Yellow Cardinal egg; (**C**) Broken Yellow Cardinal egg.

we have overlooked nesting attempts of already identified breeding pairs. However, due to the large size of the study site, we could have possibly overlooked a reproductive pair or nesting attempt that occurred before the reproductive pairs were found. Nevertheless, since none of the breeding pairs were found with fledglings, we assume that if they had prior nesting attempts, these were not successful.

Yellow Cardinal breeding failures occurred mainly as a consequence of brood parasitism by Shiny Cowbirds. The Yellow Cardinal has been reported as a host of the Shiny Cowbird in Uruguay (Azpiroz 2015), Brazil (Beier and Fontana 2019) and Argentina (Domínguez *et al.* 2015). Domínguez *et al.* (2015) and Beier and Fontana (2019) published data on the negative impact of Shiny Cowbird parasitism on Yellow Cardinals' reproductive success. The frequencies and intensities of parasitism reported in these two studies (33% and 67%, and 1.09 ± 0.09 and 1.9 ± 1.3 eggs per parasitized nest, respectively) were much lower than those presented in the current study (100% and 4.5 ± 3.4 eggs per parasitized nest). The high parasitism rates we recorded might be a

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consequence of a higher density of Shiny Cowbirds in our study site. Due to agricultural and livestock farming expansion, this area has been subject to habitat transformation (Arturi 2005, Brown and Pacheco 2006, Matteucci 2012). More open habitats and external food provisioning generate favourable conditions for Shiny Cowbirds, thus increasing their populations (Robinson *et al.* 1995, Mermoz *et al.* 2020). Increased parasitism in this area has also been recorded for the Fork-tailed Tyrant *Tyrannus savanna*, which was observed feeding Shiny Cowbird fledglings (A. Jahn pers. comm.). In other areas, this species rejects Shiny Cowbird eggs and is rarely a host of the Shiny Cowbird (D. Tuero pers. comm.). Parasite densities and host use throughout the area should be studied in order to clarify the causes of the high parasitism rates we observed.

The parasitism rates presented in this study are of great conservation concern. The absence of recruitment calls for a modification in the conservation actions that have been implemented until now. In particular, the release sites chosen for the reintroduction programmes should receive special attention. Despite being a livestock ranch, the site chosen for releases contained natural habitats over almost all its extent, suitable for Yellow Cardinals. Besides habitat suitability, release sites were also determined by the abundance of conspecifics (in order to avoid possibly negative Allee effect consequences; Deredec and Courchamp 2007) and the surveillance capacity by local authorities preventing individuals from being recaptured for illegal trafficking.

It is possible that the release area (habitat in which released organisms are expected to remain; Seddon 2013) is exhibiting a source-sink dynamic, in which the release site (the smaller location within the release area where actual releases occur; Seddon 2013) chosen for the past three releases is a sink habitat. Sink habitats are those where mortality exceeds reproductive rates, hence the population is not able to persist without immigration (Pulliam 1988). Releases into sink habitats will not be successful and will sooner or later fail, as conditions are inadequate for reproduction. In this case, the cause of failure was the high impact of brood parasitism on the population's reproductive success. However, data on demographic parameters of other populations within the release area are needed in order to calculate lambda, a finite rate of population increase, that allows determining whether the populations are in fact exhibiting a source-sink dynamic (Pidgeon *et al.* 2006). Habitat suitability plays a major role in the outcome of reintroduction projects (Osborne and Seddon 2012). In an ideal scenario, the quality of the release sites should be evaluated prior to the release (IUCN/SSC 2013). However, in a threatened species scenario, natural populations tend to be very small, thereby posing a challenge to the collection of demographic and habitat-use data required for an adequate assessment. Hence, the information gathered in post-release monitoring programmes is of utmost importance and should be used for planning future releases (Letty *et al.* 2007, Sutherland *et al.* 2010, Parker *et al.* 2013).

Currently, the populations with the highest densities of Yellow Cardinals are found in the north-eastern, central, and southern areas of its distribution in Argentina (Domínguez *et al.* 2020). These areas have also suffered loss and transformation of natural habitats as a consequence of the intensification of agricultural activities and livestock ranching (Arturi 2005, Matteucci 2012). Therefore, high densities of Shiny Cowbirds are expected (Mermoz *et al.* 2020), making brood parasitism a major threat for the species. Hence, evaluating Shiny Cowbird densities and eventually controlling Shiny Cowbird populations might be considered in future conservation plans for Yellow Cardinals. Control strategies on brood parasites have improved the reproductive success of threatened species in the past (Cruz *et al.* 2005, Krabbe *et al.* 2011, Hartmann *et al.* 2017). These studies have shown that trapping cowbirds near host nesting areas and cowbird feeding areas, as well as shooting cowbirds, resulted in marked population increases of the threatened host species. Reducing Shiny Cowbird densities in areas where the main populations of Yellow Cardinals reside, or rescued individuals are planned to be released, could result in higher recruitment and help in the recovery of this species. Moreover, a long-term management plan for agricultural-livestock practices could outline the best ways to avoid habitat modification and implement practices that avoid a drastic increase in cowbird numbers.

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References

Arturi, M. (2005) Situación ambiental en la ecorregión espinal. Pp. 241–246 in A. Brown, U. Martinez Ortiz, M. Acerbi and J. Corcuera, eds. *La situación ambiental Argentina 2005*. Buenos Aires, Argentina: Fundación Vida Silvestre Argentina.

Azpiroz, A. B. (2015) Shiny Cowbird (*Molothrus bonariensis*) Parasitism records for three globally threatened species from the South American Pampas. *Wilson J. Ornithol.* 127: 746–752.

Beier, C. and Fontana, C. (2019) Breeding biology of the endangered Yellow Cardinal *Gubernatrix cristata* in Brazil. *Rev. Bras. Ornitol.* 27: 44–52.

BirdLife International (2020) Species factsheet: *Gubernatrix cristata.* Downloaded from http://www.birdlife.org on 13/01/2020.

Brittingham, M. C. and Temple, S. A. (1983) Have cowbirds caused forest songbirds to decline? *Bioscience* 33: 31–35.

Brown, A. D. and Pacheco, S. (2006) Propuesta de actualización del mapa de ecorregiones de la Argentina. Pp. 28–30 in A. D. Brown, U. Martínez Ortiz, M. Acerbi and J. Corchera, eds. *La situación ambiental Argentina 2005*. Buenos Aires, Argentina: Fundación Vida Silvestre.

Cabrera, A. L. (1976) Regiones fitogeográficas argentinas. Pp. 1–85 in W. F. Kugler, ed. *Enciclopedia Argentina de agricultura y jardinería, Segunda Edición, Vol. II.* Buenos Aires, Argentina: Acme.

Cruz, A., Lopez-Ortiz R., Ventosa-Febles, E. A., Wiley, J. W., Nakamura, T. K., Ramos-Alvarez, K. R. and Post, W. (2005) Ecology and management of Shiny Cowbirds (*Molothrus bonariensis*) and endangered Yellow-shouldered Blackbirds (*Agelaius xanthomus*) in Puerto Rico. *Ornithol. Monogr.* 57: 38–44.

DeCapita, M. E. (2000) Brown-headed Cowbird control on Kirtland's Warbler nestingareas in Michigan. Pp. 333–341 in J. N. M. Smith, T. L. Cook, S. I. Rothstein, S. K. Robinson and S. G. Sealy, eds. *Ecology and management of cowbirds and their hosts*. Austin, USA: University of Texas Press.

De la Colina, M. A., Mahler, B. and Reboreda, J. C. (2011) Differences in morphology and colour pattern of Shiny Cowbird (*Molothrus bonariensis*) eggs found in nests of two hosts. *Biol. J. Linn. Soc. Lond.* 102: 838–845.

Deredec, A. and Courchamp, F. (2007) Importance of the Allee effect for reintroductions. *Ecoscience* 14: 440–451.

Domínguez, M., Reboreda, J. C. and Mahler, B. (2015) Impact of Shiny Cowbird and botfly parasitism on the reproductive success of the globally endangered Yellow Cardinal *Gubernatrix cristata*. *Bird Conserv. Internatn.* 25: 294–305.

Domínguez, M., Pizzarello, G., Atencio, M., Scardamaglia, R. C. and Mahler, B. (2019) Genetic assignment and monitoring of Yellow Cardinals. *J. Wildl. Manag.* 83: 1336–1344.

Domínguez, M., Lapido, R., Gorrindo, A., Archuby, D., Correa, E., Llanos, F., Reales, F., Piantanida, F., Marateo, G., Meriggi, J., Andreani, L., Encabo, M., Gomez Vinasa, M. L., Bertini, M., Perelló, M., Banchs, R., Crignoli, S., Verón, S. and Mahler, B. (2020) A citizen science survey discloses the current distribution of the endangered Yellow Cardinal *Gubernatrix cristata* in Argentina. *Bird Conserv. Internatn.* 1–12.

Hanley, D., Lopez, A. V., Fiorini, V. D., Reboreda, J. C., Grim, T. and Hauber, M. E. (2019)

Variation in multicomponent recognition cues alters egg rejection decisions: a test of the optimal acceptance threshold hypothesis. *Phil. Trans. R. Soc. B* 374: 20180195.

Hartmann, S. A., Oppel, S., Segelbacher, G., Juiña, M. E. and Schaefer, M. H. (2017) Decline in territory size and fecundity as a response to carrying capacity in an endangered songbird. *Oecologia* 183: 597–606.

IUCN/SSC (2013) *Guidelines for reintroductions and other conservation translocations*. Version 1.0. Gland Switzerland: IUCN Species Survival Commission.

Krabbe, N., Juina, M. and Sornoza, A. F. (2011) Marked population increase in Pale-headed Brush-finch *Atlapetes pallidiceps* in response to cowbird control. *J. Ornithol.* 152: 219–222.

Letty, J., Marchandeau, S. and Aubineau, J. (2007) Problems encountered by individuals in animal translocations: Lessons from field studies. *Ecoscience* 14: 420–431.

Martin, T. E. and Geupel, G. R. (1993) Nest monitoring plots: methods for locating nests and monitoring success. *J. Field Ornithol.* 64: 507–519.

Matteucci, S. (2012) Ecorregión Espinal. Pp. 349–390 in J. Morello, S. Matteucci, A. F. Rodriguez and M. E. Silva, eds. *Ecorregiones y complejos ecosistémicos argentinos*. Buenos Aires, Argentina: FADU.

Mermoz, M. E., Cruz, A., Chace, J. F. and Reboreda, J. C. (2020) Shiny Cowbird (*Molothrus bonariensis* Gmelin, 1788). Pp. 97–104 in C. T. Downs and L. A. Hart, eds. *Invasive birds: global trends and impacts*. Oxfordshire, UK: CAB International, in press.

Morello, J., Matteucci, S. D. and Rodríguez, A. F. S. (2012). *Ecorregiones y complejos ecosistémicos argentines*. Buenos Aires, Argentina: FADU.

Oppel, S., Schaefer, H., Schmidt, V. and Schroder, B. (2004) Cowbird parasitism of Pale-headed Brush-finch *Atlapetes pallidiceps*: Implications for conservation and management. *Bird Conserv. Internatn.* 14: 63–75.

Ortega, C.P. (1998) *Cowbirds and other brood parasites*. Tucson, Arizona: University of Arizona Press.

Osborne, P. E. and Seddon, P. J. (2012) Selecting suitable habitats for reintroductions: variation, change and the role of species distribution modelling. Pp. 73–104 in J. G. Ewen, D. P. Armstrong, K. A. Parker and P. J. Seddon, eds. *Reintroduction biology*. Chichester, UK: John Wiley & Sons, Ltd.

Parker, K. A., Ewen, J. G., Seddon, P. J. and Armstrong, P. D. (2013) Post-release monitoring of bird translocations: why is it important and how do we do it? *Notornis* 60: 85–92.

Pidgeon, A. M., Radeloff, V. C. and Mathews, N. E. (2006) Contrasting measures of fitness to classify habitat quality for the Black-throated Sparrow (*Amphispiza bilineata*). *Biol. Conserv.* 132: 199–210.

Pulliam, H. R. (1988) Sources, sinks, and population regulation. *Am. Nat.* 132: 652–661.

Reales, F., Sarquis, J. A., Daradanelli, S. and Lammertink, M. (2019) Range contraction and conservation of the endangered Yellow Cardinal. *J. Nat. Conserv.* 50: 125708.

Robinson, S. K., Rothstein, S. I., Brittingham, M. C., Petit, L. J., Grzybowski, J. A., Martin, T. E. and Finch, D. M. (1995) Ecology and behavior of cowbirds and their impact on host populations. Pp. 482-460 in T. E. Martin and D. M. Finch, eds. *Ecology and management of neotropical migratory birds*. New York: Oxford University Press.

Rothstein, S. I. and Cook, T. L. (2000) Cowbird management, host population limitation, and efforts to save endangered species. Pp. 323–332 in J. N. M. Smith, T. L. S. Cook, I. Rothstein, S. K. Robinson and S. G. Sealy, eds. *Ecology and management of cowbirds and their hosts*. Austin, Texas: University of Texas Press.

Seddon, P. J. (1999) Persistence without intervention: assessing success in wildlife re-introductions. *Trends Ecol. Evol.* 14: 503.

Seddon, P. J. (2013) Letter to the Editor: The new IUCN guidelines highlight the importance of habitat quality to reintroduction success – Reply to White et al. *Biol. Conserv.* 164: 177.

Segura, L. N., Perelló, M., Gress, N. H. and Ontiveros, R. (2019) The lack of males due to illegal trapping is causing polygyny in the globally endangered Yellow Cardinal, *Gubernatrix cristata*. *Rev. Bras. Ornitol.* 27: 40–43.

Sutherland, W. J., Armstrong, D. and Butchart, S. H. M. (2010) Standards for documenting and monitoring bird reintroduction projects. *Conserv. Lett.* 3: 229–235.