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Research Letters

Reintroducing the red-billed curassow in Brazil: Population viability analysis points to potential success

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ABSTRACT

Reintroduction can be enhanced by data from long-term post-release monitoring, which allows for modeling opportunities such as population viability analysis (PVA). PVA-relevant data were gathered via long-term monitoring of reintroduced red-billed curassows at the Guapiaçu Ecological Reserve (REGUA), located in Rio de Janeiro, Brazil, over 25 months. In the present article, we (1) assess the robustness of the reintroduction plan, (2) evaluate the viability of the current reintroduced population, and (3) examine mitigation options to increase the viability of this population. VORTEX indicates that the initial plan, fully implemented, was likely to establish a viable population at REGUA. The current population is unviable; the best mitigation strategies are to eliminate hunting altogether, or at least reduce it by half, and to supplement ten immature pairs in 2015. A positive long-term outcome at REGUA is still possible; we encourage the Brazilian government and private stakeholders to consider population supplementation, both to achieve success at REGUA and to improve the evidence base for future reintroductions.

Introduction

The main goal of any species reintroduction program for conservation purposes should be to establish a self-sustaining wild population, defined as one with high probability of persistence and positive stochastic growth rate (Schaub *et al.* 2004). Evaluating the success of reintroduction programs requires good data from long-term post-release monitoring (Scott & Carpenter 1987), as these allow for modeling opportunities such as population viability analysis (PVA; Beissinger & Westphal 1998).

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Fewer than ten natural populations of the red-billed curassow *Crax blumenbachii*, a cracid species (IUCN status 'Endangered', BirdLife International 2012) endemic to the Brazilian Atlantic rainforest, persist in the wild, in the states of Bahia and Espírito Santo (IBAMA 2004). Between 2006 and 2008, 46 radio-tagged birds, supplied by the CRAX Brasil breeding center in Belo Horizonte, were released into the Guapiaçu Ecological Reserve (REGUA), in the state of Rio de Janeiro. Systematic long-term monitoring for 25 months enabled the collection of PVA-relevant data on survival, home range size, social interaction, and habitat selection (Bernardo *et al*. 2011a; 2011b).

The project at REGUA was the first to include post-release monitoring for this species. Three other reintroductions, in different sites in the state of Minas Gerais during the 1990s, also involved birds from CRAX Brasil (Azeredo & Simpson 2004); fourth-generation breeding of wild-born birds is reported to have occurred at one site (Fazenda Macedônia; R. Azeredo, pers. comm.). The initial plan for REGUA was the release of 100 birds, in groups of 20 individuals per year, over a period of five years (2006-2010). These figures were based on evidence that the chances of establishing a self-sustaining free-ranging population and improving reproduction and survival rates increase with the initial founder population size (Fischer & Lindenmeyer 2000; Armstrong & Seddon 2007). However, in early 2009, when fewer than half the projected number of birds had been released, unforeseen circumstances curtailed the supply of birds. Despite a relatively high survival probability compared to other reintroduced galliforms (75%; Bernardo *et al*. 2011b), the initial population (n = 46, with a sex ratio of 2:3 males to females), was possibly too small for a viable population in the long term. In the present article, we (1) assessed the robustness of the initial plan, which was the release of 100 individuals over five years, (2) evaluated the viability of the current population at REGUA, and (3) examined which mitigation option might increase the viability of the surviving reintroduced population.

Materials and methods

Population viability analysis

For the PVA, we used the software VORTEX version 9.9b (Miller & Lacy 2005); earlier versions of this software have been widely used to model wildlife populations and, when tested against long-term field study datasets, produced accurate predictions (Brook *et al*. 2000). Population attributes (e.g. breeding success, clutch size, sex ratio at birth, initial population size) were determined mostly based on IBAMA (2004), Azeredo & Simpson (2004), and Bernardo *et al*. (2011a) (Table 1). We considered a population viable if its probability of extinction in 100 years was < 40%. We created three scenarios: (1) "initial plan": the situation that should have resulted had the project not been modified; (2) "current population": the situation that developed in 2006-2008; and (3) "strategic mitigations",: the options for guaranteeing long-term persistence of the current population.

Data on key natural history parameters (Azeredo & Simpson 2004; IBAMA 2004; Lima *et al*. 2008; Bernardo *et al*. 2011a; 2011b) were sufficient for constructing the models. However, future research should focus on chick mortality and female breeding rates in order to enhance model accuracy. Data deficiencies need not affect results when the goal of PVA is comparative (Akçakaya & Sjögren-Gulve 2000). We ran 10,000 iterations for each scenario.

Table 1 - Gender, age, marital status and ethnicity of Bauru's donors registered in REDOME (n = 3542).

Parameter	Value	References
Number of populations	1	-
Initial population size	46[a]	Bernardo *et al*. (2011b)
Carrying capacity	580[b]	[b]
Inbreeding depression	6 LE	O'Grady *et al*. (2006) Crnokrak & Roff (1999)
% of the effect of inbreeding due to recessive lethal alleles	50	O'Grady *et al*. (2006) Crnokrak & Roff (1999)
Breeding system	Monogamy	IBAMA (2004)
Age of first reproduction (♀/♂)	3 / 3	IBAMA (2004)
Maximum age of reproduction	10	IBAMA (2004)
Annual % adult females reproducing (SD)	70% (5)[b]	[b]
Mate monopolization	95%[b]	[b]
Distributional clutch size	80% (2 chicks) and 20% (1 chick)	IBAMA (2004)[c]
Maximum clutch size	2	IBAMA (2004)[c]
Overall offspring sex ratio	50:50	IBAMA (2004)[c]
Catastrophe annual frequency	2.44%	Reed *et al*. (2003)[b]
Impact of catastrophe	Survival reduced by 50%	Reed *et al*. (2003)[b]
Harvest	1 adult male & female / year	[b]

[a] In 2009, the immature birds released in 2006-2008 summed eight females and two males aged 2 years, seven females and four males aged 3 years, and four females and six males aged 4 years.
[b] Please refer to "Methods" section for further details.
[c] Reproductive rates were modeled based on data obtained at CRAX Brasil breeding center. We did not consider data obtained at REGUA, since these observations were random and not determined by a systematic methodology.

The size of released populations

For the "initial plan" scenario, we considered an initial population size of 20 immature (2-3 years) individuals (ten males, ten females) and a supplementation of ten immature pairs every year over five years. For the "current population" scenario, we considered an initial population size of 46 individuals released in 2006-2008 (26 females, 20 males) (Bernardo *et al*. 2011b). Since they were released in different years, in 2009 they had different ages (Table 1). For the "strategic mitigation" scenario, we considered the values