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Essays and Perspectives

Vocal dialects and their implications for bird reintroductions

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A B S T R A C T

Parrot species are a common target of animal trafficking, and the animals recovered from anti-trafficking operations are generally reintroduced into nature. However, these reintroductions usually fail to consider geographical vocal differences that are known to be present in some Parrot species. We investigated patterns of geographical variations in *Eupsittula cactorum* vocalizations and used those data to infer the geographical origins of recovered birds and thus predict the most appropriate reintroduction sites. We recorded four wild populations in northeastern Brazil (between the western region of Rio Grande do Norte State and northeastern Ceará State), and three groups of captive individuals seized from traffickers. We considered seven acoustic parameters to classify the flight calls of the different native populations and used a multinomial model to classify the recovered animals according to the native populations sampled. Our results indicated the existence of geographical dialects. Individual birds had been released in Quixadá, where local calls are acoustically distinct. Acoustical parameters can provide important clues about the origins of captured individuals as well as reduce acoustical contrasts between released individuals and native populations. The application of this methodology could potentially improve the efficacy of reintroduction efforts, by reducing vocal distances between released individuals and the native population.

Introduction

Vocal learning may be defined as the ability to imitate, with or without modification, the vocalizations of conspecifics (or even other species) (Bradbury and Balsby, 2016). Diverse taxa are capable of vocal learning, ranging from birds to mammals (Sewall et al., 2016). In birds, learned calls seem to be restricted to three groups: songbirds, parrots, and hummingbirds (Jarvis et al., 2000). Among the many advantages of learned calls is the possibility of coding individual (Berg et al., 2011) and acquisition of information on populations (Salinas-Melgoza and Wright, 2012; Wright, 1996), as well as vocal labeling (Wanker et al., 2005) – which could allow a bird to address a single individual within a flock (which could have special importance among social birds such as parrots). The learning process is hypothesized to often lead to rapid repertoire changes through cultural evolution (Lachlan and Servedio, 2004) and, although subject to morphological restrictions (Medina-García et al., 2015), learning processes are widely believed to lead to labile acoustical call structures (Vielliard and Silva, 2010).

The vocal abilities of parrots have long captivated the human imagination. In the famous Robinson Crusoe novel (Defoe, 1719), the main character had long "conversations" with a parrot. In fact, the ability to imitate human voices is one of the features that make parrots very desirable as pets (de Araújo, 2011), making parrots' natural populations susceptible to the pet trade. Habitat destruction and animal trafficking are the main factors threatening parrot conservation throughout the world (Berkunsky et al., 2017; Collar, 2000), and many wild South American parrot species are still being harvested from nature because of the pet trade (Daut et al., 2015; Fernandes-Ferreira et al., 2012; Nobrega Alves et al., 2013).

Many countries, including Brazil, have prohibited the commercialization of wild birds, and have curbed that practice by launching large-scale operations to arrest dealers and recover wild specimens – as exemplified by the efforts of IBAMA (the Brazilian Institute of Environmental and Renewable Natural Resources) in Brazil. Nevertheless, the practice of keeping wild birds represents a deeply-rooted cultural tradition, and the over-harvesting of

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specimens can cause severe populational reductions (Fernandes-Ferreira et al., 2012). Even thought government operations appear to be helping to change cultural habits and reduce bird harvesting, they produce another serious short-term problem: what should be done with the birds seized from traffickers? Currently, birds are usually sent to Wild Animal Screening Centers (CETAS) and eventually released back into the wild. Because of the difficulty in determining the geographical origins of captured birds (i.e. traffickers who are caught are rarely willing to point out the geographical locations of their harvesting sites or accomplices) individuals are usually released outside their natural ranges. This type of reintroduction can create serious threats to natural populations (Marini and Garcia, 2005), including the risk of establishing a new invasive species, the transmission of diseases and parasites, and the hybridization of otherwise genetically distinct races or subspecies (IUCN, 2000).

Considering this complex background, researchers have been attempting to develop novel methodologies that could determine the origins of recovered birds. Molecular analyses coupled with phylogeographic approaches have shown promising results, but assigning animals to exact geographic locations using molecular data still presents various difficulties. Large portions of the distributions of many species, for example, have not yet been sampled, making it difficult to identify the exact geographic origins of confiscated individuals – and the inferred origins of those confiscated birds could easily change if additional data were incorporated into the data set (Presti et al., 2015). Additionally, as mitochondrial DNA provides no information about the adaptive natures of genetic similarities, it could have little or no direct connection to variations in traits relevant to local adaptations, or to genetic incompatibilities between populations (Fernandes and Caparroz, 2013). Finally, molecular analyses require an invasive procedure that takes a considerable time to be achieved, and although those procedures could provide important information about the genetics of avian taxa, they are not feasible at large scales and with the necessary speed at this time – even though the information gathered would be especially valuable in terms of endangered populations.

Magroski et al. (2017) employed Ecological Niche Models (ENM) to estimate continental distributions of species in isolated patches, using specimen calls to test those ENM, and assign the specimens to appropriate patches. Despite some successes with classifying species with innate calls, the methodology demonstrated serious shortfalls when considering species capable of vocal learning (such as parrots). Wide geographic variations among those species prevented the use of call parameters to infer their broad-scale geographical origins. Those authors observed that populations of species such as the Red-shouldered macaw (*Diopsittaca nobilis*) that were separated by just a few kilometers could show considerable vocal differences, so that even populations within a given patch (but separated by hundreds of kilometers) would encompass large portions of the achievable vocal variations and mask inter-patch variations (Magroski et al., 2017). The presence of geographic dialects can difficult the reintroduction of released individuals in nature, for the ability of a bird to integrate (i.e. mate) local flocks seems to depend on their ability to acquire the unfamiliar local dialect (Wright and Dahlin, 2017).

Magroski et al. (2017) envisioned a continental analysis, and proposed that intra-patch variations prevented vocal classifications among large-scale patches. In this study, we focus on the existence of small-scale vocal variations and test if these can be used to determine the most suitable place for the release of captured *E. cactorum*, either by determining the original natural range of the individuals, but also by determining the locality with the smallest vocal divergence between the released individuals and the natural population. As geographical dialects might hinder reintroductions reintroduction (Wright and Dahlin, 2017), the reduction of the acoustical differences among reintroduced and natural populations could help guarantee the efficiency of the process.

Materials and methods

Target species and sampling

The Cactus Conure (*Eupsittula cactorum*) is a small (25 cm long) psittacid that is very common in the dry northeastern forests of South America. Its distribution encompasses the Caatinga dryland vegetation in the northernmost regions of the states of Piaui, Ceará, and Rio Grande do Norte, throughout Paraíba, Pernambuco, to Bahia, and reaching central Minas Gerais (Forshaw, 2010; Sick, 1997). It forms flocks, as do most psittacid species, which shape their social relationships through complex acoustical communication systems (Guerra et al., 2008). The species is commonly raised as pets in Northeastern Brazil (Alves et al., 2016) and is known to be sold in many localities (Nobrega Alves et al., 2013). In fact, psittacids are among the most confiscated species within Brazil (Destro et al., 2012) and illegal traffic is one of the major problems for its conservation (Berkunsky et al., 2017). Understanding the problems associated with wildlife traffic is crucial if we are to mitigate its negative effects.

Our data consisted of two distinct sets of sound recordings: the first set comprised four wild populations recorded directly in the field; the second set consisted of captive individuals recorded at the Wild Animals Screening Center (CETAS) facility in Fortaleza (CE).

We undertook expeditions to make sound recordings of wild individuals in the field from September/2015 to August/2016. Four distinct populations of Cactus Conure in the northernmost portion of their distribution range were considered, located at: Paramoti (CE); Quixadá (CE); Icapuí (CE); and Serra do Mel (RN) (Fig. 1). The recordings were made between 05:00–08:00 and 15:00–18:00, times when psittacids are most vocally active. All recordings were made using a Tascam-DR05 digital sound recorder coupled to a Shure Beta58a microphone mounted on a 50 cm diameter parabola with a 19 cm focus (Fig. 2A). All recordings were built with a 48 kHz sampling rate and 24-bit resolution.

During the sampling period, IBAMA (CETAS) informed us of new arrived groups of recovered Cactus Conures. The specimens were kept together in a large cage, and no information on their geographical origins was available. Captured specimens were placed in small individual cages and recorded using a Tascam-DR05 digital sound recorder coupled to a Shure Beta58a microphone. We kept individuals in visual contact with other captive birds so that they would be stimulated to call; a close-range recording setup was used to reduce background noise (Fig. 2B). We were able to record three different groups of individuals, referred to here as A (11 individuals), B (10 individuals), and C (12 individuals). Following the experiments, the specimens were released at Quixadá, where IBAMA maintains one of its Wild Animal Release Area bases (ASAS).

Sound analysis

Most parrot species exhibit vast vocal repertoires (e.g., de Araújo et al., 2011; de Moura et al., 2011; Fernandez-Juricic et al., 1998), with the flight (contact) call being the most studied vocal component in psittacids (Magroski et al., 2017; Medina-García et al., 2015; Salinas-Melgoza and Wright, 2012; Wright, 1996; Wright et al., 2008). In order to avoid pseudoreplication, only a single flight call of each Cactus Conure was selected from each sound recording (McGregor et al., 1992), based on its signal-to-noise ratio and overlap with acoustical artifacts. All selected calls were run through a high pass filter (300 Hz) and normalized to 0 dB preceding the analyses. This procedure was necessary to reduce problems arising