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Original investigation

Morphometric variability in *Artibeus planirostris* (Chiroptera: Phyllostomidae) in environments with different states of conservation in the Atlantic Forest, Brazil

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ABSTRACT

Rapid morphological changes associated with anthropogenic alterations have been reported in many groups of vertebrates. The Atlantic Forest is subject to serious conservation problems due to human activities and is one of the hotspots for the preservation of biodiversity. Bats play important roles in the recuperation of this type of environment as pollinators, seed dispersers and controllers of invertebrate populations. Environments altered by humans may serve as filters that determine the presence of animals with morphologically different characteristics in comparison to those found in preserved environments. In the present study, morphometric characteristics and weight were studied in flat-faced fruit-eating bats (*Artibeus planirostris*) captured in three protected areas of the Atlantic Forest located in the northern portion of the biome: one well preserved and two with conservation problems. The means of nearly all morphological characteristics evaluated were lower in the most conserved environment, including forearm size, which is directly related to flight and differed significantly between environments with different states of conservation. In recent decades, large and medium-sized trees have been cut down in the less conserved environments, resulting in fewer obstacles for bats during flight. This situation is thought to lead to selective pressure for bats with smaller wings in the more preserved environment, which implies greater flight manoeuvrability. The observation that the state of conservation of forest fragments affects morphometrics further underscores the importance of conservation measures in highly impacted biomes.

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Introduction

The destruction of natural environments caused largely by human activities has grown at an alarming rate throughout the world and threatens the survival of many species (Cushman, 2006; González-Varo, 2010; Lindenmayer and Fischer, 2013). The manner by which species respond to these environmental changes can be assessed by the study of morphology (Hoffmann and Parsons, 1991; Yom-Tov and Yom-Tov, 2005).

Rapid morphological changes associated with anthropogenic alterations in the environment have been reported in many groups of vertebrates (Amorim et al., 2017; Cureton and Broughton, 2014; Snell-Rood and Wick, 2013; Tomassini et al., 2014; Yu et al., 2017). Some of the studies cited have revealed that environmental alterations caused by human activities lead to changes in the diet (Amorim et al., 2017; Cureton and Broughton, 2014; Tomassini et al., 2014; Yu et al., 2017) or behaviour of these organisms (Cureton and Broughton, 2014), resulting in morphological changes in animals. Such changes may originate from phenotypic plasticity or may reflect the action of natural selection and genetic drift (Frankham et al., 2010; Grenier et al., 2016; Whitman and Agrawal, 2009). Since rapid morphological changes can serve as an indicator of human-induced environmental alterations (Amorim et al.,

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2017; Cureton and Broughton, 2014; Tomassini et al., 2014; Yu et al., 2017), this information may be important to the planning of effective plans to mitigate anthropogenic impacts on biodiversity (Kotiaho et al., 2005; Laurance, 1991).

The Atlantic Forest in South America is one of the richest biomes in species and endemism. However, the rampant destruction of this forest makes it one of the hotspots for the conservation of biodiversity (Myers et al., 2000). It was once one of the largest tropical forests in the Americas, originally extending for approximately 150 million hectares in Brazil, Argentina and Paraguay. Currently, little more than 11% of this area remains, consisting mostly of fragments measuring less than 50 ha (Ribeiro et al., 2009).

In an environment as altered at the Atlantic Forest, bats (Chiroptera) play important roles in environmental recuperation. The feeding habits of these organisms assist in seed dispersal, pollination and the control of invertebrate populations (Humphrey and Bonaccorso, 1979; Kageyama, 1987). Bats of the family Phyllostomidae are among the richest and most abundant in this biome (Esbérard and Bergallo, 2005; Faria et al., 2006; Fenton et al., 1992; Gazarini and Pedro, 2013; Novaes et al., 2014). Within this family, the genus *Artibeus* includes large frugivorous species (Esbérard, 2003), among which the flat-faced fruit-eating bat (*Artibeus planirostris*) is one of the most abundant in the northern portion of the Atlantic Forest (Garcia et al., 2014). This species has been recorded in different types of environments (Bernard and Fenton, 2007; Carvalho-Neto et al., 2017; Garcia et al., 2014; Zortéa and Alho, 2008), which reflects its ecological flexibility (Martins et al., 2014).

Studies evaluating changes in weight and the morphology of the ear, tragus, anterior and posterior limbs of phyllostomids have demonstrated accentuated variations within a single species (Feijó et al., 2015; Mantilla-Meluk and Baker, 2006; Vasconcelos, 2014). Some of these studies have related these morphological differences to habitat use (Louzada and Pessôa, 2013; Gregorin et al., 2008). Changes in a forest environment pose challenges to bats. The structure of the vegetation determines the quantity of obstacles that impose limits with regard to flight (Marciente et al., 2015). In less conserved environments, the quality of the matrix (structure of the vegetation, distribution of food sources and succession stage) can serve as an environmental filter through which some morphological characteristics are favoured (Farneda et al., 2015; Lees and Peres, 2008; Quesnelle et al., 2014).

In the present study, the following hypothesis was investigated: morphological characteristics of *A. planirostris* differ between

well-preserved areas and areas with anthropogenic impacts. To determine the existence of a relationship between the conservation status of forest environments and differences in morphology, structures located on the head and limbs of *A. planirostris*, which are functionally important for the flight, orientation and rest of these animals, were assessed using morphometric methods in environments with different states of conservation in the northern portion of the Atlantic forest. This is the first study to evaluate the influence of areas in different states of conservation on the morphological characteristics of a fruit-eating bat in the Neotropical region.

Material and methods

Sampling sites and capture of bats

The northern portion of the Atlantic Forest is one of the most destroyed regions of the biome. Until 1979, it was estimated that deforestation in the area was restricted to a narrow strip along the coast (Weeb, 1979). Since then, successive anthropogenic events have continued to cause the destruction to the forest (Kimmel et al., 2008). The devastation was accelerated in the 1970s as a consequence of fiscal incentives for sugarcane plantations (Proálcool), resulting in a reduction of approximately 10% of the biome coverage in the northern portion of its distribution (Kimmel et al., 2008; Ranta et al., 1998). Currently less than 2% of the original vegetation cover remains in the northern Atlantic Forest, consisting mostly of small, isolated fragments (Asfora and Pontes, 2009).

Specimens of *A. planirostris* were captured in three fragments of the Atlantic Forest in northeast Brazil: (1) The Caetés Ecological Reserve (Caetés), 7°55'27''S, 34°55'60''W, which covers around 160 ha (CPRH, 2006); (2) the Charles Darwin Ecological Refuge (Darwin), 7°48'0.3''S, 34°57'10''W, with an approximate area of 60 ha (CPRH, 2003); and (3) the Camocim Forest Wildlife Refuge (Camocim), 8°02'61''S, 35°11'45''W, which has approximately 150 ha (Cazal et al., 2009). Caetés and Darwin are separated by approximately 15 km; Darwin and Camocim are separated by approximately 35 km, and Caetés and Camocim are separated by approximately 30 km (Fig. 1).

The three fragments are dense rainforests (IBGE, 2012) surrounded by agricultural plantations with short cycles as well as forest fragments formed by Neotropical and exotic plants. Caetés is situated in the metropolitan region of the city of Recife and this therefore surrounded by a large urban centre. In 1984, this area was under preparation to become a trash dump site for the city

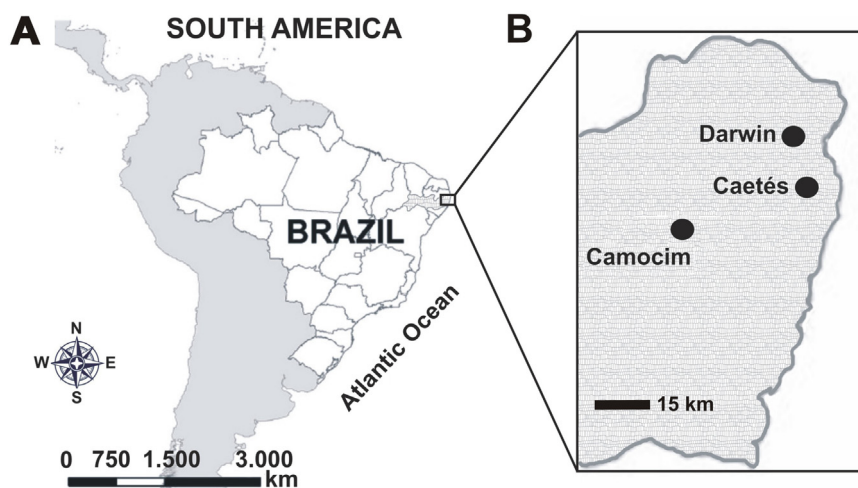


Fig. 1. (A) Map of South America; (B) Coast of state of Pernambuco (Brazil) with indication of bat sampling sites: Charles Darwin Ecological Refuge (Darwin), Caetés Ecological Reserve (Caetés) and Camocim Forest Wildlife Refuge (Camocim).

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