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ARTICLE

The avifauna of the Catimbau National Park, an important protected area in the Brazilian semiarid

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ABSTRACT: The Catimbau National Park is a protected area, located within the Caatinga Dry Forest, in the central region of the Brazilian state of Pernambuco. This protected area encompasses ~60,000 ha of an exceptional diversity of habitats, resulting in a high avian diversity, including several rare and endemic species. The park is considered an area of high biological importance and of conservation priority. Despite its relevance for conservation, human degradation due to chronic anthropogenic disturbances (hunting, birds trapping, selective logging, and livestock grazing) has modified the park's natural environments. In 2014, we initiated avian inventories within the park, as part of a long-term ecological research (LTER). Although the avifauna of the park has been described before, our systematic surveys allowed us to have a better understating of the park's avifauna and resulted in several additions to the species list. Here, we update and reevaluate the park's avifauna, discuss the presence of resident and migratory species, and include comments on endemic and rare species that occur within the park's boundaries. We sampled the avifauna through systematic surveys (point counts) and opportunistic observations between 2014 and 2017, including both dry and rainy seasons. We recorded a total of 192 species, including 25 species new to the park's list. During our point counts, we detected 117 species in the dry season, whereas 34 were recorded exclusively during the rainy season. Nearly 10% of the park's avifauna (19 species) is represented by migratory species, such as *Elaenia chilensis* and *Turdus amaurochalinus*. Catimbau National Park is important for the conservation of the Caatinga avifauna, since it harbors endemic, range-restricted, migratory, and globally threatened species. Therefore, we emphasize that environmental education and ecological restoration projects, allied to enforcing environmental laws are urgent for the maintenance of biodiversity and ecosystem services in the Catimbau National Park.

KEY-WORDS: Caatinga, long-term ecological research, migratory birds, Neotropical Dry Forests, ornithological inventory.

INTRODUCTION

The Caatinga Domain (hereafter, Caatinga) represents the largest patch of Seasonally Dry Tropical Forest in the Neotropics (Pennington *et al.* 2000). Far from representing a single vegetational type, the Caatinga is highly heterogeneous, presenting a wide diversity of ecosystems and habitats. Different combinations of soil, relief, topography and rainfall regimes create a wide variety of habitats (Egler 1951, Sarmiento 1975, Andrade-Lima 1981, Leal *et al.* 2003). Much of this variation can be found at one particular protected area in the Caatinga: the Catimbau National Park (hereafter, CNP). This exceptional diversity of habitats results in a high diversity of bird species, including several rare and endemic, which is one of the reasons the park is considered an area of high biological importance and of conservation priority (Devenish *et al.* 2009, Menezes *et al.* 2012).

Unfortunately, much of the degradation observed within the Caatinga, where over 63% of its area has already been modified by human activities (Pennington *et al.* 2009, Araújo & Silva 2017, Silva & Barbosa 2017) is also evident at the CNP. The park faces many chronic anthropogenic disturbance pressures as a result of the nearly 300 families that live within the park and depend on livestock grazing and logging to survive (Rito *et al.* 2017, Arnan *et al.* 2018). Also, the absence of a well-designed management plan, mandatory by Brazilian law (SNUC 2002), reflects negatively on the overall conservation of the National Park. At present, CNP presents many degraded areas with different histories of human land use (Cruz *et al.* 2017, MMA 2018a).

Given the remarkable habitat heterogeneity found at the park, the relatively large topographic variation (500–1100 m), and the rainfall gradient within such a small area (650–1100 mm/yr), Catimbau National Park was selected to establish a Long-term Ecological Research (LTER) Program (http://www.peldcatimbau.org). The

main purpose of Catimbau's LTER site is to evaluate how chronic anthropogenic disturbances and changes in rainfall regime affect the biota. A total of 20 permanent plots were established, covering most of the topographical, environmental, and anthropogenic disturbance gradient, offering a unique opportunity to understand patterns of diversity in many different biological groups (Rito *et al.* 2017). Each biological group studied relied on a different sample scheme, depending on the spatial scale desired. To study the avifauna, we established 2 km transects around each one of the 20 permanent plots, sampled by 10 point counts, systematically established every 200 m.

The avifauna of the CNP is relatively well known due to past surveys (Farias 2009, Sousa *et al*. 2012). The first ornithologist to present a species list of the park's avifauna, based on non-systematic inventories and opportunistic observations, included 139 species (Farias 2009). A few years later, Sousa *et al.* (2012) presented a more complete list of the park's avifauna, updating the park's list to 202 species, including important endemic and threatened species, such as *Penelope jacucaca* and *Spinus yarrellii.*

In this study, we present the results of three years (2014–2017) of systematic surveys conducted around 20 sites distributed throughout the park, and opportunistic observations conducted elsewhere within the park. We also present a new updated list of the avifauna of the CNP, with relevant information about the avian community, with important records of threatened, migratory, and endemic species. We also provide ecological aspects of species richness and patterns of species composition, highlighting the potential threats found in this protected area and its importance for the conservation of Caatinga birds.

METHODS

Study area

The Catimbau National Park (~60,000 ha), created by a federal decree on 13 December 2002, is a protected area located within three municipalities (Buíque, Tupanatinga and Ibimirim) in the central region of the Brazilian state of Pernambuco (between 8°24'00'' and 8°36'35''S; 37°0'30'' and 37°1'40''W) (Fig. 1). Climate is classified as tropical semiarid, according to Koeppen's classification; showing a mean annual temperature of 23°C, with a great inter-annually irregularity in rainfall regimes, which vary from 650 to 1100 mm/year (SNE 2002).

This protected area is located within the Caatinga Domain, a Seasonally Dry Tropical Forest. Most of the park (70%) is composed of old-growth vegetation in sandy soils, with five main phytophysiognomies with distinct vegetation structure and floras, including *i*) shrubby-arboreal Caatinga generally located on the leeward slopes and at altitudes between 600 and 800 m a.s.l., *ii*) shrubby Caatinga with Cerrado elements can be found in many sites of the Chapada São José, both in lower and surrounding areas of the hills and slopes, *iii*) shrubby Caatinga with elements of rocky fields (*campos rupestres*) occur in the plateaus and mountain ranges (800 and 1100 m a.s.l.), *iv*) evergreen arboreal vegetation (*brejos de altitude*) at the foothills, and *v*) evergreen shrubby Caatinga located on windward slopes between 600 and 800 m a.s.l. (Rodal *et al.* 1998, SNE 2002). Systematic and opportunistic methodologies were conducted in these phytophysiognomies, as well as in aquatic environments (lagoons, ponds and temporary pools) found at the CNP (Fig. 2).

Bird survey and analyses

We conducted avian surveys at the CNP between August 2014 and August 2017, including both the dry and the rainy seasons. We surveyed the avifauna using point counts with unlimited detection radius (Ralph *et al.* 1996, Bibby *et al.* 2000, Sutherland *et al.* 2004). CNP hosts 20 LTER permanent sites (plots), spatially established to remain independent from one another and to account for the climatic and land use variation found at the park (Table 1, Fig. 1). Around each of these 20 sites, we established 2 km-long transects, which we sampled conducting point counts, which were systematically distributed every 200 m, totaling 10 point counts per site and 200 in the park. All localities and point-counts were geo-referenced using a Garmin GPS unit (GPSMAP64). We sampled each point count during 10 min, when all birds detected by sight or sound were recorded. Each site was sampled three times, once during the dry season and twice during the rainy season, totaling 600 point counts. Besides our systematic surveys, we conducted opportunistic observations between point counts and throughout the park's entire area.

Birds were identified by sight and sound by an experienced observer (FMGLC). We used binoculars and digital recorders to observe and document species presence in the area. Taxonomy and nomenclature follow the Brazilian Committee of Ornithological Records (Piacentini *et al.* 2015). Species were classified according to their conservation and distribution status. Patterns of endemism (Caatinga and northeast Brazil endemics) were based on Pacheco (2004) and Araújo & Silva (2017). Threatened species were defined according to Brazilian (MMA 2018b) and international red lists (IUCN 2019). Migration status follows Somenzari *et al*. (2018), who revised migratory patterns for Brazilian birds.

For habitat we used the five types as described by

Table 1. Permanent plots from the Long-Term Ecological Research (LTER) PELD Catimbau, Brazil.

LTER Sites	Geographic coordinates		Annual mean precipitation (mm)	Altitude (m a.s.l.)
	Long (W)	Lat (S)		
P02	-37.1968	-8.5313	647	703.0
P04	-37.3551	-8.5072	591	692.2
P07	-37.3973	-8.5554	516	559.8
P08	-37.2993	-8.4496	578	665.9
P10	-37.2301	-8.5354	647	705.4
P11	-37.2248	-8.5167	673	719.8
P14	-37.3046	-8.4278	540	623.3
P15	-37.3174	-8.4133	510	577.8
P16	-37.3259	-8.4658	555	650.6
P17	-37.2329	-8.5581	940	836.8
P20	-37.3222	-8.4854	653	733.3
P21	-37.2963	-8.5209	843	876.2
P22	-37.3428	-8.4831	552	660.8
P23	-37.3118	-8.5178	785	842.1
P25	-37.238	-8.4757	588	655.2
P26	-37.2346	-8.4942	645	698.5
P27	-37.277	-8.5113	903	965.5
P28	-37.3096	-8.5372	787	829.4
P29	-37.2475	-8.5708	762	772.6
P30	-37.2449	-8.5166	913	960.6

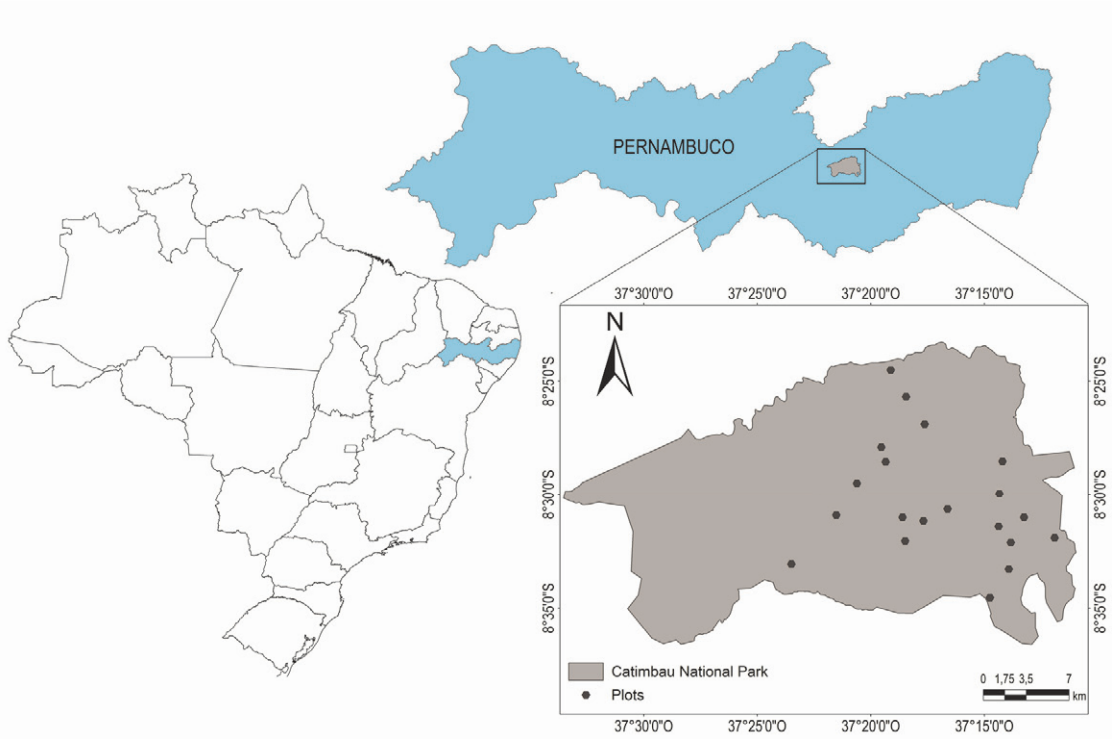

Figure 1. Location of Catimbau National Park, Pernambuco, Brazil. Distribution of the 20 plots used for bird sampling with point counts in PELD Catimbau.

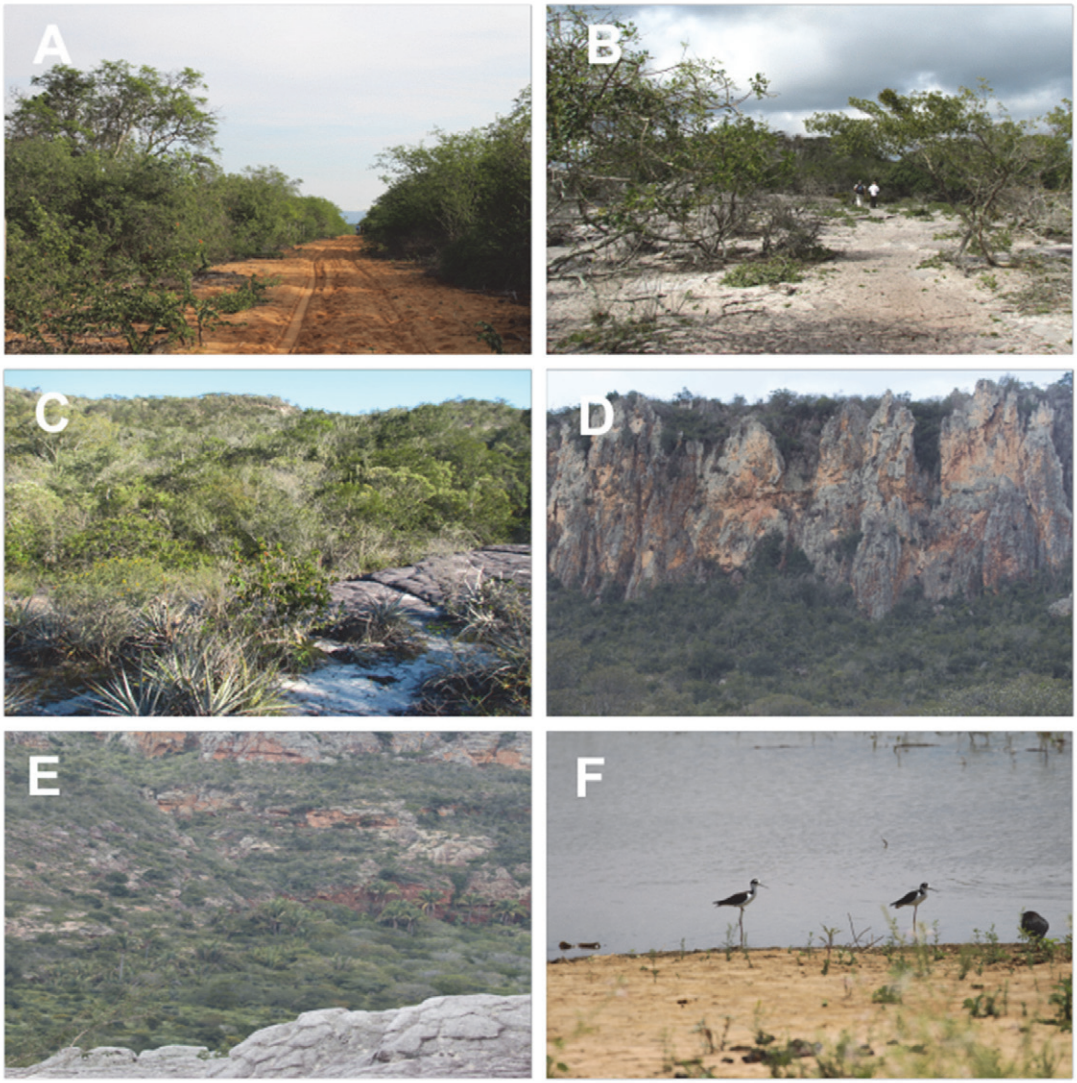

Figure 2. General view of phytophysiognomies and landscapes found at Catimbau National Park, Pernambuco, Brazil. (**A**) shrubby-arboreal Caatinga; (**B**) shrubby Caatinga with Cerrado elements; (**C**) shrubby Caatinga with rocky fields elements (Campos Rupestres); (**D**) evergreen arboreal vegetation; (**E**) evergreen shrubby Caatinga; (**F**) aquatic environment available during the rainy season. Photo author: F.M.G. Las-Casas.

Rodal *et al.* (1998) and SNE (2002): shrubby-arboreal Caatinga, Caatinga with Cerrado elements, Caatinga with rocky outcrops elements (*campos rupestres*), evergreen arboreal vegetation and evergreen shrubby Caatinga. The evergreen arboreal vegetation (*brejos de altitude*) is largely disturbed, especially by agriculture. It presents a typical vegetational composition and can be found in the foothills of the scarpment (~800 m a.s.l.). Habitat categorization for birds was based on our own records, and is applied exclusively for birds detected during this study. Photographs and/or digital recordings were archived at www.wikiaves.com and can be assessed online using the provided voucher numbers (Table 2).

To evaluate sampling effectiveness, we used Chao 1 and Jackknife 1 richness estimators (Magurran 2004), which are based on quantitative data and are known to overcome other estimators in terms of bias and precision (Gotelli & Colwell 2010). The total number of species observed at the point counts was represented by a rarefaction curve. These analyses were performed using the software EstimateS 9.1.0 (Colwell 2011). Opportunistic data were excluded from these analyses.

RESULTS

Our surveys detected 192 species of birds, 25 of which were recorded at the CNP for the first time (Table 2). Point counts resulted in the detection of 155 species (~70% of all species). Opportunistic observations added another 37 species. Bird species detected represented 48 avian families. More than half of the species (n = 106 or 55.2%) were passerines, and 86 species (44.8%) were non-passerines (Table 2). Sampling around the 20 LTER

Table 2. List of bird species recorded at the Catimbau National Park, Pernambuco, Brazil. Species recorded by Sousa *et al.* (2012), and not by us (#). New records for the park during the present study (*). Migratory species (MG) and partially migratory (PM). Undefined endemic (End): Caatinga endemic (EC), endemic northeast (EN). Threatened (Thr): "Near Threatened" (NT; IUCN 2019), "Vulnerable" (VU; MMA 2018). Habitat: aquatic environment (AE), shrubby arboreal Caatinga (SA), shrubby Caatinga with Cerrado elements (SC), shrubby Caatinga and rocky fields (RC), evergreen arboreal Caatinga (EA), evergreen shrubby Caatinga (ES).

Family and species	English names	End/Thr	Habitats	Documentation
TINAMIDAE				
Crypturellus noctivagus zabele#	Yellow-legged Tinamou	EN/VU,NT		
Crypturellus parvirostris	Small-billed Tinamou		SA/SC/EA/ES	
Crypturellus tataupa	Tataupa Tinamou		SA/SC/EA/ES	
Nothura boraquira	White-bellied Nothura		SA/ES	
Nothura maculosa	Spotted Nothura		SA	
Rhynchotus rufescens#	Red-winged Tinamou			
ANATIDAE				
Dendrocygna viduata	White-faced Whistling-Duck		AE	WA2919491
Cairina moschata#	Muscovy Duck			
Amazonetta brasiliensis#	Brazilian Teal			
CRACIDAE				
*Penelope superciliaris ochromitra**	Rusty-margined Guan	EN	EA/ES	
Penelope jacucaca#	White-browed Guan	EC/VU		
Ortalis araucuan	East Brazilian Chachalaca		AE	
PODICIPEDIDAE				
*Tachybaptus dominicus**	Least Grebe		AE	
Podilymbus podiceps#	Pied-billed Grebe			
PHALACROCORACIDAE				
Nannopterum brasilianus#	Neotropic Cormorant			
ARDEIDAE				
Tigrisoma lineatum#	Rufescent Tiger-Heron			
Nycticorax nycticorax#	Black-crowned Night-Heron			
Butorides striata#	Striated Heron			
Bubulcus ibis	Cattle Egret		SA	
Ardea alba	Great Egret		AE	
Egretta thula	Snowy Egret		AE	
CATHARTIDAE				
Cathartes aura	Turkey Vulture		SA/SC/RC/EA/ES	
Cathartes burrovianus	Lesser Yellow-headed Vulture		SA/SC/RC/EA/ES	WA2104773
Coragyps atratus	Black Vulture		SA/SC/RC/EA/ES	WA2104774
*Sarcoramphus papa**	King Vulture		SA/SC/RC/EA/ES	WA1467218
ACCIPITRIDAE				
Gampsonyx swainsonii	Pearl Kite		SA/ES	WA1874623
Elanus leucurus	White-tailed Kite		SA	
Ictinia plumbea#	Plumbeous Kite			
Geranospiza caerulescens	Crane Hawk		SA	

Family and species	English names	End/Thr	Habitats	Documentation
*Heterospizias meridionalis**	Savanna Hawk		SA	
*Urubitinga urubitinga**	Great Black Hawk		SA	
Rupornis magnirostris	Roadside Hawk		SA/SC/RC/EA/ES	WA2427047
*Parabuteo unicinctus**	Harris's Hawk		SA	WA2560060
Geranoaetus albicaudatus	White-tailed Hawk		SA	
Geranoaetus melanoleucus	Black-chested Buzzard-Eagle		SA/RC	WA2101247
Buteo nitidus[#]	Gray-lined Hawk			
Buteo brachyurus	Short-tailed Hawk		SA/EA	
Buteo albonotatus[#]	Zone-tailed Hawk			
RALLIDAE				
Aramides mangle[#]	Little Wood-Rail			
Aramides cajaneus[#]	Gray-necked Wood-Rail			
Pardirallus nigricans[#]	Blackish Rail			
Gallinula galeata	Common Gallinule		AE	
Porphyriops melanops	Spot-flanked Gallinule		AE	
Porphyrio martinicus[PM]	Purple Gallinule		AE	WA2951832
CHARADRIIDAE				
Vanellus chilensis	Southern Lapwing		SA	
RECURVIROSTRIDAE				
*Himantopus mexicanus**	Black-necked Stilt			WA2490975
JACANIDAE				
Jacana jacana	Wattled Jacana		AE	
COLUMBIDAE				
Columbina minuta	Plain-breasted Ground-Dove		SA/EA/ES/SC	
Columbina talpacoti	Ruddy Ground-Dove		EA/ES	
Columbina squammata	Scaled Dove		SA/EA/ES/SC	
Columbina picui	Picui Ground-Dove		SA/EA/ES/SC	WA1471673
*Claravis pretiosa**	Blue Ground-Dove		SA	
*Columba livia**	Rock Pigeon			
Patagioenas picazuro	Picazuro Pigeon		SA/EA/ES	
Zenaida auriculata	Eared Dove		SA	WA2723505
Leptotila verreauxi	White-tipped Dove		SA/EA/ES/SC	
Leptotila rufaxilla	Gray-fronted Dove		EA	
CUCULIDAE				
*Micrococcyx cinereus**[MG]	Ash-colored Cuckoo		SA	
Piaya cayana	Squirrel Cuckoo		SA/EA/ES/SC	WA2106950
Coccyzus melacoryphus[MG]	Dark-billed Cuckoo		SA/EA/ES/SC	WA2850701
Crotophaga major[#]	Greater Ani			
Crotophaga ani	Smooth-billed Ani		SA	
Guira guira	Guira Cuckoo		SA	WA2049012
Tapera naevia	Striped Cuckoo		SA	
TYTONIDAE				
Tyto furcata	American Barn Owl		SA	

Family and species	English names	End/Thr	Habitats	Documentation
STRIGIDAE				
Megascops choliba	Tropical Screech-Owl		SA	
Glaucidium brasilianum	Ferruginous Pygmy-Owl		SA/EA/ES	WA2677373
Athene cunicularia	Burrowing Owl		SA	WA2290250
NYCTIBIIDAE				
Nyctibius griseus	Common Potoo		SA	
CAPRIMULGIDAE				
Antrostomus rufus[#]	Rufous Nightjar			
Nyctidromus albicollis	Common Pauraque		SA	
Nyctidromus hirundinaceus	Pygmy Nightjar	EC	SA	
Hydropsalis parvula[*PM]	Little Nightjar		SA	WA2723643
Hydropsalis longirostris[*]	Band-winged Nightjar		SA	
Hydropsalis torquata	Scissor-tailed Nightjar		SA	
Nannochordeiles pusillus novaesi	Least Nighthawk	EN	SA	
Chordeiles acutipennis[#]	Lesser Nighthawk			
APODIDADE				
Tachornis squamata	Fork-tailed Palm-Swift		SA/EA	
TROCHILIDAE				
Anopetia gounellei	Broad-tipped Hermit	EC	SA/ES	
Phaethornis pretrei	Planalto Hermit		SA/EA/ES	
Eupetomena macroura	Swallow-tailed Hummingbird		SA	WA1989371
Anthracothorax nigricollis[#]	Black-throated Mango			
Chrysolampis mosquitus	Ruby-topaz Hummingbird		SA	WA1874630
Chlorostilbon lucidus	Glittering-bellied Emerald		SA/SC/RC/EA/ES	WA2918587
Polytmus guainumbi[#]	White-tailed Goldenthroat			
Amazilia fimbriata[*]	Glittering-throated Emerald		SA	WA2490872
Amazilia lactea[*]	Sapphire-spangled Emerald		SA	
Heliomaster squamosus	Stripe-breasted Starthroat		SA/SC	WA2918598
TROGONIDAE				
Trogon curucui	Blue-crowned Trogon		SA/EA/ES	WA3273333
ALCEDINIDAE				
Chloroceryle americana	Green Kingfisher			
BUCCONIDAE				
Nystalus maculatus	Spot-backed Puffbird		SA/SC/RC/EA/ES	WA2346838
PICIDAE				
Picumnus fulvescens	Tawny Piculet	EN/NT	SA/SC/RC/EA/ES	WA2687064
Veniliornis passerinus	Little Woodpecker		SA/SC/RC/EA/ES	
Piculus chrysochloros	Golden-green Woodpecker		SA	
Colaptes melanochloros	Green-barred Woodpecker		SA/SC/RC/EA/ES	
CARIAMIDAE				
Cariama cristata	Red-legged Seriema		SA/SC	
FALCONIDAE				
Caracara plancus	Southern Caracara		SA/SC	
Milvago chimachima	Yellow-headed Caracara		SA/SC	

Family and species	English names	End/Thr	Habitats	Documentation
Herpetotheres cachinnans	Laughing Falcon		SA/SC/EA/ES	WA1635330
Micrastur ruficollis	Barred Forest-Falcon		SA/SC/EA/ES	
Falco sparverius	American Kestrel		SA/SC/EA/ES	
Falco rufigularis	Bat Falcon		RC	
Falco femoralis	Aplomado Falcon		SA/SC/EA/ES	
*Falco peregrinus**[MG]	Peregrine Falcon		SA/ES	
PSITTACIDAE				
Primolius maracana[#]	Blue-winged Macaw			
Thectocercus acuticaudatus haemorrhous	Blue-crowned Parakeet	EN	SA/ES	
Eupsittula cactorum	Cactus Parakeet	EC	SA/SC/RC/EA/ES	WA2106953
Forpus xanthopterygius	Blue-winged Parrotlet		SA/SC/EA/ES	WA1989370
Amazona aestiva	Turquoise-fronted Parrot		SA/EA/ES	
THAMNOPHILIDAE				
Myrmorchilus strigilatus strigilatus	Stripe-backed Antbird	EN	SA/SC/RC	
Formicivora melanogaster bahiae	Black-bellied Antwren	EN	SA/SC/RC/EA/ES	WA1467784
*Herpsilochmus sellowi**	Caatinga Antwren	EN	SA/RC	WA2113554
Herpsilochmus atricapillus[#]	Black-capped Antwren			
Sakesphorus cristatus	Silvery-cheeked Antshrike	EC	SA/SC/RC	WA2850912
Thamnophilus capistratus	Caatinga Antshrike	EC	SA/SC/RC	WA2851005
Thamnophilus torquatus	Rufous-winged Antshrike		SA	
Thamnophilus pelzelni	Planalto Slaty-Antshrike		SA/SC/EA/ES	
Taraba major	Great Antshrike		SA/SC/RC/ES	
GRALLARIIDAE				
Hylopezus ochroleucus	White-browed Antpitta	EC/NT	SA/SC/RC/EA/ES	WA2308551
DENDROCOLAPTIDAE				
Sittasomus griseicapillus[#]	Olivaceous Woodcreeper			
Campylorhamphus trochilirostris	Red-billed Scythebill		SA	
*Dendroplex picus**	Straight-billed Woodcreeper		SA	
Lepidocolaptes angustirostris	Narrow-billed Woodcreeper		SA/SC/RC/EA/ES	WA2490963
FURNARIIDAE				
Furnarius figulus	Wing-banded Hornero		SA	
Furnarius leucopus	Pale-legged Hornero		SA/ES	
Pseudoseisura cristata	Caatinga Cacholote	EN	SA	
Phacellodomus rufifrons rufifrons/ specularis	Rufous-fronted Thornbird	EN	SA/SC/EA/ES	
Certhiaxis cinnamomeus	Yellow-chinned Spinetail		SA/SC/RC	
Synallaxis hellmayri	Red-shouldered Spinetail	EC	SA/SC/RC	
Synallaxis frontalis	Sooty-fronted Spinetail		SA/SC/RC	
Synallaxis albescens	Pale-breasted Spinetail		SA	
Synallaxis hypospodia[#]	Cinereous-breasted Spinetail			
Synallaxis scutata[#]	Ochre-cheeked Spinetail			
Cranioleuca semicinerea	Gray-headed Spinetail		SA/EA/ES	

Family and species	English names	End/Thr	Habitats	Documentation
TITYRIDAE				
Pachyramphus viridis	Green-backed Becard		SA/SC	
Pachyramphus polychopterus[PM]	White-winged Becard		SA/SC/ES	WA2918602
Pachyramphus validus[#PM]	Crested Becard			
Xenopsaris albinucha	White-naped Xenopsaris		SA	WA2491020
RHYNCHOCYCLIDAE				
Tolmomyias flaviventris	Yellow-breasted Flycatcher		SA/SC/EA/ES	
Todirostrum cinereum	Common Tody-Flycatcher		SA/SC/RC/ES	
Hemitriccus margaritaceiventer	Pearly-vented Tody-tyrant		SA/SC/RC	WA2101248
TYRANNIDAE				
Hirundinea ferruginea	Cliff Flycatcher		SA/RC	WA2288299
Stigmatura napensis bahiae	Lesser Wagtail-Tyrant	EN	SA/SC	WA2678822
Euscarthmus meloryphus	Tawny-crowned Pygmy-Tyrant		SA/SC/RC	
Camptostoma obsoletum	Southern Beardless-Tyrannulet		SA/SC/RC/EA/ES	WA2347009
Elaenia flavogaster	Yellow-bellied Elaenia		EA/ES	
Elaenia spectabilis[PM]	Large Elaenia		SA/SC/RC/ES	
Elaenia chilensis[MG]	Chilean Elaenia		SA/SC/RC/ES	WA2677969
*Suiriri suiriri bahiae**	Suiriri Flycatcher	EN	SA	WA1874629
Myiopagis viridicata[PM]	Greenish Elaenia		SA/SC/ES	
Phaeomyias murina[ND]	Mouse-colored Tyrannulet		SA/SC/RC/ES	WA2850711
Phyllomyias fasciatus cearae	Planalto Tyrannulet	EN	SA/SC/ES	
*Serpophaga subcristata**	White-crested Tyrannulet		SA/ES	WA2678868
*Myiarchus swainsoni**[PM]	Swainson's Flycatcher		SA	
Myiarchus ferox	Short-crested Flycatcher		EA/ES	
Myiarchus tyrannulus	Brown-crested Flycatcher		SA/SC/RC/EA/ES	WA1989368
Casiornis fuscus[PM]	Ash-throated Casiornis		SA/ES	WA2490796
Pitangus sulphuratus	Great Kiskadee		SA/SC/ES	
Machetornis rixosa	Cattle Tyrant		SA/ES	
Myiodynastes maculatus[PM]	Streaked Flycatcher		SA/ES	WA2490928
Megarynchus pitangua	Boat-billed Flycatcher		SC/EA/ES	
Myiozetetes similis	Social Flycatcher		SA/SC/EA	
Tyrannus melancholicus	Tropical Kingbird		SA/SC/RC/EA/ES	
*Tyrannus savana**[PM]	Fork-tailed Flycatcher		SA	
Empidonomus varius[PM]	Variegated Flycatcher		SA/SC/RC/EA/ES	WA2851003
Myiophobus fasciatus[PM]	colored Flycatcher		SA/SC/RC/ES	
Sublegatus modestus[PM]	Southern Scrub-Flycatcher		SA/ES	
Fluvicola albiventer	Black-backed Water-Tyrant		AE	WA2918597
Fluvicola nengeta	Masked Water-Tyrant		SA/ES	
Arundinicola leucocephala	White-headed Marsh Tyrant		AE	WA2288334
Cnemotriccus fuscatus	Fuscous Flycatcher		SA/SC/EA/ES	WA1635342
Knipolegus nigerrimus hoflingi	Velvety Black-Tyrant	EN	SA/RC	WA2918592
Xolmis irupero niveus	White Monjita	EN	SA	

Family and species	English names	End/Thr	Habitats	Documentation
VIREONIDAE				
Cyclarhis gujanensis	Rufous-browed Peppershrike		SA/SC/RC/ES	
Hylophilus amaurocephalus	Gray-eyed Greenlet		SA/SC/RC/ES	
Vireo chivi[PM]	Chivi Vireo		SA/SC/RC/ES	
CORVIDAE				
Cyanocorax cyanopogon	White-naped Jay		SA/SC/RC/ES	
HIRUNDINIDAE				
Stelgidopteryx ruficollis[#PM]	Southern Rough-winged Swallow			
Progne chalybea[PM]	Gray-breasted Martin		SA	
TROGLODYTIDAE				
Troglodytes musculus	Southern House Wren		SA/SC/RC/EA/ES	WA2683268
Pheugopedius genibarbis[#]	Moustached Wren			
Cantorchilus longirostris bahiae	Long-billed Wren	EN	SA/SC/RC	
POLIOPTILIDAE				
Polioptila plumbea	Tropical Gnatcatcher		SA/SC/RC/EA/ES	WA2101250
TURDIDAE				
Turdus leucomelas	Pale-breasted Thrush		EA/ES	
Turdus rufiventris	Rufous-bellied Thrush		SA/SC/RC/EA/ES	
Turdus amaurochalinus[PM]	Creamy-bellied Thrush		SA/SC	
MIMIDAE				
Mimus saturninus arenaceus	Chalk-browed Mockingbird	EN	SA/SC/RC/ES	WA2723585
MOTACILLIDAE				
Anthus lutescens	Yellowish Pipit		ES	
PASSERELLIDAE				
Zonotrichia capensis	Rufous-collared Sparrow		SA/SC/RC	WA1467779
Ammodramus humeralis	Grassland Sparrow		SA	
PARULIDAE				
Setophaga pitiayumi	Tropical Parula		SA/ES	
Myiothlypis flaveola	Flavescent Warbler		SA/EA/ES	
ICTERIDAE				
Icterus pyrrhopterus	Variable Oriole		SA/SC/RC	WA2918615
Icterus jamacaii	Campo Troupial	EN	SA/SC/RC	WA2106592
Chrysomus ruficapillus	Chestnut-capped Blackbird		SA	
Agelaioides fringillarius	Pale Baywing	EN	SA	
Molothrus bonariensis	Shiny Cowbird		SA	
Sturnella superciliaris	White-browed Meadowlark		SA	
THRAUPIDAE				
*Schistochlamys ruficapillus**	Cinnamon Tanager		RC	WA2113557
Paroaria dominicana	Red-cowled Cardinal	EC	SA/SC	WA2918606
Tangara sayaca	Sayaca Tanager		SA/SC/RC/EA/ES	
Tangara palmarum	Palm Tanager		EA/ES	
Tangara cayana	Burnished-buff Tanager		SA/SC/RC/EA/ES	
Nemosia pileata	Hooded Tanager		SA/SC/RC/EA/ES	

Family and species	English names	End/Thr	Habitats	Documentation
Compsothraupis loricata	Scarlet-throated Tanager	EN	SA/SC/RC	WA1635323
Conirostrum speciosum	Chestnut-vented Conebill		SC/EA/ES	
Sicalis flaveola	Saffron Finch		SA	
Sicalis luteola	Grassland Yellow-Finch		SA	
Volatinia jacarina	Blue-black Grassquit		SA/RC	WA2105977
Coryphospingus pileatus	Pileated Finch		SA/SC/RC	WA2850094
Tachyphonus rufus	White-lined Tanager		SA/SC/RC/ES	WA2105976
*Dacnis cayana**	Blue Dacnis		ES	
Coereba flaveola	Bananaquit		SA/SC/RC/EA/ES	
Sporophila lineola[#PM]	Lined Seedeater			
Sporophila nigricollis	Yellow-bellied Seedeater		SA	
Sporophila leucoptera[#]	White-bellied Seedeater			
Sporophila bouvreuil[#PM]	Copper Seedeater			
Sporophila albogularis	White-throated Seedeater	EC	SA/SC/RC	WA2918631
Saltator similis	Green-winged Saltator		SA	
Thlypopsis sordida	Orange-headed Tanager		SA/ES	WA2687083
CARDINALIDAE				
*Piranga flava**	Hepatic Tanager		EA/ES	
Cyanoloxia brissonii	Ultramarine Grosbeak		SA/SC/RC	
FRINGILLIDAE				
Spinus yarrellii[#]	Yellow-faced Siskin	VU		
Euphonia chlorotica	Purple-throated Euphonia		SA/SC/RC/EA/ES	
ESTRILDIDAE				
*Estrilda astrild**	Common Waxbill		SA	
PASSERIDAE				
Passer domesticus	House Sparrow		SA	

sites was fairly complete. Based on our point counts, estimated species richness was 158 (Chao 1) and 167 species (Jackknife 1). Thus, observed richness by point counts corresponds to 95.6% and 90.4%, respectively, of the estimated richness (Fig. 3).

During point counts, we made 18,272 avian contacts. The 10 most detected species during these censuses were *Zonotrichia capensis* (*n* = 926), *Eupsittula cactorum* (*n* = 850), *Zenaida auriculata* (*n* = 675), *Sakesphorus cristatus* (*n* = 626), *Stigmatura napensis* (*n* = 620), *Hemitriccus margaritaceiventer* (*n* = 592), *Columbina picui* (*n* = 559), *Polioptila plumbea* (*n* = 547), *Coryphospingus pileatus* (*n* = 545), and *Thamnophilus capistratus* (*n* = 539). On the other hand, 26 species were only recorded once (singletons) or twice (doubletons).

During the dry season we detected 117 species and 4,521 individuals. During the wet season (which we sampled twice) we detected 146 species and had a mean abundance of 6,875.2 individuals (*n* = 13,751). The five most abundant species during the dry season were *Eupsittula cactorum* (*n* = 283 individuals detected), *Chlorostilbon lucidus* (*n* = 276), *H. margaritaceiventer* (*n* = 239), *P. plumbea* (*n* = 212), and *Formicivora melanogaster* (*n* = 174). Whereas, during the wet season the five most abundant species were *Z. capensis* (*n* = 394), *Z. auriculata* (*n* = 337), *E. cactorum* (*n* = 283), *S. cristatus* (*n* = 243) and *S. napensis* (*n* = 223).

From our inventory (systematic and opportunistic) most of the species detected are considered residents. Nineteen species recorded at the CNP are considered migratory or partially migratory (Table 2). For example, *Elaenia chilensis* is an austral migrant, *Tyrannus savana* and *Turdus amaurochalinus* are considered partial austral migrants. We observed a single individual of *T. savana* flying over a disturbed open area in the CNP on March 2017. *Elaenia chilensis* and *T. amaurochalinus* were commonly recorded only during the rainy season. Similarly, two species of migratory cuckoos (*Coccyzus melacoryphus* and *Micrococcyx cinereus*) were only recorded during the rainy season. Whereas *C. melacoryphus* was

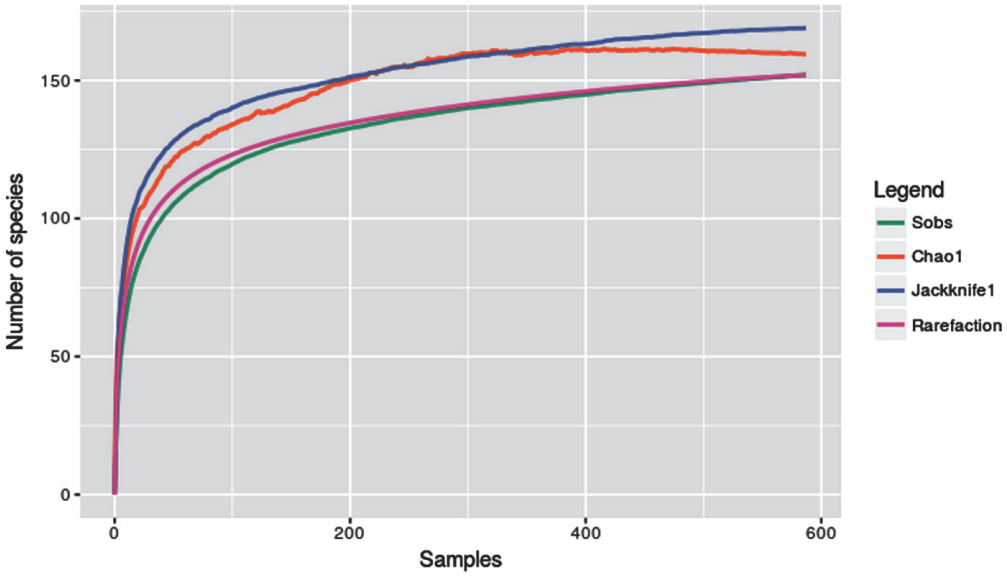

Figure 3. Observed richness (green line), rarefaction (pink line) and richness estimators Chao 1 (orange line) and Jackknife 1 (blue line) curves for the bird assemblage recorded in the Catimbau National Park, Pernambuco, Brazil.

relatively common, *M. cinereus* was recorded once on June 2017, during an opportunistic observation in a disturbed area. Some partial migrant species (*Myiophobus fasciatus*, *Casiornis fuscus*, *Myiodinastes maculatus*, *Empidonomus varius*, *Hydropsalis parvula*, *Vireo chivi*, *Pachyramphus polychopterus*, *Elaenia spectabilis*, *Myiarchus swainsoni* and *Progne chalybea*) were regularly detected during the rainy season in the park. Finally, species like *Bubulcus ibis, Xenopsaris albinucha*, *Columbina minuta*, *Columbina talpacoti*, *Patagioenas picazuro*, *Z. auriculata*, *Chrysomus ruficapillus*, *Agelaioides fringillarius*, *Molothrus bonariensis*, *Sicalis luteola*, *Volatinia jacarina*, and aquatic species such as *Dendrocygna viduata*, *Himantopus mexicanus*, as well as species from the families Podicipedidae, Ardeidae and Rallidae (Table 2) were recorded exclusively during the rainy season and are likely to carry out seasonal displacements within the Caatinga.

During our surveys most species were detected in more than one habitat. Most of the species recorded during our studies were detected in shrubby-arboreal Caatinga (162 species), followed by shrubby Caatinga with Cerrado elements (n = 85 spp.), shrubby Caatinga with elements of rocky fields (n = 59 spp.), evergreen arboreal vegetation (n = 56 spp.), evergreen shrubby Caatinga (n = 89), and 12 species related to aquatic environments.

A total of 28 taxa detected in our surveys are considered range-restricted. Nine species are endemic to the Caatinga, whereas 19 taxa are restricted to the Brazilian northeast (Table 2). *Picumnus fulvescens* a northeastern endemic and *Hylopezus ochroleucus* a Caatinga endemic are considered "Near Threatened", with decreasing trends in their populations (IUCN 2019). None of the species is considered threatened by extinction according to the Brazilian MMA (2018b). Three exotic species were recorded (*Columba livia*, *Estrilda astrild* and *Passer domesticus*), mostly in urban and peri-urban areas, but there is no evidence that they represent any threat to autoctonous species.

DISCUSSION

In this study we presented newly quantitative data on the avian assemblage found at the Catimbau National Park. During our quantitave surveys, restricted to 20 sites, we detected ~70% (155 species) of the 192 species. In addition, opportunistic observations included another 37 species of birds, mostly waterbirds that do not occur at or near our sampled sites. In fact, according to species richness estimators, our quantitative surveys detected the vast majority of the species present in our sites, showing the importance of conducting systematic surveys. The CNP avian assemblage (192 species) represented ~35% of bird species registered for the Caatinga Domain (*sensu* Araújo & Silva 2017; n = 548) and 35.8% of the 535 bird species recorded for the state of Pernambuco (Farias & Pereira 2009).

Despite our systematic surveys, we failed to find 34 bird species previously reported for the CNP by Sousa *et al.* (2012). Among the species we failed to record, 11 are linked to aquatic environments, including three species of herons (*Tigrisoma lineatum*, *Nycticorax nycticorax*, and *Butorides striata*), two of ducks (*Cairina moschata* and *Amazonetta brasiliensis*), two common inhabitants of ponds and pools (*Podilymbus podiceps* and *Nannopterum brasilianus*), two species of raptors likely occurring in low densities (*Buteo nitidus* and *Buteo albonotatus*), two species

of hummingbirds (*Anthracothorax nigricollis* and *Polytmus guainumbi*), two species of nightbirds (*Antrostomus rufus* and *Chordeiles acutipennis*), four species of birds often linked to more humid forests (*Herpsilochmus atricapillus*, *Sittasomus griseicapillus*, *Synallaxis hypospodia*, and *Pheugopedius genibarbis*), and three species of seedeaters known to have erratic populations elsewhere in the Caatinga (*Sporophila lineola*, *Sporophila leucoptera*, and *Sporophila bouvreuil*).

More important, however, were the apparent absences of three species of conservation concern, including three endemic and threatened species (*Crypturellus noctivagus zabele*, *P. jacucaca*, and *S. yarrellii*) previously reported by Sousa *et al.* (2012). These species are known to be widely hunted by poachers and for the illegal trade, and their absences may indicate local extinctions. The CNP suffers strong pressure from hunting and illegal trade, particulalry for birds. During the study period hunters and local residents were observed trapping birds within the CNP boundaries, an illegal activity outside and even inside the protected area. We found many endemic avian taxa in captivity, including *E. cactorum*, *Paroaria dominicana*, *Sporophila albogularis* and *Icterus jamacaii*, but also more widespread species, such as *Amazona aestiva* and *Cyanoloxia brissonii*, widely appreciated by the illegal trade. We are afraid that if the scenario of hunting activities, illegal logging, overgrazing by goats and cattle, hunting of wild animals (mainly mammals and birds), and bird trapping continue to occur within the park, other species may also become locally extinct. Species whose populations are locally and regionally small are more susceptible to local extinction (*e.g.*, Pereira & Brito 2005, Pereira & Azevedo-Jr. 2011, Fernandes-Ferreira *et al.* 2012, Las-Casas *et al.* 2012, Albuquerque *et al.* 2017).

On the other hand, we recorded 25 species that were not previously recorded at the CNP (Table 2), including two aquatic species (*Tachybaptus dominicus* and *Himantopus mexicanus*), three species of raptors (*Heterospizias meridionalis*, *Urubitinga urubitinga*, *Parabuteo unicinctus*); some austral and intratropical migrants (*M. cinereus*, *Serpophaga subcristata*, *T. savana*, and *Piranga flava*), whose movements are poorly known; a boreal unreported fron the park; migrant (*Falco peregrinus*); two species of exotic birds *(Columba livia* and *Estrilda astrild*), previously unreported from the park; and one endemism that likely went undersampled in the past (*Herpsilochmus sellowi*). These results suggest that the core avian assemblage of the CNP is likely very well established by now, and that future records will likely result from more nomadic aquatic species, austral and northern migrants, and possibly some widespread species that have not yet been recorded in the park. Species richness and avian composition may also vary according to differences in the methods applied, sampling effort, nocturnal observations (Vizentin-Bugoni *et al.* 2015), as well as the conservation status of the areas (Sayer *et al.* 2017, Bovo *et al*. 2018).

These results also suggest that the Caatinga bird assemblage composition presents some clear interannual variation, particularly for aquatic and low density species (Araújo & Silva 2017). During the rainy season at the CNP, there was an increment in bird species richness, with the presence of migratory birds, including both long-distance and intratropical migrants (*e.g.*, Ruiz-Esparza *et al.* 2011, Las-Casas *et al.* 2012, Lyra-Neves *et al.* 2012, Araújo *et al.* 2017).

Most of the bird species found at the CNP occured in shrubby arboreal Caatinga, which is the main phytophisiognomy found within the park boundaries. On the other hand, many species of birds can be found in more than one habitat (Table 2), a pattern that is common among birds in the Caatinga. Most of the species included in the park's list are not forest dependent, being able to explore different habitats (Araújo & Silva 2017). However, some species may be considered forest specialists. In the CNP species such as *Leptotila rufaxilla* and *Ortalis araucuan* were restricted to more humid habitats such as evegreen forests, a type of vegetation nowadays very uncommon within the park. This type of vegetation was transformed in areas of plantations and pastures (*e.g.*, Pedra do Cachorro) and the remaining tracts of evergreen forests is very fragmented and present different levels of disturbances.

We also noticed that some bird species at the CNP prefer well-conserved and/or forested habitats and rarely occur in disturbed environments (Pereira & Azevedo-Jr. 2011, Las-Casas *et al.* 2012, Lyra-Neves *et al.* 2012). This was the case of *P. superciliaris*, *Trogon curucui*, *Piculus chrysochloros*, *Micrastur ruficollis, H. sellowi*, *H. ochroleucus*, *C. trochilirostris*, *Dendroplex picus* and *S. ruficapillus.* In contrast, other species were only observed in disturbed and open areas, such as *Athene cunicularia*, *Suiriri suiriri bahiae* and *Xolmis irupero niveus*. Species such as *Sarcoramphus papa*, *Geranoaetus melanoleucus*, *Hydropsalis longirostris*, *Hirundinea ferruginea* and *Knipolgeus nigerrimus* were associated to the CNP's rocky walls. Some of those rare species were those more dependent on forested habitats and more sensitive to disturbance, preferring isolated sites with very low human interference such as *P. superciliaris*, *Claravis pretiosa*, *M. ruficollis*, *C. trochilirostris* and *S. ruficapillus*.

The Caatinga is the largest block of tropical Dry forests found within South America (Silva & Souza 2018) and is one of the most threatened in the Neotropics, with less than 10% of its original extent (Banda *et al*. 2016). In Brazil, habitat conservation is uneven among biomes (Jenkins & Joppa 2009, Oliveira & Bernard 2017) and the Caatinga represents the least protected one, with only

1.3% of the total area officially included in protected areas that receive full protection (MMA 2017).

Besides the anthropogenic pressures found within this protected area, such as bird hunting, trapping and cattle grazing, our results demonstrate that the CNP still harbors a valuable Caatinga avian diversity with the presence of range-restricted, endemic, threatened, and migratory species, highlighting its importance for bird conservation. But we emphasize the need of effective management inside and outside the park's boundaries, since pressures inside the reserve may usually reflect those occurring around (Laurance *et al.* 2012). Despite being fragmented, patches of Caatinga remain well-connected, which may facilitate recolonizations and community regeneration (Antongiovanni *et al.* 2018). Thus, the maintenance, management and expansion of protected area networks continue to be one of the most important tools for biodiversity conservation (Las-Casas *et al.* 2012, Oliveira & Bernard 2017, Antongiovanni *et al.* 2018).

The exceptional natural features of the park, allied to a rich avifauna could provide an economic opportunity through the development of birdwatching, offering new job opportunities. We emphasize that actions such as environmental education and ecological restoration projects, allied to inspection are urgent for the maintenance of the biodiversity and ecosystem services at the CNP.

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