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Analysis of population size and distribution of *Phaeton aethereus* (Linnaeus, 1758) on Raso Islet, Cabo Verde

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RESUMO

O tamanho populacional e a distribuição do *Phaethon aethereus* no ilhéu Raso foram estudados de Agosto a Dezembro de 2016. No total, recolheram-se dados de 42 variáveis biométricas de 38 adultos e quatro juvenis, e destes 41 indivíduos foram anilhados. Embora se tenham marcado alguns indivíduos em 2014, não se registou nenhuma recaptura. As médias das variáveis biométricas, obtidas para os diferentes segmentos do corpo e dos ovos, enquadram-se no intervalo de valores de *P. aethereus mesonauta* do Atlântico Norte tropical. Os dois maiores aglomerados de *P. aethereus* identificados no Raso encontram-se sobrepostos com colónias de alcatraz *Sula leucogaster*, o que permitiu uma contagem directa máxima de apenas 90 indivíduos. A existência de locais de difícil acesso permitiu a identificação e monitorização de apenas 117 ninhos. A população estimada a partir do número de ninhos foi de mais de 100 pares de indivíduos. Porém, sem que haja um censo anual é difícil estimar o tamanho populacional desta espécie. Portanto, para conhecer melhor a dinâmica populacional de *P. aethereus* no Raso recomenda-se estudos anuais.

Palavras-chave: rabo-de-junco, medidas biométricas, fenologia de reprodução

ABSTRACT

The population size and distribution of *Phaethon aethereus* on Raso Islet was studied from August to December 2016. In total, 42 biometric measures were collected from 38 adults and four juveniles. No recapture was identified although some individuals were ringed in 2014. The means of biometrics variables obtained for the different body segments and eggs were within the ranges of *P. aethereus mesonauta* from tropical North Atlantic. The two largest agglomerations of *P. aethereus* identified on Raso were overlapping colonies of brown boobies *Sula leucogaster* which allowed the maximum direct count of only 90 individuals. The inaccessibility of some breeding areas conditioned the identification and monitoring of just 117 nests. Thus, we estimate the population by the number of nests in more than 100 pairs. However, without an annual census, it is difficult to estimate the population size of this species. So, annual studies are recommended to better understand the population dynamics of *P. aethereus* on Raso.

Keywords: red-billed tropicbird, biometric measures, breeding phenology

INTRODUCTION

The red-billed tropicbird, *Phaethon aethereus* (Linnaeus, 1758), is a seabird with a distribution extending along the tropical and subtropical waters of the Atlantic oceans, northern Indian and eastern Pacific, which nests on cliffs. The spawning cycle of the species is about 11 months, laying one egg only which is incubated for 42 days (Castillo-Guerrero *et al*. 2011, BirdLife International 2013). Although it has a wide distribution area, the global population is estimated at less than 8000 breeding pairs (Lee & Walsh-McGehee 2000) and it is suspected to be declining due to predation, marine pollution and habitat destruction (BirdLife International 2013).

In the Cabo Verde Archipelago, colonies of red-billed tropicbirds were confirmed on the islands of Sal, Boavista, Santiago, Brava and Santo Antão, and on the islets of Raso and Rombo (Hazevoet 1995, Clarke 2006). Also, it has been observed on Passáros Islet, off São Vicente (Hazevoet 2010), on Fogo Island (Barone & Hering 2010) and recently Martins *et al.* (2017) described a new breed site on São Nicolau Island and they reported two locations on the coast of São Vicente. Locally, the red-billed tropicbird population has been declining (Hazevoet 1994) due to harvesting of adults and chicks, theft of eggs and in total it does not exceed 160 couples (INIDA 2007). This is the reason why, in the National Red List, this species is classified as Critically Endangered on the islands of Boavista and Sal, and Endangered on Santiago and Brava islands, and Raso and Rombo islets (Hazevoet *et al.* 1996). There is on Raso one of the largest colonies in the country, but also is where human predation was higher (Hazevoet 2010). However, there are no studies that specifically addressed this species. Presently, all the scarce data about *P. aethereus* was collected taking advantage of campaigns with other seabirds performed on Raso in 2014 and 2015 (Geraldes *et al*. 2016).

Thus, in order to know the population size and the distribution of the species on Raso, and to complement and improve the work already begun, local prospects were carried out for identifying its nests, the presence of adults, incubating adults, juveniles, chicks and nests. Therefore we aim to estimate the number of couples, collect biometric data and respective ringing of captured specimens.

MATERIAL AND METHODS

The Raso Islet is situated at northeast of the Cabo Verde Archipelago (Fig. 1A), west of São Nicolau Island, between the parallels 16º 36 'and 16º 37'N and the meridians 24º 34' and 24º 36'W. With circa 7 km^2, it is considered the largest islet of the archipelago. It is a very arid islet but it has great biodiversity, mainly in terms of seabirds and it is part of a Natural Reserve of Santa Luzia, Branco and Raso (Vasconcelos e*t al.* 2015).

The monitoring work was carried out on Raso from August to December 2016. We collected data on nests contents, classified as single adult, chick, egg or empty, and biometric measurements of captured adults. The length of the head, body and wings was measured in millimeters with a ruler. The length of the bill and tarsus, and the maximum width and height of the eggs were taken with a calliper. The weight was taken in grams with a bascule. The captured individuals were ringed in case of absence of any previous identification. Each nest was marked with white ink on the soil using as code the first letter of the name of the species plus the sample number (ex: PA12), and its respective location was recorded on a portable Global Positioning System (GPS) device. All information was organized into a database. Graphs were drawn for the different development stages and the contents of the identified nests using EXCEL. We used the direct counting method to estimate the population size and the number of nests. The coordinates were introduced in GPSVisualizer (http://www.gpsvisualizer.com/) to map the distribution of the identified nests.

Fig 1. Study area. **A**) Geographical location of Raso Islet in the Cabo Verde Archipelago and **B**) location of *Phaethon aethereus* nests on Raso Islet in 2016, with areas of greater density marked with a red circle, and the centroid of the islet marked with an X (latitude: 16.61791, longitude: -24.5877, coordinates in decimal degrees, datum WGS84).

RESULTS AND DISCUSSION

In total, data from 42 biometric variables were collected. We have measured 38 adults and four juveniles, and 41 of those individuals were ringed. Of the ringed individuals, no recapture was registered although Geraldes *et al*. (2016) had ringed some individuals in 2014.

Biometric measures obtained from the body segments in adults and their eggs were within the ranges of *P. aethereus mesonauta*

of the tropical North Atlantic (Table 1). This corresponds to the subspecies that reproduces on Cabo Verde (Cramps & Simmons 1977, Furness & Monteiro 1995). The mean values obtained by Furness & Monteiro (1995) of 56.6 by 43.4 mm on the first record of *P. aethereus* posture in the Azores, are also within the length and width range of the eggs we have measured for the same species on Raso.

Table 1. Biometric variables measured on adult and egg individuals of *Phaethon aethereus* on Raso Islet (mean ± standard deviation, SD). The length and height variables were measured in millimeters and the weight in grams**.** N stands for the number of samples; Max and Min for maximum and minimum values, respectively.

Variables	N	Mean ± SD	Max	Min
Head Length	37	121 ± 3	127	111
Body Length	38	167 ± 13	196	151
Wing Length	37	313 ± 28	334	223
Tarsus Length	38	31 ± 1	33	28
Tail Length	34	518 ± 96	679	195
Bill Length	38	65 ± 3	71	56
Bill Width	38	12 ± 1	15	8
Bill Height	38	22 ± 1	24	20
Weight	37	652 ± 51	750	560
Egg Height	11	55 ± 10	65	42
Egg Width	11	49 ± 7	58	43

It was not possible to check differences relative to the sex of the individuals. Even though according to Nunes *et al.* (2013) males are relatively larger and have relatively bills, wing cords and tails larger than females, in the current study it was not possible to see this pattern. So, we consider that sexual dimorphism in this population is apparently very limited.

We counted on Raso 117 accessible or visible nests. The areas with the highest density correspond to the southern areas of the islet and those of lower density to the comparatively more inaccessible north/ northeast areas (Fig. 1B). This difference in densities is a result of biased sampling as the latter areas of the islet were not sampled due to the existence of steep and unsafe cliffs.

The two main agglomerations of *P. aethereus* on the southern areas of the islet overlapped with the mains colonies of brown boobies *Sula leucogaster*.

In 33.3% of the identified nests it was not possible to know its content. Those corresponded to inaccessible or very deep nests. In the accessible nests, 28.2% were empty, perhaps abandoned but containing signs of previous occupancy, 13.7% had one adult with an egg, 11.1% single adult, perhaps preparing for spawning or in incubation, and only 0.9% of the nest contained an adult with a juvenile (Fig. 2). Of the occupied nests, we have verified during data collection the occurrence of 40% and 20% mortality of chicks and juveniles inside the nests, respectively, and 11.1% of broken eggs. This mortality appeared to be natural and it may have been caused by the movement of the parents during the entry or exit of the nests or possibly also due predation by the giant wall gecko *Tarentola gigas*, as individuals of this specie have already been observed preying eggs and chicks of other seabirds on Raso, such as the Cape Verde shearwater *Calonetris edwardsii* (Hazevoet 1995). Hence, for conclusive information studies to evaluate the diet of *T. gigas* and the interaction with *P. aethereus* are recommended.

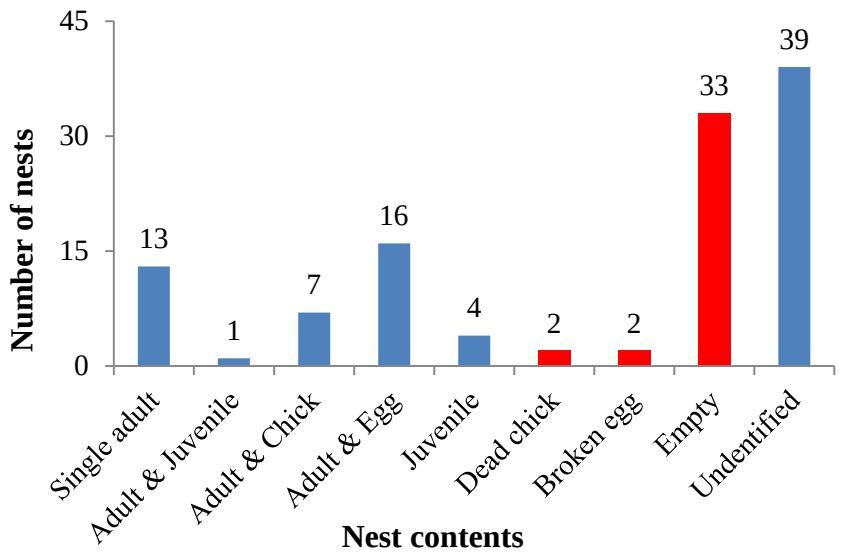

Fig 2. Representative graph of the contents of the nests of *P. aethereus* on Raso islet.

In Cabo Verde, the threats that may lead the mortality of red-billed tropicbird population are related to habitat destruction, human predation at nesting sites of adults, juveniles and eggs and of adults at sea for food purposes (INIDA 2007). Over the years, human predation has had an extremely negative impact on the populations of seabirds on Raso. Currently, although the mortality of seabirds by human action has decreased, thanks to the presence of the Biosfera I team and the awareness policy with fishermen, an effective effort is needed to increase vigilance by the government in order to reduce human interference in this islet (Almeida 2014). Due to the lack of an effective surveillance system and the depletion of fishery resources elsewhere, in 2015 Raso Islet had an increase in the number of fishermen (Geraldes *et al*. 2016). This may threat seabird species in this area by increasing direct and indirect mortality, through introducing of litter in the nests and increasing the likelihood of invasive species such as rats to enter the islet.

Regarding the population size of *P. aethereus* on Raso, we estimated more than 100 pairs of individuals based on the number of nests. The maximum direct count was only 90 individuals, but maybe this is due to the presence of a large number of red-billed tropicbird specimens next to the brown boobies, which made the counts very difficult. These results are close to the numbers indicated by Geraldes *et al.* (2016) that registered 88 specimens in 2014 by direct counts. The same authors registered by direct prospection 70 active nests, of which 54 were occupied, and an estimated reproductive population of 50 to 100 pairs in 2015.

According to Lee & Walsh-McGehee (2000), it is difficult to estimate the size of tropical bird populations, as is the case of *P. aethereus*, mainly due to problems that include inability to access colonies or observation points, ideal time of visit, the variability of behaviour and number of individuals in each colony, since birds are not always present in the nests and the intervals between the change of incubation partners or feeding of the young can last several days. Population estimation through detection of individuals in their nest/ borrow or clear signs of former usage as a nesting site (e.g. feces, feathers) appears to be complicated for the red-billed tropicbird on Raso Islet due to the existence of inaccessible cliffs and the coexistence of mixed seabird colonies. Indeed red-billed tropicbird colonies were found to spatially overlap with those from *S. leucogaster*, *C. edwardsii*, Cabo Verde little

shearwater *Puffinus assimilis boydi*, Bulwer´s petrel *Bulweria bulwerii* and Madeiran storm-petrel *Oceanodroma castro* (Almeida 2014).

All the factors above can cause underestimation or overestimation of the population size, so it is important that they all be considered when estimating the size of the breeding population. Also for *P. aethereus* the determination of its reproductive population makes it even more difficult without an annual census because it reproduces throughout the year (Geraldes *et al.* 2016).

CONCLUDING REMARKS

According to INIDA (2007), 33.3% of the red-billed tropicbird population is located in Integral Reserves and 11.1% in Natural Parks, which can confer great advantages for future research. This work refers to data from a protected area, thus it is important for the scientific community since there is little available information for this species, and still serves as the basis for future conservation projects. In this regard, to better understand its dynamics and population size, both on Raso and throughout the archipelago, studies involving annual data of *P. aethereus* are recommended.

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