Wildlife inventory from camera-trapping surveys in the Azores (Pico and Terceira islands)

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Abstract

Background

The present publication provides a dataset from five camera-trapping sampling campaigns on two islands of the Azorean archipelago (Pico and Terceira islands), between 2013-2018. This dataset was obtained as a by-product of campaigns designed for different purposes. The sampling campaigns were designed to: (i) study the ecology of introduced mammals; (ii) assess the impact of introduced mammals on native birds (Azores woodpigeon - Columba palumbus azorica and Cory’s shearwater - Calonectris diomeda borealis), through nest predation; and (iii) obtain information about the impact of vertebrates on agricultural systems, particularly on Azorean traditional vineyards. A total of 258 sites and 47 nests were sampled using camera traps. These sampling campaigns provided a large data series that allowed the creation of a vertebrate wildlife inventory.
New information

We obtained a total of 102,095 camera-trap records, which allowed us to identify 30 species of vertebrates: one amphibian, one reptile, 17 birds and ten mammal species. This represented 100% of the amphibians and terrestrial mammals, 58% of the breeding birds and 50% of the reptile species known for Pico and/or Terceira islands. Concerning the colonisation status of the species, we recorded 15 indigenous (native non-endemic or endemic) and three introduced bird species; all known terrestrial amphibians, reptiles and mammals in the Azores are introduced species. The data collected contribute to increasing knowledge on the distribution of vertebrate species on Pico and Terceira islands, where most existing records of some species were only available to Island level (e.g. mustelids and hedgehogs). None of the identified species was previously unknown to the study area.

Keywords
Camera-traps, Vertebrates, Oceanic islands, Introduced species

Introduction

Camera-trapping is commonly used to answer a variety of research questions in the fields of animal ecology, behavioural studies and conservation biology (O’Connell et al. 2011). It has also been used to assess the impacts of invasive species on native biodiversity (Hervías et al. 2012, Oppel et al. 2014) and the damage to wildlife in agriculture systems (Coates et al. 2010), as well as to address questions on spatial and temporal dynamics of animal populations (O’Connell et al. 2011). Although camera-traps are most often used to study medium- and large-sized terrestrial mammals (Tobler et al. 2008, Rovero et al. 2010), they have been successfully used to study arboreal mammals (Oliveira-Santos et al. 2008, Di Cerbo and Biancardi 2012) and small-sized species (McCleery et al. 2014, Rendall et al. 2014, Taylor et al. 2014). Camera-traps are also useful for detecting rare or elusive species (Si et al. 2014).

Cameras are triggered by passing animals, allowing a record of animal presence and date and time of the detection (O’Connell et al. 2011). This allows the estimation of abundance and density (using capture-recapture models) for individually recognisable species (Karanth 1995, O’Connell et al. 2011). However, when it is impossible to distinguish specimens individually, camera-traps can also be used to calculate relative abundance indices of species (Rovero and Marshall 2009, O’Connell et al. 2011).

Camera-trapping has demonstrated to be one of the most efficient and low-cost sampling methods for faunal assessments, although it requires a large initial investment (Silveira et al. 2003, Lyra-Jorge et al. 2008, De Bondi et al. 2010). In particular, it is a very useful technique for wildlife inventories (Tobler et al. 2008, Rovero et al. 2010, Rovero et al. 2016) and monitoring (Yasuda 2004, Glen et al. 2013, Rendall et al. 2014), given its ability to generate large data series, recording the presence of target and non-target species.
In the Azores, very few studies have been done using camera-trapping to study vertebrates (but see, for example, Hervías et al. 2012 about nest predation). Here we aim to describe the main findings of the five sampling campaigns using camera-trapping to survey vertebrates, conducted between 2013 and 2018 in the Azores, namely on the islands of Pico and Terceira.

**General description**

**Purpose:** To provide a vertebrate inventory for the Azores (Pico and Terceira islands), based on data obtained as a by-product from five field sampling campaigns using camera-trapping.

**Additional information:** Between 2013 and 2018, two sampling campaigns were conducted on Terceira island ("TER_13-15" survey) and on Terceira and Pico islands ("TER-PIC_18" survey) in order to study the ecology of introduced mammals. A third sampling campaign was performed between 2015 and 2017 in vineyards on Terceira island in order to evaluate grape consumption by vertebrate species ("Vineyards_15-17" survey). Additionally, between 2016 and 2018, two sampling campaigns were performed on Terceira island, in order to assess the impact of introduced mammals on native birds, on Cory's Shearwater (Calonectris diomedea borealis; "Calonectris_16" survey) and the Azores woodpigeon (Columba palumba azorica; "Columba_17-18" survey), through nest predation monitoring.

**Sampling methods**

**Study extent:** This dataset was obtained from different sampling campaigns performed between 2013 and 2018 in two islands of the central group of the Azores archipelago, Pico and Terceira Islands.

We described the study extent of the different sampling campaigns below:

- The survey "TER_13-15" was conducted between 2013 and 2015 on Terceira island, to investigate the ecology of introduced mammals. A total of 72 sites were sampled, but five sites were excluded due to camera failures. Each site was sampled during seven consecutive days.
- The survey "PIC-TER_18" was conducted in 2018 on Pico and Terceira islands, to investigate the ecology of introduced mammals. A total of 69 sites were sampled, with 33 and 34 sites, located in Pico and Terceira islands, respectively. Each site was sampled during ten consecutive days.
- The survey "Vineyards_15-17" was conducted in three consecutive years (2015, 2016 and 2017) in a vineyards area known as Protected Landscape Area of Biscoitos Vineyards, located in the North of Terceira island, to evaluate grape consumption by vertebrates. A total of 117 sites were sampled, with 20, 49 and 48
sites sampled during 2015, 2016 and 2017, respectively. Each site was sampled during seven consecutive days.

- The survey "Calonectris_16" was conducted in 2016 on Terceira island, to assess the impact of introduced mammals. A total of 17 nests of *Calonectris diomedea borealis* were sampled. Each nest was sampled during ten consecutive days.
- The survey "Columba_17-18" was conducted in 2017 and 2018 on Terceira island, to assess the impact of introduced mammals. A total of 30 nests of *Columba palumbus azorica* were sampled, with 9 and 21 sites sampled in 2017 and 2018, respectively. Each nest was sampled during ten consecutive days.

**Sampling description:** All sites were sampled using camera-traps that were fixed to a tree or wooden stick. The sampling effort was measured as camera-trap days, i.e. the number of camera traps multiplied by the number of days that they remained active (Rovero et al. 2010). The sensitivity of the infrared sensor was configured to high to increase the species detection (O’Connell et al. 2011). Cameras were configured to take events with 30 seconds of delay between them, recording the date and time of each event. Cameras remained active 24 hours per day.

For the surveys "TER_13-15" and "PIC-TER_18" sampling sites were randomly selected, separated at least by 1 km. In each sampling site, one camera trap and a bait were deployed, 150-200 cm apart. Bait, consisting of meat or fish, fruit or vegetables and molasses, was used to increase the species detection (du Preez et al. 2014).

For the surveys "Vineyards_15-17", "Calonectris_16" and "Columba_17-18", no bait was used. In the case of the "Vineyards_15-17" survey, sampling sites were selected at random, deploying one camera at each site, facing bunches of grapes. For
"Calonectris_16" and "Columba_17-18" surveys, one camera was installed at 50-150 cm from the study nest (Fig. 1).

**Quality control:** Taxonomic nomenclature followed the GBIF species profile and, for Azorean subspecies, we used the vertebrate checklist in Borges et al. 2010.

**Geographic coverage**

**Description:** Pico and Terceira islands, the Azores, Macaronesia, Portugal

**Coordinates:** 38.434491 and 38.7617777778 Latitude; -28.4228543692 and -27.1971972222 Longitude.

**Taxonomic coverage**

**Taxa included:**

| Rank | Scientific Name | Common Name |
|------|-----------------|-------------|
| class | Mammalia | Mammals |
| class | Aves | Birds |
| class | Reptilia | Reptiles |
| class | Amphibia | Amphibians |

**Temporal coverage**

**Data range:** 2013-9-08 - 2018-8-10.

**Usage rights**

**Use license:** Open Data Commons Attribution License

**Data resources**

**Data package title:** Wildlife inventory in the Azores using camera trapping

**Resource link:** [http://ipt.gbif.pt/ipt/resource?r=camera_trapping_azores](http://ipt.gbif.pt/ipt/resource?r=camera_trapping_azores)

**Alternative identifiers:** [https://www.gbif.org/dataset/7d6b90d2-14c0-4ba6-9e45-449b56bab878](https://www.gbif.org/dataset/7d6b90d2-14c0-4ba6-9e45-449b56bab878)

**Number of data sets:** 1
Data set name: Wildlife inventory in the Azores using camera trapping

Data format: Darwin Core Archive

Data format version: version 1

Description: The dataset was published in GBIF (see Lamelas-López et al. 2019). The following data table includes all the records for which a taxonomic identification of the species was possible. The dataset submitted to GBIF is structured as a sample event dataset, with two tables: event (as core) and occurrences. The data in this sampling event resource have been published as a Darwin Core Archive (DwCA), which is a standardised format for sharing biodiversity data as a set of one or more data tables. The core data table contains 2,308 records (eventID). One extension data table also exists with 108,186 occurrences. This large number of occurrences is a consequence of the fact that cameras were configured to take occurrences with 30 seconds of delay between them, recording the date and time of each record. Cameras remained active 24 hours per day. An extension record supplies extra information about a core record. The number of records in each extension data table is illustrated in the IPT link. This IPT archives the data and thus serves as the data repository. The data and resource metadata are available for downloading in the downloads section.

| Column label                      | Column description                                                                 |
|-----------------------------------|-------------------------------------------------------------------------------------|
| Table of Sampling Events          | Table with sampling events data                                                    |
| eventID                           | Identifier of the events, unique for the dataset                                    |
| samplingProtocol                  | The sampling method used                                                            |
| sampleSizeValue                   | The number of days that the cameras remain active in each sampling                  |
| sampleSizeUnit                    | The unit of the sample size value                                                   |
| samplingEffort                    | The number of camera-trap days expended during an event                             |
| eventDate                         | Date when the event occurred                                                       |
| habitat                           | The habitat type in which the event occurred                                        |
| locationID                        | An identifier of the camera location                                               |
| island                            | Name of the island on which camera location occurs                                 |
| country                           | Country in which camera location occurs                                             |
| countryCode                       | ISO code of the country in which camera location occurs                             |
| stateProvince                     | Name of the region in which camera location occurs                                 |
| decimalLatitude                   | The geographic latitude, in decimal degrees                                         |
| decimalLongitude                  | The geographic longitude, in decimal degrees                                        |
| geodeticDatum                     | The reference point for the various coordinate systems used in mapping the earth    |
| coordinateUncertaintyInMetres     | Uncertainty of the coordinates, in metres                                           |
Additional information

Results and Discussion

A total of 102,095 records were obtained (see example in Fig. 2): two were amphibians, 12,072 reptiles, 61,329 birds and 28,692 mammals. The majority of records were obtained on Terceira Island (94,731) since most of the sampling campaigns occurred on this island. Additionally, for 11,203 records, species identification was not possible, although most individuals could unequivocally be assigned to the mammal order Rodentia (11,055). This dataset provides reliable records that contribute to increasing knowledge on the distribution of vertebrate species on Pico and Terceira islands, where most existing records of some species were only available to Island level (e.g. *Mustela furo*, *Mustela nivalis* or *Erinaceus*...
The presence of a cat (*Felis catus*) on 21 February 2015, at 06:44 pm.

A total of 30 species were identified: one amphibian, one reptile, 17 birds and ten mammal species (Table 1). According to the most recent available Azorean biota checklist (Borges et al. 2010), we recorded 100% of the amphibians and terrestrial mammals, 58% of the breeding birds and 50% of the reptile species known for Pico and/or Terceira islands. Cattle (e.g. cows) and invertebrate species (e.g. flies, bees or snails) were also recorded, but were excluded from the analysis and results.

### Table 1.

Number of events (photos or videos) and colonisation status of species recorded in different projects in Terceira and Pico, since 2013 until 2018, based on camera-trapping. Abbreviations: endemic subspecies of Azores (azo); endemic of Macaronesia (mac); introduced (int); native non-endemic (nat).

| Class   | Species                                      | Status | TER_13-15 | PIC-TER_18 | Vineyards_15-17 | Calonectris_16 | Columba_17-18 |
|---------|----------------------------------------------|--------|-----------|------------|----------------|----------------|---------------|
| Amphibia| *Pelophylax perezi* (López-Seoane, 1885)     | int    | 0         | 2          | 0              | 0              | 0             |
| Reptilia| *Teira dugesii* (Milne-Edwards, 1829)       | int    | 56        | 985        | 11017          | 14             | 0             |
| Class | Species | Status | TER_13-15 | PIC-TER_18 | Vineyards_15-17 | Calonectris_16 | Columba_17-18 |
|-------|---------|--------|-----------|------------|----------------|----------------|---------------|
| Aves  | Coturnix coturnix conturbans | nat | 0 | 0 | 1 | 0 | 0 |
| Aves  | Calonectris borealis (Cory, 1891) | nat | 0 | 3 | 0 | 2015 | 0 |
| Aves  | Buteo buteo rothschildi | azo | 1 | 0 | 0 | 0 | 0 |
| Aves  | Larus michahellis atlantis Dwight, 1922 | azo | 4 | 0 | 0 | 0 | 0 |
| Aves  | Gallinago gallinago (Linnaeus, 1758) | nat | 0 | 2 | 0 | 0 | 0 |
| Aves  | Scolopax rusticola Linnaeus, 1758 | nat | 16 | 102 | 0 | 0 | 0 |
| Aves  | Columba livia domestica Gmelin, 1789 | int | 1 | 0 | 23 | 100 | 0 |
| Aves  | Columba palumbus azorica Hartert, 1905 | azo | 47 | 6 | 40 | 0 | 53752 |
| Aves  | Asio otus otus (Linnaeus, 1758) | nat | 7 | 0 | 0 | 0 | 0 |
| Aves  | Chloris chloris aurantiiventris (Cabanis, 1851) | int | 9 | 0 | 2 | 0 | 0 |
| Class     | Species                          | Status | TER_13-15 | PIC-TER_18 | Vineyards_15-17 | Calonectris_16 | Columbia_17-18 |
|-----------|----------------------------------|--------|-----------|------------|-----------------|----------------|----------------|
| Aves      | *Fringilla coelebs*              | azo    | 60        | 117        | 88              | 1              | 8              |
| Aves      | *Serinus canaria*                | mac    | 2         | 6          | 259             | 2              | 0              |
| Aves      | *Motacilla cinerea patriciae*    | azo    | 6         | 0          | 0               | 0              | 0              |
| Aves      | *Passer domesticus domesticus*  | int    | 2         | 3          | 1544            | 0              | 0              |
| Aves      | *Sturnus vulgaris granti*        | azo    | 10        | 0          | 0               | 1              | 0              |
| Aves      | *Sylvia atricapilla gularis*     | azo    | 4         | 248        | 65              | 2              | 2              |
| Aves      | *Erithacus rubecula rubecula*    | nat    | 25        | 92         | 6               | 6              | 0              |
| Aves      | *Turdus merula azorensis*        | azo    | 300       | 1403       | 912             | 23             | 1              |
| Mammalia  | *Mustela nivalis*                | int    | 14        | 1          | 13              | 2              | 0              |
The species with the highest number of records were the Azores Woodpigeon - *Columba palumbus azorica* (53,752), the black rat - *Rattus rattus* (40,756) and the Madeira lizard - *Teira dugesii* (24,074). In the case of the Azores Woodpigeon, the high number of records was due to the fact that adults remain in the nests for long periods, causing many camera captures.

Green frog - *Pelophylax perezi*, the European quail - *Coturnix coturnix*, Azorean buzzard-*Buteo buteo rothschildi*, Atlantic yellow-legged gull - *Larus michaellis atlantis*, common

| Class      | Species                                         | Status | TER_13-15 | PIC-TER_18 | Vineyards_15-17 | Calonectris_16 | Columba_17-18 |
|------------|-------------------------------------------------|--------|-----------|------------|-----------------|----------------|---------------|
| Mammalia   | *Mustela furo* (Linnaeus, 1758)                  | int    | 4         | 43         | 0               | 1              | 0             |
| Mammalia   | *Felis silvestris catus* Schreber, 1775         | int    | 996       | 1042       | 41              | 10             | 30            |
| Mammalia   | *Canis lupus familiaris* Linnaeus, 1758          | int    | 150       | 64         | 1               | 0              | 0             |
| Mammalia   | *Dama dama* (Linnaeus, 1758)                    | int    | 0         | 4          | 0               | 2              | 0             |
| Mammalia   | *Mus musculus* Linnaeus, 1758                   | int    | 83        | 3037       | 63              | 2              | 0             |
| Mammalia   | *Rattus norvergicus* (Berkenhout, 1769)         | int    | 0         | 2134       | 0               | 0              | 0             |
| Mammalia   | *Rattus rattus* (Linnaeus, 1758)                | int    | 0         | 20239      | 0               | 0              | 278           |
| Mammalia   | *Oryctolagus cuniculus* (Linnaeus, 1758)        | int    | 369       | 3          | 4               | 0              | 0             |
| Mammalia   | *Erinaceus europaeus europaeus* (Linnaeus, 1758) | int    | 40        | 20         | 2               | 0              | 0             |
snipe - *Gallinago gallinago*, long-eared owl - *Asio otus* and grey wagtail - *Motacilla cinerea patriciae* were the least captured species (< 10 records).

In total, we recorded 15 indigenous (native non-endemic or endemic) and three introduced bird species (Table 1). All known amphibians, reptiles and terrestrial mammals found in Azores are introduced species (Borges et al. 2010). None of the identified species was previously unknown to the study area.

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Author contributions

LLL and XP conceived the sampling protocols. LLL and PAV conceived the data paper. LLL performed the fieldwork. LLL analysed the data; LLL led the writing of the manuscript and XP, IRA and PAV contributed to the final manuscript.

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