

Diet of the exotic Madeiran wall lizard: first insights into trophic interactions in an Atlantic seabird sanctuary

Verónica Neves¹, Dorothee Rund², Catarina J. Pinho^{3,4,5}, Raquel Vasconcelos^{3,4}, Paco Bustamante^{6,7}, Petra Quillfeldt²

¹ Marine Sciences Institute – Okeanos, University of the Azores, 9901-862 Horta, Portugal

² Department of Animal Ecology & Systematics, Justus Liebig University, Giessen, Heinrich-Buff-Ring, 35390 Giessen, Germany

³ CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, InBIO Laboratório Associado, Campus de Vairão, Universidade do Porto, 4485–661 Vairão, Portugal

⁴ BIOPOLIS Program in Genomics, Biodiversity and Land Planning, CIBIO, Campus de Vairão, 4485-661 Vairão, Portugal

⁵ Departamento de Biologia, Faculdade de Ciências da Universidade do Porto, Rua do Campo Alegre 1021/1055, 4169–007 Porto, Portugal

⁶ Littoral Environnement et Sociétés (LIENSs), UMR 7266 CNRS – La Rochelle Université, 2 rue Olympe de Gouges, 1700 La Rochelle, France

⁷ Institut Universitaire de France (IUF), 1 rue Descartes 75005 Paris, France

<http://zoobank.org/F6522916-FCAC-451A-B101-B37BDC638B03>

Corresponding author: Verónica Neves (veronica.rc.neves@uac.pt)

Academic editor: Günter Gollmann ♦ Received 10 February 2022 ♦ Accepted 3 May 2022 ♦ Published 14 June 2022

Abstract

The Madeiran wall lizard *Teira dugesii* is a relatively new species to the Azores Archipelago, where it was accidentally introduced about 150 to 200 years ago. This lacertid quickly became naturalised and now occurs in all the nine main islands of the Azores. At Praia Islet, off Graciosa Island, the Madeiran wall lizard was recently observed preying on chicks of the threatened Monteiro's storm-petrel *Hydrobates montei*. To characterise the lizards' trophic niche, we conducted a study of the diet of the Madeiran wall lizard at Praia using stable isotope analysis and next-generation sequencing. Our results indicate that the Madeiran wall lizard has a varied diet, consisting of at least 23 invertebrate taxa, 17 plant species, and occasionally, birds (two species detected, including storm-petrels). Marine derived food items were present in few samples, and it is vital to monitor the trophic interactions at Praia Islet to ensure the conservation of this threatened storm-petrel.

Key Words

Azores, conservation, Macaronesia, next-generation sequencing, Praia Islet, stable isotopes

Introduction

Invasive species can pose a risk to local wildlife as predators (Mack et al. 2000) and disrupt ecosystem dynamics, especially on islands, where ecosystems are more vulnerable to introductions (Butterfield et al. 1997). The Madeiran wall lizard *Teira dugesii* is the only land reptile occurring in the Azores Archipelago (Malkmus 1995; Borges et al. 2022), where it was introduced around 150–200 years ago (Godman 1870) by the shipping trade with the Madeira Islands.

Even though lizards and other reptiles are frequently the only terrestrial vertebrates on oceanic islands, there are few studies documenting interactions between reptiles and seabirds. The interactions between the endemic tuatara *Sphenodon punctatus* and the fairy prion *Pachyptila turtur* in Stephens Island, New Zealand, are perhaps the most studied case (e.g., Wall 1978; Cree et al. 1999). The study of Matias et al. (2009) at Selvagens Islands (Madeira, Portugal) is one of the first documented evidence of a lacertid lizard, the Madeiran wall lizard (in this

case endemic) preying on seabirds, including storm-petrels, in Macaronesia. Recently, Pinho et al. (2018) found evidence that a common prey of an endemic and Endangered lizard, the giant wall gecko *Tarentola gigas*, is also an endemic and Near Threatened seabird, the Cabo Verde shearwater *Calonectris edwardsii*, showing how intricate these trophic links can be. Also in Macaronesia, Gil et al. (2020) found evidence of a trophic link between the Selvagens gecko *Tarentola (boettgeri) bischoffi* and Cory's shearwater *Calonectris borealis*.

Ground-breeding seabirds often nest exclusively on small islands, which are probably selected because of a lack of predators (Schreiber and Burger 2001); that is the case for the small Hydrobatidae species breeding in the Azores (Monteiro et al. 1999), such as the endemic Monteiro's storm-petrel, only known to breed in the islets off Graciosa Island (Bolton et al. 2008). Bried and Neves (2014) reported Madeiran wall lizard scavenging dead Monteiro's storm-petrel *Hydrobates monteiroi* chicks on Praia Islet from Graciosa in the Azores. More recently, the killing of Monteiro's storm-petrel chicks by those lizards was confirmed (Neves et al. 2017). This small seabird is classified as globally Vulnerable to extinction on the IUCN Red List (BirdLife International 2018). On those grounds, the lizard predation events detected are a cause of concern and, to our knowledge, are the first documented evidence of an introduced lacertid affecting seabirds.

This study aims to investigate the diet of Madeiran wall lizards at Praia Islet as a first step towards effectively protecting the endemic Monteiro's storm-petrel. To assess the lizards' trophic niche, we studied their diet using Stable Isotopes (SI) in blood and next-generation sequencing in faeces. Stable isotopes analyses provide information on the trophic position and diet (Kartizinel and Pringle 2015) and next-generation sequencing identifies the prey items (Pompanon et al. 2012). Stable isotopes can also provide a time-integrated depiction of consumer diet and trophic relationships (Phillips and Eldridge 2006).

Methods

Praia Islet is located about 1.2 km off Graciosa Island, one of the nine main islands of the Azores Archipelago (Fig. 1) and is a breeding site for several seabird species, including three Charadriiforms and five Procellariiforms – two species are winter breeders (Barolo Shearwater, *Puffinus lherminieri* and Band-rumped storm-petrel, *Hydrobates castro*) and all the others breed during the summer (Monteiro et al. 1999; Bolton et al. 2008). The islet is a natural reserve and Graciosa is classified by UNESCO as a Biosphere Reserve (UNESCO 2007). Fieldwork took place from May to July 2016, coinciding with the breeding season of most seabirds that breed in the islet (Cory's Shearwater, *Calonectris borealis*; Monteiro's storm-petrel, *H. monteiroi*, Bulwer's petrel, *Bulweria bulwerii*; Common tern, *Sterna hirundo*; Roseate tern, *S. dougallii* and Sooty tern, *Onychoprion fuscatus*). Lizards were caught by hand

or in traps made from 5-litre plastic containers baited with pieces of fresh fruit. Samples for SI analysis were collected in two different areas, approximately 200 m apart to try to minimise the resampling of individuals across sampling areas. One area was around the support house on the west side of the islet (Fig. 1), which was defined as the area with a low density of nesting birds. The other area was on the east side of the islet around an area with 58 artificial nests of Monteiro's storm-petrel (Fig. 1). Sample analysis was divided into two periods: 31 May–8 June, corresponding to the incubation stage of Monteiro's storm-petrels and 3–16 July, corresponding to the chick-rearing stage (Bolton et al. 2008).

Caught lizards were brought to the support house, measured (snout–vent length, SVL) and weighed. Faecal samples were collected by gentle palpation of the abdomen and stored in 70% ethanol. A blood sample (5–10 µL) was drawn with a sterile insulin syringe (0.33 × 12.7 mm, 29G) from the caudal vein (see Divers and Mader 2005) and stored in 70% ethanol. The base of the tail was disinfected using cotton dampened in 90% ethanol. After the procedure, which took approximately 10 minutes, the lizards were released where they were captured.

To provide an isotopic baseline of the food resources, we also sampled 18 food items for SI analysis: six arthropods and two plant species as terrestrial food, as well as blood from 10 Monteiro's storm-petrel chicks as marine-derived food. Blood samples were briefly centrifuged, supernatant (i.e., plasma) was discarded, and the Eppendorf tubes were put into a drying chamber to evaporate the water content of the blood cells. The dried samples were then pulverized using a mortar and pestle to obtain a fine powder, and a subsample of 0.35–0.45 mg was weighed into tin capsules. Some samples were slightly lighter if there was not sufficient blood, but no less than 0.12 mg. Stable isotope ratio for carbon and nitrogen was determined with an Isotope Ratio Mass Spectrometer at the University of La Rochelle, LIENSs SI Facility. Carbon and nitrogen ratios were determined with a continuous-flow mass spectrometer (Delta V Advantage or Delta V Plus with a ConFlo IV interface, Thermo Scientific, Bremen, Germany) coupled with an elemental analyser (Flash EA 1112 or Flash 2000, Thermo Scientific, Milan, Italy). Measurements of internal laboratory standards were conducted using acetanilide (Thermo Scientific) and peptone (Sigma-Aldrich) and indicated an experimental precision of ± 0.15‰ for both elements. Results are expressed in parts per thousand (‰), in the usual δ notation relative to Vienna Pee-Dee Belemnite for $\delta^{13}\text{C}$ and atmospheric N_2 for $\delta^{15}\text{N}$, following the formula: $\delta^{13}\text{C}$ or $\delta^{15}\text{N} = [(R_{\text{sample}}/R_{\text{standard}}) - 1] \times 1000$, where R is $^{13}\text{C}/^{12}\text{C}$ or $^{15}\text{N}/^{14}\text{N}$, respectively. Differences in the mean $\delta^{13}\text{C}$ in the different habitats before and after the hatching of the chicks were analysed using Wilcoxon rank sum test with continuity correction because the data were not normally distributed (R v3.3.2, R Core Team 2016). Significance was assumed at $P < 0.05$.

Faecal samples were dried in an incubator at 50 °C to remove the ethanol. The DNA was extracted using the

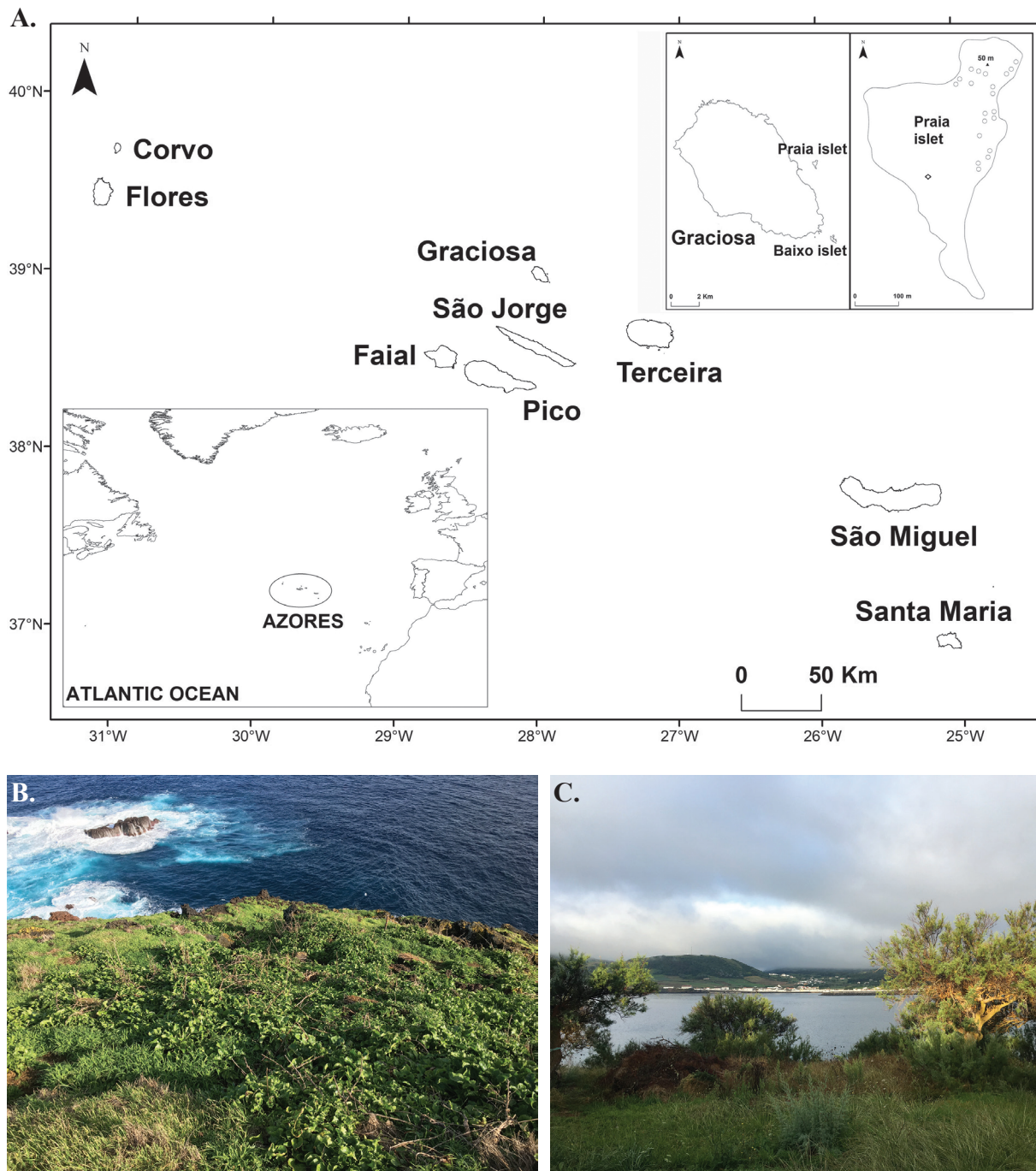


Figure 1. A. Location of Praia Islet in the Azores Archipelago. Squares marked in the east and north-east of the islet indicate the location of artificial nests of Monteiro’s storm-petrel, *Hydrobates montei*; the diamond symbol in the west of the islet indicates the location of the house. Adapted from Bried and Neves (2014); B. Study area - location ‘Nests’; C. Study area - location ‘House’.

Stool DNA Isolation Kit (Norgen Biotek Corp., Canada), following the manufacturer’s instructions. In the end, two DNA elutions were obtained with a final volume of 50 μ L each, but only the first elution was used for the next steps. To correctly identify the different prey types (vertebrates, invertebrates, and plants) three different DNA fragments were selected for amplification. For vertebrates, the V5-loop fragment of the mitochondrial 12S gene (Suppl. material 1: Table S1) was selected. The marker selected for invertebrates was the mitochondrial

16S rRNA (Suppl. material 1: Table S1) and for plants the short P6-loop of chloroplast trnL (UAA) intron (Suppl. material 1: Table S1). To allow the individual identification of each sample, all primers were modified with an individual barcode as detailed in Pinho et al. (2018). Each PCR was performed following the same protocol as detailed in Pinho et al. (2018) and the product was tested on a 2% agarose gel.

Library preparation was carried out following Illumina MiSeq protocol “16S Metagenomic Sequencing Library

Preparation” (Illumina 2013) according to the method described in Pinho et al. (2018). OBITools (<https://git.metabarcoding.org/obitools/obitools>) was used for general sequence processing according to the methods described in Pinho et al. (2018). Results were compared with Azores databases (Borges et al. 2022) and the Encyclopedia of Life database (<http://eol.org>). We removed a few haplotypes that were considered lab contamination based on published reference lists of species occurring in Azores. When the same haplotype matched more than one species or genera with similar probabilities, we only considered species or genus known to occur at Graciosa, or in other islands of the Azores.

Results

We collected and analysed for SIs 57 Madeiran wall lizard blood samples; mean values and standard deviation for carbon and nitrogen isotopes for the different sampling locations and times are given in Table 1. The food reference material collected on the islet showed clear differences in carbon isotope ratios between terrestrial and marine items with lower $\delta^{13}\text{C}$ values for terrestrial items (Table 2), but an overlap in nitrogen isotope ratios. During the incubation period, values of $\delta^{13}\text{C}$ isotopes were slightly high-

Table 1. Results of the isotopic analyses from lizard blood samples. Sample size (n), stable carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope ratios (mean \pm standard error in permillage, ‰) for the different sampling locations and periods. Check Fig. 1 for sample locations.

Location_period	n	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)
House_incubation	16	-24.53 ± 0.12	12.63 ± 0.12
House_chick-rearing	13	-24.27 ± 0.07	12.90 ± 0.23
Nests_incubation	12	-24.14 ± 0.27	11.46 ± 0.25
Nests_chick-rearing	16	-23.11 ± 0.41	12.03 ± 0.17

er in the location ‘Nests’ than in the location ‘House’ but the difference was not significant (Wilcoxon rank sum test with continuity correction, $W = 120.5$, $P = 0.265$; $n_{\text{house}} = 16$, $n_{\text{nests}} = 12$). During the chick-rearing period, values of $\delta^{13}\text{C}$ isotopes were again higher in the location ‘Nests’ and there was no significant difference between locations ($W = 135$, $P = 0.181$; $n_{\text{house}} = 13$, $n_{\text{nests}} = 16$). $\delta^{13}\text{C}$ isotope values were higher during chick-rearing for the sampling location ‘Nests’, but also not significant ($W = 61$, $P = 0.109$; $n_{\text{house}} = 12$, $n_{\text{nests}} = 16$). Around the ‘Nests’ site, there was also a much greater variance in the stable carbon isotope values (Table 1, Fig. 2). Some individuals ($n = 5$) from this study area reached as high a carbon value as the Monteiro’s storm petrel chicks – stable carbon isotope values between -21.49 and -20.10 ‰. The arthropod samples collected at the islet show an enrichment in $\delta^{13}\text{C}$ values compared to plants (Table 2), but the values were still lower than the ones found for Monteiro’s storm-petrel chicks, giving support to the hypothesis that some lizards may be feeding on seabirds.

Out of the nine faecal samples analysed, only seven worked for most markers used and two samples failed to be sequenced. In total, 43 molecular operational taxonomic units (MOTU) were identified: 17 plants, 23 invertebrates

Table 2. Results of the isotopic analyses from reference food items samples. Stable carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope ratios (mean \pm standard error in permillage, ‰) for reference food resources. Terrestrial items include two plant and six arthropod species, and the marine items consist of blood samples from Monteiro’s storm-petrel chicks.

Food items	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)
Terrestrial	-24.71 ± 0.63	9.62 ± 1.19
Plants	-26.94 ± 0.42	12.74 ± 2.92
Arthropods	-23.97 ± 0.53	8.58 ± 1.09
Marine	-20.23 ± 0.06	11.08 ± 0.07



Figure 2. A. Monteiro’s storm-petrel *Hydrobates monteiroi* in an artificial nest at Praia Islet with a recently hatched chick and remnants of eggshell; B. Madeiran wall lizard *Teira dugesii* eating a chick of Monteiro’s storm-petrel in an artificial nest at Praia Islet.

and 3 vertebrates (Suppl. material 2: Table S2 and Suppl. material 3: Dataset S1). Most faecal samples included invertebrates and/ or plants (seven and six out of seven, respectively), and some of them were composed of only one of these groups. Three out of the seven samples contained vertebrate remnants. The vertebrates matched two birds that breed at Praia Islet, the rock pigeon *Columba livia* and *Hydrobates castro*, which most likely corresponds to *H. monteiroi* considering the small fragment size, the recent taxonomic split and phylogenetic proximity, and the absence of 12S sequences of the latter in public databases. It also included the Madeiran wall lizard itself, indicating a potential failure of the blocking primer, cannibalism or scavenging.

Discussion

Our study indicates that the values for stable carbon isotopes are higher in lizards caught around nest sites than in those caught around the support house, suggesting a possible higher reliance on marine-derived items in the diet of lizards caught in proximity to breeding seabirds. The marine-derived items on the lizards' diet can include remains of hatched eggs (eggshell or membrane), prey dropped in the colony by terns and/ or seabirds (resulting from either scavenging or predation). There was also a higher marker for marine items after the hatching of the chicks than during incubation around the nests, as indicated by the higher carbon isotope levels. Although not significant, this difference is higher than the difference between the two study areas. However, this analysis does not allow distinguishing between marine items consumed and that could have been seabirds in the form of eggs (either whole or remains of eggshell and membrane after hatching), chicks, dead birds, faeces or dropped fish and regurgitate.

The SI analysis also revealed one individual with a stable carbon isotope ratio almost as high as was found in the chicks a month before the hatching started, an indication that marine food sources, other than Monteiro's storm-petrel chicks, are available. These can probably be attributed to Macaronesian shearwater and band-rumped storm-petrel, species that breed during the winter period. In general, there was a wider variance in the stable carbon ratios for the lizards at the nests which indicates that some individuals specialise more in terrestrial food and some more in marine food. Previous studies on lizards and SIs have shown that soil lithology may affect the values of stable carbon isotopes (Martín et al. 2017), but in our case the study islet is small and there is no variation in soil type.

The faecal sample analysis using metabarcoding indicated that these lizards are highly reliant on invertebrates and plants as was found for this species at Selvagens Islands (Sadek 1981; Gil et al. 2020). In addition, that analysis provided a good complement to the SI results and confirmed the presence of seabirds in the diet of Madeiran wall lizards. During fieldwork, we could confirm the deaths of three Monteiro's storm-petrel chicks in

the nesting area. Two chicks showed no injuries and the third one was dragged to the nest's entrance and lizards were eating from it, but it is unclear if the bite marks were the cause of death or if the lizards were only taking advantage of the carcass. The next-generation sequencing also showed the presence of seabirds, but we could not confirm if that resulted from scavenging or predation.

It is important to consider that Praia Islet only holds an estimated 150–183 pairs of Monteiro's storm-petrel (Monteiro et al. 1999; Oliveira et al. 2016). The restricted distribution and small breeding numbers of this endemic species make it much less resilient to any impact factors, such as putative predation by lizards. Recently, Lopes et al. (2019) found evidence that the main prey of an endemic and Endangered lizard, the Cabo Verde giant wall gecko *Tarentola gigas*, is the endemic and Critically Endangered bird Raso lark *Alauda razae*, confirming the importance of monitoring the impact of these trophic interactions, even when considering endemic species, especially during drought years when the population of Raso lark can be severely reduced (Lopes et al. 2019).

This study provides a first step towards understanding the trophic links at one of the main seabird sanctuaries in the Azores. Our results also confirm the potential of next-generation sequencing to further our understanding of the lizard/ storm-petrel trophic interactions. Marine-derived food items are not ubiquitous in a lizard's diet and to assess lizards' impact on the breeding success of Monteiro's storm-petrel it would be necessary to increase the sample size and to sample in different seasons. Further studies should also attempt to use wildlife cameras on the nests to study the interactions between lizards and storm-petrels and clarify if the presence of marine items in the diet of the Madeiran wall lizard result from direct predation of viable eggs and nestlings or from scavenging of chicks that died for other reasons or remains of the membrane from hatched eggs.

Acknowledgements

This study was conducted under permit from the Azores Government – Regional Environmental Directorate #27/2016/DRA. Funding came from the Portuguese “Fundação para a Ciência e a Tecnologia”, I.P. (FCT) and FRCT through grants to VN (SFRH/BPD/88914/2012 and FRCT/M3.1.a/F/072/2016) and national funds under the scope of ‘norma transitória’ to RV (DL57/2016/CP1440/CT0002). VN was co-financed by the Operational Program AZORES 2020, through the Fund 01-0145-FED-ER-000140 “MarAZ Researchers: consolidate a body of researchers in Marine Sciences in the Azores” of the European Union. CJP (SFRH/BD/145851/2019) was supported by a PhD grant funded by FCT, financed by the European Social Fund and the Human Potential Operational Programme, POPH/FSE. This work received national funds through the FCT under the project

UIDB/05634/2020 and UIDP/05634/2020 and through the Azores Government through the initiative to support the Research Centers of the University of the Azores and the project M1.1.A/REEQ.CIENTÍFICO UI&D/2021/010. The IUF (France) is acknowledged for its support to PB. We are grateful to G. Guillou from the “Plateforme Analyses Isotopiques” of LIENSs for running SI analysis. We thank Stefanie Klemm for help with the fieldwork and the team of Graciosa Natural Park for transport to the islet and logistic support. Finally, we express our gratitude to R. Medeiros for help with Fig. 1A and to K. Jones for help with English language editing, as well as to the editor, the layout editor and two anonymous reviewers for improving the manuscript.

References

- BirdLife International (2018) *Hydrobates montei*. The IUCN Red List of Threatened Species 2018: e.T22735624A132665118. <https://doi.org/10.2305/IUCN.UK.2018-2.RLTS.T22735624A132665118.en> [Downloaded on 27 October 2021]
- Bolton M, Smith AL, Gómez-Díaz E, Friesen VL, Medeiros R, Bried J, Furness RW (2008) Monteiro's Storm-petrel *Oceanodroma montei*: a new species from the Azores. *Ibis* 150: 717–727. <https://doi.org/10.1111/j.1474-919X.2008.00854.x>
- Borges PAV, Costa A, Cunha R, Gabriel R, Gonçalves V, Martins R, Silva AF, Vieira V [Eds] (2010) A list of the Terrestrial and Marine Biota from the Azores. Princípi, Oeiras.
- Borges PAV, Gabriel R, Arroz AM, Costa A, Cunha R, Silva L, Mendonça E, Martins AF, Reis F, Cardoso P (2022) Azorean Biodiversity Portal. Version 1.0. Universidade dos Açores. Occurrence dataset. <https://doi.org/10.15468/j0iceo> [accessed via GBIF.org on 2022-01-20]
- Bried J, Neves V (2014) Habitat restoration on Praia islet, Azores archipelago, proved successful for seabirds, but new threats have emerged. *Airo* 23: 25–35. <http://www.jstor.org/stable/43441234>
- Butterfield P, Meshaka WEJR, Guyer C (1997) Non-indigenous amphibians and reptiles. In: Simberloff D, Schmitz DC, Brown TC (Eds) *Strangers in Paradise: Impact and Management of Non-indigenous Species in Florida*. Island Press, United States, 123–137.
- Cree A, Lyon GL, Cartland-Shaw L, Tyrrell C (1999) Stable carbon isotope ratios as indicators of marine versus terrestrial inputs to the diets of wild and captive tuatara (*Sphenodon punctatus*). *New Zealand Journal Zoology* 26: 243–253. <https://doi.org/10.1080/03014223.1999.9518193>
- Divers SJ, Mader DR [Eds] (2005) *Reptile Medicine and Surgery*. Elsevier Health Sciences, UK, 1264 pp.
- Gil V, Pinho CJ, Aguiar CA, Jardim C, Rebelo R, Vasconcelos R (2020) Questioning the proverb ‘more haste, less speed’: classic versus metabarcoding approaches for the diet study of a remote island endemic gecko. *PeerJ* 8: e8084. <https://doi.org/10.7717/peerj.8084>
- Godman F (1870) *Natural History of the Azores*. John Van Voorst, UK, 358 pp.
- Kartzinel TR, Pringle RM (2015) Molecular detection of invertebrate prey in vertebrate diets: trophic ecology of Caribbean island lizards. *Molecular Ecology Resources* 15: 903–914. <https://doi.org/10.1111/1755-0998.12366>
- Lopes RJ, Pinho CJ, Santos B, Seguro M, Mata VA, Egeter B, Vasconcelos R (2019) Intricate trophic links between threatened vertebrates confined to a small island in the Atlantic Ocean. *Ecology and Evolution* 9: 4994–5002. <https://doi.org/10.1002/ece3.5105>
- Mack RN, Simberloff D, Lonsdale Evans H, Clout M, Bazzaz FA (2000) Biotic invasions: causes, epidemiology, global consequences, and control. *Ecological Applications* 10: 689–710. [https://doi.org/10.1890/1051-0761\(2000\)010\[0689:BICEGC\]2.0.CO;2](https://doi.org/10.1890/1051-0761(2000)010[0689:BICEGC]2.0.CO;2)
- Malkmus R (1995) *Die Amphibien und Reptilien Portugals, Madeiras und der Azoren*. Verlags KG, Germany. <https://doi.org/10.1163/156853898X00269>
- Mata VA, Amorim F, Corley MF, McCracken GF, Rebelo H, Beja P (2016) Female dietary bias towards large migratory moths in the European free-tailed bat (*Tadarida teniotis*). *Biology Letters* 12: e20150988. <https://doi.org/10.1098/rsbl.2015.0988>
- Matias R, Rebelo R, Granadeiro JP, Catry P (2009) Predation by Madeiran wall lizards *Teira dugesii* on Cory's shearwater *Calonectris diomedea* hatchlings at Selvagem Grande, North Atlantic. *Waterbirds* 32(4): 600–603. <https://doi.org/10.1675/063.032.0415>
- Monteiro LR, Ramos J, Pereira JC, Monteiro PR, Feio RS, Thompson DR, Bearhop S, Furness RW, Laranjo M, Hilton G, Neves VC, Groz MP, Thompson KR (1999) Status and distribution of Fea's Petrel, Bulwer's Petrel, Manx Shearwater, Little Shearwater and Band-rumped Storm-petrel in the Azores Archipelago. *Waterbirds* 22: 358–366. <https://doi.org/10.2307/1522111>
- Neves VC, Nava C, Monteiro EV, Monteiro PR, Bried J (2017) Depredation of Monteiro's storm-petrel (*Hydrobates montei*) chicks by Madeiran wall lizards (*Lacerta dugesii*). *Waterbirds* 40: 82–86. <https://doi.org/10.1675/063.040.0113>
- Oliveira N, Pipa T, Silva C, Teodósio J, Andrade J (2016) Final Report of the Monteiro's Storm-petrel Project (phase 1). Sociedade Portuguesa para o Estudo das Aves, Lisboa (unpublished report).
- Pinho C, Santos B, Mata V, Seguro M, Romeiras M, Lopes R, Vasconcelos R (2018) What is the giant wall gecko having for dinner? Conservation Genetics for Guiding Reserve Management in Cabo Verde. *Genes* 9: e599. <https://doi.org/10.3390/genes9120599>
- Phillips DL, Eldridge PM (2006) Estimating the timing of diet shifts using stable isotopes. *Oecologia* 147: 195–203. <https://doi.org/10.1007/s00442-005-0292-0>
- Pompanon F, Deagle BE, Symondson WO, Brown DS, Jarman SN, Taberlet P (2012) Who is eating what: diet assessment using next-generation sequencing. *Molecular Ecology* 21: 1931–1950. <https://doi.org/10.1111/j.1365-294X.2011.05403.x>
- R Core Team (2016) *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing.
- Sadek RA (1981) The diet of the Madeiran lizard *Lacerta dugesii*. *Zoological Journal of the Linnean Society* 73: 313–341. <https://doi.org/10.1111/j.1096-3642.1981.tb01599.x>
- Schreiber EA, Burger J [Eds] (2001) *Biology of Marine Birds*. CRC Press, United States, 740 pp. <https://doi.org/10.1201/9781420036305>
- UNESCO (2007) Biosphere Reserve Information – Portugal – Graciosa Island [Online]. <https://en.unesco.org/biosphere/eu-na/graciosa-island> [Accessed 15 October 2021]
- Walls GY (1978) The influence of the tuatara on fairy prion breeding on Stephens Island, Cook Strait. *New Zealand Journal Ecology* 1: 91–98.

Supplementary material 1

Table S1: Forward and reverse primers used in this study. The amplified region, the fragment length (in base pairs, bp), the sequences, and the reference for each primer set is given

Authors: Verónica Neves, Dorothee Rund, Catarina J. Pinho,
Raquel Vasconcelos, Paco Bustamante, Petra Quillfeldt
Data type: Word file

Explanation note: This table is referred to in the Methods section and specifies the DNA markers selected for amplification to identify prey types.

Copyright notice: This dataset is made available under the Open Database License (<http://opendatacommons.org/licenses/odbl/1.0/>). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: <https://doi.org/10.3897/herpetozoa.35.e82096.suppl1>

Supplementary material 2

Table S2: Results of the metabarcoding analyses. List of Operational Taxonomic Units (OTUs) sequenced from the faecal pellets of Madeiran wall lizard for the different taxonomic groups and the incidence (n) of the identified taxa

Authors: Verónica Neves, Dorothee Rund, Catarina J. Pinho,
Raquel Vasconcelos, Paco Bustamante, Petra Quillfeldt
Data type: Word file

Explanation note: This table is referred to in the results section and lists all the prey items identified through next-generation sequencing of Madeiran wall lizard faeces.

Copyright notice: This dataset is made available under the Open Database License (<http://opendatacommons.org/licenses/odbl/1.0/>). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: <https://doi.org/10.3897/herpetozoa.35.e82096.suppl2>

Supplementary material 3

Dataset S1: Taxonomic identification of the haplotypes sequenced for the three taxonomic groups (plants, invertebrates and vertebrates). Code, sequence, length, amplification primer, number of reads, incidence, taxonomic identification (final, at species, family, order and class level), and percentage of match in blast is given for each haplotype

Authors: Verónica Neves, Dorothee Rund, Catarina J. Pinho,
Raquel Vasconcelos, Paco Bustamante, Petra Quillfeldt
Data type: Excel file

Explanation note: This table is referred to in the Results section and contains the taxonomic identification of the haplotypes sequenced for the three taxonomic groups (plants, invertebrates and vertebrates), namely: ID, code, sequence, sequence length, amplification primer, incidence (number of reads, number of samples), taxonomic identification (final, at species, family, order and class level), and percentage of match in blast is given for each haplotype.

Copyright notice: This dataset is made available under the Open Database License (<http://opendatacommons.org/licenses/odbl/1.0/>). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: <https://doi.org/10.3897/herpetozoa.35.e82096.suppl3>

ZOBODAT - www.zobodat.at

Zoologisch-Botanische Datenbank/Zoological-Botanical Database

Digitale Literatur/Digital Literature

Zeitschrift/Journal: [Herpetozoa](#)

Jahr/Year: 2022

Band/Volume: [35](#)

Autor(en)/Author(s): Neves Verónica, Rund Dorothee, Pinho Caterina, Vasconcelos Raquel, Bustamante Paco, Quillfeldt Petra

Artikel/Article: [Diet of the exotic Madeiran wall lizard: first insights into trophic interactions in an Atlantic seabird sanctuary 107-113](#)