Mar Biodiv (2019) 49:531–537
DOI 10.1007/s12526-017-0798-9

SENCKENBERG CrossMark

SHORT COMMUNICATION

Scopoli's shearwater, *Calonectris diomedea*, in the southwest Atlantic Ocean

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Received: 3 August 2016 / Revised: 15 August 2017 / Accepted: 15 September 2017 / Published online: 3 October 2017
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Abstract Knowledge of marine biodiversity has been increased by combining modern and traditional tools that render species identification an accurate process. In addition, understanding the ecological differences between closely related species is critical for effective conservation. *Calonectris* (Aves: Procellariidae) is a four-species genus of phenotypically similar pelagic seabirds; three of the four species inhabit the Atlantic Ocean. However, this taxonomic splitting has not been completely recognised in the New World, hindering our understanding of species-specific nonbreeding distributions because of misidentification in nonbreeding areas. Here, we have presented the first Scopoli's shearwater, *Calonectris diomedea*, in the southwest Atlantic Ocean by using morphometrics, stable isotope analyses, and bill and plumage colouring. Although the southwest Atlantic Ocean is a common nonbreeding area for the sister species, Cory's shearwater, *Calonectris borealis*, and Cape Verde shearwater, *Calonectris edwardsii*, it has been considered a potential nonbreeding area for Scopoli's shearwater. This study contributes to the separation of Cory's shearwater from Scopoli's shearwater and provides a record of the latter in the southwestern Atlantic Ocean, thus contributing to a better understanding of the nonbreeding range of Scopoli's shearwater in the New World.

Communicated by P. Martinez Arbizu

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Keywords *Calonectris borealis* · Cory's shearwater · Morphometrics · Procellariiformes · Seabirds · Stable isotopes

Introduction

Calonectris shearwaters are pelagic seabirds that breed in the Northern Hemisphere (Harrison 1985). Traditionally, two allopatric species have been recognised: the streaked shearwater, *Calonectris leucomelas*, which breeds in the western Pacific Ocean, and Cory's shearwater *Calonectris diomedea* (lato sensu) breeding on the northeast Atlantic Ocean and Mediterranean Sea (Harrison 1985). However, there are taxonomic issues regarding the split of Scopoli's *C. diomedea*, Cory's *Calonectris borealis*, and Cape Verde *Calonectris edwardsii*, shearwaters, which until recently were considered subspecies of *C. diomedea*. The Cape Verde shearwater is an endemic species of the Cape Verde archipelago and was the first to be recognised as a valid species (Howell and Patteson 2008). The other two species breed in adjacent regions: Scopoli's shearwater nests mainly across the Mediterranean Islands, from Spain to Turkey, and Cory's shearwater nests mainly on islands of the Atlantic Ocean, such as Berlengas, Azores, Madeira, Salvages, and Canaries, as well as in the west Mediterranean on the Chafarinas Islands (Gómez-Díaz and González-Solís 2007). Furthermore, differences in plumage (Gutiérrez 1998; Howell 2012), morphology (Gómez-Díaz and González-Solís 2007), vocalization (Robb et al. 2008), genetics (Gómez-Díaz et al. 2006, 2009; Sangster et al. 2012), flight behaviour (Gutiérrez 1998; Fisher and Flood 2010), and nonbreeding areas (González-Solís et al. 2007) have been demonstrated between Scopoli's and Cory's shearwaters, enhancing the split based on biological and ecological aspects (Gómez-Díaz et al. 2006).

The three-species taxonomic arrangement of the Atlantic and Mediterranean forms is currently recognised by the British Ornithological Committee (Sangster et al. 2012), but it is still not accepted by the South American Classification Committee (SACC; Remsen-Jr. et al. 2016) and North American Classification Committee (NACC; American Ornithologists' Union 1998). In fact, SACC and NACC only recognise Cape Verde *C. edwardsii* shearwater and Cory's shearwater, with the latter including both *C. borealis* and *C. diomedea*. Thus, separation of Scopoli's and Cory's shearwaters has not been emphasised, and Scopoli's shearwater almost certainly has been overlooked in the New World. Nonetheless, the recently published Brazilian checklist already recognises "Cory's split" with Cory's shearwater *C. borealis* listed as the common form (as a northern visitor) and Scopoli's shearwater as an unrecorded form in Brazil (Piacentini et al. 2015). To avoid confusion, we hereafter consider *C. borealis* as Cory's shearwater, *C. diomedea* as Scopoli's shearwater, and *C. edwardsii* as Cape Verde shearwater, according to the British Ornithological Committee (Sangster et al. 2012).

Currently, a few features are available for the taxonomic classification of seabird species, allowing the correct identification of the three *Calonectris* shearwaters. First, Cory's/Scopoli's shearwaters have a much paler plumage and a pale yellow bill, whereas the Cape Verde shearwater has darker plumage and fleshy to greyish bill with a dark subterminal mark (Onley and Scofield 2007). Second, Cory's shearwater is the largest species; it is 7.2% and 31.1% larger, on average, than Scopoli's shearwater and Cape Verde shearwater, respectively (Gómez-Díaz and González-Solís 2007). Gómez-Díaz and González-Solís (2007) proposed a longitudinal phenotypic gradient including both Cory's and Scopoli's shearwaters in the Mediterranean; the body size tends to increase towards the western colonies. Male *Calonectris* species have larger body sizes than females, which may contribute to species identification based on body size once the gender is determined. Finally, Scopoli's shearwaters have a peculiar whitish mark at the base of the outer primaries, commonly referred to as underwing "tongues" in the literature. They are whitish projections into the dark wingtip, located at the largest vane and that extend beyond the greater primary coverts (Howell and Patteson 2008; Howell 2012). In Cory's shearwaters, the "tongue" is absent or very short. In the present study, we identified, to our knowledge, the first Scopoli's shearwater specimen obtained from the southwest Atlantic Ocean, based on morphometrics and colour features and confirmed using stable isotope data.

Methods

In March 2013, during a regular monthly beach monitoring in the southernmost region of the Brazilian coast (Fig. 1), we collected the carcass of a remarkably small *Calonectris* shearwater. The specimen was prepared and added to the Bird Collection of the Universidade Federal do Rio Grande-FURG (*Coleção de Aves da FURG*) under the code CAFURG 626. During the skin preparation, morphometrics were recorded: unflattened wing chord, head length (bill tip to the posterior ridge formed by the parietal-supraoccipital junction), bill depth at the nostrils, bill depth at the unguis, minimum bill depth, and total culmen (exposed culmen). We obtained the same morphometrics from all Cory's (n = 8) and Cape Verde (n = 1; CAFURG 693) shearwaters available in CAFURG, thus avoiding potential measurement errors between studies; we also compared the morphometrics of the three species with those recorded by Gómez-Díaz and González-Solís (2007). All measurements were performed by the same person (GTN). We extracted DNA from a webbed-feet sample by using the NaCl protocol (Medrano et al. 1990) and determined the sex of CAFURG 626 by amplifying the CHD genes, according to the method described by Griffiths et al. (1998).

In addition, we compared bill colours and classified the outer primaries of all the aforementioned specimens on the basis of the scheme proposed by Howell and Patteson (2008): score 1, all primaries dark (presumed Cory's shearwater); score 2, presence of a short whitish "tongue" on P10 only (presumed Cory's shearwater); score 3, a whitish "tongue" on P9, with other primaries dark (presumed Cory's shearwater); score 4, whitish to white "tongue" on 2–3 primaries among P8–P10 (presumed Cory's or Scopoli's shearwater); and score 5, distinct white "tongue" on 3 or more outer primaries, including P10 (presumed Scopoli's shearwater). Feathers were classified using a triple blind-scoring procedure by the authors (GO, GTN, and FPM) to avoid biased observations. Although this method is based on subjective traits and assessments, it can possibly aid in the identification process when combined with additional tools.

Although moult analysis does not aid specimen identification, knowledge of the moult timing and migratory movements may provide valuable information on spatial distribution when measuring stable isotopes from feathers (McMahon et al. 2013). CAFURG 626 was moulting contour feathers and the innermost rectrix (R1, just emerging from the sheath) and was thus identified as a subadult/adult (Alonso et al. 2009). Since *Calonectris* shearwaters undergo a "simple-basic" moult and breeders start the primary moult towards the end of the breeding season while on the breeding grounds, the isotopic composition of the inner primaries reflects the prey items ingested in the foraging areas around the colonies, so that measuring stable isotopes from the primaries may provide information on the source population when compared with a database. Therefore, we measured δ^{13}C and δ^{15}N stable isotopes in the left-wing primaries P1, P3, P5, P7, and P10 of the supposed Scopoli's shearwater. Briefly, the feathers were

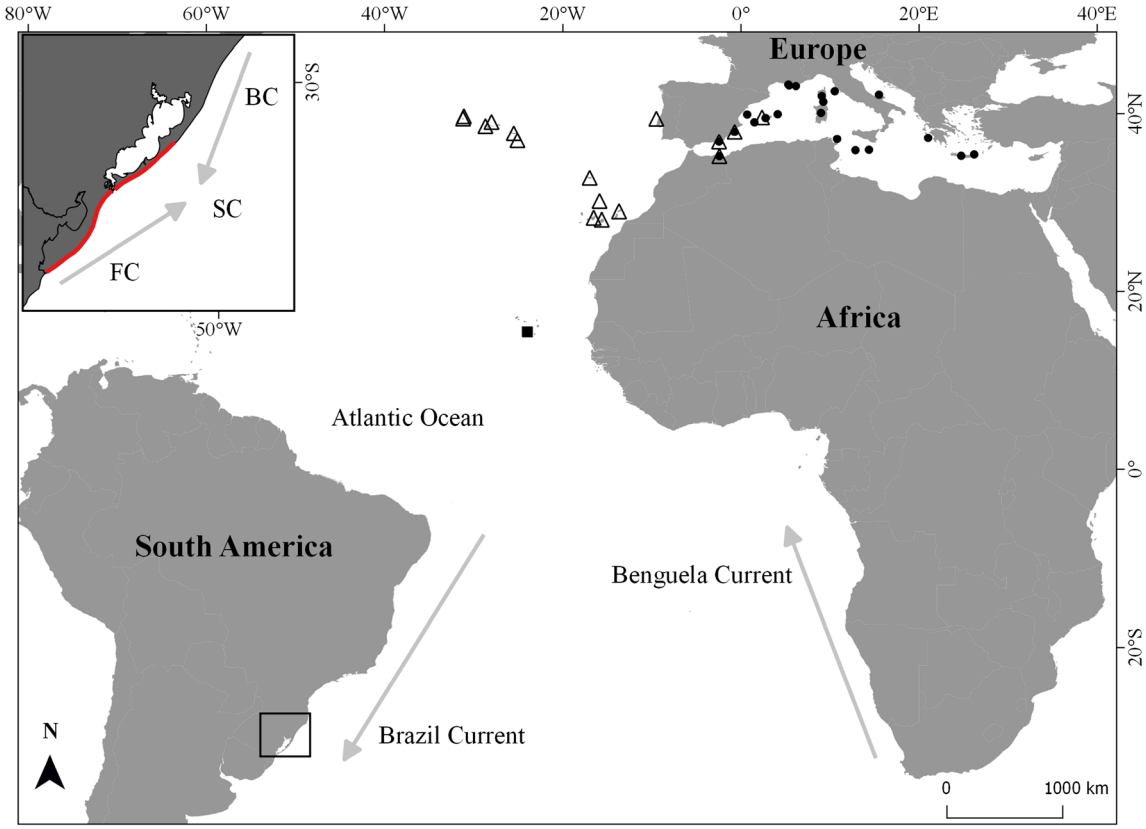

Fig. 1 Schematic map of the major southern Atlantic Ocean Currents and *Calonectris* shearwater colonies in the North Atlantic and Mediterranean Sea: open triangles for Cory's shearwater, *C. borealis*; closed square for Cape Verde shearwater, *C. edwardsii*; and closed circles for Scopoli's shearwater, *C. diomedea*. In detail, the red line refers to the routinely monitored beach where the Scopoli's shearwater specimen was found in southern Brazil, and arrows refer to the local oceanographic dynamics in the southwestern Atlantic Ocean (BC = Brazil Current; FC = Falklands Current; SC = Subtropical Convergence)

rinsed with 0.25 M NaOH solution and then rinsed with distilled water, oven-dried, cut into small fragments with scissors, and 0.7 mg of the fragments was placed in tin capsules and analysed using isotope ratio mass spectrometry at Washington State University, USA. Stable isotopes from the three forms sampled on the colonies had been previously measured and used for population and species assignment (Gómez-Díaz and González-Solís 2007), allowing effective comparison.

Fig. 2 Shearwaters deposited in the Bird Collection of the Universidade Federal do Rio Grande-FURG (CAFURG) (Bugoni et al. 2008a). From top to bottom: Cory's shearwater, *Calonectris borealis* (CAFURG 652); Scopoli's shearwater, *C. diomedea* (CAFURG 626); and Cape Verde shearwater, *C. edwardsii* (CAFURG 693)

Fig. 3 Cory's (unknown sex, top; CAFURG 652) and Scopoli's (female, bottom; CAFURG 626) shearwaters, highlighting differences in bill length and depth

Results

Dark plumage and bill colouring (i.e., pale yellow with a dark subterminal mark) were sufficient to eliminate the possibility that CAFURG 626 is a Cape Verde shearwater (Figs. 2 and 3). CAFURG 626 was slightly larger than the Cape Verde specimen for the head, culmen, bill depth at the unguis, and wing chord traits, but smaller for minimum bill depth and bill depth at the nostrils (Fig. 3). However, CAFURG 626 was smaller than all the Cory's shearwater specimens at CAFURG, varying from 6.7% for wing chord to 36.7% for minimum bill depth (Table 1). CAFURG 626 was identified as a female, as two bands were observed on the agarose gel, referring to the CHD-Z and CHD-W genes, which differ in size (Griffiths et al. 1998). As such, CAFURG 626 was smaller than the smallest female measured in 6 Mediterranean colonies (Gómez-Díaz and González-Solís 2007). Regarding scores for the outer primaries, CAFURG 626 has white "tongues" on underwing primaries P9 and P8 (score 4), but a high proportion of Cory's shearwaters (three of eight) were also classified with score 4 (see Fig. 4 for a comparison of the extreme scores). Stable isotopes in the five primaries analysed showed low variation, i.e., 11.34–11.64‰ for δ^{15}N and −17.06 to −16.77‰ for δ^{13}C. These stable isotope values are well within the range of those for P1 feathers from Scopoli's shearwaters from several colonies reported by Gómez-Díaz and González-Solís (2007) (Fig. 5).

Discussion

We have presented strong evidence that the >1-year-old female CAFURG 626 is a Scopoli's shearwater *C. diomedea*, extending their distribution towards the southwest Atlantic Ocean. The features used for the analyses were fundamental for accurate species identification. Bill colouring alone, but also the overall paler plumage of CAFURG 626, showed that the specimen was not a Cape Verde shearwater, while its morphometrics left it outside the body-size range of Cory's shearwater (Gómez-Díaz and González-Solís 2007). In addition, isotopic ratios of the CAFURG 626 inner primaries were within the isotopic range of Scopoli's shearwater and outside the Cory's standard deviations for both carbon and nitrogen (Gómez-Díaz and González-Solís 2007). Finally, paler "tongues" on the outer primaries provided further evidence, despite not conclusive, that CAFURG 626 is a Scopoli's shearwater, as score 4 is close to what is suggested for Scopoli's shearwaters. Overall, the molecular sex identification coupled to the morphometrics placed the specimen at the very low range for Scopoli's shearwater and outside the range for Cory's shearwater and confirmed the identification. The stable isotopes and "tongue" pattern of outer primaries provided additional evidence that supported the identification as Scopoli's shearwater. The small size also suggests that the bird originated from the eastern Mediterranean, where small birds are found (Gómez-Díaz and González-Solís 2007).

To our knowledge, CAFURG 626 is the first confirmed Scopoli's shearwater in the Brazilian territory and southwest Atlantic Ocean as a whole. However, Scopoli's shearwater may occur more frequently in this region, as the discrimination between Cory's and Scopoli's shearwaters requires

Table 1 Morphometrics (mean ± standard deviation, in mm) from 8 Cory's, *Calonectris borealis*; Cape Verde, *C. edwardsii* (CAFURG 693); and Scopoli's, *C. diomedea* (CAFURG 626) shearwaters deposited in the Bird Collection of the Universidade Federal do Rio Grande-FURG (CAFURG): wing chord (unflattened), head (bill tip to the posterior ridge formed by the parietal-supraoccipital junction), bill depth at the nostrils (BD - nostrils), bill depth at the unguis (BD - unguis), minimum bill depth (BD - minimum), and culmen (exposed culmen)

CAFURG shearwaters	Head	Culmen	BD - nostrils	BD - minimum	BD - unguis	Wing chord
C. borealis (*n* = 8)	107.5 ± 2.1	53 ± 1.7	19.3 ± 1.5	13.6 ± 1.1	14.1 ± 0.8	314.0 ± 26.4
C. edwardsii (*n* = 1)	88.1	42.5	14.2	9.5	9.8	279.0
C. diomedea (*n* = 1)	89.2	43.0	12.5	8.6	10.2	293.0

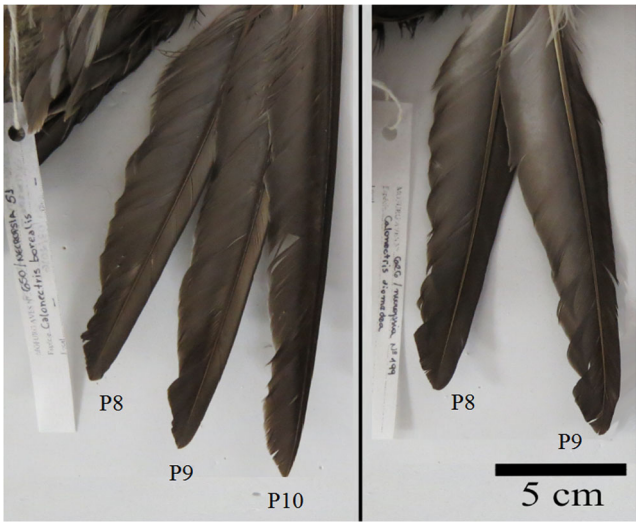

Fig. 4 Scores of the outer primary feathers based on Howell and Patteson (2008). Primary feathers of a Cory's shearwater, *Calonectris borealis* (left), and Scopoli's shearwater, *C. diomedea* (CAFURG 626, right), recorded in Brazil. The Cory's primaries (left) represent an individual scored at 1, where P8, P9, and P10 were dark, whereas CAFURG 626 was scored at 4; P10 is not shown in the picture as it had been removed for another study, but P10 of the other wing was checked instead and proved to be totally dark, while P8 and P9 presented a short whitish "tongue"

careful and detailed analysis of body size and colouring of the primaries. Discrimination between Cory's and Scopoli's shearwaters at sea is difficult, as it is necessary to compare body size and/or obtain high-resolution pictures of the birds in flight for comparison purposes, preferentially under the same light conditions and both species together. Occurrences of Cape Verde and Cory's shearwaters in Brazil have been demonstrated mainly with individuals found dead along the coastal regions (e.g., Petry et al. 2000; Lima et al. 2004; Petry et al. 2009). Furthermore, both Cape Verde and Cory's shearwaters are usually observed foraging on the continental shelf at the same latitudes during the nonbreeding period (L. Bugoni, unpub. Data), although at-sea censuses are scarce in Brazil. Tracking data has shown that the southwest Atlantic Ocean is also a destination for Mediterranean shearwaters during the nonbreeding period. Geolocators attached to individuals from Pantaleu Island (Spain) showed that most of the eight tracked individuals flew to the southeast Atlantic under the influence of the Benguela Current; however, one female Scopoli's shearwater reached the southern continental shelf off Brazil (Oro et al. 2008). The inter-individual variability in movement patterns was also demonstrated by Perón et al. (2012), when they tracked four Scopoli's shearwaters from Lavezzi Island (France); three individuals flew to the African coast, but one individual remained near the southernmost Brazilian continental shelf. Therefore, Scopoli's shearwater is probably a regular, although not abundant, visitor to the southwest Atlantic Ocean, and it is under-reported mainly owing to difficulties in species identification. Seabird observers and researchers working on stranding carcasses are urged to carefully check for species separation, as Scopoli's shearwater specimens could be easily overlooked. The use of underwing white "tongues" alone is not recommended, as it could be very variable and intermediate scores are common in both Cory's and Scopoli's shearwaters.

González-Solís et al. (2007) suggested that the movement patterns of *Calonectris* shearwaters are associated with high-productivity areas, which in turn are generated by the oceanographic dynamics of the major currents in the Atlantic Ocean (i.e., Canary, Benguela, Brazil, and Agulhas Currents). The western side of ocean gyres has lower primary productivity than the eastern side, mainly influenced by upwelling in the west face of continents (Longhurst et al. 1995). Although the Brazil Current is composed of high-salinity, warm, and oligotrophic waters, it meets the Malvinas (= Falklands) Current when it reaches the southernmost Brazilian area, generating a

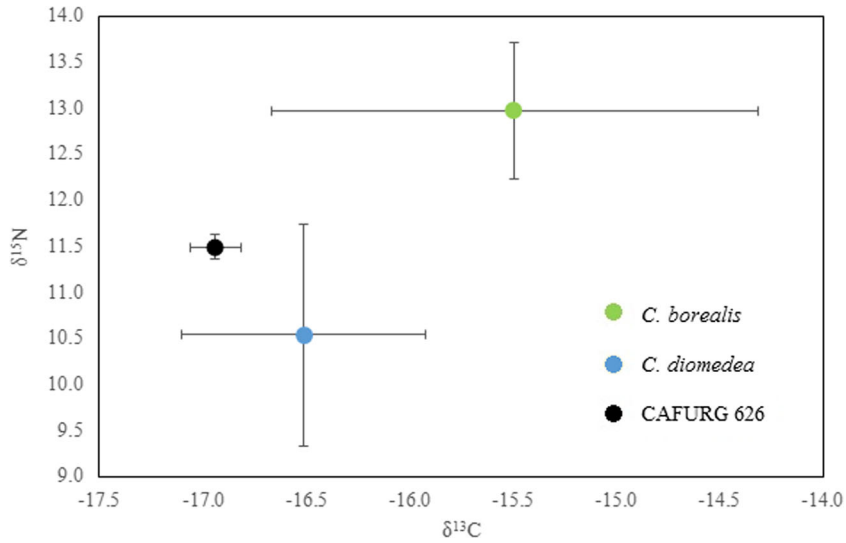

Fig. 5 Mean and standard deviation of $\delta^{13}C$ and $\delta^{15}N$, in ‰, values from P1, P3, P5, P7, and P10 feathers of the *Calonectris* shearwater CAFURG 626 found in the southernmost coastal region of Brazil, in comparison with the mean and standard deviation values obtained from P1 of seven colonies of Scopoli's shearwater, *C. diomedea*, and 10 colonies of Cory's shearwater, *C. borealis*, according to Gómez-Díaz and González-Solís (2007)

high-productivity region formed by the Subtropical Convergence and Subtropical Shelf Front (Piola et al. 2008). Therefore, oceanographic dynamics explain why southern Brazil is an important nonbreeding area for *Calonectris* shearwaters and more than a dozen Procellariiformes species (Bugoni and Furness 2009).

In summary, the southernmost Brazilian coast is a potential nonbreeding area for Scopoli's shearwaters (including individuals from the easternmost colonies), as indicated by the morphometrics of CAFURG 626 and the longitudinal body-size gradient proposed by Gómez-Díaz and González-Solís (2007). Furthermore, the present study highlights the need for correct discrimination between Cory's and Scopoli's shearwaters, especially in the nonbreeding areas off the Americas, where the separation has not even been recognised by the main committees (i.e., SACC and NACC). Species differentiation has been exhaustively demonstrated through a range of evidences from colonies, with estimated divergence between Scopoli's and Cory's shearwaters one million years ago (Gómez-Díaz et al. 2006). Evidence from colonies led to the widespread acceptance of the full species status of both forms, and the same treatment should be applicable in nonbreeding areas. In these areas, immature and adult individuals of *Calonectris* shearwaters usually feed and roost near fishing vessels (Bugoni and Furness 2009; Bugoni et al. 2010). The absence of incidental capture of *Calonectris* species in pelagic longline fisheries in the southwest Atlantic Ocean (e.g., Bugoni et al. 2008a; Jiménez et al. 2009), but the predominance of *C. diomedea* in seabird captures (66% of the birds captured) in the Mediterranean fisheries (Belda and Sánchez 2001), could be owing to the predominance of Cory's shearwaters in the southwest Atlantic and its low interaction with fisheries (but see Bugoni et al. 2008b for other fisheries where Cory's shearwaters are killed). Therefore, recognising the ecological differences and following the full specific status already adopted in Europe would be beneficial in understanding the nonbreeding distribution differences between the species as well as improving conservation based on specific peculiarities. Finally, we recommend the use of "Pardela-do-Mediterrâneo" as the common name in Portuguese to be used in the Brazilian checklist.

Acknowledgements The authors are grateful to L.S. Carvalho for preparing the feathers for stable isotope analyses, and F.A. Faria for assistance in preparing the photographs. Authors are grateful to an anonymous reviewer for comments and suggestions on a previous version, which greatly improved the current manuscript. G.O. received a scientific initiation scholarship from CNPq (National Council for Scientific and Technological Development) during the preparation of the manuscript. G.T.N. and F.P.M. received scholarships from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). L.B. is a research fellow at the Brazilian CNPq (Proc. No. 310550/2015-7).

References

Alonso H, Matias R, Granadeiro JP, Catry P (2009) Moult strategies of Cory's shearwaters *Calonectris diomedea borealis*: the influence of colony location, sex and individual breeding status. J Ornithol 150(2):329–337. https://doi.org/10.1007/s10336-008-0354-2

American Ornithologists' Union (1998) Check-list of North American birds: the species of birds of North America from the Arctic through Panama, including the West Indies and Hawaiian Islands. Allen Press, Lawrence

Belda EJ, Sánchez A (2001) Seabird mortality on longline fisheries in the western Mediterranean: factors affecting bycatch and proposed mitigation measures. Biol Conserv 98(3):357–363. https://doi.org/10.1016/S0006-3207(00)00178-6

Bugoni L, Furness RW (2009) Age composition and sexual size dimorphism of albatrosses and petrels off Brazil. Mar Ornithol 37(3):253–260

Bugoni L, Mancini PL, Monteiro DS, Nascimento L, Neves TS (2008a) Seabird bycatch in the Brazilian pelagic longline fishery and a review of capture rates in the southwestern Atlantic Ocean. Endang Species Res 5(2–3):137–147. https://doi.org/10.3354/esr005137

Bugoni L, Neves TS, Leite-Jr NO, Carvalho D, Sales G, Furness RW, Stein CE, Peppes FV, Giffoni BB, Monteiro DS (2008b) Potential bycatch of seabirds and turtles in hook-and-line fisheries of the Itaipava Fleet, Brazil. Fish Res 90(1–3):217–224. https://doi.org/10.1016/j.fishres.2007.10.013

Bugoni L, McGill RAR, Furness RW (2010) The importance of pelagic longline fishery discards for a seabird community determined through stable isotope analysis. J Exp Mar Biol Ecol 391(1–2):190–200. https://doi.org/10.1016/j.jembe.2010.06.027

Fisher A, Flood R (2010) Scopoli's shearwater off Scilly: new to Britain. Br Birds 103(12):712–717

Gómez-Díaz E, González-Solís J (2007) Geographic assignment of seabirds to their origin: combining morphologic, genetic and biogeochemical analyses. Ecol Appl 17(5):1484–1498. https://doi.org/10.1890/06-1232.1

Gómez-Díaz E, González-Solís J, Peinado MA, Page RDM (2006) Phylogeography of the *Calonectris* shearwaters using molecular and morphometric data. Mol Phylogenet Evol 41(2):322–332. https://doi.org/10.1016/j.ympev.2006.05.006

Gómez-Díaz E, González-Solís J, Peinado MA (2009) Population structure in a highly pelagic seabird the Cory's shearwater *Calonectris diomedea*: an examination of genetics, morphology and ecology. Mar Ecol Prog Ser 382:197–209. https://doi.org/10.3354/meps07974

González-Solís J, Croxall JP, Oro D, Ruiz X (2007) Trans-equatorial migration and mixing in the wintering areas of a pelagic seabird. Front Ecol Environ 5(6):297–301. https://doi.org/10.1890/1540-9295(2007)5[297:TMAMIT]2.0.CO

Griffiths R, Double MC, Orr K, Dawson RJG (1998) A DNA test to sex most birds. Mol Ecol 7(8):1071–1075. https://doi.org/10.1046/j.1365-294x.1998.00389.x

Gutiérrez R (1998) Flight identification of Cory's and Scopoli's shearwaters. Dutch Birding 20(5):216–225

Harrison P (1985) Seabirds, an identification guide. Houghton Mifflin Company, Boston

Howell SNG (2012) Petrels, albatrosses and storm-petrels of North America: a photographic guide. Princeton University Press, Princeton

Howell SNG, Patteson B (2008) Variation in Cory's and Scopoli's shearwaters. Alula 14(1):12–16

Jiménez S, Domingo A, Brazeiro A (2009) Seabird bycatch in the southwest Atlantic: interaction with the Uruguayan pelagic longline fishery. Polar Biol 32(2):187–196. https://doi.org/10.1007/s00300-008-0519-8

Lima PC, Grantsau R, Lima RCFR, Santos SS (2004) Occurrence and mortality of seabirds along the northern coast of Bahia, and the identification key of the Procellariiformes Order and the Stercorariidae Family. Atual Ornitol 121:1–63

Longhurst A, Sathyendranath S, Platt T, Caverhill C (1995) An estimate of global primary production in the ocean from satellite radiometer data. J Plankton Res 17(6):1245–1271. https://doi.org/10.1093/plankt/17.6.1245

McMahon KW, Hamady LL, Thorrold SR (2013) A review of ecogeochemistry approaches to estimating movements of marine animals. Limnol Oceanogr 58(2):697–714. https://doi.org/10.4319/lo.2013.58.2.0697

Medrano JF, Aasen E, Sharrow L (1990) DNA extraction from nucleated red blood cells. BioTechniques 8(1):43

Onley D, Scofield P (2007) Field guide to the albatrosses, petrels and shearwaters of the world. Christopher Helm, London

Oro D, Genovart M, Igual JM, Ruiz X, González-Solís J (2008) Rutes migratòries i àrees d'hivernada del Virot Gros *Calonectris diomedea* des Pantaleu (Mallorca). Anu Ornitol Balears 23(1):37–41

Perón C, Grémillet D, Culioli J-M, Faggio G, Gillet P, Mante A, Vidal P (2012) Exploring marine habitats of two shearwater species breeding on French Mediterranean islands. In Yésou P., Baccetti N, Sultana J (eds) Ecology and conservation of Mediterranean seabirds and other bird species under the Barcelona Convention: update and progress. Proceedings of the 13th Medmaravis Pan-Mediterranean Symposium, Alghero, Sardinia, Italy, 14–17 October 2011, pp 19–25

Petry MV, Bugoni L, Fonseca VSS (2000) Occurrence of the Cape Verde shearwater *Calonectris edwardsii* on the Brazilian coast. Bull Br Ornithol Club 120(3):198–200

Petry MV, Krüger L, Fonseca VSS, Brummelhaus J, Piuco RC (2009) Diet and ingestion of synthetics by Cory's shearwater *Calonectris diomedea* off southern Brazil. J Ornithol 150(3):601–606. https://doi.org/10.1007/s10336-009-0373-7

Piacentini VQ, Aleixo A, Agne CA, Maurício GN, Pacheco JF, Bravo GA, Brito GRR, Naka LN, Olmos F, Posso S, Silveira LF, Betini GS, Carrano E, Franz I, Lees AC, Lima LM, Pioli D, Schunck F, Amaral FR, Bencke GA, Cohn-Haft M, Figueiredo LFA, Straube FC, Cesari E (2015) Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee. Rev Bras Ornitol 23(2):91–298

Piola AR, Möller-Jr OO, Guerrero RA, Campos EJD (2008) Variability of the subtropical shelf front off eastern South America: winter 2003 and summer 2004. Cont Shelf Res 28(13):1639–1648. https://doi.org/10.1016/j.csr.2008.03.013

Remsen-Jr JV, Cadena CD, Jaramillo A, Nores M, Pacheco JF, Pérez-Emán J, Robbins MB, Stiles FG, Stotz DF, Zimmer KJ (2016) A classification of the bird species of South America. American Ornithologists' Union. http://www.museum.lsu.edu/~Remsen/SACCBaseline.html. Accessed 22 June 2016

Robb M, Mullarney K, The Sound Approach (2008) Petrels night and day: a sound approach guide. The Sound Approach, Poole

Sangster G, Collinson JM, Crochet PA, Knox AG, Parkin DT, Votier SC (2012) Taxonomic recommendations for British birds: eighth report. Ibis 154(4):874–883. https://doi.org/10.1111/j.1474-919X.2012.01273.x