What is known about the enigmatic Gulf of Guinea band-rumped storm petrels Hydrobates cf. castro?

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Source: Bulletin of the British Ornithologists' Club, 139(2) : 173-186

Published By: British Ornithologists' Club

URL: https://doi.org/10.25226/bboc.v139i2.2019.a10

What is known about the enigmatic Gulf of Guinea band-rumped storm petrels *Hydrobates* cf. *castro*?

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Received 21 February 2019; revised 1 May 2019; published 17 June 2019

http://zoobank.org/urn:lsid:zoobank.org:pub:A42DC23D-C8A7-4658-8F66-84D73DDF647B

Summary.—We present what is known about the Gulf of Guinea band-rumped storm petrels *Hydrobates* cf. *castro* to identify priority areas for research and conservation. Addressed are: occurrence in the Gulf of Guinea, including museum specimens, at-sea records, observations on the islands, and potential breeding sites; seasonality, the timing of breeding inferred from condition of trapped birds and birds at sea in primary moult; morphology, including biometrics, structure, plumage aspect; aerial vocalisations at the suspected breeding grounds; and taxonomy. The first photographs and sonograms pertaining to this population to be published are also presented. The evidence indicates that this storm petrel is present in the Gulf of Guinea year-round. It almost certainly breeds on São Tomé during both the wet and long dry seasons, and breeding is probably protracted, possibly seasonal. Morphology indicates a degree of distinctiveness and aerial vocalisations suggest possible taxonomic affinities with Cape Verde Storm Petrel *H. jabejabe*. Our observations are provisional and further research is required. The three most pressing matters for future research are clarifying taxonomy, locating breeding colonies and identifying key threats.

Taxa included in the band-rumped storm petrel complex (*Hydrobates castro*, *sensu lato*) breed in the North Atlantic, South Atlantic and North Pacific Oceans (Brooke 2004, Howell & Zufelt 2019; Fig. 1a). Taxonomic relationships among these cryptic black-and-white taxa are poorly understood, although several species have been recognised in recent years (e.g. Friesen *et al*. 2007, Bolton *et al*. 2008, Deane 2011, Silva *et al*. 2016). Band-rumped storm petrels in the Gulf of Guinea (*Hydrobates* cf. *castro*—hereafter Gulf of Guinea Storm Petrel), in the equatorial east Atlantic, are known from only a small number of museum specimens, and at-sea and over-land records. However, fishermen on São Tomé and Príncipe are familiar with black-and-white storm petrels under the name 'canimboto' or 'caniboto', suggesting that it is a common bird around the islands. The sole attempt to clarify the general status of the Gulf of Guinea Storm Petrel was published more than 20 years ago and it failed to clarify the taxonomy or to confirm the existence of a breeding population (Monteiro *et al*. 1997, available from the authors). Here we update and expand upon published information to identify priority areas for research and conservation, including data on specimens, at-sea and over-land observations, possible nesting sites, seasonality, and describe this population's biometrics, structure, plumage aspect and vocalisations, illustrated by the first published photographs and sonograms.

Occurrence in the Gulf of Guinea

Study area.—The Gulf of Guinea (00°20'N, 06°44'S) is located off the Atlantic Ocean coast of Central Africa. It is crossed by a volcanic arc that produced the oceanic islands

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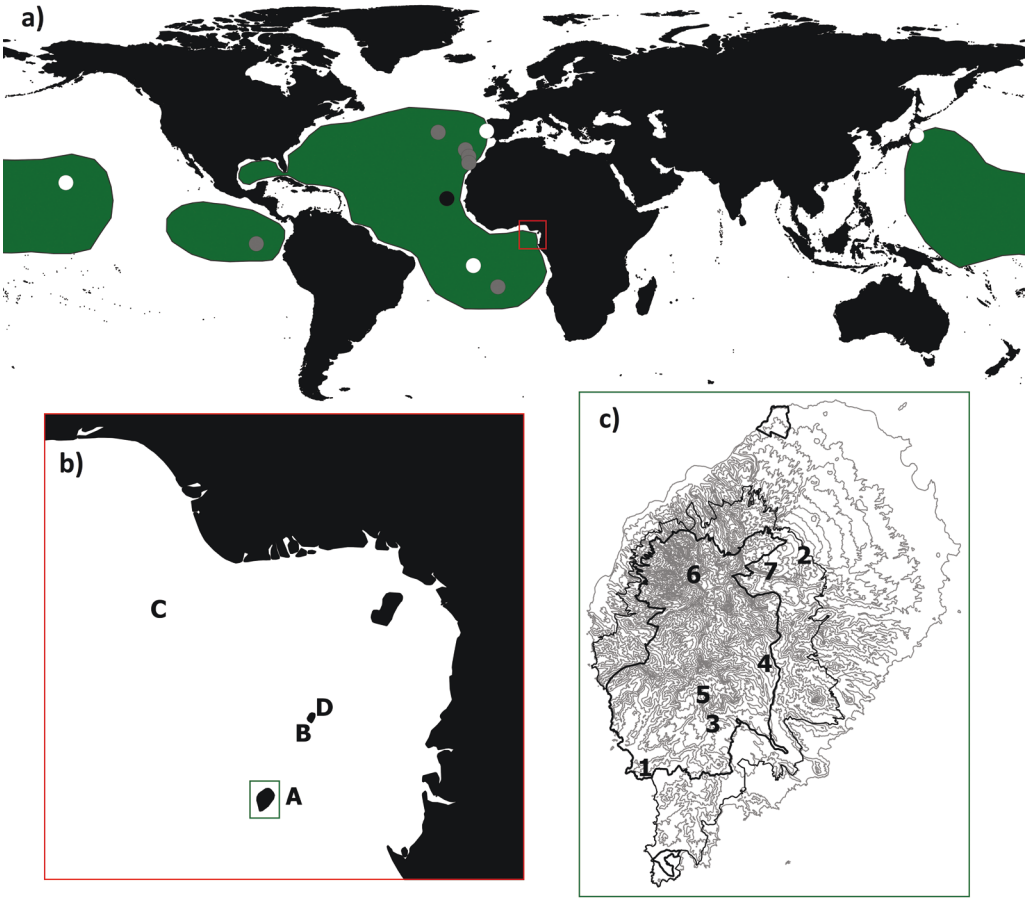

Figure 1. Gulf of Guinea Storm Petrel *Hydrobates* cf. *castro* distribution maps (background world map: Sandvik 2019). (a) global distribution of Band-rumped Storm Petrel *H. castro*. At-sea distribution shown in green (Howell & Zufelt 2019) and breeding colonies by circular symbols: white—one distinct seasonal population, grey—two distinct seasonal populations, black—protracted breeding season (Friesen *et al*. 2007). The red rectangle indicates the Gulf of Guinea. (b) At-sea observations in the Gulf of Guinea. Letter codes explained in Table 1. The green rectangle indicates São Tomé. (c) Observations on São Tomé. Numeric codes explained in Table 1. Grey lines in the background = 100 m altitudinal isolines; the thick black line = borders of Obô Natural Park; and the thin black line = border of the park's buffer zone.

of Annobón, São Tomé and Príncipe, and the continental island of Bioko (Fig. 1). Max. altitudes are: Annobón 598 m, São Tomé 2,024 m, Príncipe 948 m and Bioko 3,011 m. The mountains are very steep and there are several inland as well as coastal cliffs. The islands' climate at sea level is consistently hot year-round, but the rugged topography gives rise to a strong rainfall gradient and lower temperatures at higher altitudes (Jones *et al*. 1991). There is a long dry season between mid May and early September, a short one between late December and early February, and two wet seasons covering the rest of the year. The mountainous centres of the islands still harbour relatively extensive and well-preserved patches of old-growth forest where most of the native bird species persist (Lima *et al*. 2017).

Historical records.—J. V. Barbosa du Bocage acquired what was presumably a Gulf of Guinea Storm Petrel collected 'far offshore' São Tomé by fishermen around 1891 (Salvadori 1903 *in* Amadon 1953, Christy 1996, Jones & Tye 2006). It was held at the Museu Nacional de História Natural e da Ciência da Universidade de Lisboa, but almost certainly was lost in a huge fire in 1978 (J. Alves & R. Figueira *in litt*. 2018). J. G. C. & V. Correia collected four

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TABLE 1
Observations of band-rumped storm petrel *Oceanodroma* cf. *castro* in the Gulf of Guinea. Under Location, the general locality is provided in parentheses: ST = São Tomé, PR = Príncipe, GG = Gulf of Guinea, and the subsequent numbers and letters indicate the codes used in the maps.

Date	Type of encounter	Location	Observations	Source
c.1891	Captured	'far offshore' (ST)	Acquired by J. V. Barbosa du Bocage from Angolar fishermen; presumed lost in 1978, during a fire at the Museu Nacional de História Natural e da Ciência da Univ. de Lisboa	J. Alves & R. Figueira *in litt*.
15 Nov 1928	House lights (captured)	Roça Jou (ST-1, *c*.150 m)	Adult female: plumage slightly worn and gonads small	Correia diaries 1928–29
10 Dec 1928	House lights (captured)	Roça Jou (ST-1)	Juvenile male: fresh plumage and gonads small; adult male: plumage slightly worn and gonads swollen	Correia diaries 1928–29
14 Dec 1928	House lights (captured)	Roça Jou (ST-1)	Adult male: plumage slightly worn and gonads large	Correia diaries 1928–29
24 Mar 1997	Chum	8–19 km east of Santana (ST-A)	11	Monteiro *et al*. (1997)
18 Jul 1997	At sea (visual)	Near Tinhosas (PR-B)	One in flight at 13.30 h	Monteiro *et al*. (1997)
23 Jul 1997	Chum (visual)	(ST-A)	20—one adult caught and measured (Table 2) had a fully bare brood patch	Monteiro *et al*. (1997)
29 Jul 1997	Chum (visual)	(ST-A)	Five	Monteiro *et al*. (1997)
-	House lights	Pousada da Boa Vista (ST-2, *c*.800 m)		Jones & Tye (2006)
3 Sep 2001	Sight	(PR)	One, between Príncipe and Tinhosas	J. Drummond (eBird)
Apr 2009	Aural	Nova Moka (ST-2, *c*.800 m)	In flight	RFL
12 Aug 2009	Camp lights (captured)	Monte Carmo camping site (ST-3)	Adult: plumage slightly worn (Figs. 14–15, *c*.400 m)	N. Borrow *et al*.
6 Apr 2011	At sea (visual)	(GG- C)	Seen at 14.50 h, 11 m above sea level, from the bridge of the small cruiser MV *Prince Albert II* (now MV *Silver Explorer*). 51 total: 31 not determined, 12 not in moult (Figs. 6, 7, 12), six moulting (see text; Figs. 6, 8–13)	RLF & WHW
13 Sep 2013	Flushed (visual)	Vieira Machado (ST-4, 373 m)	One caught in a liana, in native forest at 12.42 h	RFL & A. Santana
5 Feb 2015	Visual	Cambumbé (ST-5, 861 m)	At least six in native forest, at 18.50 h	A. Santana
1–19 Jun 2015	Aural	Cambumbé (ST-5)	First recording taken on 1 June. Heard multiple times on subsequent nights	MM
21 Sep 2015	Aural	Monte Carmo (ST-3)	Several heard in native forest, flying above the canopy after sunset	RFL (eBird)
11 Dec 2015	Visual	Mesa do Pico (ST-6, *c*.1,900 m)	One in flight	A. Coelho & G. Oquiongo
28 Mar 2016	Aural	Macambrará (ST-7, *c*.1,300 m)	One vocalising in flight above the canopy of secondary forest	RFL (eBird)
2 Aug 2016	Aural	Monte Carmo camp site (ST-3)	One heard in native forest, flying above the canopy at 19.20 h	RFL (eBird), PV
8–10 Aug 2016	Aural	Cambumbé (ST-5)	Several	PV *et al*.
10–13 Aug 2016	Aural	Monte Carmo camp site (ST-3)	Several	PV *et al*.
21 Sep 2016	Aural	Macambrará (ST-7)		MM
20 Jan 2017	Chum	(PR)	None recorded	Bollen *et al*. (2018)
4 Feb 2017	?	(PR-D)	Two	B. Bronkhorst, *in* Bollen *et al*. (2018)
5 Aug 2017	Aural	Monte Carmo camp site (ST-3)	25	J. Smith (eBird)

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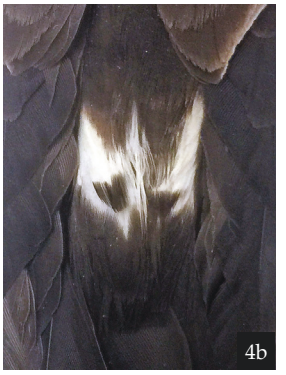

Figures 2–4. Four specimens of Gulf of Guinea Storm Petrel *Hydrobates* cf. *castro* collected by J. G. C. & V. Correia, at Roça Jou, São Tomé, 15 November–14 December 1928, now at the American Museum of Natural History (AMNH), New York, left to right (above) and top to bottom (right): AMNH 268390, AMNH 268388, AMNH 268387 and AMNH 268389; note prominent buff ulnar bars, relatively small white 'rump patch', and the relatively large size and dark plumage of AMNH 268390 (Angus Wilson & Robert L. Flood)

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TABLE 2
Gulf of Guinea Storm Petrel *Hydrobates* cf. *castro* measurements (mm). Measurements of the 1928 birds (Amadon 1953, Harris 1969) were slightly amended following cross-checks with the museum specimens (RLF). Method for measuring the 'rump patch' is described in the text. The 1997 individual had the following additional measurements: head to bill tip 40.1 mm, bill depth at nostrils 6.9 mm and bill depth at gonys 5.5 mm (Monteiro *et al*. 1997).

AMNH reg. no.	Date	Sex / age	Wing	Bill	'Rump patch'
268390	15 Nov 1928	Female	171	16.8	26
268387	10 Dec 1928	Male	156	17.0	24
268388	10 Dec 1928	Male	160	17.3	25
268389	14 Dec 1928	Male	160	15.5	25
n/a	23 Jul 1997	-	165	16.3	-

specimens at Roça Jou, in the south-west of São Tomé in late 1928 (Location 1 in Fig. 1c, Table 1). The birds entered a house at night, during heavy rain and thunderstorms, attracted by lights; the skins are at the American Museum of Natural History, New York (Figs. 2–4).

At-sea observations.—In 1997, three chumming sessions east of Santana, São Tomé, recorded Gulf of Guinea Storm Petrel, of which one was caught using a net (Location A in Fig. 1b, Tables 1–2). The same year one was observed in flight near the Tinhosas Islands (Location B in Fig. 1b, Table 1; Monteiro *et al*. 1997). In 2011, 51 Gulf of Guinea Storm Petrels were recorded midway between Príncipe and Benin, at the edge of the continental shelf, including 18 rafting birds (Location C in Fig. 1b, Table 1, Figs. 5–13). In 2017, none was found near Príncipe's 100 m-depth contour during two chumming sessions, but two were seen near Príncipe at the 1,000 m contour (Location D in Fig. 1b, Table 1; Bollen *et al*. 2018).

We add a caveat for records without documentation, as black-and-white storm petrels are notoriously difficult to identify at sea and safe identification requires an experienced eye or good photographs (Flood & Fisher 2013). It is thus possible that Gulf of Guinea Storm Petrel and migrant black-and-white storm petrel species reported in the region have sometimes been confused: Wilson's Storm Petrel *Oceanites oceanicus*, European Storm Petrel *Hydrobates pelagicus*, Leach's Storm Petrel *H. leucorhoa* and Black-bellied Storm Petrel *Fregetta tropica* (Christy & Clarke 1998, Jones & Tye 2006, Dowsett *et al*. 2017). It is also possible that representatives from other populations of the band-rumped storm petrel complex visit the region.

Observations on the islands and potential breeding sites

There are multiple strong indications that band-rumped storm petrels breed in the Gulf of Guinea, but no conclusive proof (Fig. 1, Table 1; Jones & Tye 2006). It had been suggested that Gulf of Guinea Storm Petrel could nest on the islets around São Tomé and Príncipe (Amadon 1953, Harris 1969, Williams 1984, Christy 1996). However, instead of evidence of breeding, surveys found an abundance of predatory land crabs *Johngarthia weileri* that would pose a threat to nesting storm petrels (Monteiro *et al*. 1997, Valle *et al*. 2016, Bollen *et al*. 2018). Nevertheless, it would be prudent to resurvey all of the islets.

Gulf of Guinea Storm Petrel probably breeds on the main islands, and most evidence points to nesting on São Tomé (Naurois 1983, Monteiro *et al*. 1997). In addition to the Correias' specimens, collected in south-west São Tomé, storm petrels have been attracted to the lights of the hostel Pousada Boa Vista, in the centre of the island (Banko *et al*. 1991, Monteiro *et al*. 1997), and to the lights of the EMOLVE palm oil factory, in the south-east of

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Figures 5–13. Gulf of Guinea Storm Petrels *Hydrobates* cf. *castro*, midway between Príncipe and Benin, at the edge of the continental shelf, 6 April 2011. The raft in Figs. 5–6 had 17 birds. Note the narrow white 'rump patch'. In Fig. 7, note the prominent ulnar bars in what appears to be relatively fresh plumage and the suggestion of a notched tail tip. In Figs. 8–9 note the early stages of primary moult with pp3/4–p10 old, worn plumage evident in the abraded tips to the outer primaries and untidy ulnar bars, thigh patch, and square tail tip. In Figs. 10–11, the dark replaced inner primaries contrast strongly with the old bleached and worn pp6/7–10. In Figs. 12–13, the moulting bird is almost midway through primary moult with pp7–10 old (William H. Wagstaff)

the island (R. Fonseca *in litt*. 2018). Since 2009, further evidence that reaffirms the likelihood of breeding on São Tomé comprises mostly nocturnal aural records near rugged terrain covered by native forest (Fig. 1c, Table 1). In addition, one was trapped and photographed

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Figures 14–15. Gulf of Guinea Storm Petrels *Hydrobates* cf. *castro*, near Monte Carmo, Obô Natural Park, São Tomé, 12 August 2009; note the abraded tail tip in Fig. 14 indicative of wear from time in a burrow; Fig. 15 is the only photograph that shows bill structure of a live bird (Nik Borrow)

Figure 16. Forested gully near Monte Carmo, Obô Natural Park, São Tomé; Gulf of Guinea Storm Petrels *Hydrobates* cf. *castro* are regularly heard in this forested ravine after dusk (Location 3 in Fig 1c) (Philippe Verbelen)

in native forest near Monte Carmo, in south-central São Tomé, presumably attracted to camp lights (Location 3 in Fig. 1c, Figs. 14–16). Since then, Gulf of Guinea Storm Petrel has been recorded regularly at this location and in the environs (Table 1).

Evidence is scant that Gulf of Guinea Storm Petrel breeds on other islands. Surveys for nocturnal birds on Príncipe found no evidence of it (PV & MM pers. obs.). On Annobón, a 'black bird a little smaller than White-capped Noddy *Anous minutus*' was said to have 'its abode' in the interior (Barrena 1911, Basilio 1957). However, the few ornithological studies

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on this small island have found no evidence of breeding storm petrels (Jones & Tye 2006, Sloan 2017). A survey of Bioko is required.

Breeding in mountainous equatorial forests, perhaps on inland cliffs as suggested above, would be quite unique among band-rumped storm petrels. In the Atlantic Ocean, there is some evidence of inland breeding in the Cape Verdes (Hazevoet 1995; V. Bretagnolle *in litt*. 2019), although they typically nest at low elevations in relatively barren rocky and boulder-strewn areas, in crevices, under lava screes, in the remains of walls, and in burrows constructed by White-faced Storm Petrels *Pelagodroma marina* (Hazevoet 1995, Bolton *et al*. 2008; RLF pers. obs.). At several locations, invasive predators restrict breeding to offshore islets and rock stacks. In the Pacific Ocean, breeding occurs in the equatorial Galápagos Islands in crevices and burrows (Swash & Still 2005, Smith & Friesen 2007), and in the tropical Hawaiian Islands in crevices within a cinder cone caldera and sparsely vegetated steep cliffs, with small groups breeding in wetter more vegetated areas (Raine *et al*. 2017, Galase 2019).

Seasonality

Gulf of Guinea Storm Petrel is present in the region year-round, both at sea and on land (Table 1, Fig. 17). It is present off all oceanic islands and has been observed over the Guinea Rise on which the islands are situated (Fig. 1, Table 1; Robins 1966, Harrison & Steele 1989). Local fishermen report that black-and-white storm petrels are commoner at sea during the long dry season, between mid May and early September (Monteiro *et al*. 1997, Bollen *et al*. 2018). However, research into seasonality is minimal and so we draw upon two indicators of breeding season—nesting condition and primary moult.

Breeding condition.—The Gulf of Guinea Storm Petrel captured east of São Tomé on 23 July 1997 had a fully bare brood patch (Monteiro *et al*. 1997). Two of the specimens at Roça Jou on 10 and 14 December 1928 had swollen / enlarged gonads. These observations, together with records year-round (Table 1, Fig. 17), indicate either a protracted breeding season or two distinct nesting seasons: one around December, during the wet season, and the other around July, during the long dry season.

Primary moult.—Adult band-rumped storm petrels undertake a complete post-breeding moult that commences at a late stage during chick rearing, while juveniles undertake their first complete moult *c*.10 months post-fledging, approximately two months earlier than adults (Howell 2010, 2012, Flood & Fisher 2013). The ten primaries are replaced sequentially from the innermost to the outermost (from p1 to p10) and grow at a steady rate (Flood & Fisher 2013, Ryan 2014). Six of the 18 birds photographed at sea between Príncipe and Benin on 6 April 2011 were in primary moult (Table 1). Progress of primary moult is staggered—pp3/4–p10 old, pp6/7–p10 old, p7–p10 old, p9–p10 old, and p10 old—and consistent with a protracted breeding season. Primary moult consistent with two distinct nesting seasons would be synchronised. For example, in the Gulf Stream, off North Carolina, in May–June 80–90% of band-rumped storm petrels have just 3–4 old outer primaries, while the other 10–20% are not in primary moult (respectively, cool- and hot-season breeders from Macaronesia) (Howell 2012). We do not know if the primary moult of the 12 non-moulting birds was staggered or synchronised because the photographs are

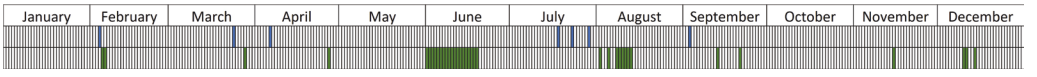

Figure 17. Seasonality of Gulf of Guinea Storm Petrel *Hydrobates* cf. *castro*; each cell represents one day; a blue cell in the top row represents an at-sea observation, and a green cell in the bottom row an observation on land.

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of insufficient quality to assess plumage wear—from fresh to heavily worn—necessary to gauge duration since completing moult.

The end of the breeding season of an adult Gulf of Guinea Storm Petrel can be estimated from its progress in primary moult (Howell 2012, Flood & Fisher 2013). Fifty percent of the primary mass is in the outermost three primaries (p8–p10) meaning that primary moult is *c*.25% complete when it reaches p5, halfway when it reaches p8, and a little over three-quarters by the time it reaches p10. Band-rumped storm petrels might take *c*.24 weeks to complete primary moult based on the timeframe within which entire populations moult (e.g. Bolton *et al*. 2008). Accordingly, when a bird starts moulting p8 it has concluded its breeding *c*.12 weeks earlier.

Based on the above parameters and assuming moulting birds were adults, the range for the end of breeding season for these birds is from late November to late February (6–22 weeks prior to 6 April). If the moulting birds were juveniles, the range for the end of fledging is between late September and late December. Both calculations coincide with the dates of the juvenile collected by the Correias on 10 December. Reasonable adjustments to '24 weeks' do not result in significantly different estimates.

Morphology

Band-rumped storm petrel populations in the Atlantic Ocean are poorly differentiated morphologically, and the main characters that separate them are depth of the white 'rump patch' and thigh patches, the tone of dark feathers not attributable to the ageing process, depth of tail notch / fork, body mass, the length of the bill, tarsus, wing and tail, as well as voice (Bolton *et al*. 2008, Robb *et al*. 2008, Shirihai 2009, Flood & Fisher 2013). Typically, hot-season birds are fork-tailed and tend to have greater body mass, longer and deeper bills, and longer wings (Deane 2011).

Depth of the white 'rump patch' is the percentage of the length of the tail that is white, measured along the mid-dorsal line of the tail. The white 'rump patch' of specimens collected by the Correias is exceptionally shallow for band-rumped storm petrels, with a mean depth 25% (Figs. 2, 4) vs. 32.3–38.3% in populations globally (Harris 1969). This depth is borne out in birds photographed in the Gulf of Guinea (Figs. 5–14).

Depth of the white 'thigh patch' is measured by calculating how far it extends from the fold over of the 'rump patch' towards the mid-ventral line of the underparts. Depth of the thigh patch is *c*.50%, similar to Macaronesian band-rumped storm petrels, but much less than the estimated 80% or more in birds breeding in April on Ascension and St Helena (RLF pers. obs.).

Photographs of Gulf of Guinea Storm Petrels mainly show square-ended tails (Figs. 5–14), unlike Atlantic Ocean hot-season taxa (Deane 2011). A photograph from March and another from April suggest a notch in the tail tip, although this could be an effect of angle (Figs. 7, 18).

We have measurements for just five Gulf of Guinea Storm Petrels (Table 2). Mean wing length is 162.4 mm, or 160.25 mm if we exclude the 171 mm of an exceptionally large adult female (AMNH 268390). In either case, the mean wing length for Gulf of Guinea Storm Petrel exceeds that of populations worldwide, whose averages range from 147.2 mm to 156.5 mm (Harris 1969). The long wing of AMNH 268390 (Amadon 1953) exceeds the

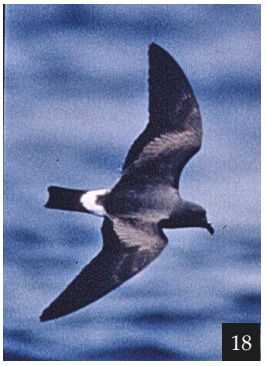

Figure 18. Gulf of Guinea Storm Petrel *Hydrobates* cf. *castro*, 8–19 km east of Santana, São Tomé, 24 March 1997; note features listed under Figs. 5–13 and the suggestion of a notched tail, and that this individual appears to have uniformly fresh plumage like a recently fledged juvenile (Martim Melo)

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longest-winged individuals from the Azores cool-season (166 mm, *n* = 129), Azores hot-season (169 mm, *n* = 209), and Cape Verde populations captured in June (165 mm, *n* = 52), and it is equalled only by the longest Cape Verde bird trapped in November (*n* = 85) (Bolton *et al*. 2008, Deane 2011). AMNH 268390 is also darker in plumage than the other specimens (Figs. 2–3). The mean bill length of Gulf of Guinea Storm Petrel is 16.6 mm, also exceeding that of populations worldwide presented by Harris (1969), whose averages range from 14.4 to 15.5 mm, while V. Bretagnolle (in *litt*. 2019) reports that bill length of Gulf of Guinea Storm Petrel lies within the upper range of 660 specimens of band-rumped storm petrels he has measured.

Vocalisations

Study of the vocalisations of band-rumped storm petrels has contributed to our understanding of the taxonomic relationships between distinct populations in the Atlantic (Robb *et al*. 2008). On São Tomé, most aerial vocalisation was noted in June–September after

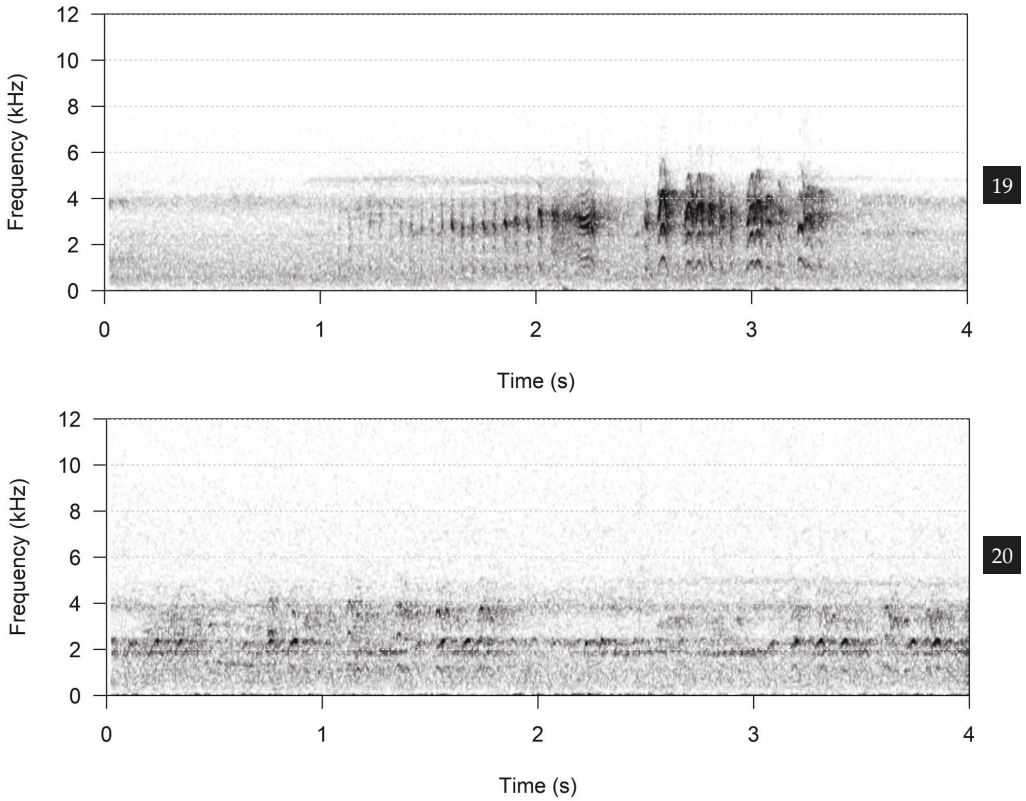

Figure 19. Aerial vocalisation of Gulf of Guinea Storm Petrel *Hydrobates* cf. *castro*, near Monte Carmo, Obô Natural Park, São Tomé, 9 August 2016 (19.25 h) (Philippe Verbelen). Short purring is visible between seconds 1.0 and 2.0, before the chatter call starts. Reversed 'v' notes are visible in the mid-section between seconds 2.5 and 3.0, and these are similar to the structure of chatter calls of Cape Verde Storm Petrels *H. jabejabe* (*cf*. Fig. 22). XC473562.

Figure 20. Aerial vocalisation of Gulf of Guinea Storm Petrel *Hydrobates* cf. *castro*, Ribeira Peixe, Obô Natural Park, São Tomé, 8 August 2016 (19:16 h) (Philippe Verbelen). The large number of notes in a downward spiral at the end of the chatter call is similar to Cape Verde Storm Petrel *H. jabejabe* (M. Robb *in litt*. 2016). XC473563.

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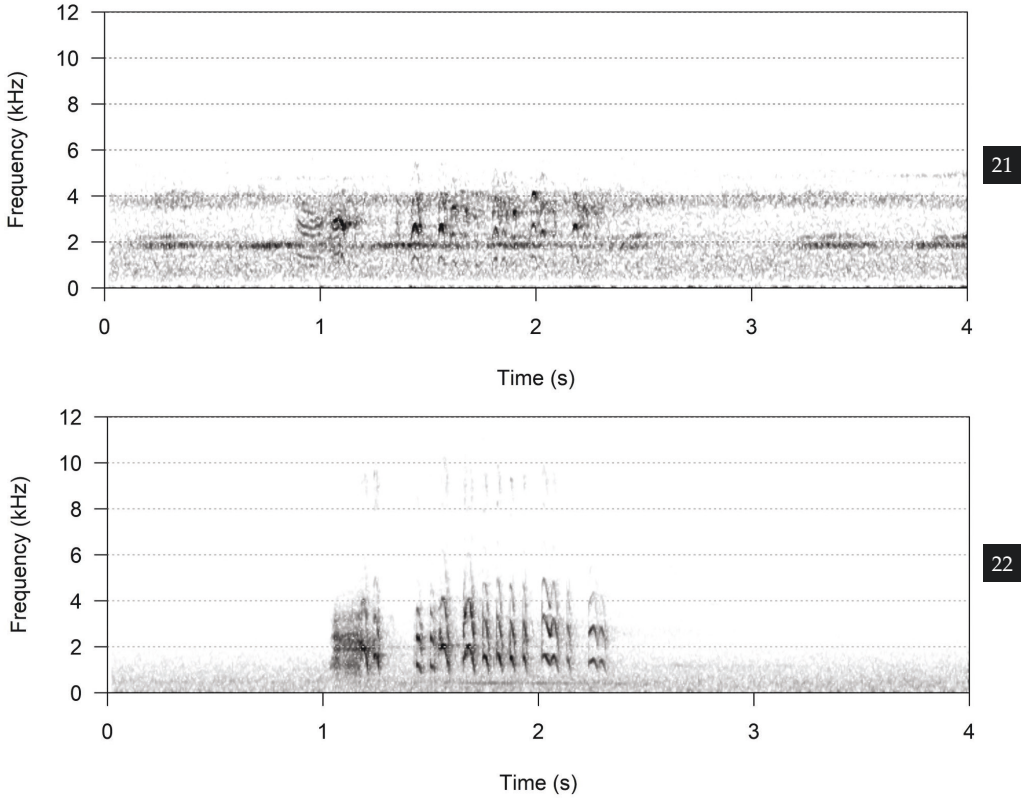

Figure 21. Aerial vocalisation of Gulf of Guinea Storm Petrel *Hydrobates* cf. *castro*, Ribeira Peixe, Obô Natural Park, São Tomé, 9 August 2016 (19.37 h) (Philippe Verbelen). Typical flight call with purring in the opening part, long middle section of chatters, ending with a short flourish. XC473564

Figure 22. Aerial vocalisation of a Cape Verde Storm Petrel *Hydrobates jabejabe*, Raso, Cape Verde Islands, 22 March 2007 (19.49 h) (Robb *et al*. 2008). The three parts of the call are clearly visible: the opening part, a long middle section of chatters, ending with a short flourish (CD2:60, Robb *et al*. 2008).

nightfall, from around 18.15 h onwards and peaking at *c*.19.00 h. The birds were probably flying to nesting sites.

On 8–13 August 2016, we employed directional microphones in combination with headphones to sound-record flight calls and to locate potential nest sites. Storm petrels were heard calling intensively in the vicinity of Monte Carmo just above the canopy, along forested ravines, and within forested gullies where breeding is suspected (Fig. 16).

The aerial vocalisation of Gulf of Guinea Storm Petrels (Figs. 19–21) has three parts: the opening purr, a long middle section of chatters, and ends with a short flourish. However, there is considerable variation in aerial calls and only a few recordings capture aerial purring or the concluding flourish. Background noise made detailed interpretation of sonograms difficult. Nevertheless, an important observation is the notable similarity with the aerial vocalisation of Cape Verde Storm Petrel (Fig. 22).

Vocalisations of Cape Verde Storm Petrel include many more chatter notes than those published for other populations of band-rumped storm petrel (Robb *et al*. 2008). Also, the climax of pitch and intensity in Cape Verde Storm Petrel usually is reached during the long middle section, while the calls of other band-rumped storm petrels become louder at the end (Robb *et al*. 2008). Gulf of Guinea Storm Petrel vocalisations appear to share the distinct

ISSN-2513-9894 (Online)

features of Cape Verde Storm Petrel. Purring calls recorded at burrow nest sites have proven important when comparing vocalisations of band-rumped storm petrels (Robb *et al*. 2008), but no nest of Gulf of Guinea Storm Petrel has been found. A selection of our Gulf of Guinea Storm Petrel sound-recordings are available on www.xeno-canto.org.

Taxonomy

Band-rumped storm petrels were treated as monotypic for many years (Cramp & Simmons 1977, Warham 1990, Brooke 2004). Recently, significant genetic structure and restricted gene flow have been recorded in Atlantic populations (Friesen *et al*. 2007). Gulf of Guinea Storm Petrel might represent an unnamed taxon (Jones & Tye 1988). The differences in the principal morphological characters from those of other band-rumped storm petrel populations support this hypothesis (Harris 1969). Similarities between the aerial vocalisations of Gulf of Guinea Storm Petrel and Cape Verde Storm Petrel suggest some taxonomic affinity. Several island groups in the Atlantic hold taxonomically distinct allochronous populations (Friesen *et al*. 2007, Silva *et al*. 2016), and we do not discard this possibility for Gulf of Guinea Storm Petrel, especially given evidence of a prolonged breeding season. Proof that Gulf of Guinea Storm Petrel represents a different taxon requires additional evidence from morphology, vocalisations and genetics.

Conclusion

The Gulf of Guinea oceanic islands are relatively small, but support an exceptionally large number of endemic bird species (Stattersfield *et al*. 1998). Like so many other oceanic islands, their biodiversity faces a variety of threats, including habitat loss, over-exploitation, and introduced invasive and predatory species (Jones *et al*. 1991, Ndang'ang'a *et al*. 2014). Add to this the tiny potential breeding range and Gulf of Guinea Storm Petrel, if classified taxonomically, will almost certainly qualify as threatened (Gascoigne 1995).

The most concerning threat to the storm petrel is the large number of non-native mammals (Dutton 1994). Predatory Black Rats *Rattus rattus* and feral cats *Felis catus* are well known for their devastating impact on seabird colonies (e.g. Zino *et al*. 2001, Madeiros 2005, Pinet *et al*. 2009). Other introduced mammals—such as African Civet *Civettictis civetta*, feral pigs *Sus scrofa* and Mona Monkey *Cercopithecus mona*—are also likely to negatively impact the storm petrel. The problem is exacerbated by the presence of these species in the remote and mountainous terrain of potential breeding colonies, where conservation efforts will be challenging. Furthermore, legal protection given to the best-preserved forest under the Obô Natural Park remains largely ineffective (Lima *et al*. 2017).

The three most pressing issues for future work on Gulf of Guinea Storm Petrel are clarifying its taxonomy, locating breeding colonies and establishing the threats to those sites. Additionally, it is important to gain a better understanding of phenology and ecology, both at sea and on land, including dispersive and migratory behaviour, and to assess population size and conservation status.

Acknowledgements

We thank Vincent Bretagnolle for refereeing the submitted manuscript. We are grateful to curators Paul Sweet and Bentley Bird (American Museum of Natural History, New York) for arranging access for RLF to the Correia diaries and the four Gulf of Guinea Storm Petrel skins collected on São Tomé by the Correias in 1928. Angus Wilson supported RLF during his visit to AMNH in November 2018. We are grateful to Judite Alves (Universidade de Lisboa, Museu Nacional de História Natural e da Ciência, Lisboa, Portugal) and Rui Figueira (Centro de Investigação em Biodiversidade e Recursos Genéticos, Universidade do Porto, Portugal) for information concerning the Bocage collection. Magnus Robb kindly commented on our Gulf of Guinea Storm Petrel sound-recordings. Hans Matheve produced the sonograms. Guides Ricardo 'Mito'

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Fonseca, 'Sherito' and Octávio Veiga accompanied PV, RFL & MM to Monte Carmo on São Tomé. An Bollen and Veerle Dossche provided welcome companionship to PV during his first field trip to São Tomé Obô Natural Park. Nik Borrow kindly permitted publication of his in-hand photographs of Gulf of Guinea Storm Petrel taken on São Tomé. Mark Van Beirs and Dani López-Velasco provided general assistance. We thank everyone who shared their observations (Table 1), and BirdLife's São Tomé and Príncipe Initiative in particular, for access to their unpublished database. RFL & MM were supported by post-doctoral grants from the Portuguese government's 'Fundação para a Ciência e para a Tecnologia' (FCT/MCTES - SFRH/BPD/91494/2012; SFRH/BPD/100614/2014).

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ISSN-2513-9894 (Online)