

Variation and identification of Barolo Shearwater and Boyd's Shearwater

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There are two main reasons why the field separation of Barolo Shearwater *Puffinus baroli* (hereafter *baroli*) from Boyd's Shearwater *P. boydi* (hereafter *boydi*) has been neglected. First, historic taxonomic classification and recent taxonomic upheaval rarely afforded either taxon species-level status; *baroli* and *boydi* variously have been grouped under 'Little Shearwater *assimilis* types' and 'Audubon's Shearwater *lherminieri* types' (eg, Murphy 1927, Brooke 2004). Recent genetic research revealed ocean-basin centered evolution (Austin et al 2004, Sangster et al 2005, Olson 2010) and that the three North Atlantic Ocean taxa *baroli*, *boydi* and Audubon's Shearwater *P. lherminieri* (hereafter *lherminieri*) form a clade. This clade is either treated as one species (Carbo-neras et al 2019), two species with *baroli* and *boydi* combined (Sangster et al 2005) or *lherminieri* and *boydi* combined (Onley & Scofield 2007), or three separate species (Olson 2010, Howell 2012, CSNA 2019). Second, *baroli* and *boydi* were assumed to be sedentary with non-

overlapping ranges (eg, Onley & Scofield 2007). Recent data logger studies, however, revealed that at-sea ranges overlap, mainly during the breeding season (figure 1-2; references in captions). They visit each other's breeding islands, *baroli* visiting the Cape Verde Islands and *boydi* the Canary Islands. *Boydi* has been photographed in the Canary Islands (Gil-Velasco 2013) and one was sound-recorded in a *baroli* colony at South Timanfaya, Lanzarote (Marcel Gil-Velasco in litt).

The combination of birders travelling farther afield, increasing popularity of pelagic birding and cumulative evidence (eg, subtly distinct vocalisations; Robb et al 2008) that *baroli* and *boydi* are indeed separate species has brought more birders into contact with these two shearwaters. Like us (Robert Flood and Rinse van der Vliet), birders are finding that separating the two is not always straightforward: a friend sent photographs of a *boydi* from the Cape Verde Islands saying, 'This white-faced little shearwater must be *baroli*, don't you think?' During a tour, a client said about

269 Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, off Lanzarote, Canary Islands, 21 August 2014 (Juan Sagardia). Close to 'classic' with large dark eye mainly surrounded by white feathers, whitish in under primaries, white undertail-coverts, and two-toned up-pewings with pale greater secondary coverts and secondaries visible on left wing.



270 Boyd's Shearwater / Kaapverdise Kleine Pijlstormvogel *Puffinus boydi*, off Raso, Cape Verde Islands, 24 March 2009 (Vaughan Ashby). Close to 'classic' with dark feathering around eye leaving bulging whitish fore-supercilium, dark under primaries contrasting with white underwing coverts, and dark in undertail-coverts.



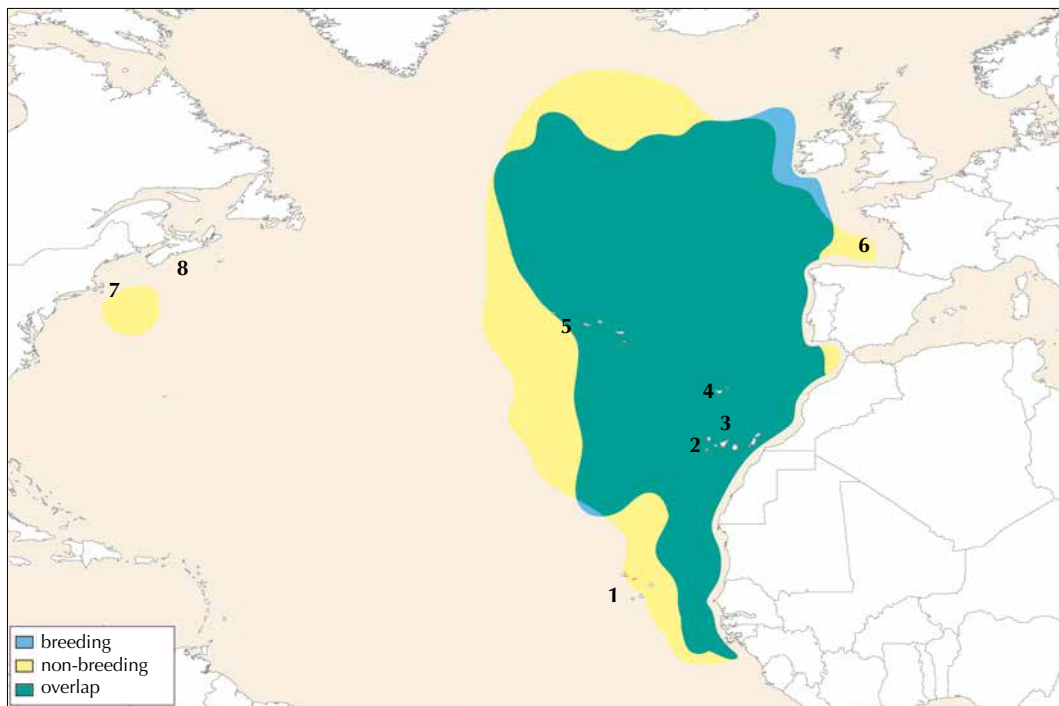


FIGURE 1 Breeding and non-breeding ranges of adult Barolo Shearwater *Puffinus baroli* from Azores, Porto Santo and Selvagens constructed from data logger results (Neves et al 2012, Ramos et al 2015, Fagundes et al 2016, Paiva et al 2016; map prepared by Ashley Fisher). Sight records incorporated for Bay of Biscay and north-western Atlantic Ocean over waters off Massachusetts, USA, and Nova Scotia, Canada. Additional extralimital records given in appendix 3. Breeding range includes results from 2010/11 when there was a marked negative North Atlantic Oscillation Index that caused low marine productivity and shearwaters to forage farther north and west than in 2011/12 (Fagundes et al 2016). **1** Cape Verde Islands, **2** Canary Islands, **3** Selvagens, **4** Madeira and Porto Santo islands, **5** Azores, **6** Bay of Biscay, **7** Massachusetts, **8** Nova Scotia.

our only *baroli* off Selvagens, 'I would like to have seen more of white in the face and in the underwings to convince me that it was *baroli*.' Photographs of a *baroli* taken from land at c 400 m range off South Uist, Outer Hebrides, Scotland, in September 2018 generated discussion on social media about the merits for *boydi*. In all cases, the questions raised were reasonable, highlight the need for this article and illustrate that the topic is not properly documented in well-used guides (eg, Blomdahl 2003, Brooke 2004, Onley & Scofield 2007, Svensson 2010, Howell 2012, Carboneras et al 2019).

Study features

We investigated 13 traits of *baroli* and *boydi*, searching for variation within and between species (plate 269-270, respectively, show 'near classics'): **1** face pattern; **2** lateral extension of dark hind-neck; **3** two-toned upperwing; **4** whitish tips to

upperwing median and greater secondary coverts; **5** pattern and tone of under primaries; **6** undertail-covert pattern; **7** fore inner underwing-covert pattern; **8** axillary pattern; **9** underwing greater secondary covert sub/terminal spots/blotches; **10** moult phenology; **11** bare parts; **12** flight behaviour; and **13** size and structure.

Data collection

Data collection involved museum skins, adults at breeding colonies and birds at sea. We studied a combined total of 246 *baroli* and 154 *boydi*.

Museum skins

We used online museum collection search platforms, contacted 38 museums in Europe and North America, and identified 25 museums that held skins of *baroli* and/or *boydi*. These museums combined held 139 *baroli* and 84 *boydi* skins. We visited museums with the largest collections of

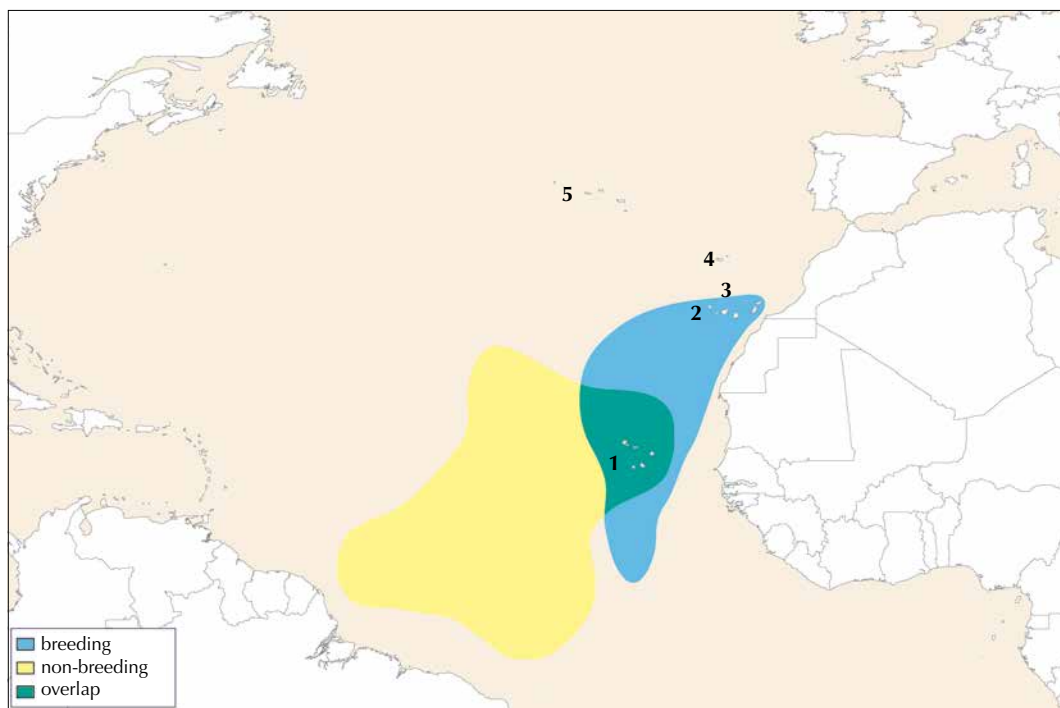


FIGURE 2 Breeding and non-breeding ranges of adult Boyd's Shearwater *Puffinus boydi* from Cima and Raso, Cape Verde Islands, constructed from data logger results (Zajková et al 2017; map prepared by Ashley Fisher). Sight records incorporated for Canary Islands. 1 Cape Verde Islands, 2 Canary Islands, 3 Selvagens, 4 Madeira and Porto Santo islands, 5 Azores.

skins where possible: Natural History Museum, Funchal, Madeira; Manchester Museum, Manchester, England; Muséum National d'Histoire Naturelle, Paris, France; American Museum of Natural History, New York, USA; and Natural History Museum, Tring, England (hereafter NHMUK). We asked curators of the other museums (see acknowledgements) to photograph where possible the nine plumage aspects mentioned above of each skin. A total of 81 *baroli* skins were examined (70 by us during museum visits, the rest using photographs taken by museum curators), and 83 *boydi* skins (44 by us during museum visits, the rest using photographs taken by museum curators). We measured bill dimensions using calipers and extracted biometric data from museum labels.

Adults at breeding colonies

We studied and photographed adult *baroli* on Cima islet, Porto Santo, Madeira, and Selvagem Grande, Selvagens. We received additional photographs and data from breeding colonies in the Azores, the Canary Islands, Madeira and Selvagem Grande (see acknowledgements). A total of 126 birds were photo-

graphed in hand at breeding colonies and we were present to see 96 of them. Seven skulls from Selvagem Grande were measured. We were unable to visit a colony of *boydi* in the Cape Verde Islands but received in-hand photographs of nine adults from the Rombo islands, eight adults from Raso and one adult from Branco (see acknowledgements).

Birds at sea

Baroli was observed numerous times offshore from several of the Canary Islands, Madeira, Porto Santo and the Selvagens, and from ferries across the Bay of Biscay; between Cádiz, Spain, and Lanzarote; between Madeira and Porto Santo; and between Tenerife and La Gomera, Canary Islands. Photographs of 39 birds were assembled from these and other trips. Videoing birds in flight proved difficult but we captured several minutes of useful video footage. *Boydi* was observed at sea in the Cape Verde Islands during five separate trips offshore from the islands Brava, Fogo, Praia, Raso, Sal, Santiago and São Nicolau. We assembled photographs of 53 birds and captured c five minutes of useful video footage.

Score design and results

We designed simple odd-numbered interval scales with a middle number to measure variation in plumage aspect. The interval scales are categories and entail a degree of subjective judgement in categorisation, so we scored birds separately and reconciled differences.

Face pattern

The common understanding among birders is that the face pattern of *baroli* is characterised by a large dark eye mainly isolated by white feathers (eg, Svensson et al 2010); the face of *boydi* is characterised by a largely dark upper face enveloping the eye (eg, Blomdahl et al 2003, Onley & Scofield 2007). However, matters are not so simple. In a study of the small North Atlantic *Puffinus* shearwaters, Lee (1988) observed: 'On all species dark face mottling extends into the white plumage to a varying degree'. Field guides note for *baroli* 'dusky shading on cheeks and ears' (Onley & Scofield 2007), and 'area around eye and upper auriculars often freckled dark' (Howell 2012). In fact, the head pattern of both shearwaters is formed by a dark cap and white face with variable dark markings from the cap to below the eye. We scored variation using the criteria in table 1 and the *crux of each score* is the amount of the area of the upper face that is white (plate 271-276). We scored birds at colonies and at sea, but not museum specimens because taxidermic work alters feather arrangement around the eye.

Figure 3A shows the result for *baroli* at colony (c 82% from the Selvagens, rest from elsewhere) and figure 3B for *baroli* at sea (c 56% off the Azores, rest from elsewhere). The mean score for birds at colony is 2.9 and the data is more or less bimodal score 2 and score 3. The mean score for birds at sea is 2.4 and the mode is 2. Median and mode scores are lower for the birds at sea, presumably because less dense face markings visible at close range are not visible at distance, even less so in strong and direct sunlight. In all likelihood, this explains the difference between 37% of birds at colony with a 'classic' white-face (score 1 and score 2) versus the 61% at sea, rather than geographical variation between populations in the Selvagens and the Azores. A noteworthy c 24% of *baroli* at colony had a 'dark face' (score 4 and score 5; eg, plate 275), which as such is not reported in the literature, although this translated to only c 3% of birds photographed at sea in the sunny climes of the breeding range. In dull conditions, we expect more than 3% to show a dark face. For example, at dusk several miles offshore

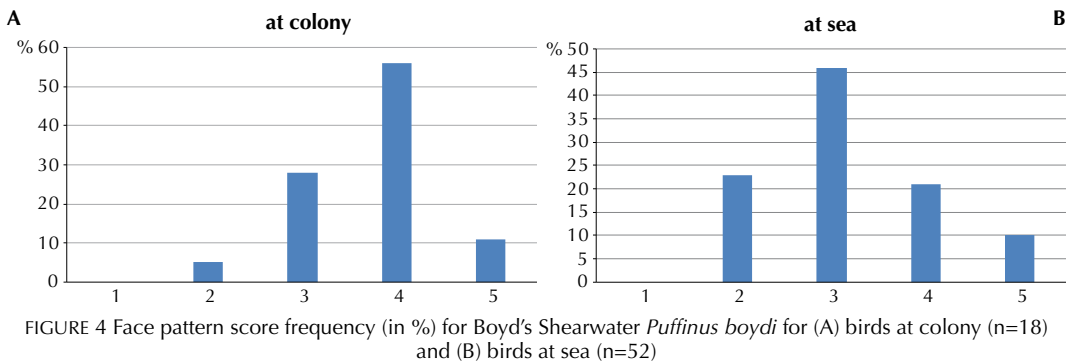
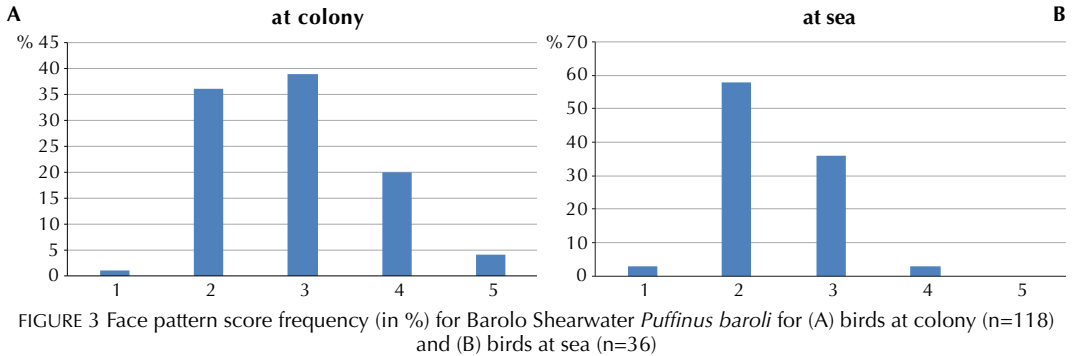
from Porto Santo in May 2018 and in April 2019, we saw over 50 *baroli* and more than a few looked dark faced.

Figure 4A shows the result for *boydi* at colony and figure 4B for *boydi* at sea. The mean score for birds at colony is 3.7 and the mode is 4. The mean score for birds at sea is 3.2 and the mode is 3. As with *baroli*, the presumed reason for lower scores of birds at sea is the effect of distance and light on the visibility of less dense markings.

The mean and mode scores for *baroli* and *boydi* indicate that, on average, *boydi* is darker faced than *baroli*. Of importance, most *boydi* around mid-score show one or both of: **1** a pale fore-supercilium bulge; and **2** a dark band from eye to cap, angled forward and upward. One *boydi* at colony had a 'white face' (score 2; appearance similar to plate 272, on which also note fore-supercilium bulge and dark band from eye to cap), which as such is not reported in the literature. C 27% of birds at sea appeared 'white faced'.

TABLE 1 Criteria for scoring face markings of Barolo Shearwater *Puffinus baroli* and Boyd's Shearwater *P. boydi*. Note that *boydi* around mid-score 2-4 typically show one or both of **1** pale fore-supercilium bulge, and **2** dark band from eye to cap, angled forward and upward.

Score Criteria	
1	Largely white upper face > 'white faced' Large dark eye isolated by mainly white feathers Thick largely white supercilium Small dark fore-supercilium smudge Ear-coverts with limited dark marks Few if any dark marks under eye Broad white gap separating cap from gape
2	Intermediate between score 1 and 3
3	Unbroken mainly narrowish white supercilium Posterior lore marked and joining cap Ear-coverts more densely marked Variable broken line of dark marks under eye Broad to narrow white gap separating cap from gape
4	Intermediate between scores 3 and 5
5	Almost complete cap to below eye > 'dark faced' Maximum small pale area in fore-supercilium May have narrow spectacles Ear-coverts densely marked Almost complete line of dark marks under eye Broad to narrow white gap separating cap from gape



Lateral extension of dark hindneck

The amount that the dark hindneck of bicolored *Puffinus* shearwaters extends laterally around the neck, and the amount that it continues under the forewing onto the fore-flank, varies *within and between* species. The blackish-grey hindneck of *baroli* typically extends a small amount laterally around the neck, leaving extensive white on the neck side, with a shallow extension under the forewing onto the fore-flank, falling just short of the upperbreast. The blackish-brown hindneck of *boydi* typically extends quite far laterally around the neck, with a deep extension under the forewing onto the fore-flank and onto the upperbreast. Compare *baroli* plate 278 with *boydi* plate 272, and *baroli* plate 289 with *boydi* plate 303. Presentation of this feature in the field is determined by the angle of view and the bird's head movements, although the 'true' lateral extension should be evident with the multiple angles seen during prolonged views (or in multiple photographs or in video footage).

Two-toned upperwing

The open upperwing of *baroli* is two-toned (Robb et al 2008, Svensson et al 2010). Photographs that

we studied of *baroli* in flight show high-contrast pale grey panels variously on the inner wing and the outer wing (eg, plate 277). The panels have been attributed to reflection (in general discussion), to wear in adults (Curtis et al 1985) or to a consistent aspect of plumage (McGehean & Mullarney 1995, BWPi 2006). The feature is not mentioned by Onley & Scofield (2007), Howell (2012) or Carboneras et al (2019). Curtis et al (1985) speculated that vagrants to north-western Europe are dispersive fresh juveniles, not worn adults with two-toned upperwings, but the point about age is disproved by geolocator studies of adults (figure 1; references in caption).

Baroli has a greyish 'bloom' structure over much of its plumage (plate 278). A property of the bloom, especially on the larger feathers of the upperwing, is its shiny pale grey appearance when catching the light, which is probably a result of the nano-structure of the feathers (appendix 1). In other words, the two-toned upperwing is attributable to the reflective property of a consistent aspect of plumage. The larger wing-feathers of near-fledged museum specimens are covered in a greyish bloom, except for matt blackish-brown fringes and shafts (plate 279). The bloom on freshly moulted



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See captions on facing page

271 Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, Selvagem Grande, Selvagens, 6 June 2010 (Frank Zino)
272 Boyd's Shearwater / Kaapverdische Kleine Pijlstormvogel *Puffinus boydi*, off São Nicolau, Cape Verde Islands, 1 April 2017 (Martin Gottschling) **273** Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, Selvagem Grande, Selvagens, 31 March 2016 (Rinse van der Vliet) **274** Boyd's Shearwater / Kaapverdische Kleine Pijlstormvogel *Puffinus boydi*, off São Nicolau, Cape Verde Islands, 1 April 2017 (Kris De Rouck) **275** Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, Selvagem Grande, Selvagens, 24 March 2016 (Thijs Valkenburg) **276** Boyd's Shearwater / Kaapverdische Kleine Pijlstormvogel *Puffinus boydi*, off Raso, Cape Verde Islands, 24 March 2009 (Vaughan Ashby).

We were forced to use photographs of *boydi* at sea because of relatively few suitable photographs available of *boydi* at colony. Left-hand column top down shows adult *baroli* with face score 1, 3, and 5, respectively. Top bird (plate 271) is 'classic white-faced' individual with large dark eye surrounded by white feathers and only limited dark markings. Middle bird (plate 273) has broken, mainly narrowish white supercilium, bulging somewhat at front, posterior lores marked and joining cap, ear-coverts quite densely marked, and some dark marks under eye. Bottom bird (plate 275) is 'dark-faced' individual with almost complete dark cap to below eye, small pale area in fore-supercilium, ear-coverts densely marked, and almost complete line of dark marks running under eye. Right-hand column top down shows *boydi* with face score 2, 3, and 5, respectively. Top bird (plate 272) is 'white-faced' rather like 'classic' *baroli*, although top and middle birds (plate 274) show characteristic *boydi* dark band in fore-supercilium, angled forward and up, from eye to cap, giving unfriendly look to face. Compared with bottom *boydi* (plate 276), extreme face score 5 has solid dark cap around and well below eye.

adults is more difficult to assess because they are at sea and the few that visit the colony out of season are mostly aerial and uncatchable (Frank Zino in litt). Photographs of fresh adults at sea give the impression of a bloom cover like near-fledglings. However, the bloom on breeding adults at colony is mainly restricted to areas of a feather protected by adjacent feathers, while the rest of the feather is matt blackish-brown where the bloom evidently has worn off (plate 280-281). Wear reduces the bloom and renders the upperwing-feathers increasingly matt and darker, not paler (contra Curtis et al 1985). It follows that the two-toned upperwing of worn *baroli* in flight should be less contrasting than fresh *baroli*.

The literature does not describe *boydi* with a two-toned upperwing. There was no opportunity for close study of freshly moulted adults for the same reason given for freshly moulted adult *baroli*. However, photographs of relatively fresh *boydi* in flight show some evidence of a greyish bloom over the larger wing-feathers (eg, plate 283 and 285), although they do not show a strongly contrasting two-toned upperwing (possibly different nanostructure cf *baroli*). There were no near-fledglings for study in museum specimens or photographed at colony. There is no clear evidence of *boydi* with a two-toned upperwing but further research is required.

Whitish tips to upperwing median and greater secondary coverts

In fresh plumage, adult *baroli* and *boydi* have white tips to the upperwing median and greater secondary coverts that form prominent white 'pencil lines' across the inner wing (plate 282-283). The pencil lines are a known feature of *baro-*

li (eg, Robb et al 2008, Svensson et al 2010, Howell 2012, although not mentioned by Onley & Scofield 2007) and a new feature for *boydi*. Juvenile *baroli* have an indistinct mid-grey pencil line across the tips of the greater secondary coverts, found on juveniles on Tenerife (this study) and museum skins at NHMUK (Howell 2012) (Robb et al 2008 show juvenile the same as a fresh adult). We were unable to check this feature for juvenile *boydi*. White pencil lines in fresh-plumaged adult *baroli* emphasize the two-toned appearance of the upperwing (plate 277).

As feathers age, the white tips become duller and wear off (noted in Howell 2012, rarely elsewhere). We found that median coverts wear more quickly than greater, and inner coverts more quickly than outer. We scored birds at colony and at sea by month by judging the prominence of the white tips in each covert tract: **1** prominent at range (fresh clean-white tip to all coverts); **2** visible with reasonable views (worn whitish tip to all coverts); **3** perhaps visible with good views (dirty white tip to about the outer third to two-thirds of the coverts); **4** probably only visible in photographs of birds in the hand (worn dingy tip to about the outer third of the coverts); and **5** completely worn off.

White tips to the median secondary coverts of 88 breeding adult *baroli* in the Selvagens were completely worn off in January and March (table 2; plate 284). White tips to the greater secondary coverts of 76 of them were either completely worn off or barely visible remnants (score 4-5) but pale tips were still potentially visible on the remaining 12 birds (score 2-3; plate 284). Light wear is expected in the few months that follow the complete post-breeding moult. Thus, the majority



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277 Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, off Madeira, 6 August 2012 (Hugo Romano/Madeira Wind Birds) **278** Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, off Graciosa, Azores, 17 August 2014 (Chris Gibbins). Bird in plate 278 shows grey 'bloom' covering dorsal surface of larger upperwing-coverts and remiges, as well as scapulars, nape to up-tail-coverts, and rectrices. Bird in plate 277 shows effect of shiny nature of this bloom with contrasting pale panels in inner wings and outer left wing. **279** Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, 'female bird of the year' (collected 4 June 1913 by D A Bannerman, Montaña Clara, Canary Islands), Natural History Museum, Tring, England, 5 April 2019 (Robert L Flood). Grey 'bloom' is apparent over entirety of these fresh feathers, except for matt fringes and shafts.

of 12 non-juveniles at sea in August showed prominent or fairly conspicuous white pencil lines across both median and greater secondary coverts (plate 282). Just two September birds were scored and, somewhat surprisingly, both showed heavy wear to tips of the median and greater secondary coverts, perhaps being older immatures or failed breeders that moulted earlier than successful breeding adults.

Of 36 *boydi* photographed at colony or at sea in February-June, white tips to the median secondary coverts were completely worn off on 35 birds (table 3; score 5; plate 285). The greater secondary coverts were largely or completely worn off on 26 birds (score 4-5), although may have been visible at sea on the other 10 birds (score 2-3; plate 285). Only three birds were photographed soon after the complete post-breeding moult, in October, and all had fairly prominent to prominent white pencil lines along both covert tracts (score 1-2; plate 283).

Pattern and tone of under primaries

Mainstream literature states that *baroli* has white under primaries with dark borders and little or no contrast between remiges and the white underwing-coverts; *boydi* has dark under primaries and strong contrast between remiges and the white underwing-coverts (eg, Onley & Scofield 2007). Carboneras et al (2019) simply liken *baroli* to Little Shearwater *P assimilis* that has 'a white underwing with dark trailing edge', and BWPi (2006) equally simply states that the underwing including the basal primary area is white. However, there are published photographs of *baroli* with dark under primaries resembling *boydi* (Holmström 2005, Crochet 2006; also plate 286-287).

We looked at the inner web of p8-10 (the most accessible/visible primaries) of 145 *baroli*, inspecting 44 museum specimens from many locations, and evaluating photographs of 101 adults at colony (86 from the Selvagens, rest from elsewhere). A clearly defined white tongue was present in c 61% of museum specimens and c 21% of



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280-281 Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, Selvagem Grande, Selvagens, 19 March 2016 (*Thijs Valkenburg*). Plate 281 shows magnified portion of plate 280. Greater secondary coverts and secondaries blackish-brown with grey 'bloom' over most of inner web and basally outer web, regions generally protected from wear by adjacent feathers, while marginal and lesser coverts are least grey. Pale grey in some of ruffled outer greater secondary/inner greater primary coverts results from shine of grey bloom. **282** Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, off Madeira, 24 August 2017 (*Martijn Verdoes*) **283** Boyd's Shearwater / Kaapverdische Kleine Pijlstormvogel *Puffinus boydi*, off São Nicolau, Cape Verde Islands, 6 October 2017 (*Martin Gottschling*) **284** Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, Selvagem Grande, Selvagens, 31 March 2016 (*Rinse van der Vliet*) **285** Boyd's Shearwater / Kaapverdische Kleine Pijlstormvogel *Puffinus boydi*, Raso, Cape Verde Islands, 14 February 2004 (*Arnoud B van den Berg*). Middle row: in fresh autumn plumage, both adult *baroli* and the presumed adult *boydi* have white tips to upperwing median and greater secondary coverts, forming two prominent white pencil lines across inner wing. Bottom row: white tips largely wear away by breeding season, here with white tips to median secondary coverts completely worn away and just remnants on outer greater secondary coverts.

Variation and identification of Barolo Shearwater and Boyd's Shearwater

TABLE 2 Barolo Shearwater *Puffinus baroli* scores by month for prominence of white tips to median (MSC) and greater (GSC) secondary coverts at colony and at sea

Month	Score 1	Score 2	Score 3	Score 4	Score 5	Tract	Location
January	–	–	–	–	1	MSC	at colony
	–	–	1	–	–	GSC	
March	–	–	–	–	87	MSC	at colony
	–	1	10	70	6	GSC	
August	–	2	7	3	–	MSC	at sea
	1	8	3	–	–	GSC	
September	–	–	–	1	1	MSC	at sea
	–	–	1	1	–	GSC	

TABLE 3 Boyd's Shearwater *Puffinus boydi* scores by month for prominence of white tips to median (MSC) and greater (GSC) secondary coverts at colony and at sea

Month	Score 1	Score 2	Score 3	Score 4	Score 5	Tract	Location
February	–	–	–	–	2	MSC	at colony
	-	-	-	1	1	GSC	
March	-	-	-	-	8	MSC	at colony
	-	-	-	2	6	GSC	
	-	-	-	–	11	MSC	at sea
	–	1	1	–	9	GSC	
April	–	–	–	–	8	MSC	at sea
	–	3	2	1	2	GSC	
May	–	–	–	–	5	MSC	at sea
	–	–	2	1	2	GSC	
June	–	–	1	–	1	MSC	at sea
	–	1	–	–	1	GSC	
October	2	1	–	–	–	MSC	at sea
	3	–	–	–	-	GSC	

TABLE 4 Number of Barolo Shearwaters *Puffinus baroli* with or without clearly defined white tongues in under primaries (Y = clearly defined white tongues, N = no clearly defined white tongues, percentages to nearest whole number). Madeira includes Desertas Islands and Porto Santo (and islets).

Location	Museum		Colony		Museum + colony	
	Y	N	Y	N	Y	N
Azores	2 (100%)	0 (0%)	8 (62%)	5 (38%)	10 (67%)	5 (33%)
Canary Islands	8 (62%)	5 (38%)	0 (0%)	1 (100%)	8 (57%)	6 (43%)
Selvagens	3 (43%)	4 (57%)	12 (14%)	74 (86%)	15 (16%)	78 (84%)
Madeira	14 (64%)	8 (36%)	1 (100%)	0 (0%)	15 (65%)	8 (35%)
Σ	27 (61%)	17 (39%)	21 (21%)	80 (79%)	48 (33%)	97 (67%)

birds at colony (plate 288), averaging out to c 33% showing this characteristic (table 4). Clearly defined white tongues may have been easier to detect on skins in the hand or, more likely, the feature is on average scarcer in the *Selvagens* population that dominated the data (more research required). The ranges of the percentages of the length of the inner web covered by a white tongue were p10 (10-60%), p9 (5-40%) and p8 (0-30%). The middle and inner primaries may also show a white tongue.

Of 23 birds photographed at sea, 20 of which were photographed off the Azores and the Canary Islands, c 69% gave at least the impression of clearly defined white tongues in the under primaries (plate 289), fairly consistent with the percentage for museum specimens. However, experienced shore-based observers gain the impression of white in the under primaries from 'most' *baroli*. Assuming *baroli* with dark-grey under primaries have not been overlooked, a factor that may explain the difference is pale tones in the under primaries other than clearly defined white tongues.

We found that many adults at colony had variable-sized diffuse off-white or pale greyish regions in the under primaries that cross-dissolve with dark grey surroundings (plate 290). These pale regions could give rise to a whitish impression when observed at range. A noteworthy c 5% of birds had wholly dark grey under primaries (plate 286). At NHMUK, we investigated reflectivity of dark grey under primaries of *baroli* and found that the paleness changed somewhat with angle of light but at no time did it appear very pale or whitish. Thus, in the field we expect c 5% of *baroli* to show dark grey under primaries in strong contrast with white underwing-coverts (the nearest example that we have is plate 287). White tongues may not be clearly visible on back-lit wings (plate 291).

Of the 18 *boydi* photographed at colony, multiple photographs showed that one had clearly defined white tongues (plate 292) and one had diffuse whitish tongues (plate 294). Of 16 specimens at NHMUK, the inner web of p10 on one specimen had c 5% clearly defined white basally, while another specimen had a diffuse whitish tongue fading out about a third of the way along the inner web (plate 296). Of 37 birds photographed at sea, 35 showed dark under primaries in strong contrast with the white underwing-coverts (plate 293), of those 35 there were several examples of under primaries reflecting light and appearing mid-grey, thus softening the contrast (plate 295), while two birds showed fairly well-defined white tongues to about a third of the way along the inner web (pres-

ent in multiple photographs of each bird; plate 297). White tongues in the under primaries is a new feature for *boydi*.

Undertail-covert pattern

Baroli is often illustrated with white undertail-coverts and *boydi* with much dark in the undertail-coverts (eg, Onley & Scofield 2007; plate 298-299, plate 306-307). However, Lee (1988) examined 25 *boydi* skins and found that about half of them had white extending well into the undertail-coverts, which led him to conclude that dark undertail-coverts are 'an unreliable field mark' for the separation of *boydi* from *baroli*.

In the *Selvagens* colony, 20% of 75 *baroli* had limited darkish markings to the tip of the longest undertail-coverts (plate 300) while the rest were unmarked (consistent with Onley & Scofield 2007, Robb et al 2008, and Howell 2012). C 80% had largely white inner and dark outer webs to the lateral undertail-coverts (plate 300) and most of the remainder also had limited to heavy markings on the inner web (plate 302), although a few had limited markings on the outer web only or an eccentric pattern. The undertail region can resemble *boydi* in cases where both webs of the lateral undertail-coverts are largely dark and the long white undertail-coverts are missing or parted (compare plate 304 of *baroli* with plate 305 of *boydi*).

The undertail-coverts of *boydi* range from largely whitish in exceptional cases (plate 301), thus resembling *baroli*, to largely dark (as suggested by Robb et al 2008; plate 303 and 305). We found the following variation in the undertail-coverts of museum specimens: all dark, dark with variable whitish distally, whitish inner web and dark outer web, and whitish with variable dark distally (similar to *Iherminieri*; Howell 2012). The lateral undertail-coverts are usually all dark (plate 305). However, shorter pairs sometimes have white inner webs that form white sides to the undertail-coverts, thereby isolating the central dark undertail-coverts. In a sort of illusion, if the large feet cover the dark central undertail-coverts, it is easy to be fooled into thinking that the hidden undertail-coverts are also white.

We broadly agree with Lee (1988), in that c 50% of *boydi* have from little to quite extensive whitish extending into the undertail-coverts, although we disagree that undertail-covert pattern is an unreliable field mark per se.

Fore inner underwing-coverts

We studied the dark triangular-shaped wedge found in the fore inner underwing-coverts (base

Variation and identification of Barolo Shearwater and Boyd's Shearwater



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286 Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, Selvagem Grande, Selvagens, 28 March 2016 (*Thijs Valkenburg*) **287** Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, off Madeira, 11 September 2009 (*Carlos Gutiérrez Expósito*) **288** Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, off Azores, 25 January 2017 (*Verónica Neves*) **289** Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, off Lanzarote, Canary Islands, 17 August 2014 (*Miguel A Rouco Fernandez*) **290** Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, Selvagem Grande, Selvagens, 25 March 2016 (*Rinse van der Vliet*) **291** Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, off Madeira, 28 August 2012 (*Hugo Romano/Madeira Wind Birds*). Middle row shows 'classic' birds, with clearly defined white tongues on inner webs of under primaries, which at sea translates to dark bordered largely whitish underwing. Top row shows birds with dark-grey under primaries like 'classic' *boydi* (although bird at sea shows some whitish in middle under primaries). In bottom row, left-hand bird shows only fairly diffuse pale regions in under primaries, while white tongues of right-hand bird are barely visible in back-lit left wing.



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292 Boyd's Shearwater / Kaapverdische Kleine Pijlstormvogel *Puffinus boydi*, Rombo islands, Cape Verde Islands, 12 March 2019 (Jacob Gonzáles-Solis) **293** Boyd's Shearwater / Kaapverdische Kleine Pijlstormvogel *Puffinus boydi*, off Raso, Cape Verde Islands, 30 April 2018 (Geoff Jones) **294** Boyd's Shearwater / Kaapverdische Kleine Pijlstormvogel *Puffinus boydi*, Rombo islands, Cape Verde Islands, 12 March 2019 (Jacob Gonzáles-Solis) **295** Boyd's Shearwater / Kaapverdische Kleine Pijlstormvogel *Puffinus boydi*, off São Nicolau, Cape Verde Islands, 25 March 2007 (René Pop) **296** Boyd's Shearwater / Kaapverdische Kleine Pijlstormvogel *Puffinus boydi* (collected 15 March 1897 by Alexander Boyd, Brava, Cape Verde Islands), Natural History Museum, Tring, England, 31 October 2018 (Robert L Flood) **297** Boyd's Shearwater / Kaapverdische Kleine Pijlstormvogel *Puffinus boydi*, off São Nicolau, Cape Verde Islands, 1 April 2017 (Martin Gottschling). Top left bird (plate 292) has clearly defined white tongues c 45% of length of inner web of p8-9 in left wing (same in right wing, except p8 diffuse whitish), middle left bird (plate 294) has diffuse whitish tongues fading out along inner webs of p8-10, and bottom left bird (plate 296) has diffuse whitish tongue fading out along inner web of outermost primary. Top right bird (plate 293) has 'classic' all dark under primaries in strong contrast with white underwing-coverts, middle right bird (plate 295) has under primaries reflecting light and appearing mid-grey, and bottom right bird (plate 297) has whitish tongues in under primaries rather like 'classic' *baroli*.

along the leading edge and apex in the lesser coverts; plate 308-309). We scored three variables: **1** size of triangle (large, medium or small); **2** pattern (uniform dark, boldly chequered or lightly chequered); **3** tone (blackish-grey, mid-grey or pale grey). For both species, most of the 27 possible combinations occurred, the most frequent size was medium, all three patterns were found in roughly equal numbers, and the tone in about half of the birds was mid-grey, with blackish-grey and pale grey each accounting for the rest in roughly equal numbers. Quite often, white shortest lesser secondary coverts running along the base of the triangle separated the dark triangle from the dark leading edge of the inner forewing.

Axillaries

We analysed the amount of dark markings in the axillaries. For both species, c half of the birds had unmarked axillaries, the rest had a relatively small amount of markings, mainly comprising a small to large dark sub/terminal spot/mark on the longest axillaries.

Underwing greater secondary covert spots

We studied the dark sub/terminal spots/markings that are often found in the greater secondary coverts. The tally for spots/markings in the following categories was similar for both species: on all of the coverts (plate 310), on the inner 75%, on the inner 50%, on the inner 25%, unmarked (plate 311). The last two categories occurred least frequently and accounted for c 20% of the birds,

while the other three categories each accounted for somewhere between 20-35% of the birds.

Moult phenology

We investigated primary moult but found moult phenology of the two species too closely aligned to be of value to the process of identification.

Bare parts

The tibia, tarsus and toes of both *baroli* and *boydi* are blue, the webs bluish/pinkish; and the outer side of the tarsus and toes, and the toe pads and claws blackish (plate 312). *Boydi* at colony mainly showed a clearly defined two-toned bill, with dark-grey nasal tubes, culminicorn and ungues, while the rest of the bill was paler grey-blue (plate 313). *Baroli* at colony had similar colours and pattern but the borders of the markings generally were not as well defined, hence the bill most typically appeared less two-toned (plate 271, 273 and 275). Research is required on a larger sample of *boydi* to establish whether a well-defined bill pattern offers a useful field mark.

Flight behaviour

In our experience, *baroli* in travelling flight flies like no other shearwater and once seen should not be forgotten. *Baroli* propels itself along (McGeehan & Mullarney 1995) rather than utilising wind to arc and shear. The flight is fast and direct, involving short series of stiff wing-beats interspersed by short glides. It tilts rather than shears, remains close to the sea surface, and fre-

298 Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, off Graciosa, Azores, 6 February 2015 (Peter Alfrey)

299 Boyd's Shearwater / Kaapverdise Kleine Pijlstormvogel *Puffinus boydi*, off São Nicolau, Cape Verde Islands, 1 April 2017 (Martin Gottschling). Undertail-coverts of small *Puffinus* shearwaters are best seen on birds resting at sea. These photographs show 'classic' *baroli* (plate 298) with white undertail-coverts and 'classic' *boydi* (plate 299) with extensive dark in undertail-coverts.



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300 Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, Selvagem Grande, Selvagens, 19 March 2016 (*Thijs Valkenburg*) **301** Boyd's Shearwater / Kaapverdische Kleine Pijlstormvogel *Puffinus boydi*, off São Nicolau, Cape Verde Islands, 25 March 2007 (*René Pop*) **302** Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, Selvagem Grande, Selvagens, 31 March 2016 (*Rinse van der Vliet*) **303** Boyd's Shearwater / Kaapverdische Kleine Pijlstormvogel *Puffinus boydi*, off São Nicolau, Cape Verde Islands, 1 April 2017 (*Martin Gottschling*) **304** Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, Selvagem Grande, Selvagens, 28 March 2016 (*Thijs Valkenburg*) **305** Boyd's Shearwater / Kaapverdische Kleine Pijlstormvogel *Puffinus boydi*, Rombo islands, Cape Verde Islands, 12 March 2019 (*Jacob González-Solís*). Left-hand column (plate 300, 302, 304) shows variation in undertail-coverts of *baroli*. Of particular note is bottom bird (plate 304) with white-tipped otherwise all-dark long lateral undertail-coverts not covered by white undertail-coverts, suggesting *boydi*. Right-hand column (plate 301, 303, 305) shows variation in undertail of *boydi*. Of particular note is top bird (plate 301) showing extensive white in undertail-coverts, suggesting *baroli*.



306 Barolo Shearwaters / Kleine Pijlstormvogels *Puffinus baroli*, Muséum National d'Histoire Naturelle, Paris, France, 12 September 2018 (*Rinse van der Vliet*) **307** Boyd's Shearwaters / Kaapverdische Kleine Pijlstormvogels *Puffinus boydi*, Muséum National d'Histoire Naturelle, Paris, France, 12 September 2018 (*Rinse van der Vliet*). Despite variation in undertail-covert coloration and pattern discussed in this article, there is fairly high degree of consistency as shown here in trays of museum specimens.





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308 Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, Selvagem Grande, Selvagens, 19 March 2016 (*Thijs Valkenburg*) **309** Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, Selvagem Grande, Selvagens, 31 March 2016 (*Rinse van der Vliet*). Left-hand example (plate 308) is most common variant with medium-sized 'triangle' that is lightly chequered and mid-grey. Right-hand example (plate 309) has fairly large 'triangle' that is reasonably uniform and blackish-grey. **310** Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, Selvagem Grande, Selvagens, 31 March 2016 (*Rinse van der Vliet*) **311** Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, Selvagem Grande, Selvagens, 28 March 2016 (*Thijs Valkenburg*). All greater secondary coverts in left-hand example (plate 310) have dark subterminal spots, while in right-hand example (plate 311) none have dark spots.

quently makes exaggerated head lifts. In light winds, *baroli* typically makes rapid stiff wing-beats, from two in less than 1 sec to 10-12 in just over 4 sec, interspersed with short glides lasting from 1 to 3-4 sec (Martin & Rowlands 2001) and often lands on the sea (Curtis et al 1985; pers obs). In moderate to strong winds, *baroli* makes low ascents, refrains from long sailing glides (Lee 1988), and banks rather than arcs (Martin & Rowlands 2001).

Boydi in light winds typically flies low to the surface, makes bursts of quick wing-beats interspersed by buoyant glides, and the slightly longer wings (see below) are visibly more flexible. In moderate to strong winds, *boydi* performs 'truer'

shearwater flight than *baroli* with relatively few wing-beats and longer glides, and makes shallow to fairly high wheeling arcs (appearing like a small *lherminieri*).

Many *baroli* and *boydi* sightings involve feeding birds. The modes of feeding behaviour in *Puffinus* shearwaters are mainly shared and not useful for identification: hydroplaning, pursuit-plunging, hanging and foot-pattering, snorkelling, pursuit diving, and surface-seizing.

Size and structure

Differences in biometrics of *baroli* and *boydi* summarized in table 5 identify several structural differences that are apparent in the field with experi-



312 Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, Selvagem Grande, Selvagens, 6 June 2010 (Frank Zino). Note colours and pattern.



313 Boyd's Shearwater / Kaapverdische Kleine Pijlstormvogel *Puffinus boydi*, Ilhéus do Rombo, Cape Verde Islands, 9 November 2018 (Jacob González-Solís). Note well-defined two-toned bill.

ence and good views (additional biometrics in appendix 2). Wing and tail measurements on average are slightly shorter for *baroli*. The wing of *baroli* is short and broad and the wing-tip can appear clipped and the wing action looks stiff. The wing of *boydi* is short-medium in length, fairly broad and the wing-tip often appears slightly blunt. The wing action looks more flexible than *baroli*. In terms of *Puffinus* shearwaters, on average the tail of *baroli* is short, while the tail of *boydi* is on average somewhat longer. Bill measurements of the two species largely overlap.

Variation between populations of baroli

We looked for evidence of differences in traits between populations of *baroli* from different island groups. Despite considerable effort, we were unable to compile sufficient data for multiple island groups, necessary to make substantive cross-comparisons. We are unable to comment on whether a greater percentage of *baroli* from the Canary Islands have dark-grey under primaries as suggested by Howell (2012). However, there is evidence that the Selvagens population has a less than average number of birds with clearly defined white tongues in the under primaries (as distinct from diffuse pale tones). We found that the dark face and the dark-grey under primaries are not specific to any island group (ie, both were evident in birds at colony and at sea off the Azores, Desertas, Madeira, Selvagens and Tenerife). We also noted that, broadly speaking, the Azores population is largest in size, the Selvagens smallest, and the Porto Santo islets intermediate (table 6).

Guidelines for separation and identification

Seven traits from the above presentation are useful to varying degrees for separation and identification of *baroli* and *boydi*: undertail-covert pattern, face pattern, pattern and tone of under primaries, two-toned upperwing, lateral extension of dark hindneck, travelling flight behaviour, and size and structure.

A notable amount of dark in the undertail-coverts eliminates *baroli* and all or nearly all white undertail-coverts virtually eliminates *boydi*. Caution is required, as c 50% of *boydi* have white extending into the undertail-coverts, and some have white running down the side to the undertail-coverts suggesting that the coverts if hidden by the feet are also white. That said, the undertail-covert pattern is a difficult feature to get to grips with in the field. In travelling flight, it is best seen in photographs taken when a bird banks, offering a ventral view. Even then the large feet of *baroli* and *boydi* can obscure most of the undertail region. Legs are used during take-off and landing offering an opportunity to see or photograph the undertail-covert pattern. Birds swimming at sea generally reveal their undertail-coverts (plate 298-299).

Face markings of *baroli* and *boydi* overlap considerably and the distribution of face markings is surprisingly variable, especially on *baroli*. On average, *boydi* is darker faced than *baroli*. In general, a white-faced bird (scores 1 and 2) is most likely to be *baroli*, while a dark-faced bird (scores 4 and 5) is most likely to be *boydi*, though only *baroli* is known to occur with face score 1. A pale fore-supercilium bulge and well-defined dark band an-

TABLE 5 Comparison of wing, tail and bill measurements (mm) of Barolo Shearwater *Puffinus baroli* and Boyd's Shearwater *P. boydi*. Data are: mean \pm 1SD, range (sample size) or range (sample size); sexes combined unless shown otherwise. ¹Olson (2010), ²Howell (2012), ³BWPi (2006), ⁴Silva & Olmos (2010), ⁵Rinse van der Vliet et al (unpublished at colony data), ⁶Robert Flood & Rinse van der Vliet (unpublished museum data) (source 2 incorporates measures from source 1).

Species	Wing	Tail	Bill
<i>baroli</i>	173.9 \pm 4.9, 165-183 (n=15) ¹ 165-183 (n=18) ² ♂ 184 \pm 4.9, 176-190 (n=7) ³ ♀ 179 \pm 5.0, 170-185 (n=6) ³ 177.9 \pm 5.8 (n=8) ⁴ 181.3 \pm 4.1, 170-192 (n=114) ⁵ 177.9 \pm 6.6, 168.9-189.2 (n=9) ⁶	71.3 \pm 3.7, 67-79 (n=15) ¹ 67-79 (n=18) ² 71.8 \pm 3.7, 67-78 (n=14) ³ 75.5 \pm 7.8 (n=8) ⁴	(24-28, n=18) ² ♂ 26.1 \pm 1.0, 24-28 (n=8) ³ ♀ 25.0 \pm 0.6, 24-26 (n=6) ³ 25.7 \pm 1.2 (n=8) ⁴ 25.0 \pm 0.8, 23.0-26.6 (n=54) ⁶
<i>boydi</i>	182.2 \pm 4.4, 174-188 (n=20) ¹ 174-188 (n=20) ² 188 \pm 3.9, 180-193 (n=15) ³ 181.6 \pm 11.4 (n=12) ⁴	76.7 \pm 2.0, 73-80 (n=20) ¹ 73-80 (n=20) ² 77.6 \pm 4.0, 71-84 (n=14) ³ 82.6 \pm 7.6 (n=12) ⁴	23-28 (n=20) ² 25.2 \pm 1.0, 23-28 (n=14) ³ 25.2 \pm 4.7 (n=12) ⁴ 24.5 \pm 0.8, 22.9-27.3 (n=42) ⁶

gled forward and upward from eye to cap are characteristic of *boydi*.

The pattern and tone of under primaries is a fairly reliable though not diagnostic way of separating *baroli* from *boydi*. Clearly defined white tongues or pale tones in the under primaries were found in c 95% of *baroli* and only c 8% of *boydi*. White tongues found in the under primaries of three *boydi* were about a third of the length of the visible under primary, shorter than many *baroli*. C 5% of *baroli* in dull light are likely to show dark under primaries contrasting with white underwing-coverts. We noted a small number of *baroli* with both dark face and dark-grey under primaries.

Two-toned upperwing as a support feature for *baroli* should be used with the caveat that our

study does not completely eliminate a two-toned upperwing in *boydi*. The two-toned upperwing of *baroli* presumably becomes less contrasting with wear thus the feature is less useful during the breeding season December-June.

Lateral extension of dark hindneck, treated with due caution, can be a useful indicator, with minimal extension pointing to *baroli*, and considerable extension pointing to *boydi*.

Overlap in the main aspects of plumage and further complications, for example, caused by light conditions and feather wear, mean that plumage traits are not always sufficiently revealing for safe separation of *baroli* from *boydi*. For this reason it is advisable to include all plumage traits in the process of identification.

Given our findings on plumage aspect, traits of

TABLE 6 Comparison of four key biometrics mass (g) and wing, tarsus and bill length (mm) for breeding adult Barolo Shearwater *Puffinus baroli* from three widespread geographical sites: Selvagem Grande, Selvagens; Cima islet, Porto Santo; and Vila, Baixo and Praia islets, Azores. Data are: mean (sample size); sexes combined, unless shown otherwise. ¹Robertson & James (1988), ²Fagundes et al (2016), ³Rinse van der Vliet et al (unpublished at colony data), ⁴Monteiro et al (1996), ⁵Veronica Neves (unpublished at colony data).

Location	Mass	Wing	Tarsus	Bill
Selvagens	♂ 160.3 (n=24) ¹ ♀ 151.2 (n=17) ¹ 163.5 (n=173) ² 165 (n=114) ³	♂ 177.5 (n=4) ¹ ♀ 178.6 (n=3) ¹ 181.1 (n=173) ² 181.3 (n=114) ³	♂ 36.8 (n=24) ¹ ♀ 36.2 (n=17) ¹ 36.7 (n=173) ² 36.6 (n=114) ³	♂ 25.4 (n=24) ¹ ♀ 25.1 (n=17) ¹
Porto Santo	169.3 (n=83) ²	182.6 (n=83) ²	37.2 (n=83) ²	
Azores	171.8 (n=157) ⁴ 202.5 (n=24) ⁵	182.6 (n=133) ⁴ 186 (n=24) ⁵	37.8 (n=93) ⁴ 37.3 (n=24) ⁵	25.4 (n=131) ⁴ 25.2 (n=24) ⁵

travelling flight behaviour, and size and structure take on an added importance. Travelling flight behaviour can be studied using video clips given in Flood & Fisher (2019). Wing and tail structure may be apparent in the field or in photographs.

Separation of *baroli* from *boydi* in most cases involves establishing agreement between a combination of the above traits. Particularly important are undertail-covert pattern, under primary pattern, face pattern and flight behaviour.

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Samenvatting

VARIATIE EN DETERMINATIE VAN KLEINE PIJLSTORMVOGEL EN KAAPVERDISCHE KLEINE PIJLSTORMVOGEL. Dit artikel biedt nieuwe inzichten in de variatie en determinatie van Kleine Pijlstormvogel *Puffinus baroli* en Kaapverdische Kleine Pijlstormvogel *P. boydi*. Uit dit onderzoek blijkt dat de variatie in sommige, voorheen belangrijk geachte kenmerken, groter is dan werd aangenomen. Zeven van de 13 bij beide soorten onderzochte kenmerken zijn meer of minder goed bruikbaar voor de determinatie. In de tekst is aangegeven welke bevindingen zijn gebaseerd op een kleine steekproef, hier moet een slag om de arm gehouden worden en is verder onderzoek nodig. De belangrijkste criteria in het verenkleed om beide soorten te onderscheiden zijn in volgorde van significantie als volgt:

Een aanzienlijke hoeveelheid donker in de onderstaartdekveren sluit *baroli* uit, terwijl volledig of bijna volledig witte onderstaartdekveren *boydi* in de meeste gevallen uitsluit. Echter de variatie is groot, zo heeft

c 50% van de onderzochte *boydi* wit op het basale deel van (vooral) de kleine onderstaartdekveren. Er zijn ook exemplaren met witte buitenvlaggen aan met name de buitenste onderstaartdekveren. Houd er bij vogels met een dergelijke tekening rekening mee dat in de vlucht de poten het grootste deel van de onderstaartdekveren bedekken. De kleur van de onderstaartdekveren is vaak goed te bepalen bij zwemmende vogels.

Er is veel overlap in de hoeveelheid tekening aan de zijkop (rond het oog en aan en bij de oorstreek). Echter, gemiddeld heeft *boydi* meer donkere tekening dan *baroli*. Een vogel met een hoofdzakelijk witte zijkop (score 1 en 2) is waarschijnlijk een *baroli*, een vogel met een uitgebreide donkere zijkop (score 4 en vooral 5) is waarschijnlijk een *boydi*.

Het patroon en de kleur aan de onderzijde van de (buitenste) handpennen is een redelijk betrouwbaar kenmerk om beide soorten te onderscheiden. Duidelijk lichte en lange tongen zijn een goede indicatie voor *baroli*. Houd hierbij rekening met het licht: door reflectie kan de onderhand lichter lijken en bij donker weer juist donkerder.

De tweekleurige bovenvleugel (met zilvergrijs zweem) van *baroli* is een aanvullend kenmerk maar sluit *boydi* mogelijk niet uit. Dit kleurcontrast op de bovenvleugel is tijdens het broedseizoen, tussen december en juni, minder opvallend door sleet.

De grootte van de zijborstvlak kan een indicatie zijn. Een vrij uitgebreide vlek wijst op *boydi*, een minder uitgebreide op *baroli*. Als het donker van de achterhals ver naar opzij loopt tot ver onder de voorvleugel op de voorflank en de bovenborst, wijst dat op *boydi*.

Door aanzienlijke overlap bij alle kenmerken is het vaststellen van een combinatie van deze kenmerken noodzakelijk, bij voorkeur ondersteund door goede foto's. Daarnaast is ook een juiste inschatting van structuur en formaat en het herkennen van de verschillende vliegwijzen van groot belang.

De twee vleugelstrepen (lichte toppen aan de grote en middelste bovendekveren) in vers kleed zijn niet diagnostisch voor *baroli*, maar ook aanwezig bij pas geruide *boydi*.

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APPENDIX 1 Nanostructures and colours in feathers

Nanostructures in feathers are responsible for blooms, shine and iridescence. A bloom results from elongated, curved and frilled barbs on the distal sides of the barbs and these wear off, revealing, for example, underlying dark in the outer primaries of terns Sternidae (Pyle 2008). Shine and iridescence result from a single layer of keratin over a melanin underlayer (Maia et al 2011) and possibly the keratin layer scratches or abrades, exposing a matt melanin underlayer. Low level magnification (20x) of coated large upperwing-coverts and upperside of remiges of Barolo Shearwater

Puffinus baroli in a trial study with Hein van Grouw at Natural History Museum, Tring, England, revealed an impression of a bloom-type nanostructure (Scanning Electron Microscopy required for confirmation). A general inspection of these wing feathers on museum skins of other species of *Puffinus* shearwater found evidence of a bloom but apparently not with the same shiny property as *baroli* (possibly the result of a different nanostructure but further research is required).

APPENDIX 2 Biometrics of Barolo Shearwater and Boyd's Shearwater (table 7-9)

TABLE 7 Biometrics of Barolo Shearwater *Puffinus baroli* from Azores; Cima islet, Porto Santo; Selvagem Grande, Selvagens; and Madeira, and museum skins from multiple locations. Data are mean \pm 1SD, range (sample size) or mean (sample size); sexes combined unless shown otherwise; mass (g), other measures (mm). TL = total length, WS = wingspan, HB = head to bill tip. ¹Monteiro et al (1996), ²Frank Zino (unpublished at colony data), ³Fagundes et al (2016), ⁴Rinse van der Vliet et al (unpublished at colony data), ⁵Robert Flood & Rinse van der Vliet (unpublished museum data).

Location	Mass	TL	WS	Wing	Tail	Tarsus	HB
Azores ¹	171.8 \pm 13.3 140-211 (n=157)			182.6 \pm 4.0 174-193 (n=133)	72 \pm 3.1 67-81 (n=48)	37.8 \pm 1.03 34.3-40.1 (n=93)	65 \pm 1.4 61.6-67.8 (n=105)
Azores ²	175.5 (n=2)	307.5 (n=2)		183.5 (n=2)	68.5 (n=2)	39.9 (n=2)	66.2 (n=2)
Madeira ²	146 (n=2)	305 (n=1)	620 (n=1)	186 (n=1)	75 (n=1)	40.6 (n=1)	
Porto Santo ³	169.3 (n=83)			182.6 (n=83)		37.3 (n=83)	
Selvagens ³	163.5 (n=173)			181.1 (n=173)		36.7 (n=173)	
Selvagens ⁴	165 (n=114)			181.3 (n=114)		36.6 (n=114)	
Selvagens ²		300.6 (n=5)	596.7 (n=3)	179.8 (n=5)	73 (n=5)	38.1 (n=6)	64.4 (n=7)
Multiple ⁵				177.9 (n=9)		36.5 (n=9)	62.5 (n=8)

Variation and identification of Barolo Shearwater and Boyd's Shearwater

TABLE 8 Biometrics of bill (all mm) of Barolo Shearwater *Puffinus baroli* from Azores and Selvagem Grande, Selvagens, and museum skins from multiple locations. Data are: mean \pm 1SD, range (sample size); sexes combined. NT = nasal tubes, C = culminicorn, MU = maxillary unguis, (l) = length, (h) = height; live birds unless museum skins. ¹Monteiro et al (1996), ²Frank Zino (unpublished), ³Robert Flood & Rinse van der Vliet (unpublished museum data).

Location	Bill	NT (l)	C (l)	MU (l)	NT (h)	C (h)	MU (h)
Azores ¹	25.4 \pm 1.0 22.9-27.7 (n=131)				8.5 \pm 0.6 7.0-9.8 (n=132)		5.5 \pm 0.4 5.0-6.9 (n=132)
Azores ²	25.7, 25.0-26.2 (n=2)						
Selvagens ²	24.5 \pm 1.3 22.7-26.6 (n=7)						
Multiple ³	24.9 \pm 0.8 23.0-26.6 (n=54)	7.8 \pm 0.5 6.5-8.6 (n=33)	6.2 \pm 0.8 4.8-7.6 (n=33)	11.1 \pm 0.9 9.1-12.6 (n=33)	7.9 \pm 0.4 7.1-8.5 (n=33)	5.0 \pm 0.4 4.1-6.0 (n=33)	5.4 \pm 0.3 5.0-6.0 (n=33)

TABLE 9 Biometrics of bill (all mm) of Boyd's Shearwater *Puffinus boydi* from museum skins from multiple locations in Cape Verdes Islands. Data are: mean \pm 1SD, range (sample size). NT = nasal tubes, C = culminicorn, MU = maxillary unguis, (l) = length, (h) = height. Robert Flood & Rinse van der Vliet (unpublished museum data).

Location	Sex	Bill	NT (l)	C (l)	MU (l)	NT (h)	C (h)	MU (h)
Multiple	mixed	24.5 \pm 0.8 22.9-27.3 (n=42)	6.7 \pm 0.8 5.1-8.4 (n=42)	6.6 \pm 1.1 3.9-8.7 (n=34)	11.1 \pm 1.0 9.1-12.7 (n=34)	7.8 \pm 0.7 6.2-9.2 (n=42)	5.2 \pm 0.5 4.0-6.6 (n=42)	5.5 \pm 0.4 4.8-6.2 (n=42)
Multiple	male	24.8 \pm 0.6 23.5-26.1 (n=16)	6.8 \pm 0.6 5.8-8.4 (n=16)	6.0 \pm 0.8 3.9-7.9 (n=13)	11.9 \pm 0.6 9.1-12.7 (n=13)	8.1 \pm 0.6 6.2-9.2 (n=16)	5.4 \pm 0.5 4.5-6.6 (n=16)	5.5 \pm 0.4 4.8-5.8 (n=16)
Multiple	female	24.5 \pm 0.9 23.1-27.3 (n=23)	6.5 \pm 0.7 5.1-7.8 (n=23)	6.8 \pm 1.0 4.9-8.7 (n=20)	11.1 \pm 0.8 9.9-12.7 (n=20)	7.7 \pm 0.6 6.3-8.6 (n=23)	5.2 \pm 0.4 4.3-6.2 (n=23)	5.5 \pm 0.3 4.3-6.2 (n=23)
Raso	mixed	24.6 \pm 0.5 23.5-25.4 (n=15)	7.0 \pm 0.5 6.3-8.4 (n=15)	6.3 \pm 0.9 4.9-8.0 (n=15)	11.3 \pm 1.2 9.1-12.7 (n=15)	7.6 \pm 0.8 6.2-9.2 (n=15)	5.2 \pm 0.6 4.3-6.6 (n=15)	5.3 \pm 0.4 4.8-5.9 (n=15)
Rombos	mixed	24.6 \pm 1.1 22.9-27.2 (n=19)	6.4 \pm 0.7 5.1-8.4 (n=19)	7.0 \pm 1.1 3.9-8.7 (n=16)	11.1 \pm 0.6 9.1-12.4 (n=16)	8.0 \pm 0.5 6.7-8.8 (n=19)	5.3 \pm 0.3 4.0-6.2 (n=19)	5.6 \pm 0.3 4.9-6.2 (n=19)

APPENDIX 3 Extralimital records of Barolo Shearwater *Puffinus baroli* in Europe

The species was scarce but regular, including double figure counts, in French and Spanish waters in August-September in the late 1990s to early 2000s from the Portsmouth/Plymouth (England) to Bilbao/Santander (Spain) ferries (especially in the southern Bay of Biscay; eg. Martin & Rowlands 2001), but is now rarely seen. The following records exclude the ferry sightings as well as birds identified as Barolo/Boyd's Shearwater *Puffinus baroli/boydi*. All records provided by national rarities committees (several committees reviewing records). The species has been deleted from the national list in Austria (two from Bodensee, Vorarlberg, now considered not proven) and Norway (review found all previously accepted reports not proven).

Britain: 45 records involving 48 birds (April 2, May 1, June 7, July 4, August 9, September 15, October 8, November 1, December 1). Records include male prospecting on Skomer, Wales from 26 June to 10 July 1982 (James & Alexander 1984, James 1986); same bird, 21 June to 25

July 1983; male singing 4-24 June 2010; same bird 21 April to 5 May 2011. Records under review (per British Birds Rarities Committee).
Belgium: 2 (Oostende, 19 September 1990; Zeebrugge, 25 September 1990)
France: 30 from 1985 onwards (April 1, May 1, June 1, August 4, September 13, October 9, November 1)
Germany: 1 (found dead, Bodensee, Baden-Württemberg, 25 April 1962)
Ireland: 24 (May 1, June 1, August 19, September 3)
Isle of Man: 1 (10-11 September 1994)
Italy: 4 (Sardinia, October 1892; Stura di Demonte river, Cuneo, October 1895; Ladispoli, Roma, May 1990; Capo Murro di Porco, Sicily, September 2001)
Northern Ireland: 1 (25 August 2004)
Portugal: 22 records involving 48 birds (including 4 from coast, 1 under review, 9 not submitted).
Spain: 3 (Cádiz, 12 May 1986; Gozón, 31 August 1991; Cádiz, 2 January 2010).