The poorly known Mohéli Shearwater *Puffinus* (*persicus*) *temptator* at the Comoro Islands, western Indian Ocean

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SUMMARY.—The results of a pelagic expedition to study Mohéli Shearwater *Puffinus* (*persicus*) *temptator* at sea off the islands of Grande Comore, Mohéli and Anjouan, in the western Indian Ocean, in November 2014, are presented. Variation in the underwing pattern of *temptator* is described for the first time, as are its foraging behaviour and behaviour at sea, providing the first natural history data for this poorly known taxon. In addition, observations of an unidentified, smaller shearwater, are also reported.

Mohéli Shearwater *Puffinus* (*persicus*) *temptator* is known to breed only on Mohéli, in the Comoro Islands, western Indian Ocean (Brooke 2004, Safford & Hawkins 2013). The taxon was described by Louette & Herremans (1985), based on a single specimen now in Tervuren, Belgium, and is among the most enigmatic Indian Ocean seabirds, while its taxonomy remains controversial (Bretagnolle *et al.* 2000, Austin *et al.* 2004). In October 2000, VB visited the Comoros: on Anjouan, he found a tiny colony of a small shearwater, which based on calls and cliff-breeding (*cf.* Bretagnolle *et al.* 2000) was assigned to Tropical Shearwater *P. bailloni*, although none was caught. He also visited the summit of Mohéli, in a successful attempt to relocate the *temptator* colony at night, although none was trapped. Based on this, we estimated the best season to visit the seas around Mohéli to conduct an ocean-based study, and, in November 2014, HS made a pelagic census of *temptator*, with the aim of documenting photographically large numbers of individuals, of all ages and moult stages, to acquire a better understanding of the taxon's characteristics. Large numbers of *temptator* were found, enabling us to describe the taxon's plumage variation, both individual and age-related. In addition, HS discovered the presence of an apparently distinct smaller shearwater, whose identity we discuss. To our knowledge, our pelagic seabird survey is the first of its kind in Comoros, but we hope that our observations will stimulate further research.

The Comoros comprise four main islands—Grande Comore, Mohéli, Anjouan and Mayotte—totalling 2,033 km², which lie halfway between Africa and Madagascar in the northern Mozambique Channel. All four islands are of volcanic origin. The capital, Moroni, is on Grande Comore, which has an active volcano, Mount Karthala. Climate is humid and tropical, with temperatures in the lowlands averaging *c.*28°C in March and 23°C in August. The monsoon lasts from December to April; rainfall peaks in January with on average 420 mm, while October is the driest month, with 85 mm mean rainfall; cyclones are frequent in summer.

Mohéli (211 km²) is the smallest of the main islands and the least populated. The island comprises a plateau at *c.*300 m, and its central ridge reaches 790 m in the west. The valleys are generally fertile and the hillsides covered by dense forests. A shallow oceanic ridge connects Grande Comore and Mohéli, and most of the foraging Mohéli Shearwaters were observed there.

Methods

As *temptator* was described based on its largely dark underwing coloration (Louette & Herremans 1985), we sought to document birds at sea with fully spread wings. In specimens the underwing pattern is not readily appreciated, and the precise pattern can be difficult to evaluate on trapped live birds as the relevant feathers often become disordered. HS used local fishing boats on Grande Comore, Mohéli and Anjouan, with each trip lasting 6–8 hours, reaching max. 25 nautical miles offshore, on five days (4, 5, 8, 9 and 14 November 2014, but on 5th the sea was sufficiently rough that it was necessary to return after *c.*2 hours).

On 5 and 8 November 2014, HS tested some of the same chumming techniques employed while searching for Fiji *Pseudobulweria macgillivrayi* and Mascarene Petrels *P. aterrima* (Shirihai *et al.* 2009, 2014), but the chum was placed in fishing nets and a floater used to keep the offal at the surface. As HS found that Mohéli Shearwaters forage mainly in association with feeding frenzies of sardine-eating seabirds and avoid the chum, he elected to employ fast boats to follow the birds. He searched at sea or chummed at locations close to or along oceanic contour lines, in seas between *c.*60 and 915 m deep. A marine GPS (Garmin Colorado 300) was used to mark positions, travel between locations, and log sightings. Surveys were possible only on days with calm, almost windless conditions as the boats were not suitable for rough seas.

Natural history of Mohéli Shearwater

Colony.—Louette & Herremans (1985) did not provide coordinates of the presumed colony of *temptator* close to the summit of Mohéli, on a forested ridge, but they indicated that the site was near 'Chalet St Antoine II', at *c.*670 m, where a cabin with a meteorological station was sited. In September and November 1983 they heard shearwaters giving a 'tcheh-tèè, 3–5 times consecutively, *ad nauseam*', mostly at *c.*19.00–20.00 h, occasionally later at night and again before dawn, but were unable to see the birds well in the darkness. Previously, on 23 February 1975, Cheke & Diamond (1986) had heard a shearwater calling in the same area at night. In October 2000 VB again heard birds vocalising near the summit of Mohéli at *c.*12°29′S, 43°67′E. Two other nights spent on the same ridge, but further east (*c.*12°31′S, 43°69′E), were unsuccessful as no shearwaters were heard. Although southern slopes are steeper, the colony seemed to be restricted to north-facing slopes, with most calling heard at *c.*600 m, on hills facing north and north-east, i.e. facing sea areas where the largest numbers of birds were later found (see below). Although the colony's precise extent is unknown, it appeared to be at least 500–750 m linearly, on steep slopes (but not on cliffs).

Numbers at sea.—During five days at sea, 265 Mohéli Shearwaters were recorded: 178 on 4th between Grande Comore and Mohéli and to the north; four on 5th between Grande Comore and Mohéli; 44 on 8th north and north-west of Mohéli; 16 on 9th north of Anjouan and between Mohéli and Anjouan; and 23 on 14th between Grande Comore and Mohéli. Three areas with concentrations of birds were noted, at 12°06′S, 43°26′E; 12°07′S, 43°38′E; and 12°05′S, 43°47′E. Mohéli Shearwaters regularly associated with tuna (Thunnini) shoals, and on 14 November fed with two Blue Whales *Balaenoptera musculus indica.*

Plumage variation.—Of 265 *temptator* counted, 157 could be aged and were scored using five codes relating to the pattern and darkness of the underwing-coverts (Table 1; Figs. 1–7).

Both adults and fledglings show similar variation, but palest birds (scores 1–2) are mostly adults (75%), with the opposite being true for darkest birds (scores 4–5), which are predominantly juveniles (87.5%). This suggests that the taxon is, to some extent, polymorphic with age, a case known only in some albatrosses and giant petrels *Macronectes*

TABLE 1
Scored (1 to 5 levels) underwing patterns of Mohéli Shearwaters *Puffinus* (*persicus*) *temptator* by the degree of dark on the underwing-coverts (see Figs. 1–7).

	Score 1	Score 2	Score 3	Score 4	Score 5	Totals
Adults (aged by moult and wear to the remiges)	30	32	6	4	1	73
Fresh juveniles (presumably fledglings)	6	15	28	24	11	84
Subtotals	36	47	34	28	12	157

Score 1: whitest example (adult; Figs. 1–2). Score 2: greater and fore coverts darker (juvenile; Fig. 3). Score 3: extensively dark but white band complete (adult; Fig. 4). Score 4: almost the darkest with rear greater coverts and fore coverts connected (adult; Fig. 5). Score 5: the darkest underwing with white band very narrow and incomplete (white axillaries and median coverts separated; Figs. 6–7) (both juveniles).

among Procellariiformes (Bretagnolle 1993), although young shearwaters of some species are darker/blacker, especially dorsally, vs. adults, e.g. *P. bailloni* (Bretagnolle & Attié 1996) and Yelkouan Shearwater *P. yelkouan* (HS pers. obs.), while plumage variation in *P. subalaris* (Galápagos Islands; HS pers. obs.) includes some birds with underwing patterns as blackish as in *temptator*, but relating age to this variation in *subalaris* remains to be established.

Breeding.—Moult stage is indicative of life-cycle stage in petrels, especially if age can be estimated. Most adults observed (>80%) or photographed showed signs of active moult in the (mostly inner) remiges and upperwing-coverts. These were probably either non-breeders or post-breeders (remiges are usually replaced in the non-breeding season in shearwaters). As non-breeding activity peaks during early chick-rearing, and because recently fledged birds were observed, we suggest that the Mohéli colony was either at the very late breeding stage, or nesting spans late winter to early summer, as in *P. bailloni* on Réunion (Bretagnolle *et al.* 2000) and *P. b. nicolae* on Seychelles (L. Calabrese, G. Rocamora & VB unpubl.).

Foraging behaviour.—Mohéli Shearwaters forage primarily within mixed-species feeding frenzies, mainly involving Sooty Terns *Onychoprion fuscatus* (up to 20 in a single aggregation) and Brown Noddies *Anous stolidus* (up to 230), and, frequently, Masked Bobbies *Sula dactylatra* (up to three) and Lesser Frigatebirds *Fregata ariel* (up to five). In addition, HS also identified several Black-naped Terns *Sterna sumatrana* in these feeding aggregations, with 23 in total. Most of the sizeable concentrations numbered several Mohéli Shearwaters. For example, on 4 November 2014, all nine feeding frenzies included 4–33 shearwaters. First to locate shoals of fish are Sooty Terns and, as they start to dive, Brown Noddies appear with the shearwaters, the latter diving below the


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Figure 1. Fresh adult Mohéli Shearwater *Puffinus* (*persicus*) *temptator*, with wing score 1, at end of post-nuptial moult (much of body, wing and tail replaced, but several unmoulted inner rectrices), off Mohéli, Comoros, November 2014 (Tubenoses Project & Extreme Gadfly Petrel Expeditions / Hadoram Shirihai)

Figures 2–7. Mohéli Shearwater *Puffinus* (*persicus*) *temptator*, off Mohéli, Comoros, November 2014, showing variation in darkness of underwing-coverts, as scored in this study (see Table 1); the upper- and middle-left (Figs. 2 and 4) and middle-right birds (Fig. 5) are adults during post-nuptial moult of the remiges, while the rest are juveniles (Tubenoses Project & Extreme Gadfly Petrel Expeditions / Hadoram Shirihai)

Figures 8–9. Mohéli Shearwater *Puffinus* (*persicus*) *temptator*, off Mohéli, Comoros, November 2014, with adult on left (recently moulted inner primaries) and a newly fledged juvenile on right, which has a more delicate greyish bill, blacker upperparts with a more sharply delimited cap, but less marked breast-sides; this taxon often appears to have a dark mask around the eye, especially in adults (Tubenoses Project & Extreme Gadfly Petrel Expeditions / Hadoram Shirihai)

surface, then boobies join in, while frigatebirds attack some of the other seabirds. As the flock disperses (or follows the terns), some of the longer/deeper diving shearwaters emerge on the surface, and take off. The primary driver of these feeding frenzies is the tuna and other large-fish predators that attack the sardine shoals, with the location and depth of these aggregations changing daily. Mohéli Shearwaters occurred in such aggregations off all of the surveyed islands, but (at least on 4 November) most were found over and at the edge of the shallow oceanic ridge connecting Grande Comore and Mohéli (12°07S, 43°38E), where shearwaters were observed to forage in association with two Blue Whales around sardine shoals at the north edge of the oceanic ridge (12°04'S, 43°38'E). Several shearwaters were simultaneously observed diving alongside a whale's rostrum, escaping just as the whale closed its mouth.

Taxonomic relationships.—Taxon *temptator* was suggested to be fairly close (if not identical in plumage) to *P. persicus* of the Arabian Sea, which taxon is now frequently treated specifically (e.g., by Onley & Scofield 2007), rather than as a subspecies of *P. lherminieri*. Its measurements (comparison between the type and specimens in Tring and Washington DC: Louette & Herremans 1985; pers. obs) agree in size (note USNM 571356, treated in Louette & Herremans 1985 as *persicus*, is probably a *bailloni*; VB pers. obs.), while molecularly *temptator* and *persicus* are very close (Austin *et al.* 2004). Comparison of many photographs of the two taxa reveals the same variation in the underwing-coverts, similar breast-side patches, degree of dark on the undertail-coverts and vent, and same overall pattern. Mohéli Shearwaters often has the impression of a dark mask around the eye, especially in adults, which is shared by *persicus*, but *temptator* almost always lacks the almost invariable, small but distinctive whitish patch in front or above the eye of *persicus*; *temptator* also seems to have bluer/greyer, less pinkish/flesh-toned bare parts, most notably the tarsi and webs.

Population and conservation.—As no burrows have been found, the population size of Mohéli Shearwater can only be guessed. Brooke (2004) suggested a total population of <500 individuals. In October 2000, VB found that colony extended over at least a few hectares, on several high ridges on the north slope of central Mohéli, much of which is inaccessible due to the lack of trails. Two nights elsewhere in the hills of central and southern Mohéli did not reveal any other colonies that year. In the colony, peak calling rate (just after nightfall) was rather high (*c.*30 calls/minute), suggesting that several hundred pairs were breeding (based on comparison with call rates at known-size colonies of *P. bailloni* on Réunion:

Bretagnolle *et al.* 2000). Equally, that nearly 300 individuals were observed during a few days at sea indicates a similar-sized breeding population at least. The altitude/vegetation where shearwaters have been heard was not inhabited or exploited by humans (at least in 2000), but the island's north slope is more impacted (and the forest's lower elevation limit is higher) than in the south. Cleared land lay just a few hundred metres from the colony in places.

Unidentified small shearwater off the Comoros

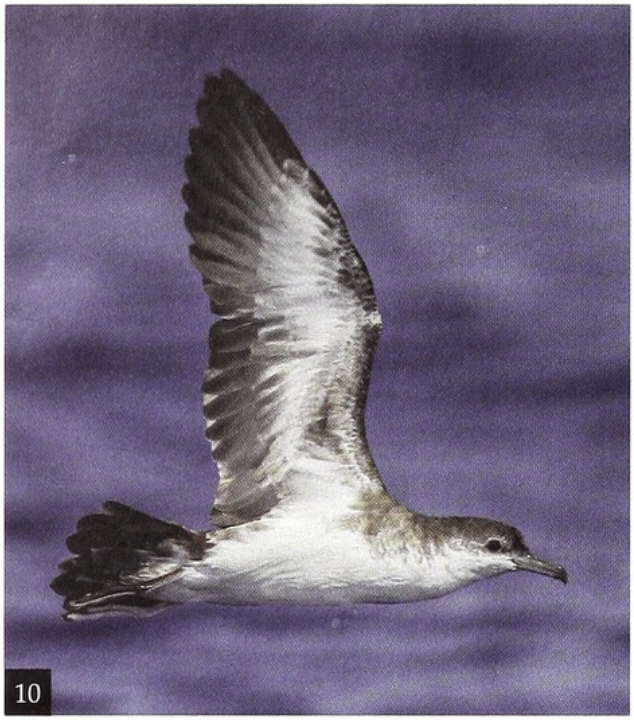
During November 2014, HS also noted several shearwaters that appeared different in size, jizz and behaviour, with different coloration patterns (Figs. 10–13). These seemed smaller and slighter with a smaller and rounder head shape, and proportionately broad and short bill. They also behaved quite differently, nearly always feeding alone, only rarely joining the mixed-species feeding frenzies of other seabirds including Mohéli Shearwaters, enabling direct comparison. In total 14 such birds were observed, on 4 (nine) and 8 November (five). Initially, HS considered the possibility of not yet fully grown fledgling Mohéli Shearwaters, as they appeared blacker above and very fresh. However, with closer views and photographs, it was clear that these birds were fresh adults completing moult of their remiges.

At least two other taxa of Tropical Shearwater may occur in these waters: *bailloni* of Réunion Island (and formerly Mauritius, as well as possibly Europa in the Mozambique Channel), and *nicolae* (including *colstoni* of Aldabra) on Seychelles (Figs. 14–15). However, the birds observed in November 2014 had dark undertail-coverts and some dark on the underwing-coverts, eliminating *bailloni*, although this taxon had been thought to be present (based on calls) on Anjouan (VB pers. obs.). Furthermore, their flight, being more elastic like Little Shearwaters *Puffinus assimilis*, with clearly bluer bills and paler ear-coverts (sometimes with an indistinct whitish supercilium), suggest they were not *nicolae*. Interestingly, they displayed quite strong variation from pale (Fig. 10) to darker underwing-coverts (Figs. 11–13), though not as extreme as the variation in *temptator*.

Concluding remarks

During November 2014 we successfully located Mohéli Shearwater, and for the first time documented its plumage photographically. We also collected basic data concerning its range and numbers at sea, as well as its behaviour, providing the first natural history information for this poorly known taxon.

Mohéli hosts the only known breeding colony of Mohéli Shearwater. Other seabirds there include a large roost of frigatebirds on the southern islets (several thousand birds; VB pers. obs.), while a rocky islet off the east coast supports breeding boobies and terns. The only other petrel breeding on the Comoros is a small shearwater found on Anjouan by VB, initially considered to be *bailloni* based on vocalisations and breeding habitat, but equally possibly could represent the unidentified small shearwater HS observed at sea in 2014. Cliff-breeding is known for *bailloni*, but was unknown for *nicolae* until recently, when very small numbers were rediscovered on Mahé, Seychelles, on the island's highest peaks (G. Rocamora pers. comm.). Therefore, cliff-breeding does not eliminate *nicolae* as the taxon on Anjouan, as originally thought. The smaller shearwaters photographed by HS represent either an extreme variation (of certain age/sex classes) of *temptator*, or an undescribed taxon superficially resembling *nicolae* and probably the same taxon as breeds on Anjouan. The combination of Little Shearwater-like characters (small size, squat jizz, pale supercilium) and predominately bluish and short, broad bill makes these birds distinctive. Unlike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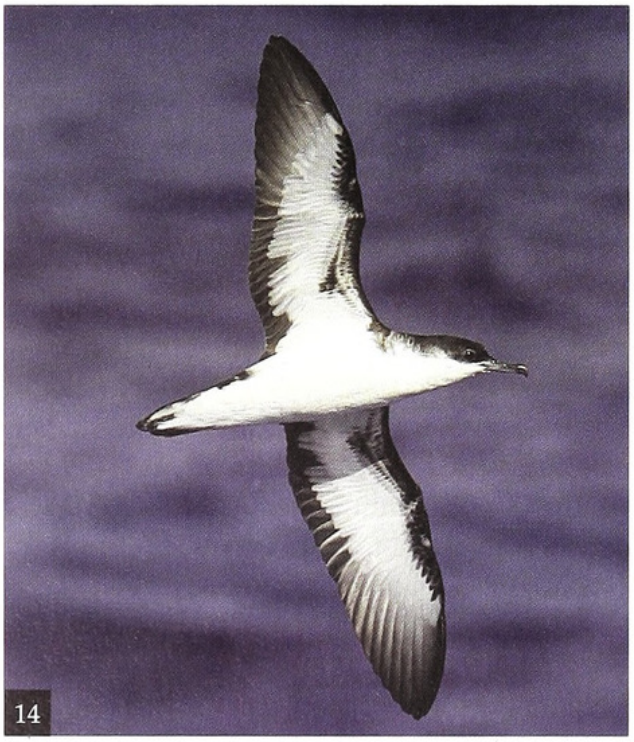
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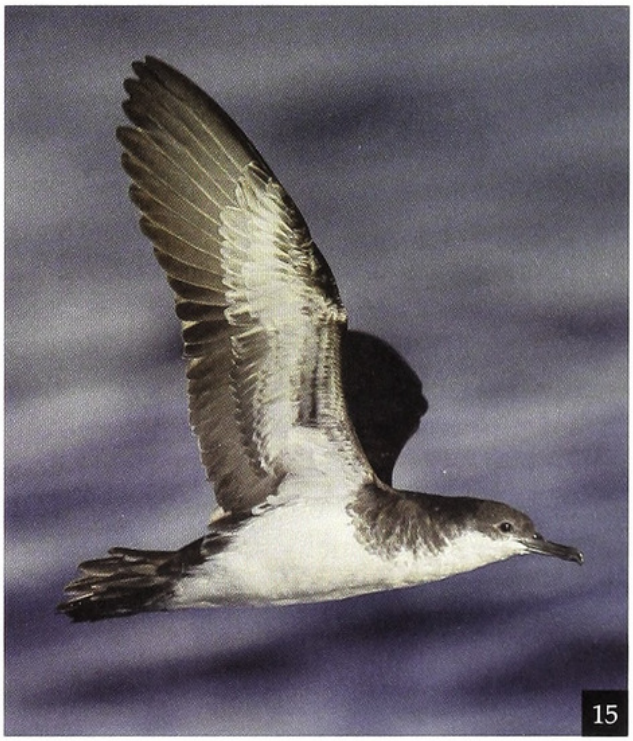
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Figures 10–13. Unidentified adult/immature small *Puffinus*, off Mohéli, Comoros, November 2014, two different individuals, with a paler underwing (top left), and a darker example (other images) (Tubenoses Project & Extreme Gadfly Petrel Expeditions / Hadoram Shirihai)

Figures 14–15. Fresh adult Tropical Shearwaters *Puffinus b. bailloni*, Réunion, December 2012 (left), and *P. b. nicolae*, Seychelles, November 2014; white undertail-coverts and extensive, whiter underwing-coverts in former, whereas these are brown and marbled dark, respectively, in latter (Tubenoses Project & Extreme Gadfly Petrel Expeditions / Hadoram Shirihai)

nicolae (including *colstoni*), the breast-side patches are weakly developed in size, colour and boldness, but are to some extent more like *bailloni*. The geographically closest breeding taxon is *colstoni* on Aldabra, but, at least in adults, this taxon is rather large (intermediate between *bailloni* and *nicolae*) with a characteristically thick bill (Shirihai & Christie 1996, Bretagnolle *et al.* 2000), making it unlikely that the unidentified Comoros shearwaters are *colstoni*. Nevertheless, most available morphometric data for these *Puffinus* are of adults and fledglings, whereas immature non-breeders are very poorly known, so we cannot eliminate that these unidentified shearwaters represent hitherto unknown age-related variation. Until such birds are captured for biometrics and DNA, their identity must remain unknown.

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